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Remarks and Instructions

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

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

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Chapter 1010	Added 1010.08(9) Radar Speed Display Sign (RSDS) Specifying the Manual for Assessing Safety Hardware (MASH) for sections: 1010.08 Temporary Traffic Control Devices 1010.09(1)(a) Concrete Barriers 1010.09(1)(c) Portable Steel Barriers 1010.09(2) Impact Attenuators 1010.10(1) Delineation - Updated guidance on paint stripe delineation both long term and short term striping Added 1010.10(5) Smart Work Zone Systems (SWZS)
Chapter 1120	Section 1120.03(7) Barriers and Terminals. The requirements for Type 1 guardrail and Type 31 guardrail now separated into separate bullets that better show their differences.
Chapter 1610	Exhibit 1610-3 Longitudinal Barrier Deflection Updated MASH deflection distances 1610.04(2) Beam Guardrail Placement – Mash updates 1610.04(3) W-Beam Barrier Height – Mash updates. 1610.05(3) High-Tension Cable Barrier Termination - Describing all available cable barrier termination options. 1610.06(1) Describing Bridge, Roadside/Median Shape, and Stiffness Transitions 1610.06(1)(a) Phasing out type 2 New Jersey concrete barrier for Type F New 1610.06(2) Concrete Barrier Placement in Front of Bridge Piers

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

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December 2019

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Engineering and Regional Operations
Development Division, Design Office

Americans with Disabilities Act (ADA) Information

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Foreword

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

The Federal Highway Administration has agreed to approve designs that follow the guidance in the *Design Manual*; therefore, following the guidance is mandatory for state highway projects. When proposed designs meet the requirements contained in the *Design Manual*, little additional documentation is required.

The *Design Manual* supplements the engineering analyses and judgment inherent with practical design and provides uniform procedures for documenting and implementing design decisions. The *Design Manual* emphasizes practical design as a means to produce environmentally conscious, sustainable, context-based designs that achieve the purpose and need for the lowest cost. Practical design considers the needs of all users, fostering livable communities and modally integrated transportation systems used safely by all, including motorists, freight haulers, transit, pedestrians, and bicyclists.

The complexity of transportation design requires designers to make fundamental trade-off decisions and sometimes incremental approaches to balance competing spatial considerations with available resources. Although this adds to the complexity of design, it acknowledges the unique needs of specific projects and the relative priorities of various projects and programs.

Updating the *Design Manual* is an ongoing process and revisions are issued regularly. The addition of new or modified design criteria to the *Design Manual* through the revision process does not imply that existing features are deficient in any way, nor does it suggest or mandate immediate engineering review or initiation of new projects. Comments, questions, and improvement ideas are welcomed. Use the comment form on the next page or the contact information on the Design Policy Internet Page: www.wsdot.wa.gov/design/policy

/s/ Steve Roark

Steve Roark, P.E.
Director & State Design Engineer,
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1010.01 General

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

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

1010.02 Definitions

The following terms are defined in the Design Manual Glossary:

- Transportation Management Area (TMA)
- Transportation Management Plan (TMP)
- work zone
- work zone impact
- work zone traffic control
- traveling public

1010.03 Work Zone Safety and Mobility

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

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

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

1010.04 Transportation Management Plans and Significant Projects

1010.04(1) Transportation Management Plan

A transportation management plan is a set of strategies for managing the corridor-wide work zone impacts of a project. A TMP is required for all projects and is the key element in addressing all work zone safety and mobility impacts. The TMP development begins in the scoping phase of a project by assessing impacts known at the time and then selecting mitigating strategies and design solutions to manage those impacts. It is very important to continue the development of the TMP throughout the project development process.
Not all work zone impacts have to be addressed with traffic control plans only. Many work zone impacts can be reduced or eliminated through project design elements like alignment choice, materials selection, structure types, overbuilding, and phased construction. Work zone impacts related to work duration may be resolved or reduced through innovative bidding and contract administration.
The three major components of a TMP are described below.

1010.04(1)(a) Temporary Traffic Control

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

- TTC strategies such as lane closures or shifts, one-lane two-way operations (flagging and or pilot car), staged construction, or full road closures and detours.
- Traffic Control Devices such as temporary signing, channelizing devices (cones, drums), changeable message signs, arrow boards, temporary signals, and temporary pavement markings.

- Corridor Project Coordination, Contracting Strategies, and Innovative Construction Strategies such as A+B bidding, incentives/disincentives, and precast members or rapid cure materials.

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

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

- Demand Management Strategies such as Transit service improvements, transit incentives, and park & ride promotion.
- Corridor/Network Management (traffic operations) Strategies such as Signal timing/coordination improvements, temporary signals, bus pullouts, reversible lanes, and truck/heavy-vehicle restrictions.
- Work Zone Safety Management Strategies such as using positive protective devices, speed limit reductions, automated flagger assistance devices, radar speed display signs, and smart work zone systems.
- Traffic/Incident Management and Enforcement Strategies such as Work Zone Intelligent Transportation Systems (ITS), Washington State Patrol, tow service, WSDOT Incident Response Team vehicle(s), traffic screens, and emergency pullouts in long work zones with narrowed shoulders.

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

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

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

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

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

1010.04(2) Significant Projects

The FHWA definition of a "significant project" is as follows:

> *A significant project is one that, alone or in combination with other concurrent projects nearby, is anticipated to cause sustained work zone impacts that are greater than what is considered tolerable based on state policy and/or engineering judgment.*
>
> *All Interstate system projects within the boundaries of a designated Transportation Management Area (TMA) that occupy a location for more than three days with either intermittent or continuous lane closures shall be considered as significant projects.*

Note: Significant projects require a TMP document addressing safety and mobility impacts with strategies or elements from all three TMP components.

The size and scale of the TMP document will depend on the project's complexity and impacts. For examples of WSDOT TMP's see:
http://www.wsdot.wa.gov/Safety/WorkZones/resources.htm

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

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

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

1010.05 Developing TMP Strategies

1010.05(1) Key Considerations

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

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

1010.05(2) Impacts Assessment

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

A complete and accurate impacts assessment will allow for the development of an effective TMP that should only need minor modifications to address construction issues. The *Traffic Manual* provides information on how to determine expected work zone congestion along with mobility management strategies.

An early and ongoing impacts assessment allows time to:

- Develop TTC, TO, and PI (see Section 1010.04(1)) strategies to address identified impacts as needed to effectively manage the project.
- Resolve potential work zone impacts within the design features of the project. Decisions that consider work zone impacts during bridge type selection, materials selection, advertisement dates, and others have the potential to resolve or minimize work zone impacts.
- Consider innovative mitigation strategies that may involve many stakeholders.

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

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

1. Bridge construction sequence or falsework opening plans need to match the TTC staging or channelization plans. Coordination with the HQ Bridge and Structures Office is essential as the bridge design schedule may differ than the project schedule. Maintain the legal height of 16 feet 6 inches as the minimum falsework opening whenever possible; anything less than this must consider overheight vehicle impacts, possible additional signing needs, and temporary bypass routes. Impacts to shoulder widths due to barrier or bridge staging may impact bicycle or pedestrian access and must be addressed in TTC plans. Refer to Chapter 720 for additional requirements and approvals. Coordination with the Permits Office may be needed.
2. If existing signal and illumination systems are not able to be maintained during the construction phases, plans for temporary systems or connections need to be included in the project.
3. Temporary relocation of existing signing (including overhead signing) may be required and should be detailed in the plans.
4. Permanent traffic loop installation (such as advance loops, turn pockets, and stop bars, and ITS loops) and pavement marking installations (crosswalks, arrows, and so on) may require specific TTC plans.

5. What type of temporary marking is most appropriate for the installation, work duration, and the pavement surface? Will the final pavement surface have a “ghost stripe” potential?
6. Lane shifts onto existing shoulders:
   - Is the depth of the existing shoulder adequate to carry the extra traffic and are there rumble stripe that need to be removed?
   - Are there any existing catch basins or junction boxes located in the shoulder that cannot accept traffic loads over them?
   - What is the existing side slope rate? If steeper than 4H:1V, does it need mitigation? Are there existing roadside objects that, when the roadway is shifted, are now within the clear zone limits?
   - Shifting of more than one lane in a direction is only allowed with temporary pavement markings. Shifting lanes by using channelizing devices is not allowed due to the high probability that devices used to separate the traffic will be displaced.
   - Signal head alignment: When the lane is shifted approaching the intersection, is the signal head alignment within appropriate limits?
7. Roundabout construction at an existing intersection requires site-specific staging plans. Roundabouts create many unique construction challenges and each roundabout has very site-specific design features.

1010.05(3) Work Duration

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

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

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

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

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

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

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

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

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

1010.05(3)(e) Mobile Work Zone

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

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

1010.05(4) Transportation Management Plan (TMP) Strategies

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

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

The *Traffic Manual* contains comprehensive information regarding work zone traffic analysis to determine expected delay and queuing.

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

1010.05(5) Temporary Traffic Control (TTC) Strategies

1010.05(5)(a) Lane Closure

When one or more traffic lanes are closed, a capacity analysis is necessary to determine the extent of congestion that may result. Night work or peak hour work restrictions may be required if the analysis shows adverse traffic impacts. On highways with speeds over 40 MPH, traffic safety drums and truck-mounted attenuators should be used in lane closures and the drums should not encroach on the open lanes. Additional lanes should be closed if encroachment is necessary. Consider closing additional lanes to increase the lateral buffer space for worker safety.

1010.05(5)(b) Shoulder Closure

A shoulder closure is used for work areas off the traveled way. On high-volume freeways or expressways, they should not be allowed during peak traffic hours. Channelization devices should not encroach on the open lanes of roadways with speeds of 45 mph and above.

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

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

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

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

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

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

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

1010.05(5)(d) Temporary Alignment and Channelization

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

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

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

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

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

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

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

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

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

Consider the following guidance for traffic split operations:

- Define the work operation and develop the traffic control strategy around the specific operation.
- Limit the duration the traffic split can be in place. Consider incentives and disincentives to encourage the contractor to be as efficient as possible. A higher level of traffic impacts may be acceptable if offset with fewer impacted days.

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

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

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

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

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

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

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

1010.05(5)(e) Total Closures and Detours

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

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

Consider the following road closure issues:

- Communication with all stakeholders, including road users, adjoining property owners, local agencies, transit agencies, the freight industry, emergency services, schools, and others, is required when considering a total closure strategy. This helps determine the level of support for a closure and development of an acceptable closure. Include Rail, Freight, and Ports; Commercial Vehicle Services; and Public Transportation Divisions to help coordinate.
- Analyze a closure strategy and compare it to other strategies, such as staged work zones, to determine which is overall more beneficial. This information helps stakeholders understand the impacts if a closure is not selected.

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

1010.05(5)(f) Intermittent Closure

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

1010.05(5)(g) Rolling Slowdown

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

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

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

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

1010.05(5)(i) Alternative Project Delivery

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

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

- Overbuild beyond normal project needs to maintain additional traffic or facilitate staged construction.
- Replace bridges using new alignments so they can be built with minimal impacts.
- Bring adjacent lifts of hot mix asphalt (HMA) to match the latest lifts (lag up), and require a tapered wedge joint to eliminate drop-off and abrupt lane edges to improve motorist safety.

- Require permanent pavement markings at intervals during multi-season projects to limit the duration temporary markings are needed and to avoid temporary marking issues during winter shut-down.

