# Chapter 1103 Design Control Selection



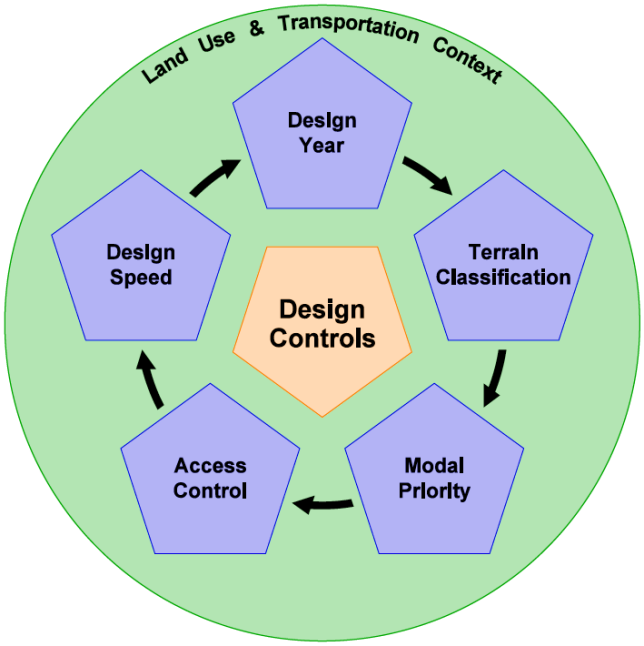
## 1103.01 General Overview

Design controls are specific factors that directly influence the selection of most design elements and their dimensions. Design controls establish fundamental boundaries for design alternatives. Selection of design controls is documented on the Basis of Design. This chapter provides guidance on the selection of design controls for state routes.

The five WSDOT design controls include:

- Design Year
- Modal Priority
- Access Control
- Design Speed
- Terrain Classification

**Exhibit 1103-1 WSDOT Design Controls**




*Reciprocal connections between design controls and land use and transportation contexts*

## 1103.02 Control: Design Year

**Design year** is the forecast year used for design. The year of opening is when the construction will be complete and the project location is fully operational. Design year selection is dependent on a decision to design for the year of opening, or for a future year based on forecast or planned conditions. Design year has historically been associated with a 20-year vehicle traffic forecast used in development of large mobility and capacity expansion projects. This is the origin of the term **horizon year**. Horizon year is typically considered to be 20 years from the year construction is scheduled to begin.

WSDOT policy on design year is intentionally flexible. The design year can be any interim year selected between the project year of opening year and the horizon year. Many lower-cost projects result in immediate performance improvements when construction is completed. Safety projects are an example of this where the basis of design may show design year as the year of opening.

Some projects may require horizon year analysis of an alternative regardless of the selected design year. A project may be required to evaluate alternatives based on the horizon year (20 years from the scheduled beginning of construction) if the project:

- Involves a federal nexus (federal funds involved, involves federal lands, or requires federal approvals or permits)
- Is a Project of Divisional Interest (See Chapter 300)
- Is a new/reconstruction project as defined in Chapter 300

Contact the region ASDE if there are questions.

## 1103.03 Control: Modal Priority

The concepts and method described in this section are adapted from National Cooperative Highway Research Program Report 855: "*An Expanded Functional Classification System for Highways and Streets"* (see http://www.trb.org/NCHRP/Blurbs/176004.aspx)

### *1103.03(1) Design Users*

"Design users" refers to the modes that are legally permitted to use a facility. The intent in identifying design users is to highlight all user needs, recognize modal interactions, and develop an integrated system for all users. Identifying the design users is the first step in determining which modes to accommodate and prioritize. On the Basis of Design, list design users with sufficient descriptive detail. Include consideration for all ages and abilities.

Division III of the document *Understanding Flexibility in Transportation Design – Washington* is a key resource for understanding the needs and characteristics of various design users.

