

WHAT IS THE TRANSPORTATION CRITERIA MANUAL?

The City of Austin's Transportation Criteria Manual (TCM) defines the design requirements for transportation infrastructure. The design requirements outlined in this manual offer standards and criteria for planning, design and coordination of applicable facilities within the Full Purpose Limits of the City of Austin (City) and its Extraterritorial Jurisdiction (ETJ), if adopted by the applicable jurisdiction, including Travis County and Williamson County.

The criteria presented in the TCM provide a foundation or starting point for engineering design decisions. It is the intent of the TCM to be used by City staff and private sector street design professionals in applying a consistent approach to street design, particularly for new streets and right-of-way planning. The TCM is also intended to provide guidance for street design in constrained right-of-way with flexible design criteria to fit existing situations that make the preferred design unobtainable. In the redesign of existing streets, additional engineering design work and public engagement may result in design features outside of the scope of this manual. Highly constrained scenarios may vary from minimums or maximums presented in this manual with approval of the applicable director or their designee. In addition, City Capital Improvement Projects (CIP), Corridor Construction Program Standards, or Project Connect Design Criteria may supersede the requirements of this manual to align with highly localized contextual design, subject to final approval by the City Traffic Engineer or applicable Director. Further engineered design will be required along Project Connect transit corridors as defined in the Project Connect Design Criteria, which may supersede the criteria of this manual, subject to final approval by the City Traffic Engineer or applicable Director. Within any of these contexts, this TCM applies a consistent and predictable approach to street design.

The standards contained herein are based largely upon the standards, guidelines and policies set forth by the American Association of State Highway and Transportation (AASHTO), National Association of City Transportation Officials (NACTO), and the Institute of Transportation Engineers (ITE). The criteria presented in the TCM are intended to meet the long-term goals of both advancing transportation mode choice through investment and prioritization of non-automobile modes of travel, implementing measures to limit transportation demand, and increased safety for all users of the transportation network.

The design criteria established in the TCM affect the review and approval of subdivision plats, zoning change applications, right-of-way dedications, site plans, preliminary plans, final development plans, and capital improvement plans within the Full Purpose Limits of the City of Austin. To achieve consistency between design practices, the manual applies to all projects that impact the public right-of-way along all City streets. Additional engineering design work will be required to safely transition streets between jurisdictional boundaries that do not adopt the same criteria. Inconsistencies between references shall be resolved by the Director of Transportation or designee for all aspects related to transportation operations. Deviations and waivers from the criteria in this manual will be at the discretion of the Director.

The TCM contains 14 Sections to guide street design for staff and private sector street design professionals:

1. **Section 1: Vision and Goals** - This section introduces the vision and goals of the TCM. This section also covers references to national and local standards, how this document relates to other plans in the City, deviations from this manual, and the history of changes to this manual in a Supplement History Table.
2. **Section 2: Street Cross Sections** - This section defines elements of street cross sections and street typologies as well as how the transportation network is intended to function and serve different modes of transportation through a Street Level classification system that aligns with the Austin Strategic Mobility Plan (ASMP).

3. **Section 3: Geometric Design Criteria** - This section covers what design controls are to be used for development of street design and dimensional design elements. This includes horizontal and vertical design components as well as cross-sectional design parameters and design of intersection treatments.
4. **Section 4: Pedestrian Zone** – This section covers the design and policies for the zone of a street that generally falls outside the edge of pavement or back of curb. The focus of this section is centered on sidewalks, pedestrian crossings, and general streetscape requirements.
5. **Section 5: Bikeways and Urban Trails** – This section covers the design of bike facilities and urban trails and general policies about when certain facilities are required.
6. **Section 6: Transit** – This section covers general design requirements for transit facilities.
7. **Section 7: Driveways** – This section covers policy governing driveway locations, design, and access management requirements on different street types.
8. **Section 8: Temporary Traffic Control** – This section outlines policies, procedures and standardized design related to temporary traffic control that deviate from national standards for localized applications.
9. **Section 9: Parking and Loading** – This section focuses on detailing design related to parking requirements, reductions, and loading policies found in the Land Development Code (LDC).
10. **Section 10: Transportation Impact Analysis** – This section outlines the administrative and content requirements for transportation analysis related to development required by the Land Development Code.
11. **Section 11: Offsets and Railing** – This section relates to lateral offset and clear zone requirements, environmental considerations in street design, and pedestrian and bridge railing design.
12. **Section 12: Rules and Design Manual for Small Network Facilities in the Right-of-Way** – This section covers rules for private use of City public right-of-way by small cell wireless network providers. **No changes to this section proposed from current adopted Rule.**
13. **Section 13: Structures in the Right-of-Way and in Easements** – This section details design criteria and policy for construction of structures in the right-of-way or easements.
14. **Section 14: Pavement Design** – This section gives an overview of the pavement design process and how to use the **Appendix B – Pavement Design** for street design.
15. **Appendix A: Definitions** – This appendix includes definitions for several terms used in the manual.
16. **Appendix B: Pavement Design** – This appendix covers the technical analysis methodology for determining an appropriate street pavement section.

The legal authority for enforcement of this document within the Full Purpose Limits of the City of Austin is derived from **Section 1-2, Title I of the Austin Code of Ordinances**. Any changes to this document shall be made in accordance with the procedure outlined in **Chapter 1-2, Title I of the Austin Code of Ordinances**. For all construction in the right-of-way, the City Traffic Engineer, applicable Director, or their designee must inspect construction and the construction must be accepted by the **applicable department**. If any term, covenant, or condition of this document is held by a court of competent jurisdiction to be invalid, void or unenforceable, the remainder of the terms, covenants and provisions of this document shall remain in full force and effect.

SECTION 1 – VISION AND GOALS

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1.1.0 – Vision

The Vision of the TCM is to provide design criteria for streets that help the City achieve the stated goals of the City's comprehensive plan, **Imagine Austin**:

- a. Grow as a compact, connected city;
- b. Use green infrastructure to protect environmentally sensitive areas and integrate nature into the City;
- c. Provide paths to prosperity for all;
- d. Develop as an affordable and healthy community;
- e. Sustainably manage water resources, and other environmental resources;
- f. Think creatively and work together.

1.2.0 – Goals

The TCM intends to align with the Goals contained within the City's comprehensive plan, **Imagine Austin**, and **Austin Strategic Mobility Plan (ASMP)** and are herein all goals of these two documents are incorporated by reference. The ASMP's top strategy is to reach a 50/50 mode split between drive alone vehicles and other modes of travel while prioritizing transportation safety and protecting Austin's health and environment. Waivers to the criteria contained within this manual shall not violate the vision or referenced goals.

1.3.0 – Reference Standards

National standards and guidelines are directly referenced in the criteria contained within the TCM and are also incorporated in many criteria in the TCM. The latest edition of each of the reference documents that are accepted by the City as it applies to the TCM shall be available in a Memorandum of Understanding (MOU) on a website maintained by the City. During the period following publication of an updated reference standard and prior to review and acceptance by the City, if conflicts between criteria arise due to referenced standards updates, the TCM criteria may supersede all other reference standard documents, subject to final approval by the City Traffic Engineer or applicable Director. Applicable director(s) or their designee(s) approval is (are) required to deviate from the TCM, until the MOU on latest edition of reference standards is updated, or the conflict is resolved by updating the criteria in the TCM. Inconsistencies between references shall be resolved by the applicable director(s) for all aspects related to transportation operations. A separate MOU shall be available on a website maintained by the City to list the applicable director, applicable staff, or administrative guidelines referenced in each section of the TCM.

The most current version of the references throughout this document may be used along with engineering judgment to justify waivers from the criteria outlined in this document, if needed, in support of the Vision and Goals of the TCM. The following national standards and guidelines govern the design of streets:

- o Travel Way:
 - AASHTO's *A Policy on Geometric Design of Highways and Streets* (the *Green Book*)
 - Texas Manual on Uniform Traffic Control Devices (TMUTCD)
 - Highway Capacity Manual
 - FHWA Roundabouts: An Informational Guide
 - FHWA Flexibility in Highway Design
 - NACTO Urban Street Design Guide
 - NACTO Global Street Design Guide
 - CNU/ITE Manual Designing Walkable Urban Thoroughfares

- CNU/ITE Implementing Context-Sensitive Design on Multimodal Corridors: A Practitioner's Handbook
- APA Complete Streets: Best Policies and Implementation Practices
- Bicycle and Pedestrian Design:
 - NACTO Urban Bikeway Design Guide
 - NACTO Urban Street Design Guide
 - AASHTO Guide for the Development of Bicycle Facilities
 - FHWA Separated Bike Lane Planning and Design Guide
 - Texas Manual on Uniform Traffic Control Devices (TMUTCD)
 - Association of Pedestrian and Bicycle Professionals (APBP) Essentials of Bike Parking
 - Americans with Disabilities Act (ADA) Standards
 - Texas Accessibility Standards
 - United States Access Board's Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG)
 - NACTO Urban Street Design Guide
 - AASHTO Guide for the Development of Bicycle Facilities
 - ITE Implementing Context Sensitive Design on Multimodal Thoroughfares
 - USDOT FRA Rails with Trails: Best Practices and Lessons Learned
- Transit Design:
 - NACTO Transit Street Design Guide
 - Capital Metropolitan Transportation Authority (CMTA) Service Guidelines & Standards
 - CMTA Transit Design Guide: Standards & Best Practices, A Resource Manual for Transit System Design
 - TCRP Report 183, A Guidebook on Transit-Supportive Roadway Strategies
 - Federal Highway Administration (FHWA). Achieving Multi-modal Networks: Applying Design Flexibility and Reducing Conflicts
- Complete Streets:
 - CNU/ITE Manual Designing Walkable Urban Thoroughfares
 - CNU/ITE Implementing Context-Sensitive Design on Multimodal Corridors: A Practitioner's Handbook
 - APA Complete Streets: Best Policies and Implementation Practices
 - NACTO Urban Street Design Guide
 - NACTO Urban Street Stormwater Guide
- Roadside Design (Offsets & Rails)
 - AASHTO's *A Policy on Geometric Design of Highways and Streets* (the *Green Book*)
 - AASHTO Roadside Design Guide
 - NACTO Urban Street Stormwater Guide

1.4.0 – Relationship to Other Plans

- A. Existing adopted mode plans and strategies already in place for bicycles, pedestrians, and transit shall be incorporated into the design process.
- B. The **ASMP** integrates all mode plans into one comprehensive strategy and shall be referenced for guidance on mode prioritization in street design.
- C. Design standards adopted by ordinance may supersede the criteria of the TCM, subject to final approval by the City Traffic Engineer or applicable Director.
- D. All use of public property for private use shall comply with the requirements of **Title 14** of the City Code or the City of Austin’s **Code of Ordinances**. When a license agreement is required, refer to Section 1802S.8 of the **Standard Specifications Manual**.

1.5.0 – Design Waiver Process

Transportation projects shall conform to the typical design criteria for the appropriate street classification whenever possible; however, in some situations, achieving conformance with all design criteria is not practical or reasonable. When constrained design criteria cannot be achieved a design waiver process is used to evaluate, document, and approve the request. A design waiver request and approval is required whenever the criteria for certain design requirements specified for a street design are not met.

Design waiver requests shall be submitted for review and approval by the applicable Director prior to incorporating into the final design of a project. The request and supporting documentation shall be submitted concurrently with the design submittal or as soon as the need for one is identified.

Associated waiver fees shall apply. Current waiver fees may be found online. Once a determination is achieved, the applicant will be informed in writing of the decision by the applicable Director.

1.6.0 – Supplement History Table

The table below allows users of this Manual to quickly and accurately determine what ordinances have been considered for codification in each supplement. Rules that are of a general and permanent nature are codified in the Manual and are considered "Included." Rules that are not of a general and permanent nature are not codified in the Code and are considered "Omitted."

In addition, by adding to this table with each supplement, users of the TCM will be able to gain a more complete picture of the Manual's historical evolution.

Rule. No.	Date Adopted	Included/ Omitted	Supp. No.
R161-14.03	4-4-2014	Included	6-2014
R161-14.04	4-4-2014	Included	6-2014
R161-17.02	1-3-2018	Included	1-2018
TBD	TBD	Included	TBD

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2.1.0 – General

The purpose of this section is to assist City staff and private sector street design professionals in applying a consistent approach to street design, particularly new streets. The TCM is also intended to provide design requirements for street design in constrained right-of-way with flexible design criteria to fit existing conditions that make the preferred design unobtainable. In the redesign of existing streets, additional engineering design work and public engagement may result in design features outside of the scope of this manual. Highly constrained scenarios may vary from minimums or maximums presented in this manual with approval of the City Transportation Engineer, applicable Director, or their designee. In addition, City Capital Improvement Projects (CIP), Corridor Construction Program Standards, or Project Connect Design Criteria may supersede the requirements of this manual to align with highly localized contextual design, subject to the final approval of the City Traffic Engineer or applicable Director.

Flexible design criteria for several street elements are presented in **Section 2.7.0** for use in street design to accommodate different scenarios. This approach can result in improved street design consistent with the implementation of the Comprehensive Plan. Typical cross sections presented in this **Section 2.8.0** are intended to reflect most street typologies in the **Austin Strategic Mobility Plan (ASMP)** in the City but are not intended to reflect all scenarios. Flexible design shall be used to reflect existing constraints, context, and mode priorities for a given street. Typical cross sections are thus representative of an acceptable design that falls within flexible design criteria but are not intended as a template for every situation.

2.1.1 – Mode Priorities

The criteria presented in the TCM are intended to meet the long-term goals of both advancing transportation mode choice through investment and prioritization of non-automobile modes of travel, implementing measures to limit transportation demand, and increased safety for all users of the transportation network. As such, street design should reflect priority for comfort and safety of vulnerable road users such as pedestrians and bikes as the highest priority. To encourage the use of these facilities and to protect these users, street trees are a critical part of the roadway infrastructure.

2.2.0 – Street Typology Development

The **ASMP** defines street elements that together make up a street typology. The Street Level, right-of-way required, mode priority networks, and number of lanes are all defined in this document.

2.2.1 – Street Typology Ingredients

The approach to street typology presented in this section is consistent with City of Austin policies and considers the following key ingredients: street level, right-of-way, mode priorities, design considerations, and number of motor vehicle lanes.

