Washington State Department of Transportation

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Remarks and Instructions

How do you stay connected to current design policy?

It's the designer's responsibility to apply current design policy when developing transportation projects at WSDOT. The best way to know what's current is to reference the manual online.
Access the current electronic WSDOT *Design Manual,* the latest revision package, and individual chapters at: www.wsdot.wa.gov/publications/manuals/m22-01.htm

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

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HQ Design Office Signature **/s/ Mike Fleming**	Phone Number 360-705-7233

Remove/Insert instructions for those who maintain a printed manual

CHAPTER/SECTION	REMOVE PAGES	INSERT PAGES
Title Page	All pages	All pages
Contents/Exhibits	Page 1 - 26	Page 1 - 26
225 Environmental Coordination	Entire chapter	Entire chapter
300 Design Documentation, Approval, and Process Review	Entire chapter	Entire chapter
710 Site Data for Structures	Entire chapter	Entire chapter
720 Bridges	Entire chapter	Entire chapter
900 Roadsides	Entire chapter	Entire chapter
1120 Preservation Projects	Entire chapter	Entire chapter
1230 Jurisdiction for Design and Maintenance	Entire chapter	Entire chapter
1239 Geometric Cross Section – Shoulders, Side Slopes, Curbs, and Medians	Entire chapter	Entire chapter
1310 Intersections	Entire chapter	Entire chapter
1320 Roundabouts	Entire chapter	Entire chapter
1330 Traffic Control Signals	Entire chapter	Entire chapter
1340 Driveways	Entire chapter	Entire chapter
1515 Shared-Use Paths	Entire chapter	Entire chapter
1610 Traffic Barriers	Entire chapter	Entire chapter
1720 Weigh Sites	Entire chapter	Entire chapter

What's changed in the Design Manual for September 2019?

Chapter 225 – Environmental Coordination	Design field work lacks an Environmental Compliance Assurance Procedure
Chapter 300 – Design Documentation, Approval, and Process Review	Superseding Design Build project delivery memo and Introducing Design ECAP
Chapter 710 – Site Data for Structures	New Exhibit 710-2 for Design Build from the Structures Office
Chapter 720 – Bridges	New section 720.04 about the US Coast Guard and existing bridges from the Structures Office
Chapter 900 – Roadsides	The general section is replaced to be clearer and better guidance for designing roadsides.
Chapter 1120 – Preservation Projects	Correcting references
Chapter 1230 – Jurisdiction for Design and Maintenance	Traveled way is incorrect so it was removed
Chapter 1239 – Geometric Cross Section – Shoulders, Side Slopes, Curbs, and Medians	Exhibit and text changes requested by Regions and corrections
Chapter 1310 – Intersections	Left-turn only had 50' plus the taper to decelerate so we added deceleration to left-turn lane. Taper length had different guidance depending on where you looked so we standardized it.
Chapter 1320 – Roundabouts	Two reference changes of the FHWA "Roundabout An Informational Guide" versions.
Chapter 1330 – Traffic Control Signals	Changed information needed for designing a basic or full signal plan from Flint Jackson.
Chapter 1340 – Driveways	Vertical alignment, driveway sections, and other guidance is added.

Chapter 1515 – Shared-Use Paths	Better explained vertical clearance over shared-use paths.
Chapter 1610 – Traffic Barriers	Updates to guidance and policy
Chapter 1720 – Weigh Sites	Replaced old WSDOT/WSP Memorandum of Understanding (MOU).

About revision marks and footer dates:

- A new date appears in the footer of each chapter that has changes.
- Changes include inserted or deleted content and existing content that shifts to a new page.
- Substantially rewritten chapters will have no revision marks.

Washington State
Department of Transportation

Design Manual

M 22-01.17

September 2019

Engineering and Regional Operations

Development Division, Design Office

Americans with Disabilities Act (ADA) Information

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

Title VI Notice to Public

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Chapter 225 Environmental Coordination

225.01 General

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 Manual and supporting web pages provide detailed instructions on how to determine what level of documentation is required and how to prepare the documents. This chapter provides a summary of the relevant provisions in the *Environmental 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 region Environmental Office and the NEPA/SEPA Compliance Section of the Headquarters Environmental Services Office routinely provide environmental documentation assistance to designers and project engineers.

225.02 Determining the Environmental Documentation

The Environmental Review Summary (ERS) provides the first indication of what form the environmental documentation will take. The ERS is developed as part of the Project Summary, which is prepared during the scoping phase of all projects in the construction program. The Project Summary (see Chapter 300 for additional information) includes two components:

- Project Definition
- Environmental Review Summary

The ERS is part of the Project Summary database. The ERS describes the potential environmental impacts, proposed mitigation, and necessary permits for a project. It establishes the initial environmental classification and identifies the key environmental elements addressed in the NEPA/SEPA process. The ERS database includes fully integrated “Help” screens. Contact your region Environmental Office or Program Management Office to get set up to work in the database.

The typical process for classifying projects and determining the level of environmental documentation 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 region Environmental Manager then concurs with the classification by approving the ERS, which enables the completed form to be included in the Project Summary package.
- For NEPA, if a project has been determined to be a Categorical Exclusion (CE), the Environmental Classification Summary/SEPA Checklist (ECS/SEPA Checklist) is completed. The NEPA environmental review process is considered complete when the region Environmental Manager approves the ECS package (guidance is provided in the online Help in the ECS/SEPA Checklist database). If it is determined that a Categorical Exclusion (CE), an 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 ECS/SEPA Checklist 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 (WACs 197-11-800 and 468-12) and require a SEPA checklist (WAC 197-11-960) or an EIS, those documents are prepared as necessary prior to Project Development Approval.

At this early stage, the ERS allows environmental staff to consider potential impacts and mitigations and required permits. For many projects, the WSDOT Geographic Information System (GIS) Workbench coupled with a site visit provides sufficient information to fill out the ERS (see the GIS Workbench online Help).

For most WSDOT projects, the Federal Highway Administration (FHWA) is the lead agency for NEPA. Other federal lead agencies on WSDOT projects are the U.S. Army Corps of Engineers, Federal Aviation Administration, Federal Railroad Administration, and Federal Transit Administration.

225.03 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 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, follow SEPA guidelines. Since many WSDOT projects are prepared with the intent of obtaining federal funding, NEPA guidelines are usually followed. (See Chapter 300 of the Environmental Manual for more information.)

225.04 Environmental 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 documentation. The file consists of proposed mitigation measures; commitments made to regulatory agencies, tribes, and other stakeholders; and other documented commitments made on the project. Further commitment types (right of way, maintenance, and so on) may be added at the region's discretion.

The region Environmental Office is responsible for creating and maintaining the commitment file as a project progresses through its development process. Whenever commitments are made, they are incorporated into project documents and added to the environmental commitment file once they are finalized. Commitments are typically included within, but not limited to, the following documents or approvals and any of their supplements or amendments:

- Memoranda, Agreements, Letters, Electronic Communications
- No-Effect Letters
- Biological Assessments
- Biological Opinions
- Concurrence Letters
- SEPA Checklists
- NEPA Categorical Exclusions
- NEPA Environmental Assessments
- NEPA/SEPA Environmental Impact Statements
- Finding of No Significant Impact (FONSI)
- Record of Decision (ROD)
- Section 106 Concurrence Letter from Tribes and Department of Archaeology & Historic Preservation
- Mitigation Plans
- Environmental Permits and Applications, and Associated Drawings and Plans

Additional information (see Procedure 490-a) for establishing a commitment file is available online at WSDOT's Tracking Commitments webpage. WSDOT has a Commitment Tracking System to organize and track commitments from the commitment file. Refer to the Environmental Manual (Chapter 490) for policies associated with tracking commitments.

225.05 Environmental Permits and Approvals

WSDOT projects are subject to a variety of federal, state, and local environmental permits and approvals. Performing field work in support of the project design may also require environmental permits or approvals. Understanding and anticipating what permits and approvals may be required for a particular project type will assist the designer in project delivery. The Environmental Permits and Approval website provides guidance on the applicability of permits and approvals. Because the facts of each project vary and the environmental regulations are complex, reliance on either the Design Manual or the Environmental Manual is insufficient. Consult region environmental staff.

The Environmental Review Summary, which is 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 caused by late discoveries. Coordinate with and communicate any project changes to region environmental staff.

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 the National Environmental Policy Act (NEPA) and the State Environmental Policy Act (SEPA). The mitigation measures developed for the NEPA/SEPA documents are captured as permit conditions on the subsequent permits.

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 Project Engineer is encouraged to meet with and discuss expectations with support groups so that preliminary field investigations are conducted in compliance with environmental permits, agreements, laws, or regulations. At a minimum, the support groups should know how to access the environmental commitments for the project and determine which ones apply to their work. If a non-compliance event occurs, coordinate with support groups so that they know to initiate the Environmental Compliance Assurance Procedure (see 225.06(1) for details).

225.05(1) *Environmental Compliance During Design Phase*

The purpose of the Environmental Compliance Assurance Procedure (ECAP) is to recognize and rectify environmental non-compliance events during all phases of the project development process including the Design phase. The ECAP provides prompt notification to WSDOT management and regulatory agencies. For purposes of ECAP, non-compliance events are defined as actions that violate environmental permits, agreements, laws, or regulations.

Responsibilities for field work during design phase.

1. **PE** or designee:
   Step A - Takes the necessary actions so that appropriate environmental documentation and permits are obtained for field work during the PE phase
   Step B - Provides permits and communicates permit conditions to support groups performing field work (Geotechnical, Utilities, Environmental, etc.)

2. The **Environmental Manager** or designee will help generate or make accessible the appropriate environmental documentation and permits.

3. **Support Group** / **Field Crew** is responsible for permit compliance, including the following:
   - Confirming they have all the permits, and understanding of the permit conditions prior to beginning work

- Evaluating field operations, including access to specific locations, and developing work plans so that permit conditions are met (Temporary Erosion and Sediment Control (TESC), etc.)
- Recognizing and identifying non-compliance issues.
- Notifying the PE and Environmental Manager when non-compliance issues/events happen.

When non-compliance is suspected or known, it is the Project Engineer's (PE) responsibility to initiate the Notification and Resolution Process below. The Regional Environmental Manager will serve as a resource to the PE and give priority to addressing the non-compliance event. The PE and Environmental Manager shall work together on an appropriate response to avoid or minimize environmental damage.

225.05(1)(a) Notification and Resolution Process

When non-compliance occurs or is suspected, the following steps are taken:

1. The person/support group who discovers an event shall immediately notify the PE.
2. The **PE** or designee shall:

   Step A – Inform the field crew to suspend all work that is causing non-compliance.

   Step B – Immediately contact the Environmental Manager or designee to help determine if it is or is not a non-compliance event. (Note: if event is compliant; stop the notification process and resume work activity).

   Step C - If non-compliant, collaborate with the Environmental Manager to determine the regulatory agencies with jurisdiction. Notify all regulatory agencies with jurisdiction.

   Step D – Consult with the Environmental Manager regarding response actions taken so far and any additional remediation actions that may be necessary.

   Step E– Notify the appropriate Assistant Region Administrator or Engineering Manager for Design and the Assistant State Design Engineer assigned to that Region or Project.

   Step F – Additional notifications (see F.1 and F.2 below) from the PE are necessary when the non-compliance event:

   - Results in a formal written/verbal enforcement action from a regulatory agency or
   - Presents significant risk to public health or
   - Presents significant risk to the environment or
   - Creates a public controversy. (The Region decides what "public controversy" means.)

   Step F.1 – Region Highway Projects: Notify the Region Administrator (give a courtesy notification to the Assistant State Design Engineer assigned to the project).

   Step F.2 – Mega Projects Highway Projects: Notify the Mega Project's Program Administrator (give a courtesy notification to the Assistant State Design Engineer assigned to the project).
3. The **Region Administrator**, Assistant **State Design Engineer, and/or Mega Projects Program Administrator** shall notify the appropriate agency executives as warranted by the situation.

4. The **Environmental Manager** or designee shall:

   Step A – Notify the Director of the Environmental Services Office (ESO) when the non-compliance event:

   - results in a formal written/verbal enforcement action from a regulatory agency;
   - presents significant risk to public health or

- presents significant risk to the environment or
- creates a public controversy. (The Region decides what "public controversy" means)

Step B - Assist the PE in determining and recognizing the underlying root cause(s) that resulted in the non-compliant event, and determining how to prevent a reoccurrence of the event.

Step C - In consultation with the PE, identify and obtain new or modified permits, approvals, or agreements as needed to rectify the non-compliance event.

5. The **Director of the ESO** shall notify the ESO Compliance Solutions Branch Manager.

225.05(1)(b) Documentation

1. The PE and the Environmental Manager shall coordinate and prepare the appropriate responses to all regulatory agencies with jurisdiction. The responses shall include documentation about the non-compliance event and how it was recognized and rectified.
2. The Environmental Manager, with assistance from the PE, shall record the details of the non-compliance event in the WSDOT Commitment Tracking System (per RCW 47.85.040), including but not limited to:
   - Project Name and location, plus the name of the PE.
   - Date of event.
   - Location(s) on the project where the non-compliance event occurred.
   - The type of work and the underlying root cause that resulted in the non-compliance event.
   - The environmental, permit, agreement, law, or regulation violated.
   - Description of how the non-compliance event was recognized, rectified, and the lessons learned.
   - Which regulatory agencies and staff were notified, including dates of notification and any tracking numbers provided.
   - Whether or not regulatory agency staff conducted a site review in response to the notification.

The ESO shall produce a yearly report of all written notifications or violations to the Washington State Legislature (per RCW 47.85.040).

225.06 Documentation

Refer to Chapter 300 for design documentation requirements.

225.07 References

225.07(1) *Federal/State Laws and Codes*

42 United States Code (USC) 4321, National Environmental Policy Act of 1969 (NEPA)

23 Code of Federal Regulations (CFR) Part 771, Environmental Impact and Related Procedures

23 CFR Part 774; 49 USC Section 303, Policy on Lands, Parks, Recreation Areas, Wildlife and Waterfowl Refuges, and Historic Sites

36 CFR Part 800, Protection of Historic and Cultural Properties

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

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

Chapter 47.85 Revised Code of Washington (RCW), Transportation Project Delivery and Review

Chapter 197-11 Washington Administrative Code (WAC), SEPA Rules

Chapter 468-12 WAC, WSDOT SEPA Rules

225.07(2) *WSDOT Environmental Resources*

WSDOT region environmental staff

Environmental Permits and Approval webpage:
https://www.wsdot.wa.gov/environment/technical/permits-approvals

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

Chapter 300 Design Documentation, Approval, and Process Review

300.01 General

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

This chapter presents critical information for design teams, including:

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

For local agency and developer projects on state highways, design documentation is also needed. It is retained by the region office responsible for the project oversight, in accordance with the WSDOT records retention policy. All participants in the design process are to provide the appropriate documentation for their decisions. See 300-04(3) for information about the approval process and authority. For more information about these types of projects, see the *Local Agency Guidelines* and *Development Services Manual* available at the Publications Services Index website:
www.wsdot.wa.gov/Publications/Manuals/index.htm

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

Office in accordance with HQ Traffic Office direction and included in the design documentation for the project.

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

300.02 WSDOT Project Delivery

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

Preservation projects with an overall project cost of $10 million and over—and all other projects with an overall project cost of $2 million and over—are required to go through the Project Delivery Method Selection process. The overall project cost is the total of the Preliminary Engineering, Right of Way, and Construction Costs.

For all projects, the delivery method is determined using WSDOT Project Delivery Method Selection Guidance (PDMSG), with the following exceptions:

- Projects under $2 million are programmatically exempt from PDMSG, do not require a Project Delivery Method Selection Checklist, and will be Design Bid Build.
- Preservation Paving projects under $10 million are programmatically exempt from PDMSG, do not require a Project Delivery Method Selection Checklist, and will be Design Bid Build.

Design Build's most likely application would be for improvement projects in the mobility, economic initiatives, or environmental subprograms where there are opportunities for innovation, greater efficiencies, or significant savings in project delivery time.

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

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

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

300.02(1) Environmental Requirements

All projects involving a federal action require National Environmental Policy Act (NEPA) documentation. WSDOT uses the Environmental Review Summary (ERS) portion of Project Summary to scope environmental impacts associated with the proposed project and document the anticipated environmental class of action (EIS/EA/CE). The environmental approval levels are shown in Exhibit 300-2.

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

300.02(2) Real Estate Acquisition

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

300.03 Design Documentation and Records Retention Policy

300.03(1) Purpose

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

300.03(2) Certification of Documents by Licensed Professionals

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

300.03(3) Project File and Design Documentation Package

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

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

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

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

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

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

300.04 Project Design Approvals

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

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

300.04(1) Design Approval

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

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

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

- Stamped cover sheet *
- A reader-friendly Design Approval memorandum that describes the project
- Project Vicinity Map
- Project Summary documents
- Basis of Design (BOD) *
- Alternatives Comparison Table
- Design Parameter Sheets
- Safety Analysis or Crash Analysis Report (CAR) *
- Current Project Design Analysis(s) *
- List of known Design Analysis documents (contact your ASDE)
- List of known Maximum Extent Feasible (MEF) documents (contact your ASDE)
- Channelization plans, intersection plans, or interchange plans (if applicable)
- Alignment plans and profiles (if project significantly modifies either the existing vertical or horizontal alignment)
- Current cost estimate

* Include the original approved documents

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

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

300.04(1)(a) Design-Build Projects

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

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

300.04(2) Project Development Approval

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

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

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

- Stamped cover sheet
- A reader friendly Project Development Approval (PDA) Memorandum that describes the project
- Project Vicinity Map
- Design Approval documents (and any supplements)
    - Updated Basis of Design (BOD) *
    - Updated list of Project Design analysis(s) *
    - Updated cost estimate
- NEPA Approvals
- SEPA Approvals

* Include the original approved documents

Project Development Approval remains valid for three years.

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

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

300.04(2)(a) Design-Build Projects

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

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

300.04(3) Local Agency and Developer Services Approvals

Local agencies or developers proposing projects for construction on state highways, or within WSDOT jurisdiction on city streets that serve as part of state highways per RCW 47.24, are required to document design decisions using the WSDOT design documentation policy (see 300.03) and as follows. The local agency or developer is required to document all decisions that change one or more design elements (see 1105.02) using the Basis of Design. Documentation is submitted to WSDOT for review and approval according to Exhibit 300-5. Where FHWA approval is indicated, WSDOT will forward submitted information to FHWA for their approval and transmit FHWA's approval, comments, and/or questions back to the submitter.

In cases where design decisions are imposed on the local agency or developer by WSDOT or FHWA, in order to secure their approval, those specific decisions are to be documented by WSDOT. Note that the requirement to submit a Basis of Design for approval may be waived by the approving authority designated in Exhibit 300-5, based on the criterion in 1100.10(1)(a). When a Region is the approval authority for the BOD and is considering an exemption, the Region approving authority can assume the role of the Assistant State Design Engineer to determine if an exemption is appropriate. For more information about the Basis of Design, see Chapters 1100 through 1106.

300.05 FHWA Oversight and Approvals

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

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

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

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

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

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

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

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

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

300.05(2) FHWA Approvals on Non-PoDI Projects

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

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

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

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

300.06 Project Documents and Approvals

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

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

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

300.06(1) Project Summary

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

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

The PD identifies the various disciplines and design elements that are anticipated to be encountered in project development. It also states the purpose and need for the project, the program categories, and the recommendations for project phasing. The PD is initiated early in the scoping phase to provide a basis for full development of the ERS, schedule, estimate, Basis of Estimate, and Basis of Design (where indicated in scoping instructions). If circumstances necessitate a change to an approved PD, the project manager and the regional program manager will document the change according to the CPDM Change Management process. For more information, see the *Program Management Manual*, Chapter 9 Managing Change.

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

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

300.06(2) Basis of Design (BOD)

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

300.06(3) Basis of Estimate (BOE)

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

300.06(4) Design Analysis

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

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

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

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

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

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

300.07 Process Review

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

The design and PS&E process review is performed at least once each year by the HQ Design Office. The documents used in the review process are the Design Documentation Package

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

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

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

300.07(1) Process Review Agenda

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

A WSDOT process review follows this general agenda:

1. Review team meets with region personnel to discuss the objective of the review.
2. Review team reviews the design and PS&E documents, construction documents, and change orders (if available) using the checklists.
3. Review team meets with region personnel to ask questions and clarify issues of concern.
4. Review team meets with region personnel to discuss findings.
5. Review team submits a draft report to the region for comments and input.
6. If the review of a project shows a serious discrepancy, the region design authority is asked to report the steps that will be taken to correct the deficiency.
7. Process review summary forms are completed.
8. Summary forms and checklists are evaluated by the Director & State Design Engineer, Development Division.
9. Findings and recommendations of the Director & State Design Engineer, Development Division, are forwarded to the region design authority for action and/or information within 30 days of the review.

300.08 References

300.08(1) Federal/State Laws and Codes

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

23 CFR 635.411, Material or product selection

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

RCW 47.28.035, Cost of project, defined

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

300.08(2) Design Guidance

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

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

WSDOT technical manuals, including those listed below:

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

- *Advertisement and Award Manual*, M 27-02, WSDOT
- *Cost Estimating Manual for WSDOT Projects*, M 3034, WSDOT
- *Design Manual*, M 22-01, WSDOT
- *Emergency Relief Procedures Manual*, M 3014, WSDOT
- *Environmental Manual*, M 31-11, WSDOT
- *Hydraulics Manual*, M 23-03, WSDOT
- *Highway Runoff Manual*, M 31-16, WSDOT
- *Plans Preparation Manual*, M 22-31, WSDOT
- *Roadside Manual*, M 25-30, WSDOT
- *Roadside Policy Manual*, M 3110, WSDOT
- *Temporary Erosion and Sediment Control Manual*, M 3109, WSDOT

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

Program Management Manual, M 3005, WSDOT
http://wwwi.wsdot.wa.gov/publications/manuals/fulltext/M3005/PMM.pdf

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

300.08(3) Supporting Information

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

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

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

Highway Safety Manual (HSM), AASHTO

Exhibit 300-1 Approval Authorities

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

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

For table notes, see the following page.

Exhibit 300-1 Approval Authorities (continued)

Notes:

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

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

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

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

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

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

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

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

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

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

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

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

Exhibit 300-2 Approvals

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

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

Exhibit 300-2 Approvals (continued)

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

Notes:

[1] Federal-aid projects only.
[2] Approved by Assistant Secretary, Engineering & Regional Operations.
[3] Approved by Director & State Design Engineer, Development Division.
[4] Approved by Right of Way Plans Manager.
[5] Refer to Chapter 210 for approval requirements.
[6] Final review & concurrence required at the region level prior to submittal to approving authority.
[7] Final review & concurrence required at HQ prior to submittal to approving authority.
[8] On Interstate projects, the Director & State Design Engineer, Development Division, (or designee) submits the approved design hearing summary to the FHWA for federal approval. (See Chapter 210.)
[9] See Exhibit 300-1 for BOD Approvals.
[10] Approved by HQ Capital Program Development and Management (CPDM).
[11] Certified by the responsible professional licensee.
[12] Submit to HQ Mats Lab for review and approval.
[13] Approved by Regional Administrator or designee.
[14] Per 23 CFR 635.111.
[15] See the *Hydraulics Manual* for approvals levels.
[16] Applies to regions with a Landscape Architect.
[17] Applies to regions without a Landscape Architect.
[18] Approved by State Traffic Engineer.
[19] Vacant.
[20] Region Traffic Engineer or designee.
[21] The State Bridge and Structures Architect reviews and approves the public art plan (see Chapter 950 for further details on approvals).
[22] State Traffic Engineer or designee.

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

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

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

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

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

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

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

1. Survey

- ❑ End areas (cut & fill)
- ❑ Staking data
- ❑ Horizontal/Vertical control
- ❑ Monumentation/Control information

2. Design Backup

- ❑ Index for all backup material
- ❑ Backup calculations for quantities
- ❑ Geotech shrink/swell assumptions
- ❑ Basis of Design, Design decisions and constraints
- ❑ Approved Design Analyses
- ❑ Hydraulics/Drainage information
- ❑ Clarify work zone traffic control/workforce estimates
- ❑ Geotechnical information (report)
- ❑ Package of as-builts used (which were verified) and right of way files
- ❑ Detailed assumptions for construction CPM schedule (working days)
- ❑ Graphics and design visualization information (aerials)
- ❑ Specific work item information for inspectors (details not covered in plans)
- ❑ Traffic counts
- ❑ Management of utility relocation

3. Concise Electronic Information With Indices

- ❑ Detailed survey information (see Survey above)
- ❑ Archived InRoads data
- ❑ Only one set of electronic information
- ❑ “Storybook” on electronic files (what’s what)
- ❑ CADD files

4. Agreements, Commitments, and Issues

- ❑ Agreements and commitments by WSDOT
- ❑ RES commitments
- ❑ Summary of environmental permit conditions/commitments
- ❑ Other permit conditions/commitments
- ❑ Internal contact list
- ❑ Construction permits
- ❑ Utility status/contact
- ❑ Identification of the work elements included in the Turnback Agreement (recommend highlighted plan sheets)

5. Construction Support

- ❑ Assign a Design Technical Advisor (Design Lead) for construction support

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

Exhibit 300-5 Local Agency and Developer Approvals

Project Type	Basis of Design (BOD) Approval	Design Analysis Approval	Design Approval and Project Development Approval
Interstate			
All projects	FHWA	FHWA	FHWA
Highways (NHS) & (Non-NHS)			
Projects on limited access highways	HQ Design	HQ Design	Region
Projects on managed access highways	Region	HQ Design	Region

Chapter 710 Site Data for Structures

710.01 General

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

710.02 Required Data for All Structures

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

Submit the structure site data to the HQ Bridge and Structures Office, Project Support unit, by email. In the email message, provide a general description of the project and provide a bullet list itemization of the structure site data forms, files, and data attached or linked in the email. Submit the structure site data as a CAD file with associated supplemental drawings and a report. (See Exhibit 710-1 for items to include in a structure site data submittal). Direct any questions relating to the preparation of structure site data to the HQ Bridge and Structures Office, Project Support unit. The *Bridge Design Manual* shows examples of required WSDOT forms.

710.02(1) Scour

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

710.02(2) CAD Files and Supplemental Drawings

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

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

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

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

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

710.02(2)(a) Plan

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

710.02(2)(b) Profile

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

710.02(2)(c) Section

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

710.02(3) Report

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

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

710.02(4) Video and Photographs

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

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

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

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

- Show riprap or other slope protection requirements at the structure site (type, plan limits, and cross section) as determined by the HQ Hydraulics Section.

- Show a profile of the waterway. The extent will be determined by the HQ Hydraulics Section.
- Show cross sections of the waterway including new streambed design, defining the bankfull width and the bank shelf widths and slopes. The extent will be determined by the HQ Hydraulics Section. The requirements for waterway profile and cross sections may be less stringent if the HQ Hydraulics Section has sufficient documentation (FEMA reports, for example) to make a determination. Contact the HQ Hydraulics Section to verify the extent of the information needed. Coordinate any rechannelization of the waterway with the HQ Hydraulics Section.
- Many waterway crossings require a permit from the U.S. Coast Guard (see *Bridge Design Manual* Chapter 2.2.4 and the *Environmental Manual*). Generally, ocean tide-influenced waterways and waterways used for commercial navigation require a Coast Guard permit. These structures require the following additional information:
    - Names and addresses of the landowners adjacent to the bridge site.
    - Quantity of new embankment material within the floodway. This quantity denotes, in cubic yards, the material below and the material above normal high water.

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

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

710.04 Additional Data for Grade Separations

710.04(1) Highway-Railroad Separation

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

710.04(1)(a) Plan

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

710.04(1)(b) Profile

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

710.04(2) Highway-Highway Separation

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

710.04(2)(a) Plan

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

710.04(2)(b) Profile

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

710.04(2)(c) Section

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

710.05 Additional Data for Widenings

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

710.05(1) Bridge Widenings

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

710.05(1)(a) Plan

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

- Description of existing barriers, railings, expansion joints, and bridge attachments, in accordance with Form 235-002A.

710.05(1)(b) Profile

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

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

710.06 Site Data for Design-Build Conceptual Drawings

Structure site data content and submittal requirements for development of structure conceptual drawings associated with Design-Build projects are similar but simplified to those associated with Design-Bid-Build projects. The simplified content requirements are outlined in Exhibit 710-2. The submittal of elements identified in Exhibit 710-2 as conceptual plan structure site data components shall conform to and be as described in Sections 710.02 through 710.05

710.07 Documentation

Refer to Chapter 300 for design documentation requirements.

710.08 References

Bridge Design Manual, M 23-50, WSDOT

Electronic Engineering Data Standards, M 3028

Environmental Manual, M31-11

Hydraulics Manual, M 23-03

Exhibit 710-1 Structure Site Data Checklist

PLAN (in CAD file)

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

TABLES (in tabular format in CAD file)

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

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

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

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

Bridge Site Data General

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

Bridge Site Data for Stream Crossings

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

Supplemental Bridge Site Data: Rehabilitation/ Modification

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

_____ Bridge Roadway Width
_____ Lane and Shoulder Widths
_____ Profile Grade and Pivot Point
_____ Superelevation Rate
_____ Survey Line
_____ Pedestrian facility width
_____ Bicycle facility width
_____ 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

Exhibit 710-2 Conceptual Plan Structure Site Data Checklist

PLAN (in CAD file)

- ____ Survey Lines and Station Ticks
- ____ Survey Line Bearings
- ____ Roadway and Median Widths
- ____ Lane and Shoulder Widths
- ____ Bicycle and Pedestrian Facility and widths
- ____ Bridge Deck Sidewalk Width
- ____ Profile Grade and Pivot Point
- ____ Roadway Superelevation Rate (if constant)
- ____ Traffic Arrows
- ____ Existing utilities Type, Size, and Location
- ____ Contours
- ____ Stream Flow Arrow
- ____ R/W Lines and/or Easement Lines
- ____ Exist. Bridge No. (to be removed, widened)
- ____ Section, Township, Range
- ____ County, City or Town
- ____ North Arrow
- ____ SR Number
- ____ Scale

TABLES (in tabular format in CAD file)

- ____ Curb Line Elevations at Top of Existing Br. Deck
- ____ Undercrossing Roadway Existing Elevations
- ____ Undercrossing Railroad Existing Elevations
- ____ Curve Data

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

- ____ Superelevation Diagrams
- ____ Profile Grade Vertical Curves
- ____ Railroad Agreement Status
- ____ Highway Classification
- ____ Design Speed
- ____ ADT, DHV, and % Trucks
- ____ In Roads reports

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

Bridge Site Data General

- ____ Pedestrian Barrier/Pedestrian Rail Height
- ____ Datum
- ____ Control Section
- ____ Project Number
- ____ Region Name
- ____ Project Name

Bridge Site Data for Stream Crossings

- ____ Water Surface Elevations and Flow Data
- ____ Bankfull Width
- ____ Bank shelf width

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

- ____ Bridge Roadway Width
- ____ Lane and Shoulder Widths
- ____ Bicycle facility width
- ____ Pedestrian facility width
- ____ Profile Grade and Pivot Point
- ____ Superelevation Rate
- ____ Survey Line
- ____ PB/Pedestrian Rail Dimensions

Chapter 720 Bridges

720.01 General

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

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

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

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

720.02 Bridge Locations

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

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

720.03 Bridge Site Design Elements

720.03(1) Structural Capacity

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

720.03(1)(a) New Structures

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

720.03(1)(b) Existing Structures

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

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

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

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

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

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

720.03(2) Bridge Widths

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

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

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

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

720.03(3) Horizontal Clearance

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

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

720.03(4) Bridge Medians

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

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

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

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

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

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

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

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

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

Exhibit 720-1 Phased Development of Multilane Divided Highways

720.03(5) Vertical Clearance

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

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

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

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

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

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

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

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

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

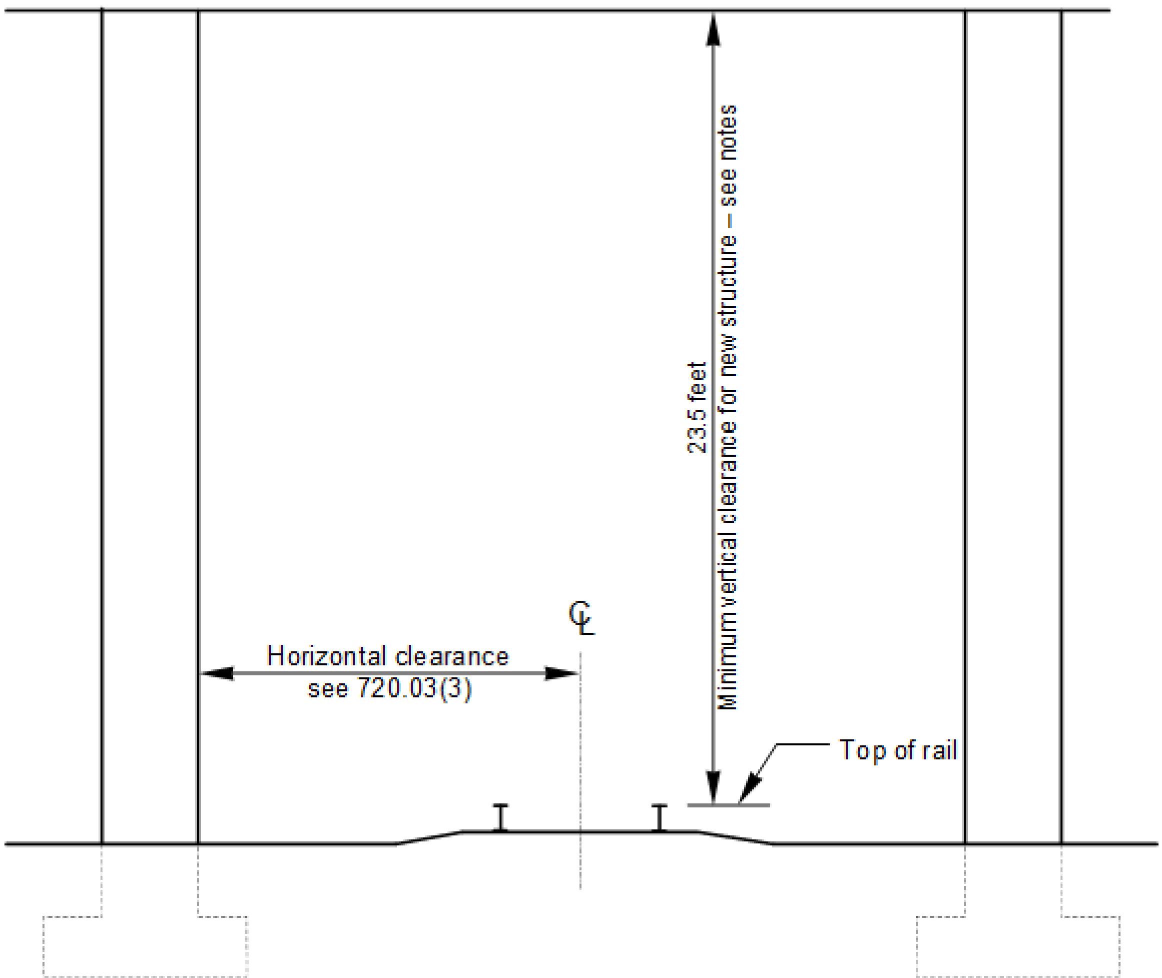
720.03(5)(b)(2) Bridge Over a Railroad Track

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

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

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

Exhibit 720-2 Highway Structure Over Railroad



Notes:

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

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

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

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

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

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

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

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

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

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

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

Exhibit 720-3 Bridge Vertical Clearances

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

Notes:

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

[2] No documentation required.

[3] Document to Design Documentation Package.

[4] Approved design analysis required.

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

[6] Maintain 17.5-ft clearance.

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

[8] See 720.03(5).

720.03(5)(d) Signing

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

720.03(5)(e) Coordination

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

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

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

720.03(6) Liquefaction Impact Considerations

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

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

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

720.03(7) Pedestrian and Bicycle Facilities

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

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

720.03(8) Bridge Approach Slab

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

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

720.03(9) Traffic Barrier End Treatment

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

720.03(10) Bridge End Embankments

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

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

720.03(11) Bridge Slope Protection

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

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

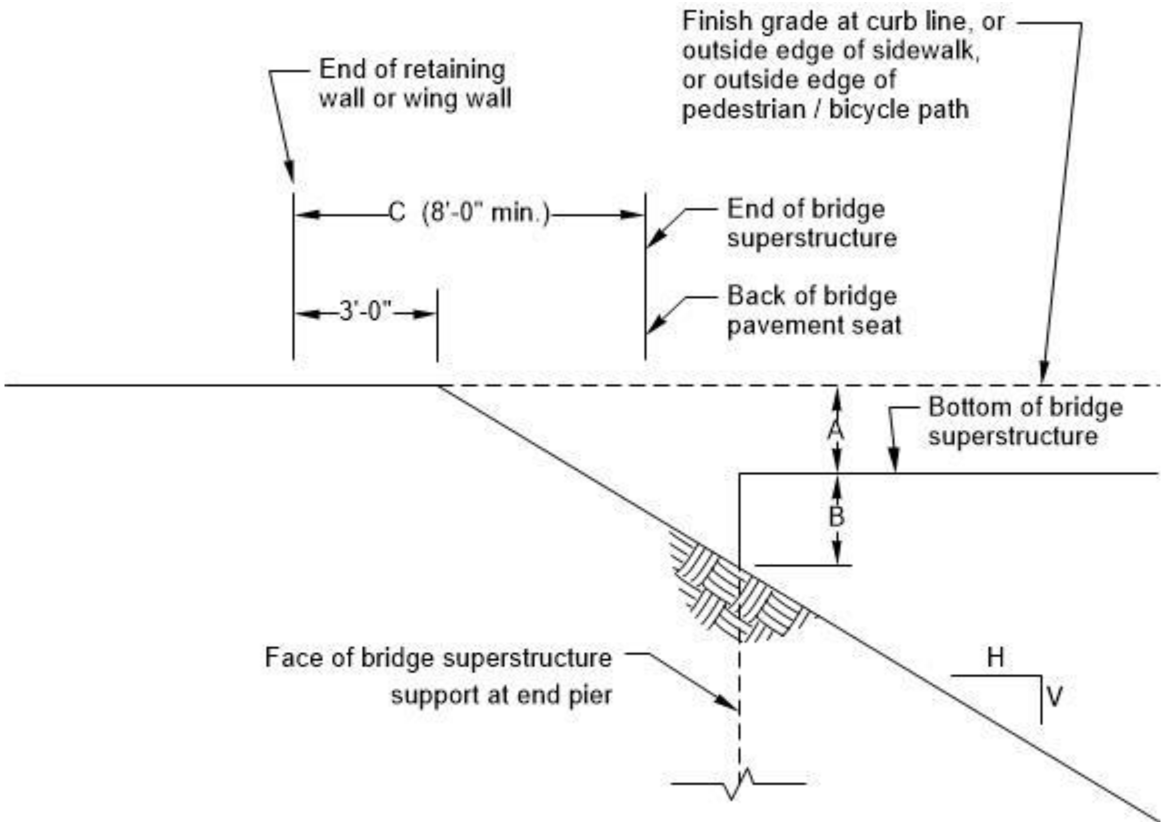
Slope protection is usually not provided under pedestrian structures.

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

720.03(12) Slope Protection at Water Crossings

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

Exhibit 720-4 Embankment Slope at Bridge Ends



Bridge End Elevation

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

Legend

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

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

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

H & V = Embankment slope: recommended by Geotechnical Engineer

720.03(13) Screening for Highway Structures

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

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

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

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

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

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

720.04 Coordination with US Coast Guard for Existing Bridges

Existing bridges crossing navigable waters occasionally require construction or maintenance activities that impact navigation channels governed by USCG permits. For fixed span bridges, this may include construction or maintenance activities that infringe upon the horizontal and vertical navigation opening defined in the USCG permit. For movable bridges, in addition to the above, this may also include adjustments to existing bridge opening operating notice and process as defined in current regulations.

Because these impacts are temporary and are limited to the duration of the construction or maintenance activity, they do not affect or change the actual USCG bridge permit. However, such temporary adjustments still require coordination with the US Coast Guard early in the project design schedule.

The primary responsibility for this contact and coordination lies with the Region Design Project Office. The scope of such coordination varies depending on the extent of the infringement into the defined horizontal or vertical navigation clearance opening, the extent of the change to the bridge operation notice or process as defined in current regulation, and the duration of the construction or maintenance activity.

This coordination activity may require the Design Project Office to conduct a survey of waterway users or to perform other background information tasks requested by the US Coast Guard.

Projects with more extensive impacts may lie outside the approval authority of the local USCG Commander and may require review and action by US Coast Guard HQ in Washington, DC. In all cases, the earlier in the design process that the Region Design Project Office initiates these coordination efforts, the more likely the USCG can complete their regulatory process without impacting the project schedule.

720.05 Documentation

Refer to Chapter 300 for design documentation requirements.

720.06 References

720.06(1) Federal/State Laws and Codes

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

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

*Note: railroads may have stricter clearances than what is required in law and each railroad should be consulted as early as possible as to allowable clearances.

720.06(2) Design Guidance

Bridge Design Manual LRFD, M 23-50, WSDOT

Geotechnical Design Manual, M 46-03, WSDOT

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

LRFD Bridge Design Specifications, AASHTO, Current Edition

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

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

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

Traffic Manual, M 51-02, WSDOT

720.06(3) Supporting Information

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

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

Chapter 900 Roadsides

900.01 General

The Washington State Department of Transportation (WSDOT) recognizes roadsides as an asset. WSDOT is committed to highway designs that meet the transportation needs in a way that reduces the potential for fatal and injury crashes, is cost-effective, ecologically appropriate, context appropriate, and maintainable by managing roadsides that balance the natural and environmental functions within the right of way.

The roadside integrates natural processes and visual continuity into the built (roadway) environment, preserving and promoting these natural and environmental functions. Highway projects achieve this integration through introduction and configuration of specific design elements such as structures, vegetation, signs, pedestrian and bicycle movement, erosion control, stormwater treatment facilities, etc.

Develop highway designs in accordance with the criteria provided in the current version of WSDOT Roadside Policy Manual (RPM). Use guidance provided in the WSDOT Roadside Manual (RM), where appropriate, when implementing the provisions of the RPM. Provide coordination and engagement with WSDOT partners when designing roadsides. Also refer to the RM when addressing design issues such as law and policy, soil bioengineering, contour grading, vegetation, irrigation, etc. These manuals can be found at: www.wsdot.wa.gov/design/roadside/.

900.02 Project Development

900.02(1) Region Landscape Architect

The region Landscape Architect is responsible for the following:

- Designs, supervises, has approval authority over, and stamps plans for wetland mitigation, roadside restoration, and revegetation.
- Coordinates the visual elements within highway corridors, in conjunction with the State Bridge and Structures Architect.
- Designs and supervises other roadside work, such as site design for park & ride lots or safety rest areas, to ensure roadside restoration is designed and constructed to WSDOT guidelines and standards.
- Provides visual discipline reports for environmental documentation.
- Assists the region in completing the plant establishment phase of projects.

The Headquarters (HQ) Roadside and Site Development Section will provide roadside and mitigation design, visual impact assessment, and construction inspection work for the project offices in regions without a Landscape Architect. Refer to the Project Management Online Guide for further descriptions of the roles and responsibilities of project teams.

900.02(2) Roadside Restoration Projects

There are typically two types of roadside restoration projects pertaining to vegetation-related roadway construction projects: regulatory and restoration.

900.02(2)(a) Regulatory

The first type of project is work related to regulatory or permit requirements. Examples are wetland mitigation work or Hydraulic Permit Approvals (HPAs). This work typically must occur by the time the impacting project is complete.

900.02(2)(b) Restoration

The second type of project is the restoration of construction impacts to roadside functions to meet the WSDOT policy requirements outlined in the *Roadside Policy Manual*.

900.02(3) Stand-Alone Project or Part of Roadway Construction?

Roadside restoration work should be evaluated by the design team to determine whether it will be most efficient as part of the roadway construction contract or as a separate stage contract.

900.02(3)(a) Roadway Construction Contract

The benefits of roadside restoration during roadway construction include the following:

- All work can be done under one contract.
- The restoration can be completed without waiting for a new contract to be let and administered.
- Plant establishment can often begin sooner.

900.02(3)(b) Separate Stage Project

A separate stage contract provides the following opportunities because it would be done when road construction is completed:

- If construction impacts are different than originally anticipated, the restoration contract can be changed. For example, if disturbance is minimized, fewer plants and soil amendments may be needed.
- The site can be watched to see how the grading and hydrology interact before plants are planted.
- The prime contractor can be someone who specializes in roadside work.

900.02(4) Plant Establishment

Plant establishment periods are included as part of roadside restoration and on all environmental mitigation projects.

- A minimum of three years of plant establishment work is required for all planted areas in western Washington, and planted and/or seeded areas in eastern Washington.
- In situations where it is important to provide a full cover of vegetation to achieve the environmental or operational functions, five years of plant establishment may be needed.
- If the plant establishment period will last longer than three years on a roadside restoration contract, discussion should occur with Program Management to request and justify additional funding.
- In an environment that uses woody plants, plant establishment may take up to 10 years for the woody vegetation to exclude weeds and reach a condition with the lowest life cycle cost.
- Regulatory aspects of projects can require 10 years of plant establishment to ensure the standards of success outlined in the permit, although aggressive weed control and favorable weather can allow sites to close out early.

The goal is to give WSDOT Maintenance a site that is nearly self-sustaining after the plant establishment period is complete.

900.03 Documentation

Refer to Chapter 300 for design documentation requirements.

900.04 References

Maintenance Manual, M 51-01, WSDOT

Roadside Manual, M 25-30, WSDOT

Roadside Policy Manual, M 3110, WSDOT

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2004

Utilities Accommodation Policy, M 22-86, WSDOT

For utility-related roadside issues, see the *Utilities Manual,* and for Scenic Classification ratings, see the *Utilities Accommodation Policy*

For WSDOT Project Management web resources, start here:
www.wsdot.wa.gov/projects/projectmgmt/

Roadside Design Guide, AASHTO, 2011

Roadside development concepts covered elsewhere in the *Design Manual* include the following:

- Fencing (Chapter 560)
- Jurisdiction (Chapters 300, 1100, 1600)
- Noise barriers (Chapter 740)
- Pedestrian facilities (Chapter 1510)

- Public art (Chapter 950)
- Retaining walls (Chapter 730)
- Roadside safety, traffic barriers, and energy attenuators (Chapters 1600, 1610, 1620)
- Safety rest areas, parks, viewpoints, and historical markers (Chapter 1710)
- Signs (Chapter 1020)

Chapter 1120 Preservation Projects

1120.01 General

This chapter provides information specific to preservation project types.

This chapter identifies those elements and features to be evaluated and potentially addressed during the course of a preservation project. The elements listed here may be in addition to the project need identified in the Project Summary or Basis of Design (see 1120.03(8)). Preservation projects may also provide opportunities for project partnering and retrofit options involving additional elements (for example see 1231.06).

Preservation projects are funded in three sub-program areas:

- **Roadway Preservation (P1) projects** preserve pavement structure, extend pavement service life, and restore the roadway for reasonably safe operations of the travel modes accommodated by the facility.
- **Structures Preservation (P2) projects** preserve the state's bridge network through cost-effective actions. There are numerous types of bridge preservation actions including: deck rehabilitation, seismic retrofit, painting steel bridges, scour repair, and others.
- **Other Facilities (P3) projects** preserve the function of guardrail and signing, major drainage, major electrical, unstable slopes and other assets.

For required design elements in these programs see Exhibit 1105-1.

For more information on these programs see the Planning & Programming – Scoping website:
http://wwwi.wsdot.wa.gov/Planning/CPDMO/PlanProgScoping.htm

1120.02 Structures Preservation (P2) and Other Facilities (P3)

For Structures Preservation (P2) and Other Facilities (P3) projects see the scoping instructions specific to the sub-program and type of work to determine the likely design elements to be addressed by the project.

See Chapter 300 for documentation requirements. If the project changes a geometric design element, replaces an existing bridge or installs a new bridge additional documentation may be required; contact your ASDE to discuss appropriate documentation.

1120.03 Roadway Preservation (P1)

This section applies to features and design elements to be addressed on Roadway Preservation (P1) projects. See Section 1120.04 for instructions on using the Basis of Design to document design elements that are changed by the project.

1120.03(1) Adjust existing features

- Adjust existing features such as monuments, catch basins, and access covers that are affected by resurfacing.
- Evaluate drainage grates and gutter pans, and adjust or replace as needed to address the potential for bicycle crashes (see Drainage Grates and Manhole Covers in Chapter 1520).
- For guidance on existing curb see Chapter 1239.
- Replace rumble strips if they are removed through project actions, or if their average depth is less than 3/8”, unless there is a documented justification for their removal (see Chapter 1600).

1120.03(2) ADA requirements

- Address ADA requirements according to WSDOT policy (see Chapter 1510 and any active project delivery memorandums or design memorandums).

1120.03(3) Cross slope lane

- Rebuild the cross slope to a minimum 1.5% when the existing cross slope is flatter than 1.5% and the steeper slope is needed to provide adequate highway runoff. See Chapter 1250 for more information about cross slope.

1120.03(4) Cross slope shoulder

- When rebuilding the lane cross slope, evaluate shoulder cross slope in accordance with Chapter 1250.

1120.03(5) Vertical clearance

- Paving projects, seismic retrofit, and other project work can change the vertical clearances of structures. For preservation projects other than bridge replacement that have no widening on or under the bridge, the minimum structure clearance is 14.5 feet. Existing structures with a vertical clearance less than 14.5 feet require a Design Analysis.
- If the vertical clearance of a structure will be changed by the project, use Sections 720.03(5)(c) and 1020.03(2) for vertical clearance requirements.
- Include vertical clearance and any other changed geometrics in the Basis of Design, the Design Parameters sheets, and the Design Documentation Package.
- See DM Section 720.03(5)(c) for details about bridge clearances for existing structures and section 1020.03(2) for vertical clearance of overhead sign assemblies.
- Contact the Commercial Vehicle Services Office when changes to vertical clearance are planned.

1120.03(6) Delineation

- Install and replace delineation in accordance with Chapter 1030 (this includes pavement markings, guideposts, and barrier delineation).

1120.03(7) Barriers and terminals

- When the preservation project design, other than a chip seal or BST, will affect the elevation of the pavement adjacent to a guardrail, terminal, and/or transition, measure the height of those systems within the project limit and adjacent to pavement edges, curbs, or sidewalks prior to construction. Measure the height to the top of the rail element from the outside paved shoulder edge when no curb is present, from the gutter line when guardrail is set above a curb, or from the sidewalk elevation if set behind a sidewalk. Guidance for this situation:
    - When the height of Type 1 guardrail, terminals, and/or transitions will be outside the height range from 26.5” to 31” after the project is finished; the guardrail, terminals, and/or transitions must be adjusted to a minimum height of 28” up to a maximum height of 31”. Guardrail posts cannot be raised. See Section 1610.04(4) for acceptable options for raising the rail. Otherwise replace with a Type 31 guardrail system.
    - When the height of Type 31 guardrail, terminals, and/or transitions will be outside the height range from 28” to 32” after the project is finished; the guardrail, terminals, and/or transitions must be adjusted to a height of 31”. Guardrail posts cannot be raised. See Section 1610.04(4) for acceptable options for raising the rail. Otherwise replace.
    - When terminals need to be raised, replace them with crash worthy terminals. Provide replacement terminals in accordance with 1610.04(5)(a or b). Terminals and anchors that are effectively shielded by another barrier are not in the Design Clear Zone, and thus do **not warrant** replacement.
    - When guardrail needs to be raised, evaluate the guardrail length of need in accordance with Chapter 1610. Notify Region Program Management if the length of need extension is longer will be longer than 250 feet. Extending length of need further than 250 feet is beyond the scope of the pavement preservation.
    - Note that removal is an option if guardrail is no longer needed based on the guidance in Chapters 1600 and 1610. Document the location of removal and the reasoning for removal in the Design Documentation Package.
    - When adjusting terminals that are equipped with CRT posts, the top-drilled holes in the posts need to be at the surface of the ground.
    - Pre-cast concrete barrier sections (either New Jersey or “F” shape) are normally installed at a 32” height, which includes provision for up to a 3” overlay. A 29” minimum height for this type of barrier must be maintained following an overlay.
    - Single slope concrete barrier may be pre-cast or cast in place, and is installed new at a height of 42”, 48”, or 54”. A 30” minimum height must be maintained for this type of barrier following an overlay.

1120.03(8) Pavement Edge Treatment

Adding a pavement edge treatment is a low-cost feature to improve safety performance for errant vehicles that depart and try to reenter the roadway. A pavement edge treatment can also help maintain the structural integrity of the roadway and pavement performance at the edge of the roadway by resisting the start of pavement cracking and/or pavement raveling.

Where practicable, install a pavement edge treatment at locations where asphalt concrete pavement is applied to the outside edge of the existing pavement. Examples where pavement edge treatment may not be practicable include, locations with roadside barrier and/or curb. After installing the pavement edge treatment, trim shoulders with material that is graded back over the edge treatment and flush with the paved roadway surface.

- For more information about pavement edge treatment, contact the HQ Design Office, and visit the FHWA website at:

  https://www.fhwa.dot.gov/innovation/everydaycounts/edc-1/safetyedge.cfm

1120.04 Documentation

For Roadway Preservation (P1) projects, use the Basis of Design and Design Parameter Sheets to document decisions when the project changes design elements that are not listed in 1120.03(1) through 1120.03(8).

Chapter 1230 Geometric Cross Section Basics

When choosing any geometric cross section dimension, including lane or shoulder width, read the guidance that is specific to the facility type. Also, read the general guidance related to common elements such as lanes, shoulders, side slopes, etc.

See Chapter 1106 for the general dimensioning guidance.

This chapter also contains guidance related to jurisdiction.

1230.01 General

The geometric cross section is composed of multiple lateral design elements such as lanes, shoulders, medians, bike facilities, and sidewalks. The designer's task is to select, size, and document these elements appropriately. There is flexibility in the selection of design element dimensioning.

All WSDOT routes, regardless of context, are referred to in the *Design Manual* as "highways." Under this definition, freeways are a subset of highways while Interstate freeways are one specific type of freeway.

Refer to the Design Manual Glossary for many of the terms used in this chapter. See Chapter 300 for design documentation requirements.

1230.02 Guidance for Specific Facility Types

Guidance regarding geometric cross sections is located in various *Design Manual* chapters. The chapter depends on the facility type. Examples of specific facility types include:

- Highways (general)
- Freeways
- Ramps
- Auxiliary lanes
- Collector-Distributor lanes
- Service lanes
- Frontage roads
- HOV facilities
- Median U-turns and crossovers
- Transit facilities including bus pull-outs
- Enforcement areas
- Slow vehicle turn-outs
- Truck weighing facilities
- Shared use paths
- Sidewalks
- Bicycle Facilities

Exhibit 1230-1 shows some common facility types along with the corresponding chapter that geometric cross section guidance can be found in.

Exhibit 1230-1 Geometric Cross Section - Guide to Chapters

Facility Type	Lane width	Turning roadway width	Shoulder width	Median width	Lateral clearance to curb or barrier	Side slope	Cross slope
Highways (General)	1231	1240	1231	1239	1239	1239	1250
Freeways	1232	1240	1232	1239	1239	1239	1250
Ramps	1360	1240	1360	1360	1239	1239	1360 & 1250
Auxiliary lanes	1270 or 1360 [1]	1240	1270 or 1360 [1]	N/A	1239	1239	1270
C-D roadways	1360	1240	1360	N/A	1239	1239	1360
HOV lanes, ramp bypass lanes, etc.	1410	1410	1410	N/A	1410 & 1239	1239	1410
Left-side direct HOV access (DHOV) facilities	1420	1420	1420	1420 (for DHOV)	1420 & 1239	1239	1250
Shared use path	1515	1515	1515	N/A	1515	1515	1515
Other	Geometric cross section guidance for other special purpose facilities is in various chapters. Examples include special use lanes, bridges, transit facilities, bus pull outs, median U-turns and crossovers, enforcement areas, truck weighing facilities, pedestrian bridges and tunnels, sidewalks & bicycle facilities						

Notes:

General guidance for curb design is in Chapter 1239. Guidance for curb is also found for numerous types of facilities (Chapter 1310 and others.)

[1] Passing and climbing lanes, see Chapter 1270; Auxiliary lanes between interchanges see Chapter 1360.

Exhibit 1230-1 is not a comprehensive list of guidance associated with either a facility or a design element. It is intended to be a quick reference to the chapter containing the primary guidance related to the specific element and facility type.

For guidance related to intersections see Chapter 1310. For guidance related to sidewalks see Chapter 1510. For guidance related to bicycle facilities see Chapter 1520. For guidance related to bridges see Chapter 720.

1230.03 Common Elements

In addition to the guidance specific to the facility type, also see the general guidance related to cross-sectional elements that are common to various facility types:

- Lanes Chapter 1231
- Shoulders, side slopes, medians & curbs Chapter 1239
- Lateral clearance to curb and barrier Chapter 1239
- Parking & streetside (behind the curb) elements Chapter 1238
- Cross slope and superelevation Chapter 1250

1230.04 Jurisdiction for Design and Maintenance

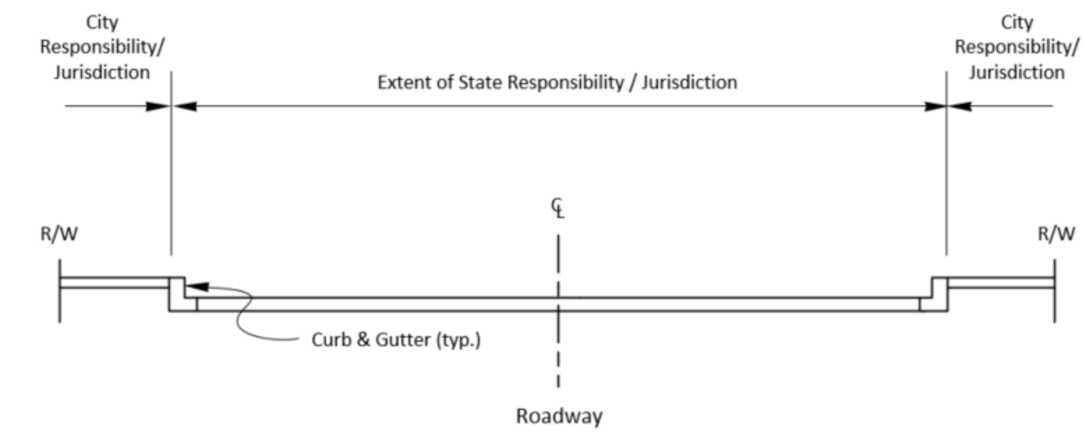
On all state highways in locations outside of cities or towns and within limited access design areas, geometric design is to be consistent with this *Design Manual*.

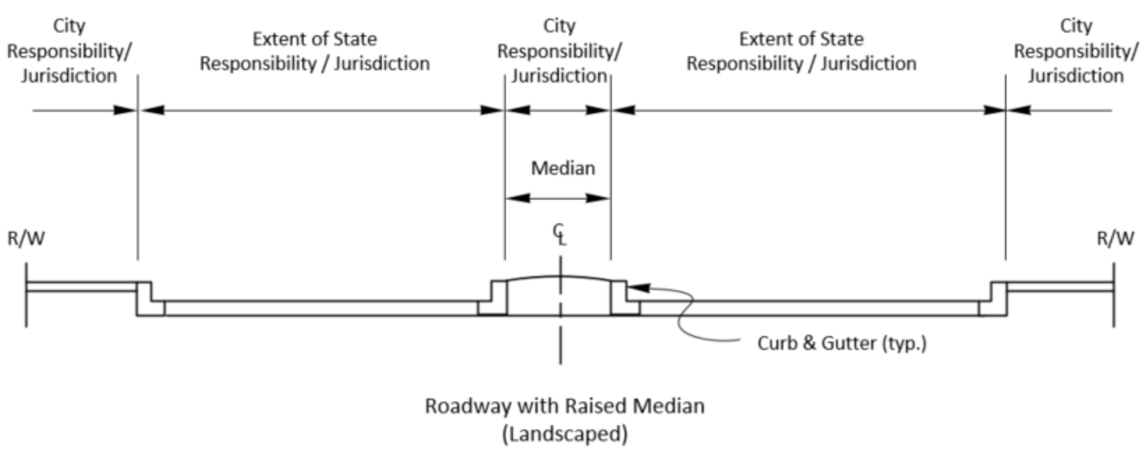
On state highways within an incorporated city or town, develop design features in cooperation with the local agency. For NHS routes, use the *Design Manual*. For non-NHS routes, the *Local Agency Guidelines* may be used for dimensioning design elements

Cross-sectional design within incorporated cities or towns can get complicated due to the joint-jurisdictional authority. WSDOT typically has jurisdiction between the backs of curbs, and cities typically have jurisdiction outside the backs of curbs (see Exhibit 1230-2). When no curb is present, the city or town holds responsibility for the roadside outside the paved shoulder. Despite the jurisdictional differences, it is extremely important to cooperatively determine a cross-sectional design.

Refer to Chapter 301 for additional information on jurisdictional maintenance responsibilities and considerations for maintenance agreements.

Exhibit 1230-2 State and City Jurisdictional Responsibilities





1230.05 References

1230.05(1) Design Guidance

Highway Runoff Manual, M 31-16, WSDOT

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

Plans Preparation Manual, M 22-31, WSDOT

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

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

1230.05(2) Supporting Information

Understanding Flexibility in Transportation Design – Washington, WA-RD 638.1, Washington State Department of Transportation, 2005
www.wsdot.wa.gov/research/reports/fullreports/638.1.pdf

Urban Street Design Guide, National Association of City Transportation Officials, New York, NY, 2013
www.nacto.org

A Policy on Geometric Design of Highways and Streets (Green Book), AASHTO, current edition
Available from the WSDOT Library.

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

1239.01 Introduction

This chapter provides information on geometric cross section components that are common to many facility types. Cross section elements include: shoulders, medians and outer separations, side slopes, and curbing.

1239.02 Shoulders

Shoulders are typically used on high, or intermediate speed limited and non-limited access facilities, some rural contexts, as well as intermediate-speed locations that do not have streetsides (curb-sections) (see Chapter 1238). Intermediate-speed locations in suburban and urban contexts that utilize streetsides do not need to include a shoulder unless determined to be necessary by shoulder function, (where intended for bicyclists for example) or safety performance analysis, hydraulic analysis or engineering judgment.

Shoulders provide space to escape potential collisions or reduce their severity. They also provide a sense of openness, contributing to driver ease at higher speeds. Shoulders also convey drainage away from the traveled way as determined by hydraulic analysis.

1239.02(1) Shoulder Width

Shoulder width ranges for highways are shown in Exhibit 1239-1. Use the mode/function/performance approach (Chapter 1106) to choose a dimension from the range given.

Exhibit 1239-1 Shoulder Widths for Highways

Posted Speed	Highway Type	Shoulder Width [1] [2]	
		Inside (median)	Outside
High speed (≥50mph)	Freeway (including Interstate)	See Chapter 1232	
	Other highway	4' – 10'	4' – 10'
Intermediate speed (40 & 45 mph)	All	4' – 8'	4' – 8'[3]
Low speed (≤35mph)	All	0' – 8' [2]	2' – 8'[3]

Notes:

[1] Bus use only shoulder width range is 12-ft to 14-ft.

[2] If curb or barrier present, see Exhibit 1239-9.

[3] Intermediate-speed and low-speed locations in urban and suburban contexts utilizing streetsides do not need to include a shoulder unless necessary for safety performance, hydraulic performance or engineering judgment. See Exhibit 1231-5, Exhibit 1231-6 (A & B), Exhibit 1231-7 (B & C), and Section 1239.02.

1239.02(1)(a) Shoulder Width Considerations

Exhibit 1239-2 lists considerations for choosing an appropriate shoulder width from the range given. The considerations listed help one to understand the modal needs and function associated with different shoulder widths.

Contact the Area Maintenance Superintendent to determine the shoulder width appropriate for maintenance operations. In some cases, a continuous width is not necessary; instead, the focus is placing the shoulder width near assets with high-frequency maintenance needs. Compare the added cost of the wider shoulders to the added benefits to maintenance operations as well as other benefits that may be derived (see Chapter 301).

The usable shoulder is the width necessary to provide the desired function (see Exhibit 1239-2). Usable shoulder width is less than the constructed shoulder width when vertical features (such as traffic barrier or walls) are at the edge of the shoulder. This is because drivers tend to shy away from the vertical feature. For widening for traffic barrier, see Chapter 1610. For requirements for lateral clearance to barrier or curb, see 1239.06.

Shoulder widths greater than 10 feet may encourage use as a travel lane. Therefore, use shoulders wider than 10 feet only to meet one of the listed functions (see Exhibit 1239-2).

When walls are placed adjacent to shoulders, see Chapters 730 and 740 for barrier guidance.

Exhibit 1239-2 Shoulder Function & Modal Accommodation Width Considerations

Shoulder Function	Shoulder Width Guidance [7]
Stopping out of the traffic lanes	8 ft – 12 ft [1]
Minimum lateral clearance to curb or barrier	See 1239.06
Part time shoulder use. (Requires a Design Analysis)	11 ft to 14 ft [2] See Section 1232.03
Bicycle use	4 ft of usable shoulder [3]
Pedestrian use	See Section 1510.06
Off-tracking of large accommodated vehicles	See Section 1310.02(5)
U-turn turnouts	Varies – See Chapter 1310
Maintenance operations (Consult Area Superintendent)	Varies [4] [5]
Law enforcement, emergency services & incident response	8 ft [5]
Transit stops	See Chapter 1430
Slow-vehicle turnouts	See Section 1270.04
Slow-vehicle shoulder driving	See Section 1270.05
Ramp meter storage (Requires a Design Analysis)	8 – 12 ft [1]
HOV ramp meter bypass (Requires a Design Analysis)	10 – 14 ft [6]
Ferry holding	8 ft – 12 ft [1]
For use as a lane during reconstruction of the through lanes	8 ft – 12 ft [1]
Structural support of pavement	2 ft
Improve sight distance in cut sections	See Chapter 1260

Notes:

[1] 10 foot minimum recommended for freight or transit vehicles.

[2] For bus use only shoulder, the range is 12 ft to 14 ft and the selected width should be determined with transit provider. For lateral clearance requirements see 1239.06.

[3] Minimum usable shoulder function width for bicycles. Additional width may be needed when combined with shoulder rumble strips, curb, or barrier (see Chapter 1600 and the *Standard Plans*). For guidance, see Chapter 1520 for accommodating bicycles.

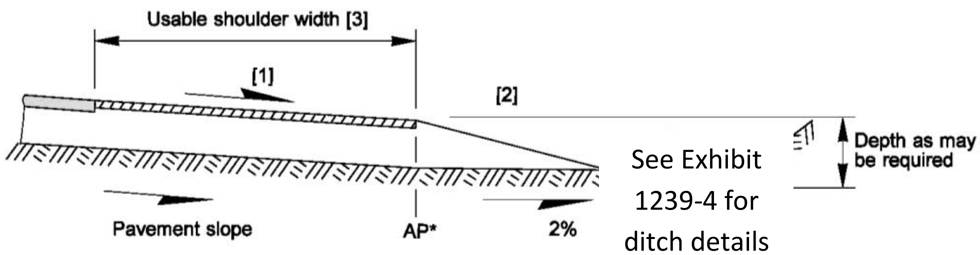
[4] 10 foot usable width to park a maintenance truck out of the through lane; 14 foot width for equipment with outriggers to work out of traffic (consult Area Maintenance Superintendent).

[5] For additional information, see Chapters 1370, 1410 and 1720.

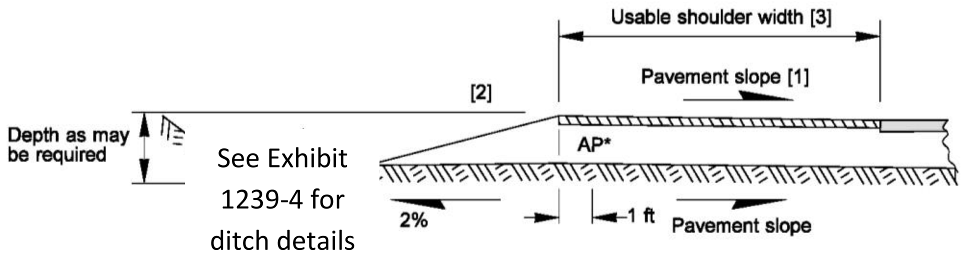
[6] Determine width with transit provider, and see 1239.06 for lateral clearance requirements.

[7] Presence of barrier or curb may require additional width. Use auto turn studies for non-tangent alignments.

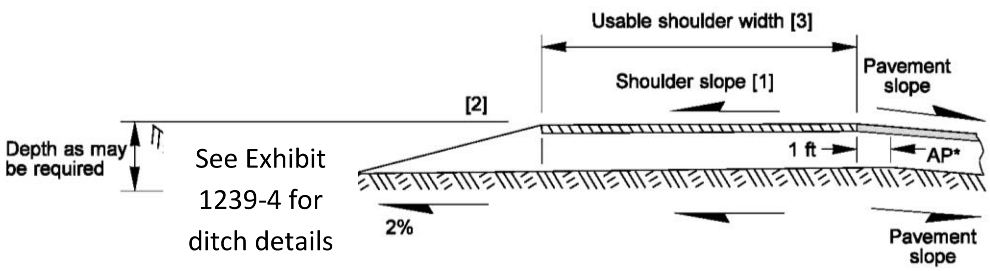
Exhibit 1239-3 Shoulder Details



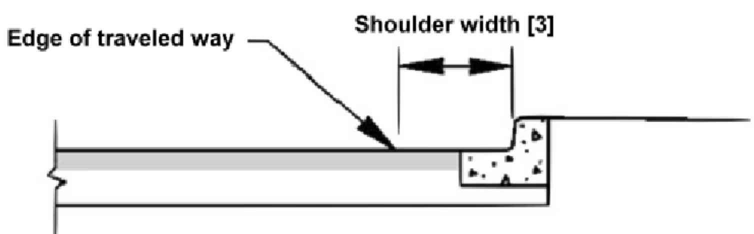
Shoulder Design on the Low Side of the Roadway for Cross Slopes Greater Than 2%



Shoulder Design on the High Side of the Roadway on Curves and Divided Roadways Shoulder Slopes With Roadway



Shoulder Design on the High Side of the Roadway on Curves and Divided Roadways Shoulder Slopes Away From Roadway



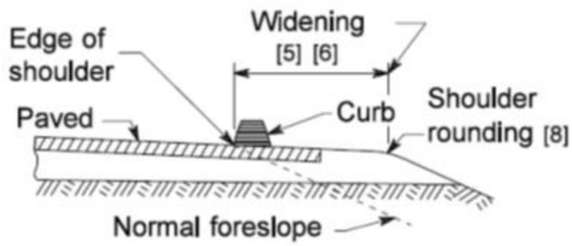
Shoulder Design with Curb [4] [5]

*AP = Angle point in the subgrade

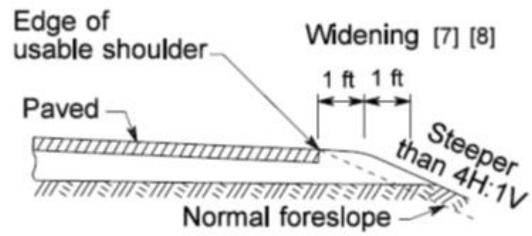
Notes:

- The top three drawings illustrate angle points in subgrade to drain stormwater away from the roadbed.
- For applicable numbered notes, see next page.

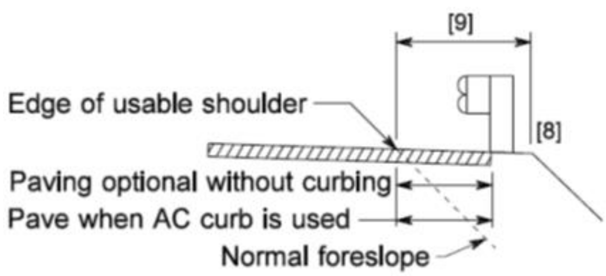
Exhibit 1239-3 Shoulder Details (continued)



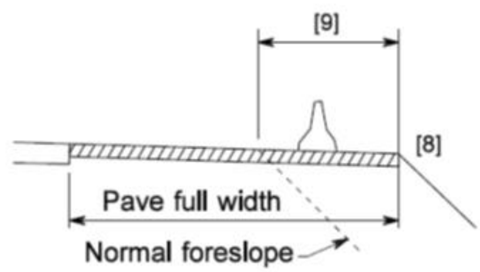
Asphalt Concrete Curb Placement



Shoulder Rounding [2]



Shoulder Widening for Guardrail



Shoulder Widening for Barrier

Notes:

[1] Shoulder cross slopes are normally the same as the cross slopes for adjacent lanes. (For examples and additional information for locations where it may be desirable to have a shoulder cross slope different than the adjacent lane, see Chapter 1250).

[2] Provide widening and slope rounding outside the usable shoulder when foreslope is steeper than 4H:1V.

[3] For shoulder width guidance, see Exhibit 1239-1.

[4] For additional requirements for sidewalks, see Chapter 1510.

[5] See 1239.05 for curb design guidance.

[6] Provide paved shoulders wherever extruded curb is placed. (See the *Standard Plans* for additional details and dimensions.)

[7] Consider using the same application of slope rounding on all ramps and crossroads, as well as the main roadway. Use end rounding on the crossroad just beyond the ramp terminals and at a similar location where only a grade separation is involved.

[8] When widening beyond the edge of usable shoulder for curb or barrier, additional widening for slope rounding may be omitted.

[9] For widening guidelines for guardrail and concrete barrier, see Chapter 1610.

General:

On divided multilane highways, see Exhibits 1239-12a through 1239-12c for additional details for median shoulders.

1239.03 Fill Sections, Cut Sections, and Ditch Sections

The design for side slopes can affect shoulder design, clear zone requirements, and whether or not traffic barrier is warranted.

There are three basic roadway sections for side slopes.

Fill sections – Roadway sections where the height of the roadway is higher than the existing natural ground.

Ditch sections - Roadway sections where the height of the roadway is higher than the existing natural ground but not as high as the needed roadside ditch so that after the needed ditch is installed there is a foreslope into the ditch and a back slope out of the ditch up to where it catches the natural ground.

Cut sections - Roadway sections where the height of the roadway is lower than the existing ground. This typically produces a foreslope into the ditch and a back slope out of the ditch up to where it catches the natural ground.

When designing side slopes, attempt to fit the slope selected for any fill section, ditch section, or cut section into the existing terrain to give a smooth transitional blend from the construction to the existing landscape when practicable. Flatter slopes are desirable, especially with higher posted speeds and when the associated cost does not significantly exceed other design options. Fill side slopes not steeper than 4H:1V, with smooth transitions where the slope changes, will provide a reasonable opportunity to recover control of an errant vehicle. Fill side slopes designed to 4H:1V or flatter are preferred. Provide widening and slope rounding outside the usable shoulder when the foreslope is steeper than 4H:1V (see Exhibit 1239-3). Do not disturb existing stable cut slopes just to meet the 4H:1V foreslope preference.

Fill-slopes steeper than 4H:1V but flatter than 3H:1V are considered traversable, but not recoverable. When providing a slope that meets these characteristics, placement of a clear area extending from the toe of the slope to the outside edge of the design clear zone is needed for an errant vehicle runout and stop (see Chapter 1600 for design clear zone guidance). Consult with Region Maintenance to determine if mowing is contemplated. When providing fill-slopes steeper than 3H:1V, it is a best practice to document the reason for the decision in the design documentation package. When mowing is contemplated, provide slopes not steeper than 3H:1V.

Where unusual geological features or soil conditions exist, treatment of the slopes depends upon results of a review of the location by the Region Materials Engineer.

See Section 1600.03(1) for when to use traffic barrier to mitigate a side slope. Unmitigated critical slopes will require a Design Analysis. The steepest slope allowed is determined by the Region Materials Engineer based on soil conditions. If more material is needed to build the roadway, consider obtaining it by flattening cut slopes uniformly on one or both sides of the highway. Consult the Region Materials Engineer to determine what percentage of the excavated material will likely be suitable for fill material. Where considering wasting excess material on an existing fill side slope, consult the Region Materials Engineer to verify that the subgrade will support the additional material.

Provide for drainage from the roadway surface and drainage in ditches (see Chapter 800). For drainage ditches, see Section 1239.03(1). At locations where vegetated filter areas or detention facilities will be established to improve highway runoff water quality, provide appropriate slope, space, and soil conditions for that purpose. (See the *Highway Runoff Manual* for design criteria and additional guidance.)

It is desirable to plant and establish low-growing vegetation on non-paved roadsides. This type of treatment relies on the placement of a lift of compost or topsoil over base course material in the roadway cross section. Consult with the area Maintenance Superintendent and the region or HQ Landscape Architect to determine the appropriate configuration of the roadway cross section and soil and plant specifications. This kind of treatment would not be done where barrier is installed along the roadway as the lift of compost or topsoil is not a suitable barrier foundation.

Flatten freeway section median cross-over foreslopes to 10H:1V (See Section 1370.03). Flatten crossroad and road approach foreslopes not steeper than 6H:1V on other highways. Grade crossroad and road approach foreslopes flatter than 6H:1V where feasible. Provide smooth transitions between the main line foreslopes and the crossroad or road approach foreslopes. Move the crossroad or road approach drainage as far away from the main line as feasible. This can locate the pipe outside the Design Clear Zone and reduce the length of pipe.

Provide slope treatment as shown in the *Standard Plans* (Slope treatment) at the top of roadway cut slopes except for cuts in solid rock. Unless Class B slope treatment is called for, Class A slope treatment is used. Call for Class B slope treatment where space is limited, such as where right of way is restricted.

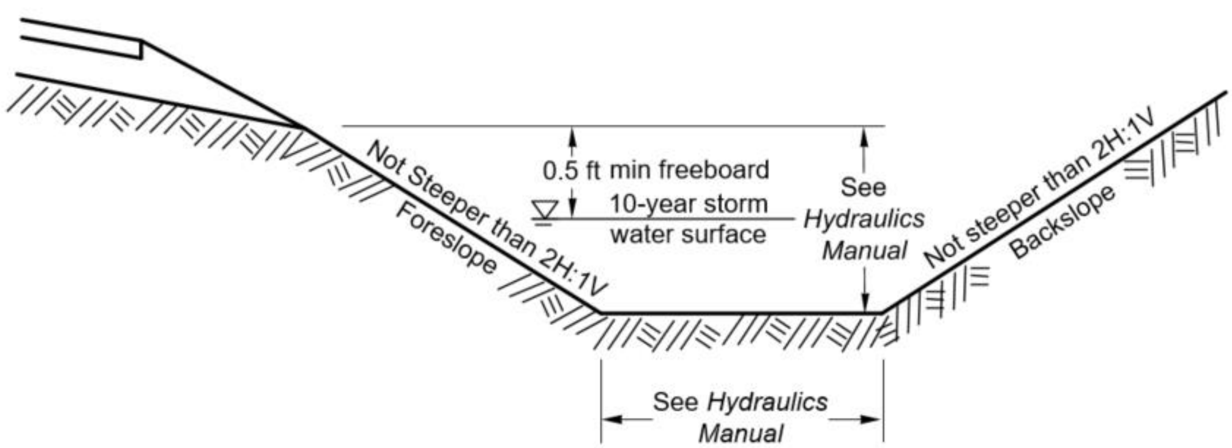
1239.03(1) Drainage Ditches

Exhibit 1239-4 provides general information regarding drainage ditch design. The preferred cross section of a ditch is trapezoidal as shown. A 'V' bottom ditch can be used where constraints, such as limited right of way or sensitive areas, preclude a trapezoidal ditch. Ensure hydraulic design requirements are still met. 'V' bottom ditches need to be deeper than a trapezoidal ditch to convey the same amount of water and a 'V' bottom ditch requires more maintenance to keep its shape than a trapezoidal ditch. Consult the Region Hydraulics Engineer for ditch depth and bottom of ditch width. 'V' bottom drainage ditches can have the effect of eroding the slope toes and in cases where the foundation soil is weak, could result in a side slope failure. As a general rule, the weaker the foundation and the higher the side slopes, the more important it is to use a trapezoidal ditch instead if a 'V' bottom ditch. Consult the Region Materials Engineer for the proper ditch type, location and appropriate foreslope and backslope.

When topographic restrictions exist, consider an enclosed drainage system with appropriate inlets and outlets.

Maintenance operations are also facilitated by adequate width between the toe of the slope and an adjacent drainage ditch. Where this type of facility is anticipated, provide sufficient right of way for access to the facility and place the drainage ditch as close to the right of way line as feasible.

Exhibit 1239-4 Drainage Ditch Details



Notes:

- Freeboard is the vertical distance from the bottom of base course to the 10-year storm water surface (see the Hydraulics Manual for more information.)
- Coordinate ditch depth and bottom of ditch width with region Hydraulics.
- Coordinate foreslope and backslope and ditch location with region Materials Engineer.
- See other sections of this chapter for shoulder and side slope details.

1239.03(2) Bridge End Slopes

Bridge end slopes are determined by several factors, including context, fill height, depth of cut, soil stability, and horizontal and vertical alignment. Coordinate bridge end slope treatment with the HQ Bridge and Structures Office (see Chapter 720). Whenever possible, design to avoid creating environments that might be desirable to the homeless, both for their safety and the safety of maintenance staff.

Early in the bridge plan development, determine preliminary bridge geometrics, end slope rates, and toe of slope treatments. Exhibit 1239-5a provides guidelines for use of slope rates and toe of slope treatments for overcrossings. Exhibit 1239-5b shows toe of slope treatments to be used on the various toe conditions.

Exhibit 1239-5a Bridge End Slopes

Bridge End Condition	Toe of Slope End Slope Rate		Lower Roadway Treatment [1]		Slope Rate
End Piers on Fill	Height	Rate	Posted speed of lower roadway	Treatment	
	≤ 35 ft > 35 ft	1¾H:1V 2H:1V [2]	> 50 mph ≤ 50 mph	Rounding No rounding	
End Piers in Cut	Match lower roadway slope [3]		No rounding, toe at centerline of the lower roadway ditch.		[4]
Lower Roadway in Cut	Match lower roadway slope [3]		No rounding, toe at centerline of the lower roadway ditch.		[4]
Ends in Partial Cut and Fill	When the cut depth is > 5 ft and length is > 100 ft, match cut slope of the lower roadway		When the cut depth is > 5 ft and length is > 100 ft, no rounding, toe at centerline of the lower roadway ditch		[4]
	When the cut depth is ≤ 5 ft or the length is ≤ 100 ft, it is designer's choice		When the cut depth is ≤ 5 ft or the length is ≤ 100 ft, it is designer's choice		[4]

Notes:

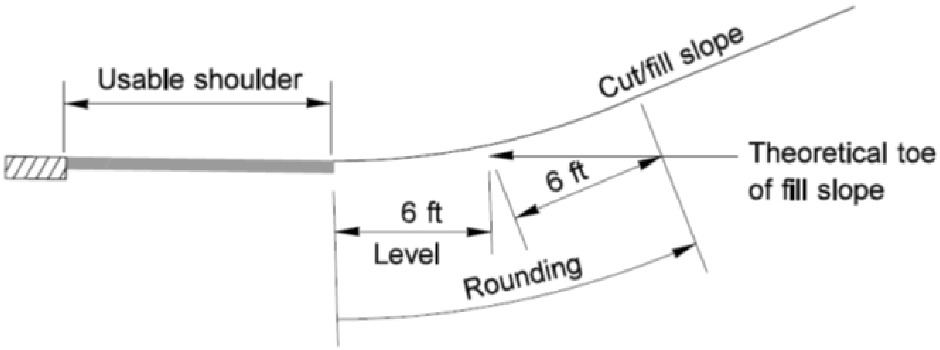
[1] See Exhibit 1239-5b.

[2] Slope may be 1¾H:1V in special cases.