### *1103.03(2) Modal Accommodation*

Modal accommodation refers to the level to which a travel mode will be addressed in the design. It is expressed on a scale of low, medium, and high, where a higher accommodation level is associated with the use of design features or criteria that tend to improve the performance of that mode compared to a lower level. Once established, the modal accommodation level is used to inform the decision on modal priority (See 1103.03(3)). Determine the modal accommodation

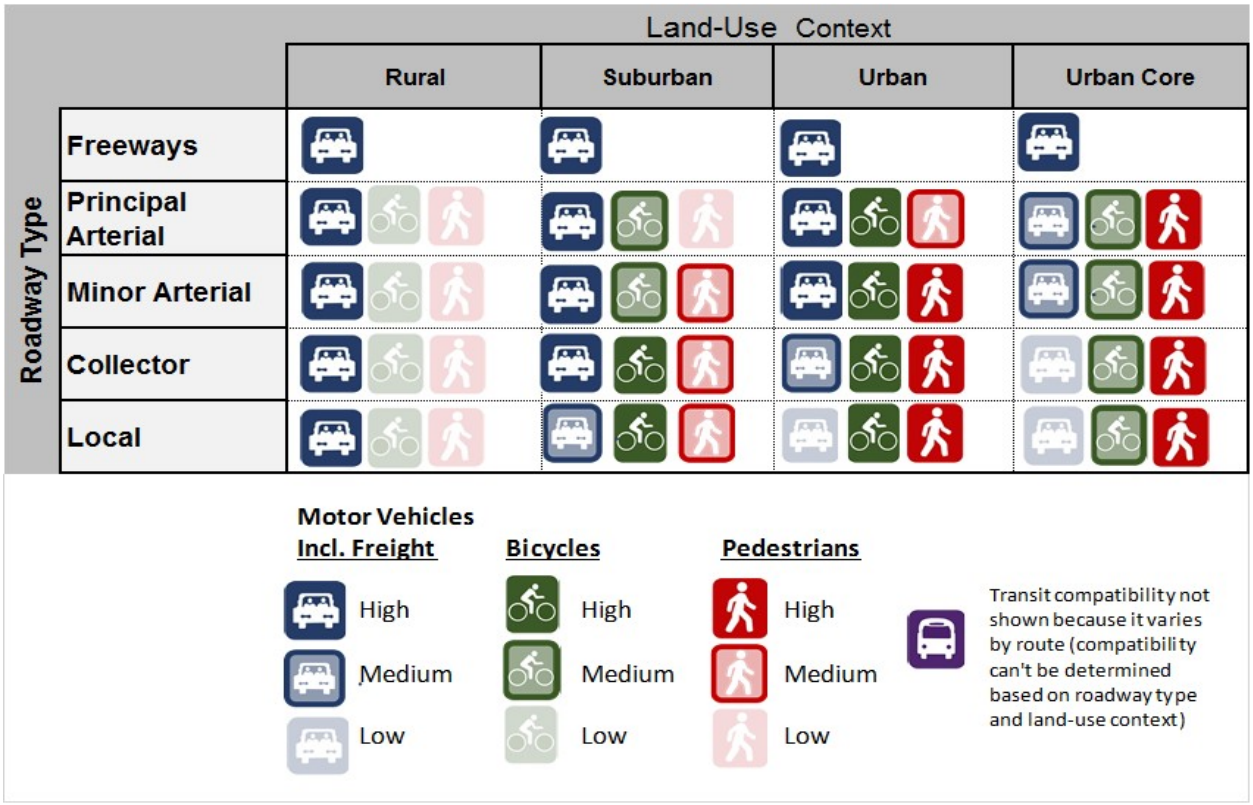
level for both the current year (prior to opening) and the design year. These are referred to as existing and future conditions in the guidance that follows. Note that in many cases, the planning documentation, data, or information in the project vicinity may not be available for the project's design year. In those cases, identify the forecast or horizon year used by the local agency or planning organization in its work and planning products, and document the use of that year as the future year for purposes of determining the modal accommodation level.

1. An **initial** modal accommodation determination, for both the current and design years, are made using Exhibit 1103-2. The initial determination uses the roadway type and land use contexts that were determined earlier and documented in Section 2 of the Basis of Design (See Chapter 1102).

2. A **final** determination for both the current and design years is made using additional information and evidence to validate or modify the initial determination.