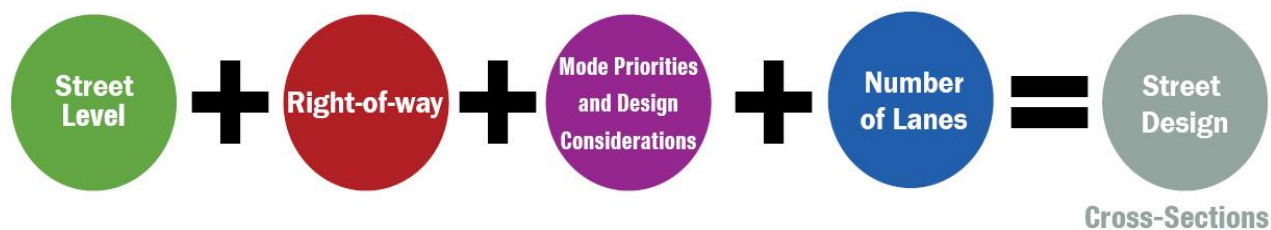


Figure 2-1 – Typology Ingredients

A. Street Level

Street Level is a functional classification naming that adapts the state or federal highway standard conventional naming to a particular urban environment. Street Level indicates the role(s) that a street should play in the overall network, further defined in **Section 2.4.0**.

B. Right-of-Way

Right-of-way (existing or future) for each segment of the street network determines the limitations of street design by defining the width of the public space available. This includes all street zones as elaborated in **Section 2.6.0**, including the Pedestrian Zone, Bicycle and Street Edge Zone, and Motor Vehicle and Transit Zone. Required right-of-way is specified in the **ASMP**. When space is available, right-of-way shall be prioritized for elements falling outside the Motor Vehicle and Transit Zone to achieve recommended element widths. In constrained circumstances, compromises shall be made to all modes in a balanced way that achieves the best possible alignment to **ASMP** goals per **Section 2.7.3**. Some elements of the street not located in the Motor Vehicle and Transit Zone may be placed outside the right-of-way in easements in constrained situations where necessary, as allowed for by the LDC. Determination of a constrained situation is further outlined in **Section 2.7.1.3**.

C. Mode Priorities and Design Considerations

1. Mode Priorities

Mode priorities are captured in the **ASMP** [Street Network Table](#) and [Street Network Map](#), which shall supersede all other mode specific plans and be the source for determination of mode priority for design of established streets or streets with constrained right-of-way per **Section 2.7.3**.

2. Pedestrian Supportive Design Strategies

Pedestrian comfort and safety are critical for all streets, but strategies for achieving these objectives can vary depending on the street drainage type, defined in **Section 2.3.0**, and existing terrain. **Section 4** provides design guidance and strategies for building streets that are safe and comfortable for pedestrians. To encourage the use of these facilities and to protect pedestrians, street trees are a critical part of the roadway infrastructure. Accommodations shall be made for pedestrians on all streets.

3. Bicycle Supportive Design Strategies

The vision of the Austin 2014 Bicycle Plan includes to "help people in Austin of all ages and abilities bicycle comfortably and safely for transportation, fitness, and enjoyment." Bicycle facilities selected for a street shall be reflective of this vision. To encourage the use of these facilities and to protect pedestrians, street trees are a critical part of the roadway infrastructure. These design strategies are outlined in **Section 5**.

4. Transit Supportive Design Strategies

Transit supportive design strategies coordinate land use with infrastructure and utilize technology and policy to help maximize the use of transit services. Street trees are a critical infrastructure element that supports transit. These design strategies are outlined in **Section 6**. Policy supporting transit is described in the **ASMP**.

D. Number of Lanes

Motor vehicle travel lanes carry more than just the personal automobile and can include a mixed-flow or designated lane for transit priority. These different purposes impact the design of a street (such as number of lanes, treatments, and lane width), especially at transit stops and intersections.

Section 2.5.0 details the approach to determining number of lanes for streets that are either defined in the **ASMP** or part of a new development.

2.3.0 – Street Drainage Types

In general, streets within the City of Austin are intended to be supportive of an urbanized context with storm drainage facilities in underground systems to free up available right-of-way at the surface level for other uses. However, in certain areas of the City, rolling terrain and environmentally sensitive areas may warrant distinct street design. These streets also require alternative bicycle facilities where a raised bicycle lane is not feasible or achievable given the additional space requirements for surface drainage. A specified region of the City where non-curbed and guttered streets are permissible with director approval is shown in Figure 2-2. In addition to this area, roadways that fall within the Hill Country Roadways Overlay, as defined in the **LDC**, shall follow design standards for non-curbed and guttered streets. Flexible design criteria are presented in **Section 2.7.3** for these streets and **Section 2.8.3** that follows includes typical cross sections for non-curbed and guttered streets.

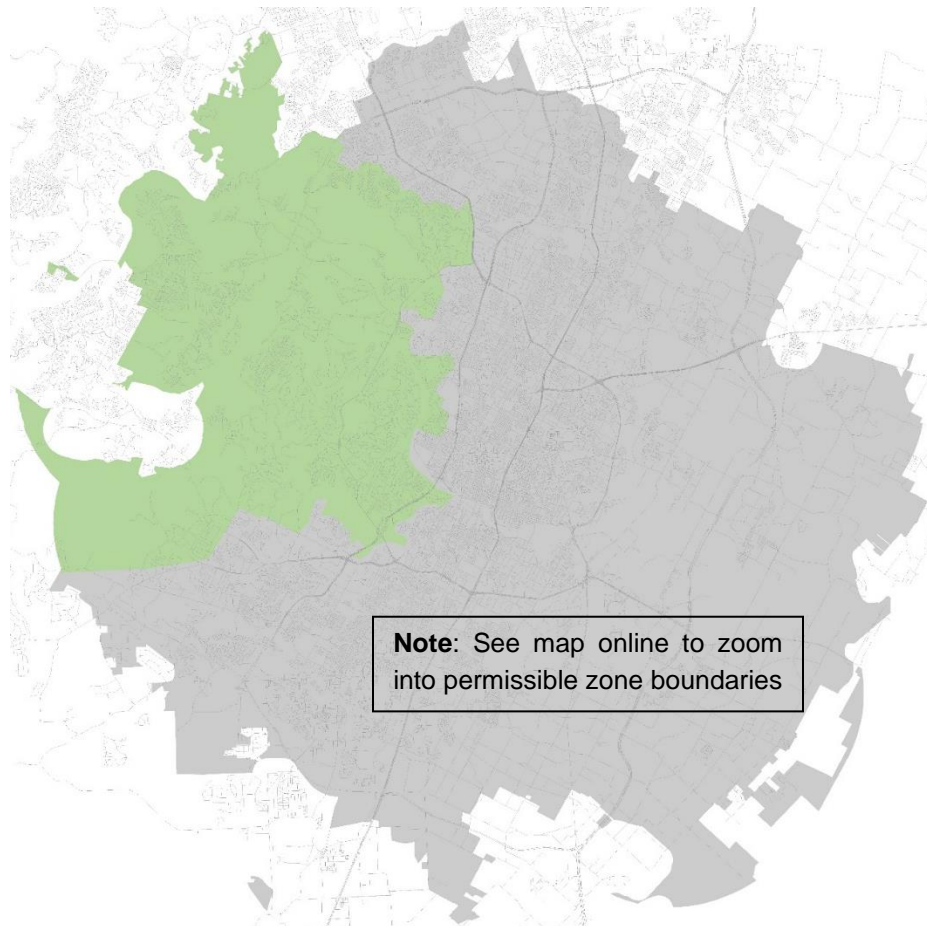


Figure 2-2 – Permissible Zone: Non-Curbed and Guttered Streets

2.4.0 – Street Levels

Each Street Level considers the function of the street in two ways: (1) how it operates within the larger network, and (2) its purpose to provide safe and effective mobility through multiple travel modes. A Street "Level" is a modernization of the nomenclature for typical street functional classifications. The Level of the street indicates the intended function of the street in the transportation network and gives options on how to achieve the functionality within different rights-of-way. Many factors play into defining each street Level including desired speeds, access, trip length, and parking. Street Levels are broken into six levels (Levels 0-5). Levels 1-5 are a hierarchy of streets based on the function of their Motor Vehicle and Transit Zone and their Bicycle and Street Edge Zone, while Level 0 refers to alleys. Street Zones are described in further detail in **Section 2.6.0**. The Street Levels shown provide a simple visual of how the different levels are intended to function. The streets range from block level uses (Level 0 - Level 1), to City uses (Level 2 - Level 4), and more Regional uses (Level 4 - Level 5). **Section 3** covers design specific elements such as target speed for each Street Level.

Additionally, the purpose of a street can change when it passes through activity centers and special districts, resulting in corresponding changes in street design. Characteristics for each Street Level can be found in the following Section 2.4.1. The **ASMP** defines Street Level designations for all streets in the City of Austin.

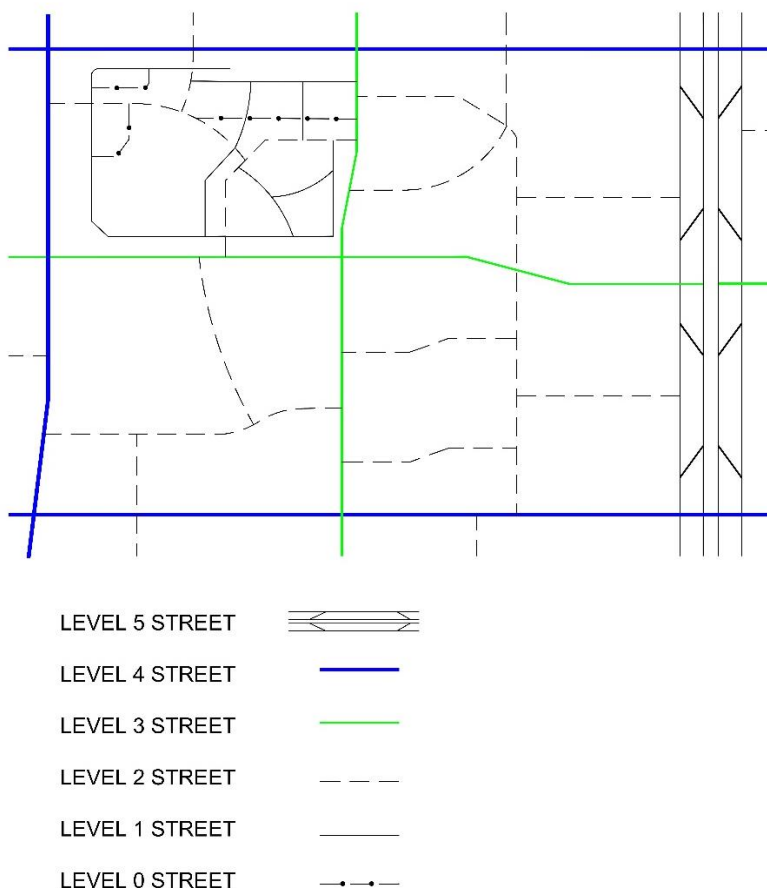
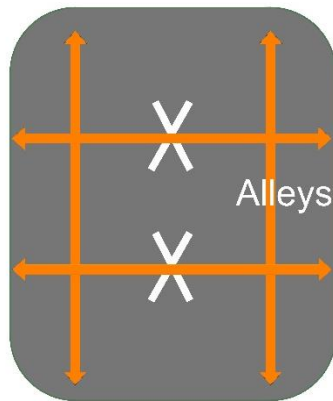


Figure 2-3 – Street Levels

2.4.1 – Level Descriptions

2.4.1.1 – Level 0 Streets

Level 0 is reserved for alleys. These streets typically provide access for service vehicles and/or residential access. Level 0 Streets may be used for fire access when approved by City Transportation Engineer or applicable Director. Figure 2-3 shows a local example of a Level 0 Street, functional classification, and primary characteristics.

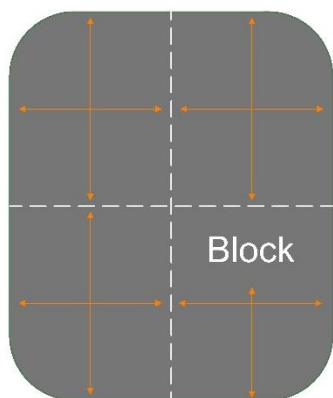


Level 0 Street Characteristics	
Functional Classification	Alleys
Primary Characteristics	Narrow right-of-way
	Very low vehicle volume and speeds
	Vehicular use only for property access
	High truck usage for garbage/delivery

Figure 2-4 – Level 0 Streets

2.4.1.2 – Level 1 Streets

Level 1 Streets serve primarily residential destinations, typically with no retail or mixed-use. In some examples, the street may be a shared street or operate with a yield condition. Their primary purpose is to provide block-level, local access and provide connectivity to higher Level Streets. Figure 2-4 shows a local example of a Level 1 Street, functional classification, and primary characteristics.



Level 1 Street Characteristics	
Functional Classification	Local, Residential Collector
Primary Characteristics	Low volumes and speeds
	Frequent driveways, unless Level 0 streets provide access
	Connects to higher Level Streets

Figure 2-5 – Level 1 Streets

2.4.1.3 – Level 2 Streets

Level 2 Streets connect neighborhoods to each other. They balance mobility with access by providing good access to neighborhood-serving business districts, retail, and services. Typically, they have lower travel speeds and traffic volumes than Level 3 and 4 Streets. They tend to connect to other Level 2, 3, and 4 Streets. They have a significant need for accommodation of high levels of use for all travel modes. Figure 2-5 shows a local example of a Level 2 Street, functional classification, and primary characteristics.

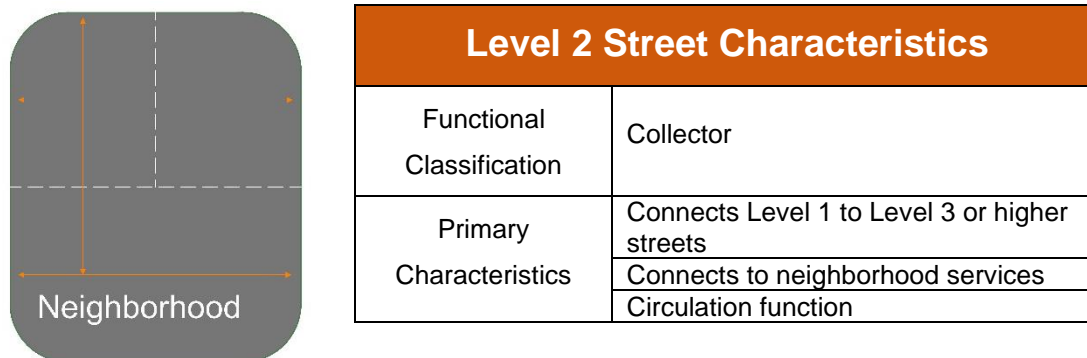


Figure 2-6 – Level 2 Streets

2.4.1.4 – Level 3 Streets

Level 3 Streets may look like Level 4 Streets but have a greater role in balancing local land access with moving people and goods. Typically, they have lower travel speeds and traffic volumes than Level 4 Streets. They also tend to be limited in width by the built environment that they serve and often have the greatest need for accommodation of high levels of use for all travel modes. Figure 2-6 shows a local example of a Level 3 Street, functional classification, local examples, and primary characteristics.