1010.05(6) Transportation Operations (TO) Strategies

The following are operational strategies to consider based on project specific needs:

1010.05(6)(a) Demand Management

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

1010.05(6)(b) Corridor/Network Management

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

1010.05(6)(c) Work Zone Safety Management

- Provide temporary access road approaches for work zone access.
- Use positive protective devices (barrier) for long-term work zones to improve the environment for workers and motorists.
- Install intrusion alarms or vehicle arresting devices.
- Use speed limit reductions when temporary conditions create a need for motorist slow-downs. Refer to the *Traffic Manual* for additional information, guidance and approval requirements for speed limit reductions in work zones.
- Use advanced queue warning systems depending on the extent of expected work zone congestion on high-speed roadways. Refer to the *Traffic Manual* for additional information and guidance for Smart Work Zone Systems and other simpler truck-mounted PCMS versions.

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

- Provide law enforcement patrols to reduce speeding and aggressive drivers.
- Provide incident response patrols during construction to reduce delays due to collisions in the work zone.

- Include work zone ITS elements in the project or coordinate with TMC to use existing equipment.
- Provide a dedicated tow service to clear incidents.

1010.05(7) Public Information (PI) Strategies

The following are strategies to consider based on project specific needs:

1010.05(7)(a) Public Awareness

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

1010.05(7)(b) Driver Information

In addition to work zone signs, provide driver information using highway advisory radio (HAR) and changeable message signs (existing or portable). Include a Smart Work Zone System to provide drivers with real time information on queuing and delays. Involve the region TMC in the development and implementation of these strategies. Additional information on smart work zone systems can be found on the Work Zone Safety web page:
🖰 www.wsdot.wa.gov/safety/workzones/

The Freight Alert system should be used to communicate information with freight industry on work zones. Each region has the capability to send alerts with this system.
🖰 http://www.wsdot.wa.gov/freight/
Work zone strategy development is a fluid process and may be ongoing as project information and design features are developed during the design process. There may be many factors involved with strategy development, and it is necessary to be well organized to make sure all the relative factors are identified and evaluated.

1010.05(7)(c) Pedestrian and Bicycle Information

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

1010.06 Work Zone Capacity Analysis

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

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

Work zone mobility impacts can have the following effects:

- **Crashes:** Most work zone crashes are congestion-related, usually in the form of rear-end collisions due to traffic queues. Traffic queues beyond the advance warning signs increase the risk of crashes.
- **Driver Frustration:** Drivers expect to travel to their destinations in a timely manner. If delays occur, driver frustration can lead to aggressive or inappropriate driving actions.
- **Constructability:** Constructing a project efficiently relies on the ability to pursue work operations while maintaining traffic flow. Delays in material delivery, work hour restrictions, and constant installation and removal of traffic control devices all detract from constructability.
- **Local Road Impacts:** Projects with capacity deficiencies can sometimes cause traffic to divert to local roadways, which may impact the surrounding local roadway system and community.
- **Public Credibility:** Work zone congestion and delay can create poor credibility for WSDOT with drivers and the surrounding community in general.
- **Restricted Access:** Severe congestion can effectively gridlock a road system, preventing access to important route connections, businesses, schools, hospitals, and so on.
- **User Cost Impacts:** Traffic delays have an economic impact on road users and the surrounding community. Calculated user costs are part of a work zone capacity analysis and may be used to determine liquidated damages specifications.

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

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

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

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

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

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

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

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

1010.06(1) Collecting Traffic Volume Data

Current volume data in the project vicinity is required for accurate traffic analysis results. Seasonal adjustment factors may be needed depending on when the data was collected and when the proposed traffic restrictions may be in place. Assess existing data as early as possible to determine whether additional data collection may be required. The region Traffic

Office and the HQ Transportation Data & GIS Office can assist with collecting traffic volume data. Coordination with local agencies may be needed to obtain data on affected local roads. Refer to the *Traffic Manual* for additional information and guidance.

1010.06(2) Short-Term Work Zone Traffic Analysis

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

Exhibit 1010-1 General Lane Closure Work Zone Capacity

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

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

1010.06(3) Long-Term Work Zone Traffic Analysis

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

Refer to the *Traffic Manual* for additional information and guidance.

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

HQ Transportation Data & GIS Office
HQ Traffic Offices

Region Work Zone Specialist
Region Public Information Office

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

1010.07 Work Zone Design

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

1010.07(1) Lane Widths

Maintain existing lane widths during work zone operations whenever practicable.
For projects that require lane shifts or narrowed lanes due to work area limits and staging, consider the following before determining the work zone lane configurations to be implemented:

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

Work zone geometric transitions should be minimized or avoided if possible. When necessary, such transitions should be made as smoothly as the space available allows. Maintain approach lane width, if possible, throughout the connection. Design lane width reductions prior to any lane shifts within the transition area. Do not reduce curve radii and lane widths simultaneously.
When determining lane widths, the objective is to use lane geometrics that will be clear to the driver and keep the vehicle in the intended lane. In order to maintain the minimum lane widths, temporary widening may be needed.

1010.07(2) Buffer Space

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

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

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

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

1010.07(3) Work Zone Clear Zone

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

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

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

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

Exhibit 1010-2 Minimum Work Zone Clear Zone Distance

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

1010.07(4) Abrupt Lane Edges and Drop-offs

Minimize, mitigate, or eliminate abrupt lane edges and drop-offs whenever practicable. When unavoidable, traffic control plans should provide a protection method. Consider temporary barriers for long duration drop off protection and contract provisions limiting the duration of edges from daily paving operations consistent with Standard Specification section 1-07.23(1).

When a temporary barrier is used to protect the drop-off, the back side the barrier shall be placed a minimum of 3-feet from the drop-off and a new edge line is required on the traffic side of the barrier with a 2-foot lateral buffer space minimum. The space behind the barrier can be reduced if the barrier is anchored. Barrier end attenuators may be required.

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

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

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

1010.07(5) Vertical Clearance

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

1010.07(6) Reduced Speeds in Work Zones

Drivers tend to reduce their speed only if they perceive a need to do so. Reduced speed limits should only be used to address an altered geometry when not able to meet design standards for the existing speed, when the roadway will be narrowed with minimal shy distance to barriers, when roadway conditions warrant a reduction like BST operations, and when there will be workers on foot within a lane width of high-volume traffic traveling at 45 mph and above without positive protection devices in place. Speed reductions are not applied as a means for selecting lower work zone design criteria (tapers, temporary alignment, device spacing, and so on).

Speed limit reductions are categorized as follows:

Continuous Regulatory Speed Limit Reduction: A speed reduction in place 24 hours a day for the duration of the project, stage, or roadway condition.

Variable Regulatory Speed Limit Reduction: A speed reduction in place only during active work hours (Class B construction signs may be used). This is a good option when positive protection devices are not used.

Advisory Speed Reduction: In combination with a warning sign, an advisory speed plaque may be used to indicate a recommended safe speed through a work zone or work zone condition. Refer to the MUTCD for additional guidance.

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

1010.07(7) Accommodation for Pedestrians and Bicyclists

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

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

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

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

1010.07(8) Warning Signs for Motorcyclists

The roadway surface condition is a far greater concern for motorcycles requiring additional warning signs to alert the motorcyclist of work zone conditions. Per RCW 47.36.200 paragraph 2, “(2) If the construction, repair, or maintenance work includes or uses grooved pavement, abrupt lane edges, steel plates, or gravel or earth surfaces, the construction, repair, or maintenance zone must be posted with signs stating the condition, as required by current law, and in addition, must warn motorcyclists of the potential hazard only if the hazard or condition exists on a paved public highway, county road, street, bridge, or other thoroughfare commonly traveled. For the purposes of this subsection, the department shall adopt by rule a uniform sign or signs for this purpose, including at least the following language, "MOTORCYCLES USE EXTREME CAUTION."

1010.07(9) Oversized Vehicles

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

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

1010.08 Temporary Traffic Control Devices

FHWA regulations require that temporary traffic control devices be compliant with the 2016 edition of the Manual for Assessing Safety Hardware (MASH) crash test requirements. In some cases, either the 2009 MASH or the National Cooperative Highway Research Program (NCHRP) Report 350 compliant devices may be used. See Standard Specification 1-10.2(3) for more information.

1010.08(1) Channelizing Devices

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

1010.08(2) Construction Signs

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

Fixed signing (Class A Construction Signs) are the signs mounted on conventional sign supports along or over the roadway. This signing is used for long-term stationary work zones.

Details for their design are in Chapter 1020 and the *Standard Plans*. Sign messages, color, configuration, and usage are shown in the MUTCD and the *Sign Fabrication Manual*. Existing signs may need to be covered, removed, or modified during construction.

1010.08(3) Warning Lights

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

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

1010.08(4) Arrow Board

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

1010.08(5) Portable Changeable Message Signs (PCMS)

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

1010.08(6) Portable Temporary Traffic Control Signals

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

1010.08(7) Portable Highway Advisory Radio (HAR)

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

1010.08(8) Automated Flagger Assistance Device (AFAD)

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

1010.08(9) Radar Speed Display Sign (RSDS)

RSDS are a work zone speed management device that display motorist's speed in real time along with a regulatory speed limit sign or advisory speed sign mounted above the speed display.
RSDS work best when a single lane of traffic remains open but may be used when multiple lanes are open. When multiple lanes are open in heavy traffic volume conditions, it may be unclear which vehicle's speed is actually displayed.
RSDS are not an automated speed enforcement speed, but a passive feedback system to drivers. Modest speed reductions of 3 to 6 mph have been recorded when used within an active work zone.

1010.09 Positive Protection Devices

Channelizing devices may not provide adequate worker and road user protection in some work zones. Positive protective devices listed in the following sub-sections are needed for the following conditions unless an engineering study determines otherwise:

- To separate opposing traffic traveling 45 mph and above normally separated by a median or existing median barrier.
- Where existing traffic barriers or bridge railings are to be removed.
- For drop-off protection during widening or excavations (see *Standard Specification* 1-07.23(1)).
- When temporary slopes change clear zone requirements.
- For bridge falsework protection.
- When equipment or materials must remain in the work zone clear zone.
- When newly constructed features in the clear zone will not have permanent protection until later in the project.
- Where temporary signs or light standards are not crashworthy.

- To separate workers from motorized traffic when work zone offers no means of escape for the worker, such as tunnels, bridges, and retaining walls, or for long-duration worker exposure within one lane-width of high-volume traffic with speeds of 45 mph and above.

1010.09(1) Temporary Barriers

Providing temporary barrier protection may become the key component of the work zone strategy. Barrier use usually requires long-term stationary work zones with pavement marking revisions, and will increase the traffic control costs of a project. The safety benefit versus the cost of using barrier requires careful consideration, and cost should not be the only or primary factor determining the use of barrier. (See Chapter 1610 for guidance on barriers.)

1010.09(1)(a) Concrete Barriers

These are the safety-shape barriers (Type F, Type 2) shown in the Standard Plans. Safety-shape barriers can be unanchored or anchored. See Chapter 1610 for more detailed information on these barriers and their deflection characteristics.

1010.09(1)(b) Movable Barrier Systems

Movable barriers are specially designed segmental barriers that can be moved laterally one lane width or more as a unit with specialized equipment. This allows strategies with frequent or daily relocation of a barrier. The ends of the barrier must be located out of the clear zone or fitted with an impact attenuator. Storage sites at both ends of the barrier will be needed for the barrier-moving machine. WSDOT owns this type of barrier and equipment and it may be available for project use. Pay items are included in the PS&E to deliver the barrier and equipment from and back to the WSDOT storage location and for operation and maintenance during the project.

1010.09(1)(c) Portable Steel Barriers

Portable steel barriers have a lightweight stackable design. They have options for gate-type openings and relocation without heavy equipment. Steel barriers can be unanchored or anchored per the manufacturer's specifications. The lateral displacement of unanchored steel barriers from vehicle impacts typically ranges from 5 to 8 feet depending on manufacturer. The lateral displacement of anchored steel barriers from vehicle impacts typically ranges from 1 to 3 feet depending on manufacturer and anchor pinning arrangement. Steel barriers are proprietary items. See manufacturer website for more information.