Make the final modal accommodation determination for each mode in consultation with the project advisory team and/or subject matter expert(s), as they may recommend modifications to the initial determinations (see 1100.04 for more information about working with the project advisory team). Exhibit 1103-3 provides examples of land-use and transportation characteristics that a project advisory team or subject matter expert(s) may consider in adjusting accommodation up or down for any particular travel mode. These characteristics can represent either the current suitability of a facility to accommodate a mode, or its future strategic role with respect to accommodating that mode. Note that the Context and Modal Accommodation Report provides a template for making and documenting decisions about modal accommodation.

### Exhibit 1103-2 – Initial Modal Accommodation Level



Additional guidance on the use of the following criteria in determining final modal accommodation level is provided on the Design Support site: http://www.wsdot.wa.gov/Design/Support.htm

### Exhibit 1103-3 Example Characteristics Related to Modal Accommodation

| Land Use Characteristic | Increased Modal Accommodation Level |
|---|---|
| High proximity to activity centers | Pedestrian, Transit, Bicycle |
| Industrial and commercial land uses in surrounding area | Auto, Freight |
| High densities of both residential and employment | Bicycle, Pedestrian, Transit |
| Minimal building setbacks adjacent to roadway | Bicycle, Pedestrian |
| Human scale architecture present | Bicycle, Pedestrian, Transit |
| **Transportation Characteristic** | **Increased Modal Accommodation Level** |
| Well-established grid network | Bicycle, Pedestrian, Transit, Auto |
| T-2 freight route | Auto, Freight |
| Streetside elements | Bicycle, Pedestrian, Transit |
| Frequent signalized intersections along route | Auto, Transit, Pedestrian |

## 1103.03(2)(a) Vehicle modal accommodation level

Consider the vehicle modal accommodation level when making design decisions that address or affect needs associated with vehicle travel. Start with the initial modal accommodation level for motor vehicles per Exhibit 1103-2, and adjust it to establish the final level based on documented project specific conditions related to the quality of travel experience, and identified performance targets, that can be influenced by the project design, such as vehicle Level of Service, travel time, access classification, and other factors determined by subject matter experts or the project advisory team.

## 1103.03(2)(b) Bicycle modal accommodation level

Consider the bicycle modal accommodation level when making design decisions that address or affect needs associated with bicycle travel. Start with the initial modal accommodation level for bicycles per Exhibit 1103-2, and adjust it to establish the final level based on documented project specific conditions related to the quality of travel experience, and identified performance targets, that can be influenced by the project design, such as bicycle route type, efficiency of travel, range, bicyclist safety, route spacing, bicycle volumes, and other factors determined by subject matter experts or the project advisory team.

## 1103.03(2)(c) Pedestrian modal accommodation level

Consider the pedestrian modal accommodation level when making design decisions that address or affect needs associated with pedestrian travel. Start with the initial modal accommodation level for pedestrians per Exhibit 1103-2, and adjust it to establish the final level based on documented project specific conditions related to the quality of travel experience, and

identified performance targets, that can be influenced by the project design, such as pedestrian route type, efficiency of travel, range, pedestrian safety, block length, and other factors determined by subject matter experts or the project advisory team.

## 1103.03(3) Modal Priority

**Accommodate** means that the roadway will be designed so that the chosen modes can use it, while **accommodation level** refers to the extent to which that accommodation may be required. **Priority** refers to the decision to optimize the design based on the performance of one or more travel modes. Modal priority is used as input to choosing the appropriate geometric cross section (see Chapter 1230).

Modal priority addresses all modes expected to use the facility. Determine modal priority using the accommodation level results, as well as other relevant information about freight, transit, and any other modes considered and documented in the Context and Modal Accommodation Report and Basis of Design. Engage the project advisory team as provided in Section 1100.04.

If the modal priority is inconsistent with assumptions made about the project during a planning or scoping phase, work with program management staff to consider the need for any changes to project scoping documentation, including scope, schedule, and budget.

Document the modal priority on the Basis of Design for both the current and future conditions.