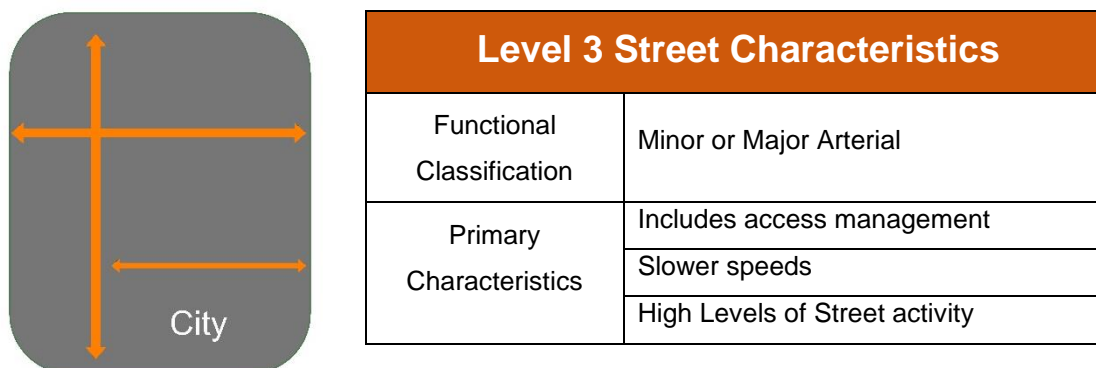
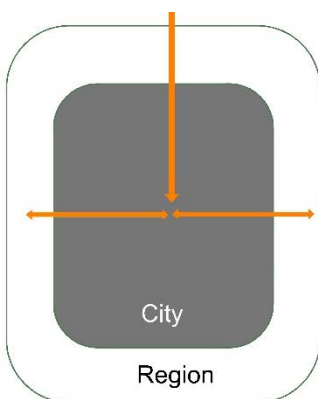


Figure 2-7 – Level 3 Streets

2.4.1.5 – Level 4 Streets

Level 4 Streets accommodate travel into and out of the City from the surrounding area. They are often multi-lane thoroughfares that generally include a landscaped median. These can also include freeway and interstate frontage roads. They provide strong commuter linkages and tend to prioritize vehicular capacity. Figure 2-7 shows a local example of a Level 4 Street, functional classification, local examples, and primary characteristics.

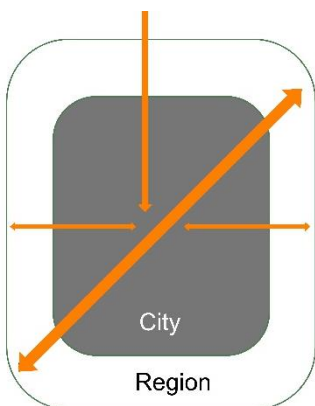


Level 4 Street Characteristics	
Functional Classification	Principal or Major Arterial
Primary Characteristics	Commuter Linkages
	Connects to Level 5 facilities
	Intra-Regional

Figure 2-8 – Level 4 Streets

2.4.1.6 – Level 5 Streets

Level 5 Streets are primarily controlled access streets (freeways and expressways). These streets are multi-lane roadways meant for higher speeds and longer distance travel. They carry traffic through the region and into and out of the City of Austin. They are often managed by entities other than the City and can include tolled and non-tolled facilities. Figure 2-8 shows a local example of a Level 5 Street, functional classification, and primary characteristics. Level 5 Streets tend to be freeway type facilities that are governed not by the City code, but by a separate set of guidelines. The Transportation Criteria Manual does not specify design for these facilities. However, as these facilities are identified in the City's bicycle and pedestrian networks, this manual provides guidance on design to conform to the City's adopted plans for non-auto modes. **Section 2.8.2.6** shows the recommended behind-curb facility for Level 5 Streets.



Level 5 Street Characteristics	
Functional Classification	Freeways & Interchanges
Primary Characteristics	Higher speeds
	Controlled access facilities
	Inter-regional

Figure 2-9 – Level 5 Streets

2.5.0 – Number of Through Lanes

The ultimate number of through lanes on a street, excluding turn lanes and auxiliary lanes, is defined in the **ASMP** for existing streets and new streets shown in the plan. If a street is proposed that is not in the **ASMP**, it shall be a Level 0 or Level 1 Street unless identified to be a higher Street Level in a Transportation Impact Analysis (see **Section 10**), City Capital Improvement Project, or as part of a City led corridor study.

2.6.0 – Street Zones

When designing a street, it is important to understand the variety of elements that comprise a street. These elements are organized into different allocations of the street space, referred to as street zones. The following Table 2-1 and Figure 2-9 show how each zone fits into the right-of-way as well as which elements of a street generally fall in each zone. Some elements of the street not located in the Motor Vehicle and Transit Zone may be placed outside the right-of-way in easements in constrained situations where necessary, as allowed for by the **LDC**. Determination of a constrained situation is further outlined in **Section 2.7.3**. Refer to the **Utilities Criteria Manual** for placement of utilities in the right-of-way.

Table 2-1 – Street Zone Elements

Elements May Include:	
Motor Vehicle and Transit Zone	Travel Lanes; Median*; Center Turn Lane; Pedestrian Islands; High Capacity Transit <i>*Median includes a 6-in. curb</i>
Bicycle and Street Edge Zone	Raised Bicycle Lanes; Parking (Parallel, head-in angle or back-in angle parking) and associated bulbouts at intersections (required); Buffered Bicycle Lanes; Loading Zones; Valet <i>Alternative Uses: Parklets; Bicycle Corrals; etc.</i>
Pedestrian Zone (<i>includes Tree & Furniture Zone</i>)	Building setbacks*; Above and Below Ground Utilities; Sidewalks; Street Trees; Furniture; Driveways; Urban Trails; Signage; Transit Stops <i>*Setbacks defer to frontage standards in the Land Development Code</i>

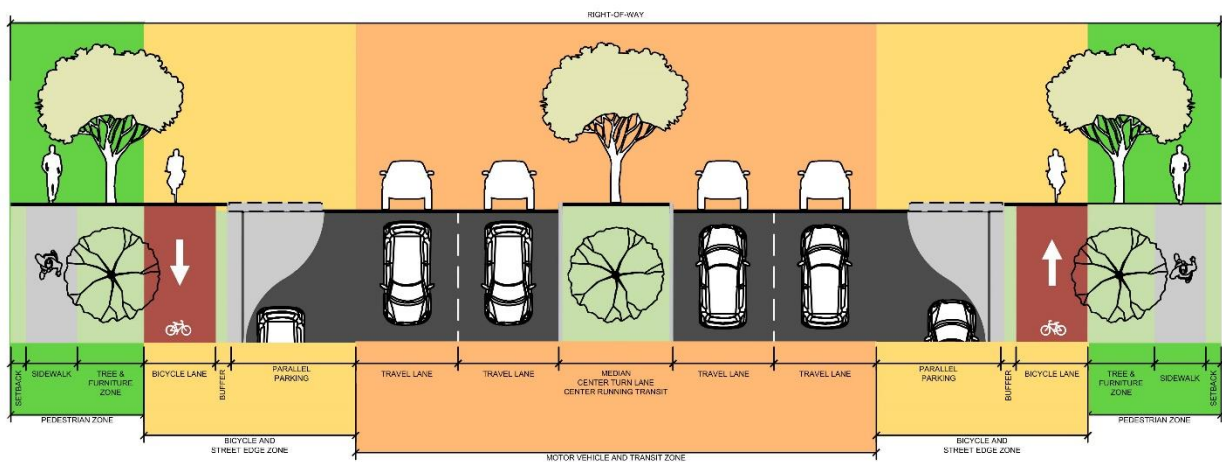


Figure 2-10 – All Street Zones

2.7.0 – Flexible Design Criteria

Flexible design criteria presented in this Section define the recommended and constrained widths of various street elements for use in design of streets. Existing right-of-way and environment may not allow for all street elements to be built to recommended widths in all scenarios. The recommended dimensions shall be utilized when right-of-way is available whereas the constrained dimensions shall be used when right-of-way is not available nor able to be obtained. Some additional consideration may also be needed regarding local utility requirements which may vary depending on location or be site-specific. Constrained dimensions are not an absolute minimum and can be further reduced at the discretion of the City Transportation Engineer or applicable Director and in compliance with reference standards in **Section 1.3.0**.

Section 2.8.0 includes typical cross sections for most combinations of Street Level, number of lanes and required right-of-way found in the **ASMP** and comply with the ranges presented for street elements in this Section and provide standardized cross sections for Level 0 and Level 1 Streets. The typical cross sections included do not account for the additional right-of-way space that may be required for exclusive space for transit operations but are accounted for in the **ASMP**. Further engineered design will be required along Project Connect transit corridors as defined in the Project Connect Design Criteria, which may supersede the criteria of this manual, subject to the final approval of the City Traffic Engineer or applicable Director. The [Street Network Table](#) and [Map](#) in the **ASMP** shows required right-of-way values that do not always match the typical cross sections in **Section 2.8.0** based on a street's typology, due to constraints along existing streets. Required horizontal and vertical clearances for landscaping, utility poles, and other street elements are in **Section 11**.

2.7.1 – Curbed and Guttered Streets Flexible Design

2.7.1.1 – Level 0 Street Design

Level 0 Streets provide vehicular access to properties and alternative access routes for emergency vehicles. In addition, Level 0 Streets provide access to city services such as waste removal and utility placement off of streets and is described in **Section 2.4.1** with other Street Levels. **Section 2.8.0** details the typical cross sections for an alley, and flexible design is not provided for these streets. Design criteria for Level 0 Streets are in **Section 3.4.1**.

2.7.1.2 – Level 1 Street Design

Level 1 Streets are intended primarily to serve traffic within a neighborhood. Level 1 Streets are not continuous through several districts. Level 1 Streets shall be designed as low speed, low volume streets that install speed management features outlined in **Section 3.3.0** to make them more pedestrian friendly. The appropriate Level 1 cross section shall be selected based on adjacent maximum building heights and for residential adjacent land uses only per figures in **Section 2.8.2.2**. Deviations from the typical cross sections in **Section 2.8.0** shall not be allowed unless approved by the City Transportation Engineer or applicable Director except for Level 1 non-curbed and guttered streets. Non-curbed and guttered Level 1 Streets have some design flexibility, which are defined in **Table 2-3**. Additional design criteria for Level 1 Streets are in **Section 3.4.2**.

2.7.1.3 – Level 2, 3, and 4 Street Design

Level 2, 3, and 4 Streets are intended to connect neighborhoods, destinations and carry people into and out of the City from surrounding areas. Table 2-2 shows ranges of widths for different facilities. Dimensions marked as "Recommended" should be used as much as is feasible, and dimensions marked as "Constrained" shall only be used when required right-of-way, per the **ASMP**, is not adequate to fit recommended dimensions and must be approved by the **applicable department**. Use of constrained dimensions shall be in a balanced way across all modes to achieve a design that fits in the required right-of-way. Constrained dimensions in Table 2-2 should not be used in situations where a new street is being designed without ROW constraints.

Table 2-2 – Curbed and Guttered Street Design Matrix ^P

	Level 2		Level 3		Level 4	
	Pedestrian Zone^C					
Toolbox:	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft
<i>Sidewalk^O</i>	6	5	7	6	7	6
<i>Tree & Furniture Zone^K</i>	8	6.5	8	6.5	10	6.5
<i>Setback^L</i>	2	1	2	1	2	1
	Bicycle and Street Edge Zone^B					
	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft
Bicycle Facility^{D,H}						
<i>Protected Bike Lanes (One or Two-Sided, Raised)</i>	7 Clear 4 Buffer ^N	6.5 Clear 2 Buffer ^N	8 Clear 4 Buffer ^N	7 Clear 2 Buffer ^N	8 Clear 4 Buffer ^N	7 Clear 3 Buffer ^N
Other Facilities						
<i>Parallel Parking^{G,I,M}</i>	8	7	9	7	n/a	n/a
	Motor Vehicle and Transit Zone^A					
	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft
<i>Outside Travel Lane Width^E</i>	12.5	11.5	12.5	11.5	12.5	11.5
<i>Interior Travel Lanes Width^L</i>	n/a	n/a	11	10	11	10
<i>Center Turn Lane Width</i>	10 ^F	10 ^F	11	10	n/a	n/a
<i>Median Width</i>	10	n/a	14	11	14	11

- A. All dimensions in Table 2-2 for the Motor Vehicle and Transit Zone are measured from face of curb or center of stripe.
 - 1. If double yellow center line is proposed, measurement is to center of double yellow
- B. Dimensions for Bicycle and Street Edge Zone are measured from face of curb, center of stripe, or edge of paved bicycle lane.
- C. Dimensions for Pedestrian Zone are measured as follows:
 - 1. For sidewalks, from edge of paved surface to edge of paved surface or right-of-way.