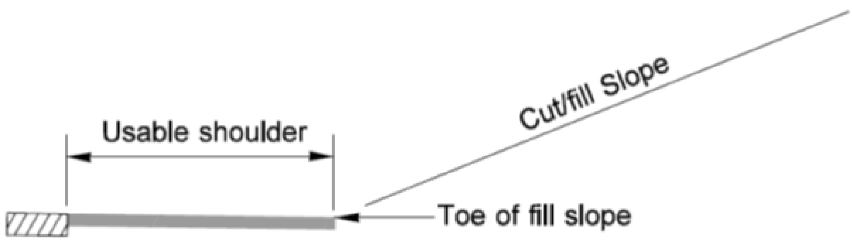
[3] In interchange areas, continuity may require variations.

[4] See 1239.03.

Exhibit 1239-5b Bridge End Slope Details



Rounding



No Rounding

Toe at ℄ of Roadway Ditch

1239.04 Roadway Sections in Rock Cuts

There are two basic design treatments applicable to rock excavation. Typical sections for rock cuts, illustrated in Exhibits 1239-6 and 1239-7, are guides for the design and construction of roadways through rock cuts. Design A applies to most rock cuts. Design B is a talus slope treatment. Changes in slope or fallout area are recommended when justified. Base the selection of the appropriate sections on an engineering study and the recommendations of the region Materials Engineer and region Landscape Architect. Obtain concurrence from the Headquarters (HQ) Materials Lab.

1239.04(1) Design A

This design is shown in stage development to aid the designer in selecting an appropriate section for site conditions in regard to backslope, probable rockfall, hardness of rock, and so on.

The following guidelines apply to the various stages shown in Exhibit 1239-6:

- **Stage 1** is used where the anticipated quantity of rockfall is small, adequate fallout width can be provided, and the rock slope is ½H:1V or steeper. Controlled blasting is recommended in conjunction with Stage 1 construction.
- **Stage 2** is used when a "rocks in the road" problem exists or is anticipated. Consider it on flat slopes where rocks are apt to roll rather than fall.
- **Stage 3** represents the full implementation of all protection and safety measures applicable to rock control. Use it when extreme rockfall conditions exist.

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

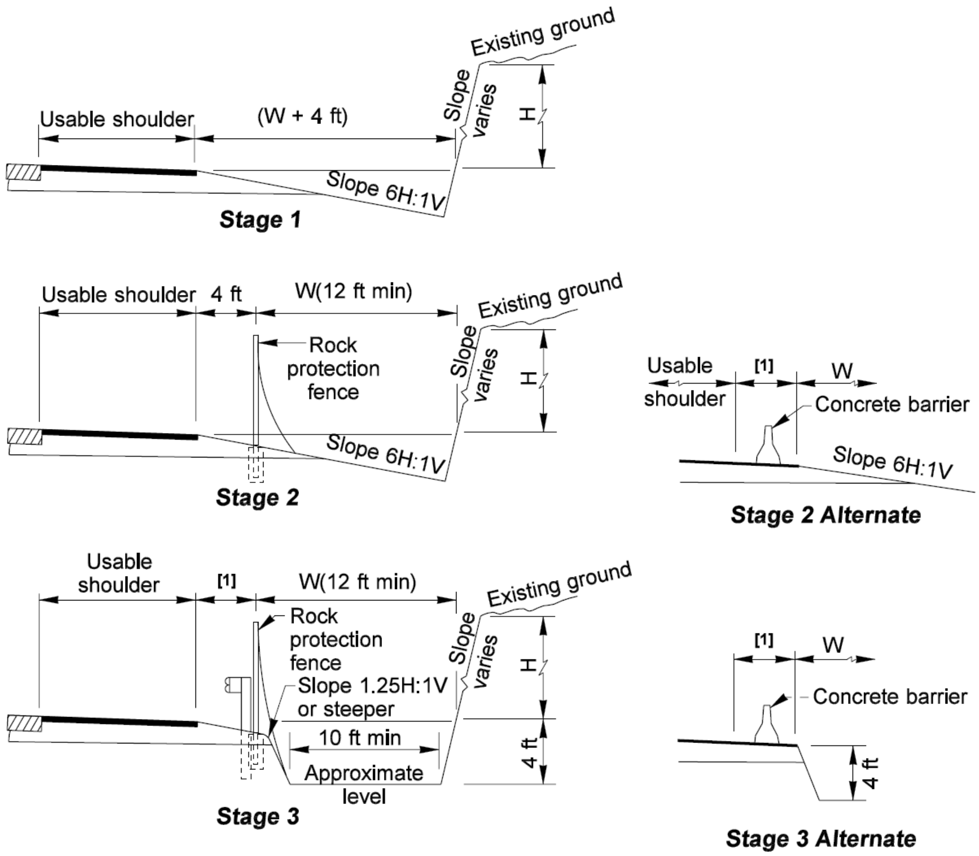
The use of Stage 2 or Stage 3 alternatives (concrete barrier) is based on the designer's analysis of the particular site. Considerations include maintenance; size and amount of rockfall; probable velocities; availability of materials; ditch capacity; adjacent traffic volumes; distance from traveled lane; and impact severity. Incorporate removable sections in the barrier at approximately 200-foot intervals. Provide appropriate terminal treatment (see Chapter 1610).

Occasionally, the existing ground above the top of the cut is on a slope approximating the design cut slope. The height (H) is to include the existing slope or that portion that can logically be considered part of the cut. Select cut slopes for a project that provide stability for the existing material.

Benches may be used to increase slope stability; however, the use of benches may alter the design given in Exhibit 1239-6.

The necessity for benches, as well as their width and vertical spacing, is established after an evaluation of slope stability. Make benches at least 20 feet wide. Provide access for maintenance equipment to the lowest bench and to the higher benches if feasible. Greater traffic benefits in the form of added safety, increased horizontal sight distance on curves, and other desirable attributes may be realized from widening a cut rather than benching.

Exhibit 1239-6 Roadway Sections in Rock Cuts: Design A



Rock Slope	H (ft)	W (ft)
Near Vertical	20 – 30	12
	30 – 60	15
	> 60	20
0.25H:1V through 0.50H:1V	20 – 30	12
	30 – 60	15
	60 – 100	20
	>100	25

Notes:

[1] For widening for guardrail and concrete barrier, see Chapter 1610.

General:

- Treat cut heights less than 20 feet as a normal roadway unless otherwise determined by the Region Materials Engineer.
- Stage 2 and Stage 3 Alternates may be used when site conditions dictate.
- Fence may be used in conjunction with the Stage 3 Alternate. (See Chapter 1600 for clear zone guidelines.)

1239.04(2) Design B

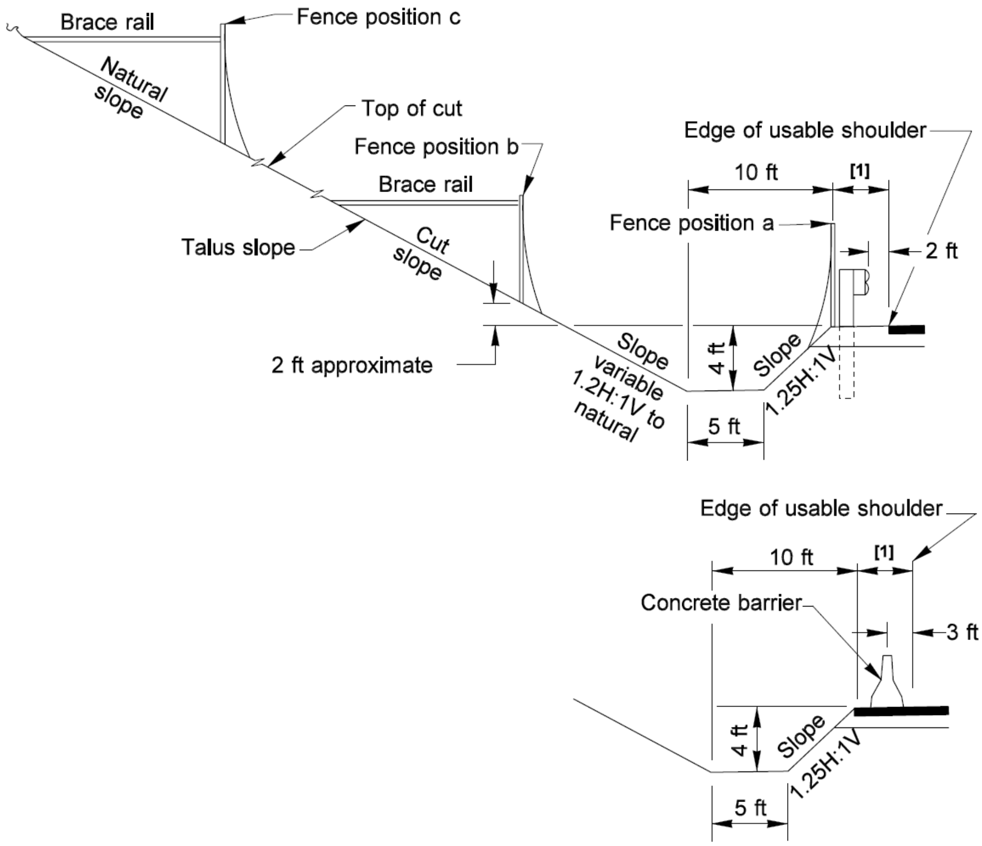
A talus slope treatment is shown in 1239-7. The rock protection fence is placed at any one of the three positions shown, but not in more than one position at a particular location. Consult with the RME for the placement of the rock protection fence in talus slope areas.

- **Fence position a** is used when the cliff generates boulders less than 0.25 yd^3 in size and the length of the slope is greater than 350 feet.
- **Fence position b** is the preferred location for most applications.
- **Fence position c** is used when the cliff generates boulders greater than 0.25 yd^3 in size regardless of the length of the slope. On short slopes, this may require placing the fence less than 100 feet from the base of the cliff.
- Use of gabions may be considered instead of the rock protection shown in fence position a. Because gabion treatment is considered similar to a wall, provide appropriate face and end protection (see Chapters 730 and 1610).

Use of the alternate shoulder barrier is based on the designer's analysis of the particular site. Considerations similar to those given for Design A alternatives apply.

Evaluate the need for rock protection treatments other than those described above for cut slopes that have relatively uniform spalling surfaces (consult with the RME).

Exhibit 1239-7 Roadway Sections in Rock Cuts: Design B



Shoulder Barrier Alternate

Notes:

[1] For widening for guardrail and concrete barrier, see Chapter 1610.

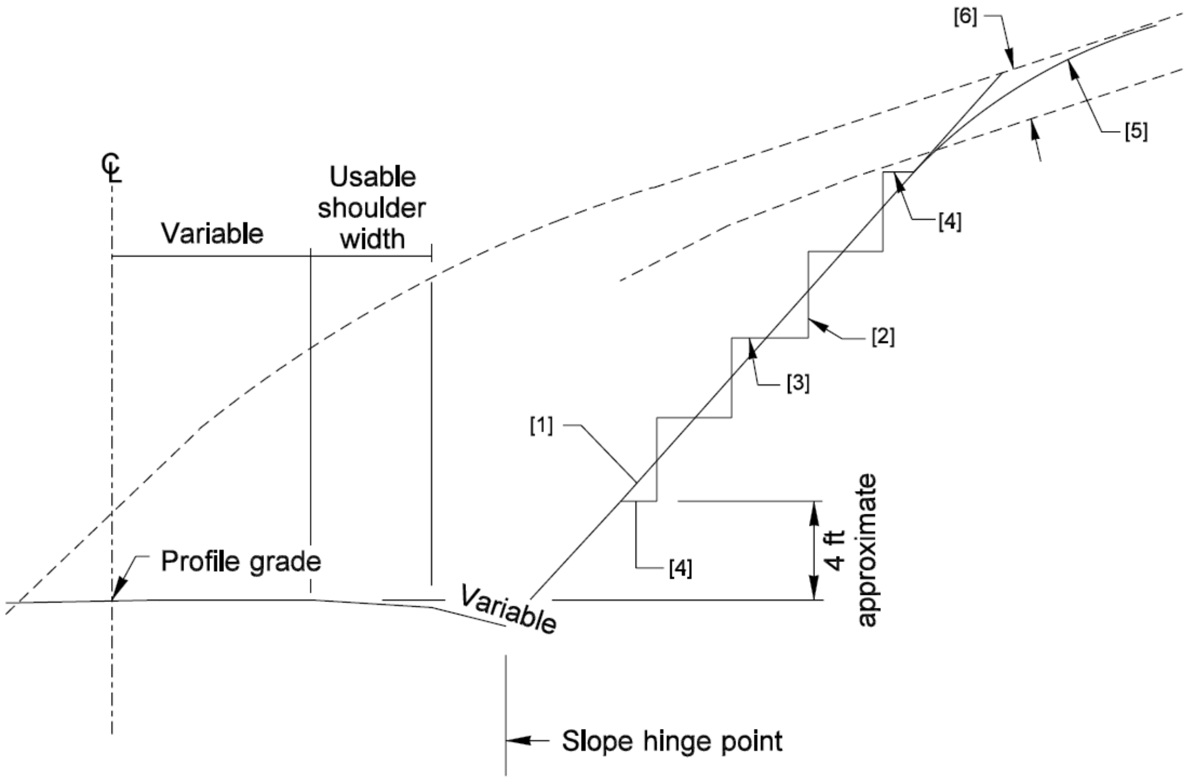
General:

- Ordinarily, place fence within a zone of 100 feet to 200 feet maximum from base of cliff, measured along the slope.
- Rock protection fence may be used in conjunction with the Shoulder Barrier Alternate when site conditions dictate.

1239.04(3) Stepped Slopes

Stepped slopes are a construction method intended to promote early establishment of vegetative cover on the slopes. They consist of a series of small horizontal steps or terraces on the face of the cut slope. Soil conditions dictate the feasibility and necessity of stepped slopes. They are to be considered on the recommendation of the RME (see Chapter 610). Consult the region landscape personnel for appropriate design and vegetative materials to be used. Use Exhibit 1239-8 for stepped slope design.

Exhibit 1239-8 Stepped Slope Design



Notes:

[1] Staked slope line: Maximum slope 1H:1V.

[2] Step rise: Height variable 1 foot to 2 feet.

[3] Step tread: Width = staked slope ratio x step rise.

[4] Step termini: Width ½-step tread width.

[5] Slope rounding.

[6] Overburden area: Variable slope ratio.

1239.05 Curbs

Curbs are designated as either vertical or mountable. Vertical curbs have a face slope 1H:3V or steeper. Mountable curbs have a sloping face that is more readily traversed.

Curbs can also be classified as mountable. Mountable curbs are sloped curb with a height of 6 inches or less; 4 inches or less is recommended to reduce underside vehicle damage if driven over. When the face slope is steeper than 1H:1V, the height of a mountable curb is limited to 4 inches or less.

1239.05(1) Vertical Curb Uses

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

- To inhibit vehicles from leaving the roadway on low-speed roadways.
- To discourage vehicles from leaving low - and intermediate-speed roadways.

- For walkway and pedestrian refuge separations.
- For raised islands on which a traffic signal or traffic signal hardware is located.
- For expediting transfer times for transit partners on low- speed roadways in urban and suburban contexts (verify curb height needed with transit provider).

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

- To inhibit midblock left turns.
- For divisional and channelizing islands.
- For landscaped islands.
- For stormwater conveyance

1239.05(2) Mountable Curb Uses

(a) Provide mountable curbs where a curb is needed but vertical curb is not suitable.

(b) Provide mountable curb where a curb is needed, but accommodation for specific design user(s) makes mountability necessary.

(c) Use mountable curbs in roundabouts. See Chapter 1320 and Standard Plan F-10.18-01.

1239.05(3) Curb Use Based On Speed

In general, curbs are not recommended on high-speed facilities. Avoid using curbs if the same objective can be attained with pavement markings. However, 4-inch-high mountable curbs may be used on high-speed facilities to control drainage or for access control. Locate mountable curb no closer to the traveled way than the outer edge of the shoulder. Provide sloping end treatments where the curb is introduced and terminated. 6-inch-high mountable curbs may be considered on high-speed urban and suburban contexts where streetside zones are provided or where traffic movements are to be restricted. Provide justification for the use of vertical curb when applied to high-speed facilities.

Intermediate speed facilities may use vertical curbs; however, consider mountable curbs for intermediate target speeds. Consider use of 12-inch to 18-inch vertical curb when analysis demonstrates a need to reduce concerns of lane departure into oncoming lane on intermediate-speed facilities. All curb types are appropriate for low-speed facilities.

1239.05(4) Curb Used For Drainage

Where curbing is provided to direct drainage, provide a design that collects the surface water at the curb and drains it without ponding in the traveled way or flowing across the roadway.

In some areas, curb may be needed to control runoff water until ground cover is attained to control erosion. Document the plan to remove the curb when the ground cover becomes adequate. A best practice is to arrange for curb removal with region maintenance staff as part of the future maintenance plans (see Maintenance Owner’s Manual guidance in Chapter 301).

When curb is used in conjunction with guardrail, see Chapter 1610 for guidance. For existing curb, particularly on high-speed facilities, evaluate the continued need for the curb. Remove curbing that is no longer needed.

1239.05(5) Curb Use Considerations

Curbs are not considered adequate to redirect an errant vehicle.

When an overlay will reduce the height of a curb, evaluate grinding (or replacing the curb) to maintain curb height if needed for pavement performance design and/or drainage performance. (See 1250.02(2) for shoulder cross slope considerations.) To maintain or restore curb height, consider lowering the existing pavement level and improving cross slope by grinding before an asphalt overlay or as determined by the pavement design. The cross slope of the shoulder may be steepened to maximize curb height and minimize other related impacts. Note that grinding can cause issues with meeting ADA criteria at curb ramps for counter slope and crosswalk running slope. See Chapter 1510 for more information.

Curbs can hamper snow-removal operations. In areas of heavy snowfall, ask the Area Maintenance Superintendent to review and concur with the use of curbing.

For curbs at traffic islands, see Chapter 1310. For curbs at roundabouts, see Chapter 1320 and Standard Plan F-10.18-01.

1239.06 Lateral Clearance to Curb and Barrier

Lateral clearance to curb or barrier is the perpendicular distance from edge of traveled way to the face of a curb or a traffic barrier (guardrail, concrete barrier, etc.). Lateral clearance includes the shoulder width. The minimum lateral clearance to the face of a curb or barrier is shown in Exhibit 1239-9. See also Chapter 1310 for intersections including clearance to curb at traffic islands.

Exhibit 1239-9 Minimum Lateral Clearance to Barrier and Curb

Posted Speed	Curb - Median [1] [2]	Curb - Right [1] [2]	Barrier
High Speed (≥50mph)	4 ft; curb not recommended [4]	4 ft; curb not recommended [4]	4 ft
Intermediate Speed (40 & 45mph)	4 ft; curb not recommended [4]	4 ft; curb not recommended [4]	
Low Speed (≤35mph)	2 ft Preferred [3]	2 ft Preferred [3]	
Ramps [5]	[6]	4 ft	

Notes:

[1] For HOV lanes on arterials streets, see Section 1410.04(4)(d)

[2] Measured from the edge of traveled way to the face of curb.

[3] On low speed urban roadways (35 mph or less), maintaining shoulder width is desirable; however, with justification, curb (mountable or vertical) may be placed at the edge of traveled way.

[4] With justification, mountable curb may be placed at the edge of traveled way for access management in urban areas. Adding mountable curb reduces lane and/or shoulder width and may require additional documentation.

[5] Raised median for two-way ramps (see 1360.03(5).)

[6] 2 ft min. for ramp design where speeds are ≤35mph (usually near the ramp terminal intersection) and 4 ft. min. where design speeds are > 35mph.

1239.07 Medians and Outer Separations

Medians are either restrictive or nonrestrictive. Restrictive medians physically limit motor vehicle encroachment, using raised curb, median barrier, fixed delineators, vegetative strips, or vegetative depressions. Nonrestrictive medians limit motor vehicle encroachment legally, and use pavement markings to define locations where turns are permissible. The main functions of an outer separation are to separate the main roadway from a frontage road or service lane, or to provide modal segregation. Consider medians or outer separations to optimize the desired performance objective, such as safety, throughput operations, pedestrian mobility needs, etc.

Provide a median or outer separation to:

- Separate traffic lanes such as HOT lanes, HOV lanes, bike lanes, etc.
- Separate divided highways with differing alignments.
- Separate opposing traffic to reduce the risk of head-on collisions.
- Manage speed.
- Provide a refuge area for emergency parking.
- Allow for future widening of a planned phase.

- Separate collector-distributor lanes, frontage roads, weigh sites, or rest areas.
- Accommodate drainage facilities.
- Accommodate bridge piers at undercrossings.
- Provide vehicle storage space for crossing and left-turn movements at intersections.
- Accommodate headlight glare screens, including planted or natural foliage.
- Provide recovery areas for errant or disabled vehicles.
- Provide a pedestrian refuge area at crossing locations.
- Provide storage space for snow and water away from traffic lanes.
- Separate modes for increased safety, comfort, and ease of operations.
- Control access.
- Provide enforcement areas.

The width of a median is measured from edge of traveled way to edge of traveled way and includes shoulders. Median widths can vary greatly based on the functional use of the median, the functional use of the shoulders, target speed, and context. Guidance for median and shoulder widths depending on their function and context is given in:

- Exhibit 1239-10 (high & intermediate speed medians),
- Exhibit 1239-11 (low & intermediate speed medians), and Exhibit
- Exhibit 1239-2 (shoulders).

1239.07(1) Median Design: High and Intermediate Speed

Exhibit 1239-10 lists width considerations for median functions common on high-speed facilities. Depending on the context and performance needs, this guidance may also apply to intermediate speed facilities as well.

When the horizontal and vertical alignments of the two roadways of a divided highway are independent of one another, determine median side slopes in conformance with 1239.03 and Chapters 1600 and 1610. Independent horizontal and vertical alignment, rather than parallel alignment, can allow for reduced grading or cut sections.

Considerable latitude in grading treatment is intended on wide, variable-width medians, provided the minimum performance needs are met or exceeded. Unnecessary clearing, grubbing, and grading are undesirable within wide medians. Use selective thinning and limited reshaping of the natural ground when feasible. For median clear zone criteria see Chapter 1600, and for slopes between the face of traffic barriers and the traveled way see Chapter 1610.

In areas where land is expensive, make an economic comparison of wide medians to narrow medians with barrier. Consider right of way, construction, maintenance, and safety performance. The widths of medians need not be uniform. Make the transition between median widths as long as practical. (See Chapter 1210 for minimum taper lengths.)

When using concrete barriers in depressed medians or on the insides of curves, provide for surface drainage on both sides of the barrier. The transverse notches in the base of precast concrete barrier are not intended to be used as a drainage feature, but rather as pick-up points when placing the sections.

At locations where the median will be used to allow vehicles to make a U-turn, consider increasing the width to meet the needs of the selected design vehicles making the U-turn. (For information on U-turn locations, see Chapter 1310.) Document the selected design vehicle and provide alternate route information for vehicles not serviced by the U-turn.

Where feasible, widen medians at intersections on rural divided multilane highways. Provide sufficient width to store vehicles crossing the expressway or entering the expressway with a left turn.

When the median is to be landscaped, or where fixed objects are to be placed in the median, see Chapter 1600 for traffic barrier and clear zone guidance. When the median will transition for use as a left-turn lane, see Chapter 1310 for left-turn lane design considerations.

Exhibit 1239-10 Median Functions and Guidance: High and Intermediate Speeds

Median Functional Use	Width Guidance
Separating opposing traffic	Varies[1] and see Chapters 1600 and 1610
Separating alignments	Varies See 1239.03 and Chapters 1600 and 1610 [2]
Recovery/Refuge areas for errant vehicles	See 1239.03 and Chapter 1600
Median signing and illumination – Undivided highways and ramps	6 ft [1] or as recommended for signing and illumination design
Storage space for snow	Consult Region Maintenance
Enforcement areas	See Chapters 1370 and 1410, and consult with Washington State Patrol
Vehicle storage space for crossing at intersections	See Chapter 1310, and consult with region traffic engineer
Median U-turn or Median crossover	See Chapters 1310 and 1370
Outer separation for frontage or collector-distributer roads	12 ft min plus shoulders [1] See Exhibit 1360-15a and Chapters 1360, 1600 and 1610
Transit use	Varies; see Chapter 1420 and discuss with Transit Agency [3]
Pedestrian refuge for crossing locations	6 ft minimum, excluding curb width (see Chapter 1510)

Notes:

[1] Conduct a safety performance analysis and include potential countermeasures identified to obtain the desired safety performance. Consult with maintenance; additional width may be appropriate

for unconstrained right of way locations, maintenance functions, or for divided highways on independent alignments.

[2] An economic comparison of wide medians to narrow medians with barrier is recommended.

[3] For planning and scoping purposes, 32 ft can be the assumed minimum for two-way transit operations or 22 ft for one-way transit operations.

1239.07(2) Median Design: Low and Intermediate Speeds

Exhibit 1239-11 provides design guidance for medians within low-speed transportation contexts. Depending on the context and performance needs, this guidance may also apply to intermediate speed facilities as well. In low-speed urban and suburban contexts, see Chapter 1600 for Design Clear Zone requirements.

A common form of restrictive median on urban managed access highways is the raised median. For more information on traffic volume thresholds for restrictive medians on managed access highways, see Chapter 540.

Exhibit 1239-11 Median Functions and Guidance: Low and Intermediate Speeds

Median Functional Use	Width Guidance
Access Control – Restrictive	Width of raised median feature [1] [2]
Access Control – Non-restrictive	1 ft minimum [3] (see Chapter 540)
Pedestrian refuge for crossing locations	6 ft minimum, excluding curb width (see Section 1510.11)
Speed management and/or aesthetic design – Vegetated	Varies [2] [4] (see Chapter 1103)
Drainage or treatment facilities	Varies [5]
Bicyclist buffer treatment	2 ft – 3 ft (see Chapter 1520)
Transit connection	Varies [6] (see Chapters 1238 and 1430)
Outer separation for frontage or collector- distributer roads	12 ft min. plus shoulders [4] [7] [8] See Exhibit 1360-15a, Design B

Notes:

[1] The width of a raised median can be minimized by using a dual-faced cement concrete traffic curb, a precast traffic curb, or an extruded curb.

[2] Consider width necessary for lateral clearance.

[3] 2 ft minimum if adjacent lane widths are less than 11 ft.

[4] Consult Region Landscape Architect; width will depend on type of plantings. Over-excavation may be necessary to prepare soil for the selected plantings to ensure mature heights are obtained.

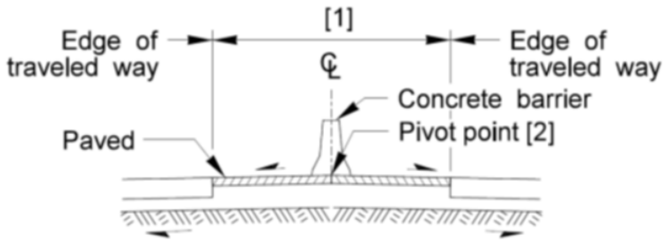
[5] Consult Hydraulic Report for width necessary for drainage or treatment facilities.

[6] Consult with the transit provider. If a transit shelter is planned, a minimum 5 ft clear area measured from the edge of shelter roofing to face of curb width, is necessary for pedestrians to move to and around the shelter and for lift extension (see Chapter 1430).

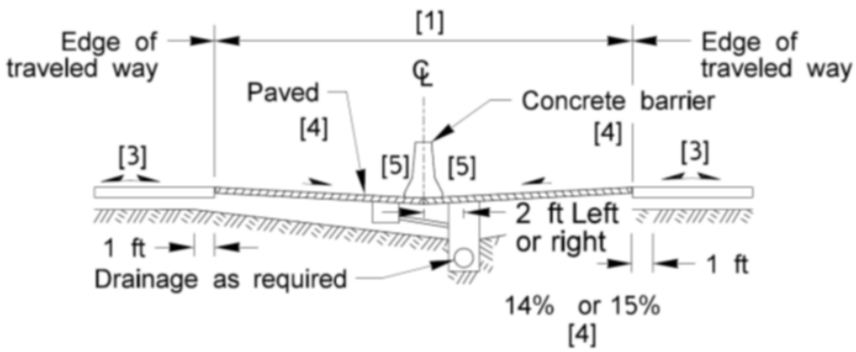
[7] Consider width needed for plantings or street furniture to create the appropriate pedestrian zone segregation and environment.

[8] See also Chapter 1510

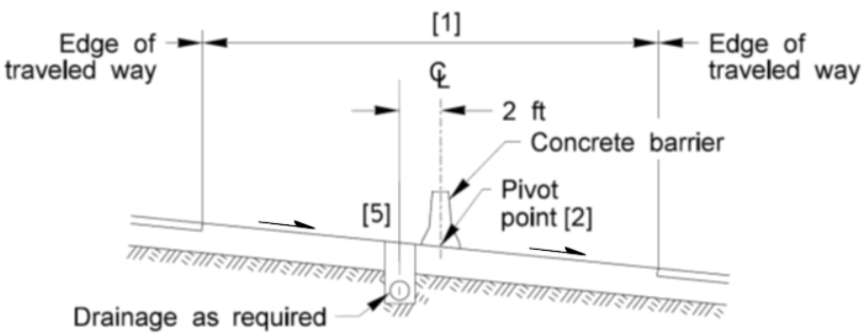
Exhibit 1239-12a Divided Highway Median Sections



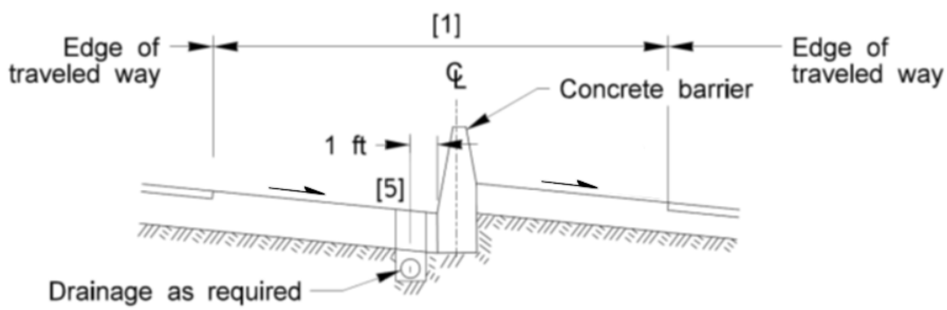
Design A: Crowned Median



Design B: Depressed Median



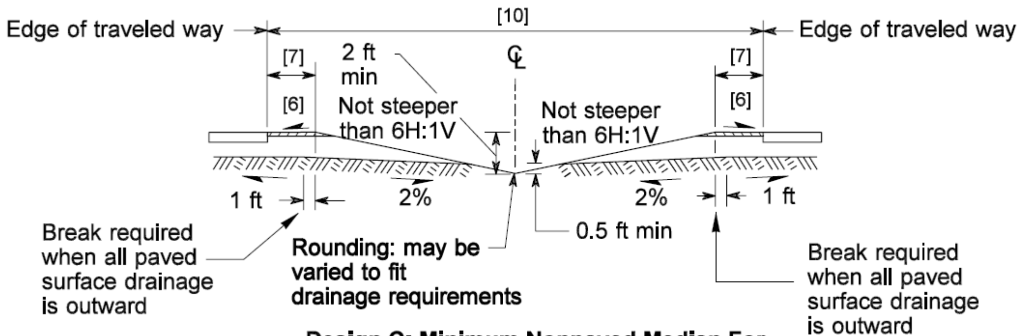
Alternate Design 1: Treatmet on Curves (Single Pivot Point)



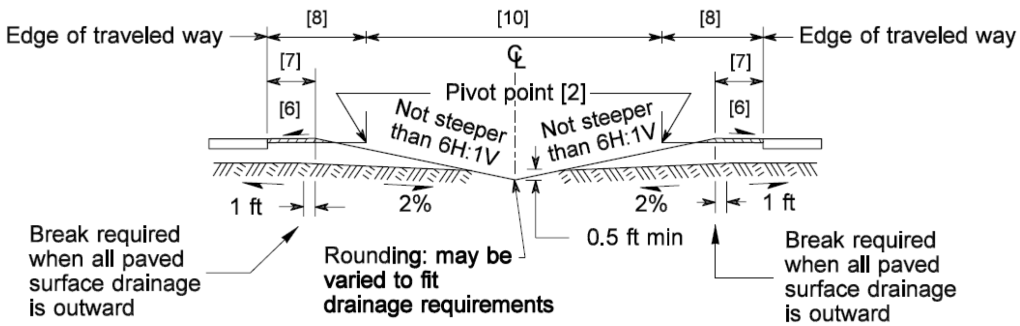
Alternate Design 2: Treatment on Curves (Seporate Pivot Points) [2]

Note:
For applicable notes, see Exhibit 1239-12c.

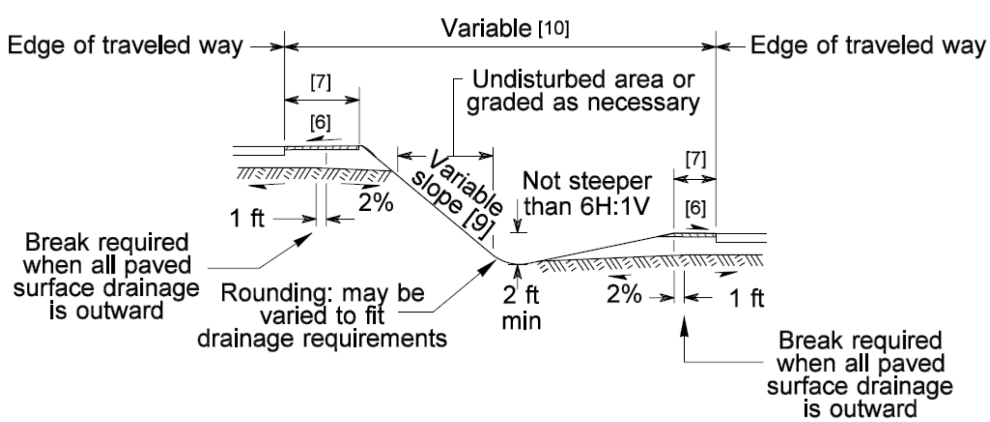
Exhibit 1239-12b Divided Highway Median Sections



Design C: Minimum Nonpaved Median For 4 or More Lanes [2]



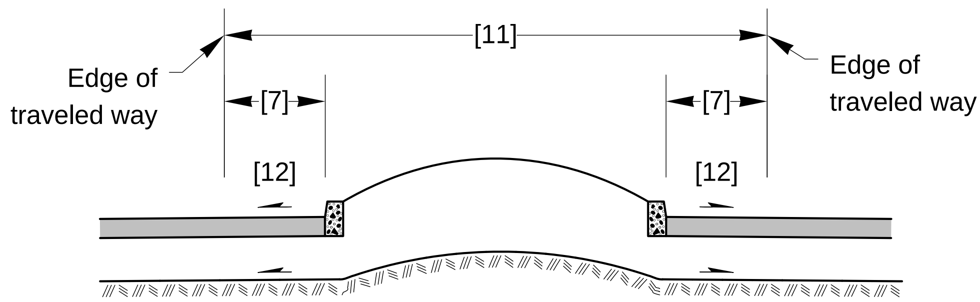
Design D: Minimum for 4 or More Lanes With Future Lanes in Median



Design E: Minimum for 4 or More Lanes With Independent Alignment

Note:
For applicable notes, see Exhibit 1239-12c.

Exhibit 1239-12c Divided Highway Median Sections



Design F: Raised Median[13]

Notes:

[1] For guidance on median widths, see Exhibits 1239-10 and -11

[2] Consider vertical clearances, drainage, and aesthetics when locating the pivot point.

[3] Generally, slope pavement away from the median. When barrier is present and the roadway is in a superelevation, size the shoulder so that standing water is not in the travel lane. Where appropriate, a crowned roadway section may be used in conjunction with the depressed median.

[4] Design B may be used uniformly on both tangents and horizontal curves. Use Alternate Design 1 or Alternate Design 2 when the "rollover" between the shoulder and the inside lane on the high side of a superelevated curve exceeds 8%. Provide suitable transitions at each end of the curve for the various conditions encountered in applying the alternate to the basic median design.

[5] Method of drainage pickup to be determined by the designer.

[6] Median shoulders normally slope in the same direction and rate as the adjacent through lane. See 1250.02(2) for examples and additional information for locations where it may be desirable to have a shoulder cross slope different than the adjacent lane.

[7] For guidance on shoulder widths, see 1239.02.

[8] Future lane width of a planned phase.

[9] Widen and round foreslopes steeper than 4H:1V as shown in Exhibit 1239-3. See Chapter 1600 for barrier recommendations.

[10] Designs C, D, and E are rural high-speed median designs. See Exhibit 1239-10 for recommended median widths.

[11] Raised medians may be paved or landscaped. For clear zone and barrier guidelines when fixed objects or trees are in the median, see Chapter 1600.

[12] Lane and shoulders normally slope away from raised medians. When they slope toward the median, provide for drainage.

[13] See 1239.05 and 1239.06 for curb design guidance.

1239.08 Documentation

Refer to Chapter 300 for design documentation requirements and approving authorities.

Chapter 1310 Intersections

1310.01 General

Intersections are a critical part of Washington State Department of Transportation (WSDOT) highway design because of increased conflict potential. Traffic and driver characteristics, bicycle and pedestrian needs, physical features, and economics are considered during the scoping and design stages to develop channelization and traffic control to provide multimodal traffic flow through intersections.

See chapters in the 1100 series for instruction on multimodal practical design, including identifying project needs, context, design controls, modal performance, alternatives analysis, and design element dimensioning.

This chapter provides guidance for designing intersections, including ramp terminals. Refer to the following chapters for additional information:

Chapter	Subject
1103	Design controls
1106	Design element dimensions
1230	Geometric cross section
1300	Intersection control type
1320	Roundabouts
1330	Traffic signals
1340	Driveways
1360	Interchanges
1510	Pedestrian facilities
1520	Roadway bicycle facilities

For assistance with intersection design, contact the Headquarters (HQ) Design Office.

1310.02 Design Considerations

Consider all potential users of the facility in the design of an intersection. This involves addressing the needs of a diverse mix of user groups, including passenger cars, heavy vehicles of varying classifications, bicycles, and pedestrians. Often, meeting the needs of one user group results in a compromise in service to others. Intersection design balances these competing needs, resulting in appropriate levels of operation for all users.

In addition to reducing the number of conflicts, minimize the conflict area as much as possible while still providing for the design vehicle (see Chapter 1103). This is done to control the speed of turning vehicles and reduce the area of exposure for vehicles, bicycles, and pedestrians. For additional information on pedestrian needs, see Chapter 1510. For intersections with shared-use paths, see Chapter 1515. For bicycle considerations at intersections, see Chapter 1520.

1310.02(1) Non-Geometric Considerations

Geometric design considerations, such as sight distance and intersection angle, are important. Equally important are perception, contrast, and a driver's age. Perception is a factor in the majority of crashes. Regardless of the type of intersection, the function depends on the driver's ability to perceive what is happening with respect to the surroundings and other vehicles. When choosing an acceptable gap, the driver first identifies the approaching vehicle and then determines its speed. The driver uses visual clues provided by the immediate surroundings in making these decisions. Thus, given equal sight distance, it may be easier for the driver to judge a vehicle's oncoming speed when there are more objects to pass by in the driver's line of sight. Contrast allows drivers to discern one object from another.

1310.02(2) Intersection Angle and Roadway Alignment

An important intersection design characteristic is the intersection angle. The desirable intersection angle is 90°, with 60° to 120° allowed. Do not put angle points on the roadway alignments within intersection areas or on the through roadway alignment within 100 feet of the edge of traveled way of a crossroad. However, angle points within the intersection are allowed at intersections with a minor through movement, such as at a ramp terminal (see Exhibit 1310-2).

When feasible, locate intersections such that curves do not begin or end within the intersection area. It is desirable to locate the PC and PT 250 feet or more from the intersection so that a driver can settle into the curve before the gap in the striping for the intersection area. Do not locate short curves where both the PC and PT are within the intersection area.

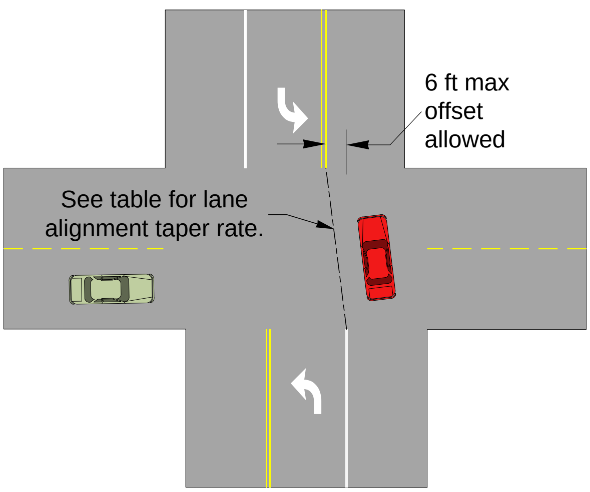
1310.02(3) Lane Alignment

It is desirable that entering through traffic is aligned with the exit lanes. However, the entering and exit lanes may be offset up to 6 feet when the following conditions are met:

- Illumination is provided.
- The intersection is not within a horizontal curve, nor is it within a crest vertical curve.
- The taper rates provided in Exhibit 1310-1 are used.
- There is a posted speed of 55 mph or less.

Consider dotted extension lines that continue through the intersection.

Exhibit 1310-1 Lane Alignment Taper Rate



Posted Speed	Taper Rate
55 mph	55:1
50 mph	50:1
45 mph	45:1
40 mph	27:1
35 mph	21:1
30 mph	15:1
25 mph	11:1

1310.02(4) Intersection Spacing

Provide intersection spacing for efficient operation of the highway. The minimum design intersection spacing for highways with limited access control is covered in Chapter 530. For other highways, the minimum design intersection spacing is dependent on the managed access highway class. (See Chapter 540 for minimum intersection spacing on managed access highways.)

As a minimum, provide enough space between intersections for left-turn lanes and storage length. Space signalized intersections and intersections expected to be signalized to maintain efficient signal operation. Space intersections so that queues will not block an adjacent intersection.

Evaluate existing intersections that are spaced less than shown in Chapters 530 and 540. Also, evaluate closing or restricting movements at intersections with operational issues. Document the spacing of existing intersections that will remain in place and the effects of the spacing on operation, capacity, and circulation.

1310.02(5) Accommodating vs. Designing for Vehicles

Accommodating for a vehicle allows encroachment of other lanes, shoulders, or other elements to complete the required maneuver. Designing for a vehicle does not require encroachment on those elements.

There are competing design objectives when considering the crossing needs of pedestrians and the turning needs of larger vehicles. To design for large design vehicles, larger turn radii are used. This results in increased pavement areas, longer pedestrian crossing distances, and longer traffic signal arms. (See Chapter 1103 for design vehicle selection criteria.)

When appropriate, to reduce the intersection area, consider accommodating for large vehicles instead of designing for them. This reduces the potential for vehicle/pedestrian conflicts, decreases pedestrian crossing distance, and controls the speeds of turning vehicles. Use turn simulation software (such as AutoTURN®) to verify the design.

1310.02(6) Sight Distance

For stopping and decision sight distance criteria, see Chapter 1260. Intersection sight distance criteria are discussed in section 1310.05.

1310.02(7) Crossroads

When the crossroad is a city street or county road, design the crossroad beyond the intersection area in cooperation with the local agency.

When the crossroad is a state facility, design the crossroad according to the *Design Manual*. Continue the cross slope of the through roadway shoulder as the grade for the crossroad. Use a vertical curve that is at least 60 feet long to connect to the grade of the crossroad.

Evaluate the profile of the crossroad in the intersection area. The crown slope of the main line might need to be adjusted in the intersection area to improve the profile for the cross traffic.

Design the grade at the crosswalk to meet the requirements for accessibility. (See Chapter 1510 for additional crosswalk information.)

In areas that experience accumulations of snow and ice for all legs that require traffic to stop, design a maximum grade of ±4% for a length equal to the anticipated queue length for stopped vehicles.

1310.02(8) Rural Expressway At-Grade Intersections

Evaluate grade separations at all intersections on rural expressways.

Design high-speed at-grade intersections on rural expressways as indirect left turns, split intersections, or roundabouts.

The State Traffic Engineer’s approval is required for any new intersection or signal on a rural expressway.

1310.02(9) Interchange Ramp Terminals

When stop control or traffic signal control is selected, the design to be used or modified is shown in Exhibit 1310-2. Higher-volume intersections with multiple ramp lanes are designed individually. Provide ramp terminal designs consistent with the speed of the crossroad.

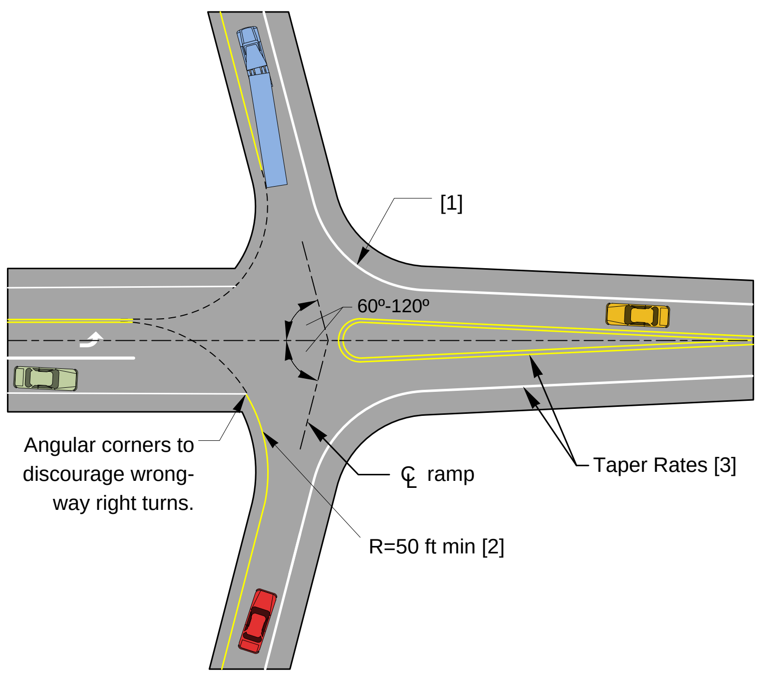
Where stop control or signal control is implemented, the intersection configuration criteria for ramp terminals are normally the same as for other intersections. One exception is that an angle point is allowed between an off-ramp and an on-ramp. This is because the through movement of traffic getting off the freeway, going through the intersection, and getting 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.

Due to the probable development of large traffic generators adjacent to an interchange, width for a median on the local road is desirable whenever such development is expected. 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.

Adjust the alignment of the intersection legs to fit the traffic movements and to discourage wrong-way movements. Use the allowed intersecting angles of 60° to 120° in designing the best alignment for efficiency and intersection operations.

Exhibit 1310-2 Ramp Terminal Intersection Details



Notes:

[1] For right-turn corner design, see Exhibit 1310-6.

[2] Use turn simulation software to verify that the design vehicle can make the turn.

[3] For taper rates, see Exhibit 1310-10a, Table 1.

1310.02(10) Wrong-Way Movement Countermeasures

Wrong-way crashes, though infrequent, have the potential to be more serious than other types of crashes, especially on high-speed facilities. Crash data show that impaired and older drivers are overrepresented and that a high percentage of these occurrences are at night. Washington State data show approximately equal numbers of crashes on the Interstate and multilane urban principal arterial highways. Discourage wrong-way maneuvers at all stages of design.

1310.02(10)(a) Wrong-Way Driving Countermeasure Categories

There are three categories of countermeasures to discourage wrong-way driving:

- Signing and delineation
- Intelligent transportation systems
- Geometric design

1310.02(10)(a)(1) Signing and Delineation

Signing and delineation countermeasures include:

- DO NOT ENTER and WRONG WAY signs.
- ONE WAY signs.
- Turn restriction signs.
- Red-backed raised pavement markers (RPMs).
- Directional pavement arrows.
- Yellow edge line on left and white edge line on right side of exit ramps.
- Pavement marking extension lines to direct drivers to the correct ramp.

Signing can be a more effective countermeasure when the signs are lowered. At night, lowered signs are better illuminated by low-beam headlights. Other improvements may include a second set of signs, supplemental sign placards, oversized signs, flashing beacons, internal illumination, overhead-mounted signs, red reflective tape on the back of signs, extra overhead lighting, and red-backed guideposts on each side of the ramp up to the WRONG WAY sign.

1310.02(10)(a)(2) Intelligent Transportation Systems (ITS)

Wrong-way ITS countermeasures are wrong-way detection and warning systems. Contact the region Traffic Office for assistance when considering an ITS wrong-way warning system.

1310.02(10)(a)(3) Geometric Design

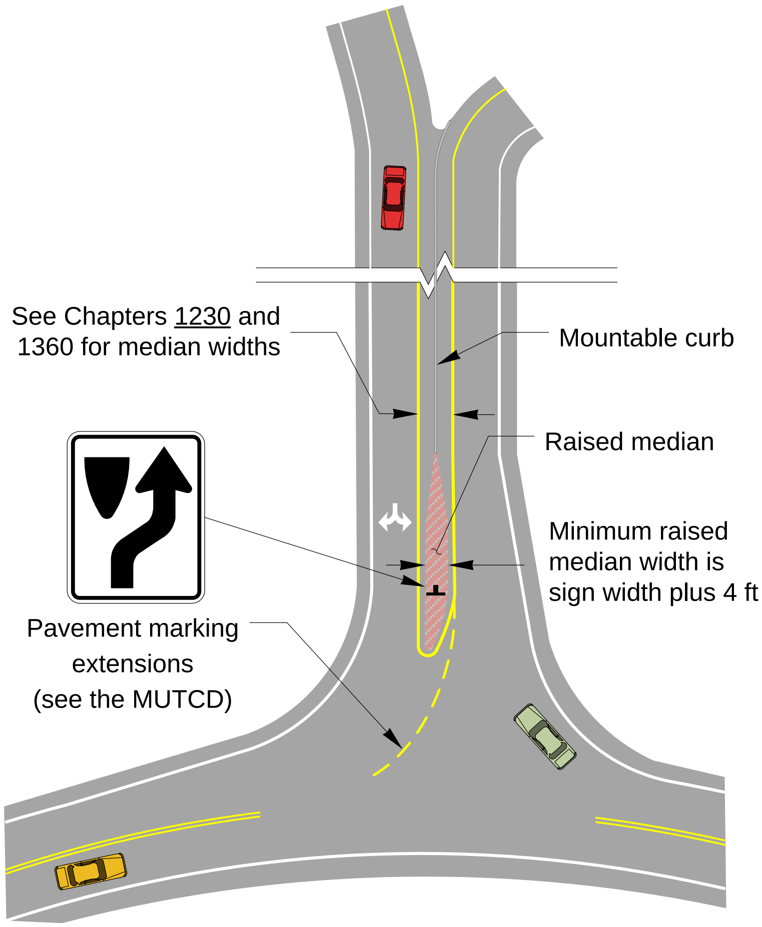
Geometric countermeasures include separating wrong-way movements from other movements, discouraging wrong-way movements, encouraging right-way movements, and improving the visibility of the right-way movement.

a. Separate On- and Off-Ramp Terminals

Consider the separation of on- and off-ramp terminals, particularly at interchanges where the ramp terminals are closely spaced (for example, partial cloverleaf ramps combined with other ramps). Wider medians between off- and on-ramp terminals provide room for signing and allow the median end to be shaped to help direct vehicles onto the correct roadway. The minimum width of the raised median is 7 feet, face of curb to face of curb, to accommodate a 36 inch sign.

Extend the raised median on a two-way ramp from the ramp terminal intersection to the split of the on- and off-ramps. The median outside of the intersection area may be reduced to the width of a dual-faced mountable curb. (See Exhibit 1310-3 for an example of the minimum median at the terminal of a two-way ramp.)

Exhibit 1310-3 Median at Two-Way Ramp Terminal



b. Reduced Off-Ramp Terminal Throat Width

Reducing the width of the off-ramp throat has been a successful method of discouraging wrong-way movements. A smaller opening makes the wrong-way entry less inviting, particularly for closely spaced ramps. When off-ramp terminals have right-turn lanes, a raised island will reduce the potential for a wrong-way movement.

c. Increased On-Ramp Terminal Throat Width

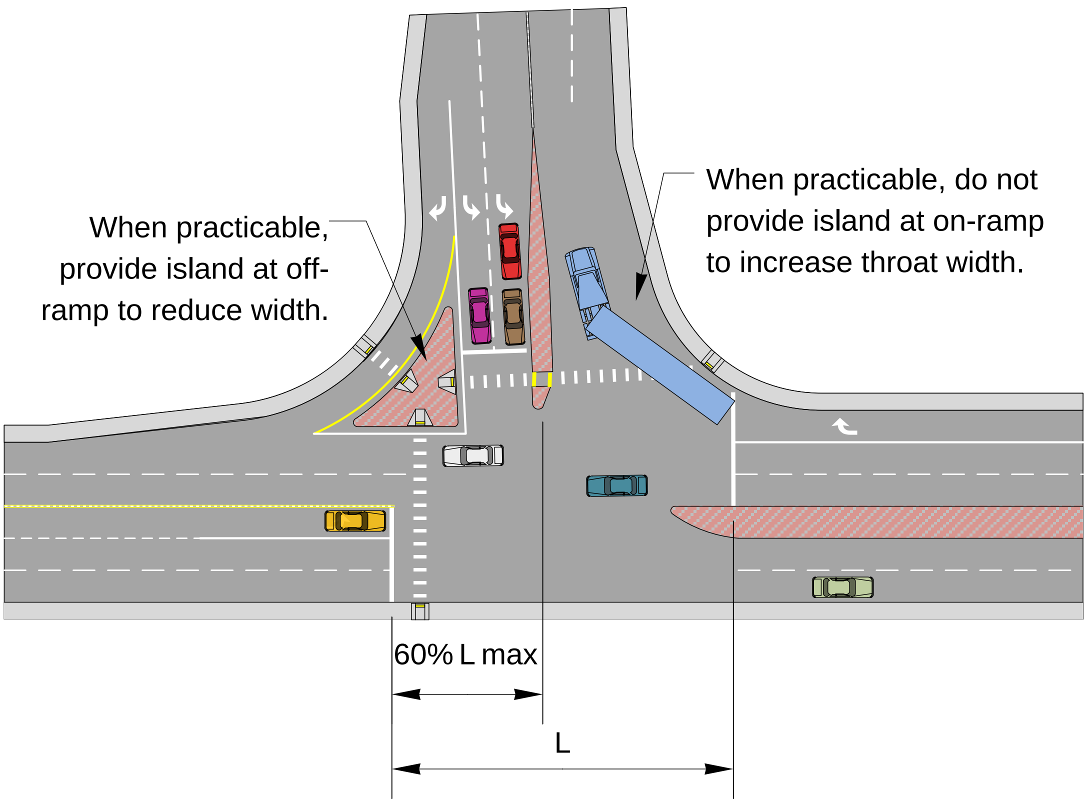
Increasing the width of the on-ramp throat can encourage right-way movements. A larger opening for the on-ramp makes it easier to turn into. To increase the throat width of on-ramps, use flat radii for left- and right-turning traffic and remove islands.

d. Intersection Balance

When drivers make a left turn, they are required to leave the intersection in the extreme left-hand lane lawfully available. As a result, left-turning drivers tend to head for a point between 50% and 60% of the way through the intersection.

At a two-way ramp terminal, the desirable throat width for the on-ramp roadway is not less than the off-ramp roadway width to accommodate this behavior (see Exhibit 1310-4). Much of this can be achieved by adjusting the stop bar position on the interchange cross street.

Exhibit 1310-4 Intersection Balance Example



e. Visibility

When drivers can see and recognize the roadway they want to turn onto, they are less likely to make a mistake and turn onto the wrong roadway. For two-way ramps and divided multilane roadways with barrier in the median, end the barrier far enough from the intersection that a left-turning driver can see and recognize the roadway going the correct direction. Drivers need to see the delineation pavement markings, curbs, or other elements to locate the correct roadway.

f. Angular Corners on the Left of Off-Ramp Terminals

Angular corners on the left side of off-ramp terminals will discourage wrong-way right turns. Provide a corner design as angular as feasible that will provide for the left turn from the off-ramp. Circular curves can look inviting for a wrong-way right turn onto the off-ramp (see Exhibit 1310-2).

1310.02(10)(b) Countermeasure Applications

Following are applications of wrong-way countermeasures for some common locations. For assistance with signing and delineation, contact the region Traffic Office.

1310.02(10)(b)(1) All Ramps

Countermeasures that can be used on almost any ramp or intersection with potential wrong-way concerns include:

- Enlarged warning signs.
- Directional pavement arrows at ramp terminals.
- Redundant signing and pavement arrows.
- Roundabout ramp terminal intersections, where room is available.
- Red-backed RPMs.

1310.02(10)(b)(2) One-Way Diamond Off-Ramp

Diamond interchanges are common, and although drivers are familiar with them, they can still get confused and go the wrong way. In addition to signing and pavement markings for these interchanges, provide:

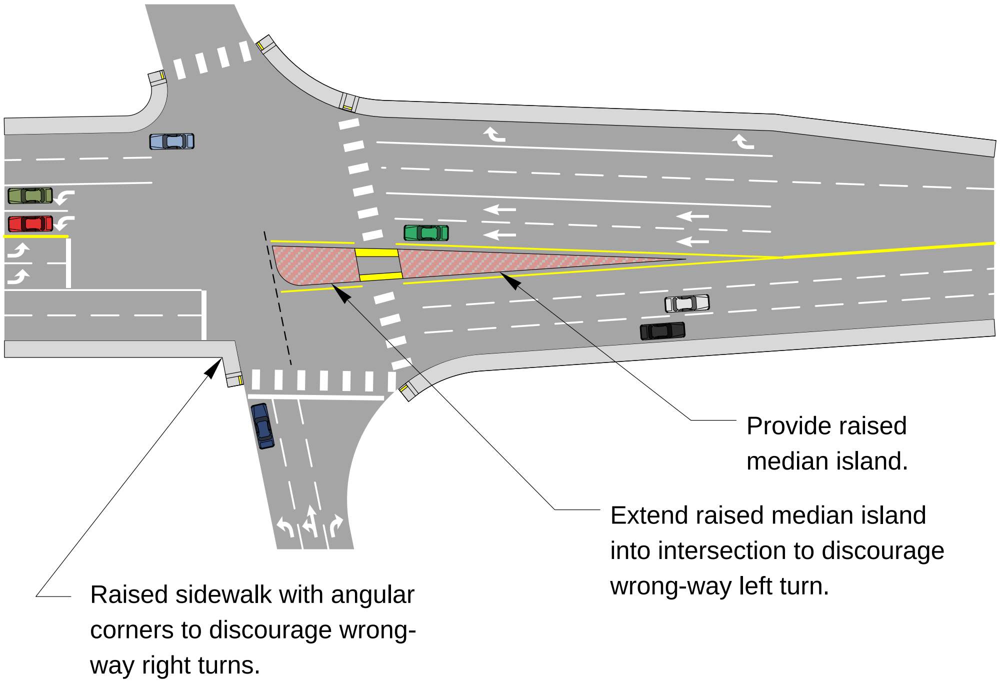
- Angular corners to discourage wrong-way right turns.

1310.02(10)(b)(3) Diamond Interchange With Advance Storage

Diamond interchanges with advance storage have left-turn storage lanes that extend from the on-ramp past the off-ramp (see Exhibit 1310-5). This allows for a potential early left turn onto the off-ramp. Following are additional countermeasures for interchanges with advanced left-turn storage:

- Provide a raised median to discourage the wrong-way left turn.
- Provide signing and directional arrows to direct traffic to the correct left-turn point.

Exhibit 1310-5 Diamond Interchange with Advance Storage



1310.02(10)(b)(4) Two-Way Ramps

Two-way ramps have the on- and off-ramp adjacent to each other. They are used at partial cloverleaf, trumpet, and button hook interchanges. Because the on and off roadways are close to each other, they are more vulnerable to wrong-way driving. Also, when the separation between on and off traffic is striping only, the ramps are susceptible to drivers entering the correct roadway and inadvertently crossing to the wrong ramp. In addition to signing and delineation, the following are countermeasures for two-way ramps:

- Separate the on- and off-ramp terminals.
- Reduce off-ramp terminal throat width.
- Increase on-ramp terminal throat width.
- Maintain intersection balance.
- Improve on-ramp visibility.
- Provide a raised median or dual-faced curb from the ramp terminal intersection to the gore nose.

1310.02(10)(b)(5) HOV Direct Access Ramps

HOV direct access ramps are two-way ramps in the median; therefore, the ability to provide separation between the on and off traffic is limited by the width of the median. An additional concern is that HOV direct access ramps are left-side ramps. Drivers normally enter the freeway using a right-side ramp and they may mistakenly travel the wrong way on a left-side ramp. Review existing and proposed signing for inadvertent misdirection. (See Chapter 1420 for HOV direct access and countermeasures for wrong-way driving at HOV direct access ramps.)

1310.02(10)(b)(6) Multilane Divided Roadways

Wrong-way driving can also occur on multilane divided nonfreeway facilities. Wrong-way drivers may enter multilane divided facilities at driveways and at-grade intersections. Countermeasures for wrong-way driving on nonfreeway multilane divided highways include:

- Wrong-way signing and delineation at the intersections.
- Right-in/right-out road approaches.

1310.03 Design Elements

When designing an intersection, identify and address the needs of all intersection users.

If pedestrian facilities are present, the design objective becomes one of reducing the potential for vehicle/pedestrian conflicts. This is done by minimizing pedestrian crossing distances and controlling the speeds of turning vehicles. Pedestrian refuge islands can be beneficial. They minimize the pedestrian 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. Use turn simulation software (such as AutoTURN®) to verify the design.

Channelization, the separation or regulation of traffic movements into delineated paths of travel, can facilitate the orderly movement of pedestrians, bicycles, and vehicles. Channelization includes left-turn lanes, right-turn lanes, speed change lanes (both acceleration and deceleration lanes), and islands.

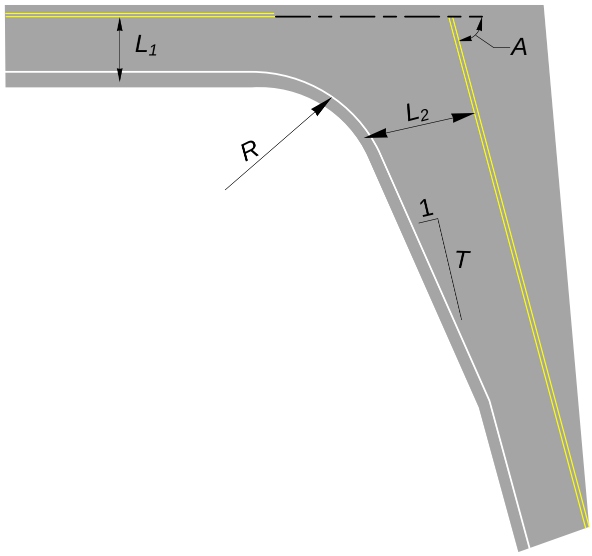
1310.03(1) Right-Turn Corners

Exhibit 1310-6 shows initial ranges for right-turn corner designs using a simple curve with a taper. These are considered approximate pavement areas to accommodate the design vehicles without encroachment on the adjacent lane at either leg of the curve.

Depending on the context of the roadway and right-turn corner (and whether the right-turn corner will be designed for or will accommodate a design vehicle), there may be several design considerations. Consider 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.

Other design considerations may include a combination of simple or compound curves, tapers at the beginning or end of the turn, and so on. Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

Exhibit 1310-6 Initial Ranges for Right-Turn Corner (Simple Curve-Taper)



L_1 = Available roadway width [2] that the vehicle is turning from

L_2 = Available roadway width [2] for the vehicle leaving the intersection

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[2]*	*T*
P	All	30	11	11	25
SU-30 & CITY-BUS	All	50	11	11	25
WB-40	All	55	11	15	7.5
WB-67	All	50-85	11	22-24	7

Notes:

[1] When available roadway width is less than 11 ft, widen at 25:1.

[2] Available roadway width includes the shoulder, less a 2-ft clearance to a curb, and all the same-direction lanes of the exit leg at signalized intersections.

General:

All distances given in feet and angles in degrees

1310.03(2) Left-Turn Lanes and Turn Radii

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 1310.03(4) for a discussion on speed change lanes.)

Design left-turn channelization to provide sufficient operational flexibility to function under peak loads and adverse conditions.

1310.03(2)(a) One-Way Left-Turn Lanes

One-way left-turn lanes are separate storage lanes for vehicles turning left from one roadway onto another. One-way left-turn lanes may be an economical way to lessen delays and crash potential involving left-turning vehicles. In addition, they can allow deceleration clear of the through traffic lanes. Provide a minimum storage length of 100 feet for one-way left-turn lanes. When evaluating left-turn lanes, include impacts to all intersection movements and users.

At signalized intersections, use a traffic signal analysis to determine whether a left-turn lane is needed and the storage length. If the length determined is less than the 100-foot minimum, make it 100 feet (see Chapter 1330).

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 congestion reduction with a left-turn lane. On two-lane highways, use Exhibit 1310-7a, based on total traffic volume (DHV) for both directions and percent left- turn traffic, to determine whether further investigation is needed. On four-lane highways, use Exhibit 1310-7b to determine whether a left-turn lane is recommended.
- A study indicates crash reduction with a left-turn lane.
- Restrictive geometrics require left-turning vehicles to slow greatly below the speed of the through traffic.
- There is less than decision sight distance for traffic approaching a vehicle stopped at the intersection to make a left turn.

A traffic analysis based on the *Highway Capacity Manual* (HCM) may also be used to determine whether left-turn lanes are needed to maintain the desired level of service.

Exhibit 1310-7a Left-Turn Storage Guidelines: Two-Lane, Unsignalized

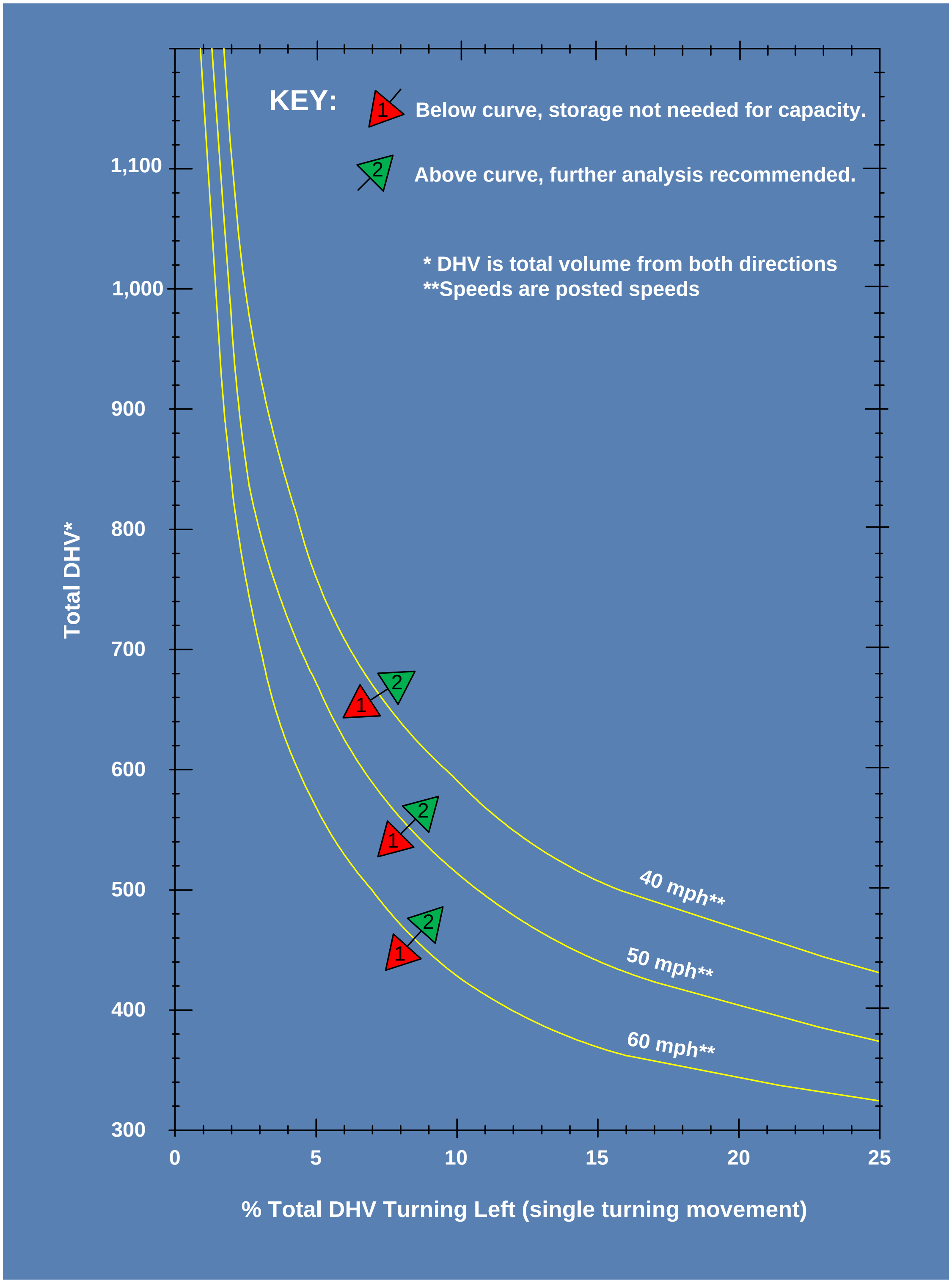
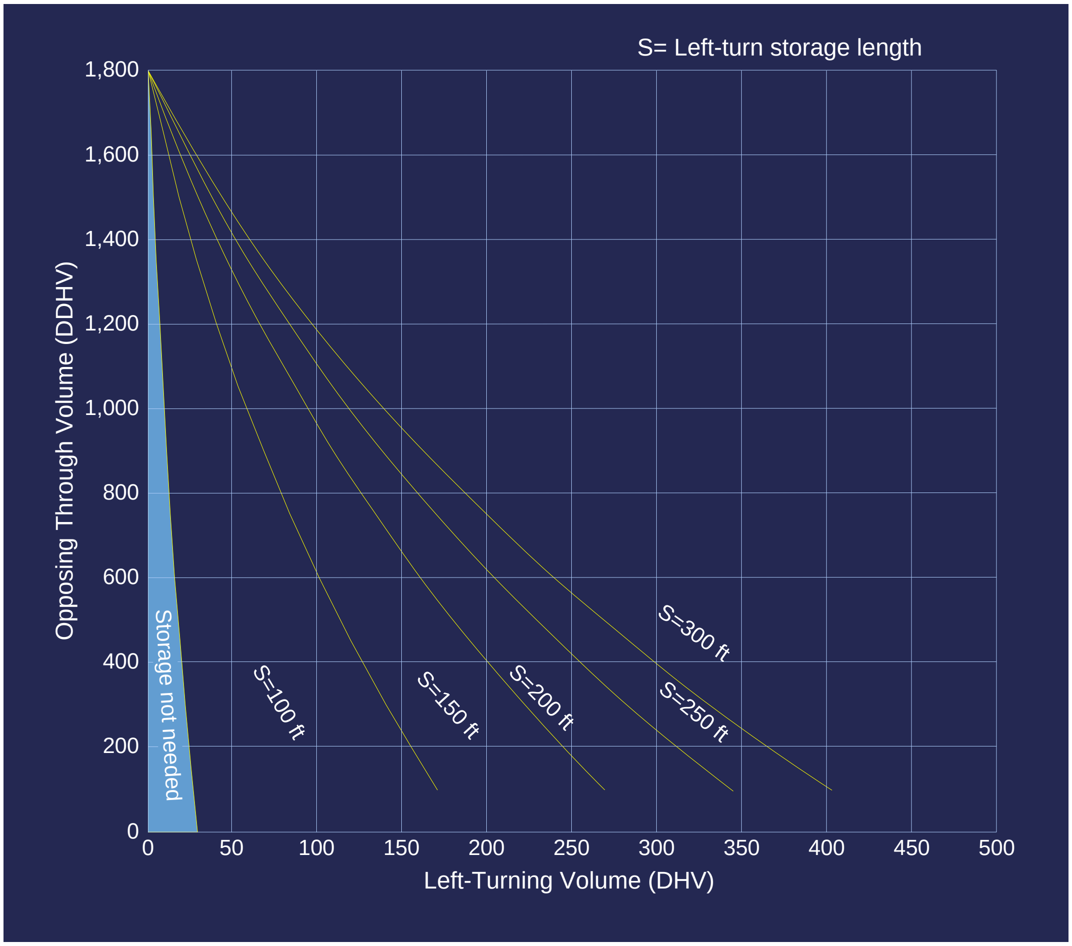


Exhibit 1310-7b Left-Turn Storage Guidelines: Four-Lane, Unsignalized



Determine the storage length on two-lane highways by using Exhibits 1310-8a through 8c. On four-lane highways, use Exhibit 1310-7b. These lengths do not consider trucks. Use Exhibit 1310-9 for storage length when trucks are present.

Use turn simulation software (such as AutoTURN®) to verify that left-turn movements for the design vehicle(s) do not have conflicts. Design opposing left-turn design vehicle paths with a minimum 4-foot (12-foot desirable) clearance between opposing turning paths.

Where one-way left-turn channelization with curbing is to be provided, evaluate surface water runoff and design additional drainage facilities if needed to control the runoff.

Provide illumination at left-turn lanes in accordance with the guidelines in Chapter 1040.

Exhibit 1310-8a Left-Turn Storage Length: Two-Lane, Unsignalized (40mph)

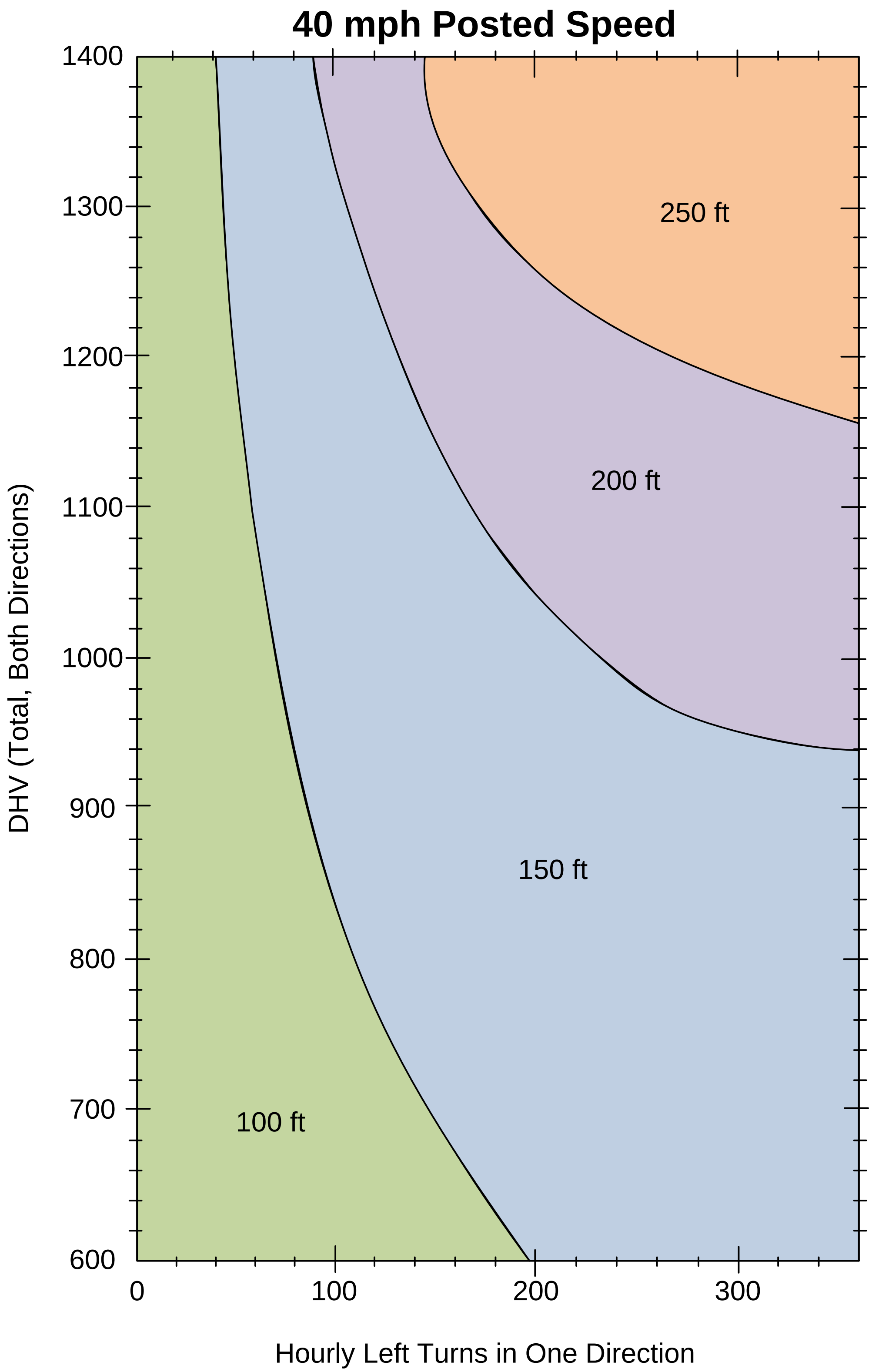


Exhibit 1310-8b Left-Turn Storage Length: Two-Lane, Unsignalized (50 mph)

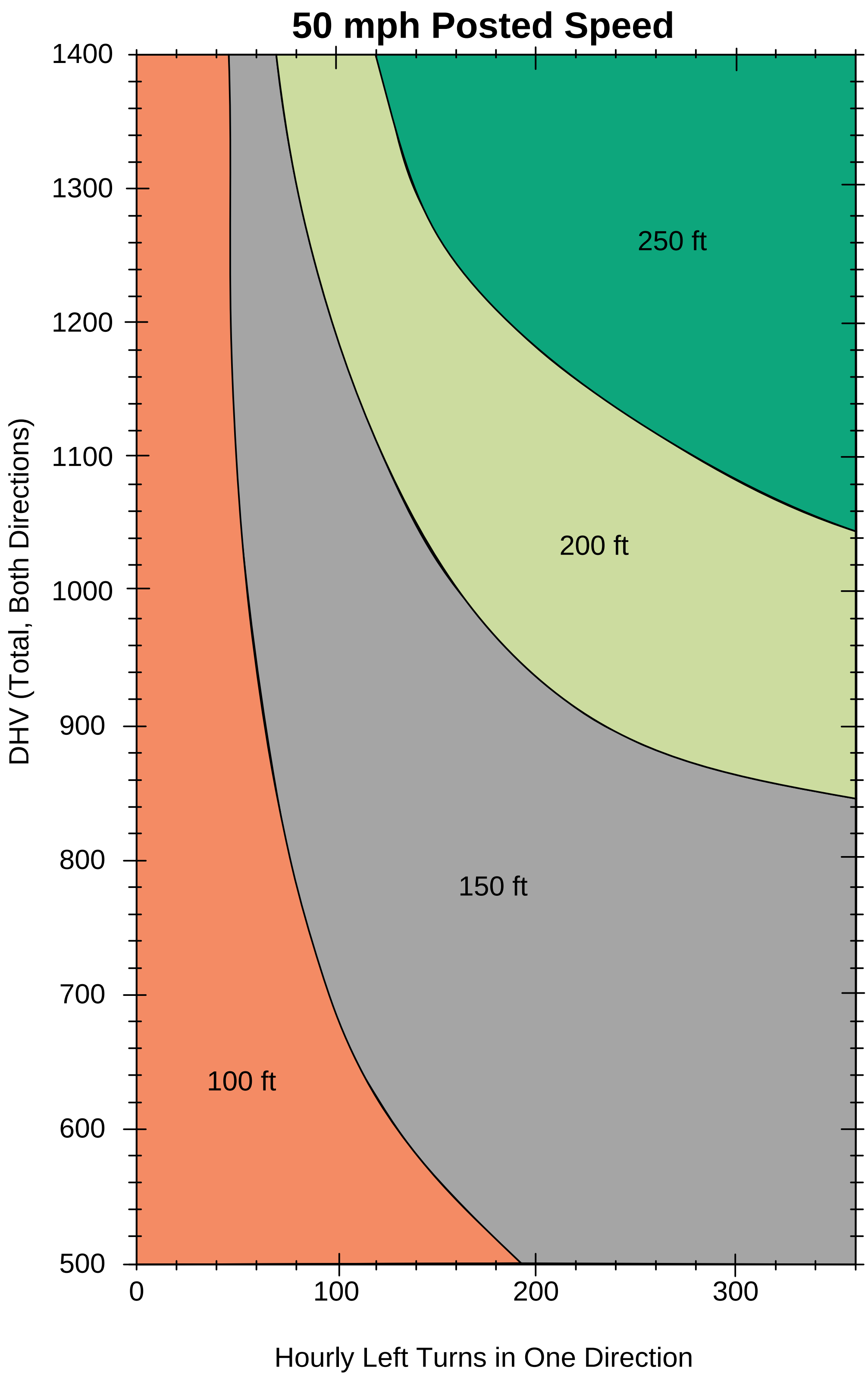


Exhibit 1310-8c Left-Turn Storage Length: Two-Lane, Unsignalized (60 mph)

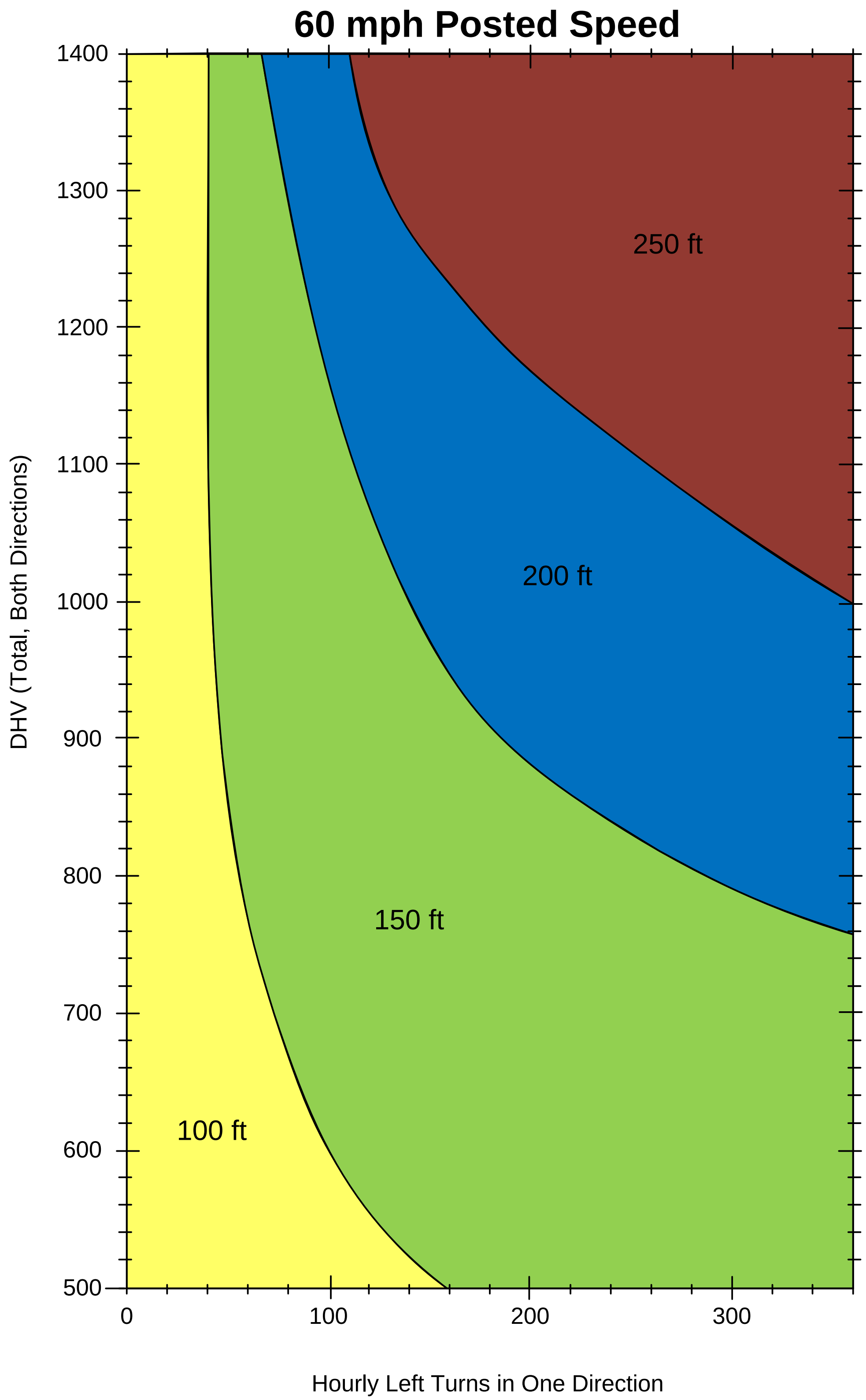


Exhibit 1310-9 Left-Turn Storage with Trucks (ft)

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 Exhibits 1310-7b and 1310-8a, 8b, or 8c.