## 1103.03(4) Intersection Design Vehicle

WSDOT policy provides flexibility when choosing the intersection design vehicle. The purpose for this policy is to balance user needs and avoid the unnecessary expense of oversizing intersections. Considerations include frequency of the design vehicle and effects on other design users, specifically pedestrian crossing distance and times, and bicycle turning and through movements. Consider providing more protected intersection treatments for pedestrians and bicyclists to mitigate turning conflicts.

An intersection design vehicle is a specific selection made at each intersection leg. Select a design vehicle that allows the largest vehicles commonly encountered to adequately complete a required turning maneuver. The objective is not necessarily to size the specific intersection curb radius (unless there is a baseline need associated with the larger vehicles), but rather to account for a reasonable path to accommodate the large vehicle turning maneuver without conflicts (see Chapter 1310). Use turn simulation software (such as AutoTURN®) to analyze turning movements.

**Example:** An intersection with a pedestrian modal priority experiences infrequent turning movements by a WB-67. A smaller curb radius would benefit pedestrians due to shorter crossing times and reduced exposure to vehicles. Using turn simulation software, a practicable path for the WB-67 can be identified, even though path intrusion into the second same direction lane or painted median may be necessary. The infrequent use by a WB-67, along with the pedestrian modal priority, validate the decision for selecting a smaller design vehicle for the intersection while accommodating the WB-67 vehicle.

Conversely, if the crossroad was identified as being within a Freight Economic Corridor, with frequent turning movements from larger vehicles, it would be appropriate to size the intersection to prevent the second lane incursion.

Consider origins and destinations of large vehicles to understand their needs at specific intersection locations. Also, consider alternatives that may help lower turning speeds and minimize pedestrian exposure. Work with stakeholders, businesses, and service providers to understand their needs (like transit, school bus and emergency vehicle movements) and define the frequency of use at specific intersections. Municipalities may have established truck routes or restrictions that govern local freight patterns.

## 1103.04 Control: Access Control

Access is a critical component informed by an understanding of the land use and transportation contexts. The type of access control selected (see Chapter 520) affects accessibility and impacts the types of activities and functions that can occur on a segment. It is important for mobility and economic vitality projects to consider whether the current access classification and/or planned access classification conforms to the context selected for design (see Chapter 1102).

During development of the state highway system, access management functioned to preserve the safety and efficiency of regional highways. However, the level of access management can also significantly affect accessibility to land uses, modal mobility needs and the economic vitality of a place.

Unless access control has already been acquired by the purchase of access rights, it is necessary to select the appropriate type of limited access control or managed access control during planning and design. Appropriate access control should be considered so as not to hinder bicycle and pedestrian accessibility, mobility, and safety.

A choice to change the current or planned access control is a major decision and is to be consistent with the context, desired performance targets, and modal priorities for a location.

> **Example:** The area around a managed access Class 2 route has incurred significant development, increasing the number of local trips on a segment of the route. Over time, additional intersections and access connection permits have been granted. In this situation, it may be appropriate to consider selecting managed access Class 4 or 5 because of the changes in functions and activities along the segment over time.
>
> Conversely, a route may have a need to improve motor vehicle travel time performance, and managed access Class 1 may be appropriate.

If an alteration to current or planned access is determined necessary, consult the Headquarters Access and Hearings Manager for preliminary approval for the selection, and document on the Basis of Design (see Chapter 1100). For additional information on access control and access management, see Chapters 520, 530, and 540.

## 1103.05 Control: Design Speed

WSDOT uses a target speed approach for determining design speed. The objective of the target speed approach is to establish the design speed at the desired operating speed. The target speed selection is derived from other design controls, as well as transportation and land use context characteristics.

Exhibit 1103-4 shows possible (planning level) target speeds for the various roadway types and land use contexts discussed in Chapter 1102. The target speeds shown in the exhibit are

suggestions only, and the target speed for the specific location may vary from those shown in the exhibit.