2. For tree & furniture zone, from edge of sidewalk to edge of bike lane or face of curb to edge of bike lane.
 3. For setback, from edge of paved surface closest to the right-of-way to the right-of way-line.
- D. Street Level Protected Bike Lanes may be used as an alternative to raised bike lanes on retrofit streets only, with the same bike lane clear width and buffer width dimensions required.
1. If Street Level protected bicycle lanes are used, the required pavement width will increase by the width of the bike lane and protective buffer.
- E. Outside lane widths are sized to be supportive of transit and define lane width when the street includes one through lane in each direction. Dimensions include the gutter and are measured from physical obstruction (face of curb, edge of parking, etc.).
1. Outside travel lanes may be reduced to 10 ft on Level 2 facilities if next to painted bicycle lanes instead of a curb on Level 2 facilities.
 2. Outside travel lanes may be reduced to 11 ft on Level 3 and 4 Streets if gutter and pavement are a smooth contiguous surface and curb inlets are recessed.
- F. On Level 2 Streets, left turn bays are required at the intersection of Level 2, 3 and 4 Streets as additional pavement width of 10 ft minimum if left turn volumes are anticipated to reach the left turn lane threshold in Table 3-16. If required, mitigation shall be eligible as offset towards applicable Street Impact Fees per **Section 10**. Alternatively, parking prohibitions near intersections, when on-street parking is present, may be sufficient for turn lane space without additional pavement.
- G. Parallel parking on Level 3 and 4 Streets shall be approved by the City Traffic Engineer, applicable Director, or their designee and dedicated as additional right-of-way beyond the required right-of-way in the **ASMP** and include bulb-outs at intersections with other streets. On Level 2 Streets, if parking is desired on both sides of a street, the larger right-of-way cross section shall be used as shown in the Level 2 84 ft ROW cross section in **Section 2.8.2.3**.
- H. Shared use paths shall only be used with a waiver and facility widths are defined in **Section 4**. The shared use path width will replace the combined width of the sidewalk and bicycle facility and buffer as shown in Table 2-2, when permitted. Street trees are required with shared use paths.
- I. Setback provided between a sidewalk and right-of-way boundary shall be a 2 ft standard unless one of the following conditions apply & the **applicable department** approves a smaller setback:
1. If no retaining wall is required or if grades are less than 5:1, may reduce to 1 ft setback
 2. If 0 lot lines, 0 ft setback may be allowed if the sidewalk extends to building face and property owner agrees to maintain with a license agreement
 3. Less than 2 ft setbacks may be allowed where an acceptable public access and/or ROW maintenance access agreement is in place
- J. If on-street parking is adjacent to an on-street protected bike lane, the parking shall be placed adjacent to the outside travel lane and the buffer between parking and the bike lane shall be 3 ft to protect bikes from the opening of car doors.
- K. When the Tree and Furniture Zone is designed to be less than the recommended 8 ft, soil cells or structural soil shall be provided for a 4 ft radius from the center of the trees planted. Reference standards for soils in the **Environmental Criteria Manual**.

- L. On multi-lane streets, if an inside travel lane is next to a lane carrying traffic in the opposing direction, lane widths may need to be wider than 10 ft to account for passing transit vehicles.
- M. Concrete parking bays between bulb-outs shall be jointed at 10 ft intervals through use of simple early transverse sawcuts on plain unreinforced slip-formed concrete or be placed in 10 ft panels. Refer to the **Appendix B** for pavement design details.
- N. On streets with a median and one lane in each direction of travel, such as in **Figure 2-19**, the buffer between the curb and raised bike lanes shall be reinforced concrete for deployment of outriggers for fire ground setup. Width on a straight street section shall be 12 ft FOC to FOC minimum.
- O. Project Connect Design Criteria or other adopted planning documents may require additional sidewalk width as part of project development when appropriate.
- P. Within the Downtown Austin Area, as defined in Figure A-2 in Appendix A, cross sections shall follow the Great Streets Master Plan, per Section 2.7.4.

2.7.2 – Non-Curbed and Guttered Street Design

The region of the City defined in **Figure 2-2** has rolling terrain, environmentally sensitive constraints and lower development densities with infrequent driveway access and intersections. These streets are generally characterized by surface drainage with non-curbed edge conditions. Table 2-3 details the width of all elements for Levels 1, 2, 3, and 4 Streets permissible within this area.

Table 2-3 – Non-Curbed and Guttered Street Design Matrix

	Level 1		Level 2		Level 3		Level 4	
Pedestrian Zone								
Toolbox:	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft
<i>Open Ditch/Swale</i>	10	8	15	12	20	15	20	15
<i>Shared Use Path</i>	n/a	n/a	12	10	12	10	12	10
<i>Sidewalk</i>	5	5	n/a	n/a	n/a	n/a	n/a	n/a
Bicycle and Street Edge Zone								
Toolbox:	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft
<i>Shoulder</i>	2	2	4	2	4	2	4	2
Motor Vehicle and Transit Zone								
Toolbox:	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft
<i>Outside Travel Lane Width</i>	11	10	11	10	11	10	11	11
<i>Interior Travel Lanes Width</i>	n/a	n/a	n/a	n/a	11	10	11	10
<i>Median Width</i>	n/a	n/a	n/a	n/a	12	11	14	11

- A. All dimensions in Table 2-3 are measured from face of curb or center of stripe

1. If double yellow center line is proposed, measurement is to center of double yellow
- B. All non-curbed and gutter streets shall be paved shoulder edge treatment
- C. A center turn lane may replace median width and be minimum of 10 ft wide with approval of City Transportation Engineer, applicable Director, or their designee.
- D. Shared use paths are the recommended facility on Level 2, 3, and 4 Streets without curb and gutter, and shall be placed on both sides of the street. If shared use paths are not used, pedestrian facilities are required on the street on both sides and a 5 ft shoulder shall be provided on both sides of the street to accommodate bikes.
- E. Refer to the **Drainage Criteria Manual** for ditch width on non-curbed and guttered streets. The width of the ditch shall be enough to convey 100-year flow.
- F. Streets in a Planned Unit Development (PUD) district shall comply with the **Fire Code**.

2.7.3 – Application of Flexible Design Criteria

After accounting for required right-of-way per the **ASMP**, some street typologies will require flexible design to be applied to assemble a cross section. When applying flexible design criteria, the following process generally applies for streets that cannot be designed to include the recommended street element widths in **Section 2.7.1** in the existing or required right-of-way:

- A. **Apply Compact Design:** Apply constrained dimensions for design elements such as travel lane widths, sidewalks, parking, and bike lanes until the street typology can be achieved within the right-of-way required. Right-of-way shall be prioritized for elements falling outside the Motor Vehicle and Transit Zone to achieve recommended element widths. In constrained circumstances, compromises shall be made to all modes in a balanced way that achieves the best possible alignment to **ASMP** goals. Depending on the degree of constraints, this scenario can require detailed design and engineering for approval by the applicable department. The number of travel lanes shall be as shown in the **ASMP** or through consultation with staff and approved administrative guidelines, if the street is not in the **ASMP** or built in a phased manner. An alternate orientation of street trees and bike facilities behind the curb for curbed and guttered streets may be used for projects on Transit Priority Corridors as defined in the **ASMP**, with specific criteria for this orientation in **Section 2.7.3.2**.
- B. **Prioritize or Privatize Elements:** When it is unlikely that additional right-of-way can be acquired or dedicated and compact design is not sufficient to achieve the desired street typology with all street elements, prioritization or privatization of design elements shall be considered in conjunction with staff. In some cases, a portion of the private realm may be dedicated to another use, such as a pedestrian realm (sidewalks, buffer, lighting, etc.). The **LDC** allows for placement of behind the curb transportation system improvements to be placed in public access easements as approved by the City Transportation Engineer or applicable Director.

2.7.3.1 – Established Streets Design

When an existing street is built with the number of lanes specified in the **ASMP**, it is defined as an “established street”. When designing modifications to an established street, constrained street element widths in **Table 2-4** for the Bicycle and Street Edge Zone and Pedestrian Zone must be maintained for street elements outside of the existing curb lines. In constrained circumstances, compromises shall be made to all modes in a balanced way that achieves the best possible alignment to **ASMP** goals.

An applicant developing land adjacent to an established street may proceed with one of two options, with **applicable department** approval, when inadequate space exists in the required right-of-way from the **ASMP** to fit street design element constrained widths:

- A. Dedicate additional right-of-way or public easement: Adjacent landowner may dedicate additional right-of-way beyond **ASMP** requirement to accommodate constrained street elements in the Bicycle and Street Edge and Pedestrian zones. Alternatively, pedestrian zone elements may be privatized or placed in a public easement with applicable transportation staff approval.
- B. Rebuild street with compact design: If the required right-of-way from the **ASMP** can accommodate a compact design, but requires street reconstruction, the adjacent land owner may rebuild the Motor Vehicle and Transit Zone within the right-of-way, maintaining constrained street element widths in Table 2-4 in addition to street elements in the Bicycle and Street Edge Zone and Pedestrian Zone, without dedicating additional right-of-way or Public Easement.

The following Table 2-4 represents the recommended and constrained widths of the Bicycle and Street Edge and Pedestrian Zones, based on Table 2-2:

Table 2-4 – Established Street Zone Minimums

Zone:	Level 2		Level 3		Level 4	
	Recommended ft	Constrained ft	Recommended ft	Constrained ft	Recommended ft	Constrained ft
<i>Bicycle & Street Edge Zone</i>	11	8.5	12	9	12	10
<i>Pedestrian Zone</i>	16	12.5	17	13.5	19	13.5

The flow chart in Figure 2-11 illustrates the process of flexible street design for different scenarios presented in this Section.

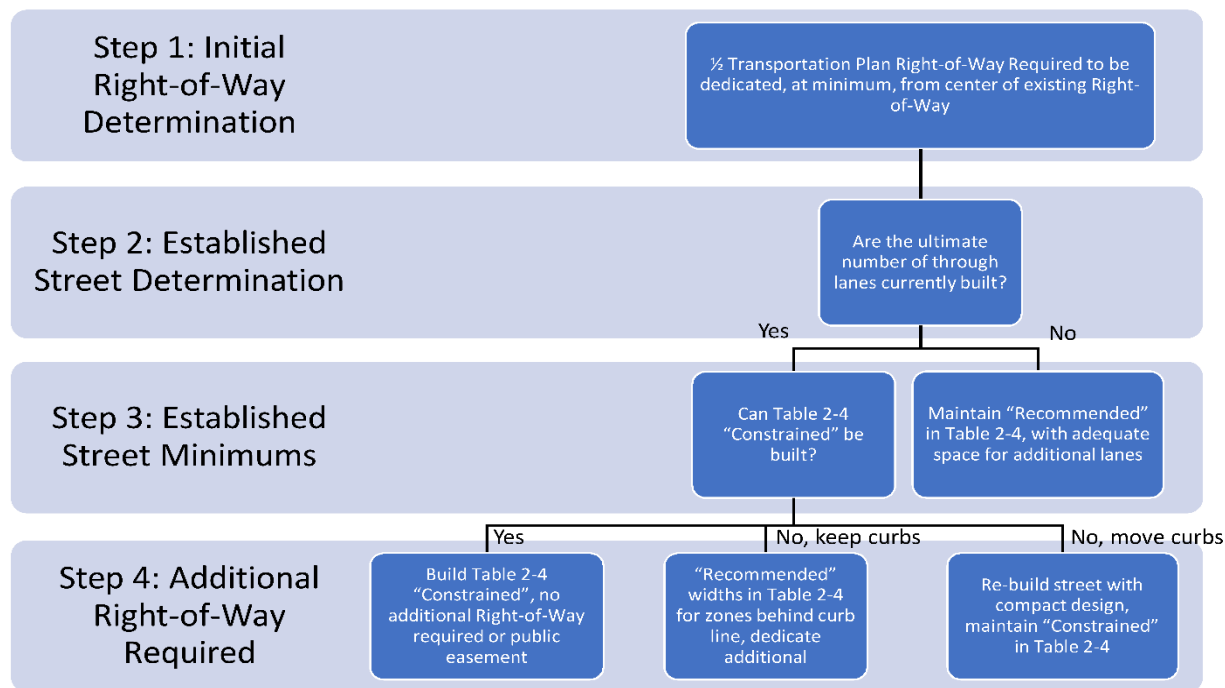


Figure 2-11 – Flexible Design Process

2.7.3.2 –Alternative Back of Curb Design

Transit Priority Corridors as defined in the ASMP [Street Network Table](#) and [Street Network Map](#) and corridors in the Corridor Construction Program shall be designed in accordance with the Corridor Design Standards, which allow for an alternative back of curb design than presented in this manual. Figure 2-12 illustrates the recommended widths and orientation for placing street trees at the back of curb, in lieu of a protected bike facility and bike buffer. This alternative configuration shall be used at staff direction for bicyclist and pedestrian safety and comfort and requires approval by City Traffic Engineer, applicable Director, or their designee on Level 3 or higher streets.

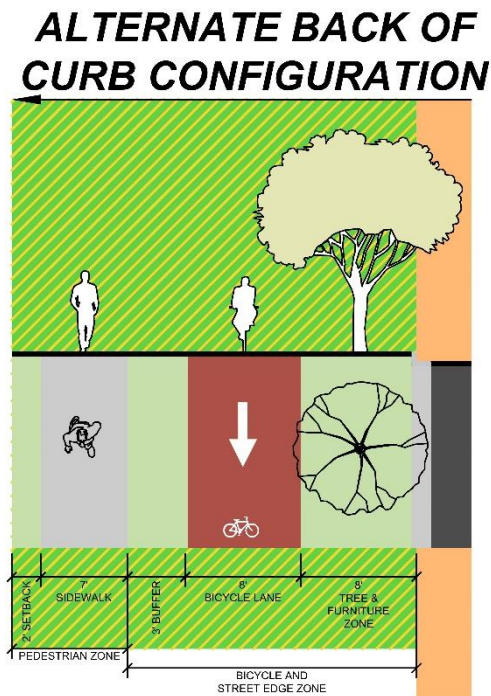


Figure 2-12 – Corridor Mobility Alternate Back of Curb Configuration

When the design in Figure 2-12 may not be practical or possible due to a constraint, the following criteria are allowable to make trade-offs to deal with special conditions that preclude desired treatments (e.g., utility conflicts, heritage trees, slopes, etc.):

- A. If insufficient right-of-way exists after reducing to constrained dimensions in **Table 2-2** and easements are unobtainable, reduce the width of the tree zone by placing the tree in a continuous trench with a suspended paver system, maintaining soil area around trees in **Section 2.7.1.3**.
 1. If a protected or heritage tree is in the right-of-way, ensure paved areas fall outside the half critical root zone. If this is not possible, consult with City Arborist for acceptable mitigation strategy.
- B. Shared Use Paths may additionally be considered if right-of-way is still not sufficient after applying reduction in (A) to fit remaining constrained element widths.