1010.09(2) Impact Attenuators

Within the Design Clear Zone, the approach ends of temporary barriers shall be fitted with impact attenuators. The information in Chapter 1620 provides all the necessary impact attenuator performance and selection information. In addition to the guidance in Chapter 1620, consider the characteristics of the work zone when selecting an attenuator. Selection should consider site specific conditions and the dynamic nature of work zones throughout the project.

Contract plans showing temporary impact attenuator placement need to include a list of the approved attenuators that a contractor may use for that installation. See the Attenuator Selection Template at:

http://www.wsdot.wa.gov/publications/fulltext/design/ProductFolder/Impact_attenuator_selection_template.xlsx

1010.09(3) Transportable Attenuators

A transportable attenuator (TA) is a positive protection device that will provide protection for the work area only a short distance in front of the device. An impact attenuator device is attached to the rear of a large truck or towed behind trailer. The minimum truck or trailer weight is specified by the manufacturer to minimize the roll-ahead distance when impacted by an errant vehicle. Use a TA on all roadway operations with speeds of 45 mph and above.

1010.10 Other Traffic Control Devices or Features

1010.10(1) Delineation

Temporary pavement markings will be required when permanent pavement markings are obliterated due to construction operations or temporary reconfigurations needed for long-term work zone strategies. Temporary pavement markings can be made using paint, preformed tape, or raised pavement markers. Complex projects will most likely require both long- and short-duration temporary markings. All temporary pavement markings must be retroreflective and match permanent pavement marking colors. All conflicting pavement markings must be completely removed. Temporary pavement markings are installed in accordance with the Standard Plans and Standard Specifications.

Short-duration temporary pavement markings are made with materials intended to last only until permanent markings can be installed on paving and BST projects, or for short durations between construction stages. Short-duration broken line patterns typically consist of a 4-foot line with a 36-foot gap for paint and tape markings but may be increased to a 10-foot line with a 30-foot gap when specified in the Contract. Short-duration broken line patterns consist of a grouping of three raised pavement markings at 3-foot spacing with a 34-foot gap. Flexible raised pavement markers are required for bituminous surface treatments but typically are not allowed on other pavement types. Temporary edge lines are installed only when specified in the plans. When specified, temporary edge lines are either solid lines or raised pavement markers at 5-foot spacing.

Long-duration temporary pavement markings layouts will match permanent pavement marking standards and should be used on projects spanning multiple seasons and/or wintering over. To enhance wet-weather visibility, long-duration temporary pavement markings should be supplemented with reflective Type 2 Raised Pavement Markers. Long-duration markings need to be detailed in the contract plans for installation and material type.

Pre-formed tapes should be used on the final pavement surface to avoid leaving scars when removed.

Lateral clearance markers are used at the angle points of barriers where they encroach on or otherwise restrict the adjacent shoulder. Barrier delineation is necessary where the barrier is less than 4 feet from the edge of traveled way.

Guideposts may be considered to aid nighttime driving through temporary alignments or diversions. (See Chapter 1030 for delineation requirements.)

1010.10(2) Screening

Screening devices can be used to reduce motorists' distraction due to construction activities adjacent to the traveled way. Consider screening when a highway operates near capacity during most of the day. Screening should be positioned behind traffic barriers to prevent impacts by errant vehicles and should be anchored or braced to resist overturning when buffeted by wind. Commercially available screening or contractor-built screening can be used, provided the device meets crashworthy criteria if exposed to traffic and is approved by the Engineer prior to installation.

Glare screening may be required on concrete barriers separating two-way traffic to reduce headlight glare from oncoming traffic. Woven wire and vertical blade-type screens are commonly used in this installation. This screening also reduces the potential for motorist confusion at nighttime by shielding construction equipment and the headlights of other vehicles on adjacent roadways. Make sure that motorists' sight distance is not impaired by these glare screens. Contact the HQ Design Office and refer to AASHTO's Roadside Design Guide for additional information on screening.

1010.10(3) Illumination

Illumination might be justified if construction activities take place on the roadway at night for an extended period of time. Illumination might also be justified for long-term construction projects at the following locations:

- Road closures with detours or diversions.
- Median crossovers on freeways.
- Complex or temporary alignment or channelization.
- Haul road crossings (if operational at night).
- Temporary traffic signals.
- Temporary ramp connections.
- Projects with lane shifts and restricted geometrics.
- Projects with existing illumination that needs to be removed as part of the construction process.

Illumination is required when:

- Traffic flow is split around or near an obstruction.

- Flaggers are necessary for nighttime construction activities (supplemental lighting of the flagger stations by use of portable light plants or other approved methods). Refer to *Standard Specification* 1-10.3(1)A.

For information on light levels and other electrical design requirements, see Chapter 1040.

1010.10(4) Signals

A permanent signal system can be modified for a temporary configuration such as temporary pole locations during intersection construction, span wire systems, and adjustment of signal heads and alternative detection systems to accommodate a construction stage (see Chapter 1330).

1010.10(5) Smart Work Zone Systems (SWZS)

A Smart Work Zone System uses real time information to optimize the safety and efficiency of traffic through the work zone.

SWZS can provide information such as queue detection for "slowed or stopped traffic ahead" messaging before motorists see brake lights, merging instructions (zipper merging where motorists use all open lanes up to the merge point where they take turns merging) to reduce the queue lengths, or travel time information so drivers can choose alternate routes.

Portable equipment used in SWZS may include portable changeable message signs, portable roadside traffic sensors and cameras that communicate wirelessly through a web-based central management platform. Pre-determined messages will be displayed on the changeable message signs approaching a work area based on traffic data from the portable sensors also placed approaching the work area. A SWZS technician will install, program and monitor the system.

Existing permanent freeway cameras and message boards could also be part of a SWZS; coordination with the region Traffic Management Center (TMC) will be required to determine how these devices may be included and the information sharing with the SWZS and the TMC.

1010.11 Traffic Control Plan Development and PS&E

WSDOT projects need to include plans and payment items for controlling traffic based on a strategy that is consistent with the project construction elements, even though there may be more than one workable strategy. A constructible and biddable method of temporary traffic control is the goal. The contractor has the option of adopting the contract plans or proposing an alternative method.

1010.11(1) Traffic Control Plans (TCPs)

"Typical" traffic control plans are generic in nature and are not intended to address all site conditions. They are intended for use at multiple work locations and roadways with little or no field modifications necessary. Typical plans may be all that are needed for basic paving

projects. Some typical plans are located at:
www.wsdot.wa.gov/design/standards/plansheet.htm

"Project-specific" traffic control plans are typical-type plans that have been modified to fit a specific project or roadway condition. Dimension lines for signs and device placement have the distances based on the project highway speed limit, and spacing charts have been removed; the lane and roadway configuration may also be modified to match the project conditions.

"Site-specific" traffic control plans are drawn for a specific location. Scaled base data drawn plans will be the most accurate as device placement and layout issues can be resolved by the designer. These types of plans should be used for temporary alignment and channelization for long-duration traffic control. Making a "project-specific" plan applicable for a site-specific location is another option, but the designer must ensure the device layout will match the site-specific location since the plan is usually not to scale.

The following plans, in addition to the TCP types above addressing the TTC strategies, may be included in the PS&E.

1010.11(1)(a) Construction Sign Plan

Show Class A Construction Signs that will remain in place for the duration of the project located by either station or milepost. Verify the locations to avoid conflicts with existing signing or other roadway features. These locations may still be subject to movement in the field to fit specific conditions. For simple projects these sign are often shown on the vicinity map sheet.

1010.11(1)(b) Construction Sign Specification Sheet

Provide a Class A Construction Sign Specifications sheet on complex or staged projects. Include location, post information, and notes for Standard Plans or other specific sign information and sign details.

1010.11(1)(c) Quantity Tabulation Sheets

Quantity Tabulation sheets are a good idea for barrier and attenuator items and temporary pavement markings on projects with large quantities of these items or for staged construction projects.

1010.11(1)(d) Traffic Control Plan Index

An Index sheet is a useful tool for projects that contain a large quantity of traffic control plans and multiple work operations at various locations throughout the project. The Index sheet provides the contractor a quick referencing tool indicating the applicable traffic control plan for the specific work operation.

1010.11(1)(e) Construction Sequence Plans

Sequence plans are placed early in the plan set and are intended to show the proposed construction stages and the work required for each stage. They should refer to the corresponding TCPs for the traffic control details of each stage.

1010.11(1)(f) Temporary Signal Plan

The temporary signal plan will follow conventions used to develop permanent signals (as described in Chapter 1330), but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations. Ensure opposing left-turn clearances are maintained as described in Chapter 1310 if channelization has been temporarily revised, or adjust signal timing to accommodate. Some existing systems can be maintained using temporary span wires for signal heads and video, microwave actuation, or timed control.

1010.11(1)(g) Temporary Illumination Plan

Full lighting is normally provided through traffic control areas where power is available. The temporary illumination plan will follow conventions used to develop permanent illumination (as described in Chapter 1040), but will be designed to accommodate temporary needs and work operations to ensure there will be no conflicts with construction operations.

1010.11(2) Contract Specifications

Work hour restrictions for lane closure operations are to be specifically identified for each project where traffic impacts are expected and liquidated damages need to be applied to the contract. Refer to the Plans Preparation Manual for additional information on writing traffic control specifications.

1010.11(3) Cost Estimating

Temporary traffic control devices and traffic control labor can be difficult to estimate. There is no way of knowing how many operations a contractor may implement at the same time. The best method is to follow the working day estimate schedule and the TCPs that will be used for each operation. Temporary signs and devices will be used on many plans, but the estimated quantity reflects the most used at any one time. To use the lump sum item to pay for all temporary traffic control, be certain how the contractor’s work operations will progress and that the traffic control plans fully define the work zone expectations.

1010.12 Training and Resources

Temporary traffic control-related training is an important component in an effective work zone safety and mobility program. Federal regulations require that those involved in the development, design, implementation, operation, inspection, and enforcement be trained at a level consistent with their responsibilities.

1010.12(1) Training Courses

The following work zone related courses are available through the Talent Development office and the State Work Zone Training Specialist can assist with the availability and scheduling of classes:

- **Work Zone Traffic Control Design:** This 2-day course, taught by the HQ Traffic Office, focuses on work zone safety and mobility through transportation management plan and temporary traffic control PS&E development.
- **Traffic Control Supervisor (TCS) Certification:** This course is a 1-day add-on to the Work Zone Traffic Control Design course for WSDOT employees that want to become certified as a TCS. For those with a current TCS card, attending this 1-day class only will provide re-certification.
- **Flagger Certification:** This course is for employees who may have flagging duties or want to become a certified Traffic Control Supervisor. The safety offices can assist with class scheduling.
- Traffic analysis, traffic engineering, pedestrian facilities design and other courses may also be available and apply to work zone safety and mobility.

The American Traffic Safety Services Association (ATSSA) offers free or low-cost training through an FHWA work zone safety grant.

1010.12(2) Resources

The responsibility of the designer to fully address all work zone traffic control impacts is very important because the level of traffic safety and mobility will be directly affected by the effectiveness of the transportation management plan (TMP). The following resources are available to assist the designer with various aspects of the work zone design effort.

1010.12(2)(a) Region Work Zone Resources

Each region has individuals and offices with various resources that provide work zone guidance and direction beyond what may be available at the project Design Office level. They include:

- Region Traffic Office
- Region Construction and Design Offices

1010.12(2)(b) Headquarters (HQ) Work Zone Resources

The HQ Traffic Office has a work zone team available to answer questions, provide information, or otherwise assist. The HQ Design and Construction offices may also be able to assist with some work zone issues. They include:

- State Assistant Traffic Design Engineer
- State Work Zone Engineer
- WSDOT Work Zone Web Page

1010.12(2)(c) FHWA Work Zone Resources

The FHWA Washington Division Office and Headquarters (HQ) Office may be able to provide some additional information through the WSDOT HQ Traffic Office. The FHWA also has a work zone web page: www.ops.fhwa.dot.gov/wz/

1010.13 Documentation

Refer to Chapter 300 for design documentation requirements.