### Exhibit 1103-4 Target Speed Based on Land Use Context and Roadway Type

| Roadway Type | Land-Use Context: Rural | Suburban | Urban | Urban Core |
|---|---|---|---|---|
| **Freeways** | High | High | High | High |
| **Principal Arterial** | High | Intermediate / High | Low / Intermediate | Low |
| **Minor Arterial** | High | Low/ Intermediate | Low / Intermediate | Low |
| **Collector** | Low/ Intermediate | Low/ Intermediate | Low | Low |
| **Local** | Low/ Intermediate | Low | Low | Low |

Engage the public, local agency staff and officials, and transit agencies prior to selecting the target speed. Once the target speed has been selected, it becomes the design speed for the project. The goal of the target speed approach is that the speed ultimately posted on the completed project is the same as the design, and ultimately, the operating speed. In order to achieve this outcome, consider:

- The impact of existing or proposed contextual characteristics
- Modal priorities
- Access control selection
- Performance need(s)
- Contributing factors analyses that have been developed for the project

**Lowering target speed:** When selecting a target speed in excess of the existing posted speed, or where excessive operating speeds were identified from contributing factors analysis of the baseline performance need, consider the use of roadway treatments that will help achieve the selected target speed (see 1103.05(2)) during alternatives formulation.

Speed management treatments are used to achieve lower vehicle speeds. When speed management treatments are proposed to accomplish a desired target speed operation concurrence of the Region Traffic Engineer is required. When a design speed is proposed for a project that is lower than the existing posted speed, the approval of the State Traffic Engineer is also required. See 1103.05(2) below for more on speed management. Careful consideration of other modal needs should be evaluated before raising target speeds.

**Raising target speed:** When selecting a target speed in excess of the existing posted speed, measures such as greater restriction of access control and segregation of modes may be necessary to reduce conflicts in activities and modal uses. Wider cross sectional elements like lanes and shoulders are used with higher speed facilities.

**Setting the posted speed:** Use caution when basing a target speed on one or more contextual characteristics that are proposed to take place after project opening, as the goal of ending up with a posted speed equal to the design speed at opening may be jeopardized.

The Region Traffic Engineer is responsible for setting the posted speed on the highway once the project is completed. Target speed is only one of the considerations used when establishing posted speed. Engage and include the Region Traffic Engineer and Traffic Office staff in key decision-making that will affect the target, design, and operating speed selection. Incorporate consideration of traffic calming measures as needed.

## *1103.05(1) Low, Intermediate, and High Speeds*

To provide a general basis of reference between target speed and geometric design, WSDOT policy provides three classifications of target speed as follows:

1. **Low Speed is 35 mph and below.** A low target speed is ideal for roadways with pedestrian and bicycle modal priorities. Locations that include frequent transit stops, intermodal connections, moderate to high intersection density, or moderate to high access densities may also benefit from lower speed environments. Low speed facilities in urban areas typically use narrower cross section elements.
2. **Intermediate Speeds are 40 mph and 45 mph.** An intermediate target speed is ideal for speed transitions between high and low target speed environments. Locations with low access densities and few at-grade intersections are also examples of where intermediate speed may be appropriate. In these locations consider a higher degree of separation between motor vehicles and bicycles and pedestrians.
3. **High Speed is 50 mph and above.** A high target speed is ideal for motor vehicle oriented roadways such as freeways and highways, often serving regional or longer-distance local trips. Rural connector roadways with infrequent farm or residential accesses are also consistent with the use of high target speeds. In high target speed locations consider the highest degree of separation between motor vehicles and bicycles and pedestrians. Highways with high speeds are associated with wider cross section elements.

## *1103.05(2) Speed Management*

Speed management is necessary within many highways to achieve an optimal multimodal facility that will support the land use and transportation contexts. Speed management may also be necessary to maintain consistent or desired speeds between adjacent roadway segments. Identify speed transition segment(s) as necessary to achieve desired speeds. Identify potential speed transition segments when scoping the project.