- C. If tree placement conflicts with underground utilities, based on the requirements provided in Section 1.10.10.4 of the **Utilities Criteria Manual**, the tree zone may be adjusted to be clear of the existing utility, provided that the constrained dimensions are maintained in **Table 2-2**.
- D. If tree placement conflicts with overhead electric lines, due to the desired type of tree species being placed based on the requirements provided in Section 1.10.10.4 of the **Utilities Criteria Manual**, the standard treatment is to adjust the tree and furniture zone to back of curb or in an easement to meet those requirements. This design criteria shall be applied on a street block basis and maintain uniform placement between two intersecting streets.
 - 1. If the desired type of tree species to be placed cannot be obtained by alternate placement, a utility compliant tree per Appendix F of the **Environmental Criteria Manual** may be used so long as the requirements provided in Section 1.10.10.4 for any tree species can be met. Outside of the conflict area, larger trees shall be used.

2.7.4 – Downtown Street Design

Downtown streets, as defined in **Figure A-2** in Appendix A, shall be designed in compliance with the latest adopted version of the Great Streets Master Plan.

2.8.0 – Typical Cross Sections

The cross sections presented in this section are broken up by Street Level, described in **Section 2.4.0**, and by street drainage type, described in **Section 2.3.0**. For each Street Level, this section will visually display compliant design examples for the most common street typologies found in the **ASMP**. The cross sections presented are not intended to be comprehensive for every street in the City. The typical cross sections included do not account for the additional right-of-way space that may be required for exclusive space for transit operations but are accounted for in the **ASMP**. In addition, cross sections do not account for the additional 14 ft of right-of-way required near intersections as specified in the **ASMP**. Right-of-way corner clips shall be provided for 15 ft in both directions at the intersection of rights-of-way. Further engineered design will be required along Project Connect transit corridors as defined in the Project Connect Design Criteria, which may supersede the criteria of this manual, subject to the final approval of the City Traffic Engineer, or applicable Director. In scenarios when right-of-way is not available for the cross section associated with a street typology shown in the **ASMP**, consideration will be given to use of narrower cross section options outlined in this section or be developed based on flexible design criteria outlined in **Section 2.7.0**.

Cross sections presented are not intended to be standardized for design except for Level 0 Streets (**Section 2.8.2.1**), Level 1 Streets (**Section 2.8.2.2**) and Level 2 Streets (**Section 2.8.2.3**). Level 5 Streets tend to be freeway type facilities that are governed not by the City code, but by a separate set of guidelines prescribed by other jurisdictional entities. Facilities not governed by City Code are governed by either State or County code and guidelines.

2.8.1 – Basis for Typical Cross Sections

Cross sections were assembled using the recommended and constrained widths as limits for street elements shown in the flexible design Tables 2-2 and 2-3 in **Section 2.7.0**. The most common combinations of required right-of-way and Street Level, as defined in the [Street Network Table](#) and [Map](#) in the **ASMP**, were utilized as a basis for the cross sections presented in this Section.

Where specified right-of-way is available, street elements are shown at the recommended element width, and in other cases street elements may be presented at the constrained width. In extremely constrained situations, flexible design shall be applied using mode priority in **Section 2.1.1** or street elements privatized, which is further elaborated on in **Section 2.7.3**. Mode priorities and other design considerations may warrant increasing or decreasing the widths of certain street elements to achieve the appropriate cross section at the discretion of the City Transportation Engineer, applicable Director or their designee.

2.8.2 – Curbed and Guttered Streets

The following are typical cross sections in the City of Austin for a given combination of Street Level and required right-of-way per the **ASMP**. **Section 2.8.3** contains typical cross sections for non-curbed and guttered streets where permissible with director approval in the area designated in Figure 2-9. All measurements in the cross sections herein are measured from face of curb (denoted as “FOC” in figures) or center of stripe.

2.8.2.1 – Level 0 Streets

The following cross sections represent Level 0 Streets. These streets represent alleys that provide alternative access methods off other streets. Design of Level 0 Streets does not vary greatly and is bounded by the paved surface width and right-of-way width. The two presented cross sections are for commercial (Figure 2-13) and residential (Figure 2-14) uses.

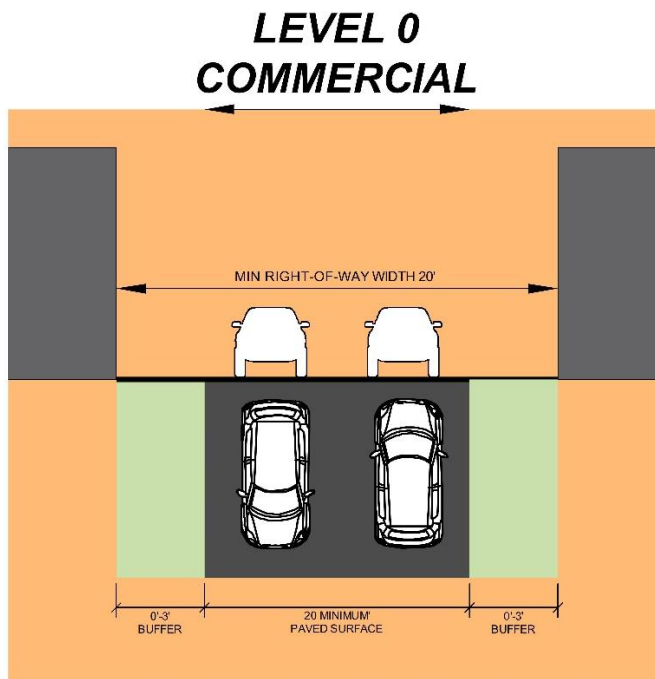


Figure 2-13 – Level 0 Commercial Street

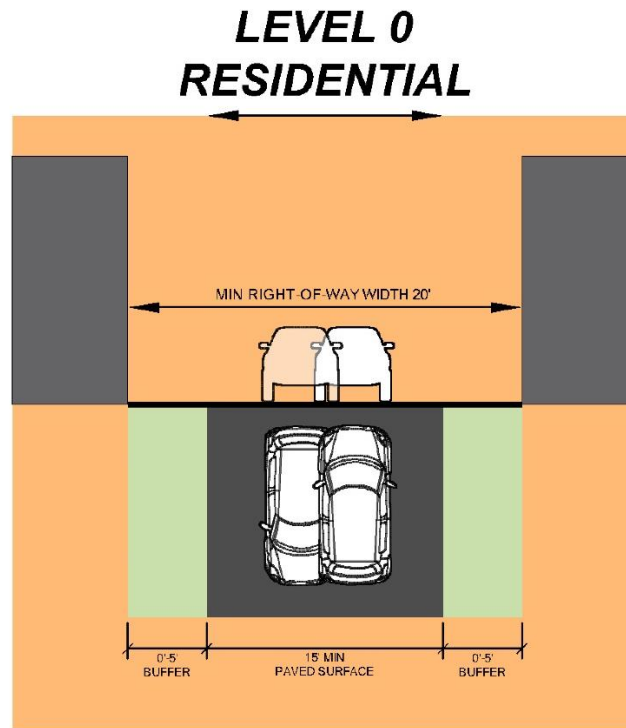


Figure 2-14 – Level 0 Residential Street

2.8.2.2 – Level 1 Streets

The cross-section below represents the standard design of Level 1 Streets for new residential developments. Any retrofit of an existing Level 1 Street or non-residential Level 1 Street should be designed in consultation with applicable staff.

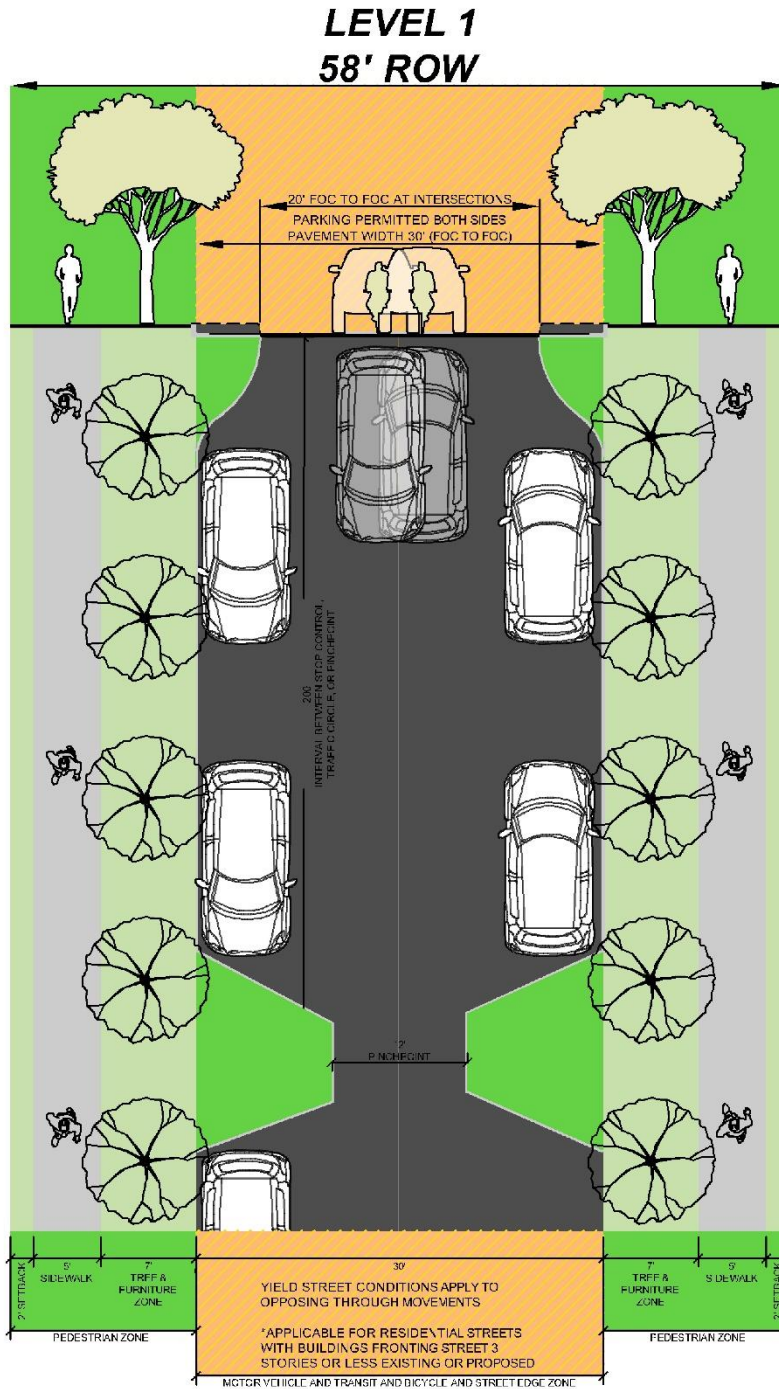


Figure 2-15 – Level 1 58 ft Street

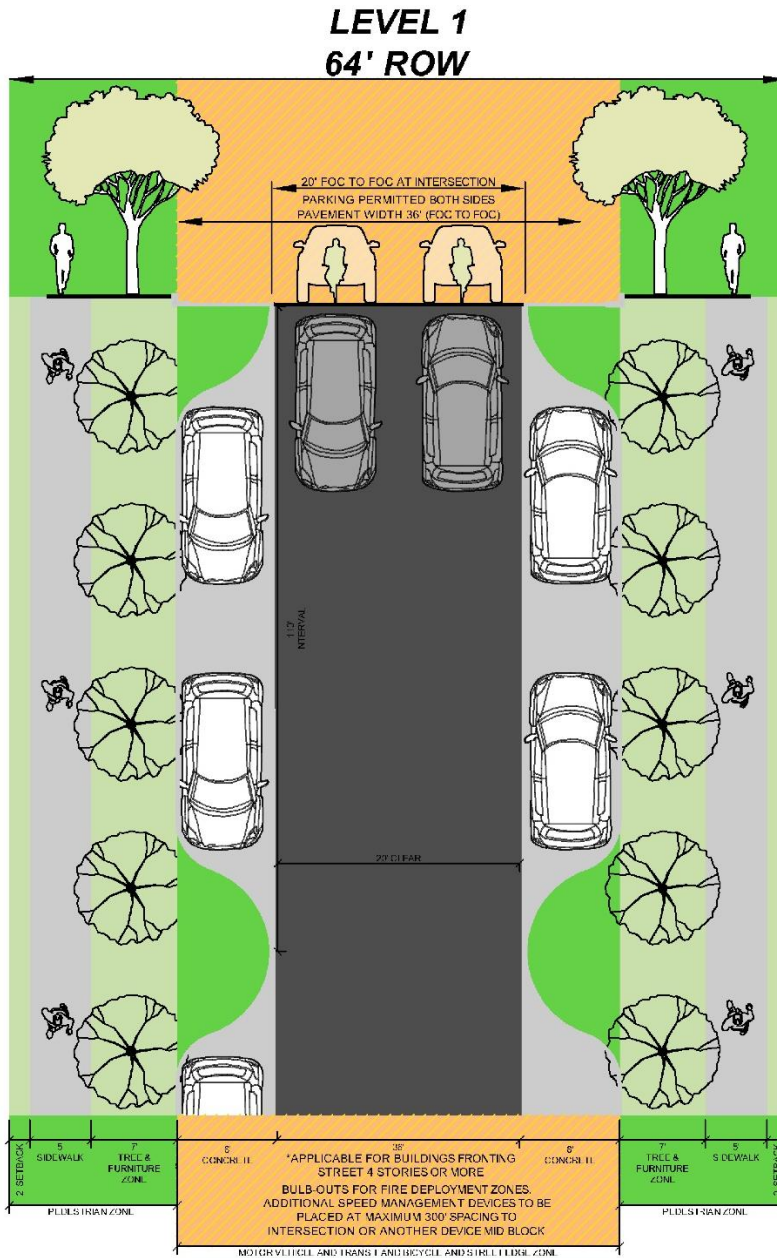


Figure 2-16 – Level 1 64 ft Street

2.8.2.3 – Level 2 Streets

The following cross sections represent typical sections for Level 2 Streets. Recommended and minimum widths of street elements are provided in **Section 2.7.0** for scenarios where the Street Level and right-of-way do not align with a typical cross section.