At signalized intersections with high left-turn volumes, double (or triple) left-turn lanes may be needed to maintain the desired level of service. For a double left-turn, a throat width of 30 to 36 feet is desirable on the exit leg of the turn to offset vehicle offtracking and the difficulty of two vehicles turning abreast. Use turn simulation software (such as AutoTURN®) to verify that the design vehicle can complete the turn. Where the design vehicle is a WB 40 or larger, it is desirable to provide for the design vehicle in the outside lane and an SU-30 vehicle turning abreast rather than two design vehicles turning abreast.

Exhibits 1310-10a through 10f show left-turn lane geometrics, which are described as follows:

1310.03(2)(a)(1) Widening

It is desirable that offsets and pavement widening (see Exhibit 1310-10a) be symmetrical about the centerline or baseline. Where right of way or topographic restrictions, crossroad alignments, or other circumstances preclude symmetrical widening, pavement widening may be on one side only.

1310.03(2)(a)(2) Divided Highways

Widening is not needed for left-turn lane channelization where medians are 11 feet wide or wider (see Exhibits 1310-10b through 10d). For medians between 13 feet and 23 feet or where the acceleration lane is not provided, it is desirable to design the left-turn lane adjacent to the opposing lane (see Exhibit 1310-10b) to improve sight distance and increase opposing left-turn clearances.

A median acceleration lane (see Exhibits 1310-10c and 10d) may be provided where the median is 23 feet or wider. The median acceleration lane might not be needed at a signalized intersection. When a median acceleration lane is to be used, design it in accordance with 1310.03(4), Speed Change Lanes. Where medians have sufficient width, provide a 2-foot shoulder adjacent to a left-turn lane.

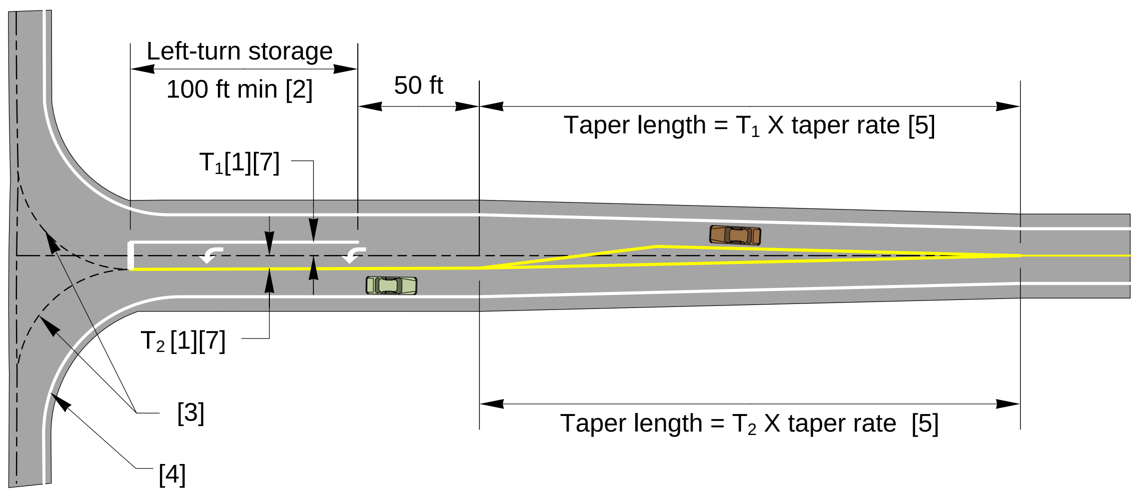
1310.03(2)(a)(3) Minimum Protected Left Turn With a Median

At intersections on divided highways where channelized left-turn lanes are not provided, provide the minimum protected storage area (see Exhibit 1310-10e).

1310.03(2)(a)(4) Modifications to Left-Turn Designs

The left-turn lane designs discussed above and given in Exhibits 1310-10a through 10e may be modified when determined by design element dimensioning (see Chapter 1106.) 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. Provide a modified design that is able to accommodate the design vehicle, and provide for the striping (see the *Standard Plans* and the MUTCD). Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®); include a plot of the design and verification.

Exhibit 1310-10a Median Channelization: Widening



Notes:

[1] The minimum width of the left-turn storage lane (T1+T2) is 11 ft.

[2] For left-turn storage length, see Exhibits 1310-7b for 4-lane roadways or 1310-8a through 8c for 2-lane roadways.

[3] Use turn simulation software (such as AutoTURN®) to verify the design vehicle can make the turn.

[4] For right-turn corner design, see Exhibit 1310-6.

[5] For desirable taper rates, see Table on this Exhibit. With justification, taper rates from the Table in Exhibit 1310-10c may be used.

[6] For pavement marking details, see the *Standard Plans* and the MUTCD.

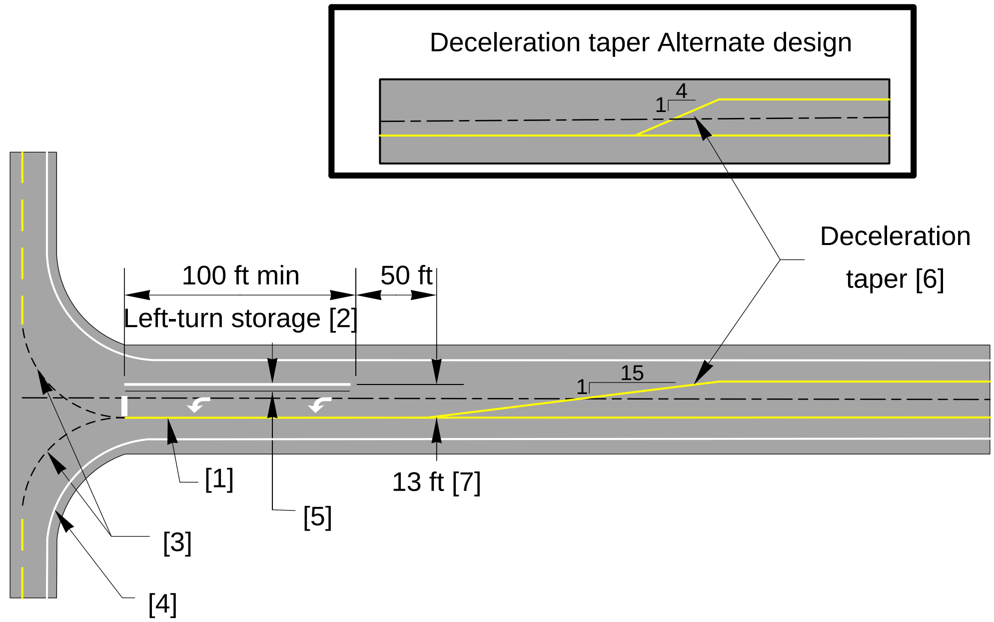
[7] Where curb is provided, add the width of the curb and the shoulders to the left-turn lane width. For shoulder widths at curbs, see 1310.03(6) and Chapter 1230.

T_1 = Width of left-turn lane on approach side of centerline

T_2 = Width of left-turn lane on departure side of centerline

Posted Speed	Desirable Taper Rate [6]
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

Exhibit 1310-10b Median Channelization: Median Width 11 ft or More



Notes:

[1] Where curb is provided, add the width of the curb and the shoulders. For shoulder widths at curbs, see 1310.03(6) and Chapter 1230.

[2] For left-turn storage length, see Exhibits 1310-7b for 4-lane roadways or 1310-8a through 8c for 2-lane roadways.

[3] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[4] For right-turn corner design, see Exhibit 1310-6.

[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.

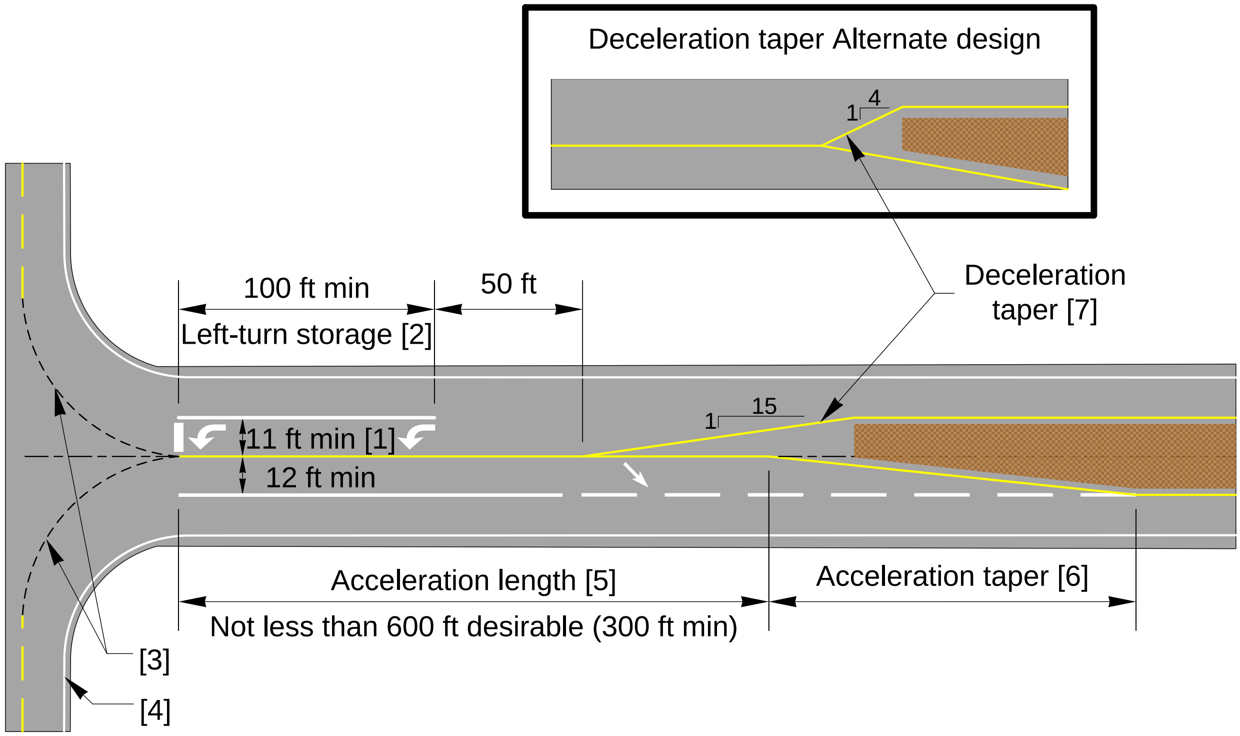
[6] For increased storage capacity, the left-turn deceleration taper alternate design may be used.

[7] Reduce to lane width for medians less than 13 ft wide.

General:

For pavement marking details, see the *Standard Plans* and the MUTCD.

Exhibit 1310-10c Median Channelization: Median Width 23 ft to 26 ft



Notes:

[1] When curb is provided, add the width of the curb.

[2] For left-turn storage length, see Exhibits 1310 7b for 4-lane roadways or 1310-8a through 8c for 2-lane roadways.

[3] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[4] For right-turn corner design, see Exhibit 1310 6.

[5] The minimum total length of the median acceleration lane is shown in Exhibit 1310-14.

[6] For acceleration taper rate, see Table on this exhibit.

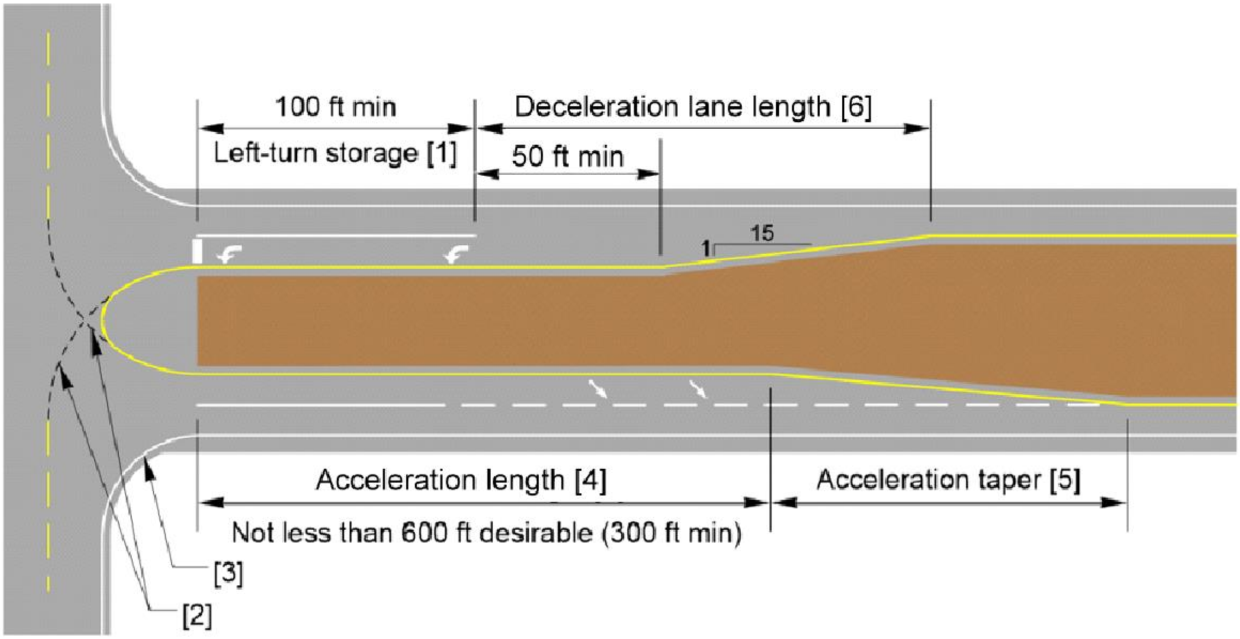
[7] For increased storage capacity, the left-turn deceleration taper alternate design may be used.

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

General:

For pavement marking details, see the *Standard Plans* and the MUTCD.

Exhibit 1310-10d Median Channelization: Median Width of More Than 26 ft



Notes:

[1] For left-turn storage length, see Exhibits 1310-7b for 4-lane roadways or 1310-8a through 8c for 2 lane roadways.

[2] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[3] For right-turn corner design, see Exhibit 1310-6.

[4] The minimum length of the median acceleration lane is shown in Exhibit 1310-14.

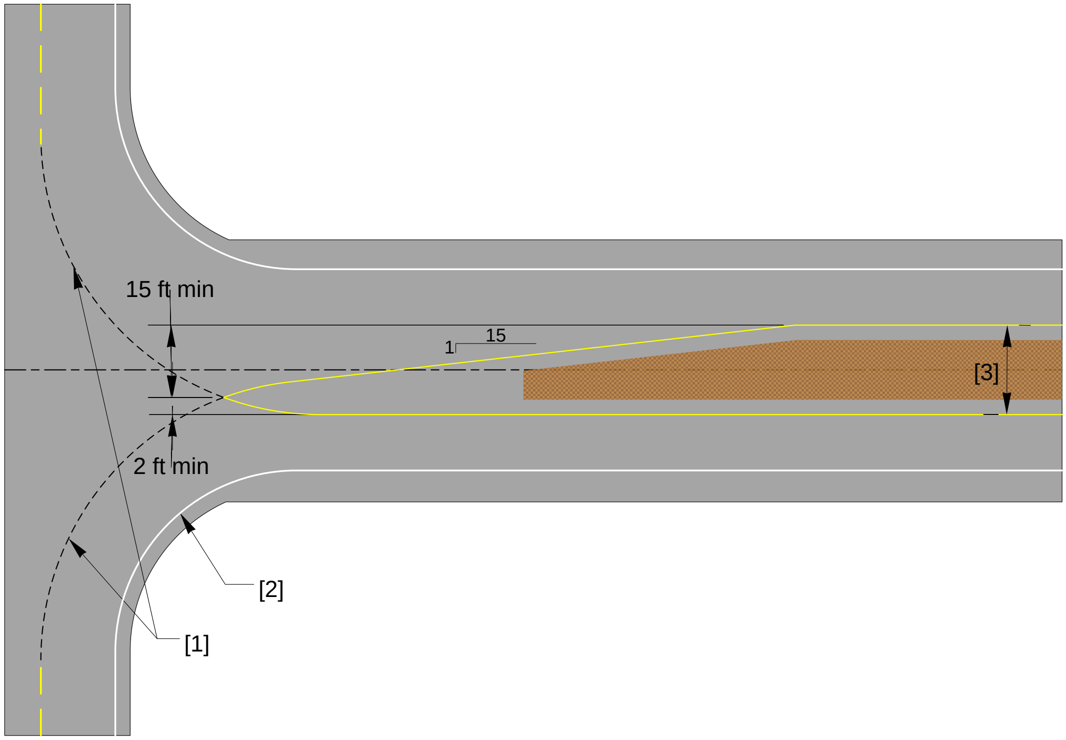
[5] For acceleration taper rate, see the Table on Exhibit 1310-10c.

[6] The desirable length of the left-turn deceleration lane including taper is shown in Exhibit 1310-13.

General:

For pavement marking details, see the *Standard Plans* and the MUTCD.

Exhibit 1310-10e Median Channelization: Minimum Protected Storage



Notes:

[1] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[2] For right-turn corner design, see Exhibit 1310-6.

[3] For median width 17 ft or more. For median width less than 17 ft, widen to 17 ft. or use Exhibit 1310-10b.

General:

For pavement marking details, see the *Standard Plans* and the MUTCD.

1310.03(2)(b) Two-Way Left-Turn Lanes (TWLTL)

Two-way left-turn lanes are located between opposing lanes of traffic. They are used by vehicles making left turns from either direction, from or onto the roadway.

Use TWLTLs only on managed access highways where there are no more than two through lanes in each direction. Evaluate installation of TWLTLs where:

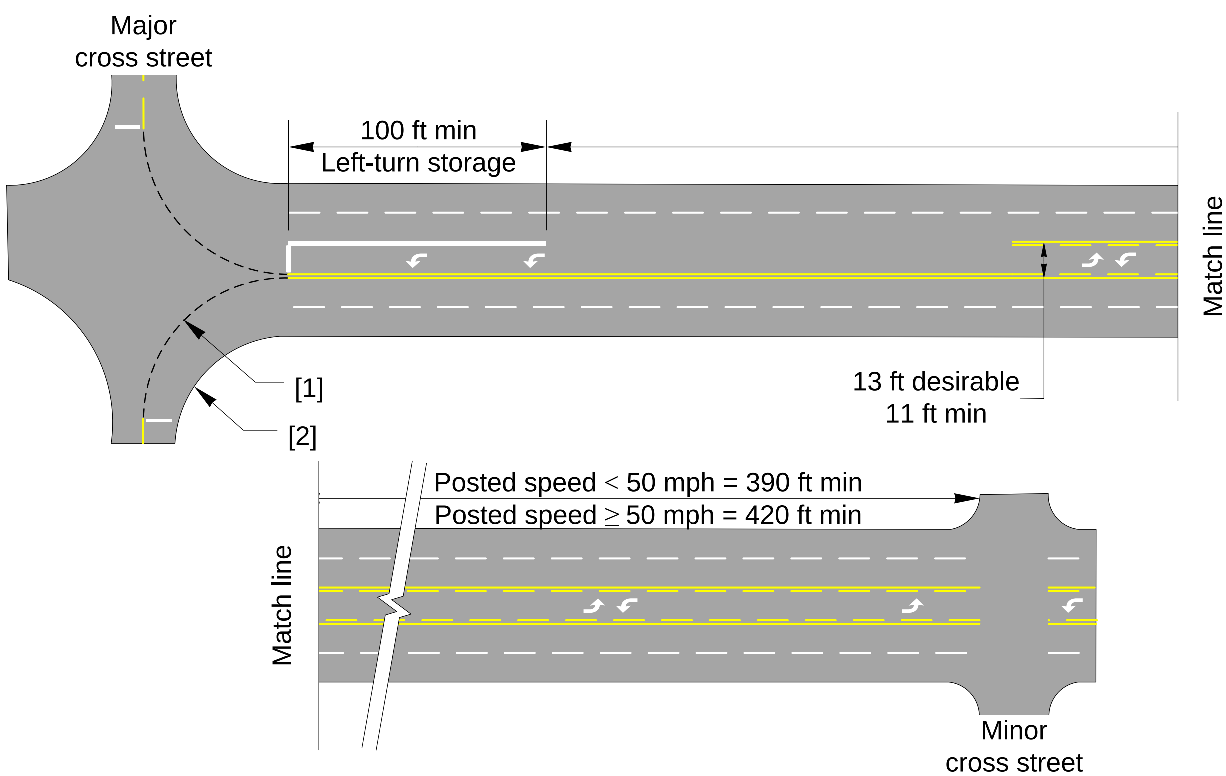
- A crash study indicates reduced crashes with a TWLTL.
- There are existing closely spaced access points or minor street intersections.
- There are unacceptable through traffic delays or capacity reductions because of left-turning vehicles.

TWLTLs can reduce delays to through traffic, reduce rear-end crashes, and provide separation between opposing lanes of traffic. However, they do not provide refuge for pedestrians and can encourage strip development with additional closely spaced access points. Evaluate other alternatives (such as prohibiting midblock left turns and providing for U-turns) before using a TWLTL. (See Chapter 540 for additional restrictions on the use of TWLTLs, and Chapter 1230 for discussion of road diets, which commonly employ a center turn lane.)

The basic design for a TWLTL is illustrated in Exhibit 1310-10f. Additional criteria are as follows:

- The desirable length of a TWLTL is not less than 250 feet.
- Provide illumination in accordance with the guidelines in Chapter 1040.
- 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 TWLTLs to one-way left-turn lanes at an intersection.

Exhibit 1310-10f Median Channelization: Two-Way Left-Turn Lane



Notes:

[1] Verify the design vehicle can make the turn using turn simulation software (such as AutoTURN®).

[2] For right-turn corner design, see Exhibit 1310-6.

General:

For pavement marking details and signing criteria, see the *Standard Plans* and the MUTCD.

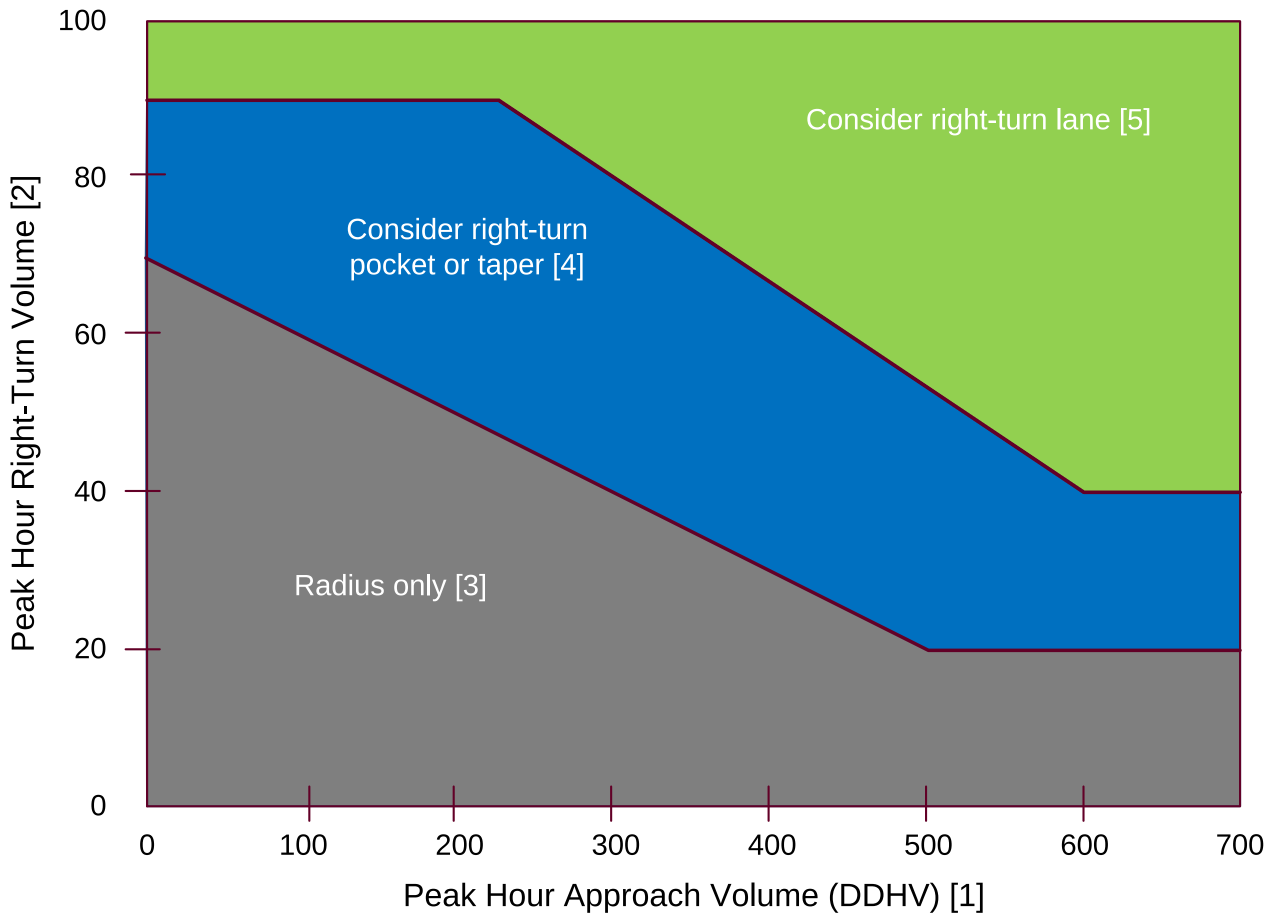
1310.03(3) Right-Turn Lanes

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 to determine when to consider right-turn lanes at unsignalized intersections:

- For two-lane roadways and for multilane roadways with a posted speed of 45 mph or above, when recommended by Exhibit 1310-11.

- A crash study indicates an overall crash reduction with a right-turn lane.
- The presence of pedestrians requires right-turning vehicles to stop.
- Restrictive geometrics require right-turning vehicles to slow greatly below the speed of the through traffic.
- There is less than decision sight distance for traffic approaching the intersection.
- For unsignalized intersections, see 1310.03(4) for guidance on right-turn lane lengths. For signalized intersections, use a traffic signal analysis to determine whether a right-turn lane is needed and what the length is (see Chapter 1330).
- A capacity analysis may be used to determine whether right-turn lanes are needed to maintain the desired level of service.
- Where adequate right of way exists, providing right-turn lanes is relatively inexpensive and can provide increased operational efficiency.
- The right-turn pocket or the right-turn taper (see Exhibit 1310-12) may be used at any minor intersection where a right-turn lane is not provided. These designs reduce interference and delay to the through movement by offering an earlier exit to right-turning vehicles.
- If the right-turn pocket is used, Exhibit 1310-12 shows taper lengths for various posted speeds.

Exhibit 1310-11 Right-Turn Lane Guidelines



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:

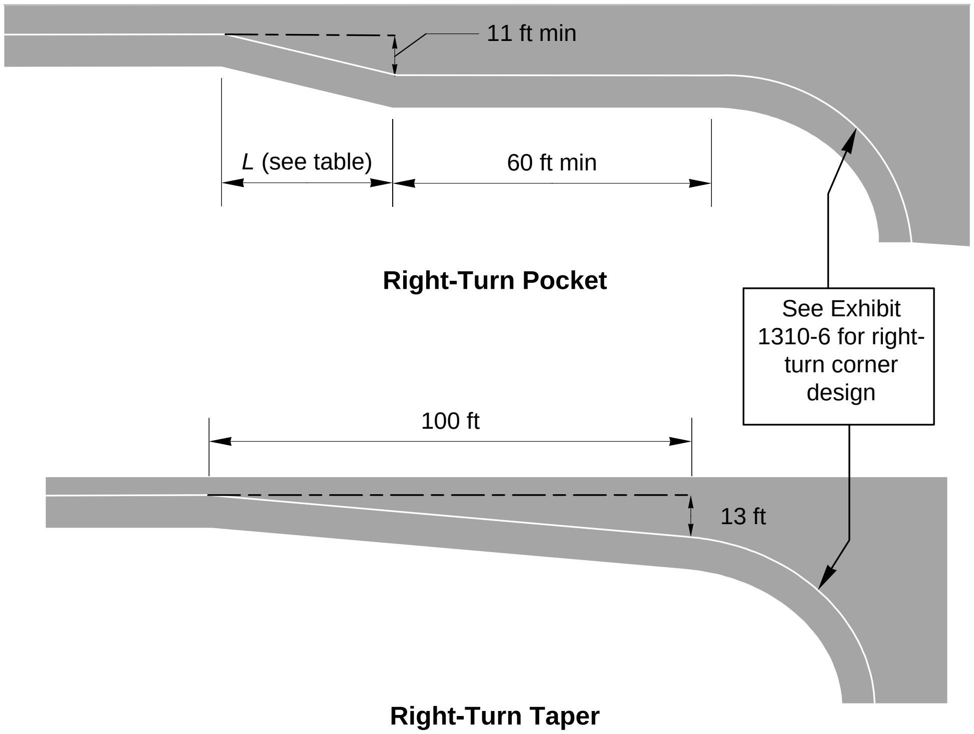
- The posted speed is 45 mph or below
- The right-turn volume is greater than 40 VPH
- The peak hour approach volume (DDHV) is less than 300 VPH

[3] For right-turn corner design, see Exhibit 1310-6.

[4] For right-turn pocket or taper design, see Exhibit 1310-12.

[5] For right-turn lane design, see Exhibit 1310-13.

Exhibit 1310-12 Right-Turn Pocket and Right-Turn Taper



Posted Speed Limit	*L*
Below 40 mph	40 ft
40 mph or above	100 ft

1310.03(4) Speed Change Lanes

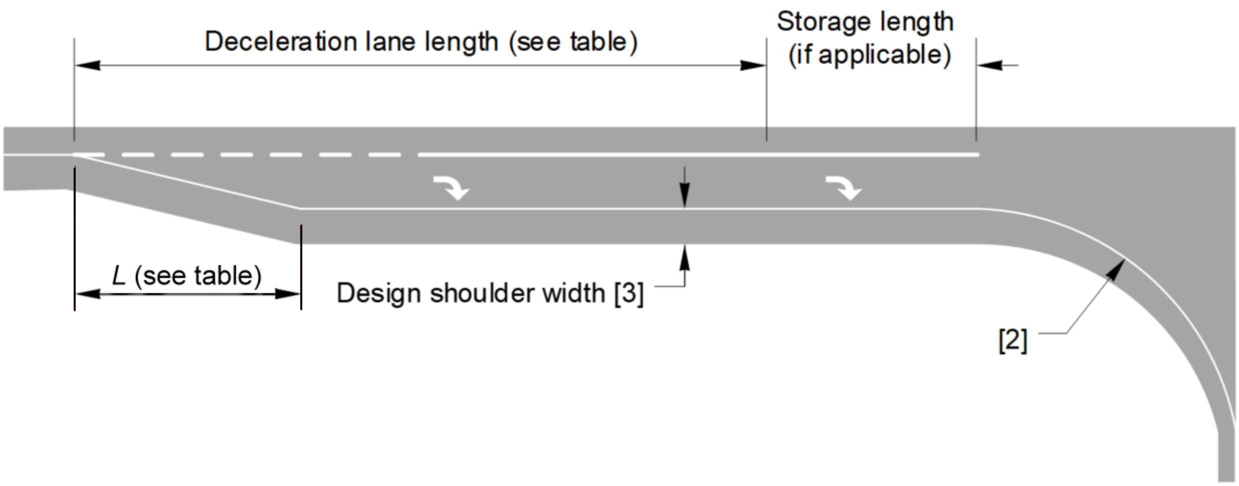
A speed change lane is an auxiliary lane primarily for the acceleration or deceleration of vehicles entering or leaving the through traveled way. Speed change lanes are normally provided for at-grade intersections on multilane divided highways with access control. Where roadside conditions and right of way allow, speed change lanes may be provided on other through roadways. Justification for a speed change lane depends on many factors, including speed; traffic volumes; capacity; type of highway; design and frequency of intersections and crash history

When either deceleration or acceleration lanes are to be used, design them in accordance with Exhibits 1310-13 and 1310-14. 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 1360. When a deceleration lane is used with a left-turn lane, add the deceleration length to the storage length.

A dedicated deceleration lane (see Exhibit 1310-13) is advantageous because it removes slowing vehicles from the through lane.

An acceleration lane (see Exhibit 1310-14) is not as advantageous because entering drivers can wait for an opportunity to merge without disrupting through traffic. However, acceleration lanes for left-turning vehicles provide a benefit by allowing the turn to be made in two movements.

Exhibit 1310-13 Right-Turn Lane



Highway Design Speed (mph)	Deceleration Lane Length (ft)
30	160 [1]
35	220
40	275
45	350
50	425
55	515
60	605
65	715
70	820

Minimum Deceleration Lane Length (ft)

Posted Speed Limit	*L*
Below 40 mph	40 ft
40 mph or above	100 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] When adjusting for grade, do not reduce the deceleration lane to less than 150 ft.

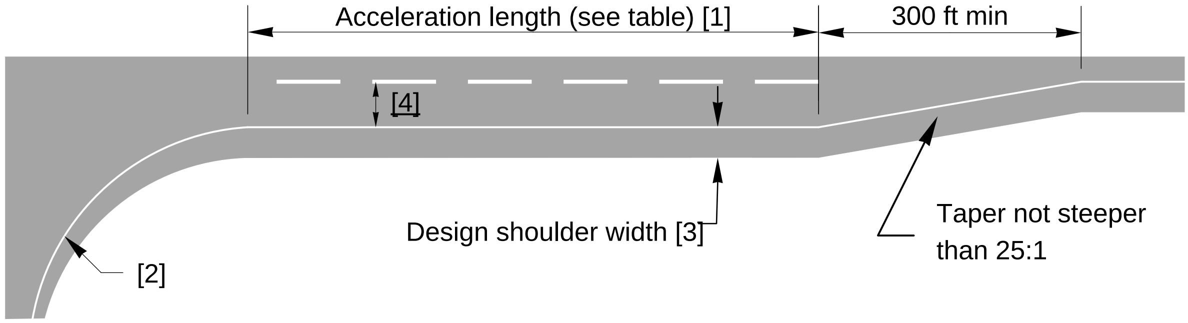
[2] For right-turn corner design, see Exhibit 1310-6.

[3] See 1310.03(6) and Chapter 1230.

General:

For pavement marking details, see the *Standard Plans* and the MUTCD.

Exhibit 1310-14 Acceleration Lane



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	1,200	1,140	1,100
65	1,410	1,350	1,310
70	1,620	1,560	1,520

Minimum Acceleration 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] For right-turn corner design, see Exhibit 1310-6.

[3] See 1310.03(6) and Chapter 1230.

[4] Lane width as determined by Chapters 1106 and 1230.

General:

For pavement-marking details, see the *Standard Plans* and the MUTCD.

1310.03(5) Drop Lanes

A lane may be dropped at an intersection with a turn-only lane or beyond the intersection. Do not allow a lane-reduction taper to cross an intersection or end less than 100 feet before an intersection. (See Chapter 1210 for lane reduction pavement transitions.)

When a lane is dropped beyond signalized intersections, 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 1,500 feet. For facilities with a posted speed lower than 45 mph, provide a lane of sufficient length that the advanced lane reduction warning sign can be placed not less than 100 feet beyond the intersection area.

When a lane is dropped beyond unsignalized intersections, provide a lane beyond the intersection not less than the acceleration lane length from Exhibit 1310-14.

1310.03(6) Shoulders

Shoulder width is controlled by its intended functional use and its contribution to achieving the desired safety performance when balanced with other design elements. See Chapter 1230 for functional uses and recommended shoulder widths.

Reducing the shoulder width at intersections facilitates the installation of turn lanes without unduly affecting the overall width of the roadway. A narrower roadway also reduces pedestrian exposure in crosswalks and discourages motorists from using the shoulder to bypass other turning traffic.

1310.03(7) 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 the following functions:

- Channelization islands control and direct traffic movements.
- Divisional islands separate traffic movements.
- Refuge islands provide refuge for pedestrians and bicyclists crossing the roadway.
- Islands can provide for the placement of traffic control devices and luminaires.
- Islands can provide areas within the roadway for landscaping.

1310.03(7)(a) Size and Shape

Divisional islands are normally elongated and at least 4 feet wide and 20 feet long.

Channelization islands are normally triangular. In rural areas, 75 ft2 is the minimum island area and 100 ft2 is desirable. In urban areas where posted speeds are 25 mph or below, smaller islands are acceptable. Use islands with at least 200 ft2 if pedestrians will be crossing or traffic control devices or luminaires will be installed.

Design triangular-shaped islands as shown in Exhibits 1310-15a through 15c. The shoulder and offset widths illustrated are for islands with vertical curbs 6 inches or higher. Where painted islands are used, such as in rural areas, these widths are desirable but may be omitted. (See Chapter 1240 for desirable turning roadway widths.)

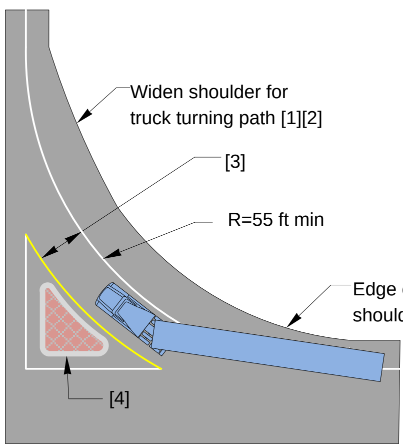
Island markings may be supplemented with reflective raised pavement markers.

Provide barrier-free access at crosswalk locations where raised islands are used. For pedestrian refuge islands and barrier-free access requirements, see Chapter 1510.

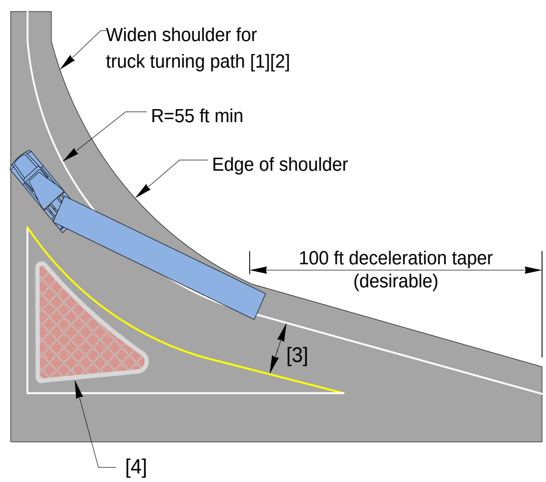
1310.03(7)(b) Location

Design the approach ends of islands so they are visible to motorists. 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 sight distance, illumination, or extension of the island.

Exhibit 1310-15a Traffic Island Designs



Small Traffic Island Design [5]



Large Traffic Island Design [5]

Notes:

[1] Widen shoulders when 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 turn simulation software (such as AutoTURN®) for the intersection design vehicle

[3] For turning roadway widths, see Chapter 1240.

[4] For additional details on island placement, see Exhibit 1310-15c.

[5] Small traffic islands have an area of 100 ft2 or less; large traffic islands have an area greater than 100 ft2.

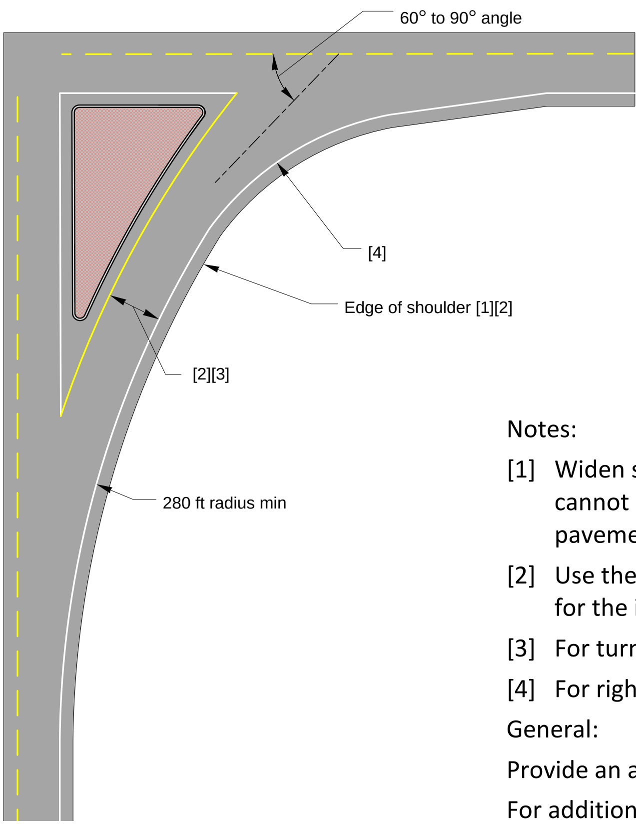
General:

- Provide an accessible route for pedestrians (see Chapter 1510).
- 60° to 90° angle at stop or yield control.
- For right-turn corner design, see Exhibit 1310-6.

1310.03(7)(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 (see Exhibit 1310-15b). This design forces the turning traffic to slow down.

Exhibit 1310-15b Traffic Island Designs: Compound Curve



Notes:

[1] Widen shoulders when 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 turn simulation software (such as AutoTURN®) for the intersection design vehicle.

[3] For turning roadway widths, see Chapter 1240.

[4] For right-turn corner design, see Exhibit 1310-6.

General:

Provide an accessible route for pedestrians (see Chapter 1510).

For additional details on island placement, see Exhibit 1310-15c.

1310.03(7)(d) Curbing

Provide vertical curb 6 inches or higher for:

- Islands with luminaires, signals, or other traffic control devices.
- Pedestrian refuge islands.

Also consider curbing for:

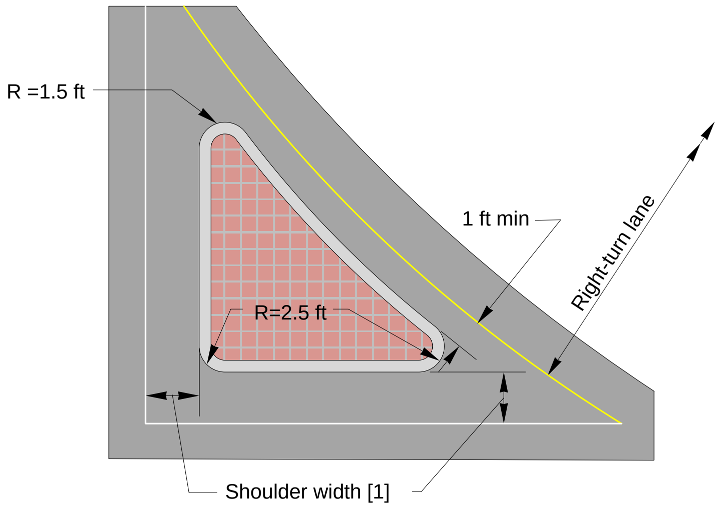
- Divisional and channelizing islands.
- Landscaped islands.
- Stormwater conveyance.

In general, except to meet one of the uses listed above, it is desirable not to use curbs on facilities with a posted speed of 45 mph or above.

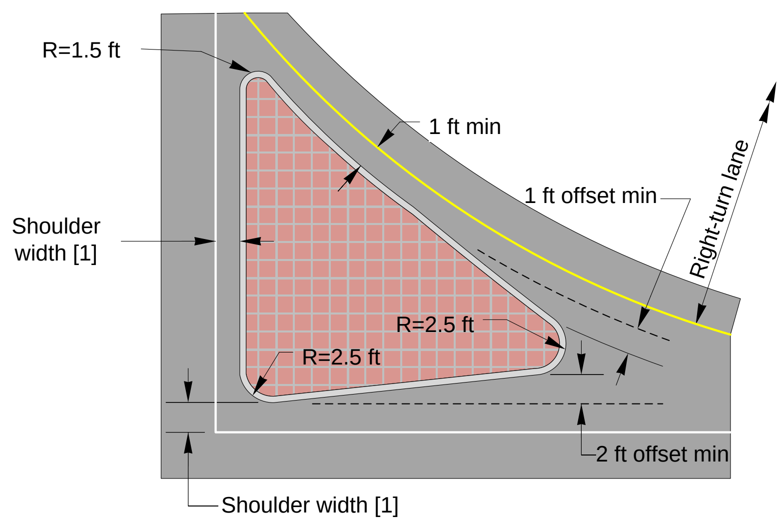
Avoid using curbs if the same objective can be attained with pavement markings.

Refer to Chapter 1230 for additional information and design criteria on the use of curbs.

Exhibit 1310-15c Traffic Island Designs



Small Raised Traffic Island [2]



Large Raised Traffic Island [2]

Notes:

[1] For shoulder width at curbs, see Chapter 1230. For additional information on shoulders at turn lanes, see 1310.03(6).

[2] Small traffic islands have an area of 100 ft2 or less; large traffic islands have an area greater than 100 ft2.

General:

Provide an accessible route for pedestrians (see Chapter 1510).

1310.04 U-Turns

For divided multilane highways without full access control that have access points where the median prevents left turns, evaluate the demand for locations that allow U turns. Normally, U turn opportunities are provided at intersections. However, where intersections are spaced far apart, U-turn median openings may be provided between intersections to accommodate U-turns. Use the desirable U-turn spacing (see Exhibit 1310-16) as a guide to determine when to provide U-turn median openings between intersections. Where the U-turning volumes are low, longer spacing may be used.

Locate U-turn median openings where intersection sight distance can be provided.

Exhibit 1310-16 U-Turn Spacing

Urban/Rural	Desirable	Minimum
Urban [1]	1,000 ft	[2]
Suburban	½ mile	¼ mile [3]
Rural	1 mile	½ mile

Notes:

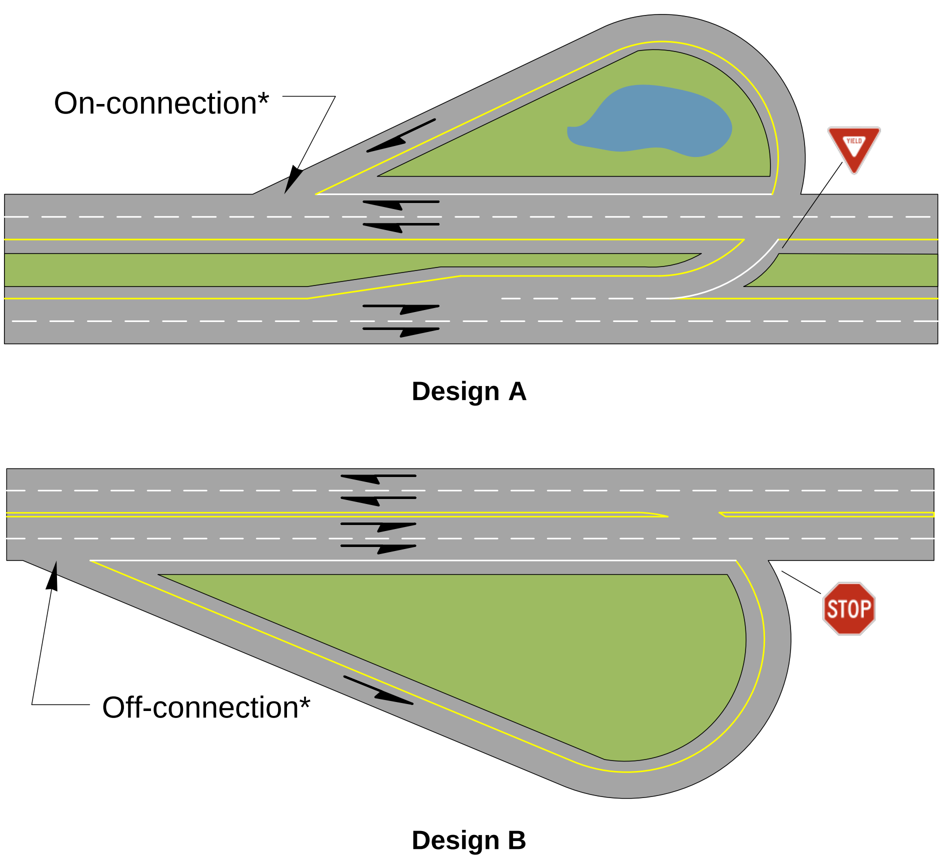
[1] For design speeds higher than 45 mph, use suburban spacing.

[2] The minimum spacing is the acceleration lane length from a stop (see Exhibit 1310-14) plus 300 ft.

[3] For design speeds 60 mph or higher, the minimum spacing is the acceleration lane length from a stop (see Exhibit 1310-14) plus 300 ft.

When designing U-turn median openings, use Exhibit 1310-18 as a guide. Where the median is less than 40 feet wide, with a large design vehicle, provide a U-turn roadway (see Exhibit 1310-17). Design A, with the U-turn roadway after the left-turn, is desirable. Use Design A when the median can accommodate a left-turn lane. Use Design B only where left-turn channelization cannot be built in the median.

Exhibit 1310-17 U-Turn Roadway

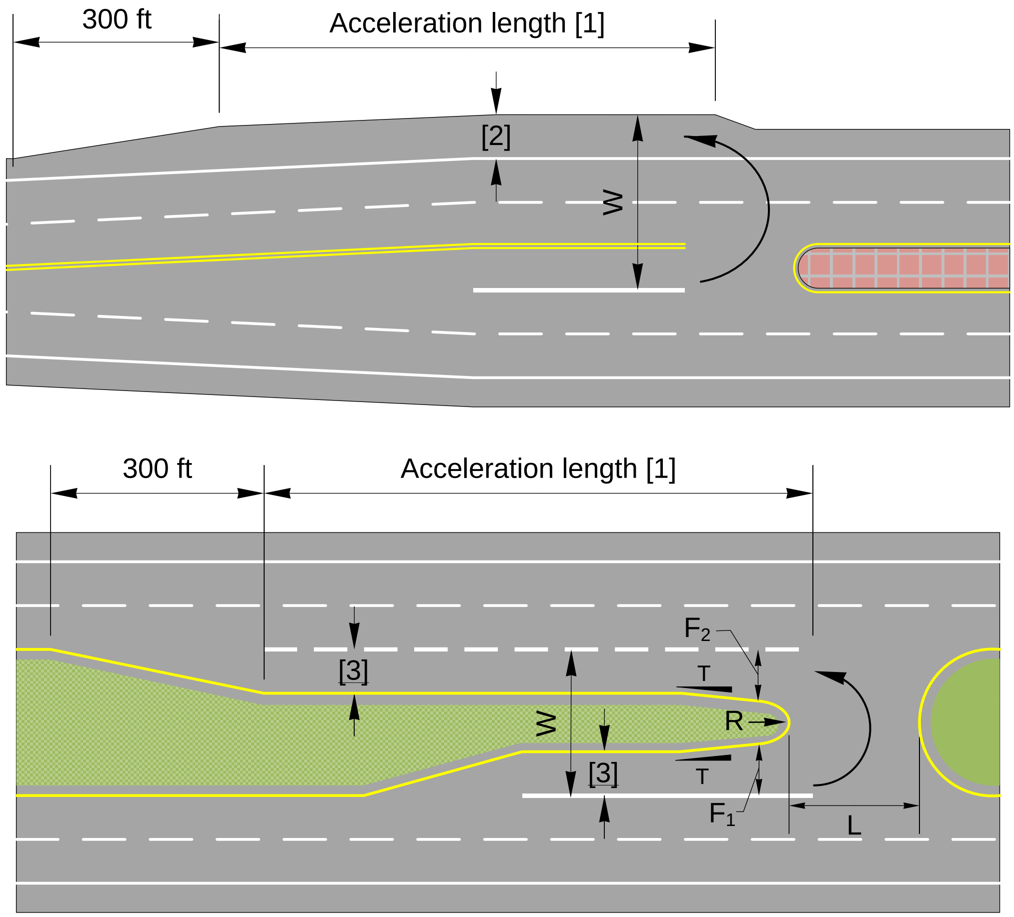


*Design on- and off-connections in accordance with Chapter 1360.

Document the need for U-turn locations, the spacing used, and the selected design vehicle. If the design vehicle is smaller than the largest vehicle using the facility, provide an alternate route.

U-turns at signal-controlled intersections do not need the acceleration lanes shown in Exhibit 1310-18. For new U-turn locations at signal-controlled intersections, evaluate conflicts between right-turning vehicles from side streets and U-turning vehicles. Warning signs on the cross street might be appropriate.

Exhibit 1310-18 U-Turn Median Openings



Vehicle	W	R	L	F_1	F_2	T
P	52	14	14	12	12	—
SU-30	87	30	20	13	15	10:1
CITY-BUS	87	28	23	14	18	10:1
WB-40	84	25	27	15	20	6:1
WB-67	94	22	49	15	35	6:1

U-Turn Design Dimensions

Notes:

[1] The minimum length of the acceleration lane is shown in Exhibit 1310-14. Acceleration lane may be eliminated at signal-controlled intersections.

[2] When U-turn uses the shoulder, provide shoulder width sufficient for the intersection design vehicle to make the turn and shoulder pavement designed to the same depth as the through lanes for the acceleration length and taper.

[3] Lane width as determined by Chapters 1106 and 1230.

General: All dimensions are in feet.

1310.05 Intersection Sight Distance

Providing drivers the ability to see stop signs, traffic signals, and oncoming traffic in time to react accordingly will reduce the probability of conflicts occurring at an intersection. Actually avoiding conflicts is dependent on the judgment, abilities, and actions of all drivers using the intersection.

The driver of a vehicle that is stopped and waiting to cross or enter a through roadway needs obstruction-free sight triangles in order to see enough of the through roadway to complete all legal maneuvers before an approaching vehicle on the through roadway can reach the intersection. Use Exhibit 1310-19a to determine minimum intersection sight distance along the through roadway.

The sight triangle is determined as shown in Exhibit 1310-19b. Within the sight triangle, lay back the cut slopes and remove, lower, or move hedges, trees, signs, utility poles, signal poles, and anything else large enough to be a sight obstruction. Eliminate parking to remove obstructions to sight distance. In order to maintain the sight distance, the sight triangle must be within the right of way or a state maintenance easement (see Chapter 510).

The setback distance for the sight triangle is 18 feet from the edge of traveled way. This is for a vehicle stopped 10 feet from the edge of traveled way. The driver is almost always 8 feet or less from the front of the vehicle; therefore, 8 feet are added to the setback. When the stop bar is placed more than 10 feet from the edge of traveled way, providing the sight triangle to a point 8 feet back of the stop bar is desirable.

Provide a clear sight triangle for a P vehicle at all intersections. In addition, provide a clear sight triangle for the SU-30 vehicle for rural highway conditions. If there is significant combination truck traffic, use the WB-67 rather than the SU-30. In areas where SU-30 or WB vehicles are minimal and right of way restrictions limit sight triangle clearing, only the P vehicle sight distance needs to be provided.

At existing intersections, when sight obstructions within the sight triangle cannot be removed due to limited right of way, the intersection sight distance may be modified. Drivers who do not have the desired sight distance creep out until the sight distance is available; therefore, the setback may be reduced to 10 feet. Document the right of way width and provide a brief analysis of the intersection sight distance clarifying the reasons for reduction. Verify and document that there is no identified crash trend at the intersection. Document the intersection location and the available sight distance as a Design Analysis.

If the intersection sight distance cannot be provided using the reductions in the preceding paragraph, where stopping sight distance is provided for the major roadway, the intersection sight distance, at the 10-foot setback point, may be reduced to the stopping sight distance for the major roadway, with a Design Analysis and HQ Design Office review and concurrence. (See Chapter 1260 for required stopping sight distance.) Document the right of way width and provide a brief analysis of the intersection sight distance clarifying the reasons for reduction. Verify and document that there is no identified crash trend at the intersection. Document the intersection location and the available sight distance as a Design Analysis.

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, intersection sight distance can be restored through the periodically scheduled maintenance of vegetation in the sight triangle within the WSDOT right of way or state maintenance easement.

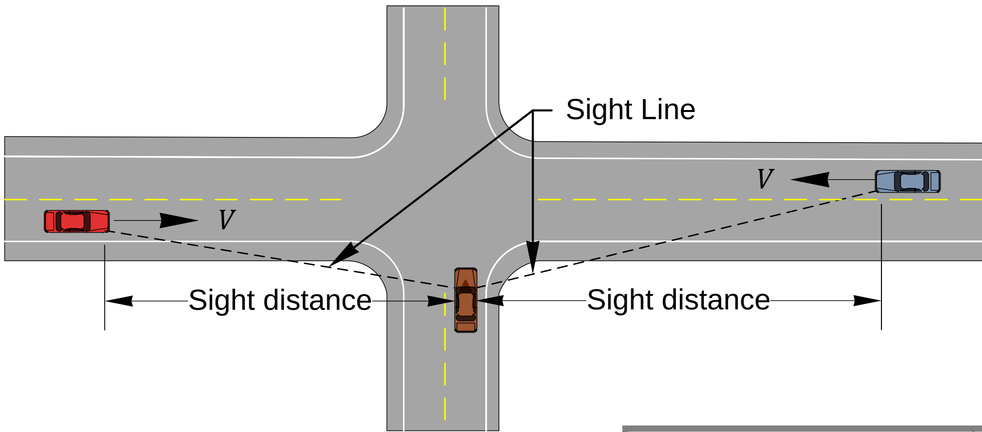
At intersections controlled by traffic signals, provide sight distance for right-turning vehicles. For intersections controlled by the geometry of roundabouts, see Chapter 1320.

Designs for movements that cross divided highways are influenced by median widths. If the median is wide enough to store the design vehicle, with a 3-foot 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 sight distance for ramp terminals as at-grade intersections with only left- and right-turning movements. An added element at ramp terminals is the grade separation structure. Exhibit 1310-19b gives the sight distance guidance 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 feet and an object height of 1.5 feet.

Document a brief description of the intersection area, sight distance restrictions, and traffic characteristics to support the design vehicle and sight distances chosen.

Exhibit 1310-19a Sight Distance at Intersections



$S_i = 1.47Vt_g$
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 (sec)

Intersection Sight Distance Equation
Table 1

Design Vehicle	Time Gap (t_g) in Sec
Passenger car (P)	7.5
Single-unit trucks and buses (SU-30 & CITY-BUS)	9.5
Combination trucks (WB-40 & WB-67)	11.5
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.	

Intersection Sight Distance Time Gaps (t_g)
Table 2

Notes:

Adjust the tg values listed in Table 2 as follows:

Crossing or right-turn maneuvers:

All vehicles subtract 1.0 sec

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 sec

All trucks and buses add 0.7 sec

Crossing maneuvers, for each lane in excess of two to be crossed, and for medians wider than 4 ft:

Passenger cars add 0.5 sec

All trucks and buses add 0.7 sec

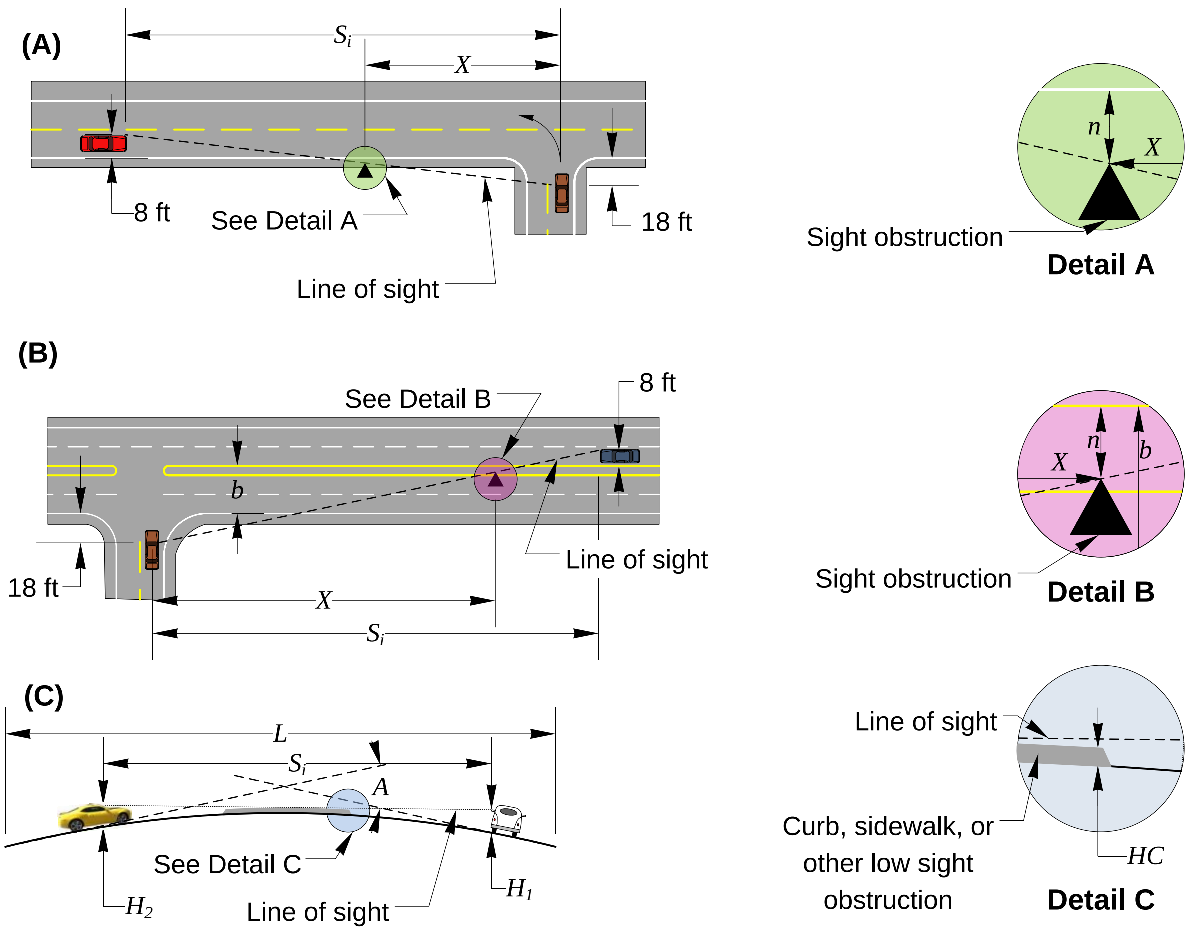
Where medians are wide enough to store the design vehicle, determine the sight distance as two maneuvers.

Crossroad grade greater than 3%:

All movements upgrade for each percent that exceeds 3%:

All vehicles add 0.2 sec

Exhibit 1310-19b Sight Distance at Intersections



For sight obstruction driver cannot see over:

$$S_i = \frac{(26+b)(X)}{(18+b-n)}$$

Where:

S_i = Available intersection sight distance (ft)
n = Offset from sight obstruction to edge of lane (ft)
b = Distance from near edge of traveled way to near edge of lane approaching from right (ft) (b=0 for sight distance to the left)
X = Distance from centerline of lane to sight obstruction (ft)

For crest vertical curve over a low sight obstruction when S<L:

$$S_i = \sqrt{\frac{100L\left[\sqrt{2(H_1-HC)}+\sqrt{2(H_2-HC)}\right]^2}{A}}$$

$$L = \frac{AS_i^2}{100\left[\sqrt{2(H_1-HC)}+\sqrt{2(H_2-HC)}\right]^2}$$

Where:

Si = Available sight distance (ft)
H_1 = Eye height (3.5 ft for passenger cars; 6 ft for all trucks)
H_2 = Approaching vehicle height (3.5 ft)
HC = Sight obstruction height (ft)
L = Vertical curve length (ft)
A = Algebraic difference in grades (%)

1310.06 Signing and Delineation

Use the MUTCD and the *Standard Plans* for signing and delineation criteria. Provide a route confirmation sign on all state routes shortly after major intersections. (See Chapter 1020 for additional information on signing.)

Painted or plastic pavement markings are normally used to delineate travel paths. For pavement marking details, see the MUTCD, Chapter 1030, and the *Standard Plans*.

Contact the region or HQ Traffic Office for additional information when designing signing and pavement markings.

1310.07 Procedures

Document design decisions and conclusions in accordance with Chapter 300. For highways with limited access control, see Chapter 530.

1310.07(1) Approval

An intersection is approved in accordance with Chapter 300. Complete the following items, as needed, before intersection approval:

- Intersection Control Type Approval (see Chapter 1300)
- Design Analyses approved in accordance with Chapter 300
- Approved Traffic Signal Permit (DOT Form 242-014 EF) (see Chapter 1330)

1310.07(2) Intersection Plans

Provide intersection plans for any increases in capacity (turn lanes) at an intersection, modification of channelization, or change of intersection geometrics. Support the need for intersection or channelization modifications with history; school bus and mail route studies; hazardous materials route studies; pedestrian use; public meeting comments; etc.

For information to be included on the intersection plan for approval, see the Intersection/ Channelization Plan for Approval Checklist on the following website:

www.wsdot.wa.gov/design/projectdev/

1310.07(3) Local Agency or Developer-Initiated Intersections

Intersections in local agency and developer projects on state routes must receive the applicable approvals in section 1310.07(1) as part of the intersection design process.

The project initiator submits an intersection plan and the documentation of design decisions that led to the plan to the region for approval. For those plans requiring a Design Analysis, the Design Analysis must be approved in accordance with Chapter 300 prior to approval of the plan. After the plan approval, the region prepares a construction agreement with the project initiator (see the *Utilities Manual*).

1310.08 Documentation

Refer to Chapter 300 for design documentation requirements.

1310.09 References

1310.09(1) Federal/State Laws and Codes

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

Revised Code of Washington (RCW) 35.68.075, Curb ramps for persons with disabilities – Required – Standards and requirements

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

1310.09(2) Design Guidance

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

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

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

1310.09(3) Supporting Information

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

Aspects of Traffic Control Devices, Highway Research Record No. 211, pp 1 18, "Volume Warrants for Left-Turn Storage Lanes at Unsignalized Grade Intersections," Harmelink, M.D.

Guidelines and Recommendations to Accommodate Older Drivers and Pedestrians, FHWA-RD-01-051, USDOT, FHWA, May 2001

Highway Capacity Manual (HCM), Special Report 209, Transportation Research Board, National Research Council

Intersection Channelization Design Guide, NCHRP 279

Chapter 1320 Roundabouts

1320.01 General

Modern roundabouts are near-circular intersections at grade. They are an effective intersection type with fewer conflict points and lower speeds, and they provide for easier decision making than other intersection types. They also require less maintenance than traffic signals. Well-designed roundabouts have been found to reduce crashes (especially fatal and severe injury collisions), traffic delays, fuel consumption, and air pollution. They also have a traffic-calming effect by reducing vehicle speeds using geometric design rather than relying solely on traffic control devices.

Roundabout design is an iterative process.

A well-designed roundabout achieves a balance of safety and efficiency.

Good design is a process of creating the smooth curvature, channelization, and deflection required to achieve consistent speeds, well-marked lane paths, and appropriate sight distance.

Roundabout

The decision to install a roundabout is the result of an Intersection Control Evaluation (ICE) (see Chapter 1300) approved by the region Traffic Engineer or other designated authority.

1320.02 Roundabout Types

There are five basic roundabout types: mini, compact, single-lane, multilane, and teardrop described in the following sections.

1320.02(1) Mini-Roundabouts

Mini-roundabouts are small single-lane roundabouts generally used in 25 mph or less urban/suburban environments. Because of this, mini-roundabouts are typically not suitable for use on higher-volume (greater than 6,000 AADT) state routes. In retrofit applications, mini-roundabouts are relatively inexpensive because they normally require minimal additional pavement at the intersecting roads. A 2-inch mountable curb for the splitter islands and the central island is desirable because larger vehicles might be required to cross over it.

A common application is to replace a stop-controlled or uncontrolled intersection with a mini-roundabout to reduce delay and increase capacity. With mini roundabouts, the existing curb and sidewalk at the intersection can sometimes be left in place.

1320.02(2) Compact Roundabouts

Compact roundabouts are a hybrid of attributes found in mini- and single-lane roundabouts. Similar to a mini-roundabout, a compact roundabout may require minimal additional pavement, has a completely mountable center island, and in many cases existing curb or sidewalk can be left in place. As a result, compact roundabouts rarely require the purchase of right of way. Compact roundabouts are similar to single-lane roundabouts regarding design vehicle assumptions, ability to process traffic volumes, and signing.

1320.02(3) Single-Lane Roundabouts

Single-lane roundabouts have single-lane entries at all legs and one circulating lane. They typically have mountable raised splitter islands, a mountable truck apron, and a landscaped central island.

Single-lane roundabout

1320.02(4) Multilane Roundabouts

Multilane roundabouts have at least one entry or exit with two or more lanes and more than one circulating lane. The operational practice for trucks negotiating roundabouts is to straddle adjacent lanes.

Multilane roundabout

1320.02(5) Teardrop Roundabout

Teardrops are usually associated with ramp terminals at interchanges: typically, at diamond interchanges. Teardrop roundabouts allow the "wide node, narrow link" concept. Unlike circular roundabouts, teardrops do not allow for continuous 360° travel resulting in less vehicle conflicts as traffic traveling on the crossroad (link) between ramp terminal intersections (nodes) does not encounter a yield as it enters the teardrop intersections. At higher ADT locations this lack of conflicting vehicles can result in a higher throughput, but can also result in limited gaps for the off ramp approach. Consult HQ or region Traffic Office for guidance.

1320.03 Capacity Analysis

Use the capacity analysis completed as part of the Intersection Control Evaluation (see Chapter 1300) to verify the number of lanes required for every individual movement in the design year.

1320.04 Geometric Design

1320.04(1) Selecting Shape and Placement

Roundabout shape is an important decision, because the shape can affect design elements that affect safety performance and operation of the roundabout.

1320.04(1)(a) Circular

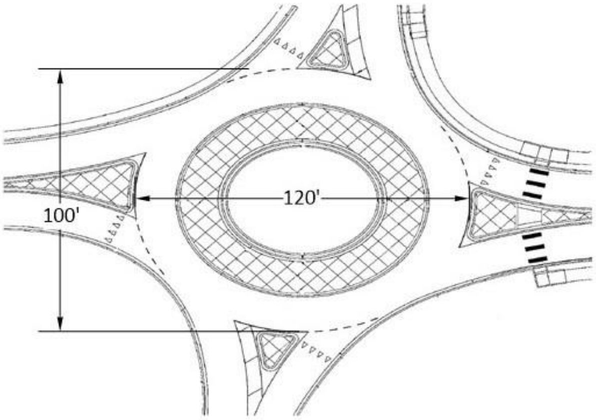
The circular shape is the most desirable roundabout shape when constraints allow. If a circular shape is not feasible, contact the region Traffic Office to investigate other shapes described below. Sometimes a circular shape can be used by slightly offsetting the placement of the roundabout.

Circular shape

1320.04(1)(b) Non-Circular

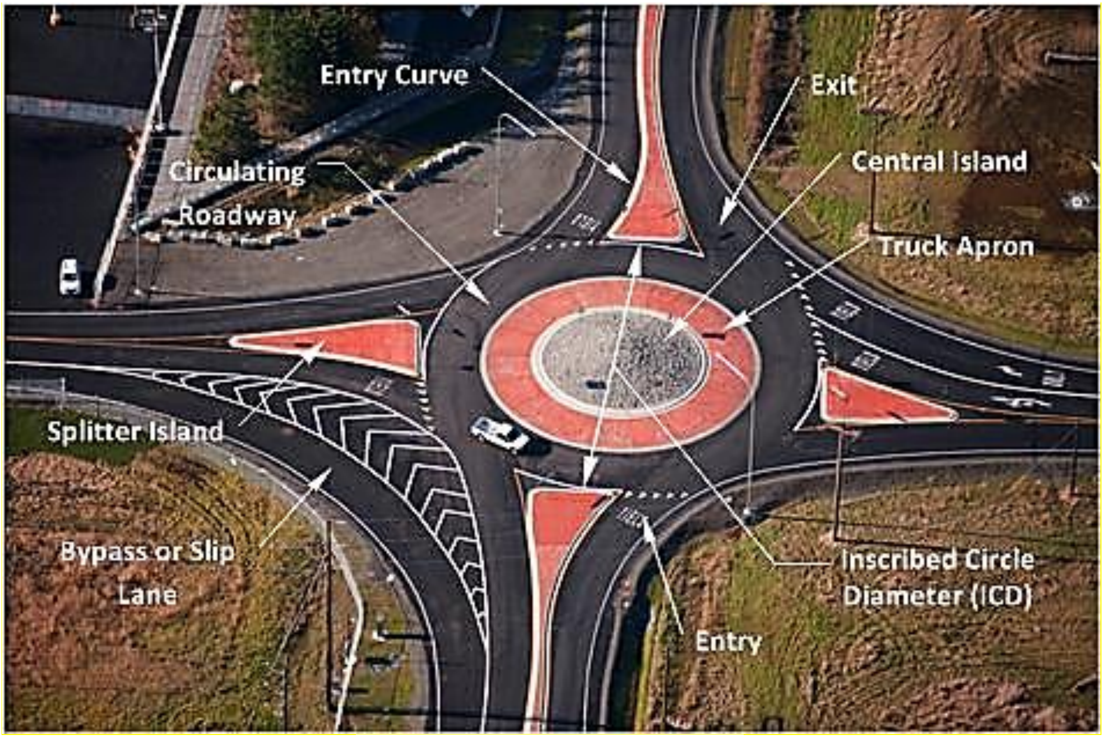
A non-circular roundabout is a good choice when constraints such as right of way, existing roadway alignments, buildings, and/or environmentally sensitive areas influence the shape.

Experiment with different roundabout sizes and radii, and use design vehicle turning software (such as AutoTURN®) to refine the shape to find the best operation while retaining desired speeds.



1320.04(2) Roundabout Design Elements

This section provides guidance for roundabout design elements. The photo below labels many of them.



Roundabout design elements

1320.04(2)(a) Curbing

All curbing within a roundabout should be rolled. The type of rolled curbing appropriate for a roundabout is shown in the Standard Plan Roundabout Cement Concrete Curbs: F-10.18.

Exception: existing curb untouched as part of a mini or compact roundabout installation may remain.

1320.04(2)(b) Truck Apron

A truck apron is the mountable portion of the central island used to accommodate the turning path of a design vehicle larger than a passenger vehicle or BUS, and helps to minimize the overall footprint of the roundabout. Generally, the truck tractor can traverse the roundabout in the circulating lane while the trailer is allowed to off track onto the apron. The apron is raised above the circulating path to provide guidance for drivers in the circulating lane.

A truck apron’s width is based on the needs of the design vehicle. If buses are a consistent vehicle using the intersection try to minimize apron use for all movements, however this is not a requirement. Use turn simulation software (such as AutoTURN®) to fine tune the width of apron needed, so as not to design an apron that won’t be used.

The apron color should be easily distinguishable in contrast with the adjacent circulating roadway and pedestrian facilities. Work with the region Landscape Architect (HQ Roadside and Site Development Section for regions without a Landscape Architect) for concrete color and texture.

Roundabout showing colored truck apron at central island and at buffer area between travel lanes and sidewalk

1320.04(2)(c) Central Island

The central island is the portion of the roundabout that is inside of the circulating roadway and typically includes an inside truck apron and a landscaped area (except for mini-roundabouts and compact roundabouts, which have no landscaped area and are entirely mountable).

Central island shape is a function of the site-specific needs of a roundabout intersection. It doesn’t have to be an identical shape of the inscribed circle diameter (ICD) dimensions, but should support the design principles of deflection and low speeds, and the accommodation of the design vehicle.

Roundabouts present opportunities to create community focal points, landscaping, and other gateway features within an intersection. The central island may include enhancements (such as landscaping, sculptures, or fountains), which serve both an aesthetic purpose and provide visual indication of the intersection for approaching motorists (this is particularly important for high speed approaches). Ideal central island treatments fit the context and result in minimal consequence to any vehicle that may encroach on the non-mountable portion of the central island. These treatments should not attract pedestrians to the central island, as pedestrians should never cross the circulating roadway. Work with the region Landscape Architect (HQ Roadside and Site Development Section for regions without a Landscape Architect) for central island features. See Chapter 950 Public Art for policy and guidance.

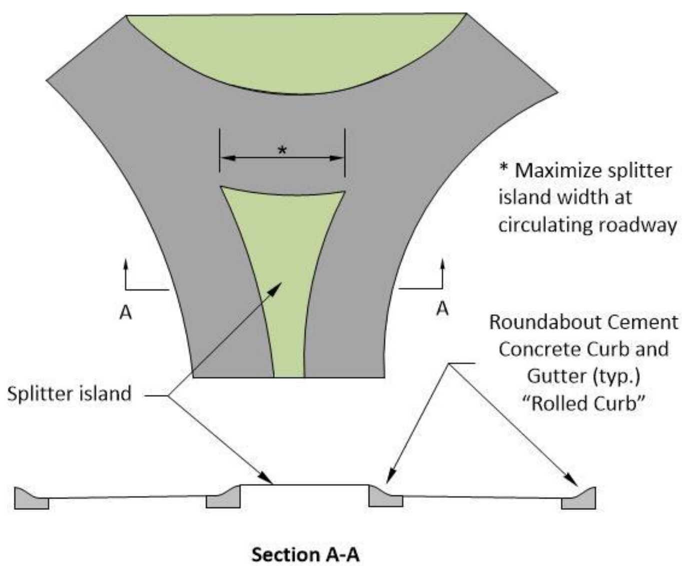
1320.04(2)(d) Splitter Island

A splitter island is the raised island at each two-way leg between entering and exiting vehicles, designed primarily to control the entry and exit speeds by providing deflection. They also discourage wrong-way movements, and provide pedestrian refuge. Splitter islands can have different shapes based on entry angle requirements and exit design speeds.

Raised channelization, or the appearance of raised curbing, is important, as research shows that drivers will slow down when they perceive that the driving width is narrowing.

The length of the splitter island will vary (typical lengths: 30 ft. to 350 ft.) based on the terrain, access considerations, site-specific mainline and crossroad operational speeds and the stepdown speeds to the final desired entry speed, which is usually 15–25 mph. (See 1320.04(3)(a) for using chicanes on higher-speed roadways.)

Try to maximize the splitter island width adjacent to the circulating roadway. The larger achieved width, the better a driver approaching the roundabout can perceive whether a driver in the circulating lane will exit or continue inside the roundabout. This results in better gap acceptance. This may also support a better pedestrian refuge design.



Splitter Island

1320.04(2)(e) Inscribed Circle Diameter (ICD)

The Inscribed Circle Diameter (ICD), that is, the overall outside diameter of a roundabout, is determined by the variables design vehicle, design speed, and the number of circulatory lanes.

The ranges of ICD in Exhibit 1320-1 are only suggestions to start a roundabout design. The ICD for noncircular shapes should be defined with dimensions along the X and Y axis.

Exhibit 1320-1 Suggested Initial Design Ranges

Design Element	Mini [1]	Compact	Single-Lane	Multilane
Number of Lanes	1	1+	1	2+
Inscribed Circle Diameter [2]	45’ – 80’	65’ – 120’	80’ – 150’	120’ – 165’
Circulating Roadway Width	N/A	N/A	14’ – 19’	29’
Entry Widths	N/A	N/A	16’ – 18’	25’

Notes:
The “+” symbol used here means that a portion of the circulating roadway may have more than one lane.
[1] Reserved for urban/suburban intersections with a 25 mph or less posted speed.
[2] The given diameters assume a circular roundabout; adjust accordingly for other shapes. Some conditions may require ICDs outside ranges shown here.

1320.04(2)(f) Entry

1. Deflection

Ideal alignment offers an entry design that provides deflection, speed control, and reasonable view angles to drivers while balancing property impacts and costs. While most intersections are at 90º angles and most through movements are straight, deflection contributes to the safety performance of a roundabout. Deflection is primarily achieved with the central island and supporting it with splitter islands on all entries to the roundabout.

2. Alignment Offset

There are three alignment choices for attaching entry legs to the circulatory roadway:

- The offset left alignment is preferred. It constrains the entry, slowing a vehicle’s approach speed, and opens up the exit for efficient egress.
- The symmetrical alignment (if needed) is acceptable for lower speed contexts such as 30 mph.
- The offset right alignment tends to allow faster entry speeds and constrains the exit; it is undesirable.

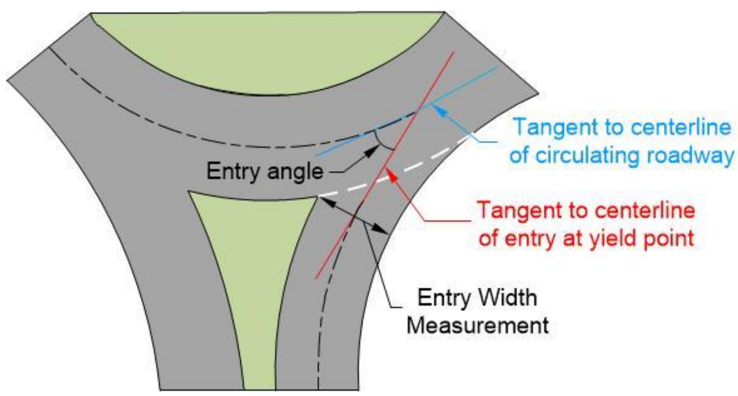
Offset left alignment (preferred)

3. Entry Angle

To achieve the proper amount of deflection for each approach to a roundabout, there is a range of angle values that are desirable. This range is usually between 20 and 40 degrees. The purpose of entry angle is so vehicles don't hit broadside.

4. Entry Width

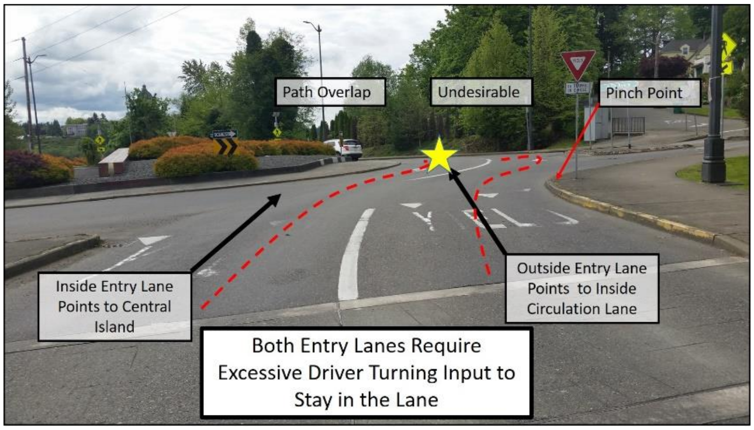
Entry width is determined by the turning template of the design vehicle turning through the entry curve at the desired entry speed. The ranges of entry widths in Exhibit 1320-1 are only suggestions to start a roundabout design.