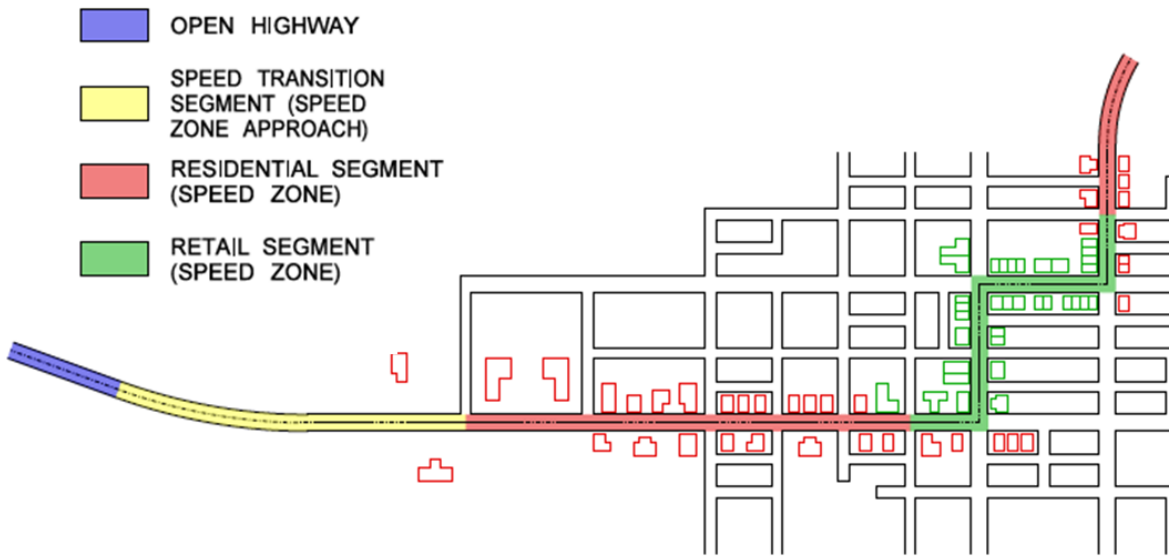
### 1103.05(2)(a) Speed Transition Segments

Include a speed transition segment where there is a need to obtain a target speed lower than the existing operating speed. A speed transition segment is not needed where existing operating speeds are within 5 mph of the target speed for a given location. The transition segment may not always directly precede the speed zone segment as shown in Exhibit 1103-5.

Example: A residential segment could benefit from introducing a speed transition segment farther upstream to increase the likelihood that approaching vehicles operate at the desired speed, for both segments.

The speed transition segment may incorporate a variety of treatments that alert motorists to a changing roadway environment. These treatments are intended to narrow driver focus and/or affect driver decision-making on that segment. Consider the transition segment location and length when providing multiple treatments in a short distance.

### Exhibit 1103-5 Speed Transition Segment Example




## 1103.05(2)(b) Speed Reduction Traffic Calming Treatments

Traffic calming treatments can serve a variety of purposes, from deterring higher volumes of motorized traffic to providing speed management. This section presents traffic calming treatment options to increase the reliability of reducing vehicular speed. Speed reduction traffic calming treatments applied independently or in combination may be beneficial depending on the type and use of the treatments. Many speed management treatments have demonstrated varied effectiveness for single applications. Multiple treatments in series and parallel that build upon the context characteristics are more effective. Contact the Headquarters Design and Traffic offices for any project implementing a speed transition segment, for assistance on selection and monitoring of treatments.

Speed management techniques vary and have different results depending on the speed and types of users at a given location. The following subsections present different options for speed-reducing traffic calming treatments.

### 1103.05(2)(b)(1) Geometric Treatments

Geometric treatments can include overall changes of the horizontal or vertical geometry to introduce features that will support maintaining the targeted speed. Exhibit 1103-6 shows geometric traffic calming treatments and potential considerations when selecting these types of treatments.

### 1103.05(2)(b)(2) Roadside and Pavement Treatments

There are a number of treatments that create an environment that influences human factors and perception. Many successful roadside treatments use landscaping in an attempt to achieve the desired behavioral effect. It is important to coordinate with project partners to evaluate landscaping features and provide for traveled way operations and sight lines. The introduction of roadside features like trees, parking, and/or bicycle lanes to alert travelers to a change in conditions may be appropriate. Applying features like vegetated medians or trees is appropriate at some locations and contexts. In landscaping discussions, include Traffic Engineers,

Maintenance, Urban Forestry, Landscape Architects, and Human Factors and Safety Experts. If the landscaping proposed is in a managed access segment with local jurisdiction responsibility for the roadside, coordinate to understand the jurisdictions' capabilities to sustain the landscaping and that it meets their clear zone goals.