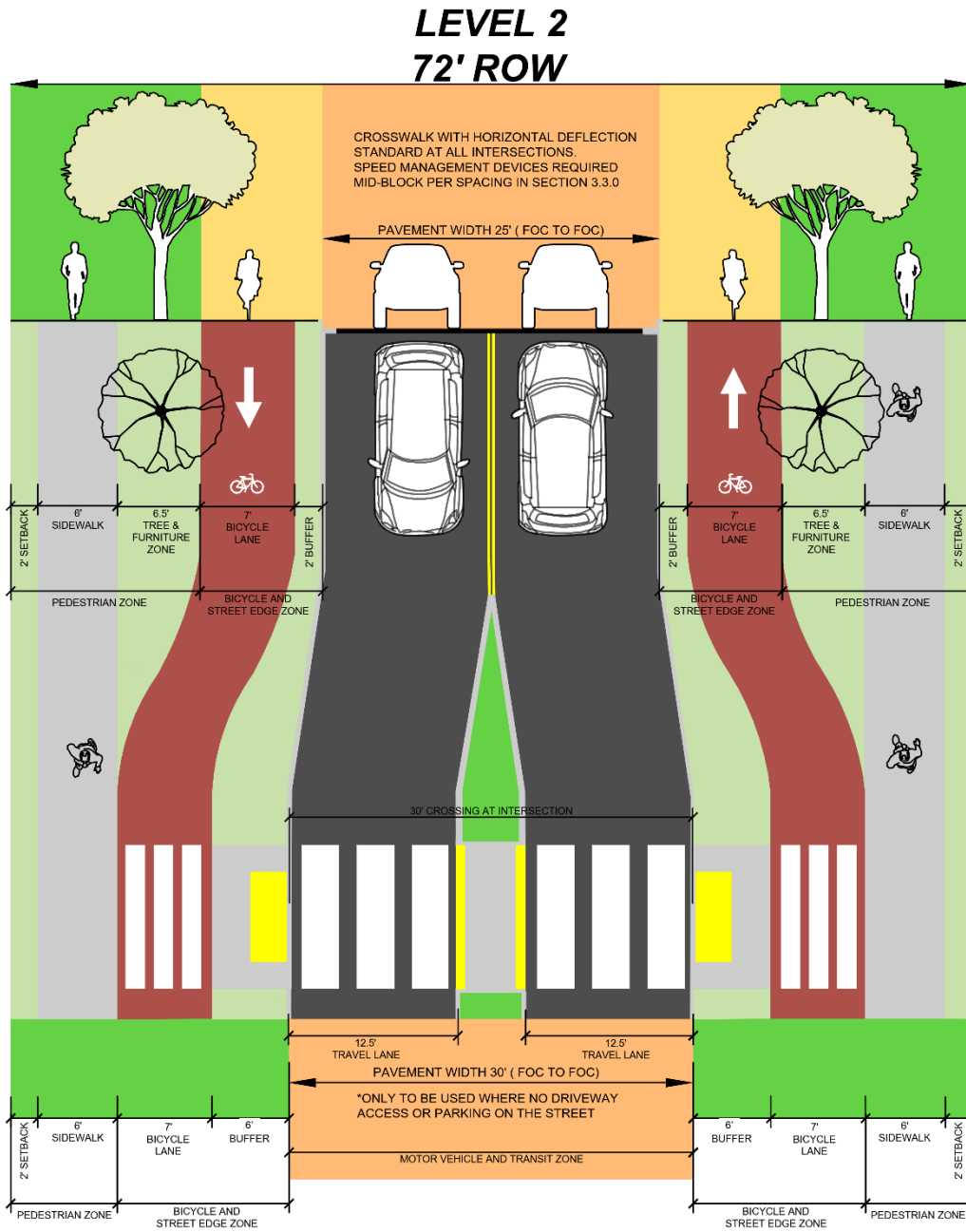


Figure 2-17 – Level 2 72 ft Street

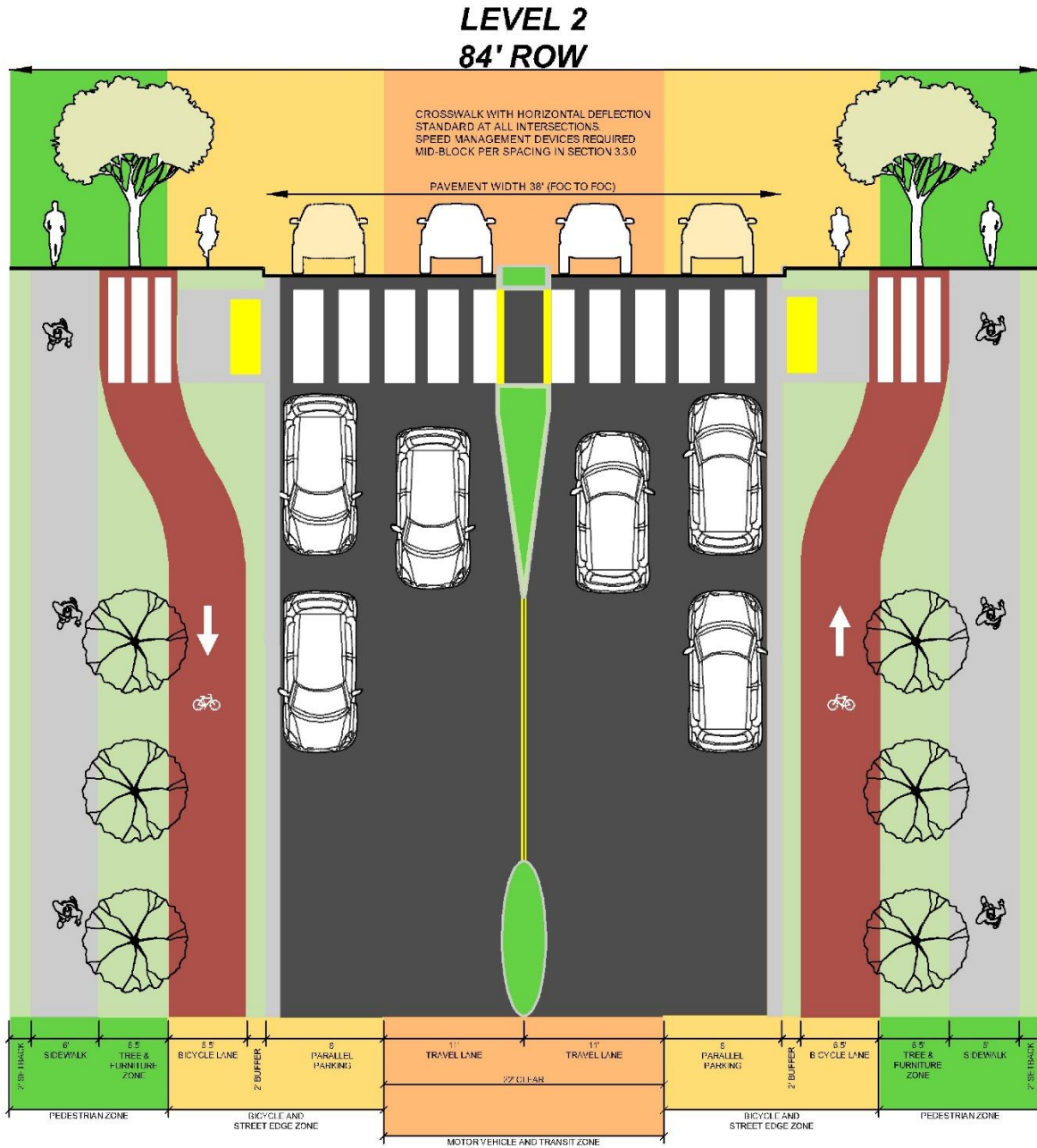


Figure 2-18 – Level 2 84 ft Street (Parking Both Sides)

2.8.2.4 – Level 3 Streets

The following cross sections represent typical sections for Level 3 Streets. Recommended and minimum widths of street elements are provided in **Section 2.7.0** for scenarios where the Street Level and right-of-way do not align with a typical cross section. **Section 7.3.1** prohibits minor driveways on Level 3 Streets.

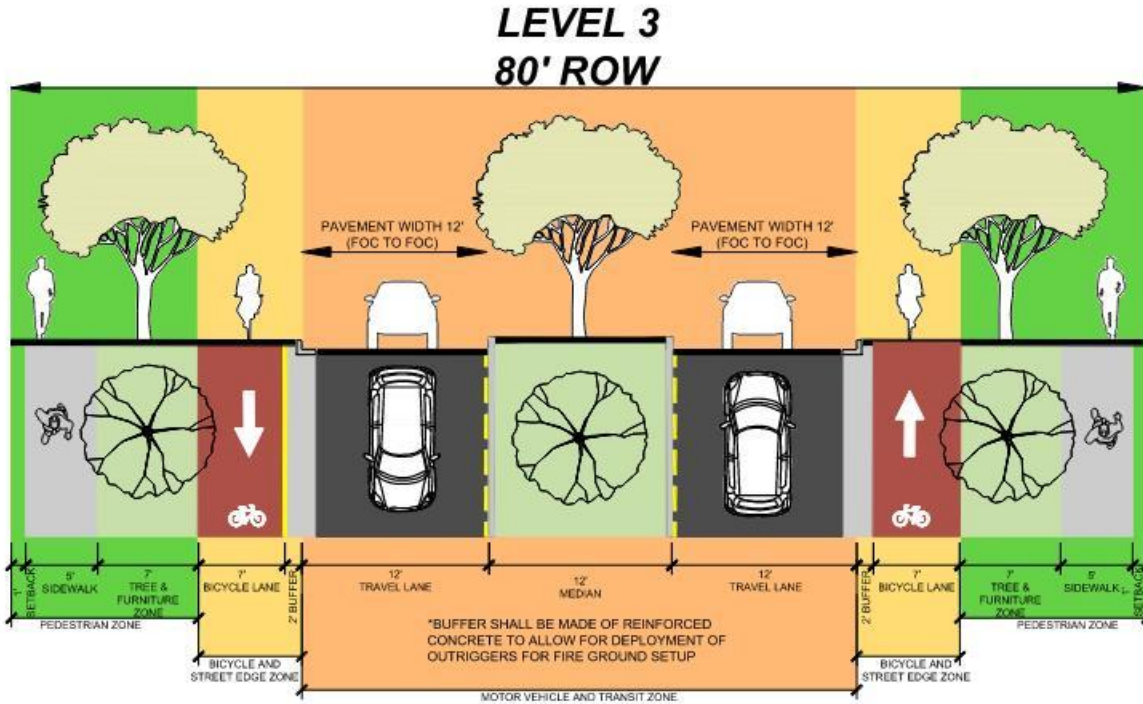


Figure 2-19 – Level 3 80 ft Street (Constrained Dimensions)

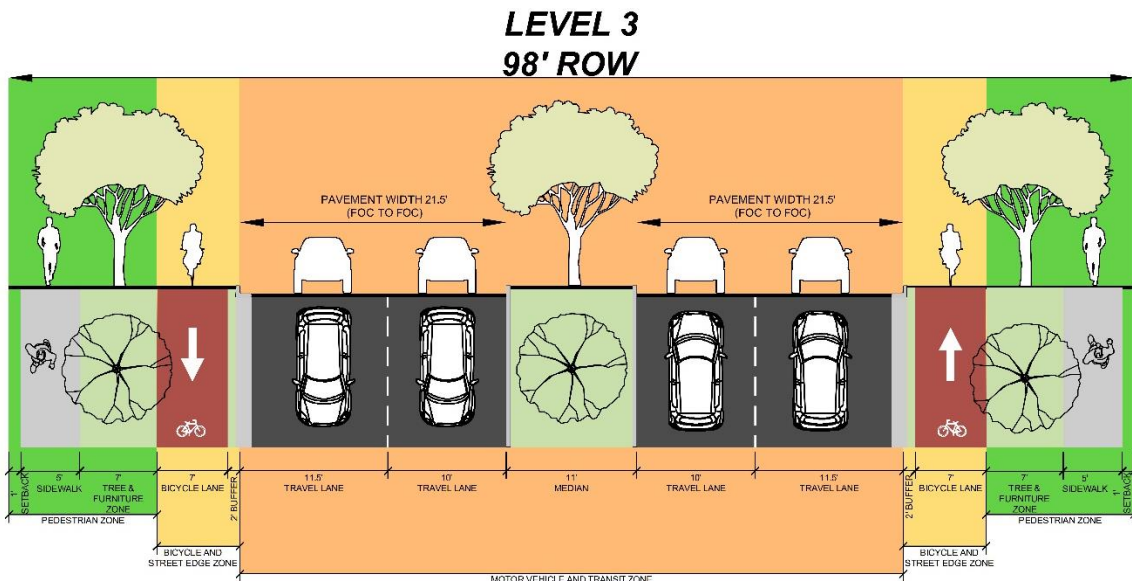


Figure 2-20 – Level 3 98 ft Street (Constrained Dimensions)

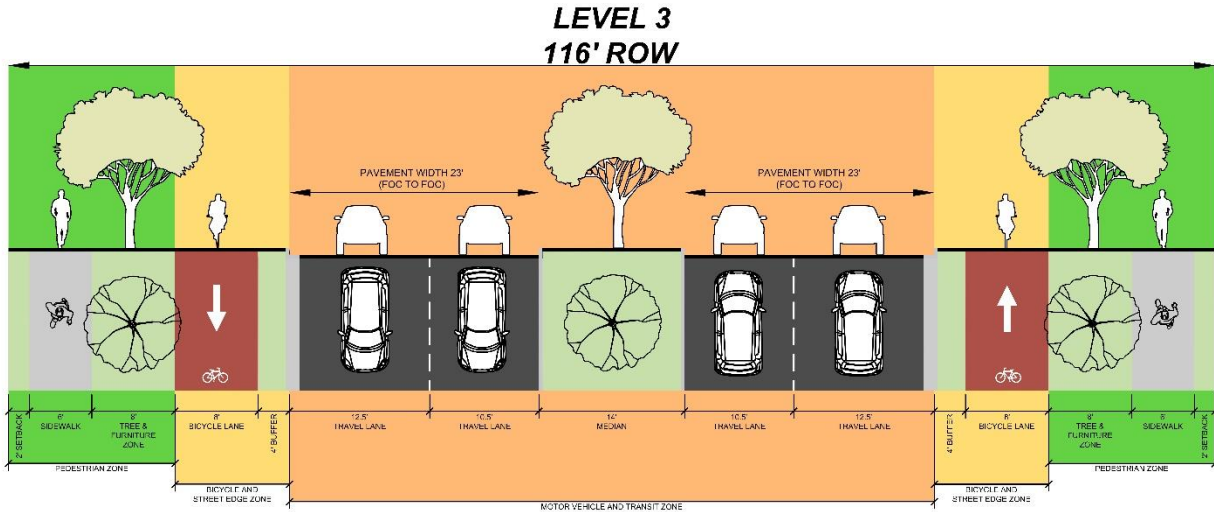


Figure 2-21 – Level 3 116 ft Street (Recommended Dimensions)