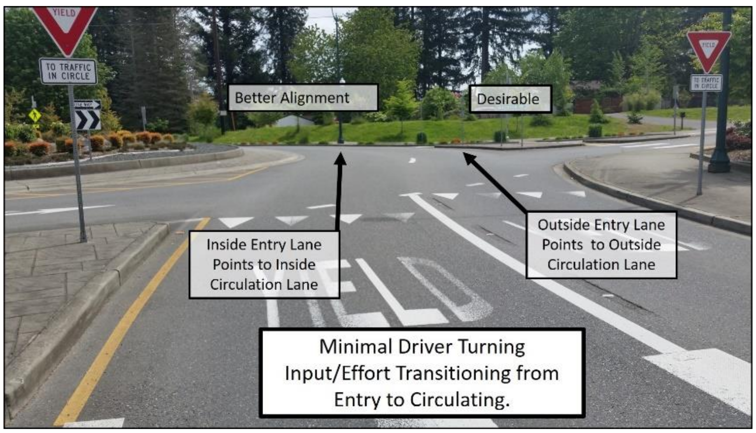
Entry angle and width

5. Path Overlap

In a multilane roundabout, if the vehicles in the entry are aligned toward the central island or the truck apron, the vehicle on the right is pointed toward the inside lane and tends to go in that direction, while the vehicle on the left tends to be squeezed to the right toward the vehicle on the right. Avoid path overlap. Avoid a design that aligns an entering vehicle at the incorrect lane in the circulatory roadway. As a vehicle enters the circulating roadway it should be headed directly toward its respective lane within the circulating roadway. For multilane roundabouts, if inside lane is pointing at truck apron this is also considered to be path overlap. If right entry lane is pointing to left circulatory lane, then there is path overlap.



Path overlap conflict

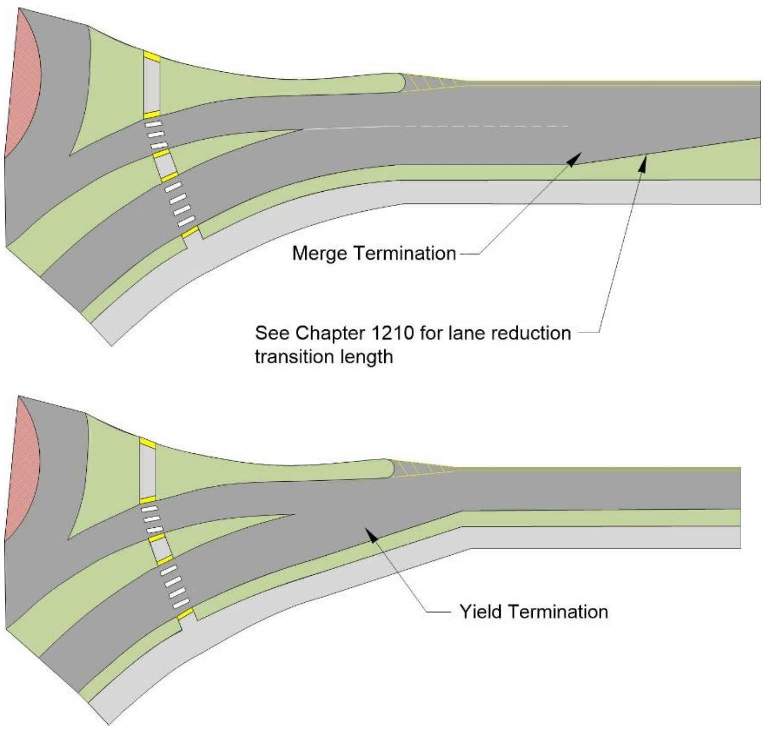


Good path alignment

1320.04(2)(g) Right-Turn Slip Lanes

Right-turn slip lanes are a proven way to increase the “life” of an intersection by removing traffic that would otherwise enter the roundabout and reduce the available capacity to other movements. If a right-turn movement has 250 vehicles/hour or more, or if over 40% of the total approach volume is taking right turns, a slip lane should be considered.

The conflicting volume of vehicles on the merge will influence the length of merge lane prior to termination. Speeds can be very low and vehicles can take turns at these low speeds. Multimodal considerations will influence the length based on crosswalk location and bicycle use.



Right-turn slip lanes showing merge and yield termination

1320.04(3) Speed Control

Roundabout operation performance is dependent on low, consistent vehicle speeds. Low and consistent operating speeds facilitate appropriate gap acceptance by an entering driver. Design for travel path operating speeds between 15 mph and 25 mph (see 1320.04(3)(b)). Design to have low-speed differentials (12 mph or under) between entering and circulating traffic. Multilane roundabouts might have higher speeds along their respective travel paths, but generally 30 mph or less.

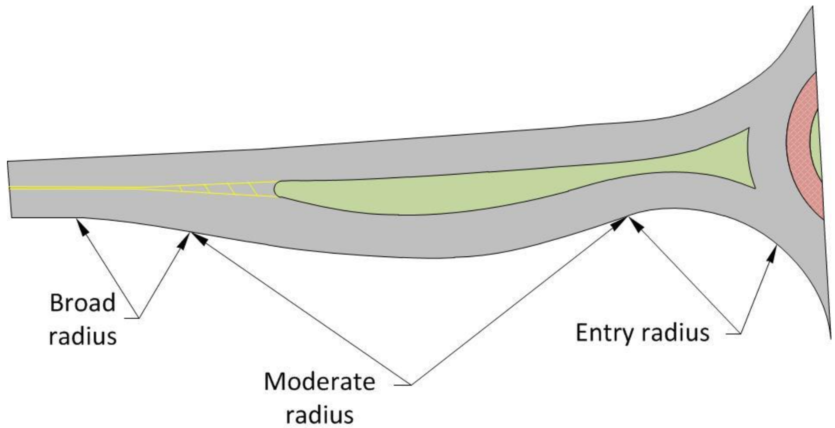
The ideal design speed mechanism has the entry and circulating speeds being similar. This varies due to size, shape and context of the roundabout.

The vehicle then moves into and through the circulation lane, being controlled all along by the design speed of the circulating lane. The circulating design speed controls the exit speed; therefore, the exit design speed, as calculated in the Travel Path section below, is not as critical.

Designing geometric entry speed control encourages lower speeds and lower speed differentials at conflict points, which reduces the potential for collisions.

1320.04(3)(a) Chicanes

Chicanes are a type of horizontal deflection used in traffic calming to reduce the speed of vehicles. Research has shown that chicanes have value in slowing down higher approach speeds.



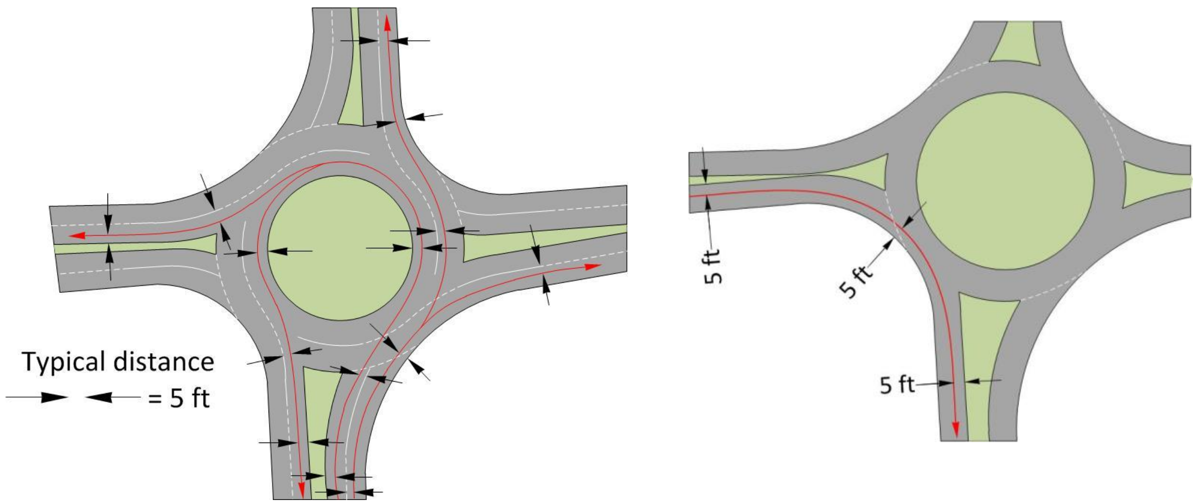
Chicane

Consider chicanes where posted speeds near the roundabout are 45 mph or higher. Design chicane curves with successively smaller radii in order to successively reduce vehicle speeds approaching the roundabout entry. Use Exhibit 1320-2 to determine the radii-speed relationship (the radii are measured using the offsets recommended in the Travel Paths section). The normal cross slope (superelevation in 1320-2) is 2% however, site conditions may require more based on how you tilt the plane of the roundabout for site specific conditions. A minus (-) 2% drains toward the central island.

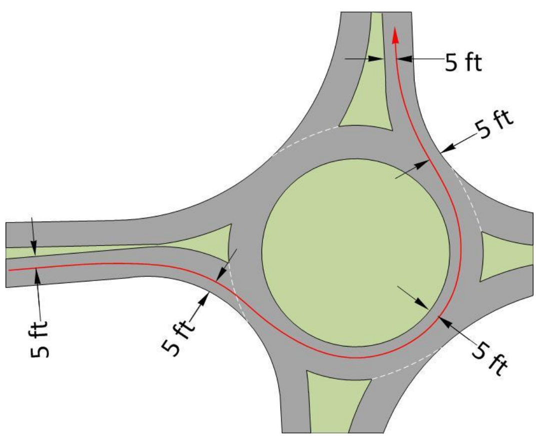
Also, consider the grade of the roadways that enter the roundabout, because a vehicle can more easily slow down on an upgrade than on a downgrade. Adjust the length of the deceleration based on the “Adjustment Factors for Grades Greater Than 3%” in Design Manual Exhibit 1360-10.

1320.04(3)(b) Travel Paths

Travel path calculations can be used on all roundabout designs to get an understanding of speeds for different paths throughout the roundabout. A travel path is the shortest path through the roundabout, no closer than 5 feet from any curb face or lane line as shown. Use Exhibit 1320-2 and R1 through R5 to determine Travel Path speeds.



Travel paths



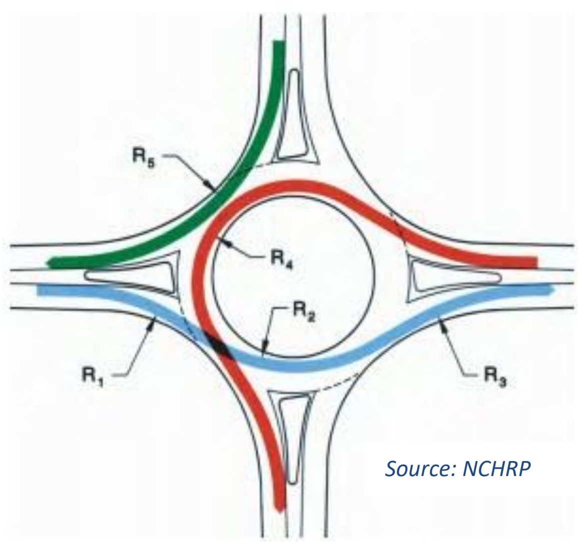
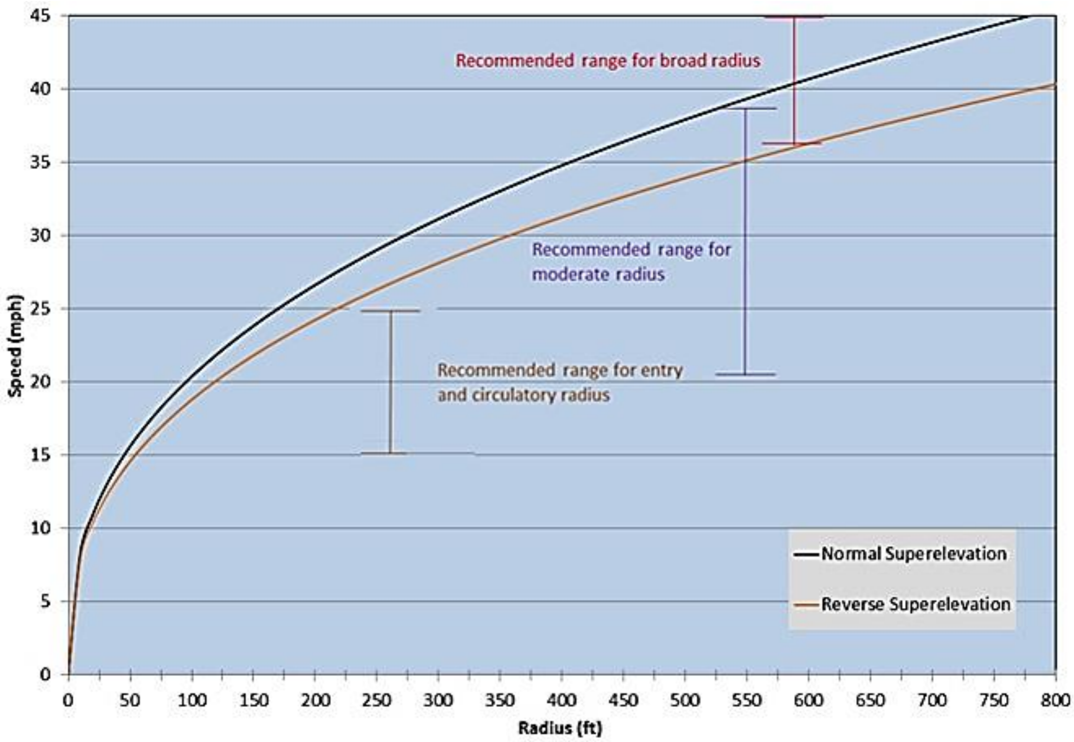


Exhibit 1320-2 Radii-Speed Relationship on Approach Legs and R Value Relationships



1320.04(4) Grades

Do not use grades as a constraint during scoping to rule out a roundabout. Be aware of how the profiles mesh with sight distances and ADA pedestrian requirements.

1320.04(4)(a) Circulatory Roadway

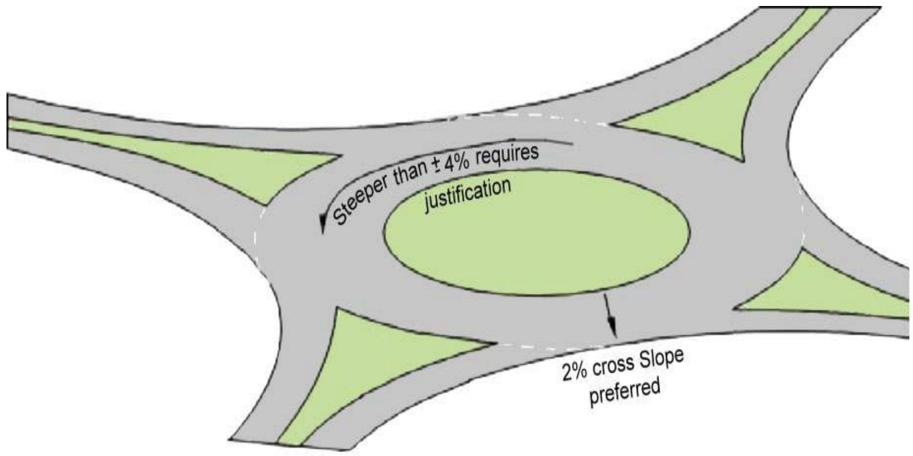
The circulatory roadway grade value should not exceed 4%. Terrain may require benching the roundabout to fit conditions.

1320.04(4)(b) Grade Transitions for Roadway Entry and Exit to the Circulatory Roadway

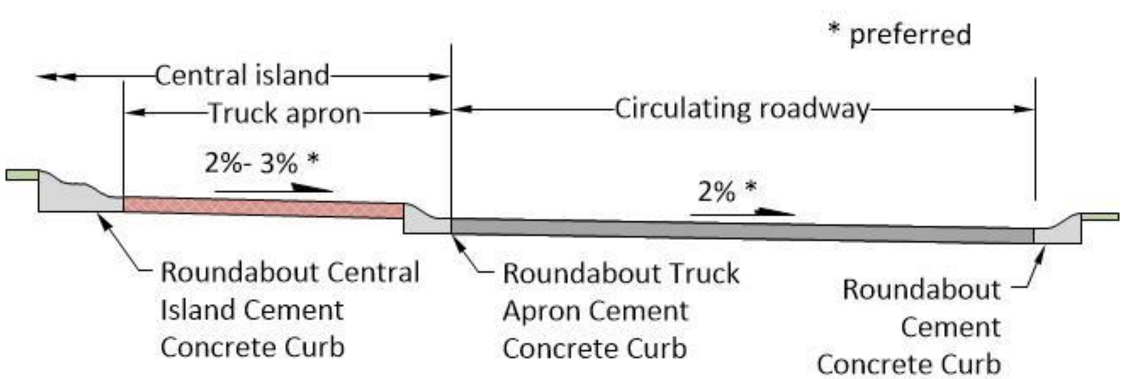
Consider the grade transitions and make them as long as feasible. When designing for pedestrians see Chapter 1510 and work with region ADA subject matter expert to ensure that grades for ADA compliance at all pedestrian crossing are met.

1320.04(5) Circulatory Roadway Profile and Cross Slope

The preferred profile grades of the circulatory roadway of a roundabout are ±4% or flatter radially around the circulatory lane(s). Profile grades steeper than ±4% require **justification**. It is preferred to bench the roundabout if practicable to reduce profile grade.



The preferred circulatory roadway cross slope may range from 1.5% to 4.0% (2.0% preferred), away from the central island to promote lower circulating speeds, improve central island visibility, minimize breaks in cross slope of entry and exit lanes, and facilitate drainage of water to the outside of the roundabout.



Drawing shows preferred cross slopes. Site conditions and drainage may require slopes outside these ranges.

1320.04(6) Design Tools

During the scoping or preliminary geometric design process, do not to use truck turning paths alone as a constraint to eliminate a roundabout at an intersection. There are several design tools available to aid in the design of a roundabout. It is important to understand how the software works, its default settings, and its application to the design process.

1320.04(6)(a) Design Vehicle Assumptions

While all highway-to-highway movements require accommodating a WB-67, there are certain assumptions that must be made with software programs that replicate truck swept paths. Determine which truck percentage defaults are to be used (recognizing that truck percentages can range from 2% to 20%) so that different segments can be modeled accurately. Recognize that within a set percentage, WB-67s may only represent a small sample of the entire truck volume on any given day. Therefore, consider whether a WB-67 should be designed for, or accommodated (also see Chapter 1103).

1. Designing for a WB 67

A roundabout that is being designed for a WB-67 may result in wider lane widths and a larger Inscribed Circle Diameter. For this situation, rolled curb design is critical to the truck's traversing the roundabout (see *Standard Plan* F-10.18 for curb details). Outside aprons may not be needed in many situations based on AutoTurn® modeling and knowledge of driver turning behavior when encountering geometric features.

2. Accommodating a WB 67

A roundabout that is designed to accommodate a WB-67 assumes that a WB-67 could utilize truck aprons to maneuver through the roundabout, if necessary, which should reduce the overall footprint of the roundabout. For this situation, rolled curb is critical to the truck's traversing the roundabout confidently. Although outside truck aprons are needed infrequently, there may be situations where the design may need to incorporate them. Contact HQ Traffic for guidance.

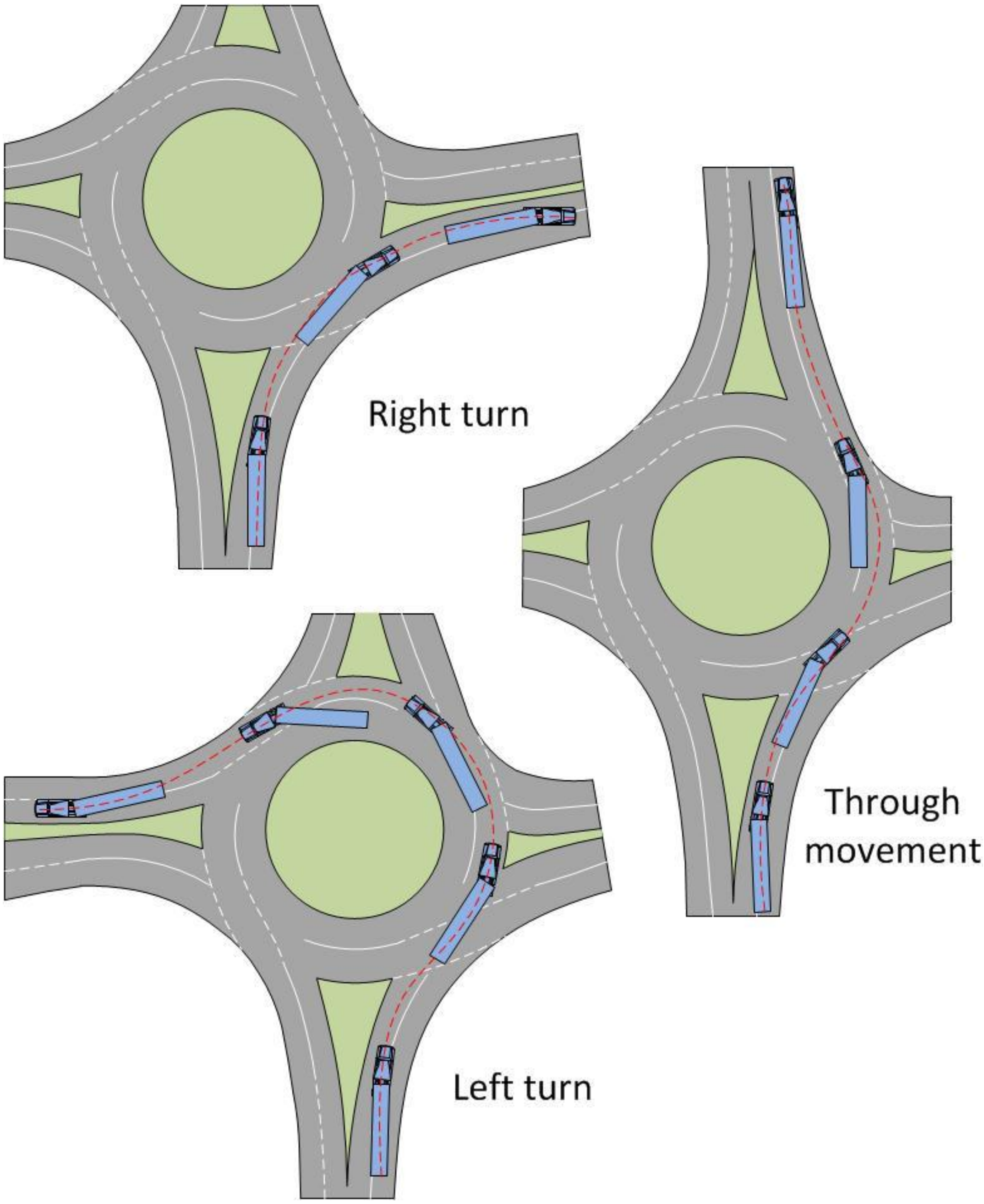
1320.04(6)(b) Truck Swept Path

In some cases, roundabouts of the perfect circular variety with symmetrical roadway attachments require less specific knowledge of truck-turning software and its applications. However, when looking at a non-circular shaped roundabout where the combination of the truck's speed, its turning angle settings, its rear axle locations, and its alignment are the critical design elements to address, a mastery of the software is required. Designers that are unfamiliar with how to apply the software inputs accurately to model a truck's swept path need to contact HQ Traffic Office for guidance. Poor alignment of a truck swept path can result in unnecessarily large roundabout footprints, higher than desired Travel Path speeds, or uncomfortable driving maneuvers by the freight community.

Assume that a truck will travel much slower through a roundabout than the Travel Path speed calculated for passenger vehicles (see 1320.04(3)(b)). Adjust the software input to allow a slower truck speed in order to make a good engineering judgment about how fast a truck may use a roundabout (for example, for AutoTURN® use 5 mph). Design tool default settings don't necessarily allow the maximization of the tool and can prohibit the designer from getting a good, balanced design between passenger car speeds and truck accommodation.

Single lane roundabout - Truck using the truck apron

When using a truck-turning software tool like AutoTURN® on multilane roundabouts, assume a truck's travel path will occupy (straddle) parts of two adjacent lanes.



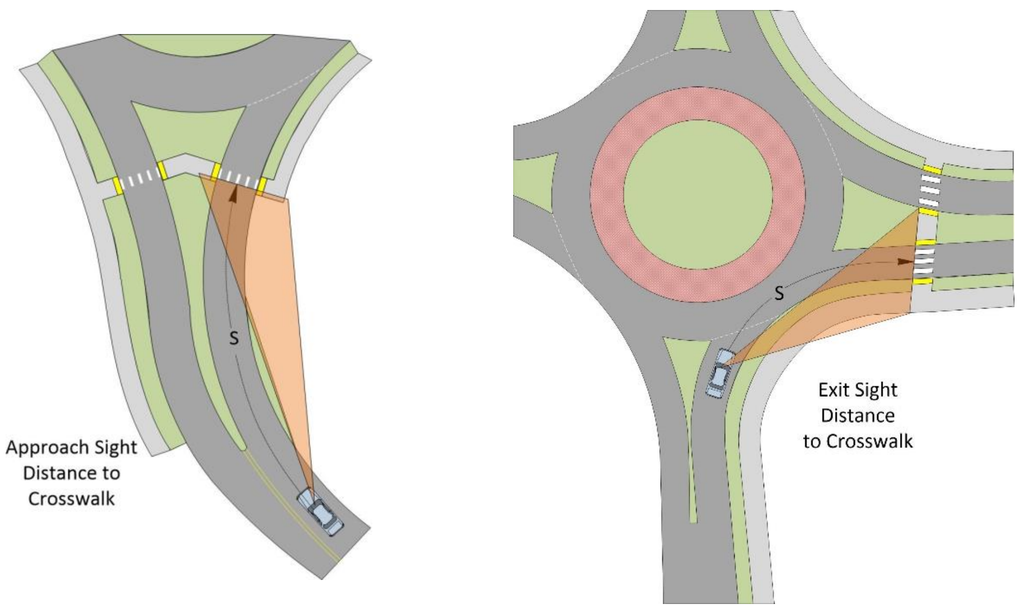
Multilane roundabout - truck straddles lanes

1320.04(7) Sight Distance

Sight distance is an important design consideration at roundabouts. Restricting sight distance across the central island with strategic landscaping may enhance the intersection by making the intersection a focal point and encouraging lower speeds. Work with the region Traffic Engineer and Landscape Architect (HQ if there is no region contact) to determine this balance. Provide sight triangle plan sheets for consideration of landscape design.

1320.04(7)(a) Stopping

Use the design stopping sight distance in Chapter 1260. Anticipated speeds throughout the roundabout can be calculated using Exhibit 1320-2, based on the Travel Path radius and direction of the particular curve. The design stopping sight distance is measured along the vehicle's path as it follows the curvature of the roadway; it is not measured as a straight line.



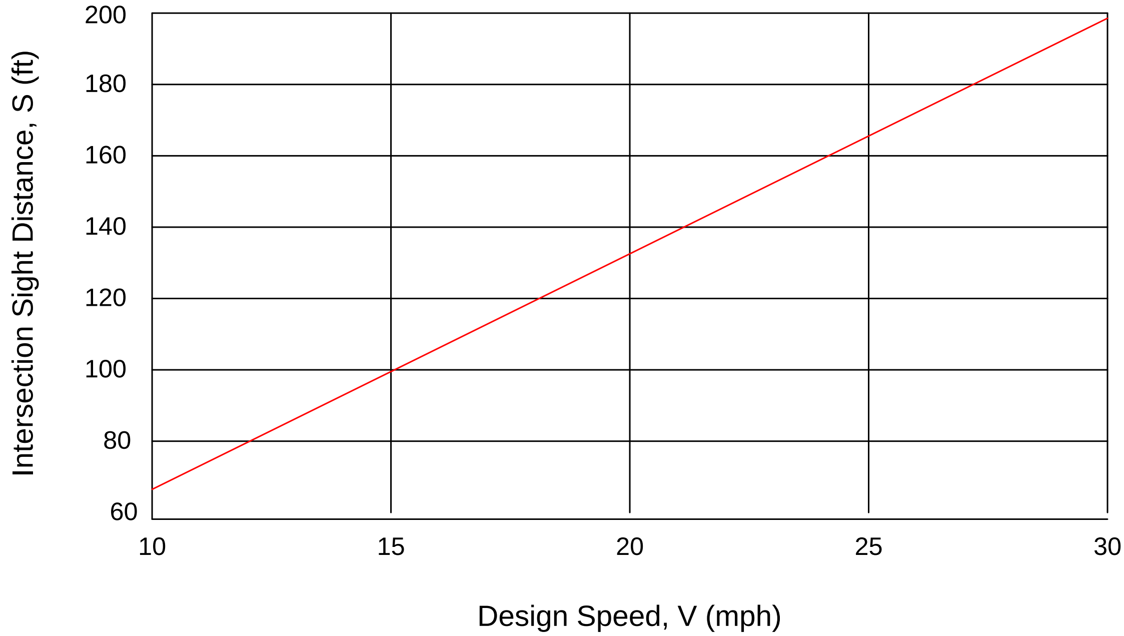
Sight distance – Approach and Exit

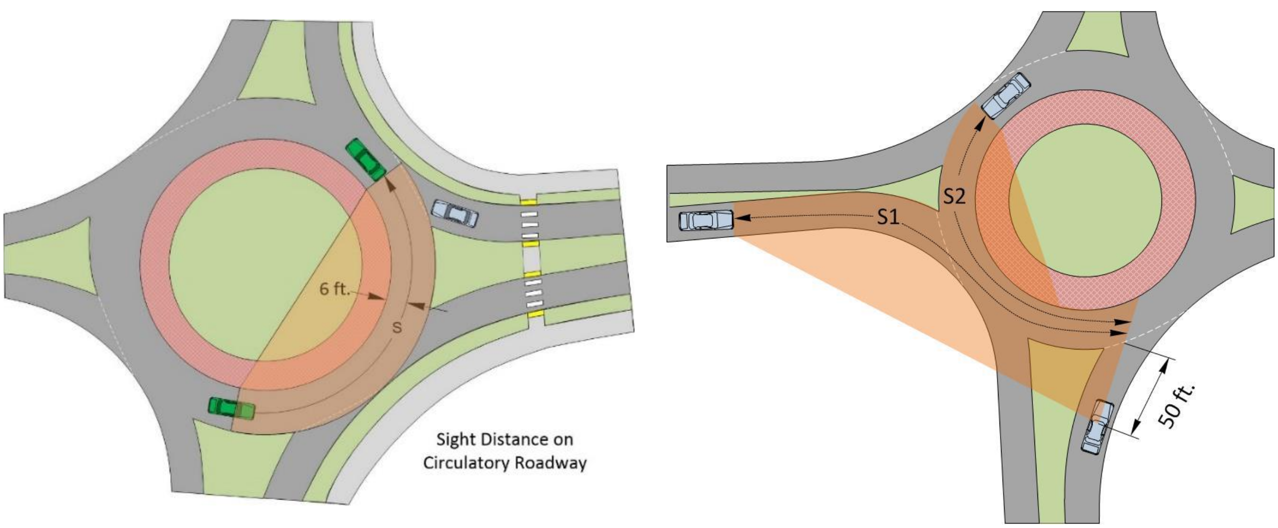
1320.04(7)(b) Intersection

Provide minimum intersection sight distance. Longer sight distances can lead to higher vehicle speeds that reduce gap opportunities for entering vehicles. For intersection sight distance at roundabouts, provide entering vehicles a clear view of traffic on the circulating roadway and on the immediate upstream approach in order to aid in judging an acceptable gap.

The intersection sight distance at roundabouts is given in Exhibit 1320-3. The S1 intersection sight distance is based on the average of the entering and circulating speeds, and the S_2 intersection sight distance is based on the left-turning speed. The sight distance may also be calculated using the intersection sight distance equation given in Chapter 1310 using a time gap (tg) of 4.5 seconds.

Exhibit 1320-3 Intersection Sight Distance





1320.04(8) Railroad Crossings

Although it is undesirable to locate any intersection near an at-grade railroad crossing, this situation exists at many locations on the highway system. Experience shows that a roundabout placed near a crossing has some operational advantages. If there is a railroad crossing near the roundabout contact HQ Traffic Office for further guidance.

1320.05 Pedestrians

As part of the approved ICE it has already been determined whether pedestrians will use the roundabout and, if so, which legs (see Chapter 1300).

With the knowledge of where pedestrian facilities are needed, design the roundabout while keeping in mind the ADA requirements for crosswalks, sidewalks, paths, and other pedestrian facilities.

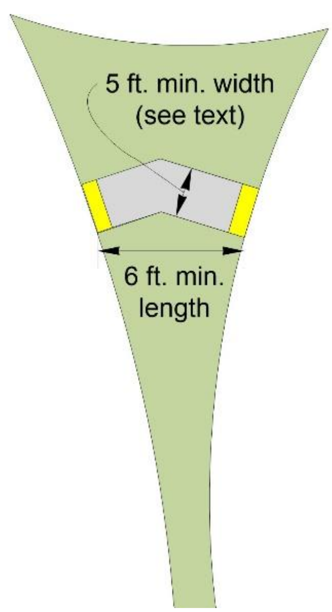
1320.05(1) Crossing Location

The pedestrian crossing located on the entry side of a roundabout leg should be at least 20 feet from the yield line so that a pedestrian can walk behind a vehicle that is waiting at the yield line. If there is an extremely large truck percentage, consider moving the crossing to accommodate the most common truck.

The crossing located in the exit side of the roundabout leg can be closer to the roundabout, because as the vehicles leave the roundabout, they accelerate and make it harder to find a break in traffic. As speed increases, drivers are less likely and less able to stop. Verify that no significant, large sight obstructions are located within the sight lines.

1320.05(2) Splitter Island Pass Through

Design the splitter island pass through a minimum of 5 feet wide, or the width of the sidewalk, whichever is greater. The length of the pass through (measured back of curb to back of curb of the splitter island) is to be a minimum of 6 feet long measured along the shortest section of the pedestrian path. Consider a "V" shape pass through as shown.



Splitter island pass through

1320.05(3) Buffers

Wherever feasible, separate sidewalks from the curb with a buffer. Landscaping or colored concrete are acceptable for the buffer. See WSDOT *Standard Plan F10-18* for dimension details. Do not compromise required vehicle sight triangle needs.

The buffer discourages pedestrians from crossing to the central island or cutting across the circulatory roadway of the roundabout. It also helps guide pedestrians with vision impairments to the designated crosswalks, and can accommodate the occasional inexperienced truck driver who encroaches up onto a curb while traversing through the roundabout.

1320.05(4) Curb Ramps

Roundabouts with buffers typically have combination-type curb ramps; otherwise, parallel curb ramps are normally used. (See Chapter 1510 and the *Standard Plans* for curb ramp information.)

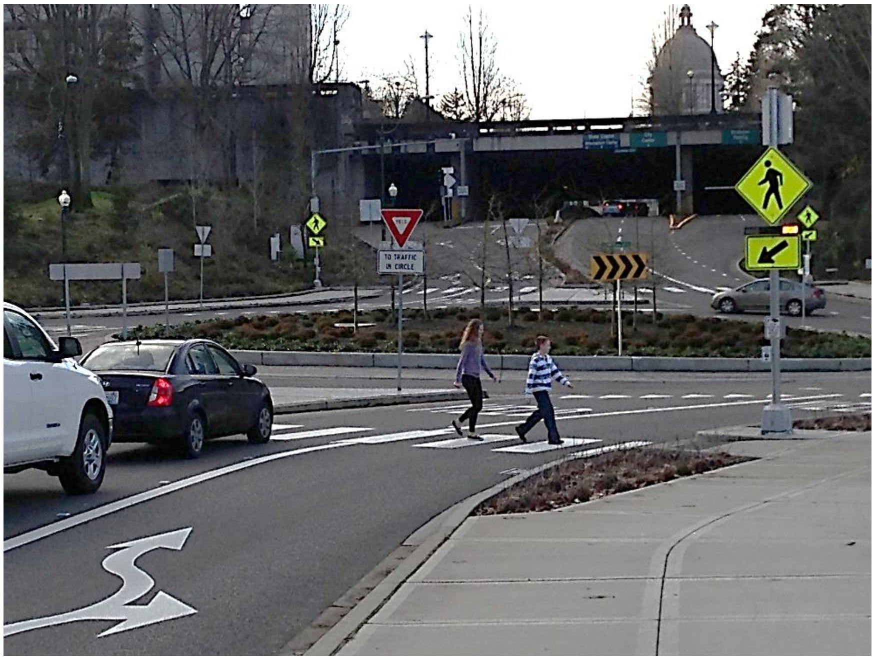
1320.05(5) Sight Triangles

A vehicle sight triangle specific to pedestrians (see 1320.04(7)) must include the whole curb ramp, including the landing, where pedestrians are likely to wait to cross.

It is also important that pedestrians are also able to see approaching vehicles.

1320.05(6) Pedestrian Beacons

On multilane roundabouts, consider installing pedestrian beacons to warn drivers when a pedestrian wants to cross the roadway. Work with the region Traffic Engineer on types and locations of pedestrian beacons.



Pedestrian beacons

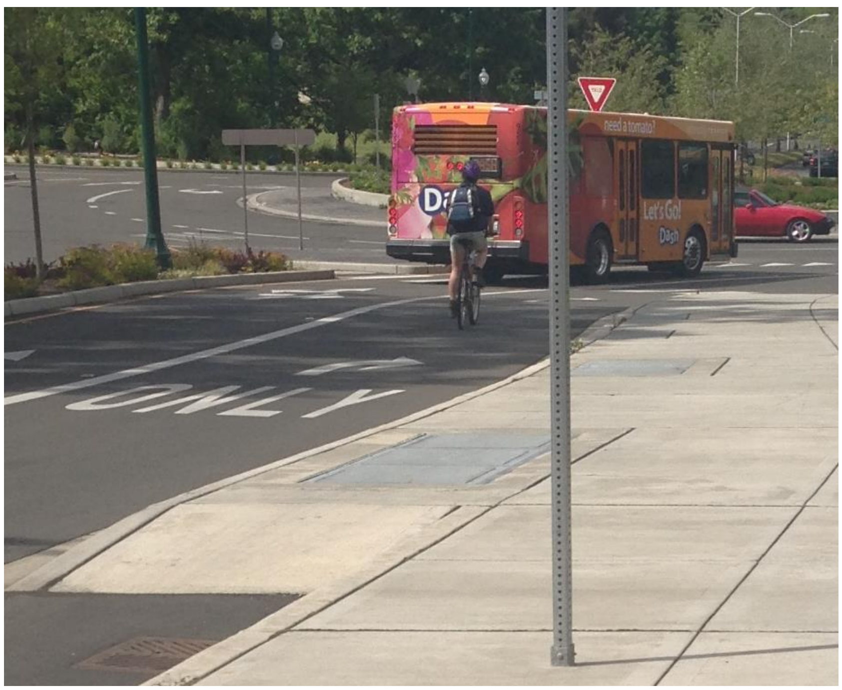
1320.06 Bicycles

Provide bicyclists with similar options to negotiate roundabouts as they have at other intersections. Consider how they navigate either as motor vehicles or pedestrians depending on the size of the intersection, traffic volumes, their experience level, and other factors.

Bicyclists are often comfortable riding through single-lane roundabouts in low-volume environments in the travel lane with motor vehicles, as speeds are comparable and potential conflicts are low.

At larger or busier roundabouts, cyclists may be more comfortable using ramps connecting to a sidewalk around the perimeter of the roundabout as a pedestrian. Where bicycle lanes or shoulders are used on approach roadways, they should end before the geometry changes the approach to the roundabout.

Contact the HQ Design Office for bicycle ramp design options.



Bicycle rider using lane

1320.07 Signing

The graphic shown is an example of potential signing for a single-lane roundabout. For additional information, refer to the MUTCD, Plan Sheet Library, and the *Standard Plans* for details on signing.

A preliminary sign plan is developed to identify existing and proposed signing on state highways. Sign plans on state routes are to be reviewed and approved by the region Traffic Engineer and then furnished to the HQ Traffic Office for review.

The plan provides an easily understood graphic representation of the signing, and it provides statewide uniformity and consistency for regulatory, warning, and guide signs at roundabouts on the state highway system. For roundabouts located near a port, industrial area, or route that accommodates oversize loads, consider using perforated square steel posts.

Signing example

1320.08 Pavement Marking

See *Standard Plan* M-12.10 for roundabout pavement marking details. Consult region Traffic on traffic pavement markings and materials.

1320.09 Illumination

Provide illumination for each of the conflict points between circulating and entering traffic in the roundabout and at the beginning of the raised splitter islands. Illuminate raised channelization or curbing. Position the luminaires on the upstream side of each crosswalk to improve the visibility of pedestrians. Light the roundabout from the outside in toward the center. This improves the visibility of the central island and circulating vehicles to motorists approaching the roundabout. Ground-level lighting within the central island that shines upward toward objects in the central island can also improve their visibility. Consult with the region Traffic office for illumination design. (See Chapter 1040 for additional information on illumination.) On higher-speed approaches, consider internally illuminated bollards (IIB) in lieu of other illumination.

1320.10 Road Approach, Parking, and Transit Facilities

Road approach (road or driveway) connections to the circulating roadway are not allowed at roundabouts unless they are designed as a leg to the roundabout. It is desirable that road approaches not be located on the approach or departure legs within the length of the splitter island. The minimum distance from the circulating roadway to a road approach is controlled by corner clearance using the outside edge of the circulating roadway as the crossroad. When minimum corner clearance cannot be met, document the decision in accordance with Chapters 530 and 540.

If a parcel adjoins two legs of the roundabout, it is acceptable to provide a right-in/right-out driveway within the length of the splitter islands on both legs. This provides for all movements; design both driveways to accommodate their design vehicles.

Roadways between roundabouts may have restrictive medians with left-turn access provided with U-turns at the roundabouts.

Parking is not allowed in the circulating roadway or on the entry or exit roadway within the length of the splitter island.

Transit stops are not allowed in the circulating roadway, in the approach lanes, or in the exit lanes prior to the crosswalk. Locate transit stops on the roadway before or after the roundabout, in a pullout, or where the pavement is wide enough that a stopped bus does not block the through movement of traffic or impede sight distance.

Right in / right out driveways

1320.11 Geometric Design Peer Review

Conduct a peer review of the roundabout design with the following participants.

- Region Traffic Office
- Assistant State Traffic Engineer
- Region Project Development Engineer or Engineering Manager
- Assistant State Design Engineer

The intent of this peer review is to review, discuss, evaluate, and provide feedback on the 2-D roundabout layout design in order to finalize the channelization plan.

1320.12 Documentation and Approvals

Refer to Chapter 300 for design documentation and approval requirements.

1320.13 References

1320.13(1) Federal/State Laws and Codes

See Chapter 1510 for Americans with Disabilities Act Policy and references

Revised Code of Washington (RCW) 47.05.021, Functional classification of highways

Washington Administrative Code (WAC) 468-58-080, Guides for control of access on crossroads and interchange ramps

1320.13(2) Design Guidance

Roundabout Cement Concrete Curbs: *Standard Plan F-10.18-01*

Roundabout Pavement Markings: *Standard Plan M-12.10*

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

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

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

1320.13(3) Supporting Information

Roundabouts: An Informational Guide (First edition 2000), FHWA-RD-00-067, USDOT, FHWA http://www.fhwa.dot.gov/publications/research/safety/00067/index.cfm

Roundabouts: An Informational Guide (Second Edition 2010), NCHRP Report 672, Transportation Research Board, 2010 http://nacto.org/docs/usdg/nchrprpt672.pdf

Highway Capacity Manual 2010 (HCM 2010), Transportation Research Board, National Research Council, Washington D.C., 2000

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

"Crash Reductions Following Installation of Roundabouts in the United States," Insurance Institute for Highway Safety, March 2000
🖰 https://www.dot.ny.gov/main/roundabouts/files/insurance_report.pdf

Understanding Flexibility in Transportation Design – Washington, WSDOT, 2005
🖰 www.wsdot.wa.gov/research/reports/600/638.1.htm

Chapter 1330 Traffic Control Signals

1330.01 General

Traffic control signals are automated traffic control devices that warn or direct motorists to take a specific action. Traffic control signals are used to control the assignment of right of way at locations where conflicts with motorists, bicyclists, and pedestrians exist or where passive devices such as signs and markings do not provide the necessary flexibility of control to move motorists, bicyclists, and pedestrians in an efficient manner.

The decision to install a traffic signal is the result of an Intersection Control Evaluation (ICE) (see Chapter 1300) that is approved by the region Traffic Engineer or other designated authority.

1330.02 Procedures

1330.02(1) Traffic Signal Permit

State statutes (RCWs) require WSDOT approval for the design and location of all conventional traffic signals and some types of beacons located on city streets forming parts of state highways. Approval by WSDOT for the design, location, installation, and operation of all other traffic control signals installed on state highways is required by department policy.

The Traffic Signal Permit (DOT Form 242-014 EF) is the formal record of the signal warrant analysis required by the MUTCD and the department's approval of the installation and type of signal. Permits are required for the following types of signal installations:

- Conventional traffic signals
- Emergency vehicle signals
- Intersection control beacons
- Lane control signals
- Movable bridge signals
- Ramp meter signals
- Pedestrian signals
- Pedestrian Hybrid Beacon signals ("HAWK" signals)
- Temporary traffic signals (only when not being used in place of a permanent, permitted signal)
- Queue-cutter traffic signals

The Permit and its supporting data must be included in the Design Documentation Package (DDP.) The permit is completed by the requesting agency and submitted, complete with supporting data, through the region Traffic Office to the approving authority for approval. See 1330.02(1)(a) for Signal Warrant information required as part of the supporting documentation.

The approving authority is the Regional Administrator or authorized delegate. The approving authority approves or denies the application and sends it back to the region Traffic Office. The region Traffic Office retains a record of the approved permit and supporting data and forwards a copy of the Permit and the supporting data to the State Traffic Engineer at WSDOT Headquarters (HQ). Preserve the approved permit as required by 1330.07 Documentation.

Emergency vehicle signals require annual permit renewal. The region Traffic Office reviews the installation for compliance with requirements. If satisfactory, the permit is renewed by the Regional Administrator with a letter to the operating agency. A copy of this letter is also sent to the State Traffic Engineer.

Permits are not required for portable traffic signals, speed limit sign beacons, stop sign beacons, or lane assignment signals at toll facilities.

A new permit application is required when the level of control is increased, such as changing from an intersection control beacon to a conventional traffic signal or adding an approach to an existing signal system.

For a reduction in the level of control, such as converting a conventional signal to a flashing intersection beacon or removal of the signal, submit the “Report of Change” portion of the traffic signal permit, complete with supporting data, to the approving authority, with a copy to the region Traffic Office and State Traffic Engineer.

If experimental systems are proposed, region Traffic Engineer review and approval is required. The region Traffic Office will send the approved proposal to the State Traffic Engineer for review and approval. The State Traffic Engineer will forward the approved proposal to FHWA for their approval. A copy of the approval from FHWA will be returned and must be preserved as required by 1330.07 Documentation.

Any signal system requiring a permit, with the exception of Ramp Meter signals, also requires Preliminary Signal Plan approval from the WSDOT HQ Traffic Office (see 1330.05).

1330.02(1)(a) Signal Warrants

A signal warrant is a minimum condition that is to be met before a signal may be considered for installation. Satisfying a warrant does not mandate the installation of a traffic signal. The warranting condition(s) supports the inclusion of a traffic signal for consideration as part of the ICE performed during the scoping of the project (see Chapter 1300). For a list of the traffic signal warrants and information on how to use them, see the *Manual on Uniform Traffic Control Devices* (MUTCD). Contact the region Traffic Engineer for region specific practices.

Address all warrants listed in the currently adopted MUTCD as part of the Signal Warrant Analysis. Mark warrants which do not apply as “Not Applicable” and include a basic supporting statement or similar justification. Include the Signal Warrant Analysis in the Signal Permit supporting data. For Warrant 7, the three year period must be used for all traffic signals installed on state highways as described in FHWA Interim Approval IA-19 (https://mutcd.fhwa.dot.gov/resources/interim_approval/ia19/index.htm).

1330.02(2) Responsibility for Funding, Construction, Maintenance, and Operation

Responsibility for the funding, construction, maintenance, and operation of traffic signals on state highways has been defined by legislative action and Transportation Commission resolutions (see Exhibit 1330-1). Responsibilities vary depending on location, jurisdiction, and whether or not limited access control has been established. Limited access as used in this chapter refers to full, partial, or modified limited access control that has been established as identified in the Access Control Tracking System:
http://www.wsdot.wa.gov/design/accessandhearings/

Exhibit 1330-1 Responsibility for Facilities

Responsibility for Various Types of Facilities on State Highways				
Area	**Responsibility**	**Emergency Vehicle Signals**	**Traffic Signals, Pedestrian Signals, & Intersection Control Beacons**	**Reversible Lane Signals & Movable Bridge Signals**
Cities with a population of 27,500 or greater	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]
All other locations	Finance	ESD [1]	State/County [3] /Other [4]	State
	Construct	ESD [1]	State/County [3] /Other [4]	State
	Maintain	ESD [1]	State	State
	Operate	ESD [1]	State	State

Notes:
[1] ESD refers to the applicable Emergency Service Department.
[2] Does not apply to state highways with established limited access control (see 1330.02(2)(c)).
[3] Beyond corporate limits due to county activity (see 1330.02(2)(d)).
[4] Other refers to signals proposed by or required due to third party activity (see 1330.02(2)(g)).

(a) Inside the corporate limits of cities with a population of 27,500 or greater where there is no established limited access control: The city is responsible for the funding, construction, maintenance, and operation of traffic signals. Population figures can be found at: www.ofm.wa.gov/pop/

(b) Inside the corporate limits of cities with a population of less than 27,500: WSDOT is responsible for funding, construction, maintenance, and operation of traffic signals. Population figures can be found at: www.ofm.wa.gov/pop/

(c) Inside the corporate limits of cities with a population of 27,500 or greater where there is established limited access control: WSDOT is responsible for funding, construction, maintenance, and operation of traffic signals. Population figures can be found at: www.ofm.wa.gov/pop/

(d) Outside the corporate limits of cities and outside established limited access control areas: WSDOT is responsible for funding, construction, maintenance, and operation of a traffic signal when a new state highway crosses an existing county road. When a new county road intersects an existing state highway, WSDOT is responsible for only the maintenance and operation of a traffic signal. The county is responsible for the construction costs of the traffic signal and associated illumination. When it is necessary to construct a traffic signal at an existing county road and state highway intersection, the construction cost distribution is based on the volume of traffic entering the intersection from each jurisdiction's roadway. The county's share of the cost, however, is limited to a maximum of 50%. The state is responsible for maintenance and operation (WAC 468-18-040).

(e) Outside the corporate limits of cities and inside established limited access control areas: WSDOT is responsible for funding, construction, maintenance, and operation of traffic signals.

(f) Emergency vehicle signals: The emergency service agency is responsible for all costs associated with emergency vehicle signals.

(g) Third party agreement signals: At those locations where WSDOT is responsible for traffic signals and third party activity justifies the installation of a traffic signal, as determined by an ICE, the following rules apply:

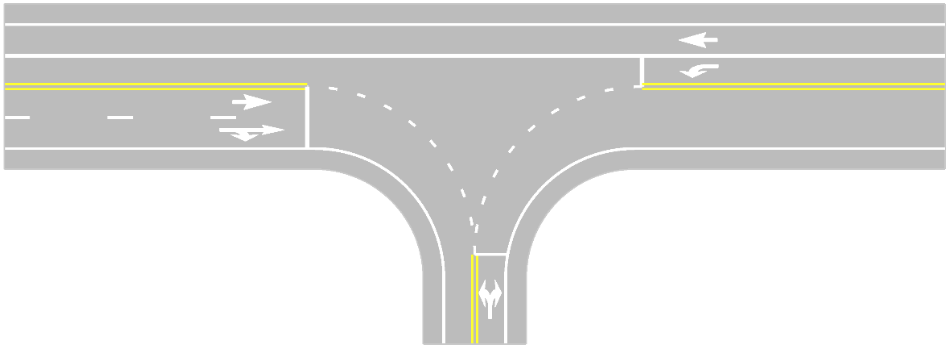
- The third party is responsible for funding the design and construction of the traffic signal system, unless another arrangement is agreed upon with WSDOT.
- The third party obtains a traffic signal permit.
- The third party agrees to design and construct the traffic signal in conformance with WSDOT's guidelines and requirements.
- The third party agrees to submit the design and construction documents to WSDOT for review and approval by the region Traffic Engineer.
- Preserve all third party provided documents and any third party agreement(s) as required by 1330.07 Documentation.

1330.03 Intersection Design Considerations

Signalized intersections require different design considerations than non-signalized intersections. These elements should be considered as early as the ICE process (see Chapters 1300 and 1310 for further guidance.) This Section discusses basic intersections with relatively simple geometry. For more complex or innovative intersection layouts such as Diverging Diamond Interchanges, Displaced Left Turns, or Single Point Urban Interchanges, contact the WSDOT HQ Traffic Office for support.

Consider providing an unrestricted through lane on the major street of a T intersection (sometimes referred to as a Continuous Green "T" (CGT) intersection). This design allows for one traffic movement to flow without restriction. When this is used on through roadways with a posted speed of 45 MPH or greater, the through lane must be separated by a physical barrier or the through movement must also be signalized. If there is a crosswalk across the through lane, the through lane must be signalized. Exhibit 1330-2 shows an example of a CGT intersection.

Exhibit 1330-2 Example Continuous Green "T" (CGT) Intersection Layout



1330.03(1) Left Turns

It is recommended that a left turn storage lane be provided for all main line roadways where left turns are allowed. This helps to avoid having stopped traffic in a through lane with a green through signal display. This also helps to support potential future changes in left turn operations. See Section 1330.06(1) for additional discussion.

Left-turning traffic can operate more efficiently when the opposing left-turn lanes are directly opposite each other. When a left-turn lane is offset into the path of an opposing through lane, the left-turning driver may assume the opposing vehicles are also in a left-turn lane and fail to yield. To prevent this occurrence, less efficient split phasing may be necessary. (See Chapter 1310 for guidance on lane offsets and opposing left-turn clearance.) Where there are opposing through lanes but no opposing left turn lane, install a striped or raised median area opposite the left turn lane if possible.

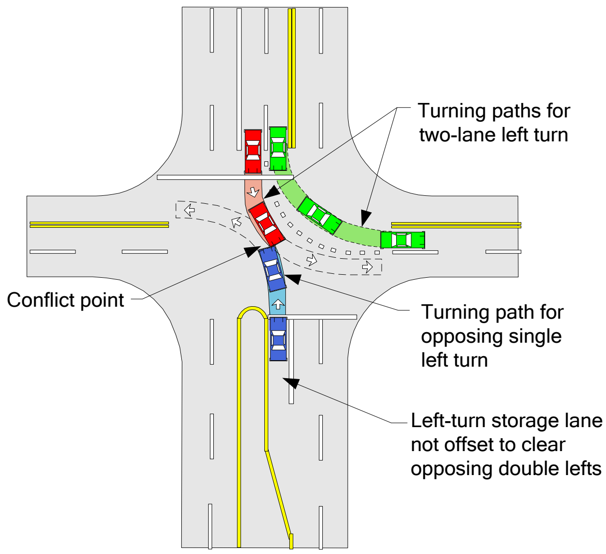
Place stop lines so that they are out of the path of conflicting left turns. Check the geometric layout by using turning templates or a computerized vehicle turning path program (such as AutoTURN®) to determine whether the proposed layout and phasing can accommodate the design vehicles. Also, check the turning paths of opposing left-turn movements. In many cases, the phase analysis might recommend allowing opposing left turns to run concurrently, but the intersection geometrics are such that this operation cannot occur. The intersection should be large enough to accommodate opposing left turning vehicle paths with a 4-foot minimum (12-foot desirable) separation between them. Where this separation cannot be achieved, less efficient signal phasing may be required to accommodate opposing left turns.

Some intersections may have multi-lane left turns. At locations with closely spaced intersections, a multi-lane left-turn storage area might be the only solution to reduce the potential for the left-turn volume to back up into an adjacent intersection. As with single left turn lanes, the intersection should be large enough to accommodate opposing left turning vehicle paths with a 4-foot minimum (12-foot desirable) separation between them. Where this separation cannot be achieved, less efficient signal phasing may be required to accommodate opposing left turns.

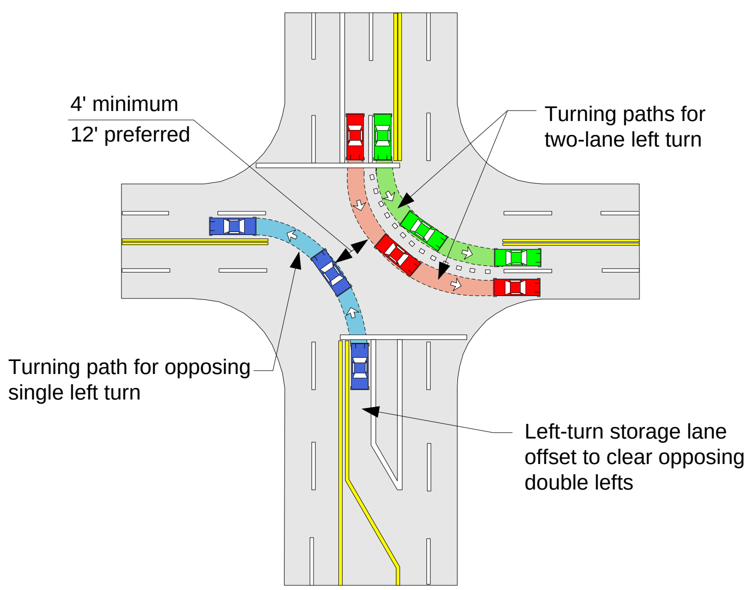
At smaller intersections, the opposing single-lane left-turn movement might not be able to turn during the two-lane left-turn phase and it might be necessary to reposition this lane. If the opposing left turns cannot time together, the reduction in delay from the two-lane left-turn phase is likely to be nullified by the requirement for a separate opposing left-turn phase. Exhibit 1330-3 shows two examples of two-lane left turns with opposing single-left arrangements.

Two receiving lanes are required for two-lane left-turn movements. In addition, these receiving lanes are to extend well beyond the intersection before reducing to one lane. A lane reduction immediately beyond the intersection can cause delays and backups into the intersection because the left-turning vehicles usually move in dense platoons, which may make merging and lane changes difficult. (See Chapter 1310 for guidance on lane reductions on intersection exits.)

Exhibit 1330-3 Left-Turn Lane Configuration Examples



Single left turn lane not offset – overlapping left turn paths



Offset single left turn lane – opposing lefts no longer in conflict

1330.03(2) Right Turns

Large right-turn curb radii at intersections sometimes have impacts on traffic signal operation. Larger radii allow faster turning speeds and might move the pedestrian entrance point farther away from the intersection area. Pedestrian crossing times are increased because of the longer crossing, thereby reducing the amount of time available for vehicular traffic. (See Chapter 1310 for guidance on determining these radii.)

At intersections with large right-turn radii, consider installing raised traffic islands. These islands are primarily designed as pedestrian refuge areas. (See Chapter 1510 for pedestrian refuge islands and traffic island designs.) Traffic islands may decrease the required pedestrian clearance intervals; however, large radii and raised traffic islands may make it difficult for pedestrians to navigate the intersection. Where pedestrians are expected to cross a right turn lane to a traffic island, it is recommended to use a compound right turn-lane design as shown in Chapter 1310.

1330.03(3) Pedestrian Features

See Chapter 1510.

1330.03(4) Road Approaches and Driveways

If roadway approaches and driveways are located too close to an intersection, the traffic from these facilities can affect signal operations. Consider eliminating the accesses or restricting them to “right in/right out”. If a driveway or road approach is directly opposite a leg of the intersection, that approach may be signalized. If the approach is signalized, it must be signalized as if it were a standard intersection leg, and the pedestrian crossing across the approach must also be signalized as if it were a standard crosswalk.

Management of driveways and road approaches should be determined early (preferably no later than scoping) so that they can be considered and addressed in the design. (See Chapters 530 and 540 for further guidance.) Consider shifting the location of advance detection upstream to clear an access point so that vehicles entering from the access point will not affect detection and operation of the signal.

1330.03(5) Skewed Intersections

Skewed intersections, because of their geometry, are challenging to signalize and delineate. Where feasible, modify the skew angle to provide more normal approaches and exits. In many cases, the large paved areas for curb return radii at skewed intersections can be reduced when the skew angle is reduced. (See Chapter 1310 for requirements and design options.) Visibility of pedestrians is of particular concern, and must also be taken into consideration.

1330.03(6) Transit Stops

Transit stop and pullout locations should be located on the far side of the intersection to minimize their impacts on signal operation. (See Chapter 1430 for transit stop and pullout designs.)

1330.03(7) Railroad Crossings

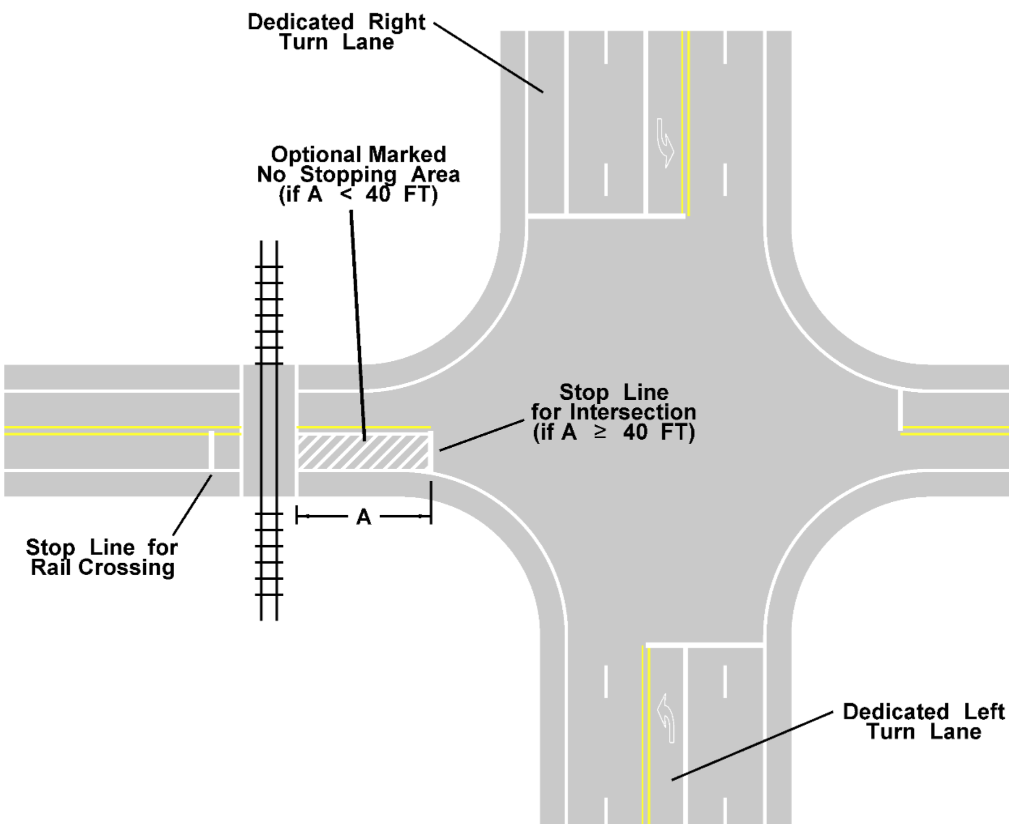
Where railroad preemption is used at a signalized intersection, install left and right turn lanes for the movements leading to the leg of the intersection with the railroad crossing if possible.

This greatly improves the efficiency of the signal during railroad preemption when turns are restricted. Also consider providing a left-turn lane for the minor leg opposing the railroad crossing. This will allow for more effective signal operations during long periods of railroad preemption.

Where there is less than 40 feet between the nearest rail and the normal location of the stop line, do not install a stop line between the tracks and the intersection. Use the same stop line for the traffic signal and the rail crossing instead. Exhibit 1330-4 shows recommended intersection features for intersections near rail crossings.

Contact the WSDOT HQ Traffic Office for assistance with standalone queue-cutter signals.

Exhibit 1330-4 Recommended Features for Intersections near Rail Crossings



1330.04 Conventional Traffic Signal Design

1330.04(1) General

The goal of any traffic signal design is to assign right of way in the most efficient manner possible and still be consistent with traffic volumes, intersection geometrics, and safety.

An advanced signalized intersection warning sign and beacon assembly to warn motorists of a signalized intersection should be installed when either of the two following conditions exists:

(a) The visibility requirements in the MUTCD are not achievable.

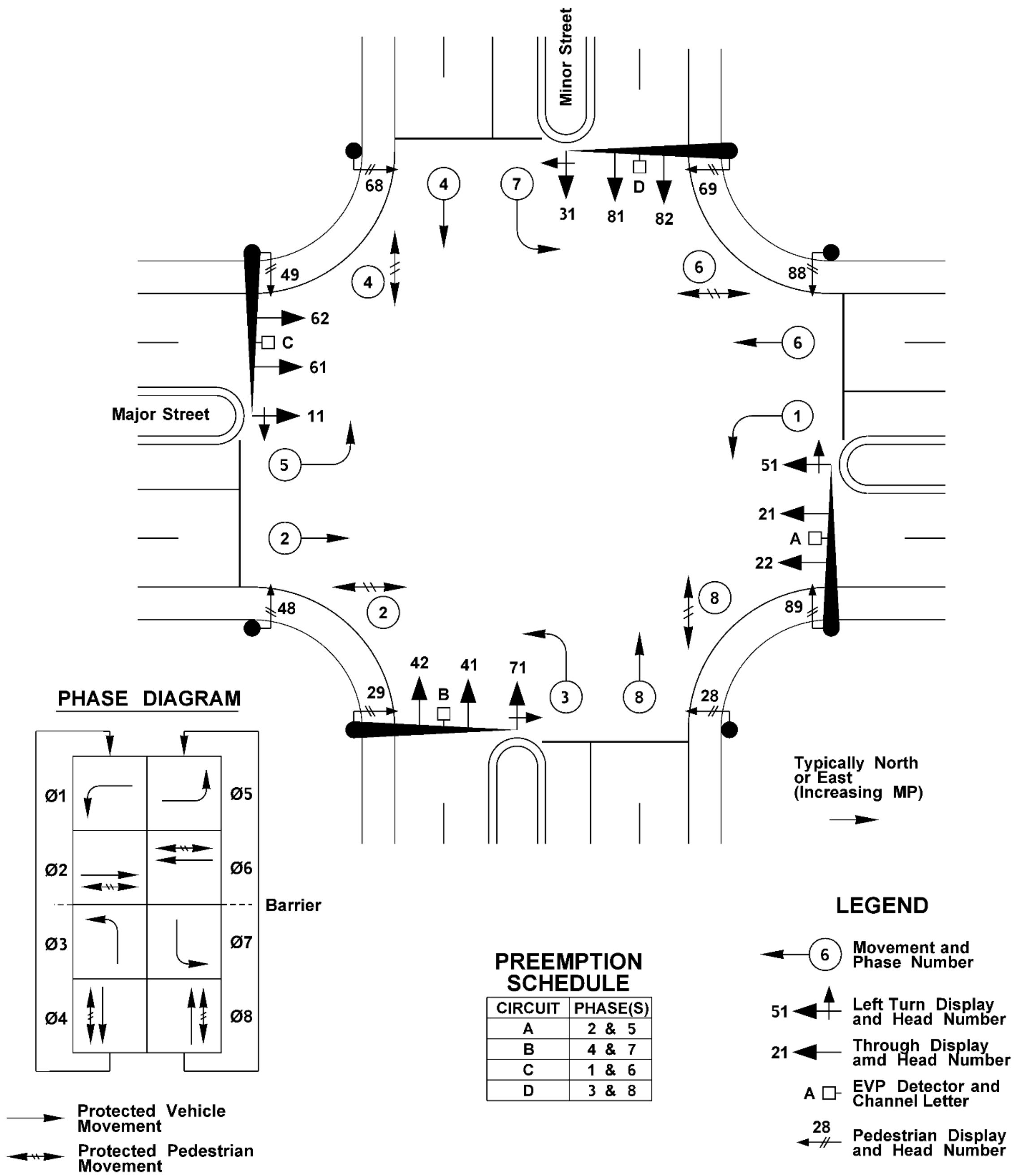
(b) The posted speed is 55 mph or higher and the next nearest signalized intersection is more than 2 miles away; this does not apply to freeway off-ramps.

This warning sign and beacon assembly consists of a W3-3 sign with Type IV reflective sheeting and one or two continuously flashing beacons. Where two beacons are used, the beacons should flash alternately instead of simultaneously. Locate the sign in advance of the intersection in accordance with Table 2C-4 (Condition A) of the MUTCD. The warning sign and beacon assembly may be omitted with approval from the region Traffic Engineer.

1330.04(2) Signal Phasing

With some exceptions, the fewer the traffic signal phases, the more efficient the operation of the traffic signal. The number of phases required for efficient operation is related to intersection geometrics, traffic volumes, composition of traffic flow, turning movement demands, and desired level of driver comfort. The traffic movements at an intersection have been standardized to provide consistency in both traffic signal design and driver expectations. (See Exhibit 1330-5 for standard intersection movements, signal head (display) numbering, and standard phase operation.)

Exhibit 1330-5 Standard Intersection Movements, Head Numbers, and Phase Operation



CIRCUIT	PHASE(S)
A	2 & 5
B	4 & 7
C	1 & 6
D	3 & 8

For WSDOT operated signals, the region Signal Operations Engineer will develop the signal phasing plan or review proposed phasing for systems designed by others. For signals operated by other jurisdictions, the operating jurisdiction should be involved in signal phasing development. Phasing development is addressed in 1330.06 Operational Considerations for Design. Phasing development should begin as soon as the decision is made to install a traffic signal and may begin as early as the intersection control evaluation. Provide the proposed channelization plans and traffic count data to the region Signal Operations Engineer or phasing designer as early as possible, as phasing information is required to complete the signal system design.

For WSDOT owned and operated signals, vehicle and pedestrian movement phase numbering is standardized to provide uniformity in signal phase numbering, signal display numbering, preemption channel identification, detection numbering, and circuit identification. For signals owned and operated by other jurisdictions, refer to that jurisdiction's guidelines for phase and equipment numbering. The following are general guidelines for the WSDOT numbering system:

1. Phases 2 and 6 are normally assigned to the major street through movements, with phase 2 assigned to the northbound or eastbound direction of the major street. This results in phase 2 being aligned with the direction of increasing mileposts.
2. Phases 1 and 5 are normally assigned to the major street protected left-turn movements.
3. Phases 4 and 8 are normally assigned to the minor street through movements, with phase 4 normally assigned to the approach to the left of the phase 2 approach (as viewed from the phase 2 stop line).
4. Phases 3 and 7 are normally assigned to the minor street protected left-turn movements.
5. Phasing on new signals installed within an already signalized corridor should be assigned to match the existing corridor phasing – even if it doesn't follow the standard phasing conventions listed above.
6. At T intersections, the movement on the stem of the T is normally assigned to either phase 4 or phase 8. Which phase is used will normally depend on the major street phase assignments.
7. At intersections where split phasing is used (opposing directions time separately) assign phases normally but show the split phase phasing diagram, unless otherwise directed by maintenance and operations staff.
8. Signal displays are numbered as follows:

    a. The first number indicates the signal phase and the second number is the number of the signal head, counting from centerline (or left edge line) to the right edge line of the approach. For example, signal displays for phase 2 are numbered, as viewed from left to right, 21, 22, 23, and so on. If the display is an overlap, the designation is the letter assigned to that overlap. For example, signal displays for overlap A are number A1, A2, A3, and so on.

    b. If the display is protected/permissive, the display is numbered with the phase number of the through display followed by the phase number of the left-turn phase. For example, a protected/permissive signal display for phase 1 (the left-turn movement) and phase 6 (the compatible through movement) is numbered 61/11. For overlap right turns, the protected portion may either be an overlap phase, or it may be the same phase as the complementing left turn phase.

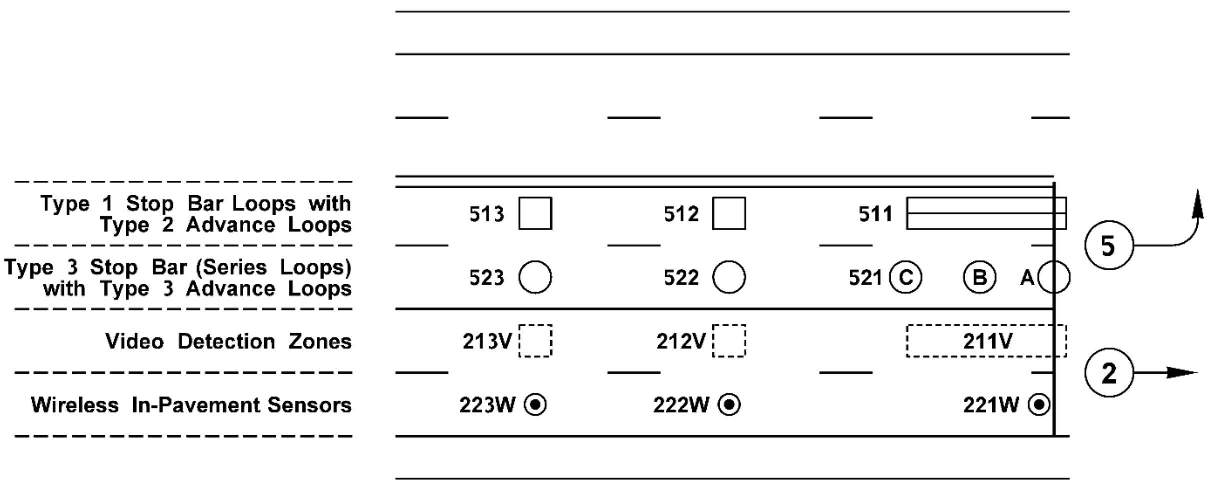
        With a conventional protected/permissive left-turn display, the circular red, yellow, and green displays are connected to the through phase (phase 6, in this example) controller output and the steady yellow and green arrow displays are connected to the left turn phase (phase 1, in this example) controller output.

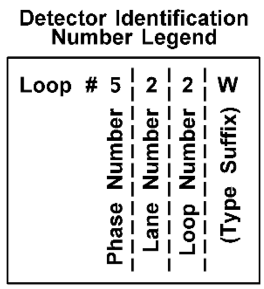
        When a flashing yellow arrow display is used, coordinate with the Signal Operations Engineer and signal maintenance group to determine appropriate wiring. For new cabinets, always specify an auxiliary output rack when protected/permissive phasing will be used.

9. Pedestrian displays and detectors are numbered with the first number indicating the signal phase and the second number as either an 8 or 9. For example, pedestrian displays and detectors 28 and 29 are assigned to phase 2. If there are more than two displays or detectors for a single pedestrian phase, use letter suffixes for additional displays and detectors (28A / 29A, 28B / 29B, etc.).
10. Vehicle detector numbering depends on the type of detection:
    a. Induction loop detectors use three digit numbers for designation. The first number represents the phase. The second number represents the lane number, starting from the left lane and moving towards the right edge line. The third number represents the loop number counting from the stop line back. For example, detection loops for phase 2 detectors are numbered 211, 212, 213 for lane 1; 221, 222, 223 for lane 2; and so on. For loops tied together in series for a single detection channel, such as a three loop series stop line detector, the individual loops in the series use a letter suffix. For a stop line detector in lane 1 for phase 2, using three loops in series, the loops would be designated 211A, 211B, and 211C.
    b. Video detectors are designated V#, where "#" is the through phase number for that approach, even if it will cover additional phases (such as left turn or overlap) for that approach. If the video detector is for advance detection, the suffix "A" is added. For example, the advance video detector for phase 6 would be V6A.

       Video detection zones may be drawn on the contract plans if desired, but these will normally be field established and adjusted and may not end up as shown in the plans. If used, video detection zones are labeled the same as loop detectors, but with a "V" suffix. For example, the stop line video detection zone for phase 5 would be 511V.
    c. Radar detectors are designated similar to video detectors, but use an "R" prefix in place of the "V". For example, the advance radar detector for phase 4 would be R4A.
    d. Wireless in pavement sensors use the same numbering scheme as induction loops, but add a "W" suffix. For example, the phase 7 stop line sensor would be 711W.
    e. Exhibit 1330-6 shows examples of standard detector numbering.
11. Emergency vehicle detectors use letter designations: Channel A detectors cover phase 2 and phase 5; Channel B detectors cover phase 4 and phase 7; Channel C detectors cover phase 1 and phase 6; and Channel D detectors cover phase 3 and phase 8. When there are multiple detectors for the same channel, the first detector uses the letter, and all other detectors use a number suffix (C, C1, C2, etc.).

Exhibit 1330-6 Detector Numbering Examples





1330.04(3) Vehicle Signal Displays

Signal displays are the devices used to convey right of way assignments and warnings from the signal controller to the motorists and pedestrians. When selecting display configurations and locations, the most important objective is the need to present these assignments and warnings to the motorists and pedestrians in a clear, concise, and uniform manner.

The use of ball, steady arrow, or flashing yellow arrow displays is dependent upon the signal phasing. Use the approved signal phasing diagram to determine which display types can be used for which movements. Typical vehicle signal displays are shown in Exhibits 1330-7a through 7h. In addition to the display requirements contained in the MUTCD, the following also apply:

1. A minimum of two indications for the through movement, if one exists at an intersection, must be provided - even if it is not the primary (predominant) movement. Provide a minimum of two indications for the major signalized turn movement of an intersection if no through movement exists, such as on the stem of a T intersection. These signal faces are to be spaced a minimum of 8 feet apart. At a T intersection, select the higher-volume movement as the primary movement and provide displays accordingly.

   A green left-turn arrow on a primary display and a green ball on the other primary display do not comply with this rule. At an intersection where left turns are prohibited, the leftmost through display may use a green up arrow in place of the green ball display. At an intersection where right turns are prohibited, the rightmost through display may use a green up arrow in place of the green ball display.

2. All displays for an approach, regardless of phase served, are to be a minimum of 8 feet apart.
3. Locate displays directly overhead and centered over the associated lane of the applicable vehicular traffic as it moves through the intersection. (See Exhibits 1330-7a through 7h for signal head locations.) For intersections with a skew for through traffic, locate signal displays for through traffic in one of the following ways:
    a. Over the center of the outbound (far side) lane
    b. Over a line drawn between the center of the approaching lane and the center of the associated outbound lane, ending at the stop lines

    Left turn displays may either be located relative to the through displays or in line with approaching traffic, dependent on ability to mount the display(s). (See Exhibit 1330-8 for skew placement examples.)
4. Locate displays a minimum of 50 feet and a maximum of 180 feet from the stop line. The preferred location of the signal heads is between 60 and 120 feet from the stop line. When the nearest signal face is located between 150 and 180 feet beyond the stop line, engineering judgment of conditions, including worst-case visibility conditions, is to be used to determine whether the provision of a supplemental or nearside signal face would be beneficial. When it is not physically possible to locate displays at least 50 feet from the stop line, the distance to the displays may be reduced as follows:
    a. 3-section vertical and 5-section cluster (doghouse) displays may be located between 40 and 50 feet from the stop line.
    b. 4-section vertical displays may be located between 41 and 50 feet from the stop line.
    c. 5-section vertical displays may be located between 45 and 50 feet from the stop line.

    The distances listed above are the minimums required to maintain 16.5 feet of clearance over the roadway with a backplate installed.

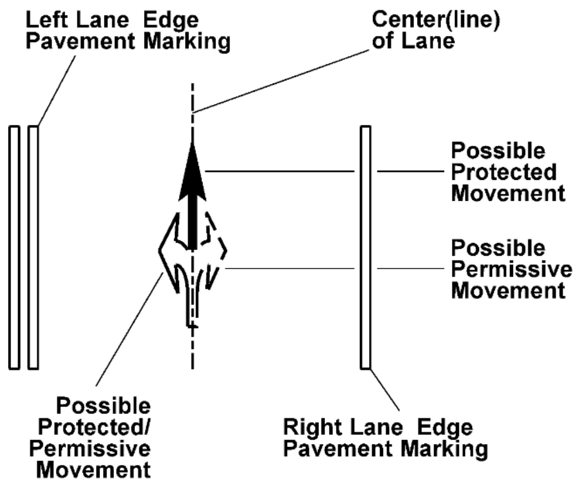
    Overhead displays should always be located on the far side of the crossing roadway for the best visibility. Locating overhead displays on the near side of the roadway results in issues with visibility and driver compliance with stop lines. When an overhead display is located on the near side of the crossing roadway, the stop line typically has to be pushed back so that the minimum visibility distance is met. However, this also pushes the stop line back too far for drivers to see cross traffic, resulting in drivers creeping past the stop line towards the intersection – especially for turning traffic. This results in both the driver being stopped past the stop line and being unable to see the signal displays.

    For ramp meter signals, place Type RM signal standards and displays at the stop line.
5. Use vertical vehicle-signal display configurations. Horizontal displays are not allowed unless clearance requirements cannot be achieved with vertical displays or unless they are being installed at an intersection to match other displays in the intersection. Approval by the State Traffic Engineer is required for the installation of horizontal displays.

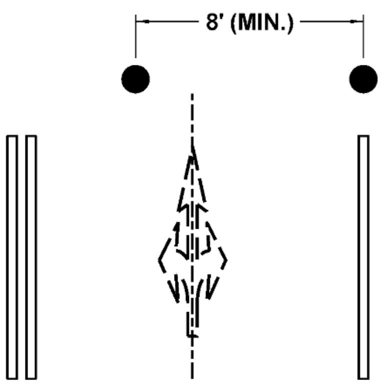
6. Use 12-inch signal sections for all vehicle displays except the lower display for a post mounted ramp meter signal.
7. Provide displays for turning movements with dedicated lanes as follows:
   a. For protected movements, use all arrow displays.
   b. For protected / permissive movements, use four section arrow displays. Alternatively, a shared five section cluster (doghouse) display may be used for both the turn lane and the adjacent through lane. Note: A three section arrow display, with bi-modal flashing yellow arrow / steady green arrow may be used in cases where windload or vertical roadway clearance will not allow for the use of a four-section display. If vertical clearance can be accommodated through adjustments to the signal display mount, such as mounting the Type M mount between different display sections, a four section arrow display should be used.
   c. For permissive right turns, a three-section arrow display with flashing yellow arrow (Exhibit 1330-7g) is optional. This display is highly recommended where there are concerns regarding permissive right turns and the conflicting pedestrian crossing movement, such as known incidents or high volumes of both pedestrian crossings and right turn movements.
8. Use steady green arrow indications only when the associated movement is completely protected from conflict with other vehicular and pedestrian movements. This includes conflict with a permissive left-turn movement. At T intersections, steady green arrow displays may not be used for a movement that has a conflicting pedestrian movement.
9. Use either Type M or Type N mountings for vehicle display mountings on mast arms, as directed by the region maintenance staff or owning agency. Provide only one type of mounting for each signal system. Mixing mounting types at an intersection is not acceptable except for supplemental displays mounted on the signal standard shaft.
10. Use backplates for all overhead-mounted displays for new, updated, or rebuilt signal faces. Add backplates to all existing signal displays that do not already have them.
11. Use Type E mountings for pedestrian displays mounted on signal standard shafts unless otherwise approved by region maintenance staff or the owning agency.
12. Include supplemental signal displays when the approach is in a horizontal or vertical curve and the intersection visibility requirements of this section and the MUTCD cannot be met, unless approved otherwise by the region Traffic Engineer.

    Supplemental far side displays are recommended at intersections with higher truck volumes, as the trucks will frequently block visibility of overhead displays for following drivers. Supplemental far side protected left turn displays are recommended for long left turns.