Pavement-related treatments can also produce undesirable impacts on other users. For pavement-related treatments, include Materials Engineers, Maintenance, Traffic, and ADA Compliance Experts to review what sustainable and effective treatments can be employed.

Exhibit 1103-7 lists roadside and pavement-related traffic calming treatments and considerations to evaluate.

## Exhibit 1103-6 Geometric Traffic Calming Treatments and Considerations

| Treatment | Considerations |
|---|---|
| **Taper for Narrow Lanes** | Narrowing the lane width can be achieved by restriping lane lines. A decision to taper in or out may depend on other treatments planned, such as introducing a median or chicanes. Base taper rates on the target speed entering the context or speed transition segment, as appropriate. It is recommended that this be the first treatment employed. |
| **Chicanes/Lane Shifts** | This treatment may be achieved with curbed features, like planter strips or striping combined with additional fixed delineators. These treatment types are more appropriate when reducing speeds from an initial intermediate speed or less. When introducing this treatment with initial high speeds, the treatment should utilize paint striping, in addition to using other treatments preceding the chicane/lane shift, rather than constructing hardscape features. |
| **Pinch Points** | Applies on intermediate to low target speed situations unless completed with striping or other pavement markings. This treatment uses striping, roadside features, or curb extensions to temporarily narrow the vehicle lane. It is likely more appropriate for maintaining a desired target speed within a segment than as part of a speed transition segment. Pinch points are not appropriate for high-speed segments. Use of pinch-point treatments on intermediate speed segments requires concurrence from the Region Traffic Engineer. |
| **Speed Cushion/Humps/Tables** | On state highways, this treatment will likely have limited application, but should not be excluded from consideration. Impacts to freight, transit, and emergency service vehicles need to be evaluated prior to selecting these vertical types of treatments. These treatments may only be used when maintaining a 25 mph target speed within a segment. |
| **Raised Intersections** | Raised intersections, similar to other vertical treatments, will have limited application on state highways. This treatment typically has higher costs to construct due to the pavement needs. This treatment may be a good option when a roundabout cannot be accommodated at a narrow intersection. It can also be considered where there is a need to improve visibility of the intersection and modal conflicts, especially at problematic stop control intersections planned to remain in place. This treatment may only be used when maintaining a 25 mph target speed within a segment. |
| **Roundabouts** | Roundabouts can be a unique feature, providing reduced fatal and serious injury crash potential, traffic calming, and gateway functions (See Chapter 1320 and the Roadside Policy Manual for details on roundabout design). Roundabouts are effective from a collision reduction and operational perspective, and they provide reduced driver workload, lower speeds, and limited conflict points. They can assist with access management or when turning movements are limited or restricted on a segment. To determine if a roundabout is appropriate at a specific location, follow the Intersection Control Evaluation process described in Chapter 1300. |