1010.14 References

1010.14(1) Federal/State Laws and Codes

23 Code of Federal Regulations (CFR) Part 630 Subpart J and Subpart K – Work Zone Safety and Mobility and Temporary Traffic Control Devices

See Chapter 1510 for Americans with Disabilities Act policy and references.

"Final Rule on Work Zone Safety and Mobility," Federal Highway Administration (FHWA), Published on September 9, 2004

www.ops.fhwa.dot.gov/wz/resources/final_rule.htm

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

1010.14(2) Design Guidance

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

Executive Order E 1001, Work Zone Safety and Mobility

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1001.pdf

Executive Order E 1060, Speed Limit Reductions in Work Zones

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1060.pdf

Executive Order E 1033, WSDOT Employee Safety

http://wwwi.wsdot.wa.gov/publications/policies/fulltext/1033.pdf

Plans Preparation Manual, M 22-31, WSDOT

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

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

Traffic Manual, M 51-02, WSDOT

Work Zone Traffic Control Guidelines, M 54-44, WSDOT

1010.14(3) Supporting Information

Construction Manual, M 41-01, WSDOT

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

Environmental Manual, M 31-11, WSDOT

Highway Capacity Manual, 2010, TRB

ITE Temporary Traffic Control Device Handbook, 2001

ITS in Work Zones www.ops.fhwa.dot.gov/wz/its/

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

Roadside Design Guide, AASHTO, 2011

Manual for Assessing Safety Hardware, AASHTO, 2009

Manual for Assessing Safety Hardware, AASHTO, 2016

Work Zone & Traffic Analysis, FHWA www.ops.fhwa.dot.gov/wz/traffic_analysis.htm

Work Zone Operations Best Practices Guidebook, FHWA, 2007
www.ops.fhwa.dot.gov/wz/practices/practices.htm

Work Zone Safety and Mobility, FHWA www.ops.fhwa.dot.gov/wz/index.asp

Work Zone Safety Web Page, WSDOT www.wsdot.wa.gov/safety/workzones/

WSDOT Project Management website: http://www.wsdot.wa.gov/Projects/ProjectMgmt/

Exhibit 1010-3 Transportation Management Plan Components Checklist

Use the following checklist to develop a formal TMP document on significant projects.

TMP Component	✓
1. Introductory Material	
Cover page	
Licensed Engineer stamp page (if necessary)	
Table of contents	
List of figures	
List of tables	
List of abbreviations and symbols	
Terminology	
2. Executive Summary	
3. TMP Roles and Responsibilities	
TMP manager	
Stakeholders/review committee	
Approval contact(s)	
TMP implementation task leaders (public information liaison, incident management coordinator)	
TMP monitors	
Emergency contacts	
4. Project Description	
Project background	
Project type	
Project area/corridor	
Project goals and constraints	
Proposed construction phasing/staging	
General schedule and timeline	
Adjacent projects	
5. Existing and Future Conditions	
Data collection and modeling approach	
Existing roadway characteristics (history, roadway classification, number of lanes, geometrics, urban/suburban/rural)	
Existing and historical traffic data (volumes, speed, capacity, volume-to-capacity ratio, percent trucks, queue length, peak traffic hours)	
Existing traffic operations (signal timing, traffic controls)	
Incident and crash data	
Local community and business concerns/issues	
Traffic growth rates (for future construction dates)	
Traffic predictions during construction (volume, delay, queue)	
6. Work Zone Impacts Assessment Report	
Qualitative summary of anticipated work zone impacts	
Impacts assessment of alternative project design and management strategies (in conjunction with each other)	
• Construction approach/phasing/staging strategies	
• Work zone impacts management strategies	

Exhibit 1010-3 Transportation Management Plan Components Checklist (continued)

TMP Component	✓
Traffic analysis results (if applicable)	
• Traffic analysis strategies	
• Measures of effectiveness	
• Analysis tool selection methodology and justification	
• Analysis results	
Traffic (volume, capacity, delay, queue, noise)	
Safety	
Adequacy of detour routes	
Business/community impact	
Seasonal impacts	
Cost-effectiveness/evaluation of alternatives	
Selected alternative	
• Construction approach/phasing/staging strategy	
• Work zone impacts management strategies	
7. Selected Work Zone Impacts Management Strategies	
Temporary Traffic Control (TTC) strategies	
• Control strategies	
• Traffic control devices	
• Corridor Project coordination, contracting, and innovative construction strategies	
Public Information (PI)	
• Public awareness strategies	
• Motorist information strategies	
Transportation Operations (TO)	
• Demand management strategies	
• Corridor/network management strategies	
• Work zone safety management strategies	
• Traffic/incident management and enforcement strategies	
8. TMP Monitoring	
Monitoring requirements	
Evaluation report of successes and failures of TMP	
9. Contingency Plans	
Trigger points	
Decision tree	
Contractor's contingency plan	
Standby equipment or personnel	
10. TMP Implementation Costs	
Itemized costs	
Cost responsibilities/sharing opportunities	
Funding source(s)	
11. Special Considerations (as needed)	
12. Attachments (as needed)	

Chapter 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 Section 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 existing Type 1 guardrail, crashworthy terminals, and/or transitions will fall outside the height range from 26.5” to 31” (26.5” to 30” for terminals) in the project’s completed condition; the existing guardrail, terminals, and/or transitions must be adjusted to a minimum height of 28” up to a maximum height of 30”. This includes buried terminals that slope down such that the guardrail height is reduced to less than 26.5-inches (measured in relation to a 10H:1V line extended from the breakpoint at edge of shoulder). See Section 1610.04(3) for acceptable options to raise standard runs of guardrail, and Section 1610.04(5) for raising guardrail terminals. Replace the Type 1 guardrail system with a Type 31 guardrail system if its height cannot be adjusted to fall within the specified range.
- When the height of existing Type 31 guardrail, crashworthy terminals, and/or transitions will fall outside the height range from 28” to 32” in the project’s completed condition; the existing guardrail, terminals, and/or transitions must be adjusted to a height of 31”. This includes buried 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). See Section 1610.04(3) for acceptable options to raise standard runs of guardrail, and 1610.04(5) for raising guardrail terminals. Replace the existing Type 31 guardrail system with a new Type 31 guardrail system if its height cannot be adjusted to fall within the specified range.
- When non-crashworthy terminals need to be raised, replace them with crashworthy terminals. Provide replacement terminals in accordance with 1610.04(5)(a or b). Non-crashworthy terminals and anchors that are effectively shielded by another barrier **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 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 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

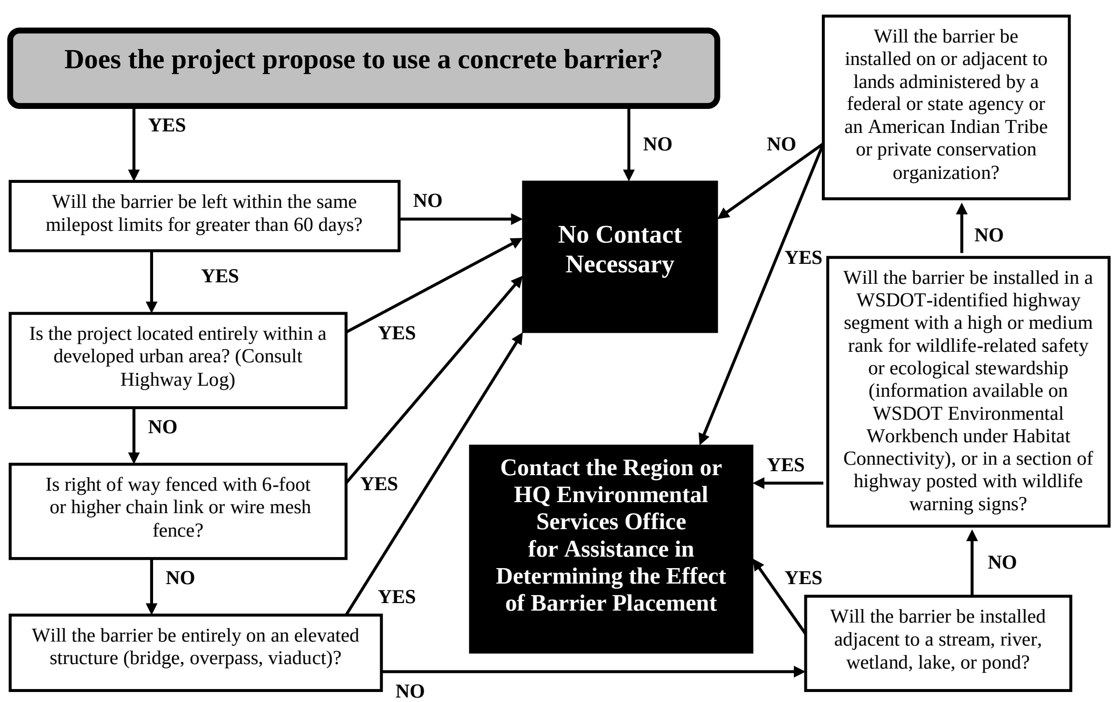
The presence of stormwater facilities or wetlands influence the choice and use of barrier systems. For example, the placement of concrete barrier may increase the amount of impervious surface, which could then result in retrofit or reconstruction of the existing retention/detention systems and environmental 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 Section 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.

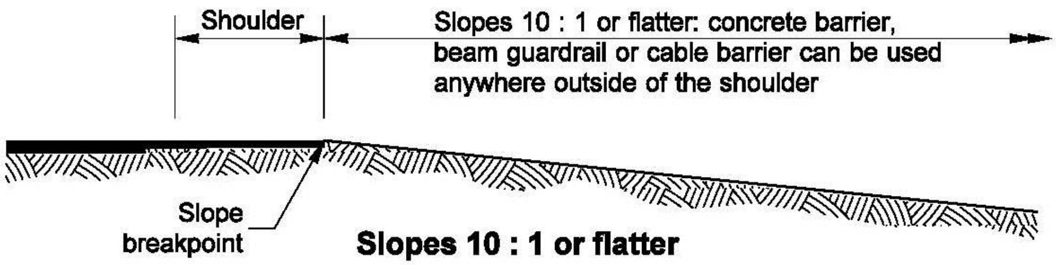
See Chapter 1239 for minimum lateral clearance requirements.

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 for certain types of 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 roadside or wide median installations of flexible and semi-rigid roadside barriers (high tension cable barrier and beam guardrail), 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).

For narrower median installations, design systems so 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. Rigid embedded barrier systems are used when no barrier deflection is necessary or desired (areas such as narrow medians, at the edge of bridge decks, or other vertical drop-off areas). Runs of rigid embedded concrete barrier can be precast, cast in place, or extruded with appropriate footings.

In locations where deflection distance is limited, precast concrete barrier can be anchored. Some movement can be expected for rigid anchored barrier systems and repairs may be more expensive (anchoring pins may damage the asphalt or concrete surface that the barrier is placed upon during a vehicle collision).

Use of an anchored precast concrete barrier and other deflecting barrier systems placed on top of a retaining wall at less than the deflection distances provided in Exhibit 1610-3 requires approval from the HQ Design Office. See 1610.06 for more information on concrete barrier.