Exhibit 1330-7a Signal Display Placements – Key to Diagrams

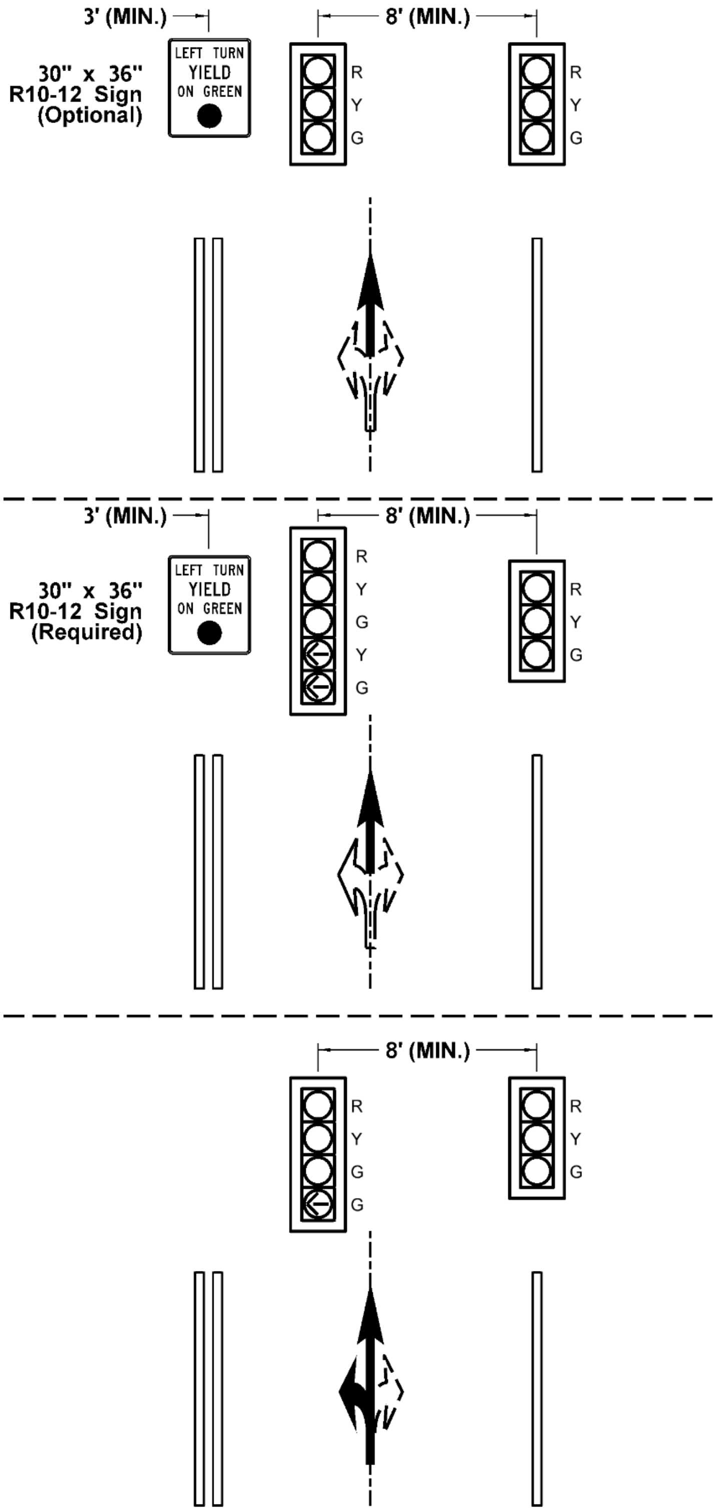


Pavement markings are used to represent possible lane lines and vehicular movements.
The lane lines shown are typical, but not necessarily required.



All signal mounts must be a minimum of 8 feet apart, measured center to center.
This example shows typical mount locations for a single approach lane.

Exhibit 1330-7b Signal Displays for Single Lane Approach

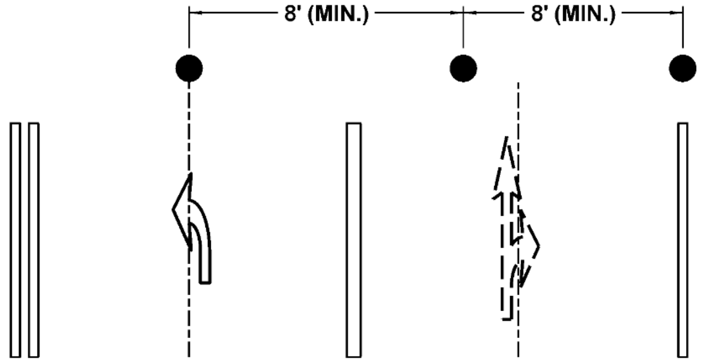


Single lane approach with permissive (or no left turns).
R10-12 sign optional.
Where left turns are prohibited, install a 30” x 30” R3-2 No Left Turn (Symbol) Sign in place of the R10-12 sign shown here.

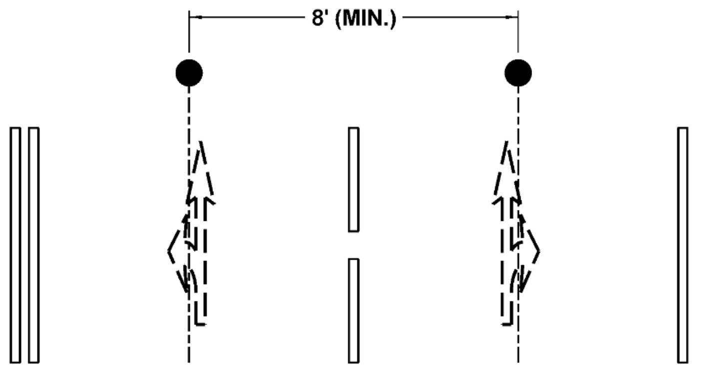
Single lane approach with protected / permissive left turns.
R10-12 sign required.

Single lane approach with protected left turns.

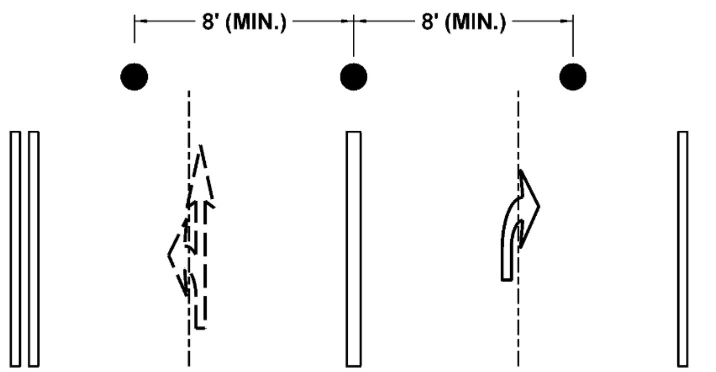
Exhibit 1330-7c Signal Display Mounting Locations for Multi-Lane Approaches



Single through lane with left turn lane(s).
Through lane displays arranged the same as for a single lane approach.
Left turn display(s) centered over lane(s).

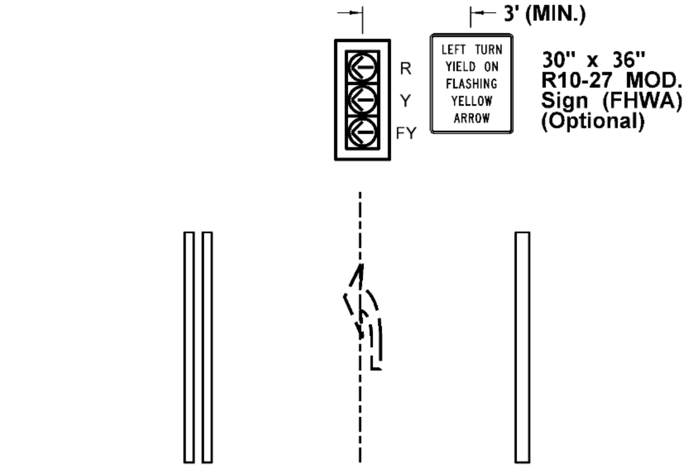


Multiple through lanes.
Center displays over each lane.

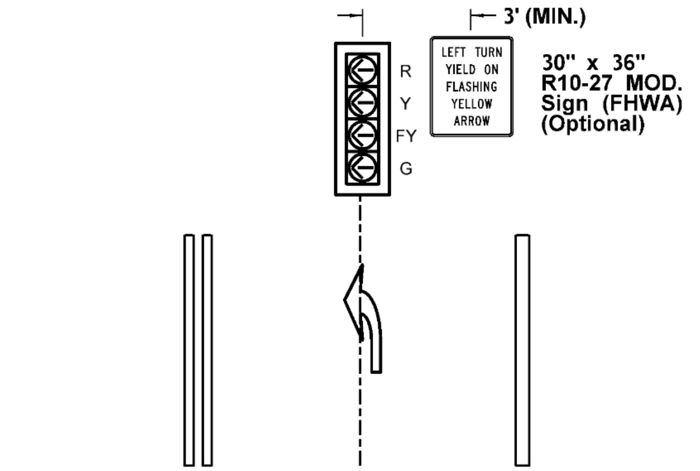


Single through lane with right turn lane(s).
Through lane displays arranged the same as for a single lane approach.
Ensure that the 8-foot spacing requirement is met if a right turn display is installed overhead.

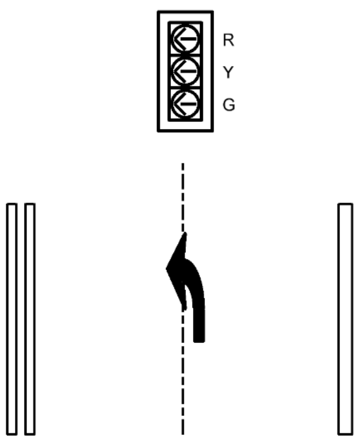
Exhibit 1330-7d Signal Displays for Dedicated Left Turn Lanes



Dedicated left turn lane with permissive left turns.
R10-27 (Modified) sign optional.

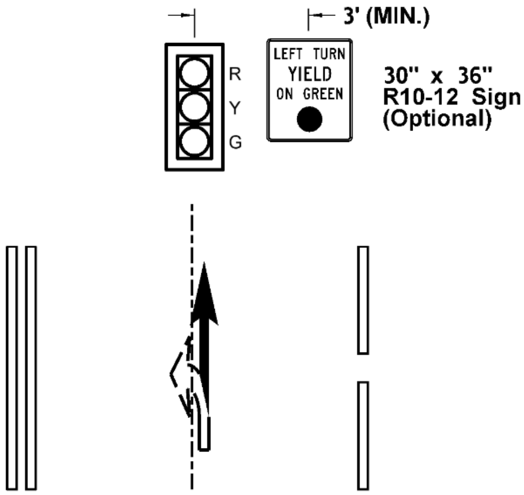


Dedicated left turn lane with protected / permissive left turns.
R10-27 (Modified) sign optional.

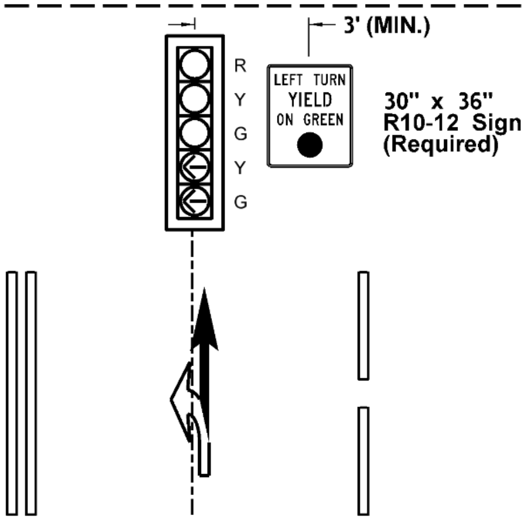


Dedicated left turn lane with protected left turns.

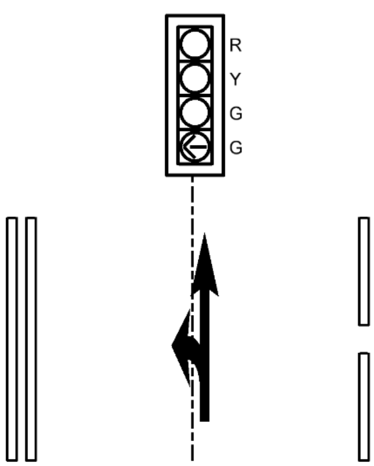
Exhibit 1330-7e Signal Displays for Shared Through-Left Lanes – Multiple Through Lanes



Shared through-left lane with permissive left turns.
R10-12 sign optional.

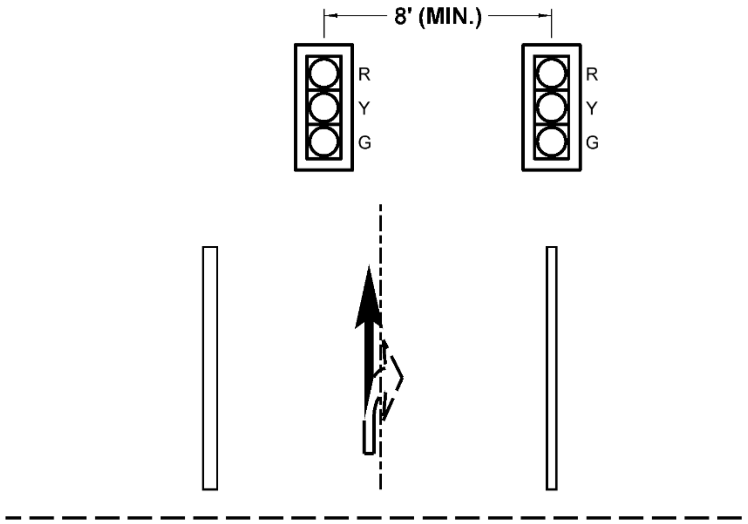


Shared through-left lane with protected / permissive left turns.
R10-12 sign required.

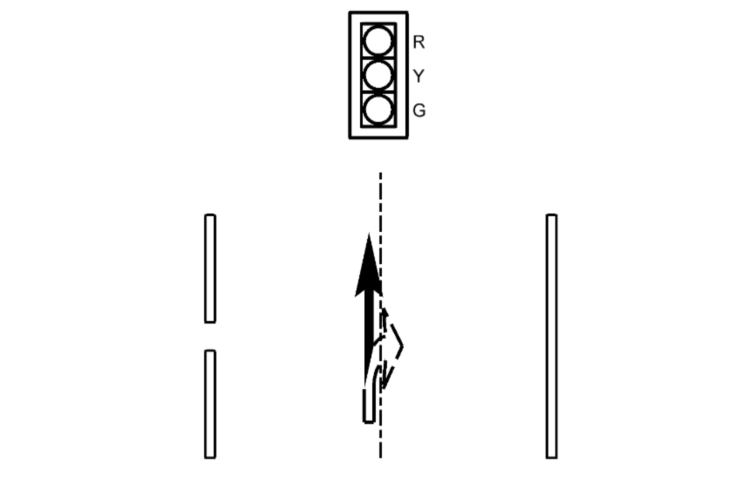


Shared through-left lane with protected left turns.

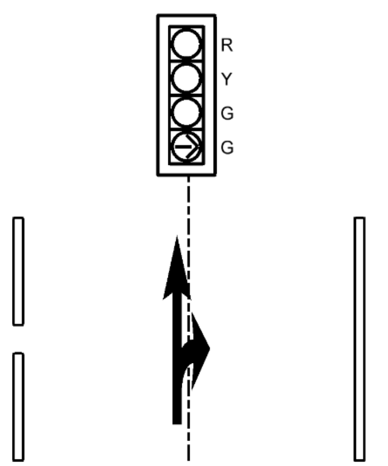
Exhibit 1330-7f Signal Displays for Shared Through-Right Lanes



Single shared through-right lane with permissive right turns.

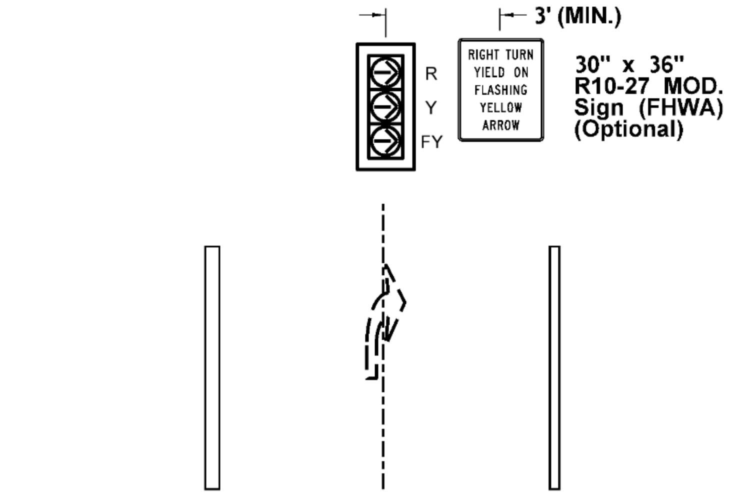


Shared through-right lane, multiple through lanes, with permissive right turns.

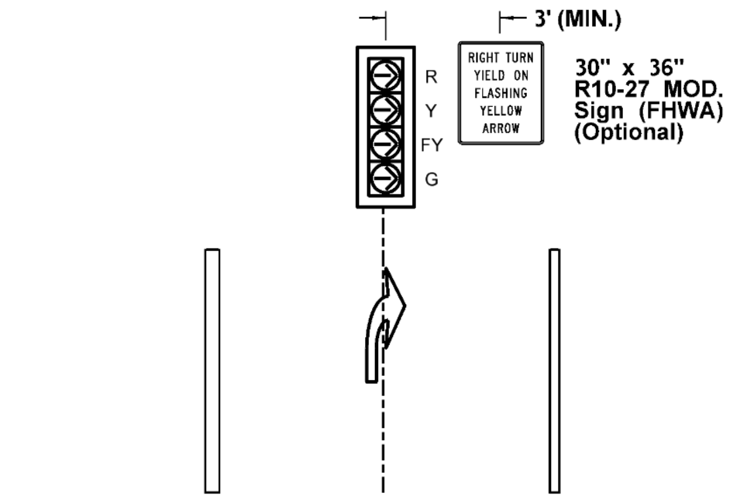


Shared through-right lane, multiple through lanes, with protected right turns.
For protected / permissive right turns, mirror protected / permissive left turn display from Exhibit 1330-7e.

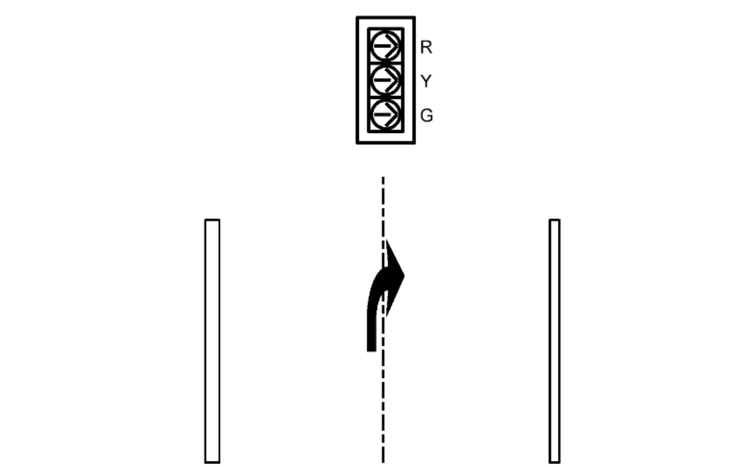
Exhibit 1330-7g Signal Displays for Dedicated Right Turn Lanes



Dedicated right turn lane with permissive right turns.
R10-27 (Modified) sign optional.

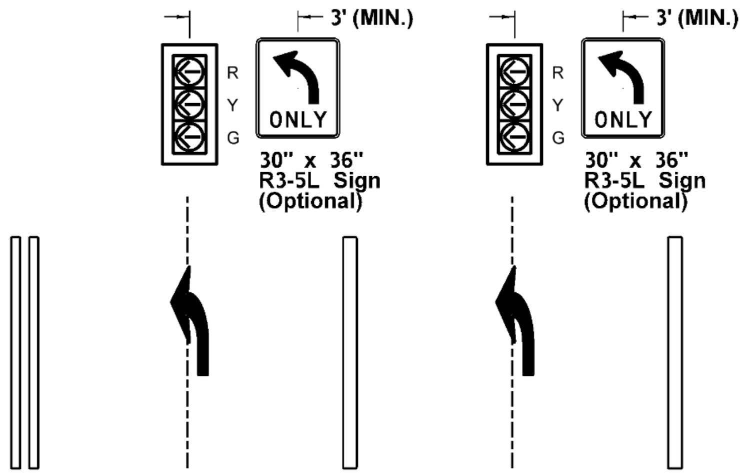


Dedicated right turn lane with protected / permissive right turns.
R10-27 (Modified) sign optional.

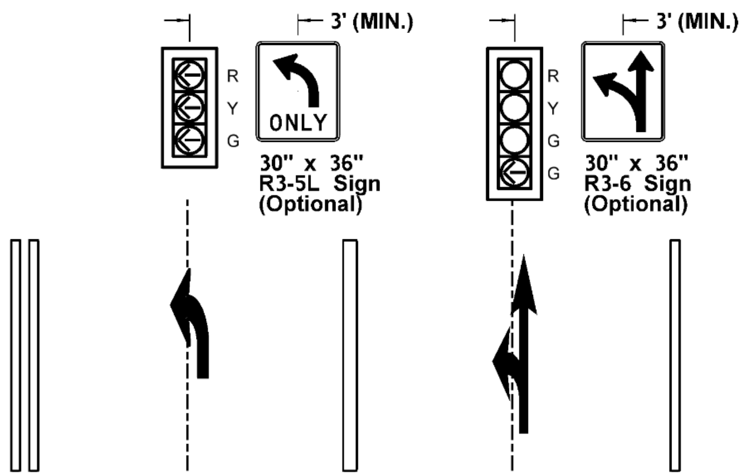


Dedicated right turn lane with protected right turns.

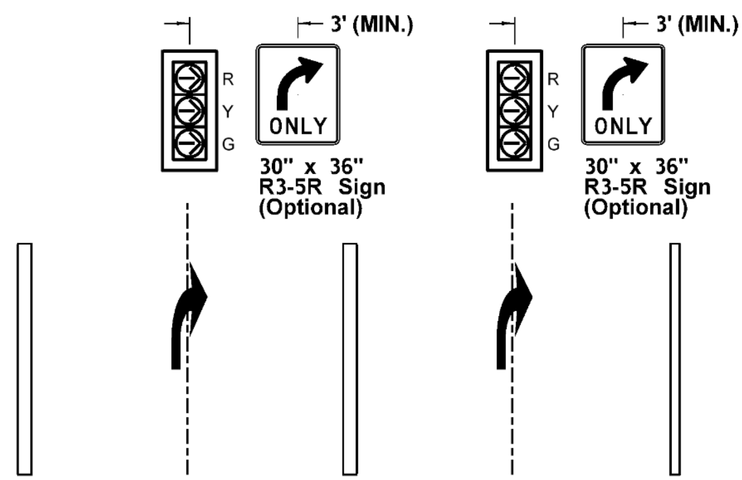
Exhibit 1330-7h Signal Displays for Multiple Turn Lanes



Multiple left turn lanes.
R3-5L signs optional.

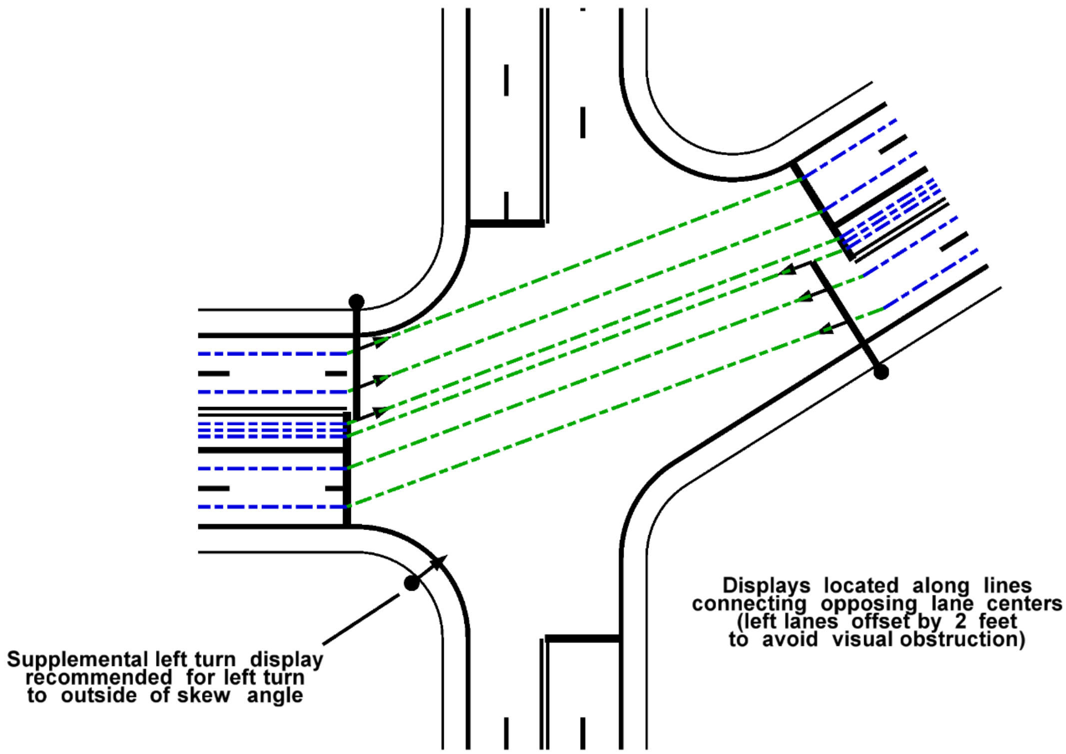


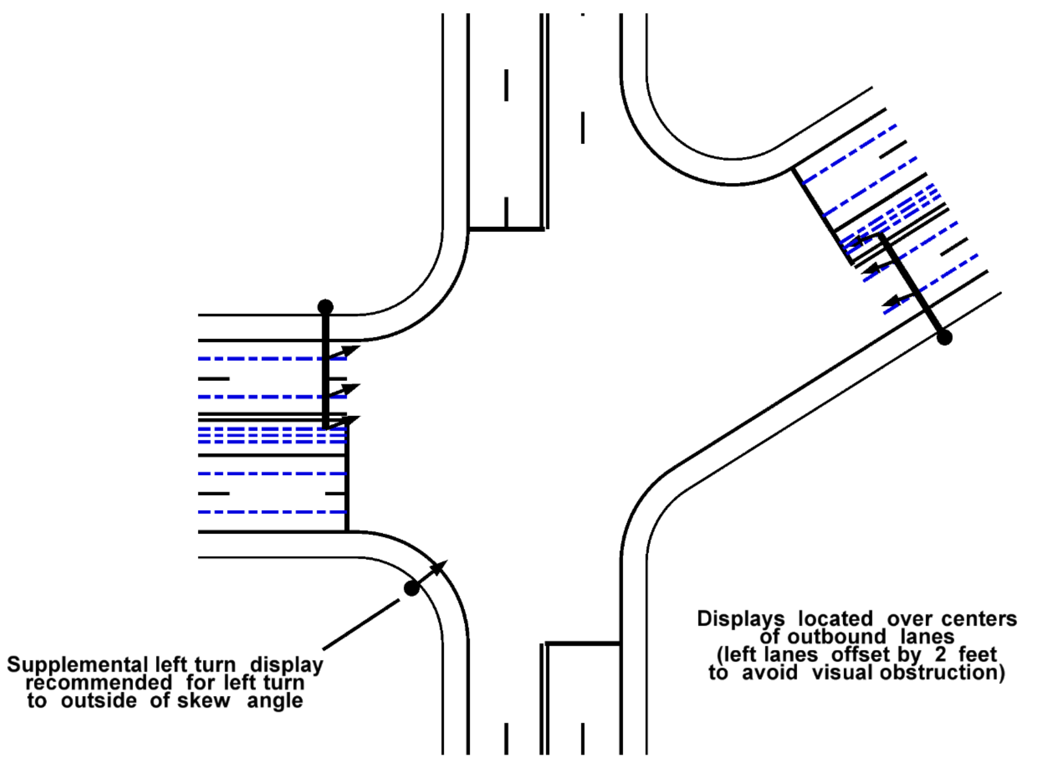
Multiple left turn lanes, with a shared through-left lane.
R3-5L and R3-6 signs optional.
Mirror for right turns.



Multiple right turn lanes.
R3-5R signs optional.

Exhibit 1330-8 Example Signal Display Placement for Skew Intersection





The minimum mounting height for overhead signal displays is 16.5 feet from the roadway surface to the bottom of the signal housing, including the backplate. There is also a maximum height for signal displays allowed by the MUTCD, since the roof of a vehicle can obstruct a motorist's view of a signal display. The maximum heights from the roadway surface to the bottom of the signal display housing with 12-inch displays are shown in Exhibit 1330-9.

Exhibit 1330-9 Signal Display Maximum Heights

Distance to Stop Line (ft)	Signal Display Arrangement	Maximum Height (to bottom of display housing [3])
40 [1]	Vertical 3-section	17.5 ft
42 [1]	Vertical 4-section	17.0 ft
45 [1]	Vertical 5-section [2]	17.0 ft
53 to 180	Vertical 3-section	22.0 ft
	Vertical 4-section	20.8 ft
	Vertical 5-section [2]	19.6 ft

Notes:

[1] Minimum distance required to achieve 16.5 feet of clearance with backplate installed.

[2] For 5-section cluster displays, use the Vertical 3-section heights.

[3] Subtract 0.5 ft for height to bottom of backplate.

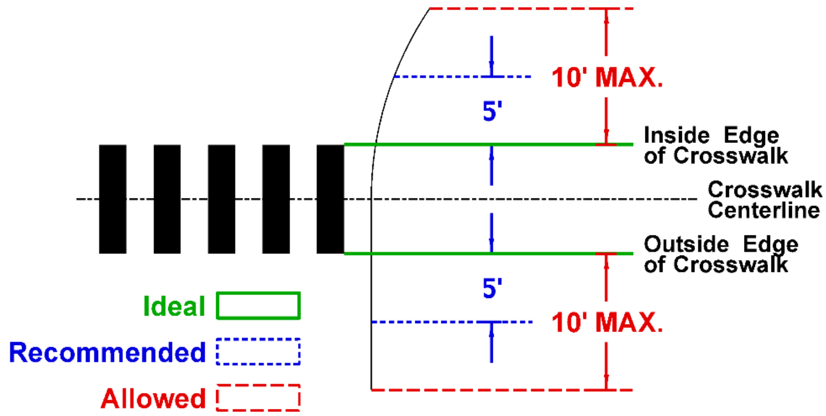
At signalized intersections with railroad preemption, install blankout signs for turning movements that do not have a dedicated signal display (3-section arrow display). Blankout signs are 36" x 36" and will display either a No Right Turn symbol (R3-1) or No Left Turn symbol (R3-2) when activated, as appropriate. Blankout signs should be placed the same as equivalent static signs.

1330.04(4) Pedestrian Equipment

Pedestrian equipment consists of pedestrian signal displays and pedestrian detectors (pushbuttons). New signal systems are required to use countdown displays and Accessible Pedestrian Signal (APS) pushbuttons. See 1330.04(4)(a) for pedestrian display and detection requirements for existing signal systems. No intersection may have a mix of APS and non-APS pushbuttons, nor may any intersection have a mix of countdown and non-countdown pedestrian displays.

Pedestrian displays are required to be installed with the bottom of the display housing no less than 7 feet or more than 10 feet above the sidewalk surface. Pedestrian displays are required to be installed to provide maximum visibility at the beginning of the controlled crosswalks. To accomplish this, pedestrian displays should be located no more than 5 feet from the outside edge of the crosswalk, as measured on a line perpendicular to the crosswalk centerline (See Exhibit 1330-10). The offset distance may be offset up to a maximum of 10 feet from the outside edge of the crosswalk if physical constraints prevent the display from being placed no more than 5 feet from the outside edge of the crosswalk.

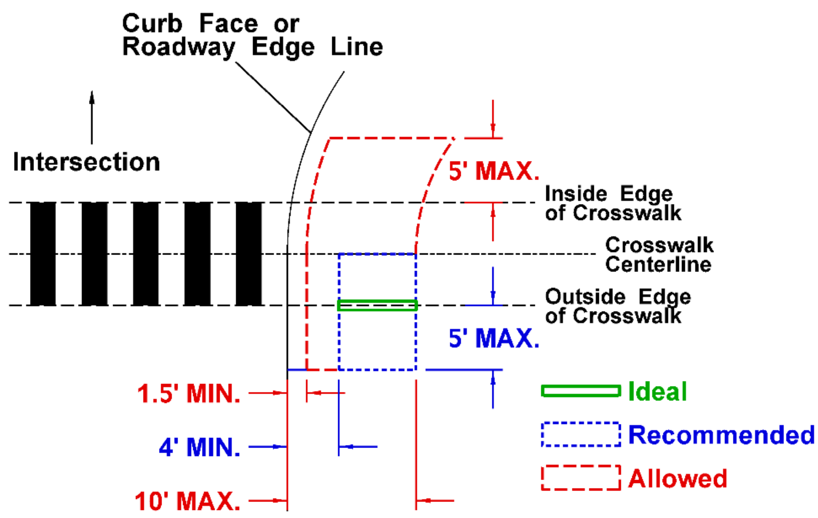
Exhibit 1330-10 Pedestrian Display Placement Requirements



Pedestrian pushbuttons (PPBs) are required to be located within a certain distance of the crosswalk being served and oriented such that the sign on the pushbutton is parallel to the crosswalk served. Pedestrian pushbutton location requirements are as follows:

- The PPB should be between 4 and 6 feet from the face of curb, where sidewalk is present, or the edge line of the roadway where there is no sidewalk. The PPB may be between 1.5 and 4 feet from the curb face or edge line, but this is not recommended due to proximity to the roadway. The PPB may not be closer than 1.5 feet from the curb face or edge line. If geometric constraints make it impractical to place the PPB within the 4-6 foot range, the PPB should not be further than 10 feet from the edge of curb, shoulder, or pavement. Contact the HQ Traffic Office if the PPB cannot be placed within 10 feet of the curb face or edge line.
- The PPB should be located as close to the outside edge of the crosswalk line as possible, so that for APS PPBs, the button and sign face towards the core of the intersection, rather than back down the adjacent approaching roadway. The PPB may be located no more than 5 feet outside either edge of the crosswalk line.
- If possible, PPBs should be located on separate poles and be separated by a minimum of 10 feet.
- See Exhibit 1330-11 for recommended and allowed PPB placement locations.

Exhibit 1330-11 PPB Placement Requirements



PPBs are required to be located so that the actual button, not just the assembly, is within 9 inches horizontally of a level all-weather surface (generally sidewalk or paved road shoulder) as described in Chapter 1510. To accomplish this, certain criteria must be met depending on the type of pole upon which the pushbutton is installed:

a. For vertical shaft poles (Type PPB, PS, I, FB, or RM), the center of the pole shall be no more than 9 inches from the edge of the level clear space. The pushbutton shall not be oriented more than 90 degrees from facing the level clear space. (See Exhibit 1330-12a.)

b. For larger signal standards (Type II, III, IV, IV, or SD), the button must face the level clear space, with the edge of the pole baseplate no more than 6 inches from the edge of the level clear space. It is recommended that the pole either be in the sidewalk, or the edge of the pole base plate be installed as close to the back of sidewalk as possible. (See Exhibit 1330-12b.) Some minor rotation of the button on the pole is possible, but even smaller angles may quickly exceed the allowed reach limit – particularly on larger poles.

Exhibit 1330-12a PPB Placement on Vertical Shaft Poles

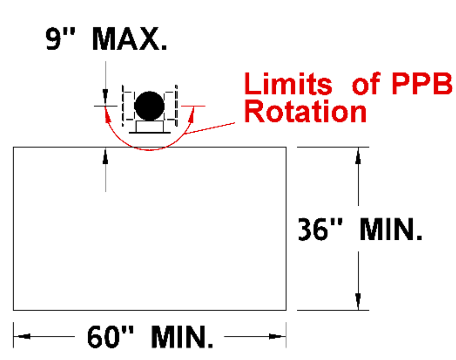
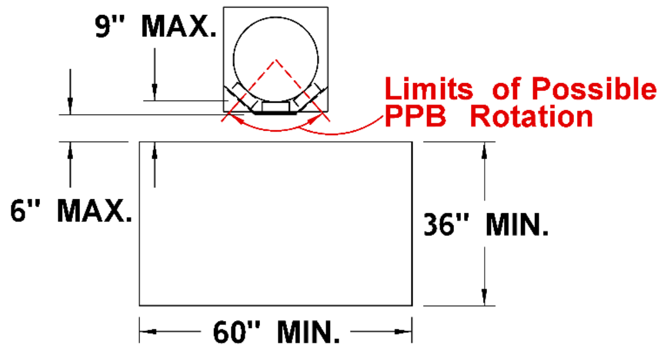


Exhibit 1330-12b PPB Placement on Large Signal Standards



In all cases, it is recommended that the pole be installed in the sidewalk for maximum accessibility. However, the pole and the pushbutton itself are obstructions and must not encroach upon the required minimum pedestrian access route widths (see Chapter 1510).

PPBs are required to be installed at 42 inches above the level clear space, as measured to the center of the actual button. Existing pushbuttons do not require a height adjustment if the center of the actual button is within a range of 36 to 48 inches above the level clear space.

Where there is a median or center island with a pedestrian refuge, consult with signal operations to determine if a pushbutton should be installed in the pedestrian refuge area. This may be justified for locations with particularly long crossings or slower moving pedestrians.

For WSDOT owned systems, pedestrian signal equipment may not be installed on light standards. Do not install pedestrian signal equipment on light standards for systems owned by other jurisdictions unless directed to do so by that jurisdiction.

1330.04(4)(a) Accessible Pedestrian Signals and Countdown Pedestrian Displays

Accessible Pedestrian Signals consist of a pedestrian pushbutton with integrated vibro-tactile and audible versions of the visual indications presented by pedestrian signal displays. APS are required at any location with a pedestrian display – *even if there was no pedestrian detection previously*. This is due to the requirement to provide non-visual indication of the pedestrian phase. All new construction traffic signals are required to include APS.

Countdown pedestrian displays are displays which use a combination of an overlapping person (walk) and hand (don't walk) indication and an adjacent two digit countdown timer display. The timer counts down the seconds remaining in the pedestrian clearance phase (flashing don't walk). For WSDOT owned traffic signals, all new construction traffic signals are required to include countdown pedestrian displays. For new construction traffic signals owned by other jurisdictions, countdown pedestrian displays are required unless directed otherwise by the owning jurisdiction.

For existing signalized intersections where pedestrian equipment was not previously installed, the installation of APS and countdown pedestrian displays is required for the entire intersection. This may require new or relocated poles, as well as additional ramp and sidewalk work beyond that necessary for basic sidewalk and ramp ADA compliance.

At signalized intersections with existing pedestrian equipment, the following criteria determine when APS pushbuttons and countdown pedestrian displays shall be installed:

1. The following are considered minor signal upgrades, and do not require the installation of APS pushbuttons or countdown pedestrian displays at that intersection:
    a. Where pushbuttons are only being adjusted in height or orientation.
    b. Where pushbuttons are being relocated on a single corner, including to a new pole, and no other work (including sidewalk or ramp work) is taking place at any other corner, pushbuttons may be relocated or replaced with the same type of pushbutton as currently exists at that intersection. Countdown pedestrian displays are not required to be installed at that intersection. New pole location(s) must meet accessibility requirements for pedestrian pushbuttons (see Chapter 1510.12). Accessibility for any affected poles must be evaluated for both existing pushbuttons and future APS pushbuttons.
2. The following types of work shall include the installation of APS pushbuttons and countdown pedestrian displays as described below:
    a. At any signalized intersection included in a project that is designated as an alteration project, as defined in Chapter 1510.05(2):
        i. For WSDOT owned traffic signal systems, install APS pushbuttons and countdown displays. For any project which has completed its scoping phase before August 1, 2018, consult with your ASDE to determine if APS pushbuttons and countdown pedestrian displays can be added to the project – documentation is not required if the project cannot support the expanded scope of work.
        ii. For traffic signal systems owned by other agencies, install APS pushbuttons and countdown displays if funded by the owning agency.
    b. At any signalized intersection where APS pushbuttons are being installed in response to a public request, replace all pushbuttons and pedestrian displays with APS pushbuttons and countdown pedestrian displays at that intersection. Additional poles may be required and ramp and sidewalk work may be necessary to support access to new APS locations / orientations.
    c. For any other project, not previously described, which requires traffic signal system work affecting pedestrian pushbuttons, replace all pushbuttons and pedestrian displays with APS pushbuttons and countdown pedestrian displays. This may require additional ramp and sidewalk work to provide required accessibility to and for APS locations / orientations beyond that already required for other ADA compliance efforts.

APS pushbuttons are required to include the following features:

1. Audible and vibrotactile indications of the WALK interval.
2. A locator tone which operates only during the DON’T WALK and flashing DON’T WALK intervals.
3. A tactile arrow on the pushbutton (control surface) indicating the crossing direction served. This arrow must be high contrast with the rest of the button – either light on dark or dark on light.

4. An integral 9” x 15” R10-3e sign.
5. If additional crossing time will be provided as part of an extended press feature, a supplemental R10-32P sign is required to be installed adjacent to or integral with the APS PPB.

1330.04(5) Signal Standards (Supports)

Signal standards consist of five main types of supports: Vertical Steel Shaft, Cantilevered Steel Mast Arm, Steel Strain Pole, Wood Strain Pole, and Signal Bridge. The type of support selected will depend on required placement of vehicle signal displays and the ability of the support to reach that location. The MUTCD states that the preferred location for signal displays is overhead on the far side of the intersection.

Signal displays may also be mounted to bridges where clearance will not allow an alternate signal standard type. Installation on bridges requires approval of both the region Traffic Engineer and the HQ Bridge and Structures Office.

Signal Standards shall be considered in the following order of preference:

1. **Cantilevered Steel Mast Arm**. These are the standard support type for permanent systems, and should be used whenever possible. Mast arm installations are preferred because they generally provide better placement of the signal displays, greater stability for signal displays in high-wind areas, and reduced maintenance costs. Mast arm lengths are limited to 65 feet from center of pole to farthest display mount – if additional length is needed, an alternate support type must be used.
2. **Span Wire System (Steel or Wood Strain Poles).** These systems may be used when displays are needed at a greater distance than a mast arm system can support, or if a system is expected to be in place for less than 5 years. Steel poles are required to be used for permanent signal systems. Temporary signal systems (systems to be removed under the same contract as installation) may use wood poles. The use of wood poles beyond the end of a contract or for longer than 5 years requires the approval of the region Traffic Engineer. Individual spans have a limit of 150 feet – longer spans require design by the HQ Bridge and Structures Office.
3. **Signal Bridge.** Signal bridges shall only be used when no other alternative can physically be installed and support displays in the required locations. Diagonal signal bridges are not recommended as they are extremely difficult to maintain and result in displays being too close to at least one of the two cross streets, resulting in poor display visibility. Diagonal spans in general are not recommended as a failure will result in the loss of the entire signal system, rather than just one or two directions.
4. **Vertical Steel Shaft.** Vertical steel shaft supports should only be used for supplemental vehicle displays or pedestrian equipment. In special cases (such as in a small historic town), vertical steel shaft supports may be used without overhead signal displays if approved by the region Traffic Engineer, as allowed by the MUTCD. This practice is not recommended, as displays are too easily obstructed from view.

When placing signal standards, the primary consideration is the visibility of signal faces. Place the signal supports as far as feasible from the edge of the traveled way without adversely affecting signal visibility. (The MUTCD provides additional guidance on locating signal supports.) Initially, lay out the location for supports for vehicle display systems, pedestrian detection systems, and pedestrian display systems independently to determine the optimal location for each type of support. Consider the need for future right-turn lanes or intersection widening when choosing the final location of the signal standards. Poles should also be located outside of sight triangles for turning traffic.

If conditions allow and optimal locations are not compromised, pedestrian displays and pedestrian detectors can be installed on the vehicular display supports. However, pole placement cannot encroach on pedestrian access route or maneuvering space requirements. Pole mounted appurtenances, such as pushbuttons, terminal cabinets, and displays, need to be taken into consideration regarding their encroachment into accessible spaces.

Another important consideration that can influence the position of signal standards is the presence of overhead and underground utilities. Verify the location of these lines during the preliminary design stage to avoid costly changes during construction:

a. **Underground Utilities:** Underground utilities must be located, marked, and surveyed. If any underground utility is within 10 feet of any foundation, consider potholing for the utility to find its actual location. Field locates are rarely precise and must be verified if a potential conflict exists.

b. **Overhead Utilities:** Signal standards may be located within close proximity to overhead communications lines (phone, cable, fiber-optic), but the lines should not touch the any part of the signal system and should not pass in front of any displays. Overhead power lines require a minimum 10-foot circumferential clearance for lines rated at 50kV (50,000 V) or below, including the neutral. For lines rated over 50kV, the minimum clearance is 10 feet plus 0.4 inches for each kV over 50kV. Overhead utilities may have to be relocated if a suitable location for signal equipment cannot be found.

Once pole locations have been selected, a soils investigation is required to determine the lateral bearing pressure, the friction angle of the soil, and whether groundwater may be encountered. Standard foundations may be used if the soil lateral bearing pressure is at least 1,000 psf, the friction angle is at least 17°, and the ground slope is 2H : 1V or flatter. Standard foundation information is found in the *Standard Plans*, and depends on the type of support system being used.

Special foundation designs are required if the soil lateral bearing pressure is less than 1,000 psf, the friction angle is less than 17°, or the ground slope is steeper than 2H : 1V. The region materials group works with the HQ Materials Laboratory to determine the bearing pressure and friction angle of the soil at the proposed foundation locations. If soils do not meet these minimum values for lateral bearing pressure and friction angle, the signal standard charts and soil conditions report (summary of geotechnical conditions for foundations) must be forwarded to the HQ Bridge and Structures Office with a request for special foundation design. The HQ Bridge and Structures Office designs foundations for the regions and reviews designs submitted by others.

Where poles are installed on structures, the anchorage must be designed by the Bridge designer. Coordinate with the Bridge designer for placement and design of pole anchorages on structures.

Do not place any signal standard in a median area. The sole exception is a Type PS or Type PPB signal standard as required for median refuge areas for pedestrians.

Coordinate with all stakeholders (Maintenance, Signal Operations, Civil Design Engineer, Drainage Engineer, and so on) in the placement of signal equipment to avoid any possible conflicts. Arrange field reviews with the appropriate stakeholders as necessary.

1330.04(5)(a) Mast Arm Signal Standards and Foundation Design

Mast arm signal standards are designated by the following types:

- Type II: Single mast arm with no luminaire mount.
- Type III: Single mast arm with luminaire mount.
- Type SD: Double mast arm, with or without luminaire mount.

Mast arm signal standards are normally located on the far right corner of the intersection from approaching traffic. A typical mast arm signal standard only has one mast arm, however two may be used. If the angle between the two arms is not exactly 90 degrees, the design must be sent to the bridge and structures office. In most cases, two arms at 90 degrees can support the necessary display positioning. Additionally, signal standards on mast arms may be rotated up to 30 degrees from center. Do not allow a mast arm for one direction to cross in front of the mast arm for a different direction if possible, as it results in a visual obstruction of the signal displays. Where two double arm signal standards are installed on opposite corners, the preferred location for the two poles are the far right corners of the mainline roadway. This way, the mast arms for the mainline traffic will not cross in front of each other.

Mast arm signal standards have a typical arm attachment point of 18 to 20 feet in height. This height range needs to be taken into consideration when placing signal displays in order to ensure that the display height requirements shown in 1330.04(3) are met. The attachment point height may be adjusted throughout this range as necessary, but increments of 0.5 feet are recommended for ease of fabrication. Connection points outside of this range are a special design, and require design support from the Bridge and Structures Office.

Mast arm signal standards are designed based on the total wind load moment on the mast arm. The moment is a function of the surface area of each appurtenance (signal display or sign), X * Y, and the distance between the vertical centerline of each appurtenance and the vertical centerline of the signal pole Z. This determines the total wind load moment, referred to as an XYZ value and measured in cubic feet, which is used to select the appropriate mast arm fabrication plan and foundation design. Preapproved mast arm fabrication plans are available at http://www.wsdot.wa.gov/Bridge/Structures/LSS.htm, and will be listed in the Contract Provisions. To determine the XYZ value for a signal standard, the XYZ value of each appurtenance must be calculated. These values are then totaled to determine the overall XYZ value for the signal standard. For signal standards with two mast arms at 90 degrees apart, the larger of the two XYZ values calculated for each mast arm is used for the overall pole XYZ value.

When determining the XYZ values, use the worst-case scenarios for signal display and sign placements. All signal displays and mast arm-mounted signs, including street name signs, must be included in this calculation. Emergency preemption detectors, preemption indicator lights, cameras, and radar detectors are negligible and are not included in determining the XYZ values. For mast arm-mounted signs, use the actual sign area (in square feet) to determine the XYZ value. For poles with luminaire supports, the luminaire and arm is also included in the total XYZ calculation. Surface areas for vehicle displays are shown in Exhibit 1330-13. Signs are limited in size as follows:

- Street name signs may be a maximum of 36 inches in height and 36 square feet in total area. Design the mast arm to support the widest sign that will fit within these limits (up to 144 inches wide), regardless of the actual sign size needed. This allows for future changes to the street name sign. Street name signs are mounted such that the edge of the pole is no less than 1 foot but no more than 2.5 feet from the vertical pole centerline, as shown in the *Standard Plans*. Use the offset necessary for the largest possible sign in the signal standard chart for the XYZ value, but refer to the *Standard Plans* for actual sign installation requirements using construction notes in the Contract Plans.
- Other mast arm mounted signs may not exceed 36 inches in height and 7.5 square feet in area.
- Signs mounted on the vertical pole may not exceed 36 inches in width and 15 square feet in area. These signs are not included in the XYZ calculation.

After calculating the total XYZ value, adjust the total XYZ value as follows:

If the total XYZ value is less than or equal to 2850 ft^3, round the XYZ value up to the next standard foundation XYZ value or 2850 ft^3, whichever is lower, to determine the design XYZ value. The design XYZ builds in some flexibility for future modifications.

- If the total XYZ value exceeds 2850 ft^3, use the calculated XYZ value. There is limited opportunity for future increased wind load when the XYZ value exceeds 2850 ft^3.

Exhibit 1330-13 Signal Display Surface Areas

Signal Display	Area
Vertical 3-section	9.2 sq ft
Vertical 4-section	11.6 sq ft
Vertical 5-section	14.1 sq ft
5-section cluster	14.4 sq ft

After the total XYZ value is determined, if a standard foundation may be used, select the correct foundation depths for the XYZ values from the table in the *Standard Plans*, using the next higher total XYZ value. For WSDOT systems, only the 700, 1350, 1900, 2600, and 3000 columns may be used. All five foundation options should be provided unless there is a known constraint preventing the use of one of the options, such as insufficient space for 4 ft diameter foundation or expected loose soil requiring the use of the Alternate 2 foundation construction.

1330.04(5)(b) Span Wire Signal Standards and Foundation Design

Span Wire Systems use poles and aerial wires to support signal displays, signs, and emergency preemption equipment. Cameras, radar detectors, and street name signs are installed on the vertical strain poles. When laying out span wires, the preferred layout is similar to mast arm supports. Displays for an approach should be installed on a span on the far side of the intersection, with poles on the two far corners. Do not use diagonal spans unless absolutely necessary, as they are extremely difficult to maintain and if the wire is broken, the entire signal system is lost and blocks the entire intersection, rather than the equipment for only one approach.

Span wire signal standards include both steel and timber strain poles. Steel and timber strain poles are designated by pole class, which is based on the horizontal tension load the pole will support. The loads and resultant forces imposed on strain poles are calculated and a pole class greater than that load is specified. Steel Pole Classes and their allowed tension loads are listed in the *Standard Plans*. Exhibit 1330-14 lists the pole classes and tension loading available for timber strain poles.

Headquarters Traffic and Headquarters Bridge and Structures office support is required for determining span tension load and pole classes. Provide the pole and span layout, the locations and sizes of all signal displays and span wire mounted signs, and the soils report. Span wire mounted signs are limited to a maximum of 36 inches in height and 7.5 square feet in area. Emergency preemption equipment locations do not need to be submitted, as they are not included in load calculations. Spans should not exceed 150 feet, if possible, in order to reduce the complexity of the design.

After the pole classes are provided by the Headquarters Bridge and Structures office, select the appropriate foundation information from the *Standard Plans* using the pole classes and soil conditions. If a standard foundation cannot be used, a foundation design will be provided along with the pole class information.

Exhibit 1330-14 Timber Strain Pole Classes

Pole Class	Tension Load Limit (lbs)
4	2400
3	3000
2	3700
1	4500
H1	5400
H2	6400
H3	7500

Pole Classes from ANSI Standard O5.1

1330.04(5)(c) Special Case Signal Supports

Special case signal supports include signal bridges and structure (typically bridge) mounts. These should only be selected if absolutely necessary, as they are difficult to design, construct, and maintain, and they frequently result in signal display locations that are difficult for drivers to see. Use of these types of supports requires approval from the Headquarters Traffic Office.

Signal bridges function the same as a diagonal span wire system, with the two supports on opposite corners of the intersection. Signal bridges require windload calculations similar to mast arm signal standards, so display and sign locations and offsets must be provided. Signal bridge foundations must be designed by the Headquarters Bridge and Structures office.

Signal displays and other equipment may be installed on structures when there is insufficient clearance below the structure to allow for a different type of signal support. Coordinate with the Bridge designer to place mounts and determine routing paths for conduit and wiring out of the structure. Structure mounts are not desirable, as they typically cannot be modified without reconstruction of the structure itself, and any equipment embedded in the structure is inaccessible after the structure is complete.

Signal displays may not be installed on sign structures such as cantilever sign structures or sign bridges. Signal displays also may not be installed on railroad cantilever structures unless the signal system and the railroad are owned by the same jurisdiction and maintained by the same staff.

1330.04(5)(d) Vertical Steel Shaft Supports

Vertical steel shaft supports include the following types of signal standards:

(a) Type PPB: Sometimes referred to as a “stub pole”, this pole is typically 5 feet tall and 3 inches in diameter. It is used strictly to support pedestrian pushbuttons. Due to the frequency of damage, regardless of location, it is recommended that breakaway bases always be used.

(b) Type PS, I, RM, and FB: These poles are effectively identical, with the difference being the total height to the slipfitter top.

- Type PS are 8 ft tall and may only have pedestrian displays mounted on the top.
- Type I are 10 ft tall and may have vehicle displays mounted on the top and pedestrian displays mounted on the side. Type RM are identical to Type I but are used for ramp meter systems only.
- Type FB are 14 feet tall, and may be used like Type I when additional height is needed for the vehicle display(s).

Placement of vertical steel shaft supports will depend on visibility requirements for displays and accessibility requirements of pedestrian features. Generally, these supports should be located at back of sidewalk, as they are farther from traffic and more likely to be out of both the pedestrian access route and the path of any users. Fixed bases should be used when located at the back of sidewalk, but slip bases may be used if circumstances recommend it. Supports located within sidewalk (includes planter strips) or in locations with only paved shoulders should always use slip bases.

1330.04(6) Vehicle Detection Systems

Vehicle detection systems are necessary for the efficient operation of traffic signals. By responding to the presence of traffic, signal systems do not have to use fixed timing. This improves efficiency by removing unnecessary delay and not providing service to an approach or movement with no traffic.

1330.04(6)(a) Vehicle Detection Zone Placement

The detection system at a traffic-actuated signal installation provides the control unit with information regarding the presence or movement of vehicles, bicycles, and pedestrians. Vehicle detection systems perform two basic functions: queue clearance and the termination of phases. Depending on the specific intersection characteristics, either of these functions can take priority. The merits of each function are considered and a compromise might be necessary.

There are two basic types of detection zones: stop bar and advance. Stop bar detection is a zone that extends from the stop line to a point 30 to 40 feet in advance of that location. Advance detection is a discrete zone (or zones) placed in advance of the stop line at a distance dependent on vehicle speed.

Basic vehicle detection requirements depend upon the speeds of the approaching vehicles:

(a) When the posted speed is below 35 mph, provide stop bar detection or one advance detection zone. See Exhibit 1330-15 for advance detection zone distances.

(b) When the posted speed is at or above 35 MPH, provide stop bar detection and at least two advance detection zones. Multiple advance detection zones are normally required to accommodate decision zone detection.

(c) Side street advance detection is not required for WSDOT owned signal systems, but may be provided through means that do not require equipment to be installed off of WSDOT right of way. For signals owned by other jurisdictions, the use of side street advance detection is at the discretion of the owning jurisdiction.

A decision zone is a location along the intersection approach where a motorist is forced to make a decision between two alternatives. As applied to vehicle detection design, this situation can occur when two vehicles are approaching a traffic signal and the signal indication turns yellow. The motorist in each vehicle must decide whether to continue through the intersection or stop prior to the intersection. If the lead vehicle decides to brake and the following vehicle does not, there may be a rear-end crash.

For posted speeds of 35 MPH or higher, there are two options for placing advance detectors to address the decision zone:

1. Fixed locations based on posted speed, which is generally the 85th percentile speed. Place loops according to the table in Exhibit 1330-15.
2. Calculated locations based on calculated decision zone detection design. This design increases the opportunity for a range of vehicles from the 90th percentile speed vehicle to the 10th percentile speed vehicle to either clear the intersection or decelerate to a complete stop before reaching the intersection. The method of calculating the decision zone and the required detection loops is shown in Exhibit 1330-16.

Although the exhibits reference loops, advance detectors may be of any approved type.

For new intersection construction where there is no existing traffic, the fixed locations based on posted (target design) speed are to be used. Fixed locations based on posted speed use the same methods as the calculated decision zone detection design, but set V90 at 5 MPH above posted speed and V10 at 5 MPH below posted speed. Engineering judgment based on similar intersections (such as geometrics and traffic volumes) may justify modifying the V90 and V10 speeds used in the calculation, with concurrence from the region Signal Operations Engineer.

Both methods require a study of the approach speeds at the intersection. For intersection approaches, conduct the speed study as follows:

- Collect data at the approximate location or just upstream of the decision zone;
- Collect data during off-peak hours in free-flow and favorable weather conditions;
- Collect data during regular commuting hours in a high volume signalized corridor during favorable weather conditions
- Only document the speed of the lead vehicle in each platoon.

It is important that the person conducting the speed study remain inconspicuous so they do not influence drivers to slow down. Normal driving patterns are needed for proper speed studies. Prior speed-study information obtained at this location may be used if it is less than 18 months old and driving conditions have not changed significantly in the area.

Preserve detection zone placements and any supporting calculations as required by 1330.07 Documentation.

Exhibit 1330-15 Fixed Vehicle Detection Placement

Fixed Detection Placement – Below 35 MPH

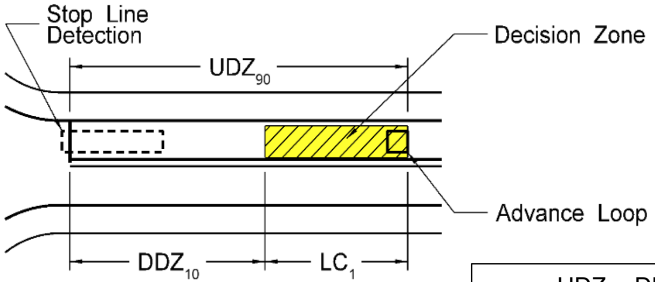
V_{85} =		V_{90} =		V_{10} =		UDZ_{90}	DDZ_{10}	LC_1	P_{MID}	LC_2	Calculated Loop 1	Rounded Loop 1
MPH	ft/s	MPH	ft/s	MPH	ft/s	ft	ft	s	ft	s	ft	ft
25	36.7	30	44.00	20	29.33	165.00	50.84	3.9	107.92	1.9	107.92	105
30	44	35	51.33	25	36.67	216.03	70.28	4	143.15	2	143.15	140

For posted speeds below 35 MPH, only the PMID detection location is used.

Fixed Detection Placement – 35 MPH and Above

V_{85} =		V_{90} =		V_{10} =		UDZ_{90}	DDZ_{10}	LC_1	P_{MID}	LC_2	Calculated Loop 1	Calculated Loop 2	Rounded Loop 1	Rounded Loop 2
MPH	ft/s	MPH	ft/s	MPH	ft/s	ft	ft	s	ft	s	ft	ft	ft	ft
35	51.33	40	58.67	30	44.00	273.78	92.40	4.1	183.09	2.1	183.09	273.78	180	275
40	58.67	45	66.00	35	51.33	338.25	117.21	4.3	227.73	2.2	227.73	338.25	225	340
45	66	50	73.33	40	58.67	409.44	144.71	4.5	277.08	2.3	277.08	409.44	275	410
50	73.33	55	80.67	45	66.00	487.36	174.90	4.7	331.13	2.4	331.13	487.36	330	490
55	80.67	60	88.00	50	73.33	572.00	207.78	5	389.89	2.5	389.89	572.00	385	575
60	88	65	95.33	55	80.67	663.36	243.34	5.2	453.35	2.6	453.35	663.36	450	665

Exhibit 1330-16 Decision Zone Detection Placement



Single Advanced Loop Design

Use when $LC_1 \le 3$ seconds

$$LC_1 = \frac{UDZ_{90} - DDZ_{10}}{V_{10}}$$

Decision Zone Endpoint Calculation

(for all loop arrangements)

Where grades are flatter than +/- 4%:

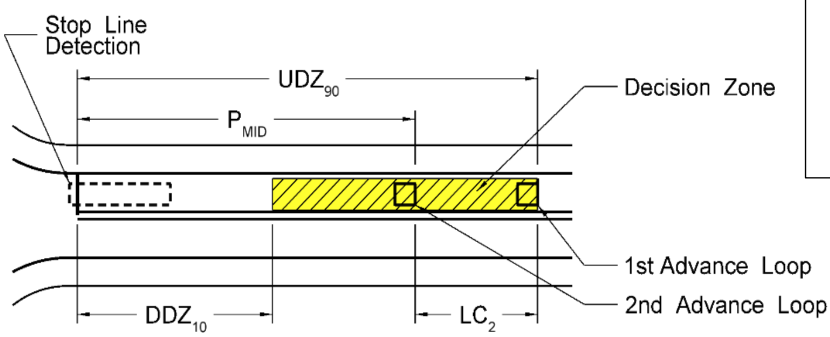
$$UDZ_{90} = \frac{(V_{90})^2}{16} + V_{90}$$

$$DDZ_{10} = \frac{(V_{10})^2}{40} + V_{10}$$

Where grades are +/- 4% or steeper:

$$UDZ_{90} = \frac{(V_{90})^2}{2(8+32.2G)} + V_{90}$$

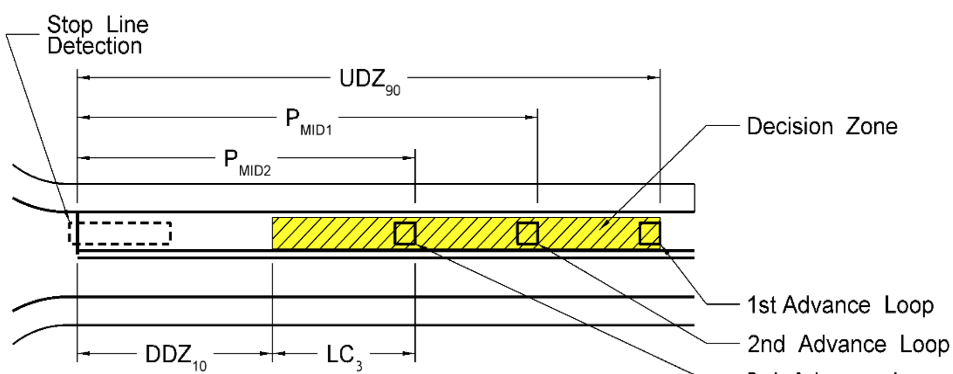
$$DDZ_{10} = \frac{(V_{10})^2}{2(20+32.2G)} + V_{10}$$



Double Advanced Loop Design

Use when $LC_2 \le 3$ seconds

$$P_{MID} = \frac{UDZ_{90} + DDZ_{10}}{2} \qquad LC_2 = \frac{UDZ_{90} - P_{MID}}{V_{10}}$$



Triple Advanced Loop Design

Use when $LC_3 \le 3$ seconds

$$LC_3 = \frac{UDZ_{90} - DDZ_{10}}{3V_{10}} \qquad P_{MID1} = \frac{[2(UDZ_{90}) + DDZ_{10}]}{3} \qquad P_{MID2} = \frac{[UDZ_{90} + 2(DDZ_{10})]}{3}$$

Where:

V_{90} = 90th percentile speed, in feet per second

V_{10} = 10th percentile speed, in feet per second

UDZ_{90} = Upstream end of decision zone, for 90th percentile speed

DDZ_{10} = Downstream end of decision zone, for 10th percentile speed

G = Grade of roadway, in decimal form, including + or – (Example: -4% = -0.04)

LC_1 = V_{10} travel time to DDZ_{10}

LC_2 = V_{10} travel time from UDZ_{90} to P_{MID}

LC_3 = V_{10} travel time from P_{MID2} to DDZ_{10}

1330.04(6)(b) Vehicle Detector Types

There are two basic categories of vehicle detectors:

- **Non-Invasive**: These are detectors installed outside of the roadway, typically overhead in a strategic location. These include camera (optical and infra-red) and radar systems.
- **In-Pavement**: These are detectors which are installed in the road itself. These include induction loops and wireless in-pavement sensors.

Non-invasive detection is generally recommended over in-pavement detection, due to the ability to revise non-invasive detection at any time and the ease of installation, repair, and replacement – particularly when supporting traffic control and impacts are taken into account. Additionally, pavement damage due to regular wear or construction activities will disable in-pavement detection, whereas non-invasive detectors will continue to function, and can even be adjusted to accommodate revised lane configurations.

Stop line detection should use non-invasive systems for detection. Although induction loop detectors are typically the most reliable for detecting cars and trucks, they do not consistently detect bicycles and motorcycles. RCW 47.36.025 specifically requires that vehicle-activated traffic control signals be capable of detecting motorcycles and bicycles.

Advanced detection may be either non-invasive or in-pavement, as these improve efficiency of the signal systems but are not as critical as stop line detection. Non-invasive is recommended for posted speeds of 45 MPH or lower, as they are currently only effective for up to about 600 feet from the location of the detector. The advantage is that advance detection can be installed at the intersection, rather than trenching long distances to place advanced detectors in pavement. For speeds over 45 MPH, non-invasive detection systems may be considered, but in-pavement systems will probably be more effective. Advance detection does not need to detect bicycles.

Selection of detector types will depend on a variety of environmental factors and locations available for placement.

1. **Radar Detectors**

   Radar detectors are located on either the signal mast arms or the signal vertical strain poles, depending on lane configuration, detector type, and location availability. Radar detectors are not affected by weather, and are typically minimally affected by mast arm motion in high wind. Consult the detector manufacturer’s installation guidance for placement details. One detector can normally cover all lanes of an approach for that type of detection (stop line or advance).

2. **Video Detectors**

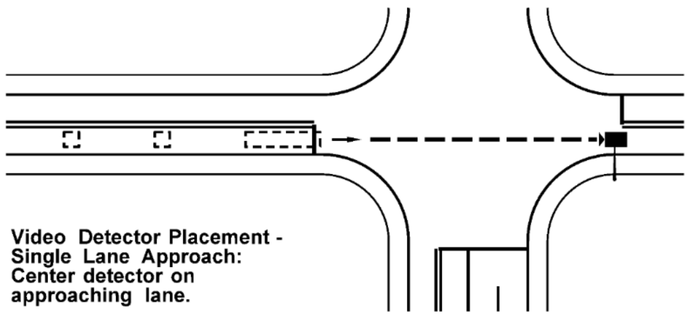
   Placement of video detectors depends on the function of the detector. Exhibit 1330-17 provides placement examples.

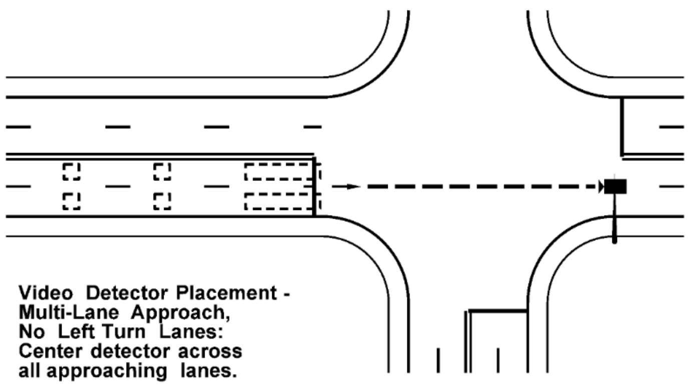
   Stop line detectors should be installed on the same mast arm as the vehicle displays for that approach. The detector should be placed on an extension of the wide line between the left turn and through lanes, if present; if there is no wide line, the detector should be centered on the through lanes. One detector can cover all lanes of an approach for that type of detection (stop line or advance).

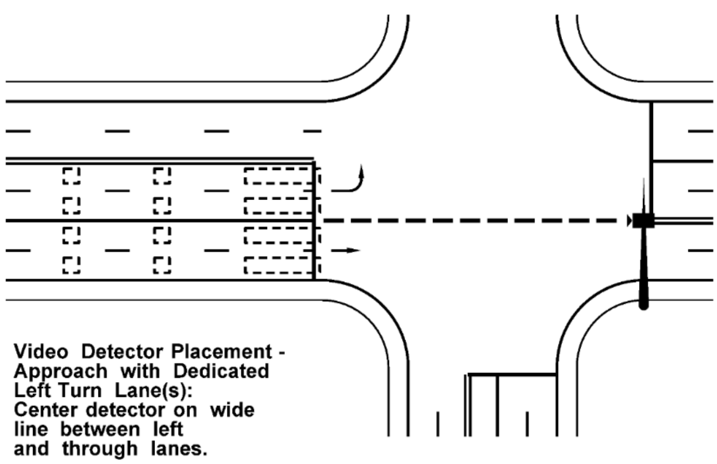
Advance detectors should be installed on a luminaire arm, preferably on the adjacent corner to the approaching lanes, as the effectiveness of the advance detection depends on height. Consider requiring a luminaire arm even if no luminaire is needed, in order to provide an optimal installation site for the detector. Advance detectors may be installed on a mast arm, but will typically have less effective range.

Both infra-red and optical cameras are available, but optical cameras are not recommended due to the adverse effects of rain, snow, fog, sun glare, and sharp shadows on their effectiveness. However, infra-red cameras may still be affected by heavy fog or other major thermal events. All video detection may be affected by mast arm motion due to high winds.

Exhibit 1330-17 Video Detector Placement







3. **Induction Loops**

   Induction Loops are coils of wire in the roadway that use the magnetic properties of vehicles to detect them. Induction loops can last a very long time when undisturbed. However, induction loops require bicycles to be in a very specific location in order to be detected, and may not detect carbon fiber bicycles. Induction loops must be installed with one per lane per detection zone – stop line loops may be larger or series loops. Where induction loops are used, loops need to be numbered in order to keep track of the wiring and lanes they are detecting. See 1330.04(2) for detector numbering requirements.

4. **Wireless In-Pavement Sensors**

   Wireless in-pavement sensors are compact detectors installed in pavement, and use either radar or magnetics to detect vehicles. They use a wireless connection to the signal cabinet. The sensors rely on a battery for operation, and require replacement of the entire unit when they fail. Sensor placement is similar to induction loops – one per lane per detection zone. The magnetic versions are subject to the same difficulties with bicycles as loop detectors. All wireless sensors are also subject to various factors that affect wireless signals such as range, signal obstructions, and possible signal interference from other radios depending on the frequency used.

Non-invasive detectors are preferred with concrete (Portland cement concrete pavement) roadway surfaces. In-pavement detectors installed in concrete panels typically cannot be revised or replaced until all affected concrete panels are replaced. In-pavement detectors installed in bridge decks must be installed when the bridge deck is constructed, and cannot be replaced unless the bridge deck is replaced. Non-invasive detection is also useful for approaches where advance detection is desired, but the approach is outside the jurisdiction of the agency that owns the signal, or for non-standard approaches such as driveways.

Temporary detection should be installed for all stop lines where existing detection will be disabled or ineffective (such as lane shifts) during construction. Temporary advance detection is recommended for high speed (45 MPH or higher) approaches where the decision zone detection will be disconnected for an extended period of time. Consult with the Signal Operations Engineer to determine if temporary advance detection should be used. Temporary advance detection zone placement should take into account any temporary speed limit revisions.

1330.04(7) Preemption Systems

1330.04(7)(a) Emergency Vehicle Preemption

Emergency vehicle preemption (EVP) is required for all traffic signals unless approved otherwise by the region Traffic Engineer. WSDOT is responsible for installing EVP detection equipment at new and rebuilt signalized intersections on state highways. At existing signalized intersections that do not have EVP detection equipment, or where an emergency service agency requests additional equipment beyond the basic required equipment, the emergency service agency is responsible for all material and installation costs. The emergency service agency is responsible for preemption emitters in all cases.

Optically activated EVP systems are used to ensure compatibility with all area emergency service agency emitters. Approval by the State Traffic Engineer is required for the installation of any other type of emergency vehicle preemption system.

Locate optical detectors facing each approach to the intersection – only one detector per approach – with a clear view of the approaching roadway. Detectors have a cone of vision of approximately 8 degrees, and an effective range of 200 to 2500 feet. Detectors should have an unobstructed view of the approach for a minimum of 1800 feet. Primary detectors are normally installed on the same support as the vehicle displays for that approach. Place the detector between the left turn lane and through lane displays on approaches with left turn lanes, or centered on the approaching lanes where left turn lanes are absent.

When the approach is in a horizontal or vertical curve, or there are other sight obstructions, non-standard placement of the primary detector or additional supplemental detectors may be necessary. Primary detectors may be located on other signal display supports (arms or spans) or vertical strain poles, depending on visibility requirements. Supplemental detectors may also be located on separate Type I or Type FB poles in advance of the intersection. On higher speed roadways, supplemental detectors can provide extended detection range – one mile in advance of the intersection is usually sufficient.

Preserve any documentation associated with the EVP system, including system type selected and any associated agreements or approvals, as required by 1330.07 Documentation.

1330.04(7)(b) Railroad Preemption

Railroad preemption is used when a railroad is in close proximity to a signalized intersection. If railroad tracks are within 1/4 mile of a signalized intersection, then a Railroad Crossing Evaluation Team is formed to determine the need (if any) for railroad preemption, interconnection, simultaneous preemption, advanced preemption, and so on. The Railroad Crossing Evaluation Team should consist of region and HQ Signal Design Engineers, region and HQ Signal Operations Engineers, HQ Railroad Liaison, HQ Rail Office representative, region Utilities Engineer, region Traffic Design Engineer, region Maintenance Superintendent, and the affected railroad representative. Where the signal is owned, operated, or maintained by a local agency, a local agency representative should also be included.

The Railroad Crossing Evaluation Team will determine what design considerations are needed at all signalized intersections near railroad crossings. For locations where the railroad tracks are located greater than 500 feet from the signalized intersection, and it can be demonstrated that the 95% maximum queue length(s) will not extend to within 200 feet of the tracks, railroad preemption may be omitted with the approval of the Railroad Crossing Evaluation Team. Include the demonstration and approval in the documentation required by 1330.07 Documentation.

Railroad preemption and interconnection are recommended when any of the following conditions occurs:

- The distance from the stop bar to the nearest rail is less than or equal to 200 feet.
- There is no dedicated left turn lane and the distance from the stop bar to the nearest rail is less than or equal to 500 feet.
- The 95% maximum queue lengths from the intersection stop bar are projected to cross the tracks. (Use a queue arrival/departure study or a traffic analysis “micro-simulation model” to determine 95% maximum queue lengths.)
- The 95% maximum queue lengths from the railroad are projected to affect an upstream traffic signal. (Use a queue arrival/departure study or a traffic analysis “micro-simulation model” to determine 95% maximum queue lengths.)

If it is determined that advanced preemption is needed, the HQ and region Signal Operations Engineers will calculate the amount of railroad preemption time required using the *Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings (TxDOT Form 2304)*.

The addition of a pre-signal is recommended when any of the following conditions occurs:

- The distance from the stop bar to the nearest rail is less than 88 feet but is at least 40 feet. (For reference, the 88 feet is derived from: the longest design vehicle permitted by statute (75 feet) + front overhang (3 feet) + rear overhang (4 feet) + downstream clear storage (6 feet)).
- The distance from the stop bar to the nearest rail is > 88 feet and < 120 feet and there are no gates for the railroad crossing.
- The sight distance triangle in Chapter 1350, Exhibit 1350-1 (Sight Distance at Railroad Crossing), cannot be met, and the railroad crossing does not have active control (lights or gates).

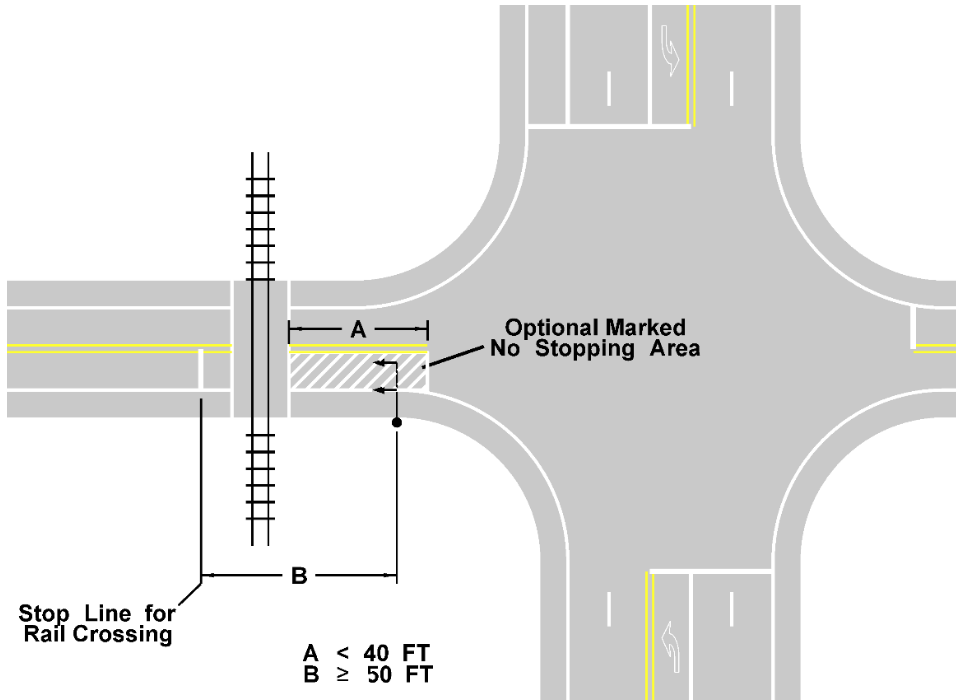
When pre-signals are used, two stop lines are used: one for the rail crossing, and one for the intersection. The pre-signal displays stop traffic at the rail crossing stop line, and the second set of signal displays stop traffic at the intersection. Use louvers on the intersection displays so that they are not visible from the stop line for the rail crossing. Optically programmed displays may be used in place of louvers, but are not recommended due to the limited benefits, complexity of installation and maintenance, and high cost.

Where the distance between the normal location for the stop bar and the approach is less than 40 feet, the same stop bar should be used for both the traffic signal and the rail crossing. Install vehicle displays on the near side of the intersection, but on the far side of the tracks from the stop line, to improve visibility and discourage drivers from stopping between the tracks and the intersection. Do not install vehicle displays on the far side of the intersection.

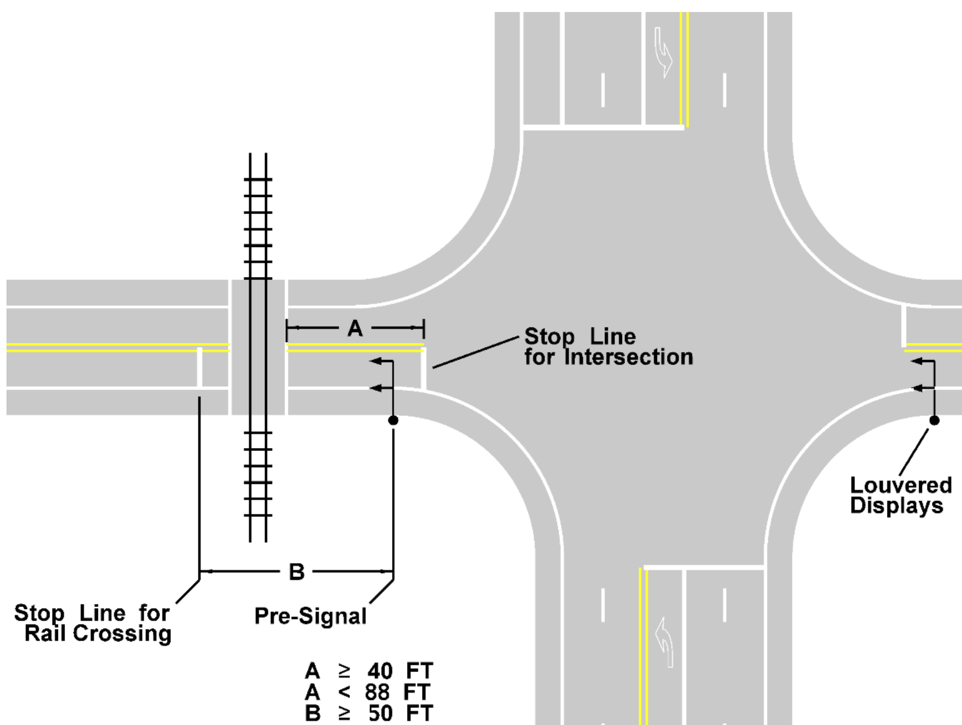
Exhibit 1330-18 shows examples of the distances and typical system layouts referenced above.

The Railroad Crossing Evaluation Team has final review and approval authority for all PS&E documents for signal design and operation at all signalized intersections near railroad crossings. All documentation associated with railroad preemption and a memo with each team member's concurrence with the PS&E documents must be preserved as required by 1330.07 Documentation.

Exhibit 1330-18 Signal Display Layout for Rail Crossings



Display Placement
Less than 40 feet between tracks (dynamic envelope marking) and intersection



Display Placement
40 to 88 feet between tracks and intersection

1330.04(7)(c) Transit Priority Preemption

Transit Priority Preemption allows for transit operations to influence signal timing, similar to emergency vehicle preemption. This can be included in mobility projects, but the transit agency assumes all costs for providing, installing, and maintaining this preemption equipment. WSDOT's role is limited to approving preemption operational strategies (phasing, timing, software, and so on) and verifying the compatibility of the transit agency's equipment with the traffic signal control equipment. Preserve all transit priority preemption decisions and agreements as required by 1330.07 Documentation.

1330.04(8) Control Equipment

The standard WSDOT Signal Controller type for traffic signals is the Type 2070 Controller. Some agencies use National Electrical Manufacturers Association (NEMA) controllers (Type TS1 or TS2). Although not normally used for new construction, WSDOT Ramp Meters and some older systems still use Type 170 Controllers. All traffic signal controllers have the following basic functions:

- Dual ring phase operation
- Eight vehicle phases
- Four pedestrian phases
- Four overlap phases
- Four emergency vehicle preemption channels
- Railroad preemption
- Start and end daylight savings time dates
- Transit preemption (some older controllers may not support this)

Type 2070 controllers and newer NEMA controllers are functionally equivalent for basic signal operations. However, Type 2070 controllers and NEMA controllers use different operating software and communications protocols, and therefore cannot be interconnected together. The type of controller should be specified as follows:

1. For WSDOT traffic signals, specify Type 2070 controllers, unless:
    a. The signal is interconnected with other signals. If the other controllers in the interconnected system are not being replaced, specify a controller (2070, NEMA, or other) that matches the rest of the interconnected system.
    b. The signal is operated by another agency. In this case, work with WSDOT and the other agency's maintenance staff to determine the appropriate controller type.
2. For traffic signals owned by other agencies, specify the controller type used by that agency.

The region or operating agency will determine the controller brand and operating software, which are included in the cabinet specifications. Each region or operating agency will provide specifications for their cabinets and the equipment contained therein. For 2070 controllers, double-width cabinets (two racks) should be specified if physically possible to allow for future communications and ITS equipment.

It is often beneficial for one of the agencies to assume responsibility for the operation of the traffic signals. This is accomplished by negotiating an agreement with the other agency. The designer needs to check region policy and make sure someone initiates the process for setting up an operational agreement with the other agency or modifying an existing agreement when applicable. (See the *Agreements Manual* for more information on signal systems and maintenance agreements.) At a new intersection, where the state owns the signal, but WSDOT has agreed to let another agency operate the signal, the controller should be compatible with that agency's system. When installing a new controller in an existing interconnected corridor, the controller should be capable of operating with the existing controllers in the corridor. In situations where it is necessary to coordinate the traffic movements with another agency, it is important that the agencies work together.