## Exhibit 1103-7 Roadside, Streetside, and Pavement-Oriented Traffic Calming Treatments

| Treatment | Considerations |
|---|---|
| **Landscaping** | Landscaping can be used in conjunction with other treatments to reinforce the surrounding context and the driver's perception of the context. It can also provide width for modal separation. Annual maintenance impacts need to be considered, weighed, and documented prior to selecting types of vegetation to be included. |
| **Raised Vegetated Medians** | Introduce a raised vegetated median following other treatments that prepare the driver for this feature. Appropriate for low to intermediate target speed locations and transition segments. |
| **Transverse Rumble Strips** | These in-lane rumble strips are intended to alert drivers to a condition change. They are likely placed in conjunction with and prior to traffic signing revisions or in advance of other speed-reducing traffic calming treatments. Appropriate for high, intermediate, or low target speed locations and transition segments. |
| **Optical Speed Markings** | This treatment is intended to influence a driver's perception. The treatment consists of 8-inch transverse paint strips within the vehicular lane extending from lane and edge markings (or curb). The striping intervals sequentially decrease, providing the perception of increasing speed, an indication to drivers to slow their operating speed. Optical Speed Markings are ideal for speed transition segments, and are recommended to be applied in conjunction with lane narrowing for high or intermediate target speed locations. |
| **Dynamic Warning Systems** | This treatment consists of actively alerting motorists about their operating speed. There are many different systems that accomplish this, including portable radar trailers and post-mounted systems. These can be either permanent or temporary installations. Appropriate for all speeds. |
| **Gateways** | The intent of a gateway feature is to alert travelers to a context change. A gateway feature is typically found on the edge of cities or towns, but can be used to highlight specific segments within cities or towns. The gateway can be anything from a banner/structure spanning the facility, to artistic work, landscaping, and/or a roundabout at the first intersection approaching a defined environment context. The gateway feature should be developed by the community. It may be of interest to design a gateway feature fitting the cultural and historic character of the location. Consideration for potential fixed object collisions is an important aspect of gateway design. Gateway features that span or are placed within state right of way will need specific approvals, as identified in Chapter 950. Appropriate for low to intermediate target speed locations and transition segments. |

## 1103.06 Control: Terrain Classification

Terrain may limit operational and safety performance for particular modes. While terrain impacts may be addressed at specific locations, it is not cost beneficial to modify terrain continually throughout a corridor. The type of terrain, context, and speed influence the potential operating conditions of the highway, and should be a consideration when selecting mobility performance targets (See Chapter 1101). For more information on grades, see Chapter 1220.

To provide a general reference between terrain and geometric design, three classifications of terrain have been established:

1. **Level:** Level to moderately rolling, this terrain offers few or no obstacles to the construction of a highway having continuously unrestricted horizontal and vertical alignment.
2. **Rolling:** Hills and foothills, with slopes that rise and fall gently; however, occasional steep slopes might offer some restriction to horizontal and vertical alignment.
3. **Mountainous:** Rugged foothills; high, steep drainage divides; and mountain ranges.

Designate terrain as it pertains to the general character along the alignment of a corridor. Roadways in valleys or passes in mountainous areas might have the characteristics of roads traversing level or rolling terrain and are usually classified as level or rolling, rather than mountainous. See the *Highway Log* for terrain classification.

## 1103.07 Documentation

Document selections for design controls in Section 3 of the Basis of Design.

## 1103.08 References

### *1103.08(1) Federal/State Directives, Laws, and Codes*

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

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

### *1103.08(2) Supporting Information*

**Design Support website** to download the Basis of Design and Context and Modal Accommodation Report: http://www.wsdot.wa.gov/Design/Support.htm

*Designing Walkable Thoroughfares: A Context Sensitive Approach*, Institute of Transportation Engineers, Washington D.C., 2010 www.ite.org

*A Policy on Geometric Design of Highways and Streets* (Green Book), AASHTO, Washington, D.C., Current Edition www.transportation.org/Pages/Default.aspx

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

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

*NCHRP Report 613 – Guidelines for Selection of Speed Reduction Treatments at High Speed Intersections*, Transportation Research Board, Washington D.C., 2008
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_613.pdf

*NCHRP Report 737 – Design Guidance for High-Speed to Low Speed Transition Zones for Rural Highways*, Transportation Research Board, Washington D.C., 2012
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_737.pdf

*NCHRP Report 600 – Human Factors Guidelines for Road Systems*, 2nd Edition, Transportation Research Board, Washington D.C., 2012
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_600Second.pdf

*NCHRP Report 855 – An Expanded Functional Classification System for Highways and Streets*
http://www.trb.org/NCHRP/Blurbs/176004.aspx

*NCHRP Synthesis 443 – Practical Highway Design Solutions*, Transportation Research Board, Washington D.C., 2012 http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_443.pdf

*Measuring Sprawl 2014*, Smart Growth America, Washington D.C., 2014
http://www.smartgrowthamerica.org/measuring-sprawl