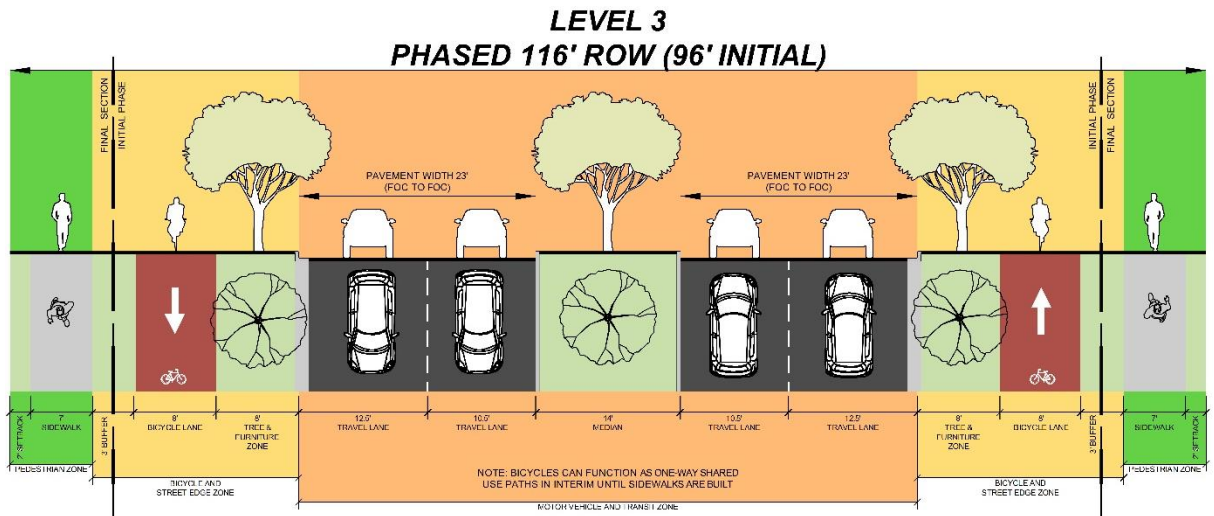


Figure 2-22 – Level 3 Phased 116 ft Street (for CIP projects, Recommended Dimensions)

Figure 2-22 represents an alternative approach to building a 4-lane divided 116 ft Level 3 Street when right-of-way may need to be acquired in a piecemeal fashion as properties develop along a corridor. In the short term, the area shown as a bike lane can function as one-way shared use paths until sidewalks are built and additional right-of-way acquired during redevelopment. This phased approach is intended for use on capital improvement plan projects only and not for use by applicants.

2.8.2.5 – Level 4 Streets

The following cross sections represent typical sections for Level 4 Streets. Recommended and minimum widths of street elements are provided in **Section 2.7.0** for scenarios where the Street Level and right-of-way do not align with a typical cross section. **Section 7.3.1** prohibits minor driveways on Level 4 Streets.

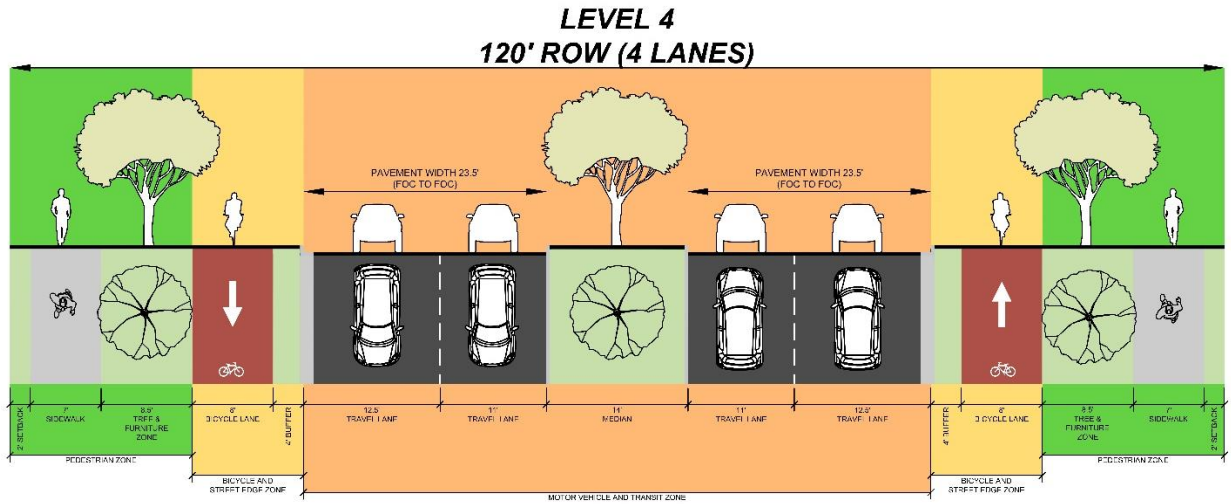


Figure 2-23 – Level 4 120 ft Street (4 Lane – Recommended Dimensions)

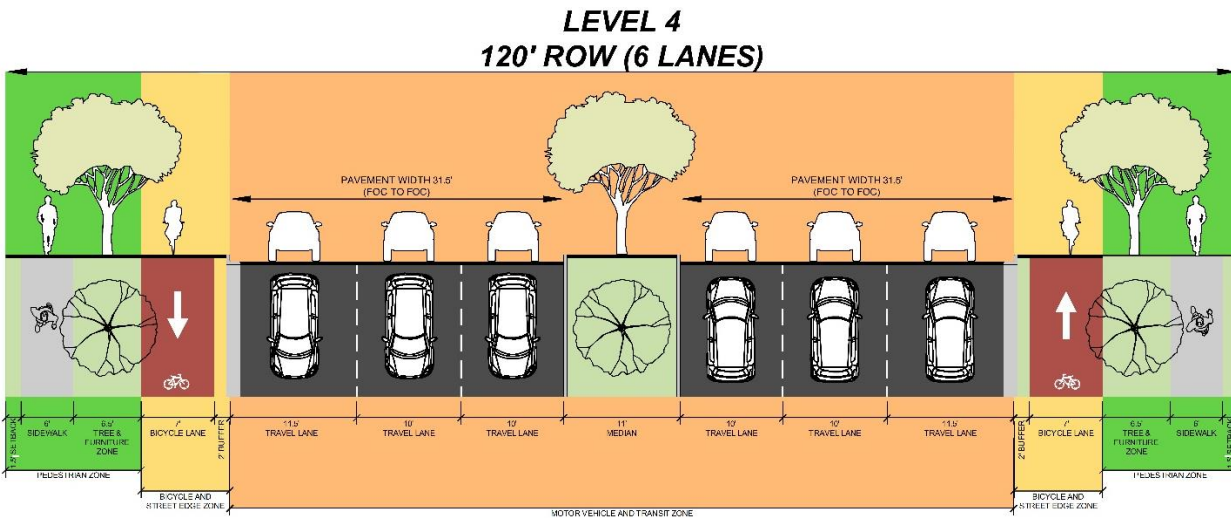


Figure 2-24 – Level 4 120 ft Street (6 Lane – Constrained Dimensions)

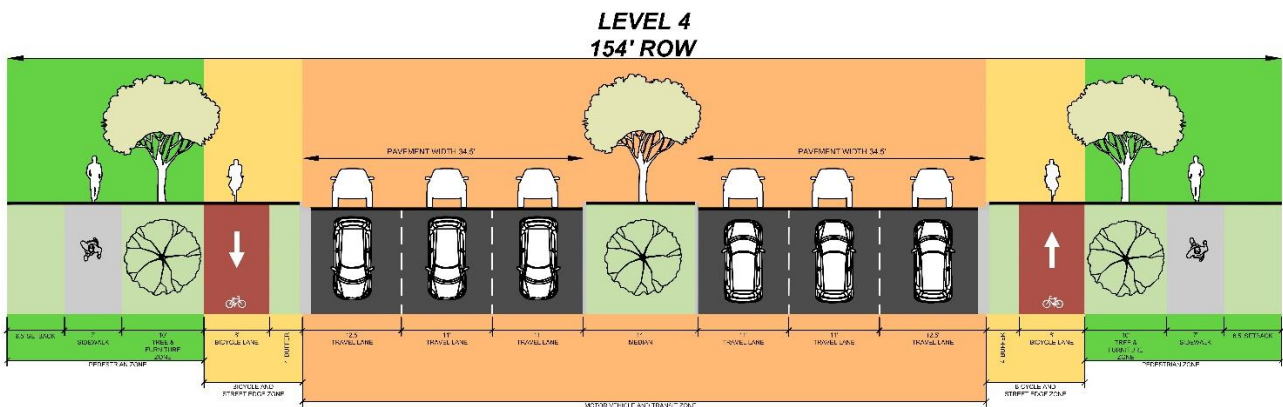


Figure 2-25 – Level 4 154 ft Street (6 Lane – Recommended Dimensions)

2.8.2.6 – Level 5 Streets and Level 4 Frontage Roads

This subsection only applies to Texas Department of Transportation (TxDOT) facilities. All Level 5 Street and Level 4 frontage road Street design shall conform with the current (TxDOT) design manuals and must be approved by the applicable TxDOT department directors. These streets are included in the bicycle and pedestrian networks of the **ASMP** and as such, are important parts of those networks to be completed either by development or larger capital projects. The desired amount and assignment of space behind the outside edge of pavement or curb is shown in Figure 2-24 for frontage roads.

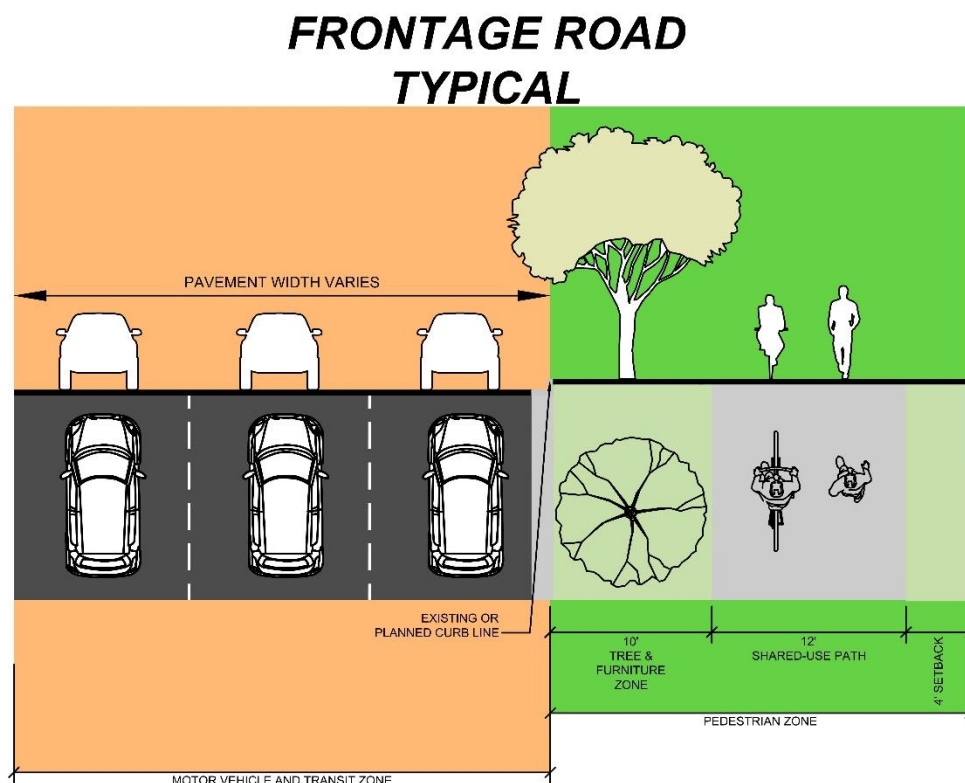


Figure 2-26 – Frontage Road Typical Streetscape

2.8.3 – Non-Curbed and Guttered Streets

The following cross sections represent typical sections for non-curbed and guttered streets previously defined in **Section 2.3.0** as a specific street drainage type. Recommended and minimum widths of street elements are provided in **Section 2.7.2** for scenarios where the Street Level and right-of-way do not align with a typical cross section.