Exhibit 1610-3 provides barrier deflection design values when selecting standard runs of longitudinal barrier. This exhibit does not provide deflection values for specialty barrier systems or installations (for example long span guardrail systems, box culvert guardrail systems, Type 31 barrier installed on a flare, etc.). Contact HQ Design for specialty barrier systems or installations deflections. 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 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 precast concrete barrier, unanchored	Rigid Unrestrained	6 ft [2] (back of barrier to object)
Temporary precast concrete barrier, unanchored [5]	Rigid Unrestrained	3 ft [3] (back of barrier to object)
Permanent precast concrete barrier, anchored	Rigid Anchored	2 ft (back of barrier to object)
Temporary precast concrete barrier, anchored [5]	Rigid Anchored	1 ft [3] [6] (back of barrier to object)
Cast in place or precast concrete barrier, embedded	Rigid Embedded	No deflection [7]

Notes:

This exhibit provides deflection values for standard runs of barrier. It does not provide deflection values for specialty systems or installations (e.g. long span guardrail systems, box culvert guardrail systems, Type 31 barrier installed on a flare, etc.).

[1] See 1610.05(2)

[2] When placed in front of a 2H:1V or flatter fill slope and not shielding fixed objects, the barrier deflection distance can be reduced to 2 feet.

[3] When used as temporary bridge rail, anchor all barrier when the back of barrier is located 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.

[5] Steel barrier is also available for temporary applications. See Ch. 1010 for more information.

[6] When anchoring temporary precast concrete barrier on bridges or other drop-offs, see applicable Standard Plans for anchorage details, lateral offsets, and deflection distances.

[7] When placed in front of a fill slope or on top of an MSE wall, provide a minimum distance of 2-feet of widening with a 10:1 or flatter slope from the back of barrier to the slope break point.

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.

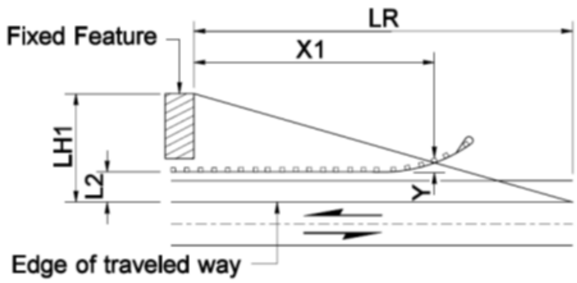
When barrier is to be installed on the outside of a horizontal curve, the length of need can be determined graphically as shown in Exhibit 1610-7. For installations on the inside of a curve, determine the length of need as though it were straight. Also, consider the flare rate, barrier deflection, and 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.

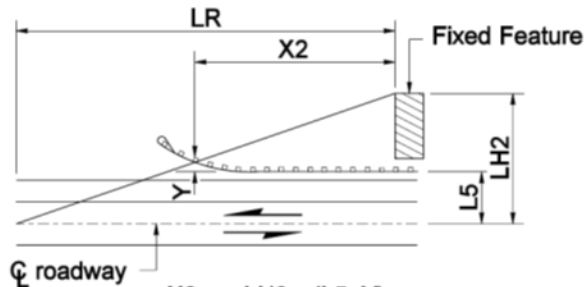
If the end of the length of need is near an adequate cut slope, extend the barrier and embed it in the slope (see 1610.04(5)). Avoid gaps of 300 feet or less. Short gaps are acceptable when the barrier is terminated in a cut slope. If the end of the length of need is near the end of an existing barrier, 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



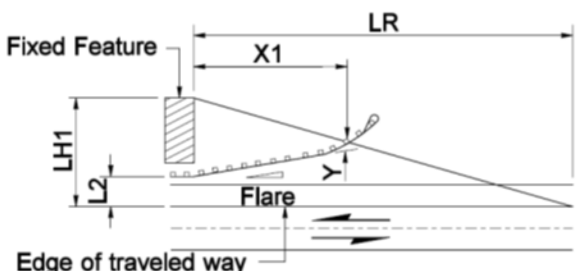
$$X1 = \frac{LH1 - (L2+Y)}{(LH1/LR)}$$

Adjacent-Side Fixed Feature
Barrier Parallel to Roadway



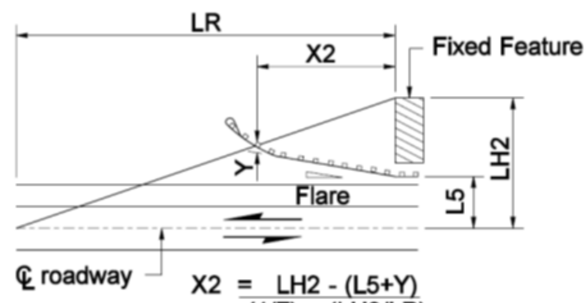
$$X2 = \frac{LH2 - (L5+Y)}{(LH2/LR)}$$

Opposite-Side Fixed Feature
Barrier Parallel to Roadway



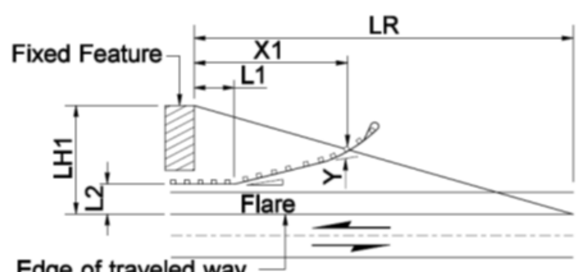
$$X1 = \frac{LH1 - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Fixed Feature
Barrier Flare Begins at Fixed Feature



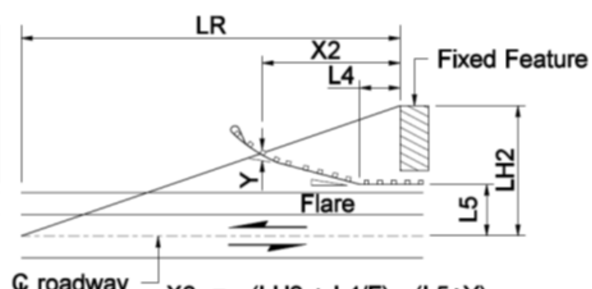
$$X2 = \frac{LH2 - (L5+Y)}{(1/F) + (LH2/LR)}$$

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.

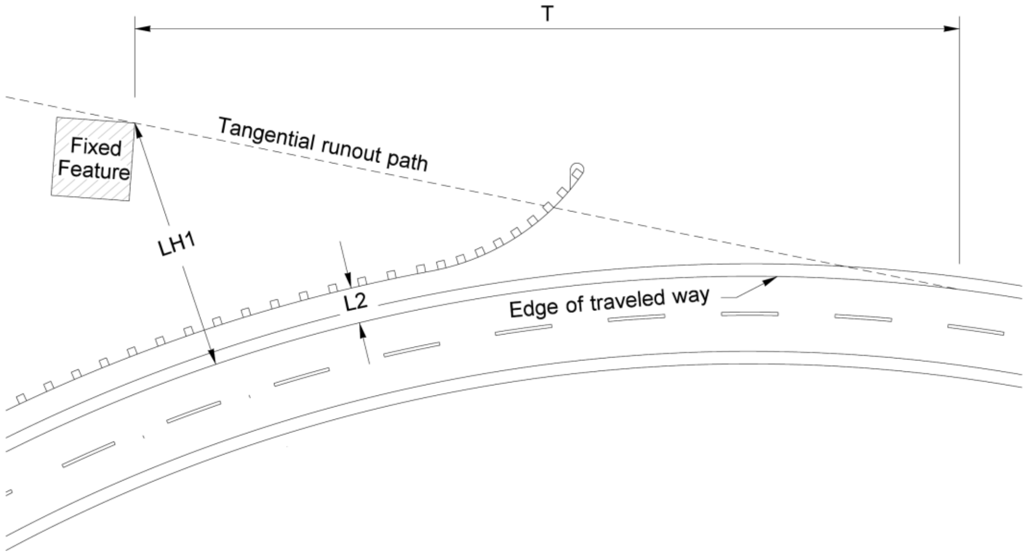
F = Flare rate value.

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.

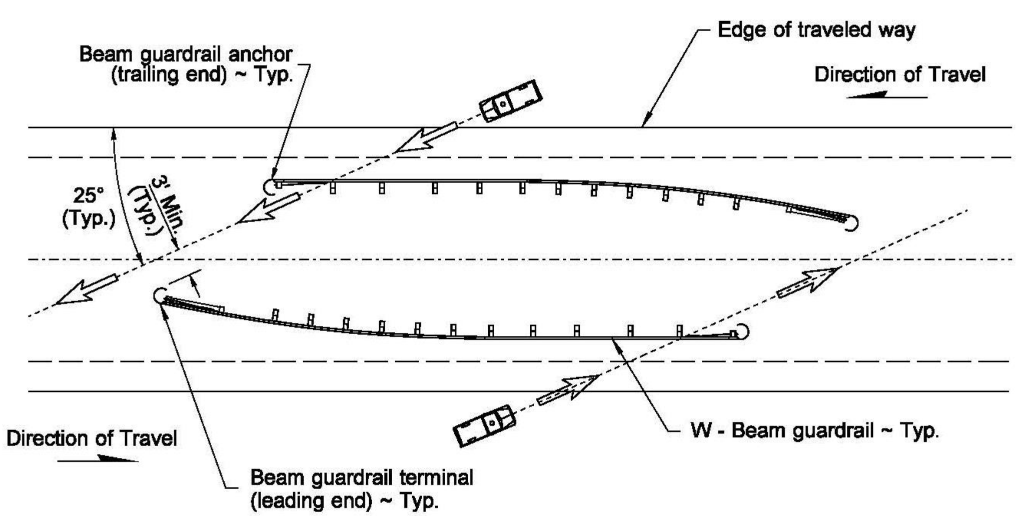
Exhibit 1610-7 Barrier Length of Need on Curves



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

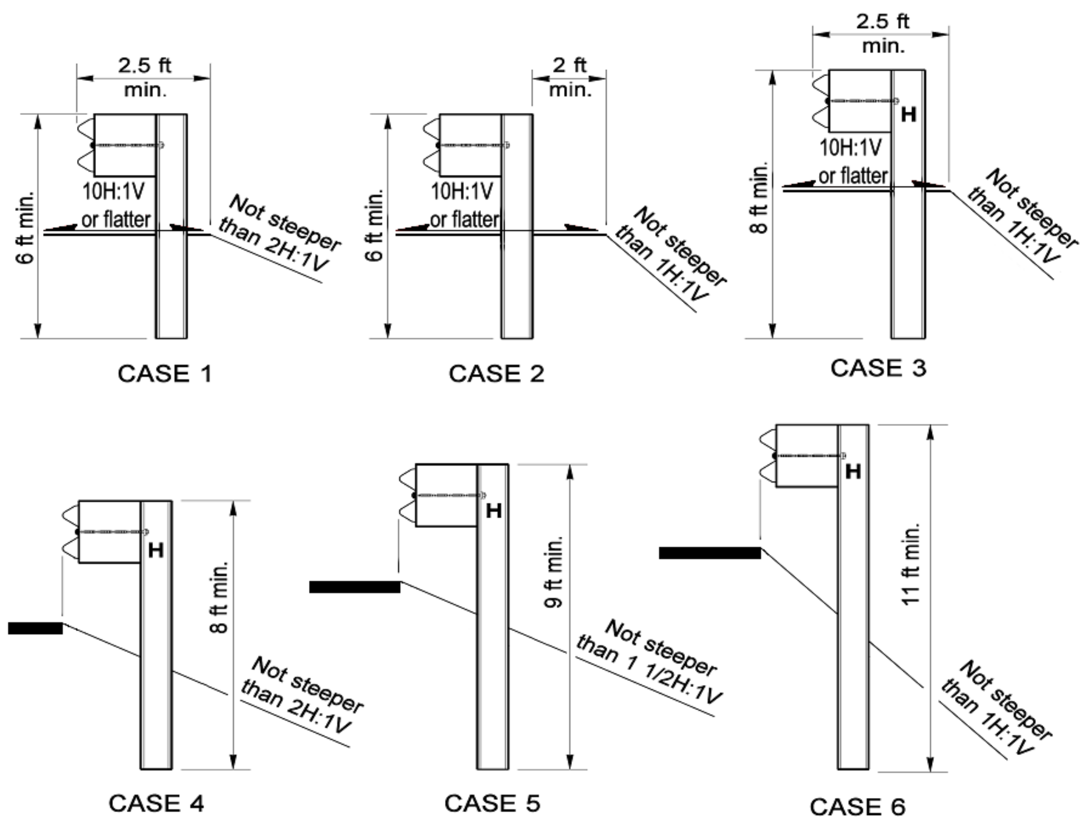
There a number of considerations regarding guardrail placement. These include:

- During the project development processes, consult with maintenance staff to help identify guardrail runs that may need to be modified.
- When existing Type 1 guardrail is replaced by Type 31 guardrail along existing shoulders with a width greater than 4 feet (5 feet for bicycles), 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.
- Type 31 or Type 1 beam guardrail can be placed anywhere outside of the shoulder on fill slopes 10:1 or flatter~~,~~.
- Type 1 beam guardrail can be placed on fill slopes between 6H:1V and 10H:1V at the slope break point of the shoulder or at least 12 feet from the slope breakpoint. This placement case does not apply to Type 31 beam guardrail.
- Do not place Type 31 or Type 1 beam guardrail with standard length posts on a fill slope steeper than 6H:1V. See Exhibit 1610-9 for allowable placement exceptions on fill slopes steeper than 6H:1V using long post beam guardrail.
- 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 widening behind the barrier is generally provided from the back of the post to the slope breakpoint

of a fill slope (see Exhibit 1610-9, 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 1610-9, 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 1610-9, 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 Post Installation



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

See Chapter 1120 when evaluating guardrail system height on Preservation (P1, P2, P3) projects.

For other projects requiring evaluation of guardrail (see Section 1105.02(1)), evaluate the guardrail system height as follows:

- For existing Type 1 guardrail with heights falling outside the range from 26.5 inches to 31 inches, adjust or replace the rail to a minimum height of 28 inches up to a maximum height of 30 inches, or replace the run with 31-inch-high Type 31 beam guardrail.
- For existing Type 31 guardrail runs with heights falling outside the range of 28 to 32 inches, adjust or replace the rail to a height of 31 inches, or replace the run with a new run of 31-inch-high Type 31 beam guardrail.

For Type 1 and Type 31 standard run W-beam guardrail, the blockout and rail element may be raised up to 4 inches by field drilling a new hole in the guardrail post. Verify that the condition of the posts and blockouts are suitable for raising in this manner. If not, the post or block will need to be replaced. See the *Standard Plans*.

If Type 1 Alternative W-beam guardrail is present, the blockout and rail element may be raised after each overlay by using the pre-drilled holes in the guardrail posts.

See Section 1610.04(5) for information on adjusting the height of guardrail terminals.

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. The preferred solutions are either to eliminate the need for the barrier, or realign the crossroad or driveway to accommodate the necessary guardrail run length. Alternatively, an intersection design guardrail system can be installed at the intersection. See 1610.04(7)(a) for more information. 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.
- In most cases, the use of curb in conjunction with beam guardrail is discouraged. When a curb is needed place the curb as follows:
    - For Type 1 W-beam guardrail, a 3-inch high curb is preferred and it is placed flush with the face of rail or placed behind the face of the rail. The 3-inch high curb can be used for any posted speed. If necessary, a 4-inch high extruded curb is placed flush with the face of rail or placed behind the face of the rail and can be used for any posted speed. Finally, a 6-inch high extruded curb is placed flush with the face of rail or placed behind the face of the rail and can be used 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.)

- For Type 31 W-beam guardrail, a 3-inch, 4-inch, or 6-inch curb is placed flush with the face of rail or placed behind the face of the rail and can be used for any posted speed. Use the shortest height curb possible. 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.
    - List all the locations of omitted posts in the project plans to ensure that posts are omitted following the conditions described in this section.
- 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*).

See Chapter 1120 for guidance regarding the evaluation of terminals on Preservation projects (P1, P2, and P3).

For other projects requiring evaluation of terminals (see Section 1105.02(1)), evaluate the terminals as follows:

Replace guardrail terminals that do not have a crash-tested design with MASH compliant 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 or anchor, as measured from the ground to the top of the rail element, will be affected by the project, adjust the terminal or anchor based upon the following criteria:

- If the height of the terminal or anchor 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 or anchor 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 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.
- When adjusting the height of a terminal or anchor, adjust it by raising the posts of the terminal or anchor and tamping the ground around the posts to prevent settlement of the raised posts. Note: do not raise the blockouts or rail of the terminal or anchor by drilling new holes in the terminal posts.

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 Type 31 non-flared terminals, no additional embankment widening is required at the terminal when installed on slopes 10:1 or flatter.

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 1610-10 and 1610-11 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 1610-9 Placement Case 2.

For information regarding transitions used with (Old) Type 1 guardrail see: http://www.wsdot.wa.gov/Design/Policy/RoadsideSafety.htm.

Exhibit 1610-10 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 1610-11 Transitions and Connections

Connecting Type 31 W-Beam Guardrail to:			Transition Type*	Connection
Bridge Rail [1]	New Installation		21, 24 [3]	D
	Existing Concrete	Concrete Parapet > (Greater Than) 20 in.	21, 24 [3]	Exh. 1610-10 [2]
		Concrete Parapet < (Less Than) 20 in.	21, 24 [3]	Exh. 1610-10 [2]
	Thrie Beam at Face of Curb	Approach End	23	n/a
		Trailing End (two-way traffic only)	23	n/a
	Thrie Beam at Bridge Rail (curb exposed)	Approach End	22	n/a
		Trailing End (two-way traffic only)	22	n/a
Concrete Barrier	Rigid & Rigid Anchored		21, 24 [3]	Exhibit 1610-10
	Unrestrained		21, 24 [3]	A
Connecting Thrie Beam Guardrail to:			**Transition Type***	**Connection**
Bridge Rail or Concrete Barrier	See the thrie beam transition in the Plan Sheet Library			Exhibit 1610-10

*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.
- 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 (including terminals and anchors) 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. Note: This guardrail design may require fall protection. See Section 730.04(7)(b) for worker fall protection requirements. See Section 1510.15(3) for pedestrian fall protection requirements. When a fall protection system is located within the deflection zone of the barrier system, contact HQ Design for options.
- 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)).
- Type 31 guardrail placement with less than 5-feet from face of guardrail to a fixed or breakaway object – There may be instances where Type 31 beam guardrail cannot be placed at least 5-feet from the face of rail to the front edge of an object

which does not meet the minimum deflection distance of the Type 31 guardrail system. Contact HQ Design to discuss barrier placement options when this occurs.

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.

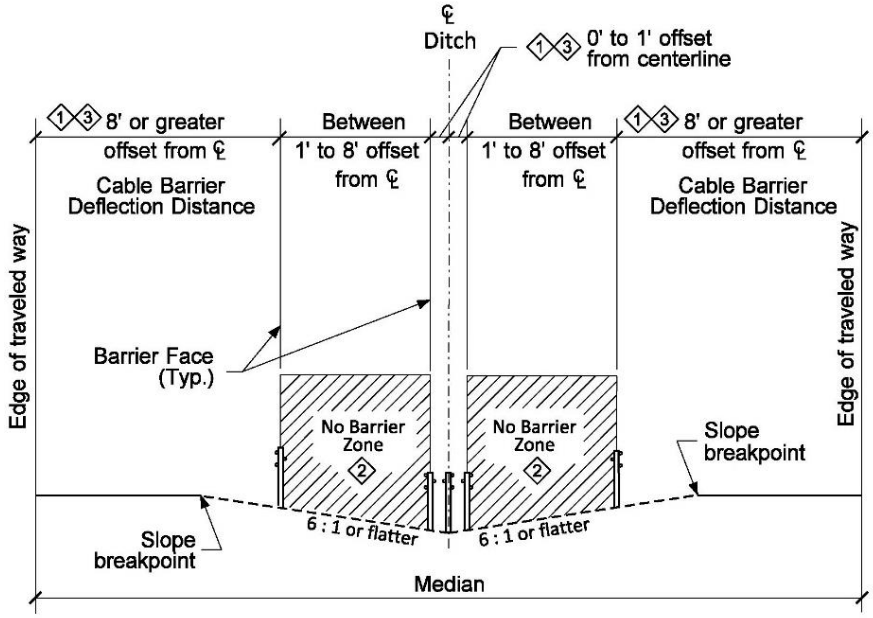
1610.05(1)(a) Median Applications

For typical cable barrier installations in a median, the following apply (see Exhibit 1610-12a):

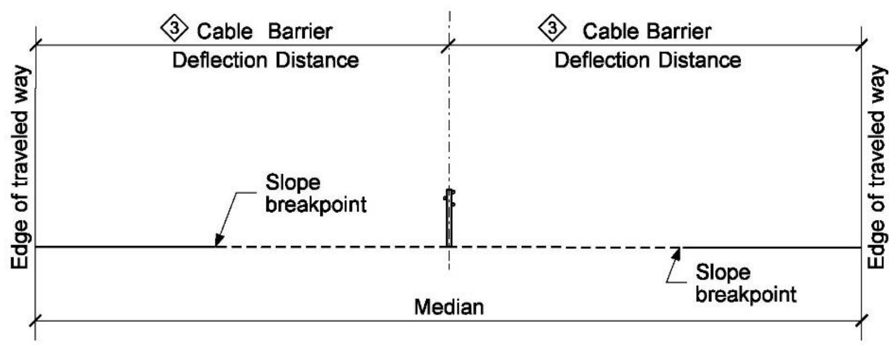
- Install the cable barrier as far from the edge of traveled way as site constraints allow. Consider a minimum placement distance of 8 feet from the edge of traveled way to allow vehicles to use this area for refuge.
- Install cable barrier on slopes 6H:1V or flatter.
- There are approved high-tension 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 1610-12a.
- 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 1610-12a):

   - 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 1610-13a.
- 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 1610-12a 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

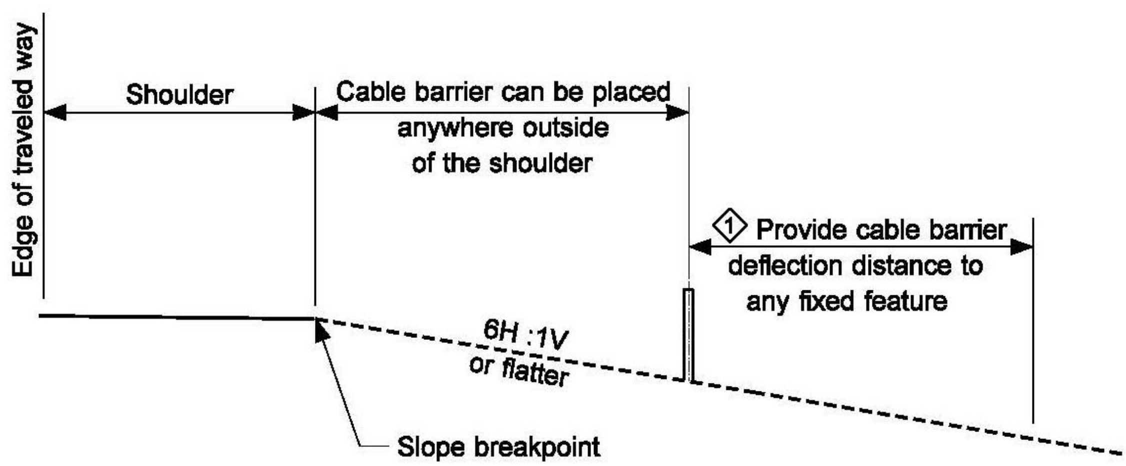
vehicle's encroachment into the opposite lane of travel. See 1610.05(2) for more information.