Intersections within ½ mile of each other on state highways should be interconnected. Perform an operational analysis to determine need for interconnection where intersections are within 1 mile of each other on state highways with a posted speed of 45 MPH or higher. The preferred method for interconnection is fiber optic cable, but other methods such as IP over copper or wireless interconnect may be considered after discussion with maintenance staff and approval by the region Traffic Engineer. Where fiber optic cable is used, it must be routed through pull boxes and cable vaults – bending fiber optic cable through standard junction boxes typically results in the cable being broken. Consider using a separate pull box or vault for coiling the fiber optic interconnect cable to allow for the large-bend radii. Add a construction note in the plans stating to coil additional cable in the adjacent pull box or vault, not the controller cabinet. This will save on space in the controller cabinet and provides additional cable in case an errant vehicle hits the cabinet.

Coordinate with the operations and maintenance staff to determine the optimum controller cabinet location and the cabinet door orientation. The controller cabinet is positioned to provide the best maintenance access and clearest view of the intersection possible. Preferred visibility allows for as many signal displays and roadway approaches visible as possible from a single location. Cabinets should not be placed where they might block the view of turning traffic (intersection sight triangle). If possible, position the controller where it will not be affected by future highway construction.

Cabinets require a minimum of 36 inches of level space in front of each door, including the concrete pad. Do not place cabinets where flooding might occur or where the cabinet might be hit by errant vehicles. If there is a steep down slope or drop off near the cabinet, personnel fall protection (such as fencing) is required in accordance with standards established by the Department of Labor and Industries. Fall protection may not encroach on the required clear space for the cabinet. The location must also have adequate room for a maintenance vehicle to park near the cabinet. Sufficient space for a bucket truck to park is preferable.

If a telephone line (voice or DSL), fiber optic, wireless, or other connection is desired for remote access to the equipment in the cabinet, provide the appropriate equipment in the controller cabinet and/or nearby junction box or cable vault with separate conduits and junction boxes for the remote communications equipment. Communications connections to outside utilities require their own separate conduit and box/vault system.

Consult with maintenance and operations staff to determine if a backup power source, such as an Uninterruptible Power Supply (UPS) or backup generator, is needed for the signal cabinet. Install the backup power supply on the same concrete pad as the signal cabinet. Service and other cabinets may also be installed on the same concrete pad as the signal cabinet (see the

Standard Plans for concrete cabinet pad layouts). Refer to Chapter 1040 for electrical service types, overcurrent protection, and descriptions and requirements for other components.

1330.04(9) Wiring, Conduit, and Junction Boxes

Consider cost, flexibility, construction requirements, and ease of maintenance when laying out the electrical circuits for the traffic signal system. Consolidate roadway crossings (signal, illumination, ITS conduits, and so on) whenever possible to minimize the number of crossings and take advantage of single crossing construction (joint trenches or consolidated directional boring). Include all electrical design calculations in the Project File.

1330.04(9)(a) System Wiring

Traffic signal systems use multi-conductor cables to connect most of the equipment. Single conductor cable is limited to cabinet power and street lighting circuits.

The following describes typical WSDOT wire type selection:

- 5c cables for signal displays. One 5c per signal phase may connect the signal cabinet to the terminal cabinet on the pole. Separate 5c cables should connect each signal display to the terminal cabinet. Protected / permissive displays may either use one 7c cable or two 5c cables (one for each phase on the shared display).
- 5c cables for pedestrian displays. Consult with region maintenance to determine if the same 5c cable is used for associated pedestrian detection.
- 3cs cables for emergency preemption detectors.
- 2c cables for induction loop detectors. Shielded cable is not required for modern loop detector cards. Older systems may still need shielded cable (2cs), but it is recommended to replace the loop detector cards instead.
- Manufacturer specified cables for video and radar detectors. Video detectors typically use a combined RG9/5c (#18) cable. Radar detectors typically use proprietary 6c and 8c cables. These cables are roughly the size of 7c cables (for calculating conduit fill).
- Use 2c cables for isolated pedestrian detectors (separate pole from associated pedestrian display). For connecting 4-wire APS units, a 7c cable may be used between the PPB post and the signal pole with the pedestrian display (where the APS control unit is located).

To simplify potential repairs for smaller signal standards (Type FB and smaller), consider routing signal display and detection conductors through terminal cabinets on larger signal standards (Type II and larger) before connecting to smaller signal standards. This reduces the amount of wire which may need to be replaced if a smaller signal standard is knocked down and the wiring damaged.

1330.04(9)(b) Conduit

Refer to the *Standard Specifications* for conduit installation requirements. At existing intersections, where roadway reconstruction is not proposed, conduits are to be placed beyond the paved shoulder or behind existing sidewalks to reduce installation costs. All conduits shall be a minimum of 2 inches in size, with the following exceptions:

1. Conduits entering Type PPB signal standards shall be 1 inch. This may be increased to 1 1/4 inch when two APS PPBs are installed on the same pole.
2. Lighting conduits entering pole foundations (signal or light standards) shall be a minimum of 1 inch. See Chapter 1040 for additional requirements for light standards with slip bases.
3. Conduits entering Type PS, I, RM, and FB poles may be a minimum of 1-inch and a maximum of 2-inch.
4. The conduit for the service grounding electrode conductor may be a minimum of ½-inch.

Install spare conduits at all road crossings. Spare conduits at road crossings should be a minimum of one 3-inch conduit or two 2-inch conduits. Install a minimum 2-inch (preferably 3-inch) spare conduit into the controller cabinet.

It is recommended to use full inch conduit sizes to simplify construction and reduce the different types of conduits required for the system. This helps to provide future capacity and reduce costs through bulk material purchasing. Size all conduits to provide 26% maximum conductor fill for new signal installations. A 40% fill area can be used when installing conductors in existing conduits. (See Exhibit 1330-19 for conduit and signal conductor sizes.)

Exhibit 1330-19 Conduit and Conductor Sizes

Conduit Sizing Table			
Trade Size	**Inside Diam. (inches)**	**Maximum Fill (inch^2)**	
		26%	**40%**
1/2"	0.632	0.08	0.13
3/4"	0.836	0.14	0.22
1”	1.063	0.23	0.35
1 1/4"	1.394	0.40	0.61
1 1/2"	1.624	0.54	0.83
2”	2.083	0.89	1.36
2 1/2"	2.489	1.27	1.95
3”	3.09	1.95	3.00
3 1/2"	3.57	2.60	4.00
4”	4.05	3.35	5.15
Conductor Size Table			
Size (AWG)	**Area (inch^2)**	**Size (AWG)**	**Area (inch^2)**
# 14 USE	0.021	2cs (# 14)	0.090
# 12 USE	0.026	3cs (# 20)	0.070
# 10 USE	0.033	4cs (# 18)	0.060
# 8 USE	0.056	5c (# 14)	0.140
# 6 USE	0.073	7c (# 14)	0.170
# 4 USE	0.097	10c (# 14)	0.290
# 3 USE	0.113	6pcc (# 19)	0.320
# 2 USE	0.133		

Minimize roadway crossings whenever possible. Usually only three crossings are needed (one main line) for a four-leg intersection, and only two roadway crossings are needed for a T intersection. In most cases, the conduit should cross both the main line and side street from the corner where the controller is located.

Directional boring should normally be used when crossing the state route (main line). Open cut trenching may only be used to install conduits under the following circumstances:

1. Existing roadways where the roadway is being resurfaced.
2. Existing roadways where substantial obstacles under the roadway will be encountered.
3. Where there is insufficient room for jacking or boring pits at the edges of the roadway.

Open cut trenching is not permitted across limited access roadways unless the entire pavement surface is being replaced. Sign or signal bridges may not be used for roadway crossings.

1330.04(9)(c) Junction Boxes

Provide junction boxes at the following locations:

- Adjacent to the signal cabinet. A pull box or larger vault may be used in place of multiple junction boxes.
- Adjacent to each signal pole. One box may serve multiple poles. The distance from a pole to the first junction box should not exceed 10 feet without concurrence from maintenance staff. Pole bases may not be used as junction boxes.
- Adjacent to each set of detector loops. These boxes contain the detector loop splices. One box may serve multiple lanes, but the box should be no more than 50 feet from the detector loop.
- At the end of each road crossing.
- In the middle of conduit runs where the number of bends would equal or exceed 360°.

Where possible, locate junction boxes out of paved areas and adjacent to (but not in) sidewalks. New junction boxes may not to be placed in the pedestrian curb ramp or ramp landing of a sidewalk. If a new junction box must be placed within sidewalk, locate it at the edge of the sidewalk and designate it to be slip-resistant. Existing junction boxes located within new or existing sidewalk, including ramps or landings, must be revised as follows:

- Existing junction boxes containing power conductors for the traffic signal (not including street lighting), or wiring for the signal displays, may remain in place, even if they will be within a sidewalk ramp or ramp landing.
- Existing junction boxes containing detector wiring may remain in sidewalks, but must be relocated outside of sidewalk ramps and ramp landings. Designate that the relocation work, including conduit adjustments and rewiring, be completed within a single shift or provide temporary detection using another conduit path.
- All junction boxes which will be within sidewalk, sidewalk ramps, or ramp landings, must be slip-resistant junction boxes. This includes replacing existing junction boxes with slip-resistant junction boxes.

- Under no circumstances may a junction box be located in a grade break for a sidewalk ramp. Either the ramp must be redesigned or additional accommodations made in construction to allow for the box to be relocated.

The fundamental principle is that if relocating a junction box requires shutting down a traffic signal system, the junction box may remain in its existing location but must be replaced with a slip-resistant junction box. See Chapter 1510 for additional ADA requirements.

Do not place junction boxes within the traveled way unless absolutely necessary. Make every effort to locate new junction boxes and to relocate existing junction boxes outside the travel lane or paved shoulder. If there is no way to avoid locating the junction box in the traveled way or paved shoulder, heavy-duty junction boxes must be used. Avoid placing junction boxes in areas of poor drainage. Do not place junction boxes within 2 feet of ditch bottoms or drainage areas, or within vegetative filter strips or similar water treatment features which may be present. The maximum conduit capacities for various types of junction boxes are shown in the *Standard Plans*.

1330.05 Preliminary Signal Plan

All traffic signal work which installs or modifies detection or display equipment, with the sole exception of projects where induction loops are being removed and replaced in the same location, requires a preliminary signal plan for the Project File. The type of preliminary signal plan depends on the type of work being performed. For a new traffic signal system or complete system replacement, a Full Preliminary Signal Plan is required. For all other work, a Basic Preliminary Signal Plan is required. Include a brief discussion of the issue that is being addressed by the project. Provide sufficient level of detail on the preliminary signal plan to describe all aspects of the signal installation, including proposed channelization modifications. The plan scale should not be smaller than “1 inch = 30 feet” (“1 inch = 20 feet” is preferable) – plans may be reduced to “1 inch = 40 feet” with prior approval.

Submit a copy of the preliminary signal plan to the State Traffic Engineer for review and comment. A preliminary signal plan must be submitted to the State Traffic Engineer regardless of the originator of the design. Allow two to three weeks for review of the preliminary signal plan. After addressing all review comments, finalize the plan and preserve as required by 1330.07 Documentation. Prepare the contract plans in accordance with the *Plans Preparation Manual.*

If HQ Traffic is preparing the contract Plans, Specifications, and Estimate (PS&E) package for the signal system portion of the project, submit the following items with the preliminary signal plan:

1. Contact person.
2. Charge numbers.
3. Critical project schedule dates.
4. Existing and proposed utilities, both underground and overhead.
5. Existing intersection layout, if different from the proposed intersection.
6. (Turning movement traffic counts (peak hour for isolated intersections) and a.m., midday, and p.m. peak-hour counts if there is another intersection within 500 feet.
7. Electrical service location, source of power, and utility company connection requirements.

After the PS&E package for the signal system portion of the project is prepared, the entire package is transmitted to the region for incorporation into its contract documents.

1330.05(1) Basic Preliminary Signal Plan

The Basic Preliminary Signal Plan includes the following elements, at a minimum:

a. All pavement markings.

b. Sidewalks, curb ramp, and level landing areas.

c. All pole types and locations.

d. All vehicle and pedestrian display types and locations.

e. All vehicle (car and/or bicycle) detector types and locations. Include detection zones for non-loop detectors.

f. All pedestrian pushbutton types and locations.

g. All emergency vehicle preemption (EVP) detector locations.

h. Phase diagram, including pedestrian movements and EVP channel assignments.

1330.05(2) Full Preliminary Signal Plan

The Full Preliminary Signal Plan includes all elements required for the Basic Preliminary Signal Plan, with the following additional items (list is continued from above):

a. Cabinet locations with door orientations.

b. Traffic barrier (guardrail, concrete barrier, etc.) locations.

c. Drainage items.

d. Left-turn radii, including beginning and ending points.

e. Corner radii, including beginning and ending points.

f. Railroad preemption requirements.

g. Illumination treatment, including a calculation summary showing the average light level, average/minimum uniformity ratio, and maximum veiling luminance ratio. (See Chapter 1040 for more information on illumination design requirements.)

h. Traffic counts, including left-turn movements.

i. Speed study information indicating 90th, 85th, and 10th percentile speeds for all approaches. For any new approach, or any approach where the existing speed will change, the design posted speed may be provided instead.

j. Utilities information, for any potential overhead or underground utility conflicts.

1330.06 Operational Considerations for Design

This section describes operational guidance for traffic signals. These operational requirements will directly affect the design of the traffic signal, particularly in regards to signal display types and locations.

All traffic signals should be periodically re-evaluated, to determine if timing or phasing changes would result in more efficient operation of the traffic signal, or in the case of interconnected systems, the corridor or network. Changes in traffic volumes, posted speeds, or other factors may influence turning movement phasing operations (protected, protected/permissive, or permissive), green times, yellow change intervals, and other operational parameters.

1330.06(1) Left-Turn Phasing

Left-turn phasing can either be permissive, protected/permissive, or protected. It is not necessary that the left-turn mode for an approach be the same throughout the day. Varying the left-turn mode on an approach among the permissive only, protected/permissive, and protected-only left-turn modes during different periods of the day is acceptable. Examples are included in the phase diagrams shown in Exhibit 1330-20 and Exhibit 1330-21.

For permissive left turns, the permissive left turn phase shall not terminate separately from the conflicting phase(s) (typically, the opposing through phase). This is to prevent placing left turning traffic in a yellow trap.

1. Permissive Left-Turn Phasing

Permissive left-turn phasing requires the left-turning vehicle to yield to opposing through traffic and pedestrians. Permissive left-turn phasing is used when the following are true:

a. Turning volume is minor.

b. Adequate gaps occur in the opposing through movement.

c. Adequate sight distance beyond the intersection is provided.

This phasing is more effective on minor streets where providing separate protected turn phasing might cause significant delays to the higher traffic volume on the main street. On single-lane approaches with a posted speed of 45 mph or above, or where sight distance approaching the intersection is limited, channelization should include a separate left-turn storage lane for the permissive movement to reduce the potential for rear-end-type collisions and delay to through movements.

Unless there is a dedicated left-turn lane, do not provide a separate display for permissive left turns. When there is a dedicated left-turn lane, a three-section flashing yellow arrow display (with steady red arrow, steady yellow arrow, and flashing yellow arrow displays) should be used for the left-turn lane, as this provides a more positive indication of the permissive turning movement.

2. Protected/Permissive Left-Turn Phasing

Protected/permissive left-turn phasing provides both a protected phase and a permissive phase for the same lane, using the same signal display. Where left-turn phasing will be installed and conditions do not warrant protected-only operation, consider protected/permissive left-turn phasing. Protected/permissive left-turn phasing can result in increased efficiency at some types of intersections, particularly “T” intersections, ramp terminal intersections, and intersections of a two-way street with a one-way street where there are no opposing left-turn movements.

Protected/permissive left-turn phasing is NOT allowed under the following conditions:

a. For new signals, on an approach where Warrant 7 is met and there are five or more left-turning collisions on that approach included in the warranting collisions. This condition requires protected left turn phasing.

b. For existing signals, when documentation shows that existing protected left-turn phasing was installed due to left-turn collisions.

c. When sight distance for left-turning vehicles, as outlined in AASHTO’s *A Policy on the Geometric Design of Highways and City Streets*, cannot be met.

d. On intersection approaches where the opposing approach has three or more lanes (including right-turn lanes) and either the posted speed limit or 85th percentile speeds for the opposing approach are at or above 45 mph.

e. On intersection approaches that have dual left-turn lanes, including approaches with left only and through-left lanes.

Where there is a separate left-turn lane, protective/permissive displays may use either of the following display arrangements:

- A dedicated four-section arrow display, with steady red arrow, steady yellow arrow, flashing yellow arrow, and steady green arrow displays (four-section FYA). A three-section display with a bi-modal flashing yellow arrow / steady green arrow may only be used if the signal support cannot accommodate a four-section signal display.
- A shared five-section cluster (doghouse) display, placed over the wide line between the left turn lane and the adjacent through lane.

Where there is no separate left-turn lane, only a five-section vertical (recommended) or cluster display may be used. The five-section display is used in place of the left of the two required through displays for that approach.

Protected/permissive displays may run as lead or lag. The display cycle will depend on the display type and whether the protected left leads or lags:

- Leading 4-section FYA: steady green arrow, steady yellow arrow, steady red arrow, flashing yellow arrow, steady yellow arrow, steady red arrow.
- Leading 5-section: green arrow, yellow arrow, red ball, green ball, yellow ball, red ball. Option: green ball may come up with green arrow, but the arrow and ball displays should cycle to yellow and red together (similar to lagging 5-section)
- Lagging 4-section FYA: flashing yellow arrow, steady green arrow, steady yellow arrow, steady red arrow
- Lagging 5-section: green ball, green ball with green arrow, yellow ball with yellow arrow, red.

3. Protected Left-Turn Phasing

Protected left-turn phasing provides the left-turning vehicle a separate phase, and conflicting movements are required to stop.

Use protected left-turn phasing under the following conditions:

a. Multi-lane left turn movements, including left and through-left from the same approach.

b. The left-turn is onto a roadway with a rail crossing.

c. Where Warrant 7 is met and there are five or more left-turning collisions on that approach included in the warranting collisions. Protected left-turn phasing is recommended even when there are as few as three left-turning collisions on that approach. This includes left-turning collisions involving pedestrians.

d. Where the peak-hour turning volume exceeds the storage capacity of the left-turn lane and one or more of the following conditions is present:

   i. The posted speed or the 85th percentile speed of the opposing traffic is 45 mph or higher.

   ii. The sight distance to oncoming traffic is less than 250 feet when the posted or 85th percentile speed is 35 mph or below, or less than 400 feet when the posted or 85th percentile speed is above 35 mph.

   iii. The left-turn movement crosses three or more lanes (including right-turn lanes) of opposing traffic.

   iv. Geometry or channelization is confusing, such as skewed intersections, offset-T intersections, or intersections which require unusual maneuvers to traverse.

There are three typical operational arrangements for protected left turns:

- Leading Lefts: The left turns are served before the associated through movements. This is the most common operational arrangement. Example: Phases 1 and 5 (major street lefts) are served first, then phases 2 and 6 (major street throughs) are served.
- Lagging Lefts: The left turns are served after the associated through movements. Example: Phases 4 and 8 (minor street throughs) are served first, then phases 3 and 7 (minor street lefts) are served.
- Offset (or Lead/Lag) Lefts: One left turn is served before the associated through movements, and the opposing left turn is served after the associated through movements. Example: Phase 1 (one major left turn) is served first (phase 6 may be served at the same time), then phases 2 and 6 (major throughs) are served, and then phase 5 (opposing major left turn) is served (phase 2 may still be served with phase 5).

Check that all turning movements provide turning clearance for opposing turn phases. If the opposing left-turning vehicle paths do not have 4-foot minimum—12-foot desirable—separation between them, split or offset (lead/lag) phasing will have to be used.

1330.06(2) Right-Turn Phasing

Right turns typically do not operate with their own phasing unless there is a dedicated right turn lane. When there is no dedicated right turn lane, right turns are normally a permissive movement from the right most through lane, depending on pedestrian phases in use. When there is a dedicated right turn lane, right-turn phasing effectively operates the same as left-turn phasing.

Dedicated right turn lanes may be operated the same as left turn lanes: permissive, protected/permissive, or protected. However, right turn phase operation needs to take into account any pedestrian crossing on the receiving side of the right turn. If there is a conflicting pedestrian phase – typically a pedestrian phase running concurrent with the through phase from which the right turn is being made – the right turn phase may only be operated as permissive.

Dedicated right turn lanes operated as permissive and protected/permissive are recommended to have their own displays, but may use a shared display with the adjacent through lane. Dedicated right turn lanes operated as protected must use their own display. Right turn displays are arranged and operated the same as those listed for left turns in 1330.06(1). As with left turns, a permissive right turn phase shall not terminate separately from the conflicting phase(s) (typically, the opposing through phase).

Separate right turn phasing also needs to consider some additional operational modes and issues:

1. Right-Turn Overlapped Phasing

A right turn overlap is when a protected right turn is allowed at the same time as a complementary protected left turn, and is recommended when the lane and phase configuration will support this operation. When this operation is used, the left turn must be signed that U-turns are prohibited.

When right turn overlaps are used, the wiring of the right turn displays will depend on the operating mode of each display section:

- Permissive: Connect permissive display sections to the same terminals as the associated through phase.
- Protected: Protected display sections may either be:
    - (a) Connected to the complementary left turn phase. Use this arrangement when the protected right turn will only be run concurrent with the complementary left turn phase.
    - (b) Connected to an overlap phase. Use this arrangement when the protected right turn will be run with both the complementary left turn phase and with the through phase associated with the right turn.

2. Multiple-Lane Right-Turn Phasing

Multiple-lane right turns may be run independent or overlapped as described above. Multiple-lane right turns can cause operational challenges when “right turn on red” is permitted at the intersection. Verify that there is adequate sight distance and adequate receiving lanes are available to minimize the possibility of collisions. In most cases, a single unrestricted “right-turn-only” lane approach with a separate receiving lane (auxiliary lane) will have a similar capacity as the two lane right-turn phasing.

1330.06(3) Typical Signal Phasing Arrangements

The following diagrams show typical phasing diagrams for four-way and three-way intersections.

Exhibit 1330-20 Phase Diagrams: Four-Way Intersections

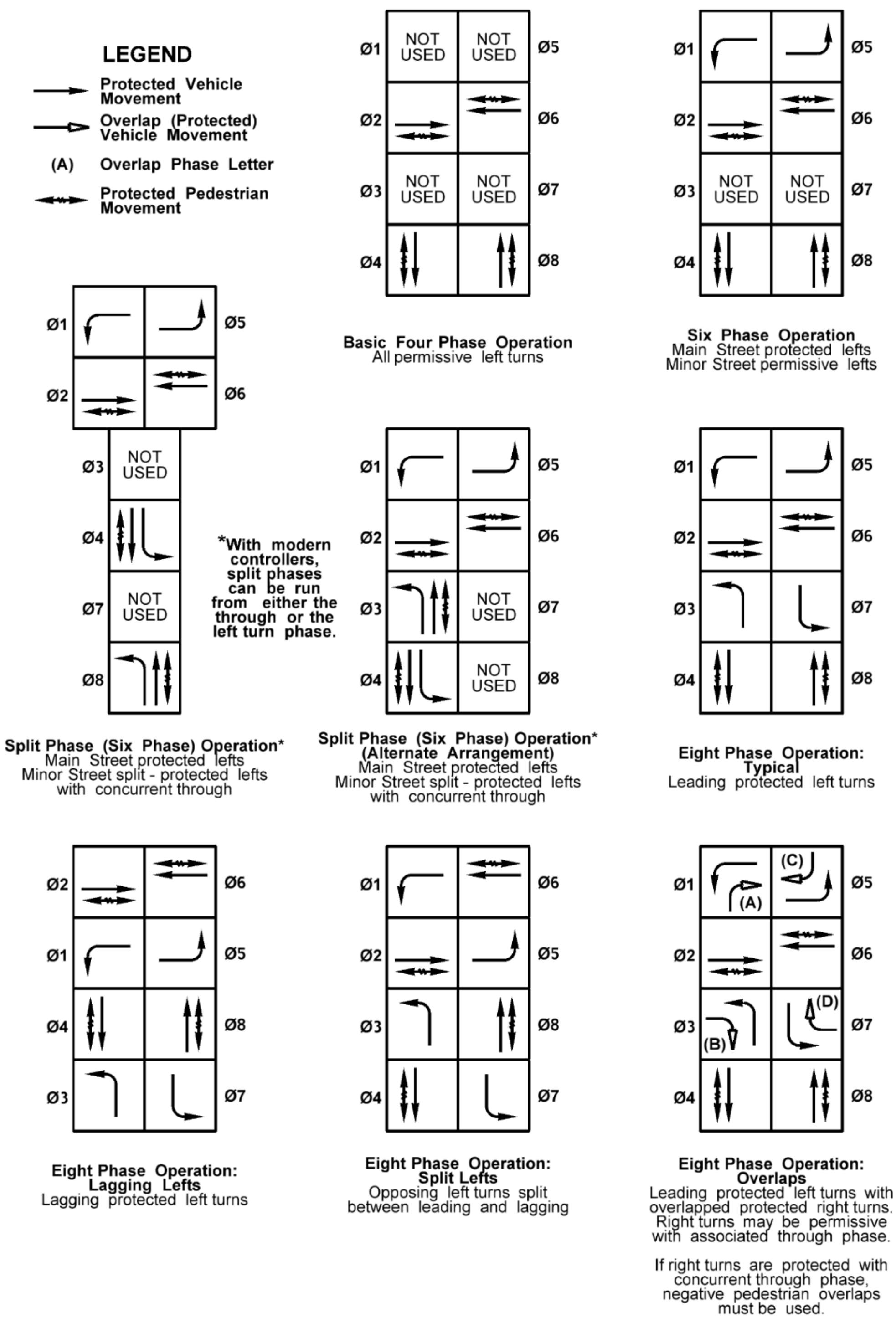
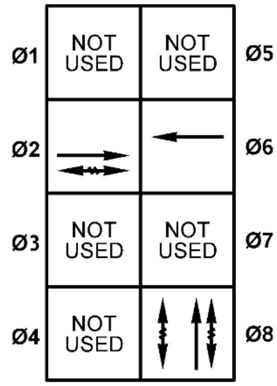
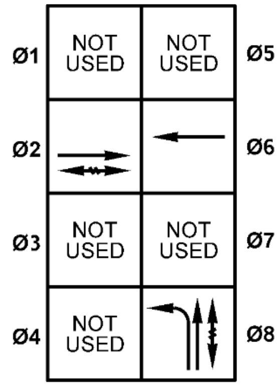


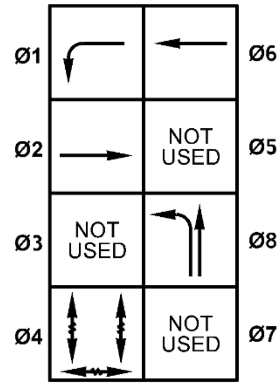
Exhibit 1330-21 Phase Diagrams: Three-Way Intersections



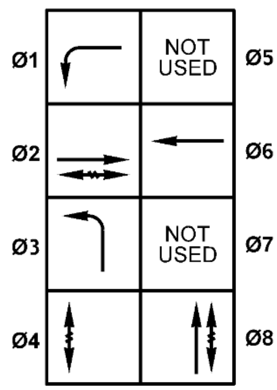
Basic Three Phase Operation
All permissive turns



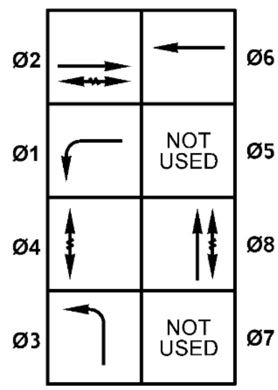
Three Phase Operation: Restricted Peds
Protected left turn from side street by removing conflicting pedestrian phase (and crossing)



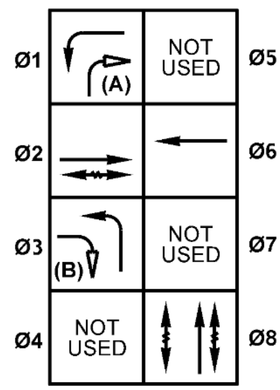
Five Phase Operation: Exclusive Peds
All pedestrian crossings run together as separate phase



Six Phase Operation: Typical
Leading protected left turns



Six Phase Operation: Lagging Lefts
Lagging protected left turns



Six Phase Operation: Overlaps
Leading protected left turns with overlapped protected right turns. Right turns may be permissive with associated through phase.

If right turns are protected with concurrent through phase, negative pedestrian overlaps must be used.

LEGEND

Protected Vehicle Movement

Overlap (Protected) Vehicle Movement

(A) **Overlap Phase Letter**

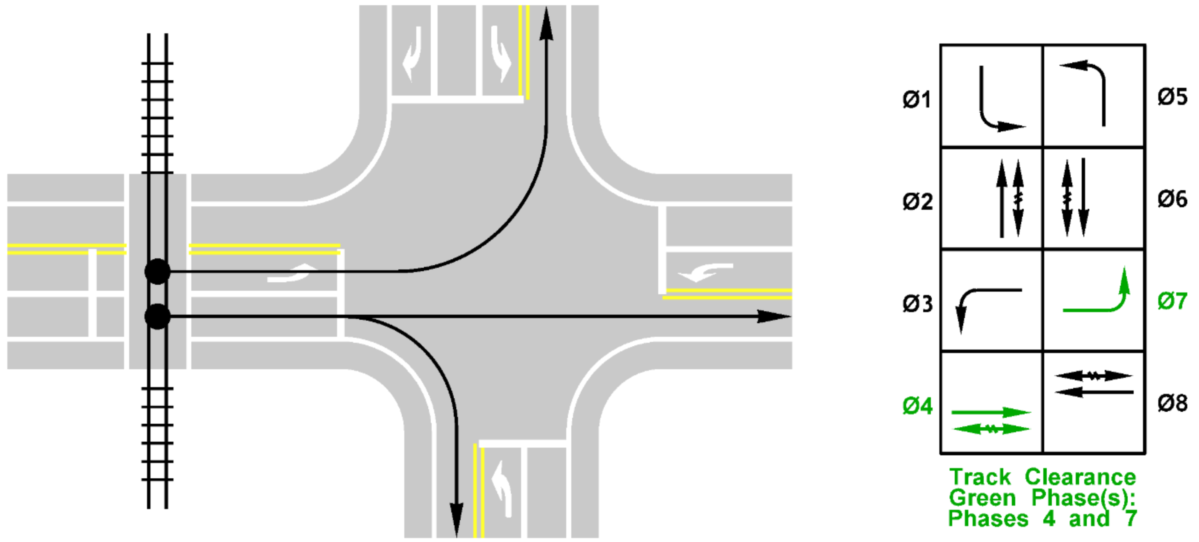
Protected Pedestrian Movement

1330.06(4) Phasing at Railroad Crossings

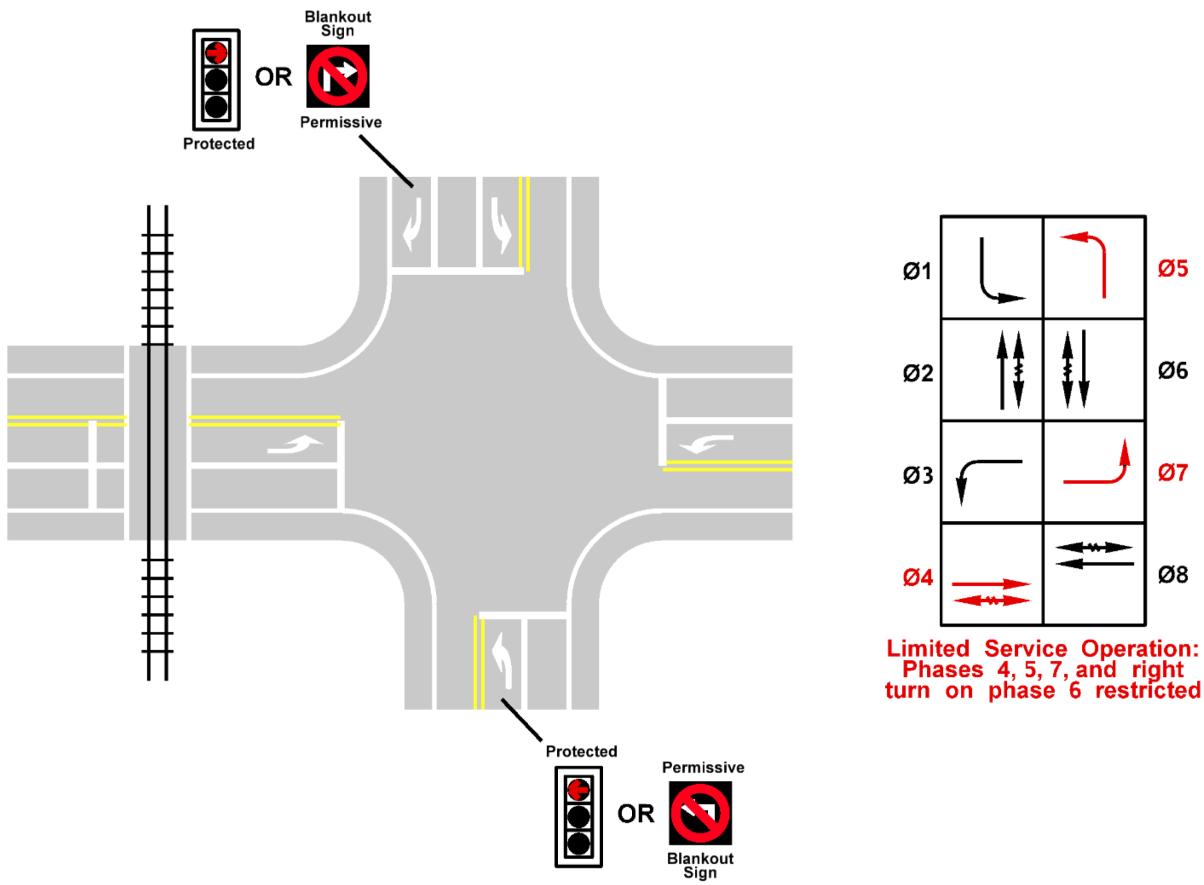
Traffic signals near railroad crossings have additional special phasing arrangements. To provide for efficient signal operations during a rail crossing, ensure that there are dedicated turn lanes for movements turning onto the tracks. These turn lanes should be on their own dedicated phases, so that they may be omitted from the signal timing (held in red) during the rail crossing. This allows for as many of the other intersection movements as possible to continue to operate – a timing scheme referred to as "Limited Service Operation" (LSO).

Just prior to LSO, when railroad preemption is used, the traffic signal will shift to a "Track Clearance Green" (TCG) phase. TCG shifts non-conflicting phases to green to allow vehicles to clear the railroad tracks. Examples of a TCG phase and LSO are shown in Exhibit 1330-22. Standalone queue cutter signals do not have a TCG phase – contact the HQ Traffic Office for operational guidance on standalone queue cutter signals.

Exhibit 1330-22 Phasing at Railroad Crossings



Track Clearance Green



Limited Service Operation

1330.06(5) Accessible Pedestrian Signals (APS)

APS are required to be operated as follows:

1. All APS at an intersection must use either rapid tick or speech messages – mixed operations at a single intersection are not allowed.
2. Street names in speech messages shall be limited to the basic street name. Do not include cardinals (N, S, E, etc.) or street type (street, avenue, road, etc.) unless needed to avoid confusion where two streets have the same name, such as 2nd Avenue and 2nd Street or Center Drive at Center Way.
3. Walk messages shall be in the format “Walk sign is on to cross <street>”.
4. Button press messages during flashing or solid DON’T WALK phases shall be in the following formats:
    a. Short press: “Wait”.
    b. Long press: “Wait to cross <street1> at <street2>”. Street names shall use the same format described above.
    c. Long press with extended crossing time: “Wait to cross <street1> at <street2> with extended crossing time”.
5. Audible countdowns shall not be used. The APS shall default to the locator tone during any phase other than WALK.

1330.07 Documentation

The following original signal design documents shall be included in a Signal System file and provided to the region Traffic Office or owning agency:

1. Signal Permit, including Signal Warrant Analysis and supporting documentation.
2. FHWA Approval for Experimentation.
3. Signal Standard Design Chart, including signal support engineering calculations.
4. Signal Detection Zone Placement. Include calculations if used.
5. Signal Wiring Diagram and Conduit Fill calculations.
6. Railroad preemption calculation and interconnect setup.
7. Any third party documentation provided.
8. Approved Preliminary Signal Plan.
9. Emergency Preemption Equipment selected.
10. Transit Priority Preemption and associated agreements.

Copies of items 1 and 2 are also required to be included in the DDP. Copies of items 3 through 10 are also required to be included in the Project File (PF).

Refer to Chapter 300 for additional design documentation requirements.

1330.08 References

The following references are used in the planning, design, construction, and operation of traffic control signals installed on state highways. The RCWs noted are specific state laws concerning traffic control signals, and conformance to these statutes is required.

1330.08(1) Federal/State Laws and Codes

Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35)

Revised Code of Washington (RCW) 35.77, Streets – Planning, establishment, construction, and maintenance

RCW 46.04.450, Railroad sign or signal

RCW 46.04.600, Traffic control signal

RCW 46.04.62250, Signal preemption device

RCW 46.61.050, Obedience to and required traffic control devices

RCW 46.61.055, Traffic control signal legend

RCW 46.61.060, Pedestrian control signals

RCW 46.61.065, Flashing signals

RCW 46.61.070, Lane-direction-control signals

RCW 46.61.072, Special traffic control signals – Legend

RCW 46.61.075, Display of unauthorized signs, signals, or markings

RCW 46.61.080, Interference with official traffic-control devices or railroad signs or signals

RCW 46.61.085, Traffic control signals or devices upon city streets forming part of state highways – Approval by department of transportation

RCW 46.61.340, Approaching train signal

RCW 47.24.020(6) and (13), Jurisdiction, control

RCW 47.36.020, Traffic control signals

RCW 47.36.025, Vehicle-activated traffic control signals – Detection of motorcycles and bicycles

RCW 47.36.060, Traffic devices on county roads and city streets

Washington Administrative Code (WAC) 468 18-040, Design standards for rearranged county roads, frontage roads, access roads, intersections, ramps and crossings

WAC 468-18-050, Policy on the construction, improvement and maintenance of intersections of state highways and city streets

“City Streets as Part of State Highways: Guidelines Reached by the Washington State Department of Transportation and the Association of Washington Cities on the Interpretation of

Selected Topics of RCW 47.24 and Figures of WAC 468-18-050 for the Construction, Operations and Maintenance Responsibilities of WSDOT and Cities for Such Streets," April 30, 1997.

WAC 468-95, Manual on Uniform Traffic Control Devices for Streets and Highways (Washington State Supplement)

1330.08(2) Design Guidance

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

Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings (TxDOT Form 2304) and Instructions for Form 2304 (TxDOT Form 2304-I), Texas Department of Transportation
http://www.txdot.gov/inside-txdot/forms-publications/forms/rail.html

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

Plans Preparation Manual, M 22-31, WSDOT

Revised Draft Guidelines for Accessible Public Rights-of-Way, (PROWAG), November 23, 2005, United States Access Board

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

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

WSDOT Traffic Design Resources
www.wsdot.wa.gov/design/traffic/

Chapter 1340 Driveways

1340.01 General

For the purpose of this chapter, and to remain consistent with WSDOT's *Standard Plans* and AASHTO terminology, the terms "access" and "approach" will be referred to as "driveway." An access on a managed access highway is defined as an "access connection," while an access on a limited access highway is defined as an "approach."

Driveways are as much about access as they are about driveway design. This chapter describes the pertinent access criteria along with the design guidelines, including two design templates based on design vehicle, sidewalks, and sight distance criteria, for driveway connections on the state highway system. WSDOT controls driveways on all limited access state highways, and regulates driveways on all managed access state highways outside the incorporated limits of a city or town. RCW 47.50.030 states that cities and towns, regardless of population size, are the permitting authority for managed access state highways within their respective incorporated city and town limits. The RCW also requires those cities and towns to adopt standards for access permitting on managed access state highways that meet or exceed WSDOT standards, provided those adopted standards are consistent with WSDOT standards.

1340.02 Access Control

Limited access highways are roadways to which WSDOT has acquired the access rights from abutting property owners. Driveways, if they have been allowed, are documented and recorded in the deed and right-of-way limited access plan. Chapter 530 describes the three levels of limited access highways: full, partial, and modified. Any change to the number, type, and use of a limited access driveway must be approved by Headquarters through the process outlined in Chapter 530 and Chapter 550. A general permit is required to allow any new construction or repairs for a deeded road approach on a limited access highway. Access connection permits are not issued on limited access highways.

Any state highway that is not a limited access highway is a managed access highway. Chapter 540 describes the five classes of managed access highways: Class 1 (most restrictive) to Class 5 (least restrictive). In addition to the five access control classes, there are also corner clearance criteria that must be used for access connections near intersections (see Section 540.04 and Exhibit 540-2). An access connection permit is required to allow the use, operation, and maintenance of a driveway connection on a managed access highway, outside incorporated cities, where WSDOT is the access permitting authority. Check with Development Services to ascertain where WSDOT has permitting authority (such as tribal lands or National Parks).

When evaluating access connections or approaches on a project, review existing driveways for possible alterations, relocations, consolidations, or closures. The first step in that process is to determine the legality of each driveway. The region Development Services Office can provide a list of the permitted driveway connections on a managed access highway, noting that, per RCW 47.50.080, Permit removal, "Unpermitted connections to the state highway system in existence on July 1, 1990, shall not require the issuance of a permit and may continue to provide access to the state highway system, unless the permitting authority determines that such a connection does not meet minimum acceptable standards of highway safety." As a result, driveway connections on a managed access state highway can be considered to be permitted, grandfathered, or unpermitted as described below:

- *Permitted* driveways hold a valid permit and shall remain valid until modified or revoked.
- *Grandfathered* driveways that were in existence and in active use consistent with the type of connection on July 1, 1990, may continue to provide connection to the state highway system. The term "Grandfathered" driveway, or connection, is not a term defined in statute or rule. It is a commonly used term to define legal connections to managed access state highways, in place prior to July 1, 1990. They do not require the issuance of a new permit and may continue to provide access to the state highway system, unless the permitting authority determines that such a connection does not meet minimum acceptable standards of highway safety.
- *Unpermitted* driveways are not allowed. The permitting authority may initiate action to close the unpermitted driveway in compliance with the applicable chapters of 47.50 RCW and 468-51 and 468-52 WAC. These are driveways that do not have a permit and were constructed after July 1, 1990.

If a WSDOT project proposes to alter, relocate, consolidate, or close a driveway—regardless of whether the driveway is permitted, grandfathered, or unpermitted—it is required that a new access connection permit be issued for any driveways that are to remain. If a driveway is to be removed, formal notification to the property owner will be provided as specified in WAC 468-51-040. Unless determined otherwise, the affected property owners of driveways that will be altered, relocated, consolidated, or closed will not have the right of an Adjudicative Hearing.

Additional information regarding this process can be obtained by contacting your region's Development Services Office.

On limited access highways, both the region Development Services and Real Estate Services offices may provide assistance to determine the legality of an existing driveway. Federal Highway Administration approval is required for driveway modifications on Interstate facilities.

1340.03 Driveway Design

The design of a driveway is based on the usage, design vehicle, and traffic volumes anticipated for the driveway. Generally, the driveway should be designed to accommodate the largest vehicle that will regularly use the driveway. For example, a residential driveway connection will typically have smaller radii and a narrower access width than a higher-volume commercial driveway.

However, if the property owner regularly has larger-wheelbase vehicles using the driveway, such as a home-based work vehicle, recreational vehicle, or truck and boat trailer combination, then a larger driveway may be appropriate.

Conversely, some driveways, such as a rural locked and gated utility, farm, or logging access that larger vehicles sometimes use, may be better served with a smaller and narrower access. This is based on infrequent use and to prevent unauthorized use or dumping of debris on or near the driveway. Other design considerations are:

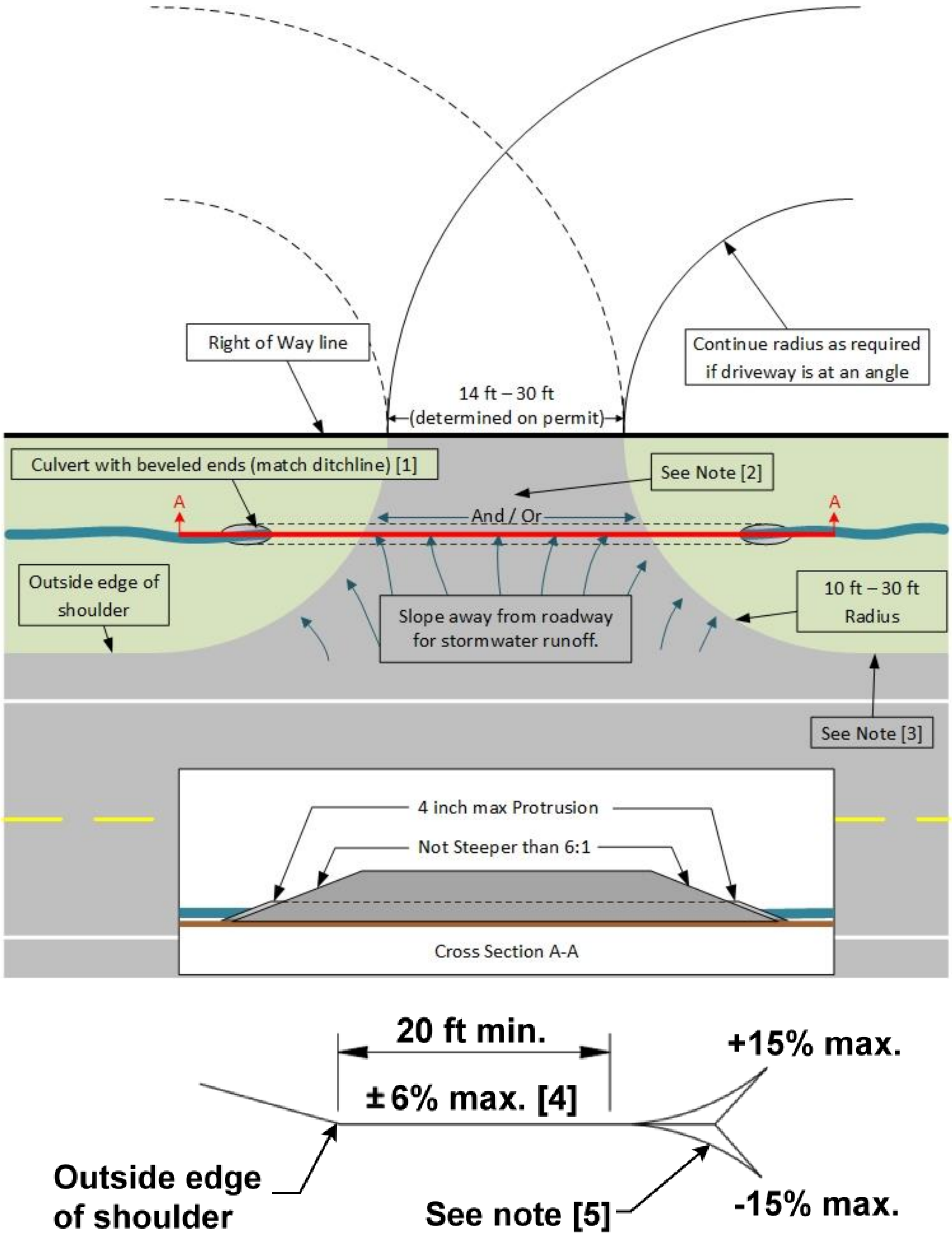
- Prevent stormwater from flowing onto the roadway from the driveway.
- Properly size culverts under the driveway to adequately accommodate the conveyance of stormwater in the roadway ditches and swales.
- Provide driveway sight distance.
- Accommodate for mailbox placement.
- Ensure surfacing materials and depths are appropriate.
- Generally, extend paving to the right of way line depending on the location/purpose of the driveway. The desirable intersection angle of the driveway is 90°, with 60° to 120° allowed.
- Where driveways intersect sidewalks, bike lanes, shared-use paths, or trails especially near schools, consider narrowing the driveway and/or reducing the radii to the minimum required to accommodate the design vehicle. Narrower driveway width and/or smaller driveway radii can reduce exposure and speed differentials between vehicles entering / exiting the driveway and pedestrians or bicycles.

1340.03(1) Design Templates

There are two driveway design templates for use where there is no adjacent sidewalk. When a driveway connection has or will have adjacent sidewalk, see Section 1340.04. In both template designs, the sideslopes of the driveway shall not be steeper than 6H:1V. These templates may be used on both limited access and managed access state highways. If an Interstate limited access driveway is allowed, it must be gated. Use the design template dimensions that will accommodate the intended use of the driveway and will not adversely affect the operations of the traveled way of the state highway. See Chapter 530 and Chapter 550 for documentation requirements for access approaches to limited access facilities. Design driveways with as small a foot print as possible while accommodating the design vehicle specific to that driveway. Use turn simulation software (such as AutoTURN®) to verify the driveway design will accommodate the largest vehicle that will regularly use the driveway. Considering the context of use, Exhibit 1340-1 is generally used for private, special use, and low volume commercial driveways with design vehicles of SU-30, BUS, and smaller. Exhibit 1340-2 is generally used for low volume commercial and special use driveways with design vehicles of SU-30, BUS, and larger.

Driveways to developments with greater than 1,500 (estimated) average daily trips both entering and exiting the development (shopping malls, housing developments, commercial complexes, etc.) should be designed as an intersection leg (see Chapter 1310).

Exhibit 1340-1 Driveway Design Template SU-30 and Smaller



Notes:

[1] Culvert pipe with beveled end treatment (see Chapter 1600). See Hydraulics Manual, Road Approach and Driveway Culverts for details.

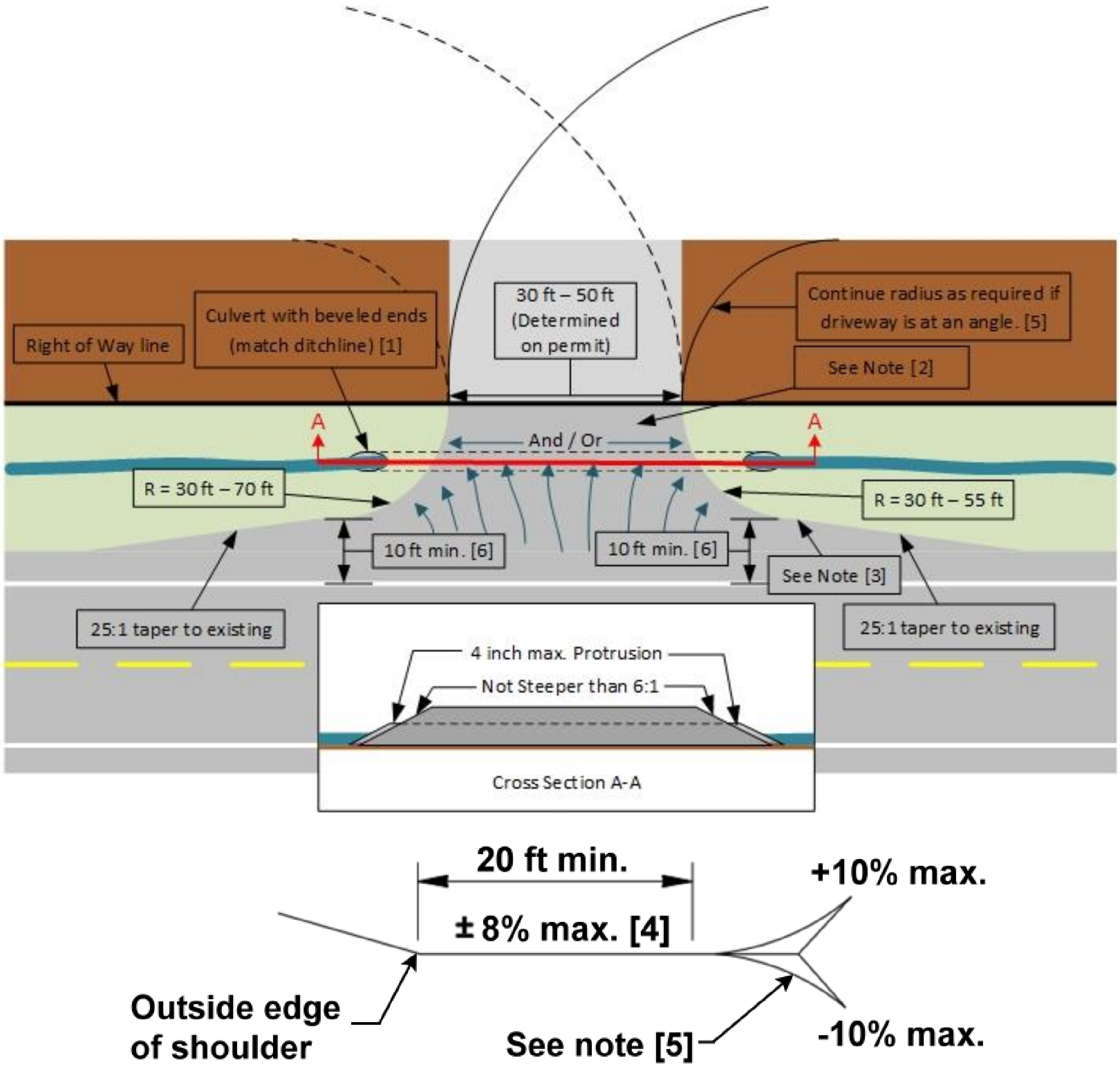
[2] When the travel lanes are bituminous, a similar surface may be used on the approaches.

[3] For mailbox location and type, see Section 1340.07 and Chapter 1600.

[4] Not to exceed ±8% maximum algebraic difference from shoulder slope.

[5] Vertical alignment not to exceed a 3¼-inch hump or a 2-inch depression in a 10-foot chord

Exhibit 1340-2 Driveway Design Template SU-30 and Larger



Notes:

[1] Culvert pipe with beveled end treatment (see Chapter 1600). See Hydraulics Manual, "Private Road Approach and Driveway Culverts" for details.

[2] When the travel lanes are bituminous, a similar surface may be used on the approaches.

[3] For mailbox location and type, see Section 1340.07, Chapter 1600.

[4] Not to exceed ±8% maximum algebraic difference from shoulder slope.

[5] Vertical alignment not to exceed a 3¼-inch hump or a 2-inch depression in a 10-foot chord.

[6] Check turning template of driveway design vehicle

1340.03(2) Sidewalks

Driveways adjacent to sidewalks shall be designed and constructed in accordance with this chapter and Standard Plan F-80.10. Driveway width will be as stated on the access permit. The sidewalk shall be designed and constructed in accordance with Chapter 1510 and Section F of the *Standard Plans*.

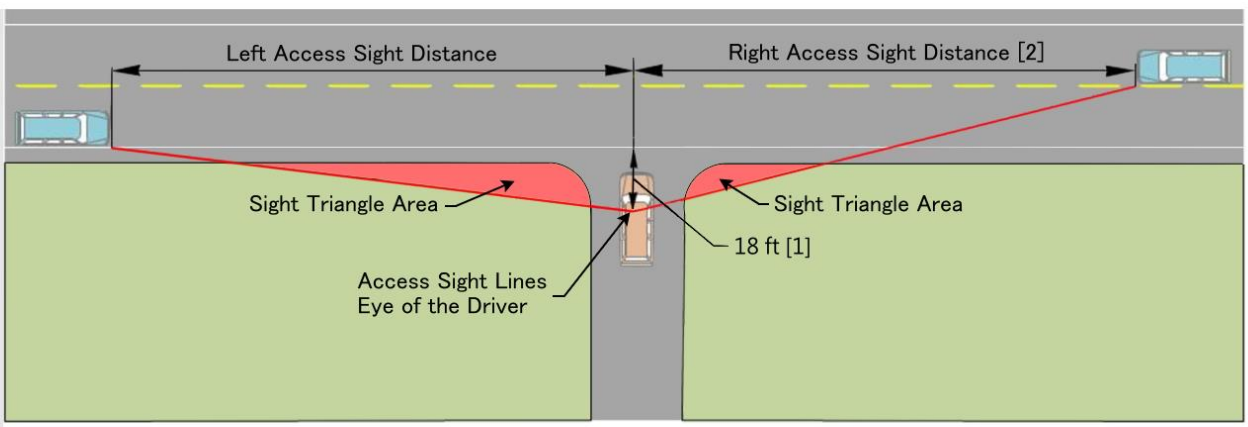
1340.03(3) Sight Distance

A driver on the highway needs to see far enough ahead to understand, react, and take actions appropriate for the conditions, such as a vehicle entering or leaving the highway at a driveway. In addition, drivers entering the highway from a driveway need to see enough of the highway, left and/or right, so they can enter the highway in a reasonably safe manner.

Design and locate driveways such that the sight distances, based on an eye height of 3.5 feet and an object height of 3.5 feet, meet or exceed the distances shown in Exhibit 1340-3; these distances may require an approaching vehicle to reduce speed or stop to prevent a collision. In addition, provide decision sight distance for through traffic at all utility and special-use driveways on facilities with limited access control (see Chapter 1260). The sight triangle areas created by the sight lines should be clear of sight obstructions that might block or affect a driver's view of potentially conflicting vehicles. See Exhibit 1340-3.

Use intersection sight distance (see Section 1310.05) for road approaches with greater than 1,500 (estimated) average daily trips both entering and exiting the development at full build out.

Exhibit 1340-3 Driveway Sight Distance



Mainline Posted Speed (mph)	25	30	35	40	45	50	55	60	65	70
Driveway Sight Distance (ft) Eye and object height 3.5 ft.	155	200	250	305	360	425	495	570	645	730

Notes:

[1] Measured from the edge of traveled way to the drive's eye. If the desirable 18-foot setback cannot be achieved, obtain as much as practicable, down to a 10-foot minimum.

[2] Not required for driveways that are restricted by raised channelization to be right in and right out only.

1340.03(4) Stormwater and Drainage

Slope driveways away from the highway to prevent stormwater and and other debris from flowing onto the highway traveled lanes and shoulders. Use of curbs, catch basins, or other measures may be needed to divert stormwater where it is not feasible to slope the driveway away from the highway. Locate catch basins outside of the vehical paths of the driveway.

Install beveled end culverts sized in accordance with the *Hydraulics Manual* if the driveway traverses an existing ditch or swale in the state highway right of way. Contact either the Region Hydraulic Engineer or the applicable Region Maintenance Office for assistance. Consider placing quarry spalls at each end of the open culvert to prevent erosion.

Profile the road approach as shown in Exhibits 1340-1 or 1340-2 while ensuring that roadway runoff is not a problem. Locate culverts as far from the traveled way as possible. In Exhibits 1340-1 and 1340-2, roadway runoff can be a concern if the grade from the edge of shoulder to the right of way line and the slope parallel to the mainline is a flat or minus grade. If needed, a curb may be placed and if needed, a catch basin can also be placed as shown in Exhibit 1340-2. When considering a curb, see Chapter 1239 as allowable curb locations, heights, and offset distances can vary based on mainline speed. Construct road approaches and related areas such that they do not impair drainage within the right of way or alter the stability of the roadway subgrade.

1340.03(5) Mailboxes

Refer to Chapter 1600, Roadside Safety, Mailboxes, for guidance regarding the placement of mailboxes.

Standard Plans, Mailbox Support Types, H-70.10-01, H-70.20-01, and H-70.30-02

1340.04 Documentation

Refer to Chapter 300 for design documentation requirements.

1340.05 References

1340.05(1) State Laws and Codes

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

Chapter 47.50 RCW, Highway access management

Chapter 47.52 RCW, Limited access facilities

Chapter 468-51 Washington Administrative Code (WAC), Highway access management access permits – Administrative process

Chapter 468-52 WAC, Highway access management – Access control classification system and standards

Chapter 468-58 WAC, Limited access highways

1340.05(2) Design Guidance

Right of Way Manual, M 26-01, WSDOT

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

Development Services Manual, M 3007, WSDOT

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

Chapter 1515 Shared-Use Paths

1515.01 General

Shared-use paths are designed for both transportation and recreation purposes and are used by pedestrians, bicyclists, skaters, equestrians, and other users. Some common locations for shared-use paths are along rivers, streams, ocean beachfronts, canals, utility rights of way, and abandoned railroad rights of way; within college campuses; and within and between parks as well as within existing roadway corridors. A common application is to use shared-use paths to close gaps in bicycle networks. There might also be situations where such facilities can be provided as part of planned developments. Where a shared-use path is designed to parallel a roadway, provide a separation between the path and the vehicular traveled way in accordance with this chapter.

As with any roadway project, shared-use path projects need to fit into the context of a multimodal community. Exhibits are provided throughout this chapter to illustrate possible design solutions, which should be treated with appropriate flexibility as long as doing so complies with corresponding laws, regulations, standards, and guidance. Engage various discipline experts, including landscape architects, soil and pavement engineers, maintenance staff, traffic control experts, ADA and bicycle coordinators, and others. Additionally, when designing such facilities, consider way-finding.

This chapter includes technical provisions for making shared-use paths accessible to persons with disabilities. Design shared-use paths and roadway crossings in consultation with your region's ADA Coordinator, Bicycle Coordinator, and State Bicycle and Pedestrian Coordinator. For additional information on pedestrian and bicycle facilities, see Chapters 1510 and 1520, respectively.

1515.02 Shared-Use Path Design

When designing shared-use paths, the bicyclist may not be the critical design user for every element of design. For example, the crossing speeds of most intersections between roads and pathways should be designed for pedestrians, as they are the slowest users. Accommodate all intended users, and minimize conflicts. When designing to serve equestrians, it is desirable to provide a separate bridle trail along the shared-use path to minimize conflicts with horses.

Exhibit 1515 - 1 Shared-Use Path

1515.02(1) Design Speed

The design speed for a shared-use path is based on bicycle use and is dependent on the terrain and the expected conditions of use. Design the shared-use path to encourage bicyclists to operate at speeds compatible with other users. Higher speeds are discouraged in a mixed-use setting. Design shared-use paths to maintain speeds at or below the speeds shown in Exhibit 1515-2 by designing to the horizontal curve radii shown.

Exhibit 1515 - 2 Bicycle Design Speeds

Conditions	Design Speed (mph)	Curve Radius (ft)
Long downgrades (steeper than 4% and longer than 500 ft)	30	166
Open country (level or rolling); shared-use paths in urban areas	20	74
Approaching intersections	12	27

When minimum radius curves cannot be obtained because of right of way, topographical, or other constraints, consider installing the following mitigation measures for traffic calming to slow bicyclists when approaching curves:

- Intermittent curves to slow or maintain desired speeds.
- Standard curve warning signs and supplemental pavement markings in accordance with the MUTCD.

- Perpendicular stripes painted on the pathway in decreasing intervals to provide the perception of increased speed. This has been shown to slow drivers when applied to roadways.
- Changes in pavement texture to encourage reductions in speed at tight curve approaches.

The negative effects of tight radius curves can also be partially offset by widening the pavement through the curves. Steeper vertical grades affect the running speed of bicycles. A shared-use path should be designed not to exceed 5%. Refer to 1515.04(3) for further guidance.

1515.02(2) Widths, Cross Slopes, Side Slopes, and Clearances

1515.02(2)(a) Shared-Use Path Widths

The appropriate paved width for a shared-use path depends on the context, volume, and mix of users. The desirable paved width of a shared-use path, excluding the shoulders on either side, is 12 feet. The minimum paved width, excluding the shoulders on either side, is 10 feet.

A paved width of more than 12 feet, excluding the shoulders on either side, may be appropriate when substantial use by both pedestrians and bicyclists is expected or maintenance vehicles are anticipated.

Shared-use path shoulders are typically unpaved and 2 feet wide on either side. Exhibits 1515-3 through 1515-5 provide additional information and cross-sectional elements.

On bridges or tunnels, it is common to pave the entire shared-use path, including shoulders. This usable width can be advantageous for emergency, patrol, and maintenance vehicles and allows for maneuvering around pedestrians and bicyclists who may have stopped. It also keeps the structure uncluttered of any loose gravel shoulder material.

1515.02(2)(b) Exceptions to Minimum Path Widths

A reduced path width of 8 feet may be designed at locations that present a physical constraint such as an environmental feature or other obstacle. Refer to the MUTCD for signing and pavement markings for such conditions.

In very rare circumstances, a reduced width of 8 feet may be used where the following conditions prevail:

- Bicycle traffic is expected to be low, even on peak days or during peak hours.
- Pedestrian use of the facility is not expected to be more than occasional.
- Horizontal and vertical alignments provide frequent, well-designed passing and resting opportunities.
- The shared-use path will not be regularly subjected to maintenance vehicle loading conditions that would cause pavement edge damage.
- The share-use path is a short distance such as a spur connection to a neighborhood.

1515.02(2)(c) Existing Shared-Use Paths – Considerations

Some existing shared-use paths were constructed with narrower dimensions, generally providing 8 feet of pavement. Evaluate existing older paths for current needs. Consider widening an existing shared-use path to meet current geometric standards.

1515.02(2)(d) Cross Slope

The maximum cross slope on a paved shared-use path is to be 2%. The cross slope of the shoulders can be no steeper than 6H:1V. To accommodate drainage, the entire section, including shoulders, should transition through curves. It is desirable to design the pivot point on the outside edge of one side of the shoulder or the other to avoid a pavement crown (see Exhibits 1515-3 through 1515-5).

It is best practice to design the cross slope to be less steep than the allowed maximum to account for some tolerance in construction. For example, design for a 1.5% cross slope (rather than the 2% maximum).

Sloping the pavement surface to one side is desirable and usually simplifies drainage design and surface construction. Generally, surface drainage from the path is dissipated as it flows down the side slope.

1515.02(2)(e) Side Slopes and Pedestrian Rail

Side slopes along shared-use paths are an important design feature. Embankment side slopes of 6H:1V or flatter provide a gently sloping path border.

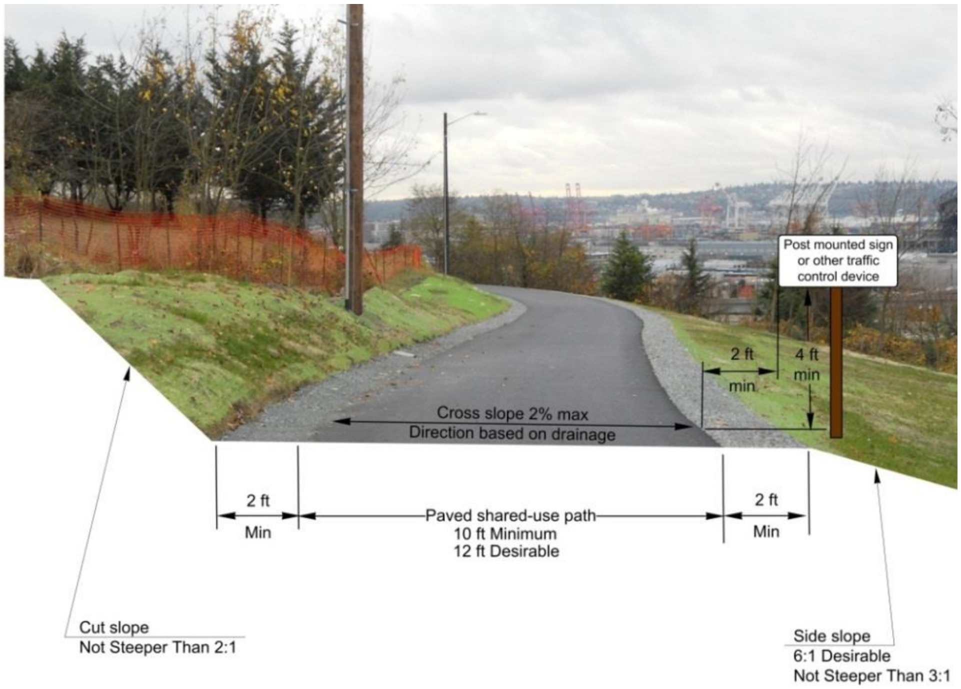
For shared-use paths with side slopes steeper than 3H:1V, or where obstacles or waterways may exist, evaluate the potential risk and provide mitigation such as:

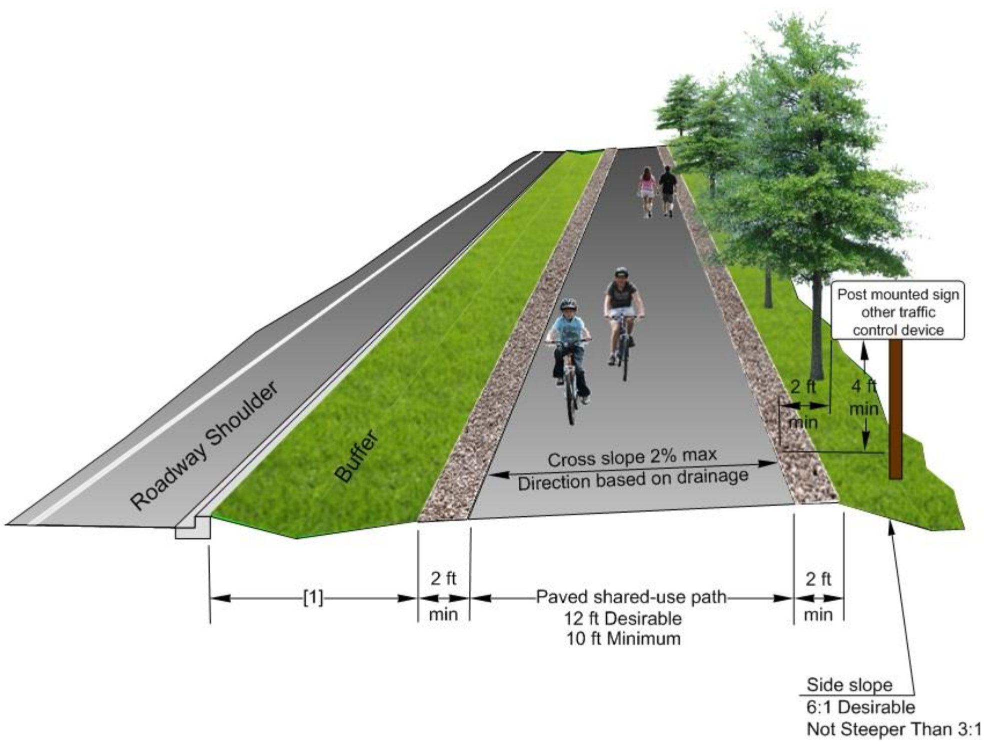
- A minimum 5-foot separation from the edge of the pavement to the embankment edge. This can be accomplished by providing a 5-foot shoulder as shown in Exhibit 1515-5, Example 2.
- A natural barrier such as dense shrubbery on the side slopes.
- A physical barrier, such as a pedestrian rail.
- Where a shared-use path is adjacent to a vertical drop of 2 feet 6 inches or more, a pedestrian rail is needed (see Exhibit 1515-5, Example 4).
- If the vertical drop is less than 2 feet 6 inches, a pedestrian rail, chain link fence, or 4-inch curb at the edge of the shared-use path may be installed to delineate the edge.
- Where a shared-use path is constructed on the side of a hill, drainage facilities may need to be considered.

1515.02(2)(f) Clearances

The minimum horizontal clearance from the edge of pavement to an obstruction (such as bridge piers or guardrail) is 2 feet. For vertical clearances see 1515.04 Grade Separation Structures.

Exhibit 1515 - 3 Two-Way Shared-Use Path: Independent Alignment

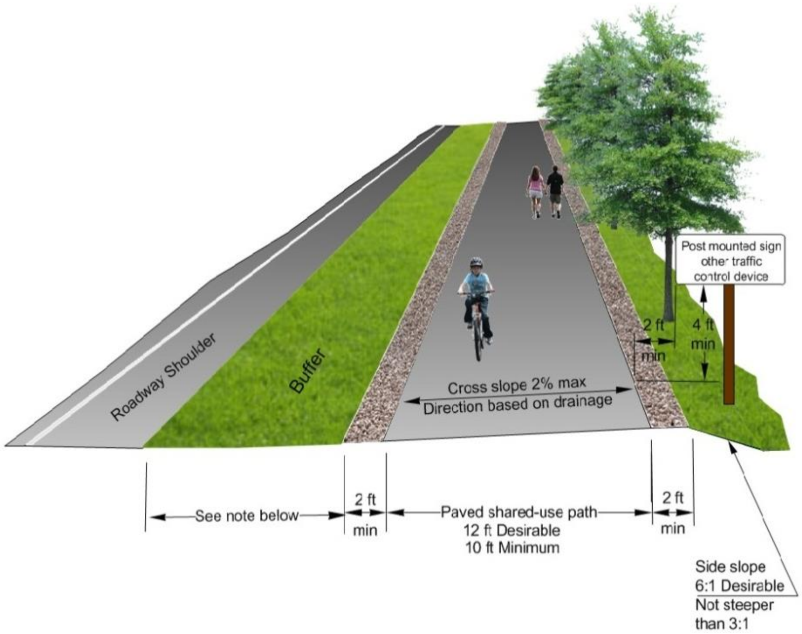




Note:

[1] 3 ft minimum. Provide as much separation from the roadway as practicable.

Exhibit 1515 - 4a Two-Way Shared-Use Path: Adjacent to Roadway (≤ 35 mph)

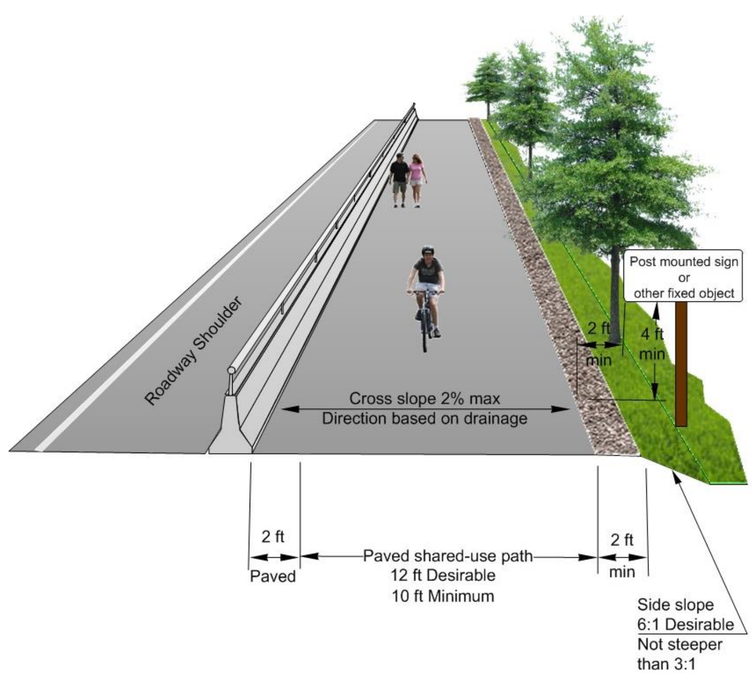


Notes:

A separation greater than 5 feet is required for path user comfort. If separation greater than 5 feet cannot be obtained, provide barrier separation in accordance with Exhibit 1515-4c.

See Chapter 1600 for roadway clear zone design guidance for fixed objects.

Exhibit 1515-4b Two-Way Shared-Use Path: Adjacent to Roadway (> 35mph)

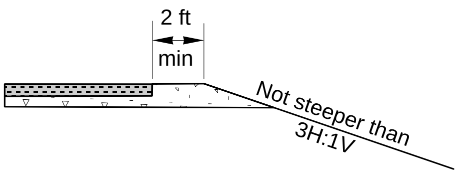


Notes:

It is desirable for the cross slope to slope toward grass areas for drainage.

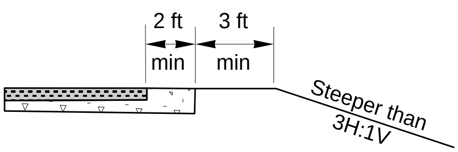
See Chapter 1610 for barrier design. Pedestrian rail height minimum is 42 inches.

Exhibit 1515 - 5 Shared-Use Path Side Slopes and Railing



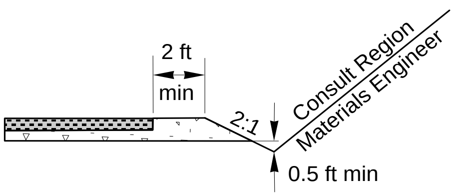
Example 1: Embankment

Based on context, flatter slopes are desirable.



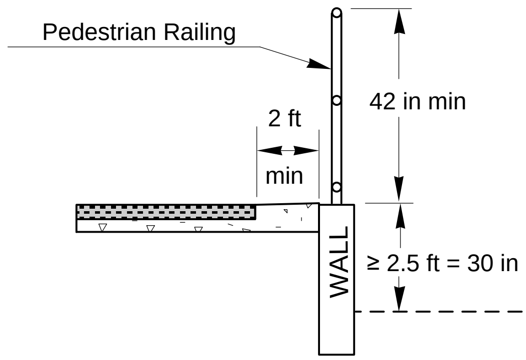
Example 2: Shoulder widening to 5 feet or more

Used with steeper fill slopes to provide clear space between the hinge point and path. Vegetation can also be used as a buffer on slopes. Consider a natural or physical barrier in lieu of 3 ft additional widening.



Example 3: Cut section with ditch

Consult with the Region Materials Engineer to determine for appropriate cut slopes.



Example 4: Railing used at drop off

Apply railing or fencing a minimum of 42 inches high when a drop off is present, such as along a retaining wall. Consult with the Region Materials Engineer to determine if the shoulder along the wall should be paved.

Note: These drawings depict some common applications for various slope alternatives.

1515.02(3) Running Slopes, Landings, and Rest Areas

1515.02(3)(a) Running Slopes

Design running slopes (grades) on shared-use paths less than or equal to 5% to accommodate all user types, including pedestrians with disabilities.

When the path is within the highway right of way, its running slope can match the general grade established for the adjacent roadway.

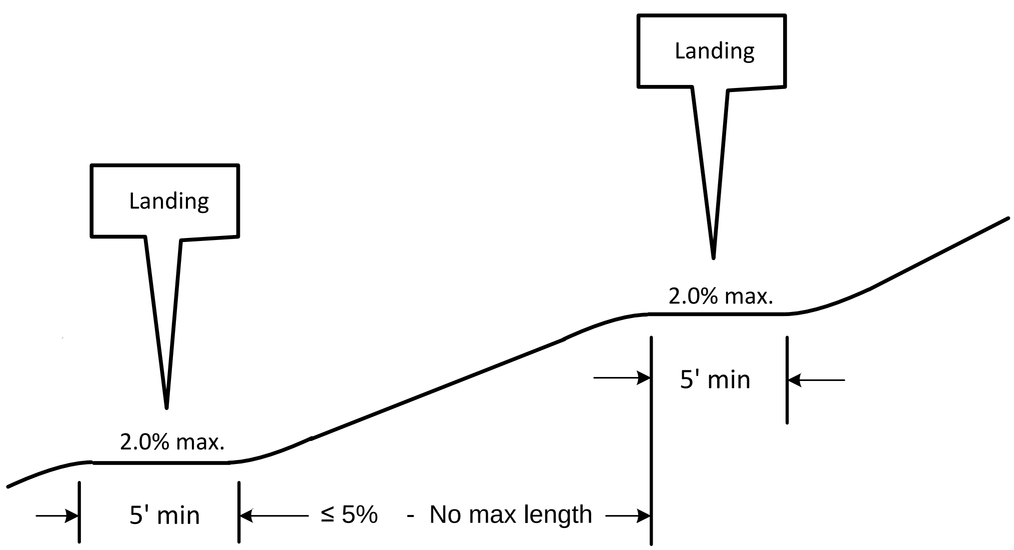
1515.02(3)(b) Landings

Shared-use path landings provide users a level place to rest on extended grades. Exhibits 1515-6 and 1515-7 show these features.

Design landings to:

- Permit users to stop periodically and rest.
- Not exceed maximum running slopes and cross slopes of 2%.
- Be in line and as wide as the shared-use path. Landings are to be at least 5 feet long.
- Avoid abrupt grade changes or angle points. Design transitions to landings using vertical curves.

Exhibit 1515 - 6 Shared-Use Path Landing Profile



Notes:

Landings are desirable on extended grades.

Design vertical curves to transition from the grade to the landing.

Exhibit 1515-7 illustrates a landing and a rest area.

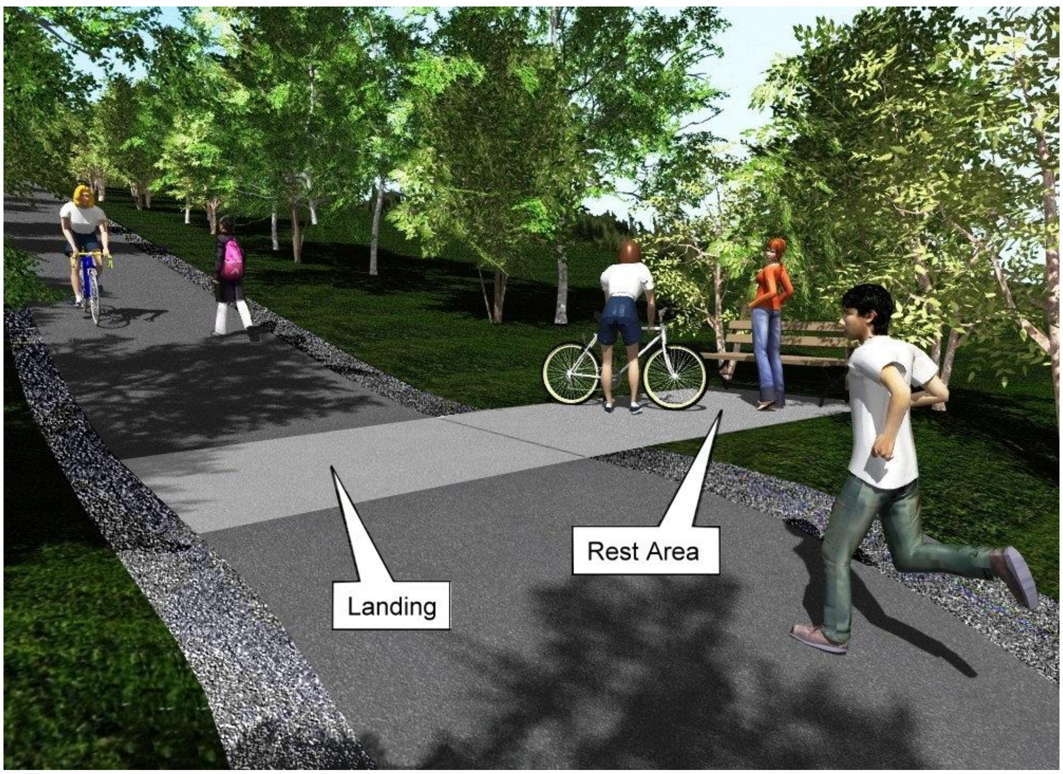
1515.02(3)(c) Rest Areas

Although not required, rest areas may be provided adjacent to the shared-use path outside of the path travelled way as shown in Exhibit 1515-7.

Requirements for rest areas include:

- The maximum running slope and cross slopes are 2%.
- The minimum size is to be 5 feet by 5 feet.
- If features such as benches are provided, they must meet ADA requirements; consult with the region ADA Coordinator for guidance.

Exhibit 1515 - 7 Shared-Use Path Landing and Rest Area



Notes:

Design inline landings at least 5 feet long and as wide as the shared-use path.

Design inline landings with a maximum cross slope and running slope of 2%.

1515.02(4) 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 path. (Design loads are normally maintenance and emergency vehicles.) Provide a firm, stable, slip-resistant pavement surface.

Design the pavement structural section as recommended by the Region Materials Engineer.

Use crushed rock or other suitable material for shoulder graded areas as recommended by the Region Materials Engineer. On bridges or tunnels, it is common to pave the entire shared-use path, including shoulders across the structure.

1515.02(5) Stopping Sight Distance

The distance needed to bring a shared-use path user to a complete stop is a function of the user's perception and braking reaction time, the initial speed, the coefficient of friction between the wheels and the pavement, the braking ability of the user's equipment, and the grade. Exhibits 1515-14a and 14b provide a graph and an equation to obtain minimum stopping sight distances for various design speeds and grades.

1515.02(5)(a) Stopping Sight Distance on Crest Vertical Curves

Exhibit 1515-15 provides a chart or equations to obtain the minimum lengths of crest vertical curves for varying stopping sight distances and algebraic differences in grade. The values are based on a 4.5-foot eye height for the bicyclist and a 0-foot height for the object (path surface).

1515.02(5)(b) Stopping Sight Distance on Horizontal Curves

Exhibit 1515-16 gives the minimum clearances to line-of-sight obstructions for sight distance on horizontal curves. Provide lateral clearance based on the sum of stopping sight distances from Exhibits 1515-14a and 14b for bicyclists traveling in both directions and the proposed horizontal curve radius. Where this minimum clearance cannot be obtained, provide curve warning signs and use centerline pavement markings in accordance with the MUTCD.

Exhibits 1515-14a, 14b, 15, and 16 are presented at the end of the chapter.

1515.03 Intersections and Crossings Design

This section covers path/roadway intersections and grade-separated crossings. Detectable warning surfaces are required where shared-use paths connect to the roadway.

1515.03(1) Intersections with Roadways

Clearly define who has the right of way and provide sight distance for all users at shared-use path and roadway intersections.

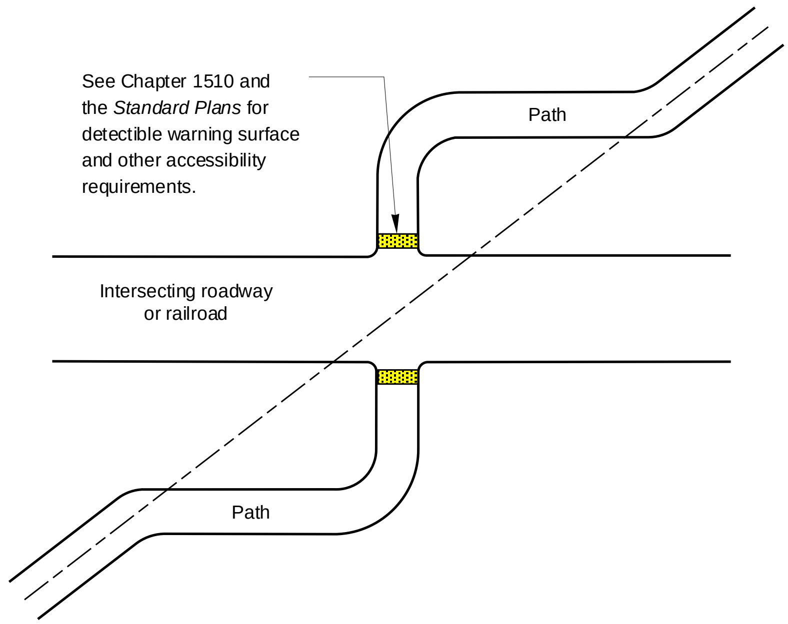
The common types of shared-use path/roadway at-grade intersection crossings are midblock and adjacent.

For roadway intersections with roundabouts, see Chapter 1320.

Midblock crossings are located between roadway intersections. When possible, locate the path crossings far enough away from intersections to minimize conflicts between the path users and motor vehicle traffic. It is preferable for midblock path crossings to intersect the roadway at an angle as close to perpendicular as practicable. A minimum 60-degree crossing angle is acceptable to minimize right of way needs. A diagonal midblock crossing can be altered as shown in Exhibit 1515-8.

There are other considerations when designing midblock crossings. They include traffic right of way assignments; traffic control devices; sight distances for both bicyclists and motor vehicle operators; refuge island use; access control; and pavement markings.

Exhibit 1515 - 8 Typical Redesign of a Diagonal Midblock Crossing



Notes:

For path and highway signing and markings, see the MUTCD and the *Standard Plans*.
http://www.wsdot.wa.gov/publications/fulltext/Standards/english/PDF/m09.60-00_e.pdf

For radii approaching roadway intersections, see Exhibit 1515-2.

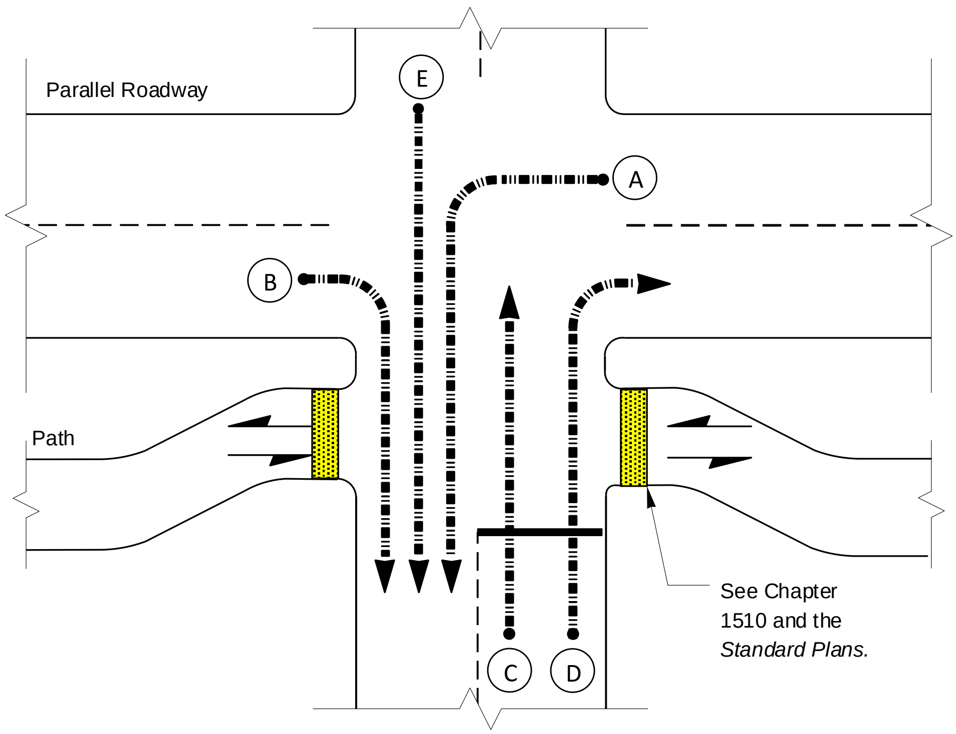
Adjacent path crossings are located at or near public intersection crosswalks and are normally placed with them. These crossings are usually placed with pedestrian crossings, where motorists can be expected to stop. If alternate intersection locations for a shared-use path are available, select the one with the greatest sight distance.

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 Exhibit 1515-9. It is desirable to integrate this type of crossing close to an intersection so that motorists and path users recognize one another as intersecting traffic. The path user faces potential conflicts with motor vehicles turning left (A) and right (B) from the parallel roadway and on the crossed roadway (C, D, and E).

Consider crossing improvements on a case-by-case basis. Suggested improvements include: move the crossing; evaluate existing or proposed intersection control type; change signalization timing; or provide a refuge island and make a two-step crossing for path users.

Important elements that greatly affect the design of these crossings are traffic right of way assignments, traffic control devices, and the separation distance between path and roadway.

Exhibit 1515 - 9 Adjacent Shared-Use Path Intersection



Note:

For signing and pavement markings, see the MUTCD and the *Standard Plans*.

Additional Roadway/Path Intersection Design Considerations

Additional roadway/path intersection design considerations include the following:

Evaluate Intersection Control

Determine the need for traffic control devices at 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. Provide traffic signal timing set for pedestrians.

Signal Actuation Mechanisms

Place the manually operated accessible pedestrian pushbutton in a location that complies with ADA requirements. For additional information, see Chapters 1330 and 1510. A detector loop in the path pavement may be provided in addition to the manually operated accessible pedestrian push button.

Signing

Provide sign type, size, and location in accordance with the MUTCD. Place path STOP signs as close to the intended stopping point as feasible. Do not place the shared-use path signs where they may confuse motorists or place roadway signs where they may confuse shared-use path users. For additional information on signing, see the MUTCD and Chapter 1020.

Approach Treatments

Design shared-use path and roadway intersections with level grades, and provide sight distances. Provide advance warning signs and pavement markings that alert and direct path users that there is a crossing (see the MUTCD). Do not use speed bumps or other similar surface obstructions intended to cause bicyclists to slow down. Consider some slowing features such as horizontal curves (see Exhibits 1515-2 and 1515-8). Avoid locating a crossing where there is a steep downgrade where bike speeds could be high.

Sight Distance

Sight distance is a principal element of roadway and path intersection design. At a minimum, provide stopping sight distance for both the roadway and the path at the crossing. Decision sight distance is desirable for the roadway traffic. Refer to Chapter 1260 for stopping sight distance for the roadway and 1515.04(5) for shared-use path stopping sight distance.

Curb Ramp Widths

Design curb ramps with a width equal to the shared-use path. Curb ramps and barrier-free passageways are to provide a smooth transition between the shared-use path and the roadway or sidewalk (for pedestrians). Curb ramps at path/ roadway intersections must meet the requirements for curb ramps at a crosswalk. For design requirements, see Chapter 1510, and for curb ramp treatments at roundabouts, see Chapter 1320.

Refuge Islands

Consider refuge islands where a shared-use path crosses a roadway when one or more of the following applies:

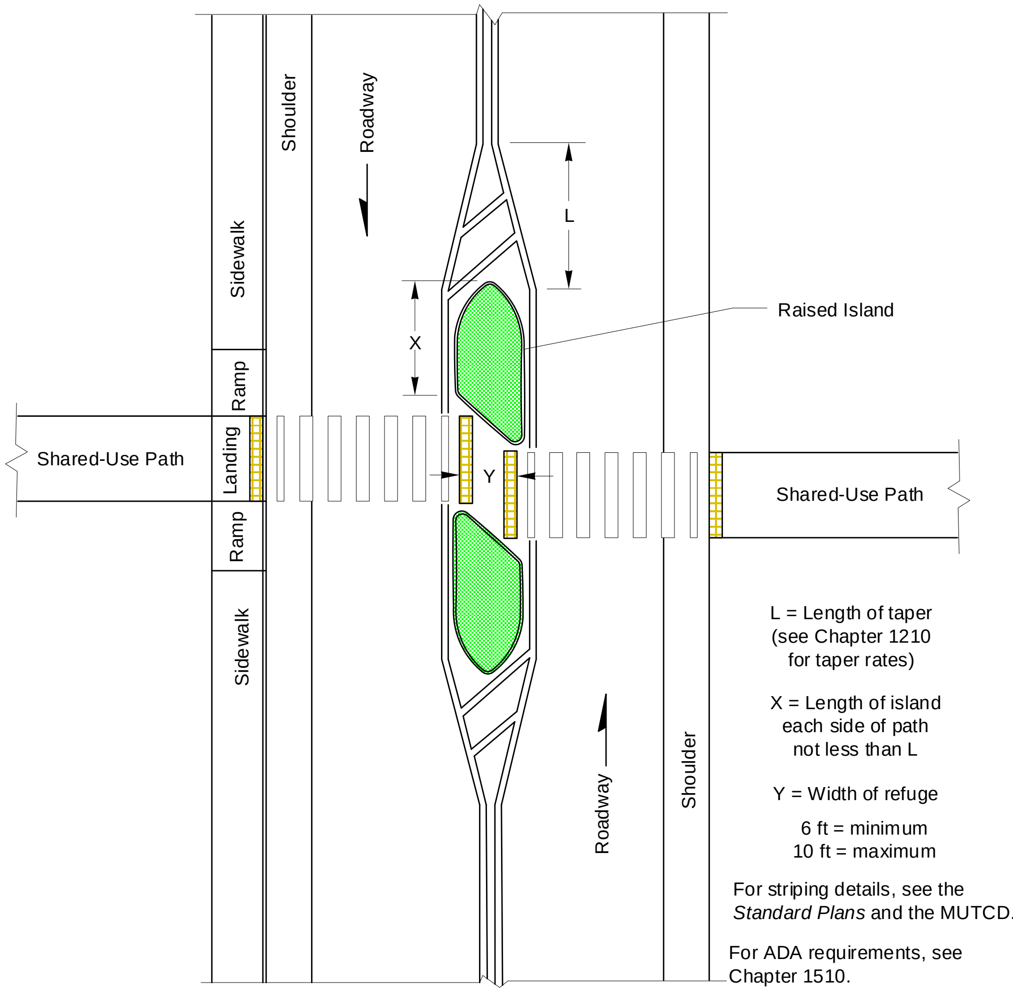
- High motor vehicle traffic volumes and speeds
- Wide roadways
- Use by the elderly, children, the disabled, or other slow-moving users

The refuge area may either be designed with the storage aligned perpendicularly across the island or be aligned diagonal (as shown in Exhibit 1515-10). The diagonal storage area has the added benefit of directing attention toward oncoming traffic since it is angled toward the direction from which traffic is approaching.

1515.03(2) At-Grade Railroad Crossings

Wherever possible, design the crossing at right angles to the rails. For signing and pavement marking for a shared-use path crossing a railroad track, see the MUTCD and the *Standard Plans*. Also, see Chapter 1510 for design of at-grade pedestrian railroad crossings.

Exhibit 1515 - 10 Roadway Crossing Refuge Area



Note:

This exhibit shows a case where a path intersects a roadway framed with both a sidewalk and a paved shoulder, for the purpose of showing detectible warning surface placements.

1515.04 Grade Separation Structures

Provide the same minimum clear width as the approach paved shared-use path plus the graded clear areas.

Carrying full widths across 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.

For undercrossings and tunnels, it is the Designer's responsibility to determine the correct minimum vertical clearance (shared use path pavement surface to overhead obstruction) of each undercrossing or tunnel based on coordination with maintenance and emergency services. The minimum vertical clearance for bicyclists and equestrians is 10 feet.

Consult the region Maintenance Office and the HQ Bridge Preservation Office to verify that the planned path width and vertical clearance meets their needs. If not, widen and/or increase vertical clearance to their specifications.

Use expansion joints that accommodate shared-use path users. Expansion joints should be perpendicular to the path and have a maximum gap of ½ inch or be covered with a slip-resistant plate.

The installation of protective screening is analyzed on a case-by-case basis. Refer to Chapter 720 for guidance.

Exhibit 1515 - 11 Shared-Use Path Bridge and Approach Walls

Note:

On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for additional information.

Exhibit 1515 - 12 Bridge and Pedestrian Rail

Notes:

The photo above shows a bridge with a shared-use path separating the users from the roadway. Pedestrian rail is used on the outside edge.

On structures, the bridge railing type and height are part of the structure design. Contact the HQ Bridge and Structures Office for additional information.

1515.05 Signing, Pavement Markings, and Illumination

Generally, WSDOT does not provide continuous centerline striping or channelization for user modes on shared-use paths. However, signing and pavement markings can be beneficial to warn shared-use path users of curves, grades, obstructions, and intersections.

Refer to the MUTCD for guidance and directions regarding signing (regulatory, warning, and way finding) and pavement markings.

The *Standard Plans* shows shared-use path pavement markings at obstructions in accordance with the MUTCD and also shows placement of detectible warning surfaces.

For pavement marking around bollards and other obstructions, see Standard Plan M-9.60:
http://www.wsdot.wa.gov/publications/fulltext/standards/english/pdf/m09.60-00_e.pdf

The level of illumination on a shared-use path is dependent on the amount of nighttime use expected and the nature of the area surrounding the facility. If illumination is used, provide illumination in accordance with Chapter 1040.

1515.06 Restricted Use Controls

This section presents considerations on use of fencing and other treatments to restrict roadway and path users to their domains.

1515.06(1) Fencing

Limited access highways often require fencing or other forms of controlling access. Shared-use paths constructed within these corridors, such as shown in Exhibit 1515-13, likely require fencing. For guidance on fencing, limited access controls, and right of way, refer to Division 5 of the *Design Manual*. Evaluate the impacts of fencing on sight distances.

Exhibit 1515 - 13 Shared-Use Path in Limited Access Corridor

1515.06(2) Restriction of Motor Vehicle Traffic

Shared-use paths often need some form of physical barrier at roadway intersections to prevent unauthorized motor vehicles from entering.

Bollards have been used by many path owners to prevent unauthorized vehicle access. However, bollards should not be applied indiscriminately, and there are other considerations to bollard installation.

1515.06(2)(a) Landscaped Islands

A preferred method of restricting entry of motor vehicles is to split the entry way into two sections separated by low landscaping, thereby splitting a path into two channels at roadway intersections. This method essentially creates an island in the middle of the path rather than installing a bollard. Such an island could be planted with low-growing, hardy vegetation capable of withstanding the occasional authorized vehicle traveling over it. When splitting a path, employ MUTCD pavement markings and signing, such as is used for bollards and obstructions.

1515.06(2)(b) Bollard Considerations

Typically, one bollard located in the center of the path is sufficient to control motor vehicle access to the path. If more than one bollard is needed, the additional bollards should be placed at the edge of the shared-use path.

Install bollards at entrances to shared-use paths to discourage motor vehicles from entering. Do not use bollards to divert or slow path traffic. When locating such installations, stripe an envelope around the bollards and paint and reflectorize them to be visible to path users both day and night. Bollards located on or adjacent to shared-use paths represent an object that needs to be avoided by bicyclists and pedestrians. To increase the potential for appropriate maneuvering to occur, provide designs where the post is clearly visible and recognizable.

When designing bollards, the following apply:

- The desirable design is to provide a single bollard, installed in the middle of the path to reduce confusion.
- When multiple bollard posts are used in wide path sections, use a minimum 5-foot spacing between the edge of concrete footings to permit passage of bicycle-towed trailers, wheelchairs, and adult tricycles, with room for bicycle passage without dismounting.
- Provide 4 feet minimum (5 feet desirable) clear width between the edge of concrete footing and edge of path.
- At a minimum, provide stopping sight distance to bollards. An ideal location for bollard placement is in a relatively straight area of the path where the post placement has the stopping sight distance given in Exhibit 1515-14a and 14b. Do not place bollards in difficult-to-see locations (for example, immediately upon entering a tunnel).
- For cases where multiple posts are used longitudinally along the path, locate them at least 20 feet apart, with the first post in line from each direction having stopping sight distance.
- Use a contrasting striping pattern on the post.
- Use reflective materials on the post, such as a band at the top and at the base.
- Design all bollards along a corridor to be uniform in appearance. Frequent cyclists can become familiar with the posts and recognize them easily.
- Provide pavement markings in accordance with the *Standard Plans* and MUTCD at all bollards on paved paths.
- Use removable bollards (Bollard Type 1) to permit access by emergency and service vehicles.
- Non-removable bollards (Bollard Type 2) may be used where access is not needed.

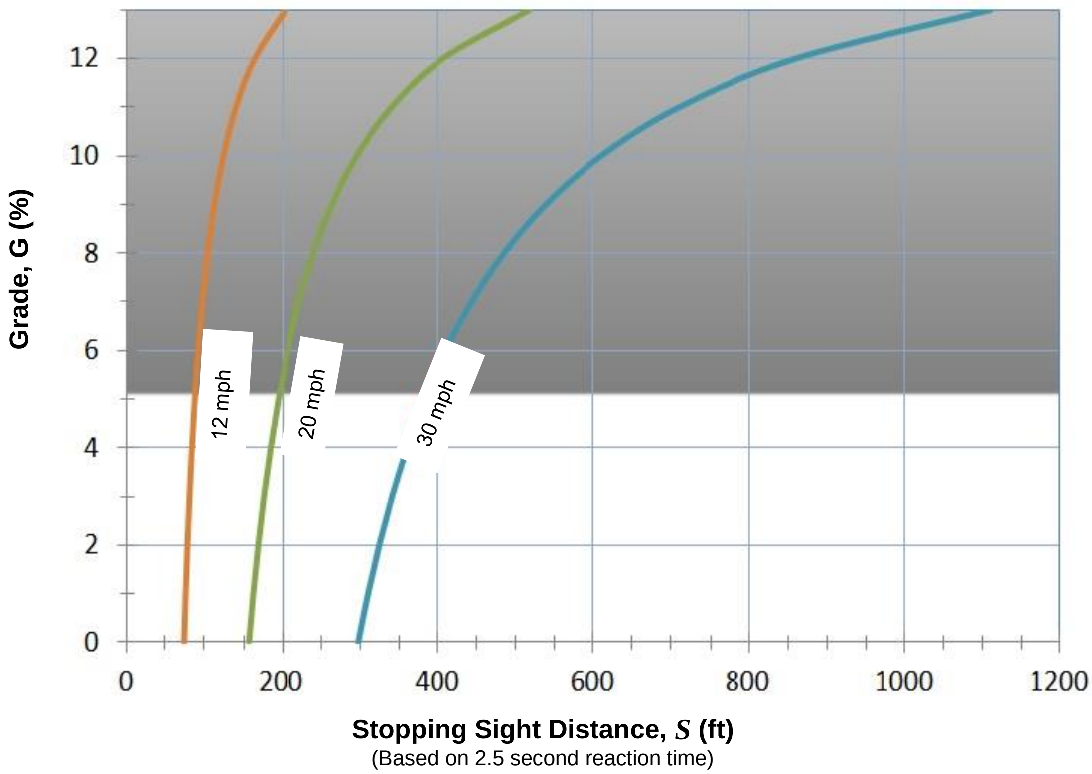
Refer to the *Standard Plans* for bollard designs and the *Standard Plans* and MUTCD for pavement markings at bollards.

When bollards need to be placed near the roadway, see Chapter 1600 for clear zone requirements.

1515.07 Documentation

For the list of documents required to be preserved in the Design Documentation Package and the Project File, see the Design Documentation Checklist:
www.wsdot.wa.gov/design/projectdev/

Exhibit 1515 - 14a Stopping Sight Distance for Downgrades



Note:

Shaded area represents grades greater than 5%.

$$S = \frac{V^2}{0.30(f - G)} + 3.67V$$

Where:

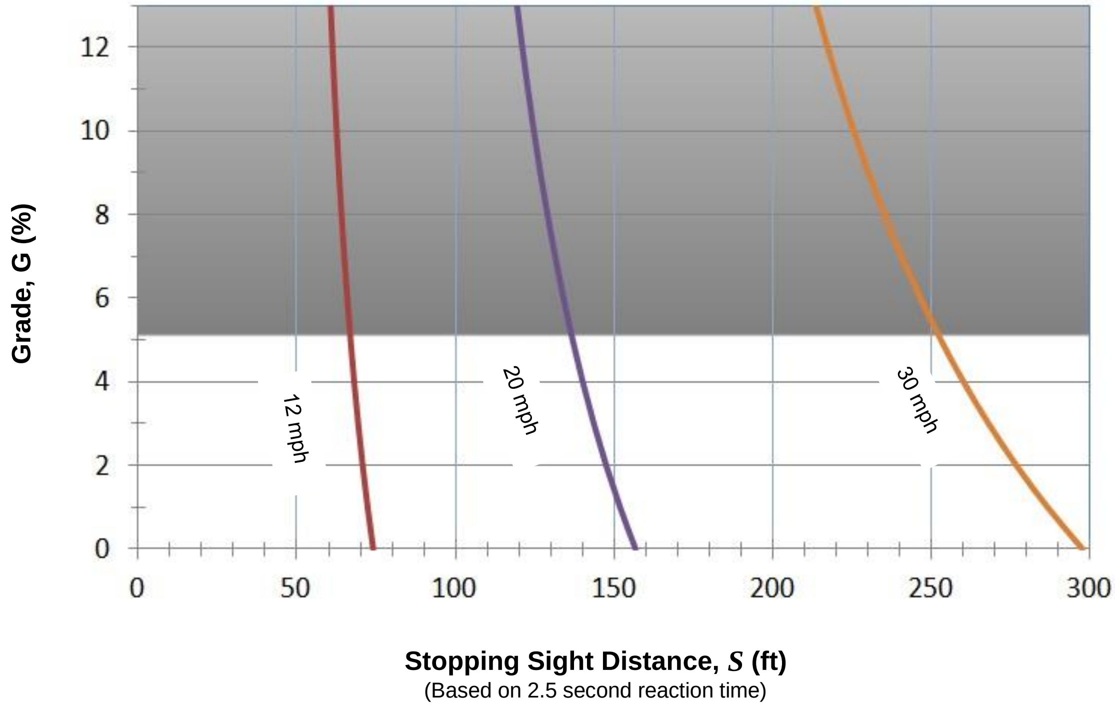
S = Stopping sight distance (ft)

V = Speed (mph)

f = Coefficient of friction (use 16)

G = Grade (%)

Exhibit 1515 – 14b Stopping Sight Distance for Upgrades



Note:

Shaded area represents grades greater than 5%.

$$S = \frac{V^2}{0.30(f + G)} + 3.67V$$

Where:

S = Stopping sight distance (ft)

V = Speed (mph)

f = Coefficient of friction (use 16)

G = Grade (%)

Exhibit 1515 - 15 Minimum Lengths for Crest Vertical Curves

A (%)	Stopping Sight Distance, S (ft)													
	40	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	
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	1,000
11	3	38	78	122	176	240	313	396	489	592	704	826	958	1,100
12	5	45	85	133	192	261	341	432	533	645	768	901	1,045	1,200
13	11	51	92	144	208	283	370	468	578	699	832	976	1,132	1,300
14	16	56	100	156	224	305	398	504	622	753	896	1,052	1,220	1,400
15	20	60	107	167	240	327	427	540	667	807	960	1,127	1,307	1,500
16	24	64	114	178	256	348	455	576	711	860	1,024	1,202	1,394	1,600
17	27	68	121	189	272	370	484	612	756	914	1,088	1,277	1,481	1,700
18	30	72	128	200	288	392	512	648	800	968	1,152	1,352	1,568	1,800
19	33	76	135	211	304	414	540	684	844	1,022	1,216	1,427	1,655	1,900
20	35	80	142	222	320	436	569	720	889	1,076	1,280	1,502	1,742	2,000
21	37	84	149	233	336	457	597	756	933	1,129	1,344	1,577	1,829	2,100
22	39	88	156	244	352	479	626	792	978	1,183	1,408	1,652	1,916	2,200
23	41	92	164	256	368	501	654	828	1,022	1,237	1,472	1,728	2,004	2,300
24	43	96	171	267	384	523	683	864	1,067	1,291	1,536	1,803	2,091	2,400
25	44	100	178	278	400	544	711	900	1,111	1,344	1,600	1,878	2,178	2,500

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 (ft)

A = Algebraic difference in grade (%)

L = Minimum vertical curve length (ft)

Based on an eye height of 4.5 ft and an object height of 0 ft.

Note:

Below ▬▬ represents $S \leq L$.

Shaded area represents A>10%.

Exhibit 1515 - 16 Lateral Clearance for Horizontal Curves

Height of eye: 4.50 ft

Height of object: 0.0 ft

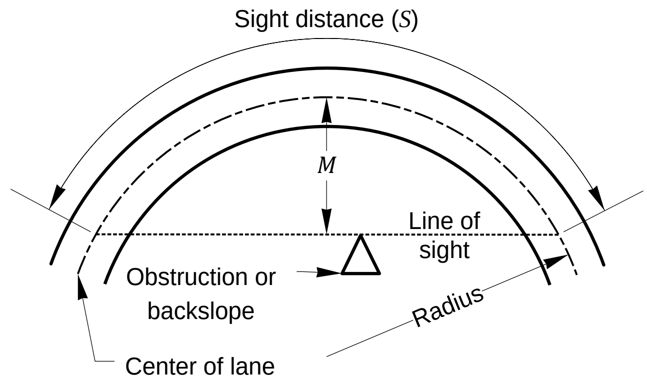
Line of sight at the M distance is normally 2.3 ft above centerline of inside lane at point of obstruction, provided no vertical curve is present in horizontal curve.

$$M = R\left(1 - \cos\frac{S\,28.65}{R}\right)$$

$$S = \frac{R}{28.65}\left[\cos^{-1}\left(\frac{R-M}{R}\right)\right]$$

$S \leq$ Length of curve

Angle is expressed in degrees.



Where:

S = Sight distance (ft)

R = Centerline radius of inside lane (ft)

M = Distance from inside lane centerline (ft)

***R* (ft)**	**Stopping Sight Distance, *S* (ft)[1]**													
	40	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**
25	7.6	15.9												
50	3.9	8.7	15.2	23.0	31.9	41.5								
75	2.7	5.9	10.4	16.1	22.7	30.4	38.8	47.8	57.4	67.2				
95	2.1	4.7	8.3	12.9	18.3	24.6	31.7	39.5	47.9	56.9	66.2	75.9	85.8	
125	1.6	3.6	6.3	9.9	14.1	19.1	24.7	31.0	37.9	45.4	53.3	61.7	70.5	79.7
150	1.3	3.0	5.3	8.3	11.8	16.0	20.8	26.2	32.1	38.6	45.5	52.9	60.7	69.0
175	1.1	2.6	4.6	7.1	10.2	13.8	18.0	22.6	27.8	33.4	39.6	46.1	53.1	60.4
200	1.0	2.2	4.0	6.2	8.9	12.1	15.8	19.9	24.5	29.5	34.9	40.8	47.0	53.7
225	0.9	2.0	3.5	5.5	8.0	10.8	14.1	17.8	21.9	26.4	31.2	36.5	42.2	48.2
250	0.8	1.8	3.2	5.0	7.2	9.7	12.7	16.0	19.7	23.8	28.3	33.0	38.2	43.7
275	0.7	1.6	2.9	4.5	6.5	8.9	11.6	14.6	18.0	21.7	25.8	30.2	34.9	39.9
300	0.7	1.5	2.7	4.2	6.0	8.1	10.6	13.4	16.5	19.9	23.7	27.7	32.1	36.7
350	0.6	1.3	2.3	3.6	5.1	7.0	9.1	11.5	14.2	17.1	20.4	23.9	27.6	31.7
400	0.5	1.1	2.0	3.1	4.5	6.1	8.0	10.1	12.4	15.0	17.9	20.9	24.3	27.8
500	0.4	0.9	1.6	2.5	3.6	4.9	6.4	8.1	10.0	12.1	14.3	16.8	19.5	22.3
600	0.3	0.7	1.3	2.1	3.0	4.1	5.3	6.7	8.3	10.1	12.0	14.0	16.3	18.7
700	0.3	0.6	1.1	1.8	2.6	3.5	4.6	5.8	7.1	8.6	10.3	12.0	14.0	16.0
800	0.2	0.6	1.0	1.6	2.2	3.1	4.0	5.1	6.2	7.6	9.0	10.5	12.2	14.0
900	0.2	0.5	0.9	1.4	2.0	2.7	3.6	4.5	5.5	6.7	8.0	9.4	10.9	12.5
1,000	0.2	0.4	0.8	1.2	1.8	2.4	3.2	4.0	5.0	6.0	7.2	8.4	9.8	11.2

Minimum Lateral Clearance, M (ft)

Note:

[1] S is the sum of the distances (from Exhibits 1515-14a and 14b) for bicyclists traveling in both directions.

Chapter 1610 Traffic Barriers

Chapter Organization: The first sections (Introduction and Barrier Impacts) present information to consider when deciding whether to install a barrier. The next section (General Barrier Design Considerations) contains guidance common to ALL barrier types, such as deflection distance, length of need and sight distance. The remaining sections present design information organized by specific barrier type (beam guardrail, cable barrier, etc.).

Refer to the *Design Manual* Glossary for many of the terms used in this chapter.

Refer to Chapter 300 for design documentation requirements.

1610.01 Introduction

WSDOT uses traffic barriers to reduce the overall severity of crashes. Consideration is given as to whether a barrier is preferable to the recovery area it may replace. In some cases, installation of a traffic barrier may result in more crashes as it presents an object that can be struck. Barriers are designed so that such encounters might be less severe and not lead to secondary or tertiary crashes. However, traffic barriers are not guaranteed to redirect an impacting vehicle without resulting injury to its occupants or triggering additional crashes. Barrier performance is affected by the characteristics of the vehicles that collide with them. Different vehicles will react differently given the characteristics and dynamics of the crash. Therefore, vehicles will be decelerated and redirected differently given the size, weight and direction of force imparted from the vehicle to the barrier.

Barriers are not placed with the assumption that the system will restrain or redirect all vehicles in all conditions. It is recognized that the designer cannot design a system that will address every potential crash situation. Instead, barriers are placed with the assumption that, under typical crash conditions, they might decrease the potential for excessive vehicular deceleration or excessive vehicle redirection when compared to the location without the barrier.

Traffic barriers do not prevent crashes or injuries from occurring. They often lower the potential severity for crash outcomes. Consequently, barriers should not be used unless a reduced crash severity potential is likely. No matter how well a barrier system is designed, optimal performance is dependent on drivers' proper maintenance and operation of their vehicles and the proper use of passenger restraint systems. The ultimate choice of barrier type and placement should be made by gaining an understanding of site and traffic conditions, having a thorough understanding of and applying the criteria presented in Chapters 1600 and 1610, and using engineering judgment.

Barrier systems and vehicle fleets continue to evolve. The choice of a barrier is based on the characteristics of today's vehicle fleet and testing criteria, not on speculative assumptions of future vehicle designs. This continuum of change does not allow engineers to predict the future with any degree of certainty. Consequently, engineering decisions need to be made based on the most reliable and current information.

Engineers are constantly striving to develop more effective design features to improve highway safety. However, economics, asset management and maintenance needs, and feasibility do not permit the deployment of new designs as soon as they become available on the market or are invented by a manufacturer. Further, most new designs only make marginal changes to systems and do not imply that old designs are unsafe or need modification.

Solutions may consider crash frequency and severity. As discussed previously, performance of the system relies on the interaction of the vehicle, driver, and system design at any given location. Additionally, the ability to safely access, maintain and operate over time is incorporated into the final barrier decision.

When barriers are crash-tested, it is impossible to replicate the innumerable variations in highway conditions under which the barrier applications occur. Therefore, barriers are crash-tested under standardized conditions. These standard conditions were previously documented in National Cooperative Highway Research Program (NCHRP) Reports 230 and 350. These guidelines have been updated and are now presented in the AASHTO publication, *Manual for Assessing Safety Hardware* (MASH).

As roadside safety hardware changes occur on the highway system they will use MASH crash testing criteria instead of NCHRP Report 350. To learn more about WSDOT's plan for implementing MASH-compliant hardware see the following website:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.01(1) Site Constraints

Site constraints play a major role in decisions regarding guardrail selection and placement. Depending on the location, these constraints may include (but are not limited to) environmental considerations, topographic challenges, restricted right-of-way, geologic concerns or conflicts with other infrastructure to name just a few. Document barrier location decisions, including any site constraints encountered that influenced those decisions. A decision to install barrier using criteria outside the guidance provided in this chapter requires a Design Analysis (See Chapter 300).

1610.02 Barrier Impacts

Engineering judgment is required in determining the appropriate placement of barrier systems, therefore consider the location of the system and the possible impacts the barrier may have to other highway objectives.

1610.02(1) Assessing Impacts to Stormwater and Wetlands

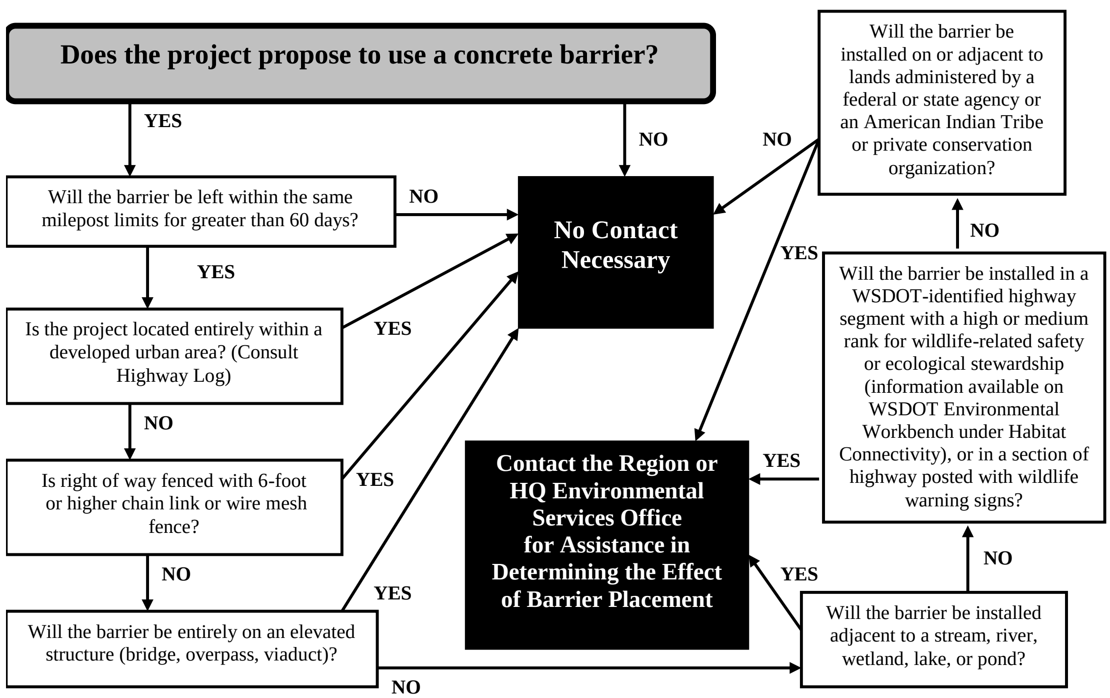
The presence of stormwater facilities or wetlands influence the choice and use of barrier systems. For example, the placement of concrete barrier may increase the amount of impervious surface, which could then result in retrofit or reconstruction of the existing retention/detention systems and environmental impact requirements and studies. Assess whether concrete barrier or beam guardrail placement will cause the need for an evaluation by the HQ Environmental Services Office. Conduct this evaluation early in the project's development process to allow adequate time for discussion of options.

1610.02(2) Assessing Impacts to Wildlife

The placement of concrete barriers in locations where wildlife frequently cross the highway can influence wildlife-vehicle crash potential. When wildlife encounters physical barriers that are difficult to see beyond or cross, such as concrete barriers, they often stop or move parallel to those barriers, increasing their time on the highway and their exposure.

Traffic-related wildlife mortality may play a role in the decline of some species listed under the Endangered Species Act. To address wildlife concerns, see Exhibit 1610-1 to assess whether barrier placement needs to have an evaluation by the HQ Environmental Services Office to determine its effect on wildlife. Conduct this evaluation early in the project development process to allow adequate time for discussion of options.

Exhibit 1610-1 Concrete Barrier Placement Guidance: Assessing Impacts to Wildlife



1610.03 General Barrier Design Considerations

See Chapter 1105 Design Element Selection for guidance regarding required design elements for the various different project types (programs and subprograms).

Chapter 1120 identifies those elements and features to be evaluated and potentially addressed during the course of a Preservation project.

Follow the guidance in this chapter for any project that introduces new barrier onto the roadside (including median section) and follow the guidance in Chapter 1600 for removal of barrier that is not needed. Slope flattening is recommended when the crash reduction benefit justifies the additional cost to eliminate the need for barrier.

When selecting a barrier, consider the barrier system's deflection characteristics, cost, maintainability and impacts to traffic flow during repair. Barriers are categorized as flexible, semi-rigid, or rigid depending on their deflection characteristics (see Exhibit 1610-3). Barrier types include:

- Beam Guardrail
- Cable Barrier
- Concrete Barrier
- Bridge Traffic Barrier
- Other Barriers

Since non-rigid systems typically sustain more damage during an impact, consider the amount of traffic exposure maintenance crews might incur with the more frequent need for repairs.

The costs for procuring and maintaining the barrier system are important factors when considering what system to install. Considerations may include:

- Consultation with the Area Maintenance Superintendent to identify needs or recommendations.
- Drainage, alignment, and drifting snow or sand are considerations that can influence the selection of barrier type. Beam guardrail and concrete barrier can contribute to snow drifts. Consider long-term maintenance costs associated with snow removal at locations prone to snow drifting. Cable barrier is not an obstruction to drifting snow.
- Analysis of potential reduction of sight distance due to barrier selection and placement.
- Additional widening and earthwork requirements. With some systems, such as concrete barrier and beam guardrail, the need for additional shoulder widening or slope flattening is common. Selection of these types of barriers may require substantial environmental permitting or roadway reconstruction. Permits issued under the SEPA and NEPA processes may lead to the use of a barrier design, such as cable barrier, which has fewer potential environmental impacts and costs.
- For concrete barrier systems:
  - Lower maintenance costs than for other barrier types.
  - Deterioration due to weather and vehicle impacts is less than most other barrier systems.
  - Unanchored precast concrete barrier can usually be realigned or repaired after a vehicle impact. However, heavy equipment may be necessary to reposition or

replace barrier segments. Therefore, in medians, consider the shoulder width and the traffic volume when determining the acceptability of unanchored precast concrete barrier versus rigid concrete barrier. See Exhibit 1610-3 for deflection area requirements.

Consider the following for existing barrier systems:

- Install, replace, or modify transitions as discussed in 1610.04(6) Transitions and Connections.
- When installing new terminals, extend the guardrail to meet the length-of-need criteria found in 1610.03(5).
- When replacing damaged terminals, consider extending the guardrail to meet the length of need criteria in 1610.03(5)
- When the end of a barrier has been terminated with a small mound of earth, remove and replace with a terminal as described in 1610.06(3).
- Special use or aesthetic barriers may be used on designated Scenic Byway and Heritage Tour routes if funding, permits, and approvals can be arranged (see 1610.08).
- Design Manual Chapter 1120 identifies specific requirements to be addressed for a Preservation project. For other projects, address barrier runs that include:
    - W-beam guardrail with 12-foot 6-inch post spacing, or no blockouts, or both.
    - W-beam guardrail on concrete posts.
    - Cable barrier on wood or concrete posts.
    - Half-moon or C-shaped rail elements.

1610.03(1) Barrier Placement Considerations

Proper installation of a barrier system is required for the system to perform similar to the crash tests that resulted in its acceptance for use on our highways. Maximize the distance between the barrier and the travelled way.

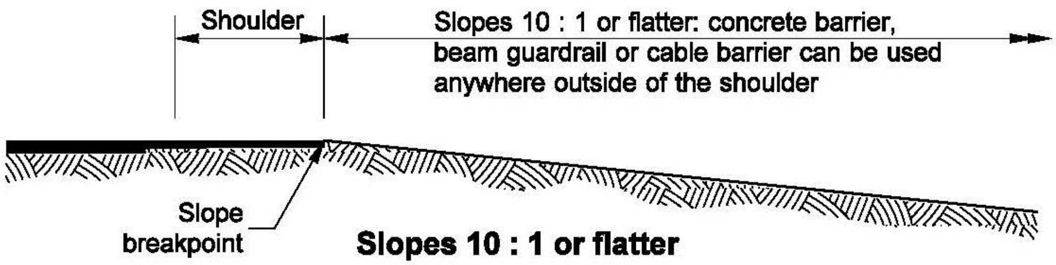
See Chapter 1239 for minimum lateral clearance requirements.

1610.03(1)(a) Placement on a Slope

Slopes may affect barrier placement. Considerations for barrier placement on a slope include:

- For slopes that are 10:1 or flatter, concrete barrier, beam guardrail or cable barrier can be installed anywhere beyond the edge of shoulder. See Exhibit 1610-2.
- For additional placement guidance see 1610.05(1) for cable barrier, see 1610.04(2) for beam guardrail, and see 1610.06 for concrete barrier.

Exhibit 1610-2 Traffic Barrier Locations on Slopes



1610.03(1)(b) Placement in Median Locations

Considerations for barrier placement in a median include:

- Address the design deflection characteristics of the barrier to avoid placement of barrier where the design deflection extends into oncoming traffic.
- Narrow medians provide little space for any maintenance activities, including repair or repositioning of the barrier. Installing barriers in medians that provide less than 8 feet from the edge of the traveled way to the face of the barrier will likely require temporarily closing the adjacent lane during maintenance activities. This will impact the travelling public and impact maintenance staff, and maintenance staff should be consulted. See Chapter 301 Design and Maintenance Coordination.
- At locations where the roadways are on independent alignments and there is a difference in elevation between the roadways, the slope from the upper roadway might be steeper than 6H:1V. In these locations, position the median barrier along the upper roadway and provide deflection and offset distance as discussed previously. Barrier is generally not needed along the lower roadway except where there are fixed features in the median.
- In wider medians, the selection and placement of barrier might depend on the slopes in the median. At locations where the median slopes are relatively flat (10H:1V or flatter), unrestrained precast concrete barrier, beam guardrail, and cable barrier can be used depending on the available deflection distance. At these locations, position the barrier as close to the center of the median as possible so that the recovery distance can be maximized for both directions. There may be a need to offset the barrier from the flow line to avoid impacts to the drainage flow.
- In general, cable barrier is recommended with medians that are 30 feet or wider. However, cable barrier may be appropriate for narrower medians if adequate deflection distance exists.
- When W-beam barrier is placed in a median as a countermeasure for cross-median crashes, design the barrier to be struck from either direction of travel. For example, the installation of beam guardrail might be double-sided (Type 31-DS).
- For additional placement guidance see 1610.05(1) for cable barrier, see 1610.04(2) for beam guardrail, and see 1610.06 for concrete barrier.

1610.03(2) Sight Distance

When selecting and placing a barrier system, consider the possible impact the barrier type and height may have on sight distance. In some cases, barriers may restrict the sight distances of road users entering the roadway, such as from road approaches, intersections, and other locations. In these cases, the barrier may need to be adjusted to meet the sight distance requirements at these locations.

1610.03(3) Barrier Deflections

Expect all barriers, except rigid barriers (such as concrete bridge rails, barrier integral to retaining walls, or embedded cast-in-place barriers), to deflect when hit by an errant vehicle. The amount of deflection is primarily dependent on the stiffness of the system. However, vehicle speed, angle of impact, and weight of the vehicle also affect the amount of barrier deflection. For flexible and semi-rigid roadside barriers, the deflection distance is designed to prevent the impacting vehicle from striking the object being shielded. For unrestrained rigid systems (unanchored precast concrete barrier), the deflection distance is designed to help prevent the barrier from being knocked over the side of a drop-off or steep fill slope (2H:1V or steeper).

In median installations, design systems such that the anticipated deflection will not enter the lane of opposing traffic. When evaluating new barrier installations, consider whether impacts would require significant traffic closures to accomplish maintenance. Use a rigid system where deflection cannot be accommodated, such as in narrow medians or at the edge of bridge decks or other vertical drop-off areas. Runs of rigid concrete barrier can be cast in place or extruded with appropriate footings.

In some locations, where deflection distance is limited, anchor precast concrete barrier. Unless the anchoring system has been designed to function as a fully rigid barrier, some movement can be expected and repairs may be more expensive. Use of an anchored or other deflecting barrier on top of a retaining wall without deflection distance provided requires approval from the HQ Design Office. See 1610.06 for more information on concrete barrier.

Refer to Exhibit 1610-3 for barrier deflection design values when selecting a longitudinal barrier. The deflection values for cable and beam guardrail are minimum distances, measured between the face of the barrier to the fixed feature. The deflection values for unanchored concrete barrier are minimum distances, measured from the back edge of the barrier to the fixed feature, drop-off or slope break.

Exhibit 1610-3 Longitudinal Barrier Deflection

Barrier Type	System Type	Deflection Distance
High-tension cable barrier	Flexible	6 ft to 10 ft typical [1] (face of barrier to object)
Beam guardrail, Types 1, 1a, 2, and 10	Semi-rigid	3 ft [4] (face of barrier to object)
Beam guardrail, two-sided Types 3, and 4	Semi-rigid	4 ft (nearest face of barrier to object)
Beam guardrail Type 31 (including two-sided and omitted post)	Semi-rigid	5 ft (face of barrier to object)
Permanent concrete barrier, unanchored	Rigid Unrestrained	3 ft [2] (back of barrier to object)
Temporary concrete barrier, unanchored	Rigid Unrestrained	2 ft [3] (back of barrier to object)
Precast concrete barrier, anchored	Rigid Anchored	6 inches
Rigid concrete barrier	Rigid	No deflection

Notes:
[1] See 1610.05(2)
[2] When placed in front of a 2H:1V or flatter fill slope, the deflection distance can be reduced to 2 feet.
[3] When used as temporary bridge rail, anchor all barrier within 3 feet of a drop-off.
[4] Place any new objects a minimum of 5 feet from the face of existing beam guardrail type 1.

1610.03(4) Flare Rate

A roadside barrier is considered flared when it is not parallel to the edge of the traveled way.

Flare the ends of longitudinal barriers where site constraints allow (see 1610.01(1)). The four functions of a flare are to:

- Maximize the distance between the barrier (and its terminal) and the travelled way.
- Reduce the length of need.
- Redirect an errant vehicle.
- Minimize a driver’s reaction to the introduction of an object near the traveled way.

Keeping flare rates as flat as site constraints allow preserves the barrier’s redirectional performance and minimizes the angle of impact. It has also been shown that an object (or barrier) close to the traveled way might cause a driver to shift laterally, slow down, or both. The flare reduces this reaction by gradually introducing the barrier so the driver does not perceive the barrier as an object to be avoided. The flare rates in Exhibit 1610-4 are intended to satisfy the four functions listed above. Flares that are more gradual may be used. Flare rates are offset parallel to the edge of the traveled way. Transition sections are not flared.

Situations exist where hardware installations may have barrier flare rates different than shown in Exhibit 1610-4. If a *Standard Plan* for a barrier installation shows a different flare rate than is shown in Exhibit 1610-4, the flare rate shown on the *Standard Plan* can be used.

Exhibit 1610-4 Longitudinal Barrier Flare Rates

Posted Speed (mph)	Rigid & Rigid Anchored System	Unrestrained Rigid System	Semi-rigid
65–70	20:1	18:1	15:1
60	18:1	16:1	14:1
55	16:1	14:1	12:1
50	14:1	12:1	11:1
45	12:1	11:1	10:1
40 or below	11:1	10:1	9:1

1610.03(5) Length of Need

Length of need refers to the total length of longitudinal barrier needed to shield a fixed feature.

In many cases, there may be a portion of the traffic barrier installation that is not redirective in capability. For instance, if a run of concrete barrier is terminated with an impact attenuator, there will likely be a section of the impact attenuator that is not redirective (see Chapter 1620 for more information). Therefore, in most cases, the Length of Need does not equal (i.e., it is shorter than) the actual physical length of the traffic barrier installation required to achieve that length of need.

Length of need is dependent on the location and geometrics of the object, direction(s) of traffic, posted speed, motor vehicle traffic volume, and type and location of traffic barrier.

When designing a barrier for a fill slope (see Chapter 1600), the length of need begins at the point where the need for barrier is recommended. For fixed objects and water, Exhibit 1610-5 shows design parameters for determining the needed length of a barrier for both adjacent and opposing traffic on relatively straight sections of highway.

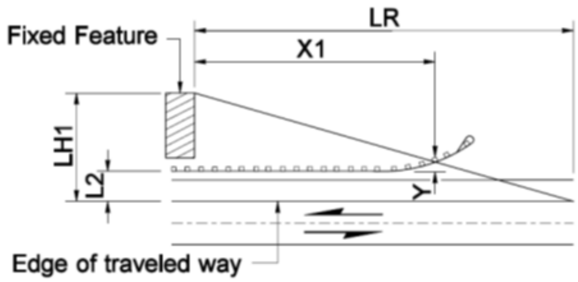
When barrier is to be installed on the outside of a horizontal curve, the length of need can be determined graphically as shown in Exhibit 1610-7. For installations on the inside of a curve, determine the length of need as though it were straight. Also, consider the flare rate, barrier deflection, and barrier end treatment to be used.

When beam guardrail is placed in a median, consider the potential for impact from opposing traffic when conducting a length of need analysis. When guardrail is placed on either side of objects in the median, consider whether the trailing end of each run of guardrail will shield the leading end of the opposing guardrail. Shield the leading end when it is within the Design Clear Zone of opposing traffic (see Exhibit 1610-8). This is also a consideration when objects are placed in the outer separations between the main line and collector-distributors.

Before the actual length of need is determined, establish the lateral distance between the proposed barrier installation and the object shielded. Provide a distance that is greater than or equal to the anticipated deflection of the longitudinal barrier. (See Exhibit 1610-3 for barrier deflections.) Place the barrier as far from the edge of the traveled way as possible while maintaining the deflection distance.

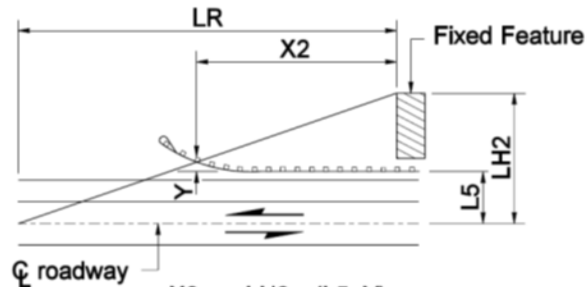
If the end of the length of need is near an adequate cut slope, extend the barrier and embed it in the slope (see 1610.04(5)). Avoid gaps of 300 feet or less. Short gaps are acceptable when the barrier is terminated in a cut slope. If the end of the length of need is near the end of an existing barrier, it is recommended that the barriers be connected to form a continuous barrier. Consider maintenance access issues when determining whether or not to connect barriers.

Exhibit 1610-5 Barrier Length of Need on Tangent Sections



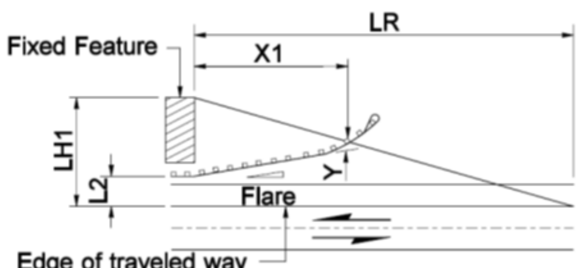
$$X1 = \frac{LH1 - (L2+Y)}{(LH1/LR)}$$

Adjacent-Side Fixed Feature
Barrier Parallel to Roadway



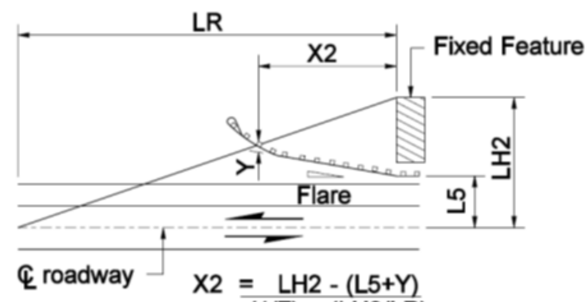
$$X2 = \frac{LH2 - (L5+Y)}{(LH2/LR)}$$

Opposite-Side Fixed Feature
Barrier Parallel to Roadway



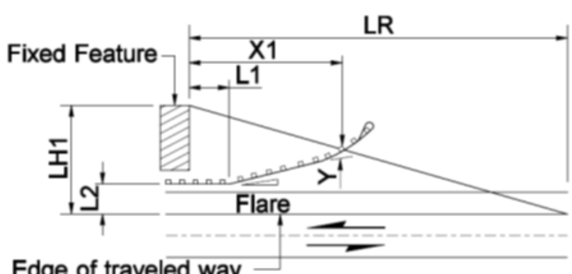
$$X1 = \frac{LH1 - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Fixed Feature
Barrier Flare Begins at Fixed Feature



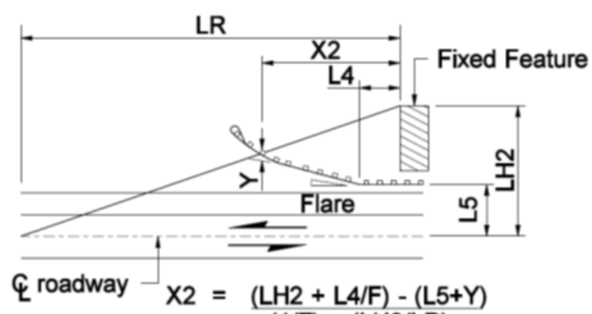
$$X2 = \frac{LH2 - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Fixed Feature
Barrier Flare Begins at Fixed Feature



$$X1 = \frac{(LH1 + L1/F) - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Fixed Feature
Barrier Flare Begins Before Fixed Feature



$$X2 = \frac{(LH2 + L4/F) - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Fixed Feature
Barrier Flare Begins Before Fixed Feature

Note: For supporting length of need equation factors, see Exhibit 1610-6

Exhibit 1610-6 Barrier Length of Need

Posted Speed (mph)	Design Parameters						
	ADT				Barrier Type		
	Over 10,000	5,000 to 10,00	1,000 to 4,999	Under 1,000	Rigid & Rigid Anchored Barrier	Rigid Unrestrained Barrier	Semi-rigid Barrier
	LR (ft)	LR (ft)	LR (ft)	LR (ft)	F	F	F
70	360	330	290	250	20	18	15
65	330	290	250	225	20	18	15
60	300	250	210	200	18	16	14
55	265	220	185	175	16	14	12
50	230	190	160	150	14	12	11
45	195	160	135	125	12	11	10
40	160	130	110	100	11	10	9
35	135	110	95	85	11	10	9
30	110	90	80	70	11	10	9
25	110	90	80	70	11	10	9

L1 = Length of barrier parallel to roadway from adjacent-side fixed feature to beginning of barrier flare. This is used if a portion of the barrier cannot be flared (such as a bridge rail and the transition).

L2 = Distance from adjacent edge of traveled way to portion of barrier parallel to roadway.

L4 = Length of barrier parallel to roadway from opposite-side fixed feature to beginning of barrier flare.

L5 = Distance from centerline of roadway to portion of barrier parallel to roadway. ***Note:*** If the fixed feature is outside the Design Clear Zone when measured from the centerline, it may only be necessary to provide a crash-tested end treatment for the barrier.

LH1 = Distance from outside edge of traveled way to back side of adjacent-side fixed feature. ***Note:*** If a fixed feature extends past the Design Clear Zone, the Design Clear Zone can be used as LH1.

LH2 = Distance from centerline of roadway to back side of opposite-side fixed feature. ***Note:*** If a fixed feature extends past the Design Clear Zone, the Design Clear Zone can be used as LH2.

LR = Runout length, measured parallel to roadway.

X1 = Length of need for barrier to shield an adjacent-side fixed feature.

X2 = Length of need for barrier to shield an opposite-side fixed feature.

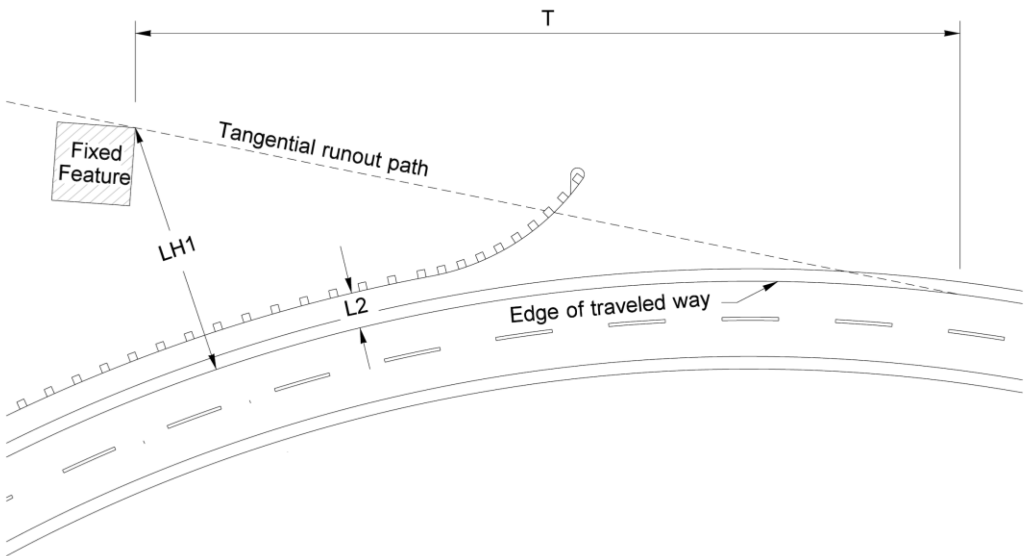
F = Flare rate value.

Y = Offset distance needed at the beginning of the length of need.

Different end treatments need different offsets:

- For the SRT 350 and FLEAT 350, use Y = 1.8 feet.
- For evaluating existing BCTs, use Y = 1.8 feet.
- For the FLEAT TL-2, use Y = 0.8 feet.
- No offset is needed for the non-flared terminals or impact attenuator systems. Use Y = 0.

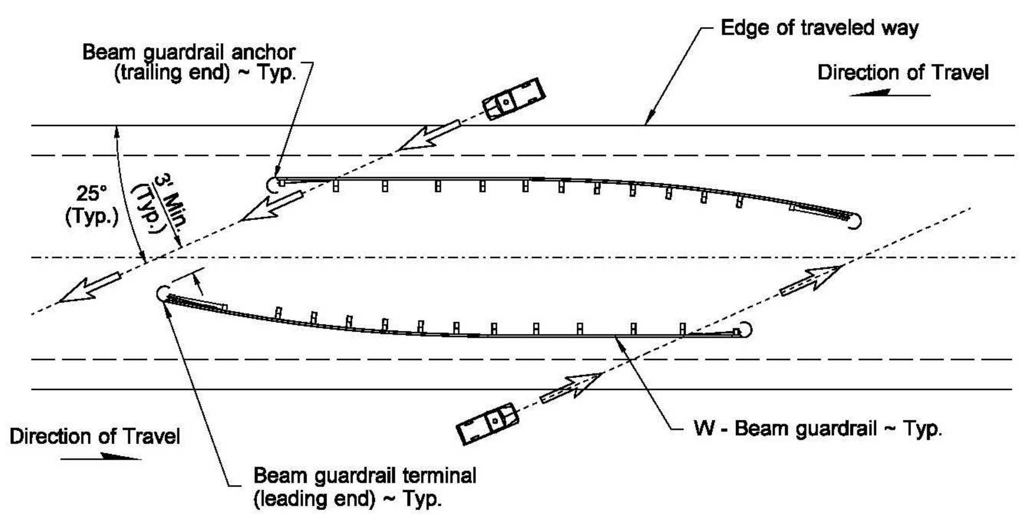
Exhibit 1610-7 Barrier Length of Need on Curves



Notes:

- This is a graphical method for determining the length of need for barrier on the outside of a curve.
- On a scale drawing, draw a tangent from the curve to the back of the fixed feature. Compare T to LR from Exhibit 1610-6 and use the shorter value.
- If using LR, follow Exhibits 1610-5 and 6.
- If using T, draw the intersecting barrier run to scale and measure the length of need.

Exhibit 1610-8 W-Beam Guardrail Trailing End Placement for Divided Highways



1610.03(6) Barrier Delineation

Refer to Chapter 1030 for barrier delineation requirements.

1610.04 Beam Guardrail

Strong post W-beam guardrail and thrie beam guardrail are semi-rigid barriers used predominantly on roadsides. They have limited application as median barrier. A strong-post W-beam (commonly referred to as W-Beam) guardrail system is the most common type of guardrail system used. The design uses wood or steel posts, rail, and blockouts to support the rail away from the post. The system resists a vehicle impact through a combination of the tensile and flexural stiffness of the rail and the bending or shearing resistance of the post.

Installed incorrectly, strong post W-beam guardrail can cause vehicle snagging or spearing. This can be avoided by lapping the rail splices in the direction of traffic (as shown in the *Standard Plans*), by using crash-tested end treatments, and by blocking the rail away from the posts.

Beam guardrail systems are shown in the *Standard Plans*.

1610.04(1) Beam Guardrail Systems

1610.04(1)(a) Type 31 Beam Guardrail

Use Type 31 guardrail for new installations. The Type 31 system uses many of the same components as the old WSDOT Type 1 system. The main differences are that the blockouts extend 12 inches from the posts, the rail height is 31 inches from the ground to the top of the rail, the deflection requirements are 2 feet greater, and the rail elements are spliced between posts.

Type 31 guardrail offers tolerance for future HMA overlays. The system allows a 3-inch tolerance from 31 inches to 28 inches without adjustment of the rail element.

Type 31 guardrail is available double-sided, which can be used in medians.

1610.04(1)(b) (Old) Type 1 Beam Guardrail

Previous WSDOT standard practice was to install W-beam guardrail at a rail height of 27 to 28 inches, and is referred to as “Type 1” guardrail. WSDOT is phasing out the use of Type 1 guardrail. Do not use Type 1 guardrail for new installations, except when the Type 1 guardrail weak post system is the best choice at an intersection due to site constraints (see 1610.04(7)(a)). Place new objects a minimum of 5 feet behind the face of existing beam guardrail type 1. For more information on (Old) Beam Guardrail Type 1, see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

Existing runs of Type 1 guardrail are acceptable to leave in place. If an existing run of Type 1 guardrail requires extending, use the Beam Guardrail Type 31 to Beam Guardrail Type 1 Adaptor shown in the *Standard Plans*, and complete the guardrail extension using Type 31 guardrail.

1610.04(1)(c) Other Guardrail Types

W-beam guardrail Type 2 and Type 3 have a height of 30 inches and utilize a rubrail. A rubrail is a structural steel channel added below the W-beam rail and is used in these specific designs to reduce vehicle snagging on the post. Existing runs of Type 2 or Type 3 guardrail are acceptable to leave in place. If the existing run of Type 2 or 3 requires extending contact WSDOT Design Office to identify appropriate extension methods.

Type 4 guardrail is a double-sided version of the Type 1 guardrail system. For new installation, use the Type 31 double-sided w-beam guardrail instead of Type 4 guardrail. Existing runs of Type 4 guardrail are acceptable to leave in place. If the existing run of Type 4 requires extending contact WSDOT Design Office to identify appropriate extension methods to transition to the Type 31 double-sided system.

Type 10 and Type 11 are thrie-beam guardrail systems. Existing runs of Type 10 or 11 guardrail are acceptable to leave in place. If an existing run of Type 10 or Type 11 guardrail requires extending, contact the WSDOT Design Office to discuss options.

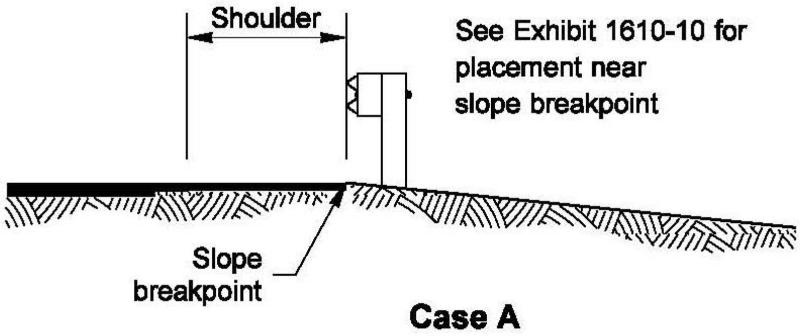
Weak post W-beam guardrail (Type 20) and thrie beam guardrail (Type 21) are flexible barrier systems primarily used in conjunction with a Service Level 1 bridge rail system for bridges with timber decks. These systems use weak steel posts. For information on Type 20 and Type 21 guardrail see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(2) Beam Guardrail Placement

There a number of considerations regarding guardrail placement. These include:

- During the project development processes, consult with maintenance staff to help identify guardrail runs that may need to be modified.
- When guardrail is installed along existing shoulders with a width greater than 4 feet, the shoulder width may be reduced by 4 inches to accommodate the 12-inch blockout. A Design Analysis is not required for the reduced shoulder width. If the remaining shoulder width is 4 feet or less, see Chapter 1030 for barrier delineation guidance.
- Keep the slope of the area between the edge of the shoulder and the face of the guardrail 10H:1V or flatter.
- On fill slopes 10:1 or flatter, beam guardrail can be placed anywhere outside of the shoulder.
- On fill slopes between 6H:1V and 10H:1V, place beam guardrail at the shoulder or at least 12 feet from the slope breakpoint (as shown in Exhibit 1610-9).
- Do not place beam guardrail on a fill slope steeper than 6H:1V
- On the high side of superelevated sections, place beam guardrail at the edge of shoulder prior to the slope breakpoint.
- For W-beam guardrail installed at or near the shoulder, 2 feet of shoulder widening behind the barrier is generally provided from the back of the post to the slope breakpoint of a fill slope (see Exhibit 1610-10, Case 2). If the slope is 2H:1V or flatter, this distance can be 2.5 feet measured from the face of the guardrail rather than the back of the post (see Exhibit 1610-10, Case 1).
- On projects where no roadway widening is proposed and site constraints prevent providing the 2-foot shoulder widening behind the barrier, long post installations are available as shown in Exhibit 1610-10, Cases 3, 4, 5, and 6. When installing guardrail where the roadway is to be widened or along new alignments, the use of Cases 5 and 6 requires a Design Analysis.

Exhibit 1610-9 Beam Guardrail Installation on 6:1 to 10:1 Slopes



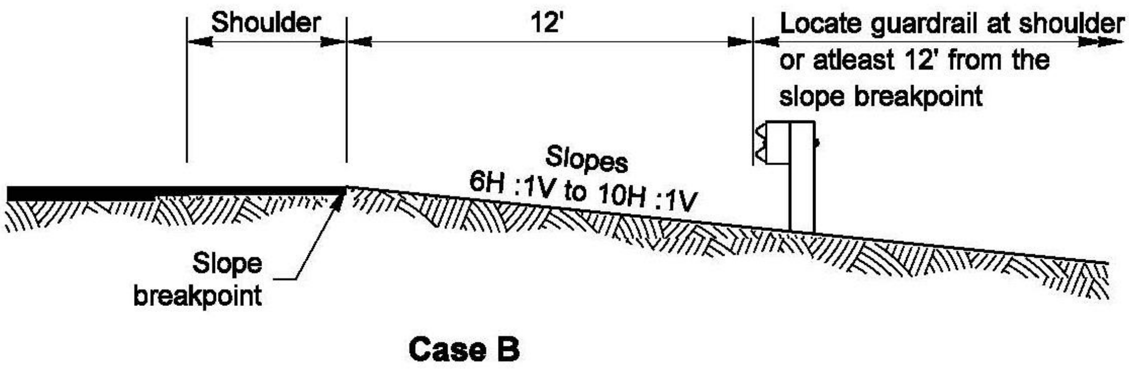
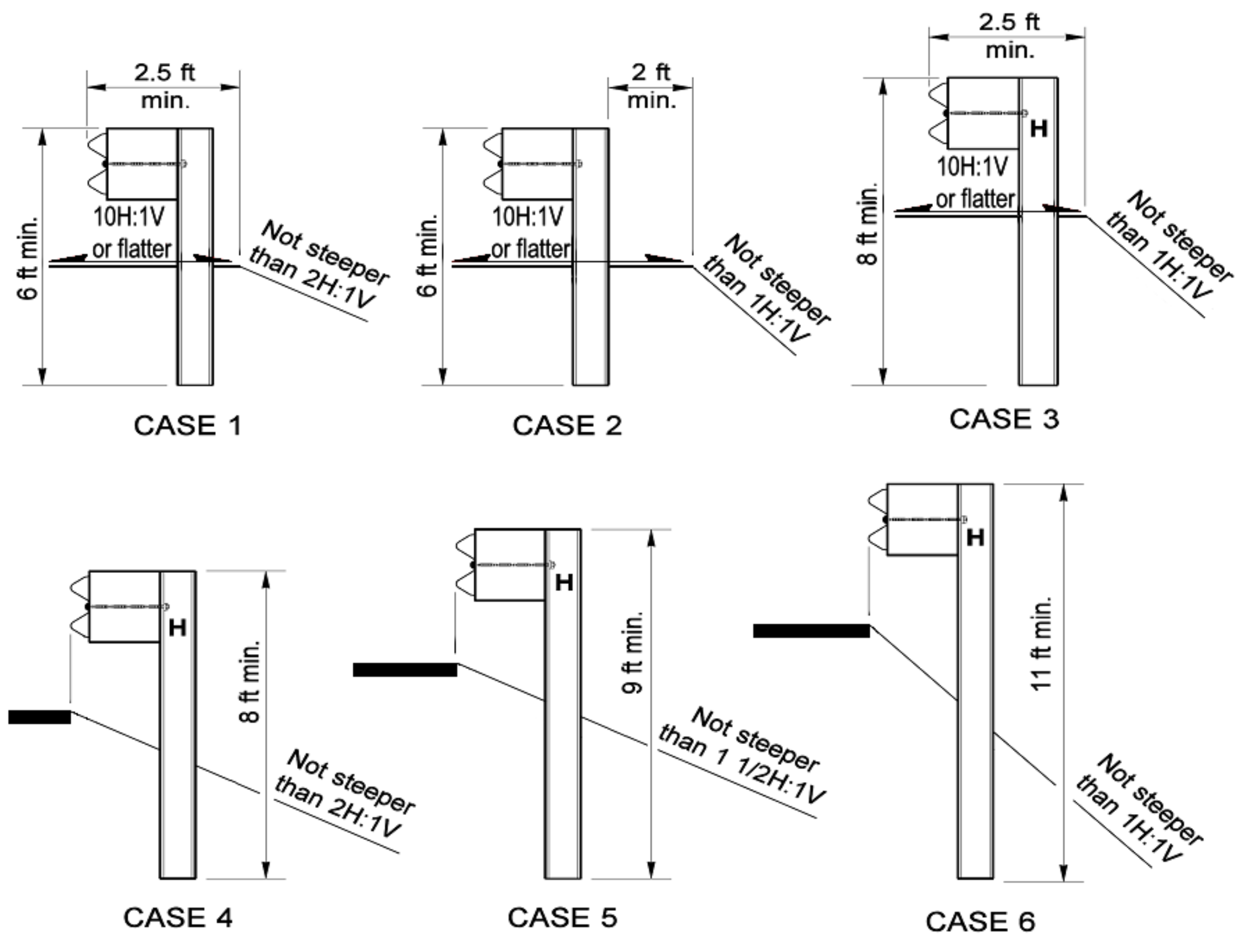


Exhibit 1610-10 Beam Guardrail Post Installation



Type 31 Shown

Notes:

- Use Cases 1 and 3 when there is a 2.5-foot or greater shoulder widening from face of guardrail to the slope breakpoint.
- Use Case 2 when there is a 4.0-foot or greater shoulder widening from the face of the guardrail to the slope breakpoint.
- Use Cases 4, 5, and 6 when there is less than a 2.5-foot shoulder widening from face of guardrail to the slope breakpoint.
- Cases shown do not apply to terminals, transition sections or anchors. Install terminals, transition sections and anchors per the *Standard Plans*.

1610.04(3) W-Beam Barrier Height

For Pavement Preservation (P1) projects see Chapter 1120.

For other projects with existing Type 1 guardrail runs under 26.5 inches, adjust or replace the rail to a height of 28 inches minimum to 30 inches maximum, or replace the run with the 31-inch-high Type 31 beam guardrail.

If Type 1 Alternative W-beam guardrail is present, the rail element may be raised after each overlay. If Type 1 Alternative is not present, the blockout and rail element may be raised up to 4 inches. This requires field drilling a new hole in the guardrail post. See the *Standard Plans*.

1610.04(4) Additional Guidance

Additional guidance related to w-beam guardrail:

- Crossroad and driveway locations cause gaps in the guardrail creating situations requiring special consideration. Eliminating the need for the barrier is the preferred solution. At these locations, a barrier flare might be needed to provide sight distance.
- Snowload post and rail washers are not used in new guardrail installations or guardrail terminal installations. Snowload post and rail washers installed on existing guardrail installations may remain in place except when the rail element is removed from post for any reason. If this occurs, remove and discard the snowload post and rail washers before reassembling the guardrail components.
- The use of curb in conjunction with beam guardrail is discouraged. If a curb is needed, the 3 inch-high curb is preferred. If necessary, the 4-inch-high extruded curb can be used behind the face of rail for any posted speed. The 6-inch-high extruded curb can be used at locations where the posted speed is 50 mph or below. When replacing extruded curb at locations where the posted speed is above 50 mph, use 3 inch-high or 4-inch-high curb. (See the *Standard Plans* for extruded curb designs.)
  - When curb is used in conjunction with Type 31 W-beam guardrail, an acceptable option is to place up to a 6-inch-high extruded curb at a maximum 6 inch offset in front of the rail face at any posted speed. Contact the WSDOT Design Office for more information.
- Guardrail posts should be able to rotate when the rail is impacted. When installing strong post W-beam guardrail posts in a rigid surface such as asphalt or concrete pavement, use leave-outs. Leave-outs are areas around the post that has no rigid material, which allows the post to rotate. Contact the WSDOT Design Office for more information.
- For (Old) Guardrail Types 1, 2, 3, and 4, it is acceptable to use blockouts that extend the rail element from the post for a distance not to exceed 16 inches.
- Where it is not feasible to install a post on a Type 31 system (i.e. utility or drainage conflict), one post may be omitted every 56.25 feet (9th post), except that an omitted post must be a minimum of 75 feet from an anchorage post, a minimum of 35 feet from the beginning of a thrie beam transition, and a minimum of 35 feet from the point where a terminal system joins the standard run.
  - Do not omit posts in guardrail runs with posts placed less than 2 feet from the slope break point. Guardrail runs with omitted posts must have at least 2 feet of 10:1 or flatter embankment behind them as shown in DM Exhibit 1610-10 Case 2.
  - Do not omit posts where curb is in front the guardrail.

- Consult HQ Design for acceptable conditions to omit single posts in guardrail runs with 12' – 6", 18' – 9", or 25' – 0" span systems (see Std. Plan C-20.40) placed within the run.

- In locations where shallow fill depth prevents the installation of standard length guardrail posts (i.e. box culverts, drainage), guardrail can be spanned over the location or be attached to the top of the structure (see standard plans). Other shallow fill designs are available. Contact HQ Design for more information about these alternative designs.

1610.04(5) Terminals and Anchors

A guardrail anchor is required at the end of a run of guardrail to develop tensile strength throughout its length. In addition, when the end of the guardrail is subject to head-on impacts, a crash-tested guardrail terminal is required (see the *Standard Plans*).

Replace guardrail terminals that do not have a crash-tested design with crash-tested guardrail terminals. Common features of systems that do not meet current crash-tested designs include:

- No cable anchor.
- A cable anchored into concrete in front of the first post.
- Second post not breakaway (CRT).
- Design A end section.
- Design C end sections may be left in place if the terminal is otherwise a crash-tested design —see the *Standard Plans* for end section details.
- Terminals with beam guardrail on both sides of the posts (two-sided).
- Buried guardrail terminals that slope down such that the guardrail height is reduced to less than 28 inches (measured in relation to a 10H:1V line extended from the breakpoint at edge of shoulder).

When the height of a terminal, as measured from the ground to the top of the rail element, will be affected by the project, adjust the terminal based upon the following criteria:

- If the height of the terminal adjoining Types 1, 2, 3, or 4 guardrail will be reduced by the project to be less than 26.5 inches or increased to greater than 30 inches, adjust the height of the terminal to a minimum of 28 inches and a maximum of 30 inches. A terminal height of 30 inches is desirable to accommodate future overlays.
- If the height of the terminal adjoining Type 31 guardrail will be reduced by the project to be less than 28 inches or increased to greater than 32 inches, adjust the height of the terminal to 31 inches.

When adjusting terminals that are equipped with CRT posts, the top-drilled holes in the posts need to remain at the surface of the ground.

One terminal that was used extensively on Washington's highways was the Breakaway Cable Terminal (BCT). This system used a parabolic flare similar to the Slotted Rail Terminal (SRT) and a Type 1 anchor (Type 1 anchor posts are wood set in a steel tube or a concrete foundation). For guidance regarding BCT's and other terminals on Preservation projects see Chapter 1120. For non-Preservation projects, replace BCTs with a currently approved terminal using the following guidance:

Verify length of need, and adjust the terminal location as required. Replace adjacent transition sections that are not compliant with 1610.04(6). Transition from Type 1 to Type 31 using the adaptor (Standard Plan C-25.80) where required. Raise or replace the entire run if engineering judgement indicates that it is prudent for that situation. Use the grading criteria shown on the terminal standard plans (C-22.40 or C-22.45). When using existing grading, check to see that it complies with the grading criteria shown on the current terminal standard plans. Remove curbs from in front of terminals if hydraulically acceptable.

Information regarding (Old) Type 1 beam guardrail terminals can be found at:
http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(5)(a) Buried Terminal (BT) for Type 31 Beam Guardrail

A buried terminal is designed to terminate the guardrail by burying the end in a backslope. The BT is the preferred terminal because it eliminates the exposed end of the guardrail.

For new BT installations, use the Buried Terminal Type 2. Previously, another BT option (the Buried Terminal Type 1) was an available choice. For existing installations, it is acceptable to leave this option in service as long as height requirements and other design criteria is met. See the plan sheet at: www.wsdot.wa.gov/design/standards/plansheet.

The BT uses a Type 2 anchor to develop the tensile strength in the guardrail. The backslope needed to install a BT is to be 3H:1V or steeper and at least 4 feet in height above the roadway. The entire BT can be used within the length of need for backslopes of 1H:1V or steeper if the barrier remains at full height in relation to the roadway shoulder to the point where the barrier enters the backslope.

For backslopes between 1H:1V and 3H:1V, design the length of need beginning at the point where the W-beam remains at full height in relation to the roadway shoulder—usually beginning at the point where the barrier crosses the ditch line. If the backslope is flatter than 1H:1V, provide a minimum 20-foot-wide by 75-foot-long clear area that is free of fixed features behind the barrier and between the beginning length of need point at the terminal end to the mitigated object to be protected.

Flare the guardrail to the foreslope/backslope intersection using a flare rate that meets the criteria in 1610.03(4). Provide a 4H:1V or flatter foreslope into the face of the guardrail and maintain the full guardrail height to the foreslope/backslope intersection in relation to a 10H:1V line extending from edge of shoulder breakpoint. (See the *Standard Plans* for details.)

1610.04(5)(b) Non-flared Terminals for Type 31 Beam Guardrail

If a buried terminal cannot be installed as described in 1610.04(5)(a), install a non-flared terminal. These systems use W-beam guardrail with a special end piece that fits over the end of the guardrail. When hit head on, the end piece is pushed over the rail, absorbing the energy of the impacting vehicle in the process. An anchor is included for developing the tensile strength of the guardrail. The length of need does not begin at the impact head, but will vary by system. Non-flared terminals may be provided for two different design levels that are based on the posted speed of the highway. For highways with a posted speed of 50 mph or above, use only a

TL-3 (Test Level 3) product. For highways with a posted speed of 45 mph or below, either a TL-2 or a TL-3 product is acceptable. See the *Standard Plans*.

The availability and acceptance of these systems is expected to change rapidly over time. Refer to the Type 31 Beam Guardrail Terminals website for the latest information on availability or acceptance of different systems (see http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm).

Although non-flared terminals do not need to have an offset at the end, a flare is recommended so that the end piece does not protrude into the shoulder. See the *Standard Plans*.

Four feet of additional widening behind the terminal is needed at the end posts to properly anchor the systems (See the *Standard Plans*). When widening includes an embankment, properly placed and compacted fill material will be necessary for optimum terminal performance (see the *Standard Specifications* for embankment widening for guardrail).

For guardrail runs that are located more than 12 feet from the slope break (as shown in Exhibit 1610-9) no additional embankment widening is required at the terminal.

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

WSDOT does not currently use a flared terminal system for the Type 31 guardrail system.

Note: Approved shop drawings for terminals can be found by accessing the following website: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.04(5)(c) Terminal Evolution Considerations

Some currently approved terminals have been in service for a number of years. During this time, there have been minor design changes. However, these minor changes have not changed the devices' approval status. Previous designs for these terminals may remain in place.

Note: If questions arise concerning the current approval status of a device, contact the HQ Design Office for clarification when replacement is being considered.

1610.04(5)(d) Anchors

A guardrail anchor is needed at the end of a run of guardrail to develop tensile strength throughout its length.

- Use the Type 10 anchor to develop the tensile strength of the guardrail on the end of Type 31 guardrail runs where a crash-tested terminal is not needed.
- A Type 2 anchor is used with the buried terminal.