1610.05(1)(b) Roadside Applications

For typical non-median roadside applications, the following apply:

- 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 1610-12b Roadside Cable Barrier Placement



Notes:

1 Provide an obstruction free zone within the cable barrier's lateral deflection distance, see Section 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:

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.

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 maximum 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. Whenever practicable, locate high-tension cable barrier terminals in areas where they are least likely to be hit by errant vehicles (e.g. located outside clear zone, located behind another barrier system).

Often, high-tension cable barrier systems will overlap/interface with a stiffer barrier system (typically beam guardrail but can be concrete barrier). When terminating a cable barrier run to begin a beam guardrail run, there are essentially four choices for the overlap/interface of the two barrier systems (contact HQ Design when terminating a cable barrier run to begin a concrete barrier run). The four choices are:

Connect Cable Barrier to Beam Guardrail: This placement connects the cable barrier directly onto the beam guardrail runs (such as cable barrier connected to beam guardrail transitions coming off bridge rails) or to a different cable barrier anchorage system.

When connecting cable barrier onto beam guardrail, the guardrail must continue at least 75 feet downstream from the point where the cable barrier attaches to the beam guardrail, or the beam guardrail needs to be connected to a stiffer system (i.e. bridge rail, concrete barrier) to reduce the chance of beam guardrail posts pulling out of the ground from the tension in the cable barrier system. When terminating cable barrier in this manner; review field conditions, check local maintenance personnel needs, and specify the required connection option in the contract documents.

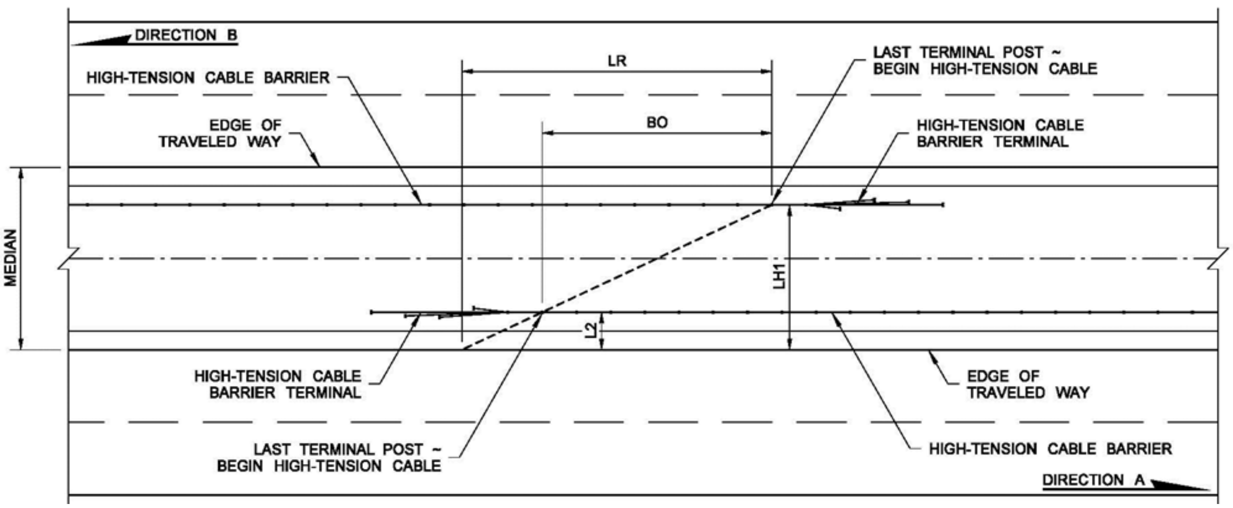
When cable barrier is connected directly to a more rigid barrier, a transition section is typically needed. Contact the HQ Design Office for further details.

Install Cable Barrier Behind Beam Guardrail: This placement terminates the cable barrier behind the beam guardrail system. Ensure the lateral distance between the two barrier systems exceeds the deflection distance of the beam guardrail system placed in front of the cable barrier system. This will reduce the chances of having the two barrier systems interfering with each other during a vehicle impact, or having an errant vehicle rebound off the cable barrier into the back of the beam guardrail during a vehicle impact. Exhibit 1610-13b shows an example of terminating cable barrier behind a beam guardrail system.

Install Cable Barrier in Front of Beam Guardrail: This placement terminates the cable barrier in front of the beam guardrail system. Ensure that the standard run of cable barrier extends to, or past, the Length of Need post of the beam guardrail terminal, and provide a minimum lateral distance of 4-feet between the two barrier systems. This will reduce the chances of having the two barrier systems interfere with each other during a vehicle impact. Exhibit 1610-13b shows an example of terminating cable barrier in front of a beam guardrail system.

Terminate Cable Barrier in Advance of Beam Guardrail: This placement terminates the cable barrier in advance of the beam guardrail system. This placement leaves a gap in guardrail coverage and can be a maintenance concern if both terminals are hit by an errant vehicle. However, this placement can be used when side slope grades become an issue (i.e. slope is too steep to place cable barrier or beam guardrail, slope widening requires large amounts of fill to accommodate barrier systems). Exhibit 1610-13b shows an example of terminating cable barrier in advance of a beam guardrail system.

Exhibit 1610-13a Cable Barrier Placement: Overlap on Divided Highways



Cable Barrier Median Overlap

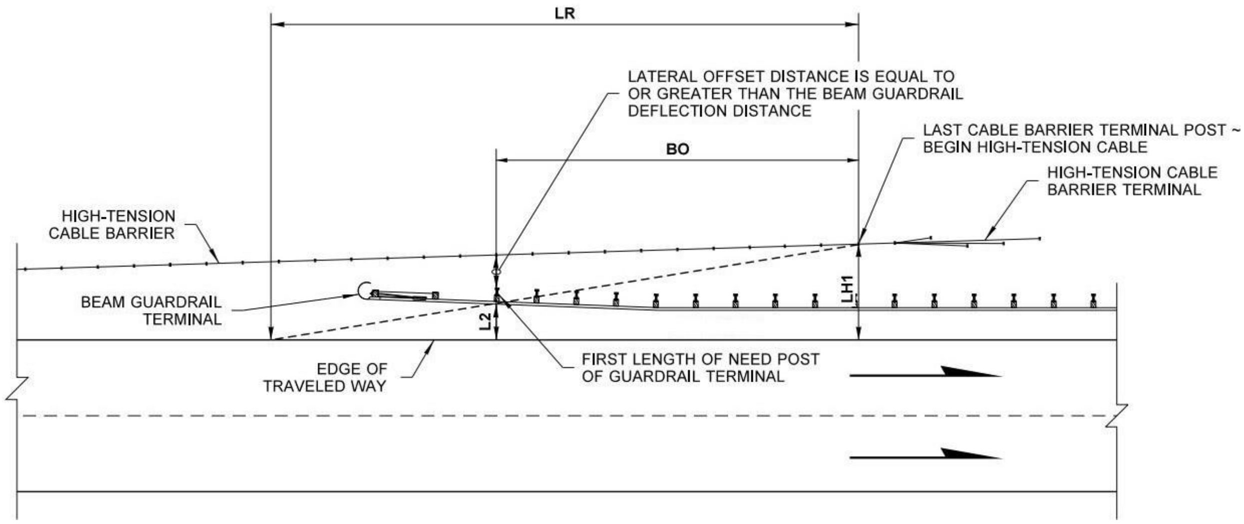
$$BO = \frac{LH1 - L2}{\frac{LH1}{LR}} \text{ (Direction A shown)}$$

Notes:

[1] Calculate barrier overlap (BO) from both directions of travel. Use the greatest value of BO obtained.

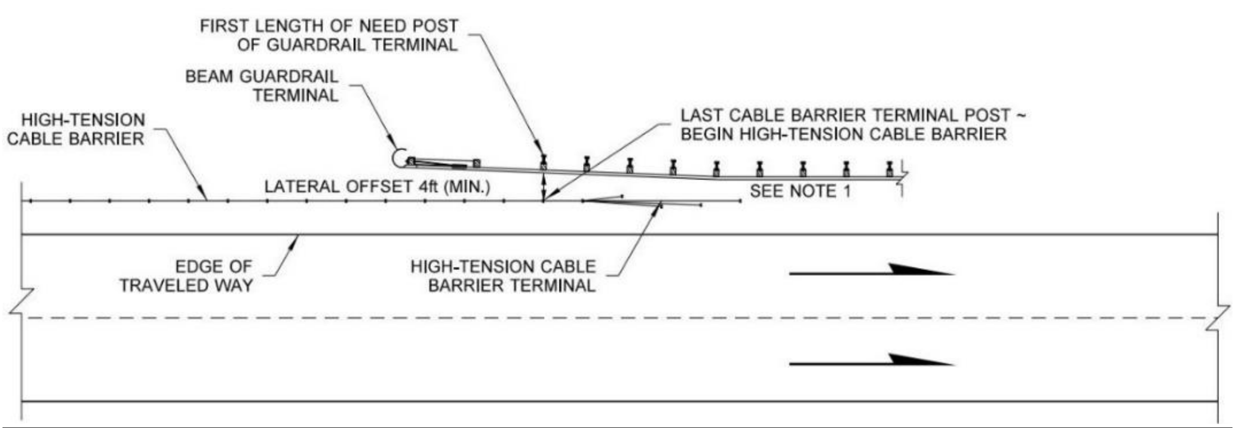
[2] For supporting length of need equation factors, see Exhibit 1610-6.

Exhibit 1610-13b Cable Barrier Placement: Cable Barrier Termination/Overlap with Beam Guardrail



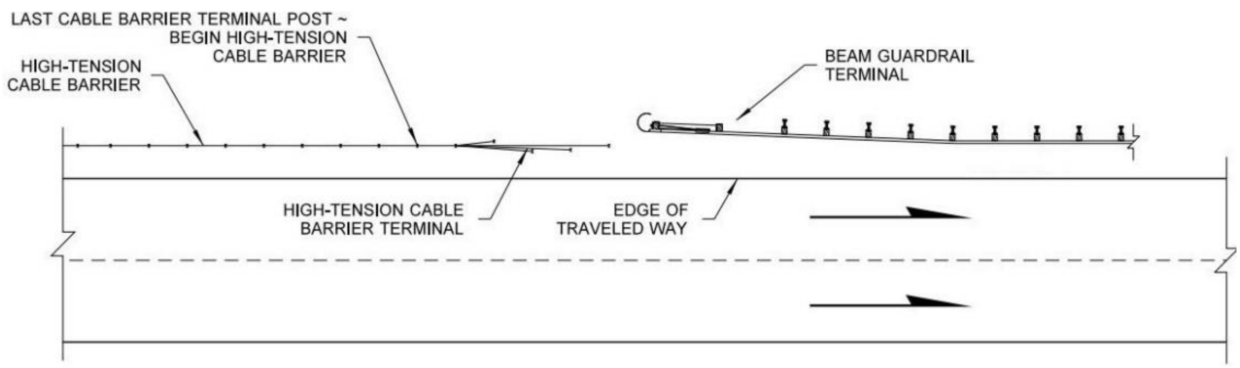
$$BO = \frac{LH1 - L2}{LH1/LR}$$

Cable Barrier Termination: Install Behind Beam Guardrail



Cable Barrier Termination: Install in Front of Beam Guardrail

Exhibit 1610-13b Cable Barrier Placement: Cable Barrier Termination/Overlap with Beam Guardrail (cont)



Cable Barrier Termination: Terminate In Advance of Beam Guardrail

Notes:
These barrier placements can be placed in both roadside and medians.