For information on anchor types used in runs of (Old) Beam Guardrail Type 1, see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

1610.04(6) Transitions and Connections

When there is an abrupt change from one barrier type to a more rigid barrier type, a vehicle hitting the more flexible barrier may be caught in the deflected barrier pocket and directed into the more rigid barrier. This is commonly referred to as "pocketing." A transition stiffens the more flexible barrier by decreasing the post spacing, increasing the post size, and using stiffer beam elements to reduce the possibility of pocketing.

When connecting beam guardrail to a more rigid barrier or a structure use the transitions and connections that are shown in Exhibits 1610-11 and 1610-12 and detailed in the *Standard Plans*. Verify the length of need (see 1610.03(5)) when designing transitions, particularly transitions between beam guardrail or end terminals to bridge structures.

Type 21 transitions can be used on highways with all posted speeds to connect w-beam guardrail to single slope, safety shape or vertical concrete barriers.

Type 22 and Type 23 transitions are used to connect w-beam guardrail to thrie beam on bridges.

Type 24 transitions can be used on highways with a posted speed of 45 mph or less to connect w-beam guardrail to single slope, safety shape or vertical concrete barriers.

When connecting a Type 21 or Type 24 Transition to an existing vertical faced bridge rail with a low parapet, a special connection plate may be required. Coordinate with the WSDOT Bridge and Structures Office (BSO). The transition pay item includes the connection.

Install transitions on 10:1 or flatter slopes with the 10:1 or flatter slope extending a minimum of 2 feet behind the guardrail transition post similar to what is shown in DM Exhibit 1610-10 Placement Case 2.

For information regarding transitions used with (Old) Type 1 guardrail see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

Exhibit 1610-11 Guardrail Connections

Condition	Connection
Unrestrained precast concrete barrier	A
Rigid, rigid anchored, untapered safety shape bridge rails or barriers [1]	B
Bridge rails with curbs 9 inches or less in width	B
Bridge rails with curbs between 9 and 18 inches wide	C
Vertical walls, single slope bridge rail or concrete barrier, or tapered safety shape barrier [1]	D
All bridge rail and concrete barrier types located on trailing ends of one-way roadways	F

Note:

[1] New single slope and safety shape bridge rails are designed with the toe of the barrier tapered so that it does not project past the face of the approach guardrail.

Exhibit 1610-12 Transitions and Connections

<table>
<tr><th colspan="3">Connecting Type 31 W-Beam Guardrail to:</th><th>Transition Type*</th><th>Connection</th></tr>
<tr><td rowspan="7">Bridge Rail [1]</td><td colspan="2">New Installation</td><td>21, 24 [3]</td><td>D</td></tr>
<tr><td rowspan="2">Existing Concrete</td><td>Concrete Parapet > (Greater Than) 20 in.</td><td>21, 24 [3]</td><td>Exh. 1610-12 [2]</td></tr>
<tr><td>Concrete Parapet < (Less Than) 20 in.</td><td>21, 24 [3]</td><td>Exh. 1610-12 [2]</td></tr>
<tr><td rowspan="2">Thrie Beam at Face of Curb</td><td>Approach End</td><td>23</td><td>n/a</td></tr>
<tr><td>Trailing End (two-way traffic only)</td><td>23</td><td>n/a</td></tr>
<tr><td rowspan="2">Thrie Beam at Bridge Rail (curb exposed)</td><td>Approach End</td><td>22</td><td>n/a</td></tr>
<tr><td>Trailing End (two-way traffic only)</td><td>22</td><td>n/a</td></tr>
<tr><td rowspan="2">Concrete Barrier</td><td colspan="2">Rigid & Rigid Anchored</td><td>21, 24 [3]</td><td>Exhibit 1610-12</td></tr>
<tr><td colspan="2">Unrestrained</td><td>21, 24 [3]</td><td>A</td></tr>
<tr><td>Rigid Structures such as Bridge Piers</td><td colspan="2">See Placement Cases 11A-31 through 11C-31</td><td>21, 24 [3]</td><td>n/a</td></tr>
<tr><th colspan="3">Connecting Thrie Beam Guardrail to:</th><th>Transition Type*</th><th>Connection</th></tr>
<tr><td>Bridge Rail or Concrete Barrier</td><td colspan="3">See the thrie beam transition in the Plan Sheet Library</td><td>Exhibit 1610-12</td></tr>
</table>

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

Notes:

[1] For Service Level 1 bridge rail, see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm., Type 1 Beam Guardrail Placement Cases, Placement Case 14.

[2] When connecting a Type 21 or Type 24 Transition to an existing vertical faced bridge rail with a low parapet, a special connection plate may be required. Contact the WSDOT BSO for details.

[3] Transition Type 21 is acceptable for use on highways with all posted speeds. Transition Type 24 is acceptable for use on highways with posted speeds 45 mph or below.

1610.04(7) Guardrail Placement Cases

The *Standard Plans* and Plan Sheet Library contain placement cases that show beam guardrail elements needed for typical situations. For new installations, use the appropriate Type 31 placement option (except as noted below).

Information regarding placement cases for (Old) Type 1 beam guardrail can be found at http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

1610.04(7)(a) Beam Guardrail Placement Cases

- Case 1-31 is used where there is one-way traffic. It uses a crash-tested terminal on the approach end and a Type 10 anchor on the trailing end.
- Case 2-31 is used where there is two-way traffic. A crash-tested terminal is used on both ends.
- Case 3-31 is used at railroad signal supports on one-way or two-way roadways. A terminal is used on the approach end, but usually cannot be used on the trailing end because of its proximity to the railroad tracks. If there is a history of crossover collisions, consider additional protection such as an impact attenuator.
- Case 4-31 is used where guardrail on the approach to a bridge is to be shifted laterally to connect with the bridge rail. A terminal is used on the approach end and a transition is needed at the bridge end. Curves (bends) are shown in the guardrail to shift it to the bridge rail. However, the length of the curves are not critical. The criterion is to provide smooth curves that are not more abrupt than the allowable flare rate (see Exhibit 1610-4).
- Case 5-31 is a typical bridge approach where a terminal and a transition are needed.
- Case 10 (A-31, B-31, and C-31) is used at roadside fixed features (such as bridge piers) when 5 or more feet are available from the face of the guardrail to the feature. The approach end is the same for one-way or two-way traffic. Case 10A-31 is used with two-way traffic; therefore, a terminal is needed on the trailing end. Case 10B-31 is used for one-way traffic when there is no need to extend guardrail past the bridge pier and a Type 10 anchor is used to end the guardrail. Case 10C-31 is used for one-way traffic when the guardrail will extend for a distance past the bridge pier.
- Case 11 (A-31, B-31, and C-31) is used at roadside fixed features (such as bridge piers) when the face of guardrail is to be placed within 5 feet of the feature. Since there is no room for deflection, the rail in front of the feature is to be considered a rigid system and a transition is needed. The trailing end cases are the same as described for Case 10.
- The Beam Guardrail Type 31 Placement 12'-6", 18'-9", or 25'-0" Span design is used when it is necessary to omit one, two, or three posts. This application is typically used when guardrail is installed over a shallow buried obstruction, such as drainage structures. This design may be used in other situations where there are no above ground objects located behind the guardrail and within the lateral deflection distance. Three CRT posts are provided on each end of the omitted post(s). Type 31 guardrail must extend at least 62.5 feet (10 posts) upstream and downstream from the ends of the outer CRT posts (furthest from obstruction) in order for the guardrail

system to function as designed during a vehicle crash. Also, this guardrail design has specific grading requirements, see applicable standard plan.

- Guardrail Placement at intersections – Two solutions are currently available for use where bridge ends or similar conditions exist in close proximity to a roadway intersection or driveway. These designs are used at crossroads or road approaches where a barrier is needed and where the length of need cannot be achieved using standard components such as standard longitudinal barrier runs, transitions, and terminals. The “Strong Post Intersection Design” uses Type 31 guardrail and is available for use in new installations. A “Weak Post Intersection Design,” which uses Type 1 guardrail, is available and may also be used in new installations (see 1610.04(1)(b)).

1610.05 High-Tension Cable Barrier

Cable barrier is a flexible barrier system that can be used on a roadside or as a median barrier. Early cable barrier designs centered around low-tension cable systems. With research and crash analysis of these systems, the designs evolved into high-tension cable systems. These high-tension cable systems are primarily used in medians and are preferred for many installations due in part to high benefit-to-cost ratios. Read about advantages for selecting a cable barrier system here:
http://www.wsdot.wa.gov/publications/fulltext/design/Policy/CableBarriers.pdf.

There are a number of manufacturers of high-tension cable barrier systems. These systems have been designed using either three or four-cables fixed to metal posts placed at a fixed spacing. Each cable system has specially designed anchors placed at both ends of the barrier run to provide the proper tensioning in the cables. Currently, both three and four-cable high-tension cable barrier systems are installed along WSDOT state routes. See additional information about these approved cable barrier systems here:
http://www.wsdot.wa.gov/publications/fulltext/design/Policy/CableBarriers.pdf.

Use four-cable high-tension cable barrier systems for all new installations.

1610.05(1) High-Tension Cable Barrier Placement

High-tension cable barrier can be placed in a median or along the roadside.

Note: Additional placement cases are shown in the WSDOT *Standard Plans*. For non-typical installations, such as double runs of cable barrier or median ditch cross sections that differ significantly from those shown, contact the HQ Design Office for guidance.

1610.05(1)(a) Median Applications

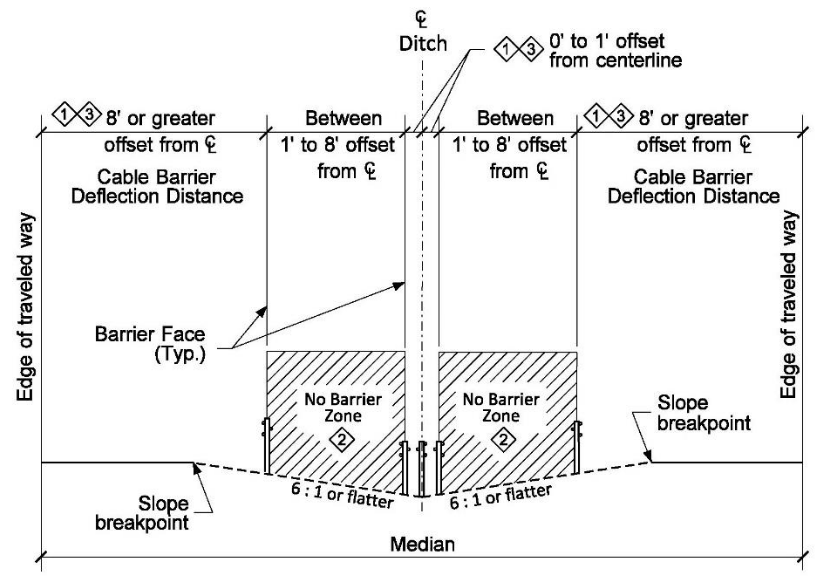
For typical cable barrier installations in a median, the following apply (see Exhibit 1610-13a):

- Install the cable barrier as far from the edge of traveled way as site constraints allow. Consider a minimum placement distance of 8 feet from the edge of traveled way to allow vehicles to use this area for refuge.

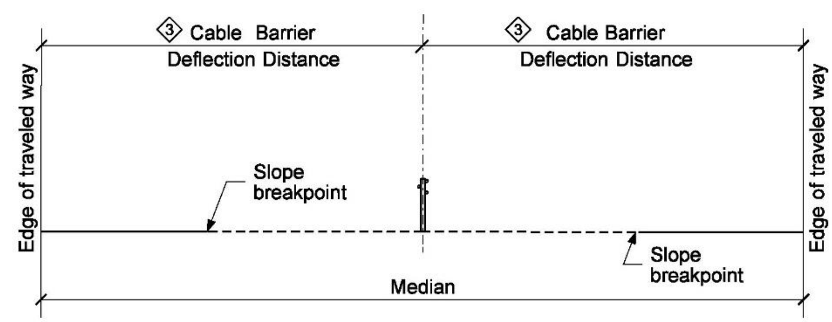
- Install cable barrier on slopes 6H:1V or flatter.

- There are approved high-tension cable barrier systems that can be placed on slopes as steep as 4H:1V. The use of these systems requires special placement considerations, contact the HQ Design Office for guidance.
- Provide an obstruction free zone within the cable barrier system's lateral deflection distance (see 1610.05(2)).
- On tangent sections of a roadway where no ditch is present, consider installing the cable barrier in the middle of the median. See Exhibit 1610-13a.
- Along horizontal curves, consider installing the cable barrier along the inside of the curve. Reduce the post spacing per manufacturer's recommendations.
- In medians with ditches, install the cable barrier as follows (See Exhibit 1610-13a):
  - The preferred location is to install the cable barrier at an 8-foot or greater offset from the ditch centerline.
  - Alternatively, the cable barrier can be installed at the centerline of the ditch out to a 1-foot offset either side of the ditch centerline. While permissible, this is not the preferred area to install cable barrier due to the potential of post scour, possible interference with drainage structures, and maintenance concerns.
  - Do not install cable barrier in the area between 1-foot to 8-foot offset from the ditch centerline to avoid "under-riding" of vehicles crossing the ditch.
- In some situations, it may be advantageous to terminate a run of cable barrier on one side of the median (to provide maintenance access to a feature, for example) and then begin an adjacent cable barrier run on the opposite side of the median. In this application, it is important to provide adequate cable barrier overlap distance between the two runs. For placement guidance, see Exhibit 1610-14.
- Narrow medians provide little space for maintenance crews to repair or reposition the barrier. Wherever site conditions permit, provide at least 14 feet of clearance from the adjacent lane edge to the face of the cable barrier.

Exhibit 1610-13a Median Cable Barrier Placement



Median Cable Barrier Placement (Ditch Section with 6 : 1 or Flatter Slopes)



Median Cable Barrier Placement (No Ditch)

Notes:

1. Cable barrier may be installed at an 8-foot or greater offset from centerline (preferred placement), or it may be installed in the center of the ditch out to a 1-foot offset from the ditch centerline (left or right).

2. Avoid installing cable barrier in the area between 1-foot to 8-foot offset from the ditch centerline (left or right).

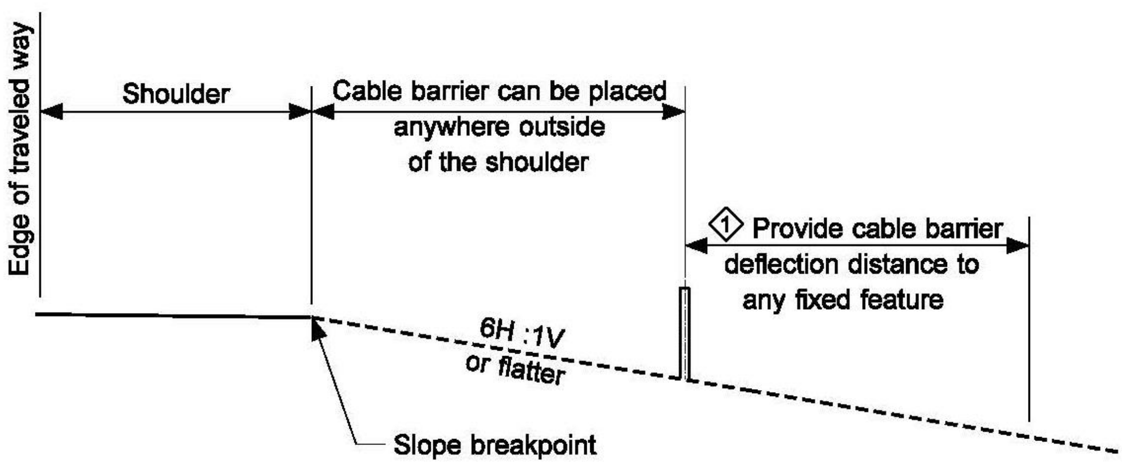
3. Provide an obstruction free zone within the cable barrier's lateral deflection distance, and provide sufficient lateral barrier deflection distance to prevent a vehicle's encroachment into the opposite lane of travel. See 1610.05(2) for more information.

1610.05(1)(b) Roadside Applications

For typical non-median roadside applications, the following apply (see Exhibit 1610-14b):

- Install the cable barrier as far from the edge of traveled way as site constraints allow.
- Consider a minimum placement distance of 8 feet from the edge of traveled way to allow vehicles to use this area for refuge.
- Install cable barrier on slopes 6H:1V or flatter
- There are approved high-tension cable barrier systems that can be placed on slopes as steep as 4H:1V. The use of these systems requires special placement considerations, contact the HQ Design Office for guidance.
- Along horizontal curves, consider installing along the inside of the curve. Reduce post spacing per manufacturer's recommendations
- Provide an obstruction free zone within the cable barrier system's lateral deflection distance, see 1610.05(2).

Exhibit 1610-13b Roadside Cable Barrier Placement



Notes:

1 Provide an obstruction free zone within the cable barrier's lateral deflection distance, see 1610.05(2)

1610.05(2) High-Tension Cable Barrier Lateral Deflection Distances

Depending on the high-tension cable barrier system, lateral deflection distances for each barrier system vary based upon the length of the barrier run, the spacing of the end anchors, and post spacing. Provide an obstruction free zone within the system's lateral deflection distance for the following situations:

1. In the direction of travel (located in the median or along roadside), locate the cable barrier system so that there are no fixed objects within the limits of the cable barrier lateral deflection distance.

2. For opposing traffic (where present), locate the cable barrier to provide lateral deflection distance to prevent a vehicle's encroachment into the opposite lane of travel.

Low–tension cable barrier systems require 12 feet of lateral deflection. Use high-tension cable barrier systems in new cable barrier installations. High-tension barrier systems have lateral deflection distances between 6 to 10 feet. Specify the minimum allowable lateral deflection distance in the contract documents in order for the contractor to select a cable barrier manufacturer that meets the lateral deflection requirements.

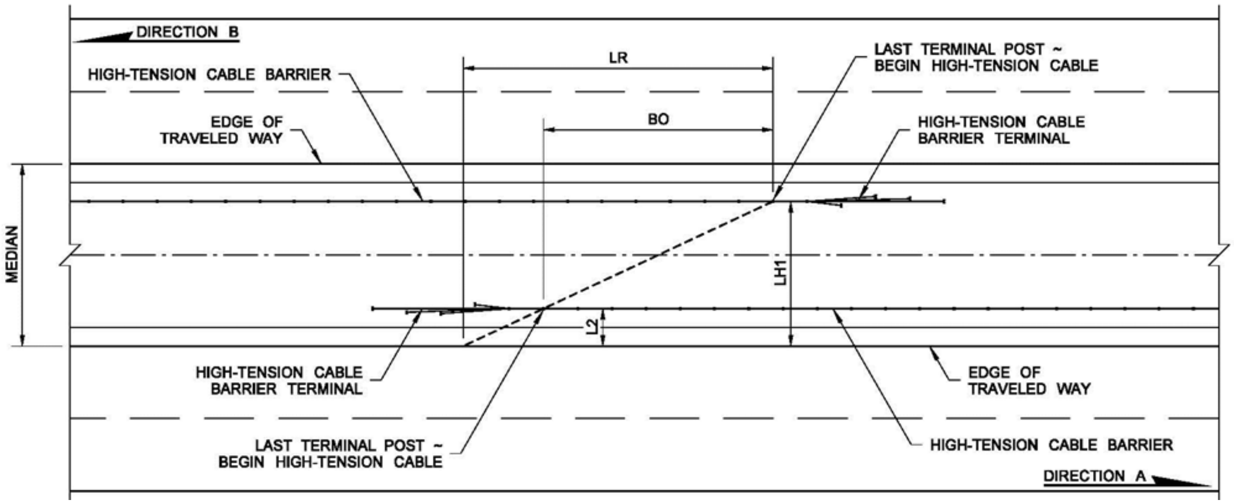
Note: There are new high-tension cable barrier systems under development that may change selection and placement criteria. For example, newer systems may allow placement on steeper slopes or have reduced deflection distances. Contact the HQ Design Office for guidance.

1610.05(3) High-Tension Cable Barrier Termination

Manufacturers of high-tension four-cable barrier systems provide designed anchors for the ends of cable barrier runs. Other alternatives to end a cable barrier include:

- It is possible to terminate high-tension cable barrier systems by connecting directly to beam guardrail runs (such as transitions to bridge rails) or to a separate cable barrier anchorage system. Review field conditions, check local maintenance personnel needs, and then specify the required connection option in the contract documents. If a separate anchorage system is used, refer to Exhibit 1610-15 for placement guidance.
- When cable barrier is connected to a more rigid barrier, a transition section is typically needed. Contact the HQ Design Office for further details.

Exhibit 1610-14 Cable Barrier Placement for Divided Highways

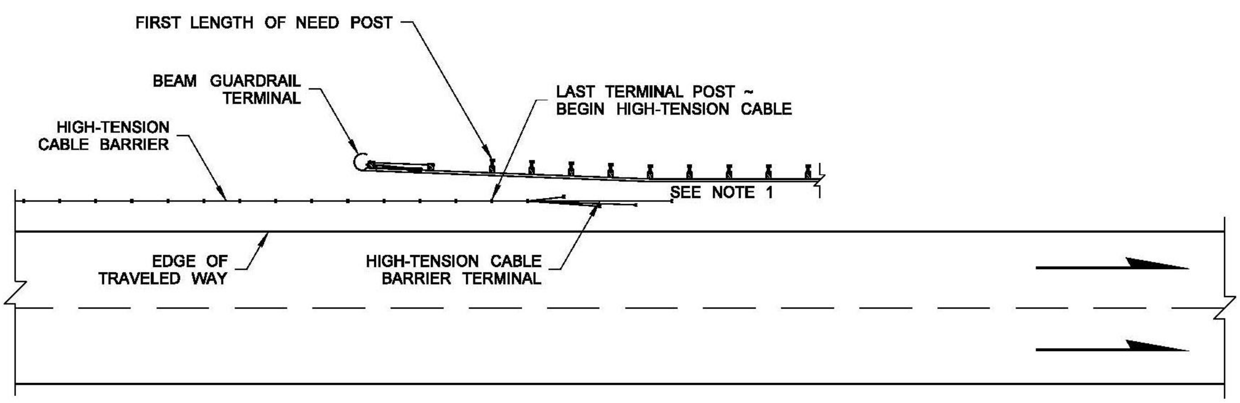


Cable Barrier Median Overlap

BO = (Direction A shown)

Note:

Calculate barrier overlap (BO) from both directions of travel. Use the greatest value of BO obtained.



Cable Barrier Overlap with Beam Guardrails

Notes:

- The beam guardrail may need to be extended and flared to maintain adequate barrier overlap and shoulder width.
- Typical applications may be at either bridge transitions or where high-tension cable and beam guardrail systems end or begin.
- For supporting length of need equation factors, see Exhibit 1610-6.

1610.05(4) High-Tension Cable Barrier Curb Placement

Avoid the placement of curb in conjunction with high-tension cable barrier systems. Currently, there are no known acceptable cable barrier systems that have been successfully crash tested with this feature present.

1610.06 Concrete Barrier

Concrete barriers are identified as either rigid, rigid anchored, or unrestrained rigid systems. They are commonly used in medians and as shoulder barriers. These systems are stiffer than beam guardrail or cable barrier, and impacts with these barriers tend to be more severe. Consider the following when installing concrete barriers:

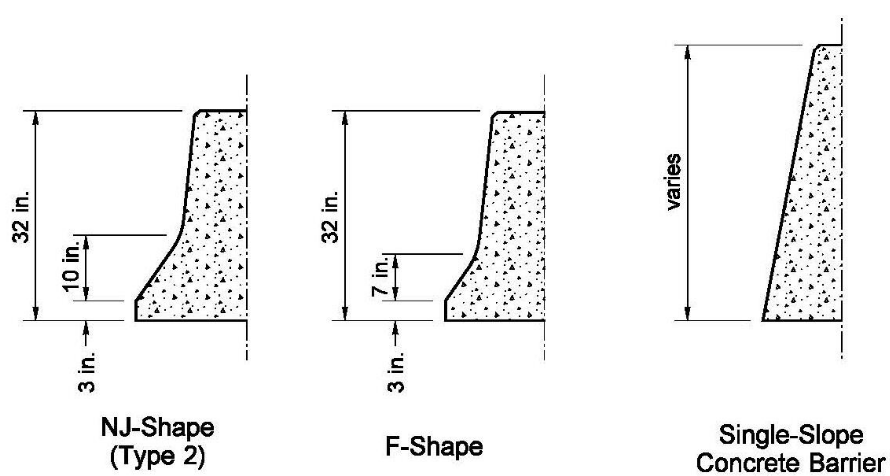
- For slopes 10H:1V or flatter, concrete barrier can be used anywhere outside of the shoulder.
- Do not use concrete barrier at locations where the foreslope into the face of the barrier is steeper than 10H:1V.
- Light standards mounted on top of precast concrete median barrier must not have breakaway features. (See the concrete barrier light standard section in the *Standard Plans*.)
- When considering concrete barrier use in areas where drainage and environmental issues (such as stormwater, wildlife, or endangered species) might be adversely impacted, contact the HQ Hydraulics Office and/or the appropriate environmental offices for guidance. Also, refer to 1610.02.

1610.06(1) Concrete Barrier Shapes

Concrete barriers use a single-slope or safety shape (New Jersey or F-Shape) to redirect vehicles while minimizing vehicle vaulting, rolling, and snagging. A comparison of these barrier shapes is shown in Exhibit 1610-15.

The single-slope barrier face is the recommended option for embedded rigid concrete barrier applications.

Exhibit 1610-15 Concrete Barrier Shapes



When the single-slope or F-Shape face is used on structures, and precast barrier is selected for use on the approaches, a cast-in-place transition section is needed so that no vertical edges of the barrier are exposed to oncoming traffic. For details on bridge rail designs, see the *Bridge Design Manual*.

For aesthetic reasons, avoid changes in the shape of the barrier face within a project or corridor.

The New Jersey shape and F-shape barriers are commonly referred to as “safety shapes.” The New Jersey shape and F-shape have an initial overall height of 32 inches. This height includes provision for up to a 3-inch future pavement overlay that can reduce the barrier height to 29 inches minimum.

As part of the implementation of MASH-compliant hardware WSDOT is transitioning from predominantly using New Jersey shape barrier (Type 2 barrier) for precast concrete barrier to using F-shape concrete barrier (Type F barrier) instead. For projects with an Ad date prior to December 31, 2019; permanent installations of non-embedded precast concrete barrier F-shape (Type F) barrier is preferred, but New Jersey shape (Type 2) barrier is still allowed. For projects with an Ad date after December 31, 2019; F-shape (Type F) will be the only non-embedded precast concrete barrier allowed for permanent installations, and New Jersey shape (Type 2) barrier will only be allowed in temporary installations.

For projects requiring variations of Type F barrier with no Standard Plan yet available, using Type 2 barrier instead is appropriate, or contact the HQ Design Office for more information.

To learn more about WSDOT’s plan for implementing MASH-compliant hardware see the following website: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

1610.06(1)(a) Safety Shape Barrier

Concrete Barrier Type F (see the *Standard Plans*) is a freestanding precast barrier that has the F-shape on both sides. It can be used for both median and shoulder installations. Unanchored units are connected with steel pins through metal loops. For permanent installation, this barrier is placed on a paved surface and a paved surface is provided beyond the barrier for deflection. See Exhibit 1610-3 for deflection requirements.

The New Jersey shape face is primarily used on precast concrete barrier. Concrete Barrier Type 2 (see the *Standard Plans*) is a freestanding precast barrier that has the New Jersey shape on two sides. It can be used for both median and shoulder installations. Unanchored units are connected with steel pins through wire rope loops. For permanent installation, this barrier is placed on a paved surface and a paved surface is provided beyond the back of barrier for deflection. See Exhibit 1610-3 for deflection requirements.

The cost of precast safety shape barrier is significantly less than the cost of the cast-in-place barriers. Therefore, consider the length of the barrier run and the deflection needs to determine whether transitioning to precast barrier is desirable. If precast safety shape barrier is used for the majority of a project, use the safety shape for small sections that need cast-in-place barrier, such as for a light standard section, see the *Standard Plans* for additional details for transitioning the barrier faces.

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

Precast barrier can be anchored where a more rigid barrier is needed. (Anchoring methods are shown in the *Standard Plans*.) Anchors Type 1 and Type 2 are for temporary installations on a rigid pavement. Type 3 anchors can be used in temporary or permanent installations on an asphalt pavement. Consult the WSDOT BSO for details when anchoring permanent precast concrete barrier to a rigid (Portland cement concrete) pavement.

Precast barrier used on the approach to bridge rail is to be connected to the bridge rail by installing loops embedded into the bridge rail with epoxy resin and as detailed in the *Standard Plans*.

Place unrestrained (unanchored) precast concrete barrier on slopes of 5% (20H:1V) or flatter where possible. The maximum slope for placement of concrete barrier is 10% (10H:1V).

1610.06(1)(b) Single-Slope Barrier

Single-slope barrier is available in various heights as shown in the *Standard Plans*. Single-slope concrete barrier can be cast-in-place or precast. Single-slope barrier is considered a rigid system regardless of the construction method used provided that precast barrier is embedded a minimum of 3-inches in the roadway wearing surface (asphalt or concrete) on both sides, precast barrier is embedded a minimum of 10-inches in soil on both sides, and cast-in-place barrier is embedded a minimum of 3-inches in the roadway wearing surface (asphalt or concrete) or soil on both sides.

For new installations in asphalt, concrete, or soil; the minimum height of the single-slope barrier above the roadway is 2 feet 10 inches which allows a 2-inch tolerance for future overlays. The minimum total height of the barrier section is 3-feet-6 inches (including embedment). The single-slope barrier can be installed with grade separation between roadways as follows:

- For cast-in-place barrier with a minimum 3-inch embedment, or pre-cast barrier installed in asphalt or concrete with a minimum 3-inch embedment; a grade separation of up to 4-inches is allowed when using a 3-foot-6-inch tall barrier section, a grade separation of up to 7-inches is allowed when using a 4-foot tall barrier section, and a grade separation of up to 10-inches is allowed when using a 4-foot-6-inch tall barrier section as shown in the *Standard Plans*.

- For pre-cast barrier installed in soil with a minimum 10-inch embedment; a grade separation of up to 4-inches is allowed when using a 4-foot tall barrier section, and a grade separation of up to 10-inches is allowed when using a 4-foot-6 inch tall barrier section.

- The barrier is to have a depth of embedment equal to or greater than the grade separation. Contact the WSDOT BSO for grade separations greater than 10-inches.

- Cast-in-place and pre-cast High Performance single-slope barrier can be installed with a grade separation between the roadways as well, see the *Standard Plans*.

1610.06(1)(c) High-Performance Concrete Barrier

High-Performance Concrete Barrier (HP Barrier) is a rigid barrier with a minimum height of 3-foot-6-inch above the roadway surface. This barrier is designed to function more effectively during heavy-vehicle crashes. This taller barrier may also offer the added benefits of reducing headlight glare and reducing noise in surrounding environments. WSDOT HP Barrier utilizes the single-slope shape. (See the *Standard Plans* for barrier details.)

Use HP Barrier in freeway medians of 22 feet or less. Also, use HP Barrier on Interstate or freeway routes where crash history suggests a need or where roadway geometrics increase the possibility of larger trucks hitting the barrier at a high angle (for example, on-ramps for freeway-to-freeway connections with sharp curvature in the alignment).

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

1610.06(1)(d) Low-Profile Barrier

Low-profile barrier designs are available for median applications where the posted speed is 45 mph or below. These barriers are normally used in urban areas. They are typically 18 to 20 inches high and offer sight distance benefits. For barrier designs, terminals, and further details, contact the HQ Design Office.

1610.06(2) Concrete Barrier Height

Overlays in front of safety shape concrete barriers can extend to the top of the lower, near-vertical face of the barrier before adjustment is necessary.

- Allow no less than 2-foot 5 inches from the pavement to the top of the safety shape barriers. Allow no less than 2-foot 8-inches from the pavement to the top of the single-slope barrier.

1610.06(3) Concrete Barrier Terminals

Whenever possible, bury the blunt end of a concrete barrier run into the backslope of the roadway. If the end of a concrete barrier run cannot be buried in a backslope or terminated as described below, terminate the barrier using a guardrail terminal and transition or an impact attenuator (see Chapter 1620).

To bury the blunt end of the barrier into a backslope, the following conditions must be met:

- The backslope is 3H:1V or steeper
- The backslope extends minimum of 4 feet in height above the edge of shoulder
- Flare the concrete barrier into the backslope using a flare rate that meets the criteria in 1610.03(4)
- Provide a 10H:1V or flatter foreslope into the face of the barrier and maintain the full barrier height until the barrier intersects with the backslope. This might create the need to fill ditches and install culverts in front of the barrier face.

The 7-foot-long precast concrete barrier Type 2 and the 10- to 12-foot single-slope barrier terminal (precast or cast-in-place) may be used for the following conditions:

- Outside the Design Clear Zone.
- On the trailing end of the barrier when it is outside the Design Clear Zone for opposing traffic.
- On the trailing end of one-way traffic.
- Where the posted speed is 25 mph or below.

See the *Standard Plans* for barrier terminal details.

1610.07 Bridge Traffic Barriers

Bridge traffic barriers redirect errant vehicles and help to keep them from going over the side of the structure. (See the *Bridge Design Manual* for information regarding bridge barrier on new bridges and replacement bridge barrier on existing bridges).

When considering work on a bridge traffic barrier consult the WSDOT Bridge and Structures Office (BSO).

- The standard bridge traffic barrier is a 3 foot 6 inch single slope or F Shape traffic barrier.
- For corridor continuity, a 2 foot 10 inch single slope or 2 foot 8 inch F Shape traffic barrier may be used with a pedestrian railing attached to the top for a total height of 3 foot 6 inch height inches. This also meets requirements for worker fall protection.

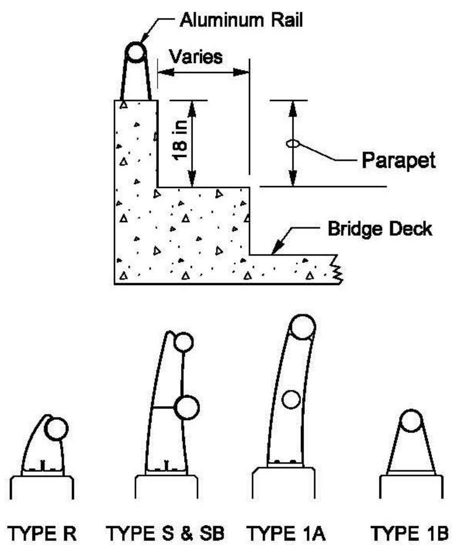
Approach barriers, transitions, and connections are usually needed on all four corners of bridges carrying two-way traffic and on both corners of the approach end for one-way traffic. (See 1610.04(6) for guidance on transitions). A transition is available to connect the Type 2 concrete barrier (New Jersey shape) and the bridge barrier (F-Shape.) (See the *Standard Plans* for further details).

Bridge railing attaches to the top of the bridge barrier. When bridge barrier is included in a project, the bridge rails, including crossroad bridge rail, are to be addressed. Consult the WSDOT BSO regarding bridge rail selection and design and for design of the connection to an existing bridge. Consider the following:

- Use an approved, NCHRP 350 or MASH crash-tested bridge traffic barrier on new bridges or bridges to be widened. The *Bridge Design Manual* provides examples of typical bridge rails. The BSO's minimum crash test level for all state and interstate bridges is a TL-4.
- An existing bridge rail on a roadway with a posted speed of 30 mph or below may remain in place if it is not located on a bridge over a National Highway System (NHS) highway. When Type 7 bridge rail is present on a bridge over an NHS highway with a posted speed of 30 mph or below, it may remain in place regardless of the type of metal rail installed. Other bridge rails are to be evaluated for strength and geometrics. (See 1610.07(1) for guidance on retrofit techniques.)
- The Type 7 bridge rail is common. Type 7 bridge rails have a curb, a vertical-face parapet, and an aluminum top rail. The curb width and the type of aluminum top rail are factors in determining the adequacy of the Type 7 bridge rail, as shown in Exhibit 1610-17. Consult the WSDOT BSO for assistance in evaluating other bridge rails.

When considering an overlay on a bridge, consult the WSDOT BSO to verify the overlay depth can be placed on the bridge deck based on the type of traffic barrier. There may be instances where the height of the bridge barrier will not allow for the planned overlay depth without removal of existing pavement.

Exhibit 1610-16 Type 7 Bridge Rail Upgrade Criteria



Aluminum Rail Type	Curb Width	
	9 Inches or Less	Greater Than 9 Inches*
Type R, S, or SB	Bridge rail adequate	Bridge rail adequate
Type 1B or 1A	Bridge rail adequate	Upgrade bridge rail
Other	Consult the WSDOT BSO	

*When the curb width is greater than 9 inches, the aluminum be able to withstand a 5 kip load.

1610.07(1) Bridge Barrier Retrofit

If the bridge barrier system does not meet the criteria for strength and geometrics, modifications to improve its redirectional characteristics and its strength may be needed. Consult the WSDOT BSO to determine which retrofit method described below can be completed.

1610.07(1)(a) Concrete Safety Shape

Consult the WSDOT BSO to determine whether the existing bridge deck and other superstructure elements are of sufficient strength to accommodate this bridge barrier system and provide design details for the retrofit. Retrofitting with a new concrete bridge barrier is costly and requires authorization from Program Management when no widening is proposed.

1610.07(1)(b) Thrie Beam Retrofit

Retrofitting the bridge barrier with thrie beam is an economical way to improve the strength and redirectional performance of a bridge barrier. The thrie beam can be mounted to steel posts or the existing bridge barrier, depending on the structural adequacy of the bridge deck, the existing bridge barrier type, the width of curb (if any), and the curb-to-curb roadway width carried across the structure. Exhibit 1610-17 shows typical retrofit criteria.

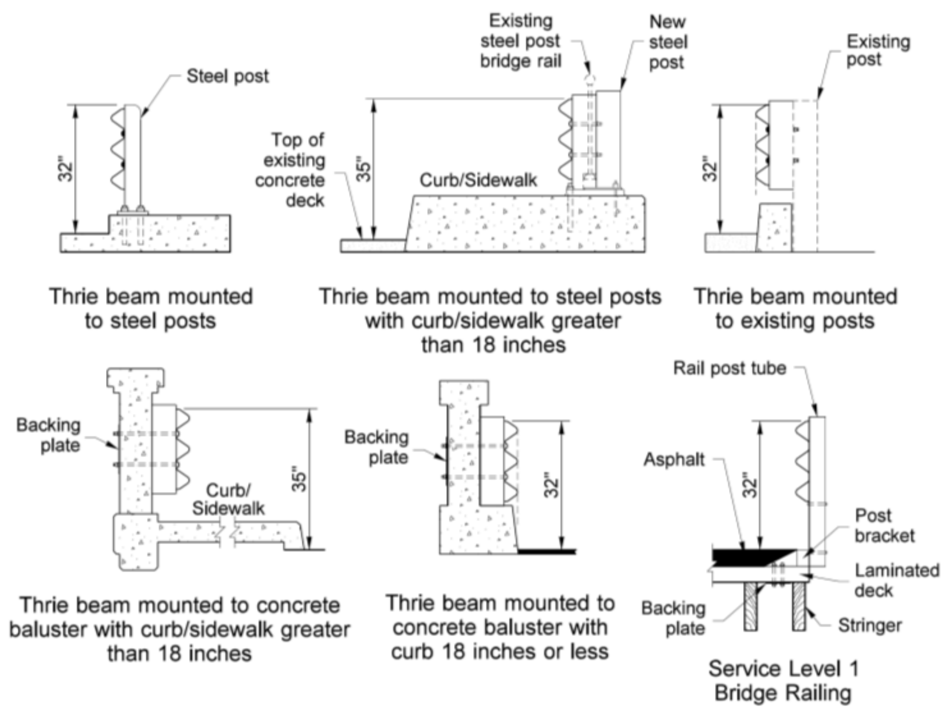
Note that Bridges designated as historical landmarks may not be candidates for thrie beam retrofitting. Contact the Environmental Services Office regarding bridge historical landmark status.

Consider the Service Level 1 (SL-1) system on bridges with wooden decks and for bridges with concrete decks that do not have the needed strength to accommodate the thrie beam system. Contact the WSDOT BSO for information needed for the design of the SL-1 system.

If a thrie beam retrofit results in reduction in sidewalk width ensure ADA compliance is addressed, see Chapter 1510.

Exhibit 1610-17 Thrie Beam Rail Retrofit Criteria

Curb Width	Bridge Width	Concrete Bridge Deck: Concrete Bridge Rail (existing)	Concrete Bridge Deck: Steel or Wood Post Bridge Rail (existing)	Wood Bridge Deck or Low- Strength Concrete Deck
<18 inches		Thrie beam mounted to existing bridge rail [2] and blocked out to the face of curb. Height = 32 inches.	Thrie beam mounted to steel posts [2] at the face of curb. Height = 32 inches	• Service Level 1 Bridge Rail. [2] • Height = 32 inches. • Curb or wheel guard needs to be removed.
>18 inches	**> 28 ft (curb to curb)**	Thrie beam mounted to steel posts[2] at the face of curb. [1] Height = 32 inches.		
>18 inches	**< 28 ft (curb to curb)**	Thrie beam mounted to existing bridge rail.[2] Height = 35 inches.	Thrie beam mounted to steel posts [2] in line with existing rail. Height = 35 inches.	



Notes:

[1] To maximize available curb/sidewalk width for pedestrian use, thrie beam may be mounted to the bridge rail at a height of 35 inches.

[2] Contact the WSDOT BSO for design details on bridge rail retrofit projects.

1610.08 Other Barriers

1610.08(1) Redirectional Landform

Redirectional landforms, also referred to as earth berms, were formerly installed to help mitigate crashes with fixed objects located in depressed medians and at roadsides. They were constructed of materials that provided support for a traversing vehicle. With slopes in the range of 2H:1V to 3H:1V, they were intended to redirect errant vehicles. The use of redirectional landforms has been discontinued. Where redirectional landforms currently exist as mitigation for a fixed object, provide alternative means of mitigation of the fixed object, such as remove, relocate, upgrade with crash-tested systems, or shield with barrier. Landforms may be used to provide a smooth surface at the base of a rock cut slope.

1610.08(2) Aesthetic Barrier Treatment

An aesthetic barrier may be desired on a project, or it may be required by a memorandum of understanding, a Scenic Byway designation, an easement or corridor management plan, or as a result of stakeholder engagement. Contact the region or HQ Landscape Architect Office to confirm this requirement, and to verify any specific conditions with respect to the barrier's appearance in the applicable plan or corridor document. Reactive coloring agents and powder coating are approved treatment options for w-beam guardrail, and may be applicable to other barrier types. Check with the manufacturer and/or the product documentation when specifying aesthetic treatment for proprietary devices, such as guardrail terminals.

One alternative to the use of aesthetic treatments are barriers designed to be aesthetic, such as steel-backed timber guardrail and stone guard walls. These alternative barriers will likely necessitate a partnering effort because of their higher costs, although grants may be available for this purpose if the need is identified early in the project definition phase.

1610.08(3) Steel-Backed Timber Guardrail

Steel-backed timber guardrails consist of a timber rail with a steel plate attached to the back to increase its tensile strength. There are several variations of this system that have passed crash tests. The nonproprietary systems use a beam with a rectangular cross section that is supported by either wood or steel posts.

A proprietary (patented) system, called the Ironwood Guardrail, is also available. This system uses a beam with a round cross section and is supported by steel posts with a wood covering to give the appearance of an all-wood system from the roadway. The incorporation of the Ironwood Guardrail will need to be documented. Consult with the Assistant State Design Engineer to determine what justification (proprietary or a public interest finding) will be required.

The most desirable method of terminating the steel-backed timber guardrail is to bury the end in a backslope, as described in 1610.04(5). When this type of terminal is not possible, use of the barrier is limited to highways with a posted speed of 45 mph or below. On these lower-speed highways, the barriers can be flared away from the traveled way as described in 1610.03(4) and terminated in a berm outside the Design Clear Zone.

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

1610.08(4) Stone Guardwalls

Stone guardwalls function like rigid concrete barriers but have the appearance of natural stone. These walls can be constructed of stone masonry over a reinforced concrete core wall or of simulated stone concrete. These types of barriers are designed to have a limited textured projection of the stones to help aid in the redirectional characteristics of the barrier. The most desirable method of terminating this barrier is to bury the end in a backslope, as described in 1610.06(3). When this type of terminal is not possible, use of the barrier is limited to highways with a posted speed of 45 mph or below. On these lower-speed highways, the barrier can be flared away from the traveled way and terminated in a berm outside the Design Clear Zone.

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

1610.08(5) Dragnet

The Dragnet Vehicle Arresting Barrier consists of chain link or fiber net that is attached to energy absorbing units. When a vehicle hits the system, the Dragnet brings the vehicle to a controlled stop with limited damage. Possible uses for this device include the following:

- Reversible lane entrances and exits
- Railroad crossings
- Truck escape ramps (instead of arrester beds—see Chapter 1270)
- T-intersections
- Work zones
- Swing span bridges

Coordinate with the HQ Design Office for design details.

1610.09 References

1610.09(1) Design Guidance

WSDOT Roadside Safety site: 🖰 http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm

Bridge Design Manual LRFD, M 23-50, WSDOT

Roadside Design Guide, AASHTO, 2011 with Errata (July 2015)

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

Traffic Manual, M 51-02, WSDOT

1610.09(2) Supporting Information

Manual for Assessing Safety Hardware (MASH), AASHTO, 2009

NCHRP 350, TRB, 1993

Determining Length of Need. This e-learning course for WSDOT employees covers the "Length of Need," which is a calculation of how much longitudinal barrier is necessary to shield objects on the roadside. Request this training via the web-based Learning Management System.

Chapter 1720 Weigh Sites

1720.01 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 WSDOT and the Washington State Patrol (WSP).

1720.02 Definitions

Note: For definitions of ***roadway, traveled way***, ***lane***, ***median***, outer separation, ***shoulder***, ***decision sight distance***, ***sight distance***, and ***stopping sight distance***, see the Glossary.

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.

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.

Static scale: A scale that requires a vehicle to stop for weighing.

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.

1720.03 Planning, Development, and Responsibilities

The WSP works with WSDOT Strategic Planning and Programming 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 the Program Management Office of Strategic Planning and Programming a Project Definition, which 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. The region then 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, Exhibit 1720-8, contains details about the various responsibilities of WSDOT and the WSP.

1720.04 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.

1720.04(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, and impact on the environment. Water, electricity availability, and sewage treatment and disposal are other considerations for site selection. Additionally, use the following criteria:

- Locate the facility such that its operation will not hinder the operation of the highway or other related features such as intersections and interchanges.
- To the extent feasible, eliminate options for truck traffic to bypass the weigh site.
- Base the site selection on the type and volume of trucks using the route.

An Access Revision Report (ARR) is required for weigh sites on multilane divided highways with access control (see Chapter 550).

1720.04(2) Design Features

On multilane highways, provide off- and on-connections as shown in Chapter 1360. Exhibit 1720-1 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. Off- and on-connections, as shown in Chapter 1360, are preferred. However, with justification, on-connections may be designed as intersections (see Chapter 1310). Exhibit 1720-2 is a guide for the design of weigh sites on two-lane highways.

The following special design features apply to weigh sites:

- Level cement concrete approach slabs are required at both ends of the scales.
- Hot mix asphalt (HMA) approach slabs will be allowed only when adequate soil conditions exist, projected truck volume is light, and benefit/cost analysis justifies the HMA 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 trucks do not impede the main line 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 scalehouse 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. Exhibit 1720-3 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 1600 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.
- When 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 the Collector-Distributor: Outer Separations exhibit in Chapter 1360.)
- Provide a clear view of the entire weigh site for the facility’s operator and the driver of an approaching vehicle.
- Hot mix asphalt 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 1040 for additional information on illumination.)

1720.05 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.

1720.05(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 in Exhibit 1720-4, are used with two-way traffic and on multilane highways with low traffic volumes. Major portable scale sites (see Exhibit 1720-5) are for use on expressways, freeways, and where traffic volumes are high.

Locate the weighing facility such that its operation will not hinder the operation of the highway or other related features such as intersections.

An ARR is required for weigh sites on multilane divided highways with access control (see Chapter 550).

1720.05(2) Design Features

The following special design features apply to portable facilities:

- Off- and on-connections, as shown in Exhibits 1720-4 and 1720-5, are preferred; however, with justification on highways with no access control, on-connections may be designed as intersections (see Chapter 1310).
- 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 exhibit in Chapter 1360.)
- Provide adequate parking and storage to ensure trucks do not impede the main line through traffic. The WSDOT Regional Administrator and the WSP agree on the area to be provided.
- Hot mix asphalt 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 1040 for additional information on illumination.)

1720.06 Shoulder Sites

Shoulder sites are used by the WSP to pull a truck over for inspection and weighing with portable scales.

1720.06(1) Site Locations

Design shoulder sites to best fit the existing conditions. Small shoulder sites (see Exhibit 1720-6) are for use on lower-volume roadways (ADT 5000 or less) with two-way traffic. Large shoulder sites (see Exhibit 1720-7) 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 intersections.

1720.06(2) Design Features

Shoulder sites are designed in coordination with the WSP. Input from the local WSP Commercial Vehicle Enforcement personnel will ensure 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.

Hot mix asphalt 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 (see Chapter 1360).

When the shoulders are designed to be used for deceleration and acceleration lanes, the minimum width is 12 feet with full pavement depth for the deceleration/ acceleration lane lengths (see Chapter 1360).

Use a maximum 2% slope in order to optimize portable scale efficiency and facilitate drainage.

1720.07 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/acceleration lanes, passing lanes, driveways, parking areas, scale approach slabs, vehicle inspection facilities, roadway illumination, and signing.

1720.08 Procedures

Prepare site plans for all truck weighing facilities that include:

- Class of highway and design speed for main line (see Chapter 1103).

- Curve data on main line and weigh site.
- Number of lanes and width 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.

1720.09 Documentation

Refer to Chapter 300 for design documentation requirements.

Exhibit 1720-1 Truck Weigh Site: Multilane Highways

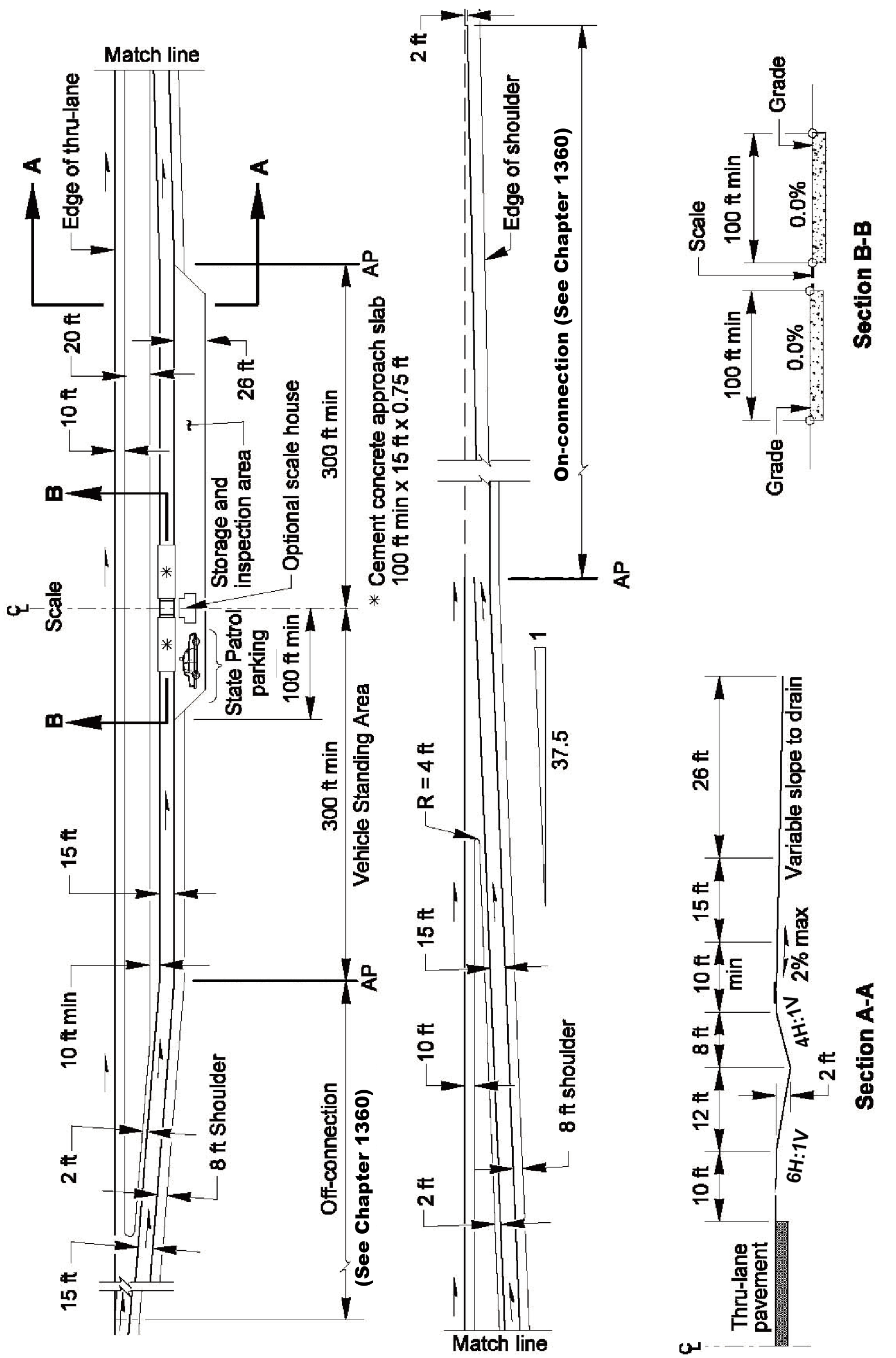


Exhibit 1720-2 Truck Weigh Site: Two-Lane Highways

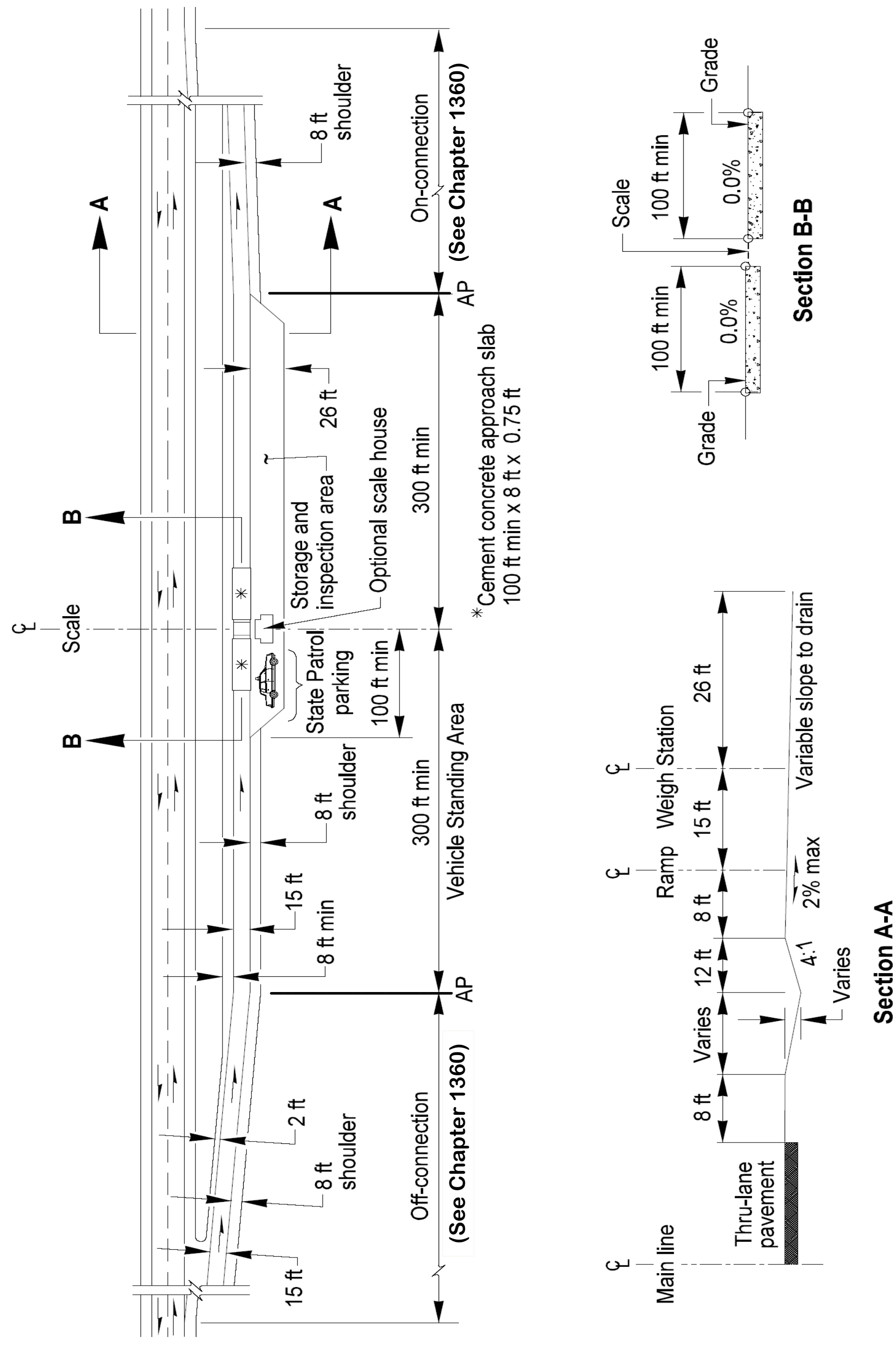


Exhibit 1720-3 Vehicle Inspection Installation

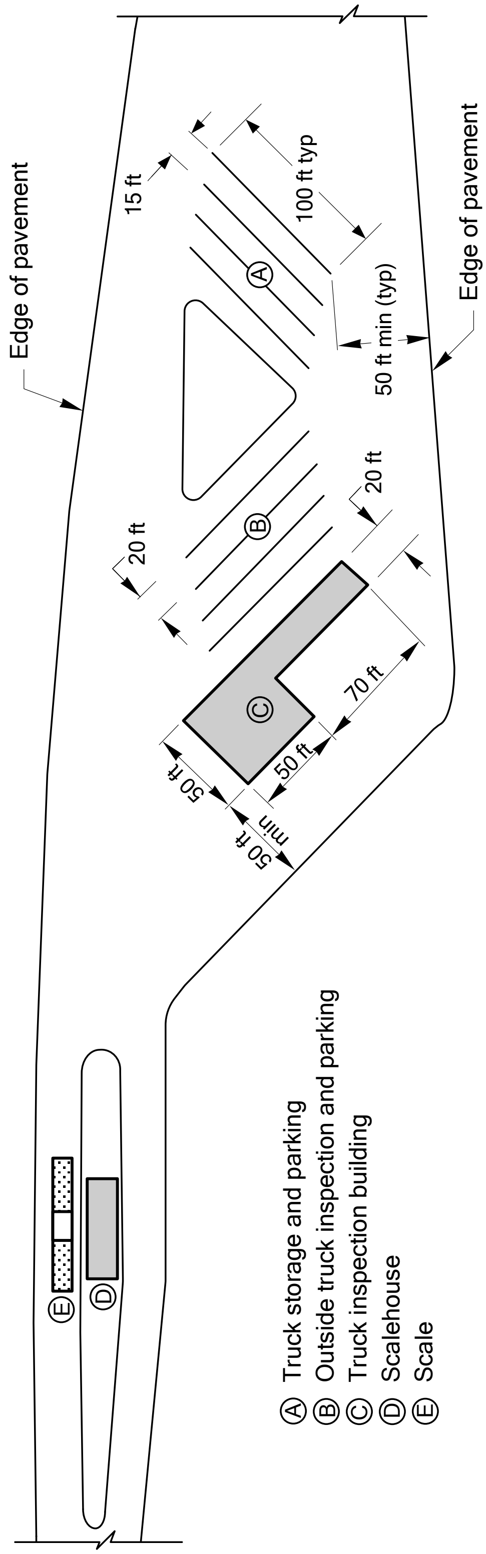
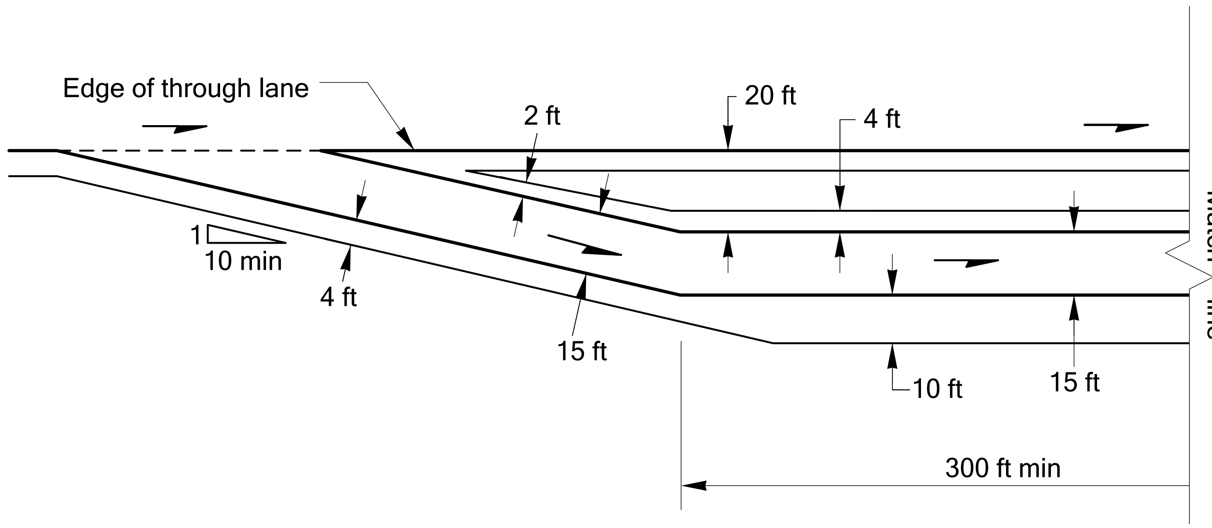


Exhibit 1720-4 Minor Portable Scale Site



(Not to Scale)

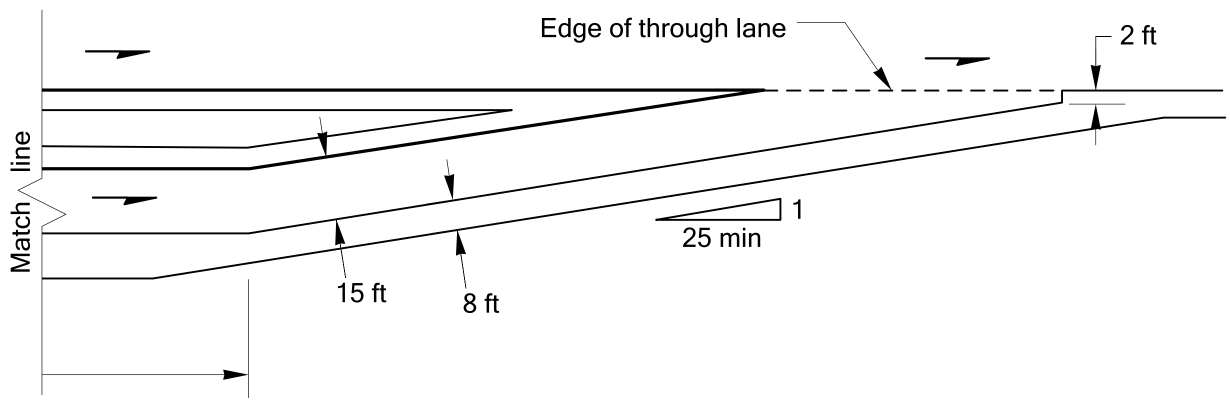
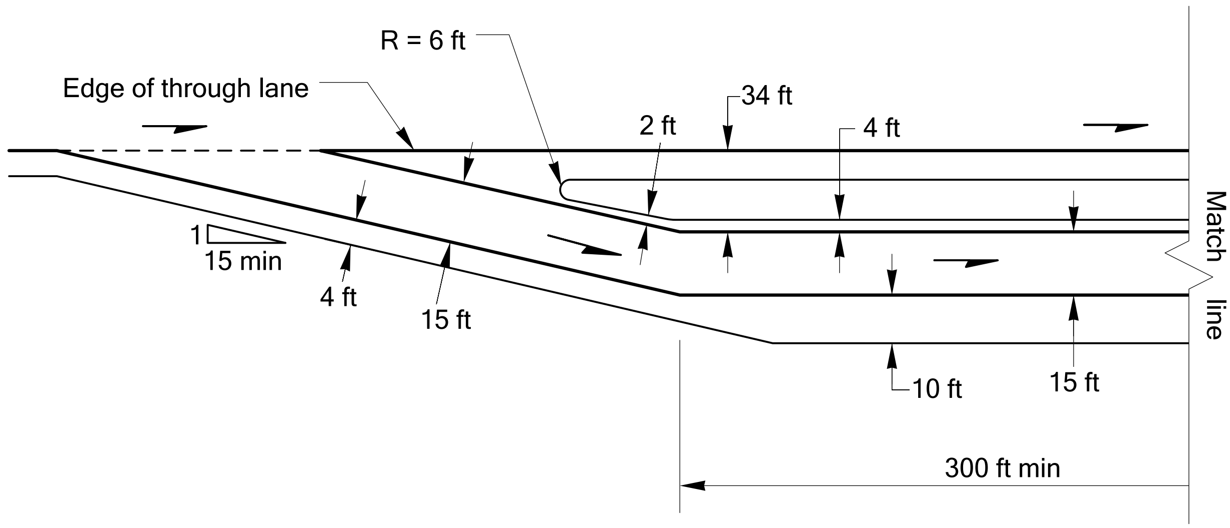


Exhibit 1720-5 Major Portable Scale Site



(Not to Scale)

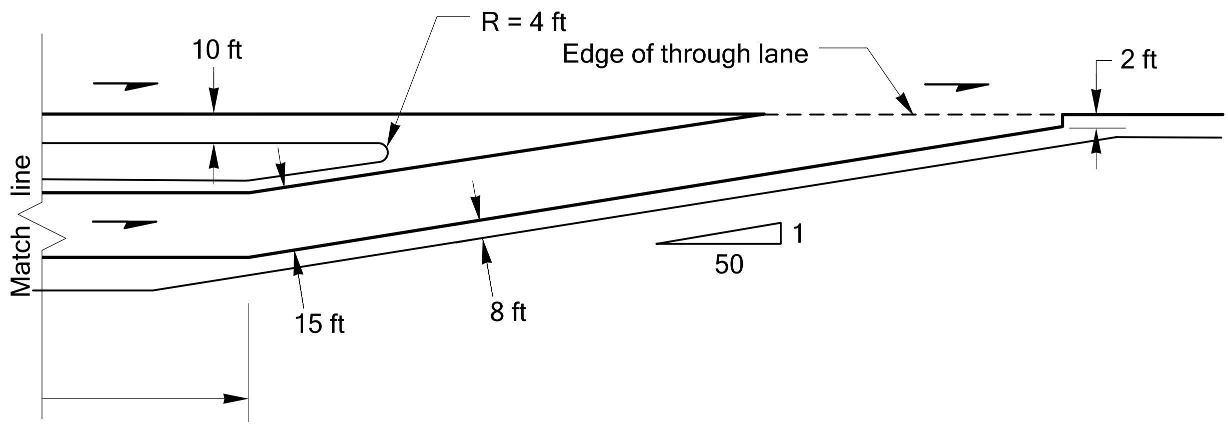


Exhibit 1720-6 Small Shoulder Site

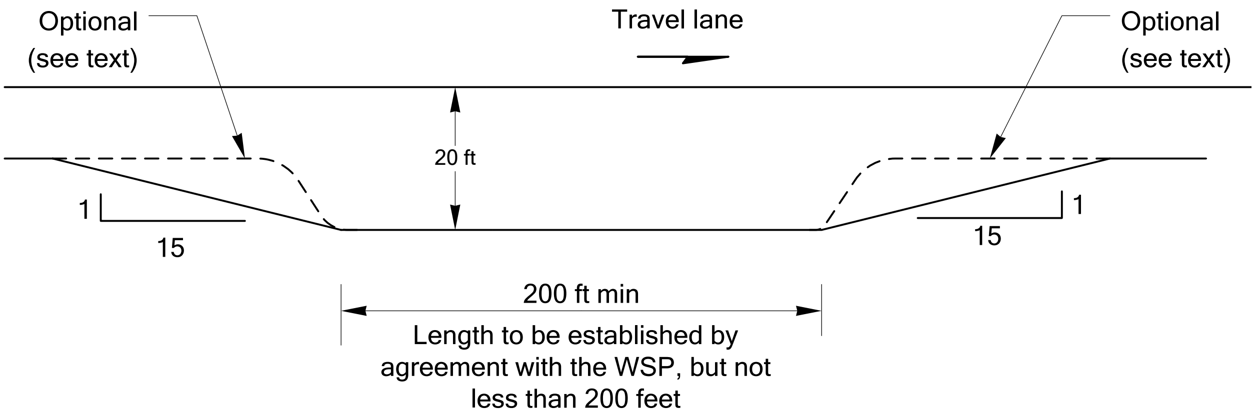


Exhibit 1720-7 Large Shoulder Site

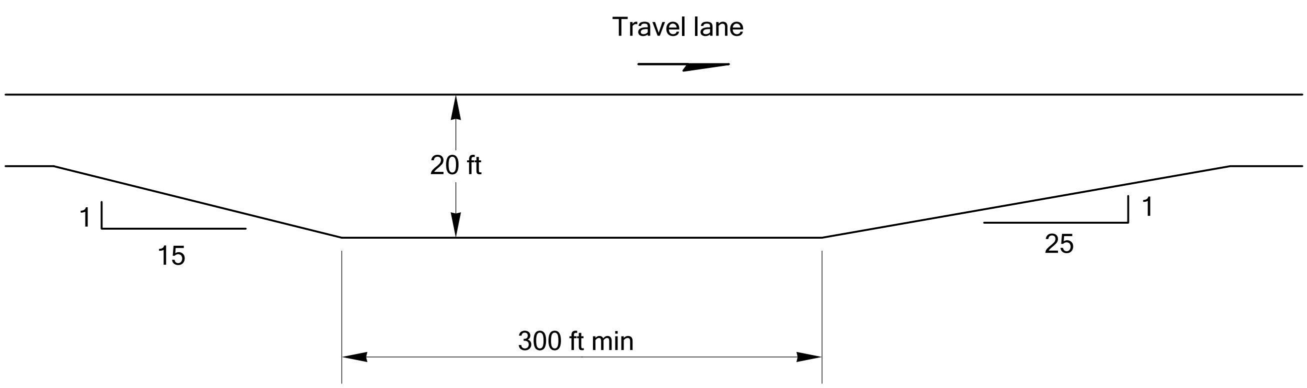


Exhibit 1720-8 MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract C116790GSC

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 "WSDOT, and the Washington State Patrol, hereinafter called the "WSP" 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 improvement needed as a result of these facilities.

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 WSP and the WSDOT as needed on state highways.

It is mutually recognized that:

WSDOT is responsible for planning, designing, constructing, and perpetuating public highways of the State Highway system for the safety and benefit of the traveling public;

WSP is responsible for enforcement of the laws of the state of Washington regarding vehicle weight enforcement programs and vehicle safety inspection programs;

WSP has standards and guidelines for the construction and maintenance of weigh station facilities that must be applied uniformly in the state of Washington regarding vehicle weight enforcement programs and vehicle safety inspection programs:

WSP and WSDOT understand different rules related to purchasing may apply depending on whether state or federal funds are being used:

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 WSDOT and the WSP mutually agree to the division of responsibilities as outlined in the following table:

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MOU – Vehicle Weighing &
Equipment inspection Facilities

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract C110790G SC

	WSP	WSDOT Region	WSDOT CVS	WSDOT Capital Programs
Strategic Planning				
Develop a biennial prioritized list of weigh station needs: • New permanent facilities • New portable facilities • Weigh-in-Motion (WIM) equipment to include WIM computers • CVISN equipment both mainline and inside the facility • Vehicle inspection facilities • Virtual weigh sites • Sanitation/restroom facilities.	X (Lead)		X	
WSP will provide WSDOT Capital Programs 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.	X (Lead)		X	X
WSDOT Capital Programs will send the prioritized list information to the Regional Administrator (RA) for preparation of a project summary.	X	X	X	X (Lead)
The RA, or designee, will work with WSP to identify the specific location of the facility, prepare a design decision estimate, and submit it to the WSDOT Capital Programs for inclusion in the biennial program.	X	X (Lead)	X	X
Develop a biennial prioritized list of weigh station site maintenance needs: • Scale approach slab construction • Ramp repairs • Guardrail	X	X (Lead)	X	
WSP will provide WSDOT Capital Programs with a project definition for each maintenance project, which will include statement of need, purpose of project, type of work, and general location of the project. Capital Programs will include this in the biennial program.	X (Lead)	X	X	X

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MOU – Vehicle Weighing &
Equipment inspection Facilities

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract C110790GSC

	WSP	WSDOT Region	WSDOT CVS	WSDOT Capital Programs
WSP and WSDOT will develop a biennial list of weigh station maintenance needs to include items such as: • Servers, PCs, Printers • WIM equipment to include WIM computers • Roadside Equipment • Static Scales • Scale facility	X	X (if applicable)	X	
WSP and WSDOT will prepare and submit funding packages as necessary to ensure consistent and reliable weigh station operations.	X		X	
Project Planning				
For WIM facilities and for facilities deploying Commercial Vehicle Information Systems and Networks (CVISN), select sites in cooperation with WSDOT that minimize the need for pavement reconstruction.	X (Lead)	X	X	
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, siting of a new facility, etc. with the appropriate WSDOT Region and WSDOT Commercial Vehicle Services (CVS).	X (Lead)	X	X	
Initiate action for the relocation of an existing facility when necessary due to the relocation of a highway or expansion of an existing highway, and obtain concurrence of the WSP.	X	X (Lead)	X	
Negotiate agreements with WSP regarding addition, expansion and relocation of facilities.	X	X (Lead)	X (If CVISN equipped)	
Negotiate and execute any formal agreements required for the design or construction of vehicle weighing and inspection sites.	X	X (Lead)	X (If CVISN equipped)	

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MOU – Vehicle Weighing & Equipment Inspection Facilities

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract C110790GSC

	WSP	WSDOT Region	WSDOT CVS	WSDOT Capital Programs
Project Design				
Perform the preliminary engineering and submit the design and PS&E documents for the static scale, WIM, scale house, and inspection facility to the WSDOT for review and processing for approval with the Federal Highway Administration (FHWA), if applicable, using Capital Project design funding.	X (Lead –*If WSP administers the contracts)*	X (Lead-*if WSDOT administers the contracts)*	X (If CVISN equipped)	
For facilities deploying CVISN, perform preliminary engineering and design for the e screening mainline hardware and software, to include the WIM communication software for conformance with CVISN standards.	X	X (Lead)	X	
For CVISN equipped weigh stations, provide an equipment storage room within the scale facility.	X (Lead)	X	X	
Right of Way and Site Construction				
On all newly located or existing highways, acquire the necessary right of way, construct the required acceleration and deceleration lanes, on and off ramps, driveways, passing lanes, scale approach slabs, and parking areas, including surfacing thereof, excavate the static scale pits, and construct the inspection parking and roadway illumination.	X	X (Lead)	X (If CVISN equipped)	
Project Construction				
For facilities deploying CVISN construct the special approaches and provide traffic control for installation of the WIM.		X (Lead)	X	
For facilities deploying CVISN, purchase and install all mainline hardware and software, to include the WIM communication software for conformance with CVISN standards.		X	X (Lead)	
For facilities deploying CVISN provide all CVISN computer systems.		X	X(Lead)	
For facilities deploying CVISN provide communications to the CVISN system and the user interface.	X	X	X (lead)	

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MOU – Vehicle Weighing & Equipment inspection Facilities

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract a1107906GSC

	WSP	WSDOT Region	WSDOT CVS	WSDOT Capital Programs
Construct the weigh station scale, scale house and commercial vehicle inspection facility (if applicable).	X (Lead-if WSP administers the contracts)	X (Lead-if WSDOT administers the contracts)	X	
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 WSDOT expense.		X (Lead)	X	
All construction in the state or interstate right-of-way will be under the responsibility of a WSDOT region engineer.		X (Lead)		
For existing weigh stations being upgraded to include CVISN, provide an equipment storage room within the scale facility.	X (Lead)	X	X	
For CVISN equipped weigh stations, provide CVISN hardware (Servers, PCs, Monitors, Printers) and software located within the facility.	X		X (Lead)	
Virtual Weigh Stations				
Acquire the necessary right of way, construct and maintain the Large Shoulder Sites and the Major Portable Scale Sites. Construct and install the inspection site(s) illumination.	X	X (Lead)	X	
Perform the preliminary engineering and submit the design and PS&E documents.	X	X (Lead)	X	
Perform preliminary engineering and design for all mainline hardware and software, to include the WIM communication software for conformance with CVISN standards.	X	X Lead	X	
Provide all CVISN computer systems...		X	X(Lead)	
Purchase and install all mainline hardware and related software to include the WIM and the WIM communication software for conformance with CVISN standards.	X	X	X (Lead)	

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MOU – Vehicle Weighing &
Equipment inspection Facilities

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract C110790GSC

	WSP	WSDOT Region	WSDOT CVS	WSDOT Capital Programs
Construct the CVISN roadside apparatus at the same time as WIM equipment is installed, e.g.: cantilevered mounting poles, guard rail, conduit, and raceway installation at WSDOT expense.		X (Lead)	X	
Provide communication to the CVISN system and the user interface.	X	X	X (Lead)	
Maintenance				
For CVISN equipped weigh stations; operate and maintain WIM signs to include; the Variable Message Signs; Changeable Message Signs: as well as the static scales and WIM roadside computer.	X			
For all weigh stations responsible for lighting, water, heat, telephone, garbage pickup and toilet facilities inside the weigh station.	X			
For all weigh stations responsible for toilet facilities outside the weigh station.	X			
Incidental costs including, but not limited to paper and toner for printers.	X			
For CVISN equipped weigh stations; provide maintenance of the CVISN hardware and software located within the facility.			X	
For CVISN equipped weigh stations; provide maintenance of the Automated License Plate Recognition (ALPR) equipment located on the mainline.			X	
For CVISN equipped weigh stations; provide maintenance of the Automated Infrared equipment located on the ramp.			X	
For CVISN equipped weigh stations; provide maintenance of the Automated Vehicle Identification (AVI) equipment located on the mainline.			X	

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract C110790GSC

	WSP	WSDOT Region	WSDOT CVS	WSDOT Capital Programs
Standard signing at all weigh stations. Standard signing includes the Black/White Regulatory signs; the non-electrical Open/Close signs; the electrical Open/Close signs; and the Green/White Non Regulatory signs. (To include replacement)		X		
Sign at each Port of Entry (POE) identifying Washington as a NORPASS state.			X	
Sign on the ramp at each CVISN equipped weigh station providing a transponder toll free number.			X	
Roadway and all parking lot lighting maintenance of electrical lighting and other components, such as transformers, service cabinets, vaults, etc.		X		
Electrical service to weigh station facilities and CVISN equipment including service cabinets, power to WIM cabinets, vaults, inside facility electrical circuits, etc.	X			
Annually or as requested, and as able, provide the following grounds maintenance: • Mowing and/or vegetation management around the scale facility and the WIM cabinet • Highway litter removal • Parking lot flushing (where permitted), cleaning and Vac-All. • Vac-All for cleaning of the static scale pits • Snow removal (after highways are cleared) • Storm cleanup as part of overall clean-up activities • Ice removal (ramp and parking lot)		X		
Snow and ice removal from the sidewalks and walkways surrounding the facility.	X			
Coordinate traffic control when closure of any lane is required for maintenance of the WIM system.	X (Lead)	X		
Maintenance and repairs to the security cameras mounted outside of the weigh station facility.	X (Lead)			

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MOU – Vehicle Weighing & Equipment inspection Facilities

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract C110790GSC

	WSP	WSDOT Region	WSDOT CVS	WSDOT Capital Programs
Maintenance and repairs to the interior and exterior of the scale facility to include the commercial vehicle inspection building.	X			
Pavement markings and jersey barriers		X		
In the event either WSP or WSDOT cannot fulfill the responsibilities specified above for maintenance of the weigh station facilities; they may request the other party to perform the work on the basis of a written agreement that includes reimbursement for the costs.	X	X	X	
Damages				
Provide notification (within 24 hours) when damage occurs to roadside equipment.	X (Lead)	X	X	
If damage is the result of a traffic accident provide a copy of the accident report.	X (Lead)	X	X	

Note: In many areas all parties are involved; therefore a Lead is designated and the Lead's responsibility will be to coordinate with the other parties.

Additionally, the WSP and WSDOT agree to follow the Federal Highway Administration's *Guidance for Local Agency Roadway Projects within Interstate Rights-of-Way*, as outlined in Attachment A.

Conclusions and Approvals

The Regional Administrators for WSDOT, the Commercial Vehicle Division Commander for the WSP, and the Property Management Division Commander for the WSP are encouraged to consult with each other and to agree on such matters that fall within their scope of responsibility.

This Memorandum of Understanding (MOU) may be amended or supplemented by mutual agreement between the signers or their successors.

Either party may terminate this MOU upon thirty (30) calendar 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.

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.

Exhibits and Attachments

All exhibits, attachments, and documents referenced in this contract are hereby incorporated into this Agreement.

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract C110790GSC

Agreement Execution.

The signatories to this Agreement represent that they have the authority to bind their respective organizations to this Agreement.

ALL WRITINGS CONTAINED HEREIN

This Agreement contains all the terms and conditions agreed upon by the parties. No other understandings, oral or otherwise, regarding the subject matter of this Agreement shall be deemed to exist or to bind any of the parties hereto.

IN WITNESS WHEREOF, the parties have executed this Agreement.

State of Washington Department of Transportation	Washington State Patrol
Bill Ford	D. K
Signature	Signature
Bill Ford, Asst. Secretary of Admin. Operations	Deputy Chief David I Karnitz ~~Chief John Batiste~~
Title	Title
4-1-11	4-15-11
Date	Date

C110790GSC

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MOU – Vehicle Weighing & Equipment inspection Facilities

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract C110790GSC

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 award:** The local agency must confer with the WSDOT Project Engineer on any pre-award 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 ______________ and must evidence their approval.

Only local agencies with full certification acceptance authority may enter into such an agreement with WSDOT.

The agreement must be submitted to FHWA for approval. FHWA reserves the right to assume full oversight of the project.

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MOU – Vehicle Weighing &
Equipment inspection Facilities

Exhibit 1720-8 (continued) MOU Related to Vehicle Weighing and Equipment: Inspection Facilities on State Highways

WSDOT Contract K510
WSP Contract a110790GSC

	WSP	WSDOT Region	WSDOT CVS	WSDOT Capital Programs
Construct the weigh station scale, scale house and commercial vehicle inspection facility (if applicable).	X (Lead-if WSP administers the contracts)	X (Lead-if WSDOT administers the contracts)	X	
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 WSDOT expense.		X (Lead)	X	
All construction in the state or interstate right-of-way will be under the responsibility of a WSDOT region engineer.		X (Lead)		
For existing weigh stations being upgraded to include CVISN, provide an equipment storage room within the scale facility.	X (Lead)	X	X	
For CVISN equipped weigh stations, provide CVISN hardware (Servers, PCs, Monitors, Printers) and software located within the facility.	X		X (Lead)	
Virtual Weigh Stations				
Acquire the necessary right of way, construct and maintain the Large Shoulder Sites and the Major Portable Scale Sites. Construct and install the inspection site(s) illumination.	X	X (Lead)	X	
Perform the preliminary engineering and submit the design and PS&E documents.	X	X (Lead)	X	
Perform preliminary engineering and design for all mainline hardware and software, to include the WIM communication software for conformance with CVISN standards.	X	X Lead	X	
Provide all CVISN computer systems...		X	X(Lead)	
Purchase and install all mainline hardware and related software to include the WIM and the WIM communication software for conformance with CVISN standards.	X	X	X (Lead)	

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