[1] The beam guardrail may need to be extended and flared in advance of a cable barrier terminal to maintain adequate barrier overlap, lateral offset distance between barrier systems, and shoulder width.

[2] Typical applications may be at either bridge transitions or where high-tension cable and beam guardrail systems end or begin.

[3] 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

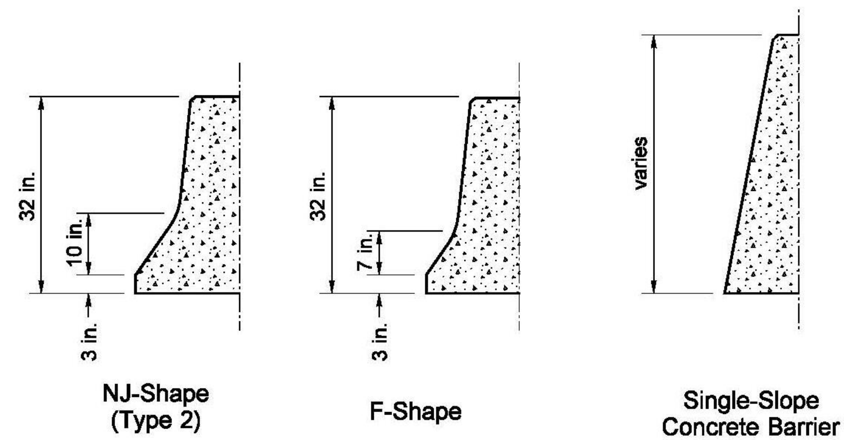
impacted, contact the HQ Hydraulics Office and/or the appropriate environmental offices for guidance. Also, refer to 1610.02.

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 1610-14.

The single-slope barrier face is the recommended option for embedded rigid concrete barrier applications.

Exhibit 1610-14 Concrete Barrier Shapes



Bridge Transitions: When the single-slope or F-Shape face is used on structures and precast barrier is selected for use on the approaches; a transition section is needed to provide gradual stiffening from the less rigid precast barrier system to the more rigid bridge rail system and to ensure that no vertical edges of the barrier are exposed to oncoming traffic due to the difference in shapes and height of the barriers. Note: Precast concrete barrier transitions to bridges are currently under development. Contact HQ Design for more information. For details on bridge rail designs, see the *Bridge Design Manual*.

Roadside/Median Shape Transitions: Use a transition section when it is necessary to change the shape of the barrier within a single run (i.e. Type F to Single Slope, Type 2 to Type F). Transition designs will differ when used on roadside/wide median applications (subject to vehicle impacts on one side only), or narrow median applications (subject to vehicle impacts on both sides). Note: Precast concrete barrier shape transitions for roadside and median applications are currently under development. Contact HQ Design for more information.

Stiffness Transitions: A transition section is also needed when changing the stiffness of the barrier system within a single run but not the barrier shape (i.e. Type F anchored to Type F unanchored). This type of transition requires a change in anchoring pin configuration when moving from an unanchored barrier system to an anchored barrier system. There is no other change to the barrier other than the anchoring pin configuration. Note: Precast concrete barrier transition plans for barrier system stiffness changes are currently under development. Contact HQ Design for more information.

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 has transitioned from using New Jersey shape barrier (Type 2 barrier) for precast concrete barrier to using F-shape concrete barrier (Type F barrier) instead. F-Shape (Type F) barrier is used in permanent or temporary installations. New Jersey shape (Type 2) barrier is only allowed to be used in temporary installations. Existing runs of Type 2 barrier permanently installed are allowed to remain in place. When replacing concrete barrier, use Type F. When removing and resetting Type 2 barrier, contact HQ Design for more details.

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. The F-Shape barrier can be used in permanent or temporary installations. It can be used for both median and shoulder installations. Unanchored units are connected with steel pins through metal loops. For permanent installations, this barrier is placed on a paved surface and a paved surface is provided beyond the barrier for deflection. For temporary installations, this barrier can be placed on a paved or a compacted unpaved surface with the respective surface provided beyond the barrier for deflection. Do not anchor Type F barrier on a compacted unpaved surface. See Exhibit 1610-3 for deflection requirements.

Concrete Barrier Type 2 (see the *Standard Plans*) is a freestanding precast barrier that has the New Jersey shape on two sides. The Type 2 barrier is only used in temporary installations. It can be used for both median and shoulder installations. Unanchored units are connected with steel pins through wire rope loops. For temporary installations, this barrier can be placed on a paved surface or a compacted unpaved surface with the respective surface provided beyond the barrier for deflection. Do not anchor Type 2 barrier on a compacted unpaved surface. 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 single slope barrier for small sections that need cast-in-place barrier (such as for a light standard section). Precast concrete barrier transitions are currently under development. Contact HQ Design for more information.

Type F narrow base is a precast, single-faced F-Shape barrier. These units are not freestanding and are to be placed against a rigid structure (or anchored to the pavement in temporary installations). If Type F narrow base barriers are used back to back, fill any gap between them to prevent tipping.

Type F barrier can be anchored where a more rigid barrier is needed. The barrier can be anchored in permanent or temporary installations on asphalt pavement, concrete pavement, or bridge decks (Anchoring methods are shown in the *Standard Plans*). Consult with the WSDOT BSO for details when anchoring permanent precast concrete barrier to a rigid (Portland cement concrete) pavement or bridge deck.

Precast Type 2 barrier can be anchored where a more rigid barrier is needed. The barrier can be anchored in temporary installations using Type 1 and Type 2 anchors for rigid concrete pavement, and Type 3 anchors for asphalt pavement (Anchoring methods are shown in the *Standard Plans*). Consult with the WSDOT BSO for details when anchoring precast concrete barrier to a bridge deck.

Precast barrier used on the approach to bridge rail is to be connected to the bridge rail by installing loops or a loop bar 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 compacted soil (i.e. CSBC, select borrow, gravel borrow, native 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 compacted soil on both sides.

For new installations in asphalt, concrete, or compacted 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 compacted 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 Placement in Front of Bridge Piers

Consult with the HQ Bridge traffic barrier specialist when placing concrete barrier in front of bridge piers for projects with new or reconstructed bridges. See Standard Plans for barrier placement in front of bridge piers for retrofit projects.

1610.06(3) 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(4) 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 Section 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 10- to 12-foot single-slope barrier terminal (precast or cast-in-place) may be used in 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. Note: The Type F concrete barrier terminal standard plans are currently under development. Contact HQ Design for information.

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.

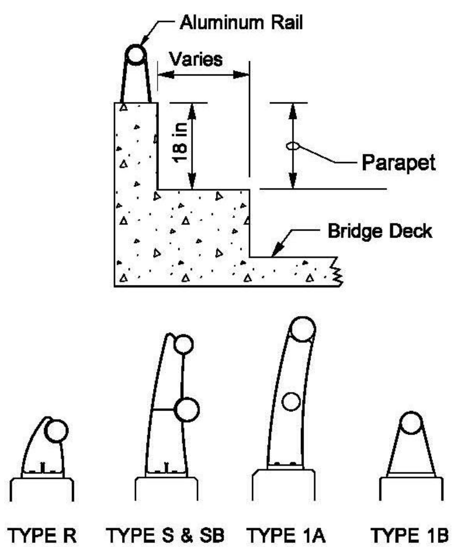
Approach barriers, transitions, and connections are usually needed on all four corners of bridges carrying two-way traffic and on both corners of the approach end for one-way traffic. (See 1610.04(6) for guidance on beam guardrail transitions). A concrete barrier transition is being made available to connect the Type F concrete barrier (F-shape) and the bridge barrier (F-Shape or Single Slope) (Note: Transitions are currently under development. Contact HQ Design 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 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 1610-15. 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 1610-15 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 rail must 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 1610-16 shows typical retrofit criteria.

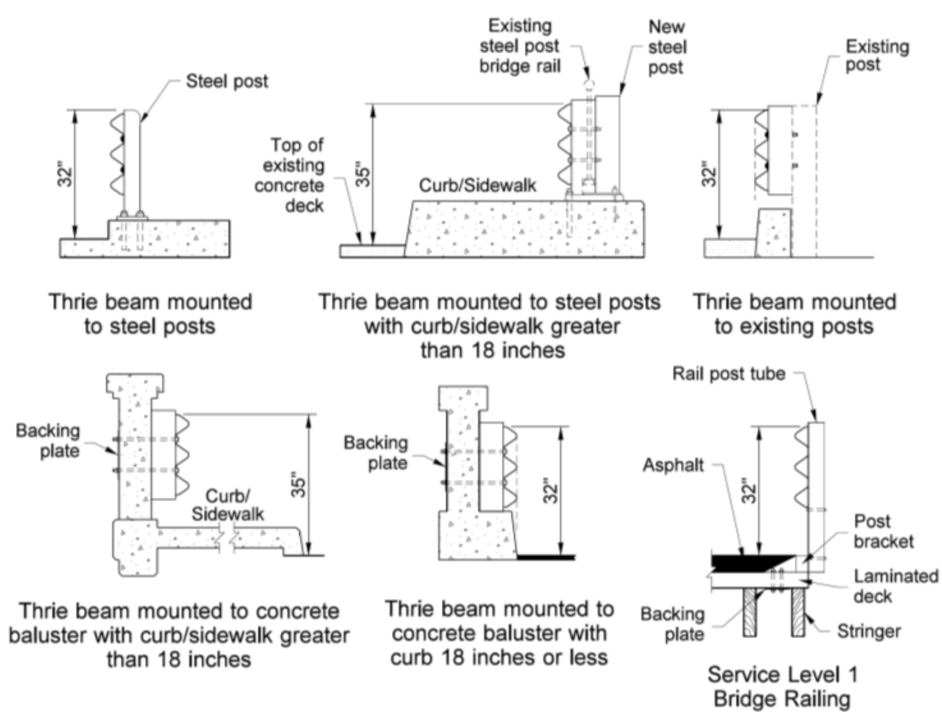
Note that Bridges designated as historical landmarks may not be candidates for thrie beam retrofitting. Contact the Environmental Services Office regarding bridge historical landmark status.

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 1610-16 Thrie Beam Rail Retrofit Criteria

Curb Width	Bridge Width	Concrete Bridge Deck		Wood Bridge Deck or Low- Strength Concrete Deck
		Concrete Bridge Rail (existing)	Steel or Wood Post Bridge Rail (existing)	
<18 inches		Thrie beam mounted to existing bridge rail [2] and blocked out to the face of curb. Height = 32 inches.	Thrie beam mounted to steel posts [2] at the face of curb. Height = 32 inches	• Service Level 1 Bridge Rail. [2] • Height = 32 inches. • Curb or wheel guard needs to be removed.
>18 inches	> 28 ft (curb to curb)	Thrie beam mounted to steel posts[2] at the face of curb. [1] Height = 32 inches.		
>18 inches	< 28 ft (curb to curb)	Thrie beam mounted to existing bridge rail.[2] Height = 35 inches.	Thrie beam mounted to steel posts [2] in line with existing rail. Height = 35 inches.	



Notes:

[1] To maximize available curb/sidewalk width for pedestrian use, thrie beam may be mounted to the bridge rail at a height of 35 inches.

[2] Contact the WSDOT BSO for design details on bridge rail retrofit projects.

1610.08 Other Barriers

1610.08(1) Redirectional Landform

Redirectional landforms, also referred to as earth berms, were formerly installed to help mitigate crashes with fixed objects located in depressed medians and at roadsides. They were constructed of materials that provided support for a traversing vehicle. With slopes in the range of 2H:1V to 3H:1V, they were intended to redirect errant vehicles. The use of redirectional landforms has been discontinued. Where redirectional landforms currently exist as mitigation for a fixed object, provide alternative means of mitigating the fixed object, such as removing, relocating, changing the fixed object to a crash-tested breakaway system, or shielding with barrier.

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, 2016

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.