LEVEL 1 - NO CURB OR GUTTER 58' ROW

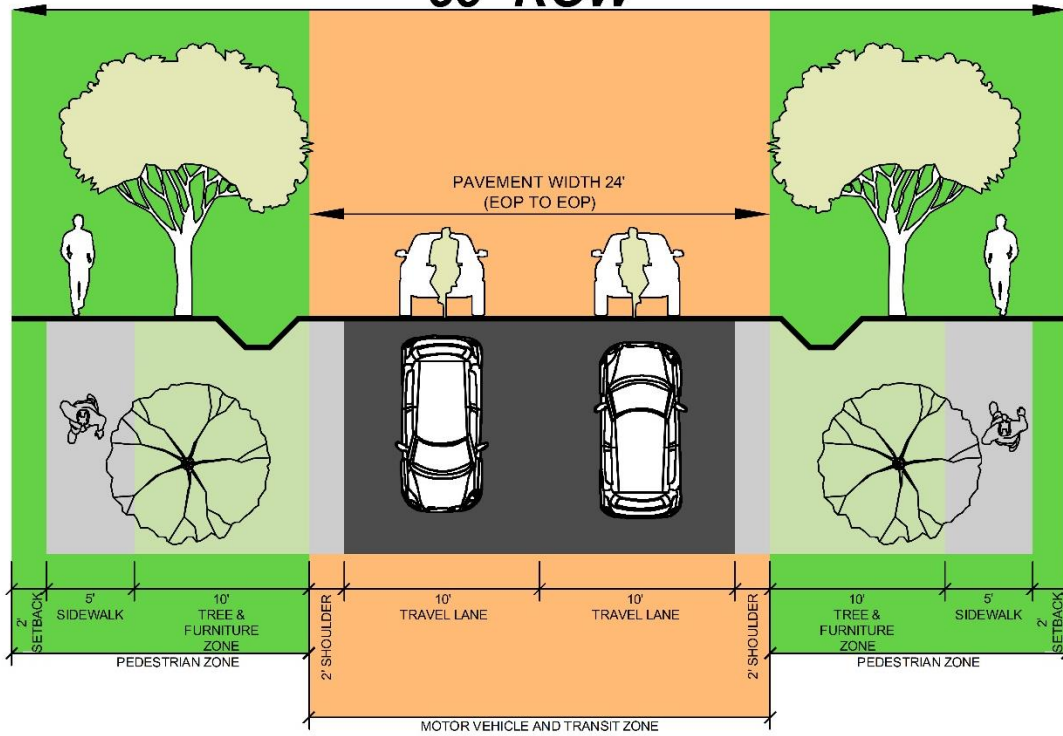


Figure 2-27 – Level 1 Non-Curbed and Guttered Street

LEVEL 2 - NO CURB OR GUTTER 80' ROW

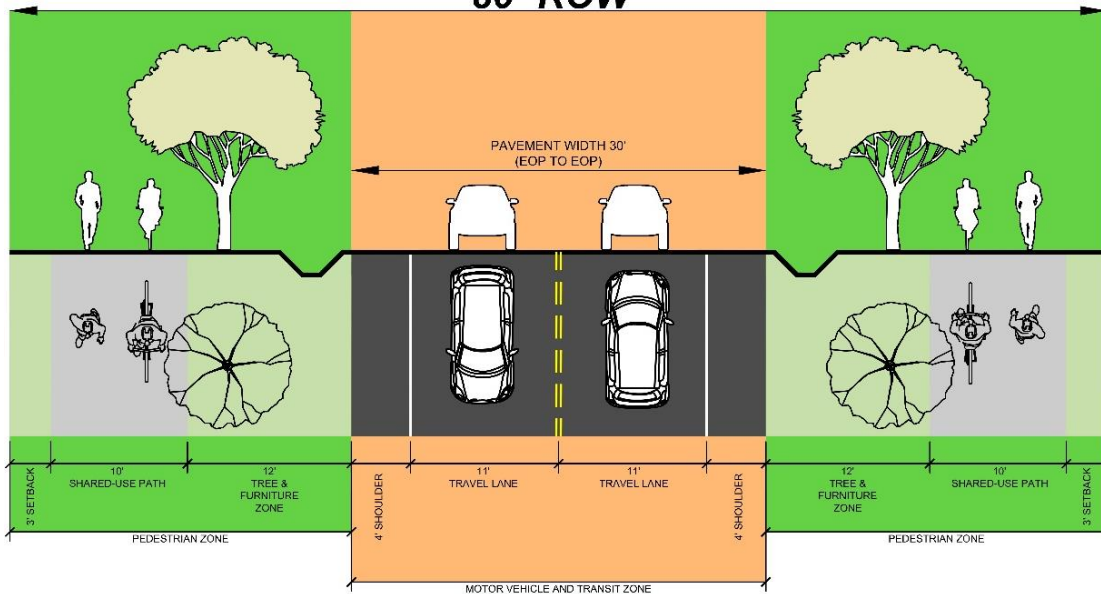


Figure 2-28 – Level 2 Non-Curbed and Guttered Street

LEVEL 3 - NO CURB OR GUTTER
100' ROW

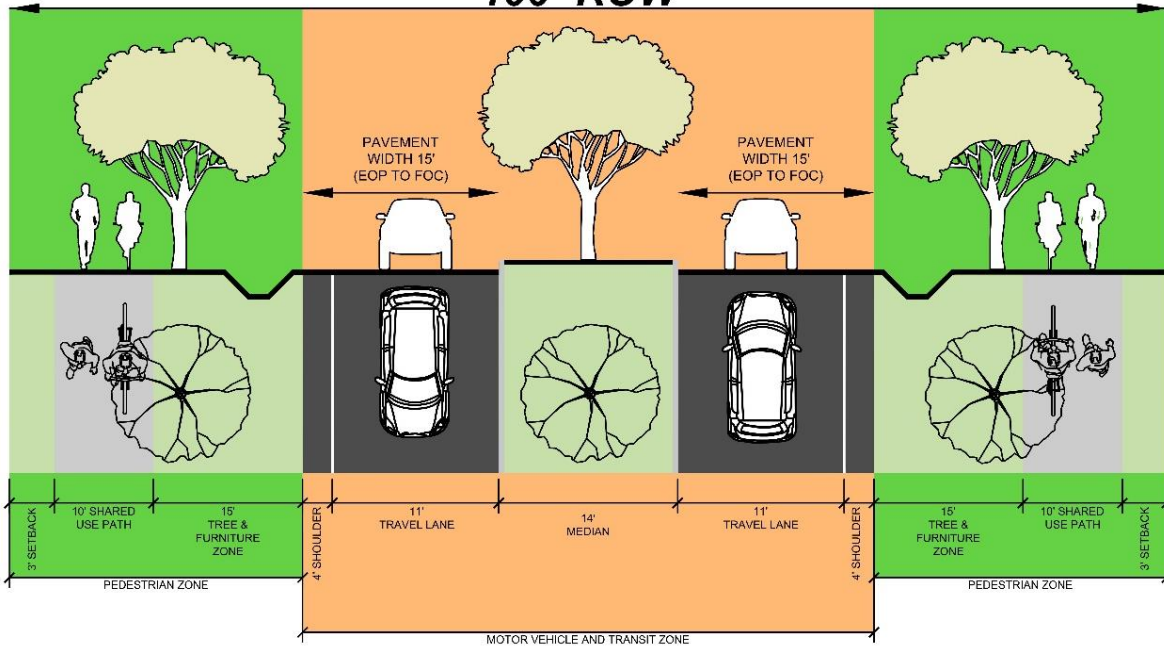


Figure 2-29 – Level 3 Non-Curbed and Guttered Street

LEVEL 4 - NO CURB OR GUTTER
120' ROW

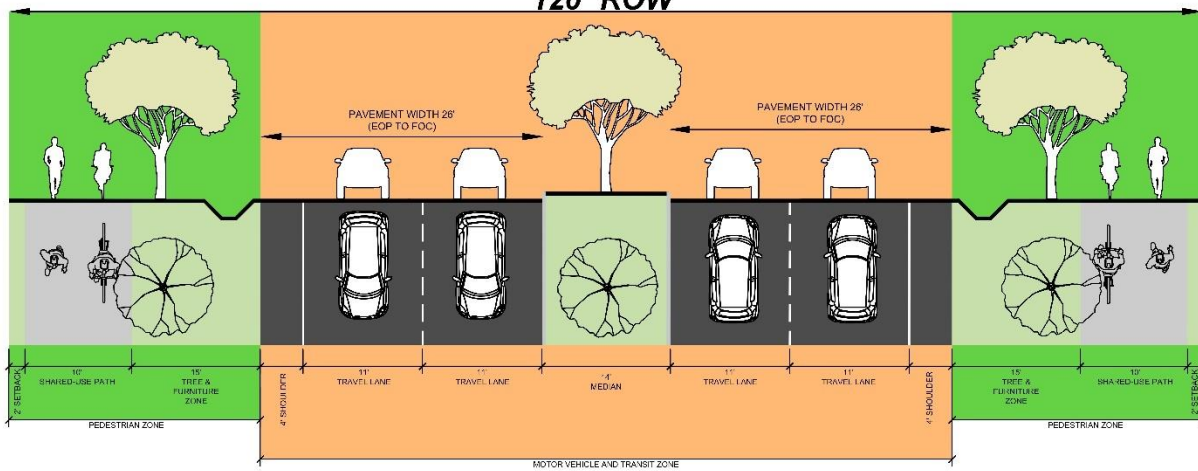


Figure 2-30 – Level 4 Non-Curbed and Guttered Street

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This section details the geometric design of various street elements contained within the Motor Vehicle and Transit Zone as defined in **Section 2.6.0**. This section expands upon the street typologies and specific elements of typical sections defined in **Section 2**, with specific details for design geometries for horizontal and vertical components of the street.

The purpose of this section is to assist City staff and private sector street design professionals in applying a consistent approach to street design, particularly new streets. The TCM is also intended to provide design requirements for street design in constrained right-of-way, as defined in **Section 2.7.1.3**, with flexible design criteria to fit existing conditions that make the preferred design unobtainable. In the redesign of existing streets, additional engineering design work and public engagement may result in design features outside of the scope of this manual. Highly constrained scenarios may vary from minimums or maximums presented in this manual with approval of the City Transportation Engineer, applicable Director, or their designee. In addition, City Capital Improvement Projects (CIP), Corridor Construction Program Standards, or Project Connect Design Criteria may supersede the requirements of this manual to align with highly localized contextual design, subject to final approval by the City Traffic Engineer or applicable Director.

3.1.0 – Designing for Safety

The criteria presented in the TCM are intended to meet the long-term goal of advancing transportation mode choice through investment and prioritization of non-automobile modes of travel and implementing measures to limit transportation demand. The criteria presented in this section are intended to promote safety for vulnerable street users by designing streets in a way that reduces the speed of vehicles, increases visibility of non-automobile modes, and prioritizes facilities that serve these street users. The ultimate goal of the City is to achieve a vision of zero deaths due to traffic related crashes.

3.2.0 – Design Controls

Geometric design of streets involves several horizontal and vertical features governed by safety, the natural environment, the dimensions of the vehicles using the street, and other elements within the Right-of-Way. It is necessary to define various design controls to determine facility dimensions to accommodate various vehicle types and road users. These design controls are factors that influence the geometry of the street and are used as a framework for general street design.

3.2.1 – Design & Control Vehicles

In order to balance the needs of vehicular and non-vehicular users of each street, careful attention needs to be placed on which vehicles are used in the design of streets. Vehicle types are broken into two categories, design vehicles and control vehicles. The design vehicle is the most frequent vehicular user of the street which regulates roadway design through more strict encroachment policies applied to a passenger design vehicle. The control vehicle is a less frequent larger vehicular user of the street that also regulates design but is allowed make wider turns and drive over mountable features in the roadway with less strict encroachment policies. **Figure 3-1** and **Figure 3-2** illustrate this concept further by showing how an intersection corner can be designed to accommodate a design and control vehicle differently. Street design must restrict street space to limit turning speeds.

As discussed further in **Section 3.6.2.2** the applicant shall use these vehicles when running turning simulations to determine street geometries. Reference **Section 3.6.2.2** for which design and control vehicle to use based on Street Level. Design and control vehicles vary greatly in size and turning behavior, the following figures and criteria outline the dimensions and driving characteristics of each vehicle, as well as a sample of a turning movement diagram that is required to be submitted by the applicant.

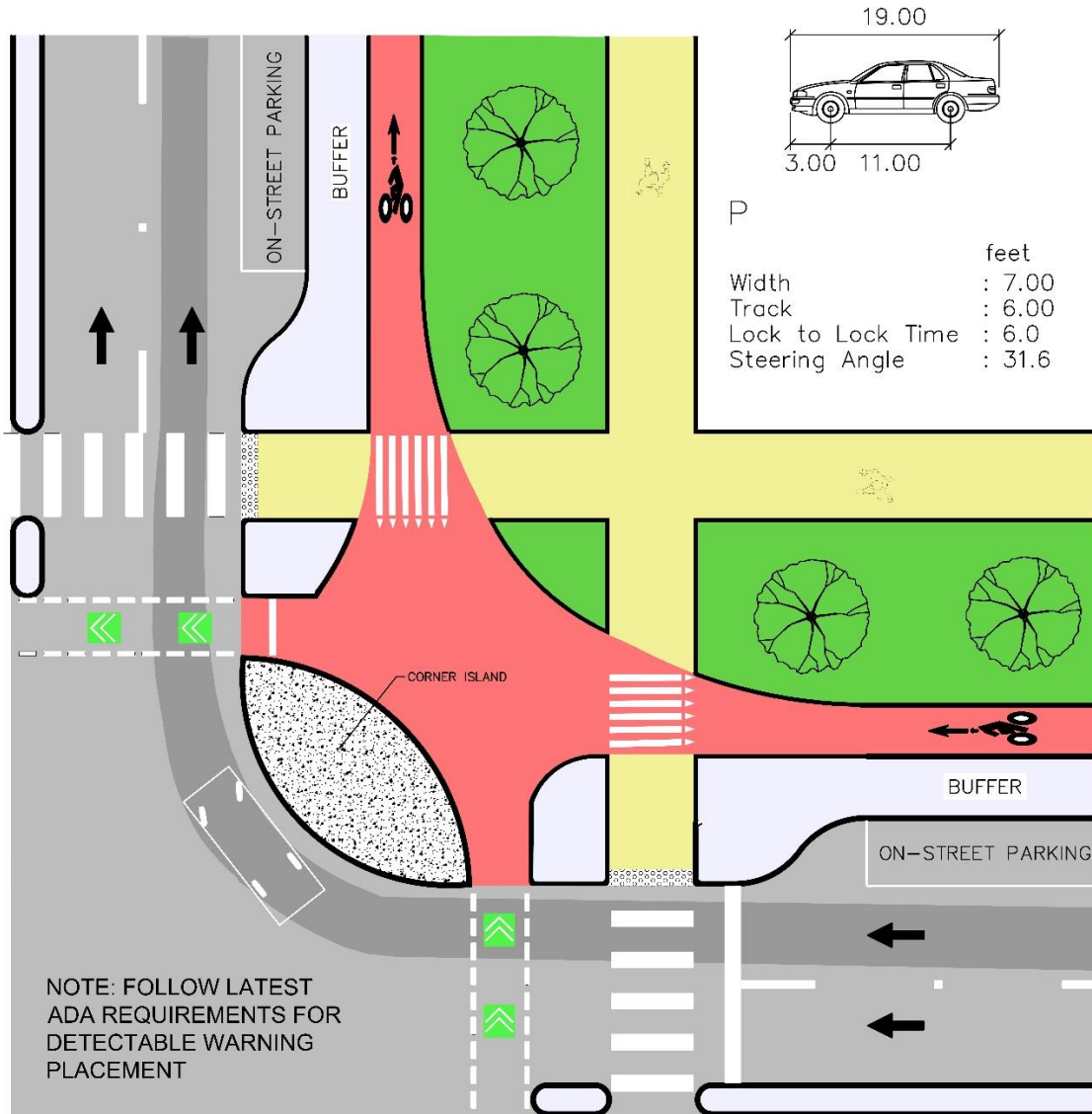


Figure 3-1 – Design Vehicle

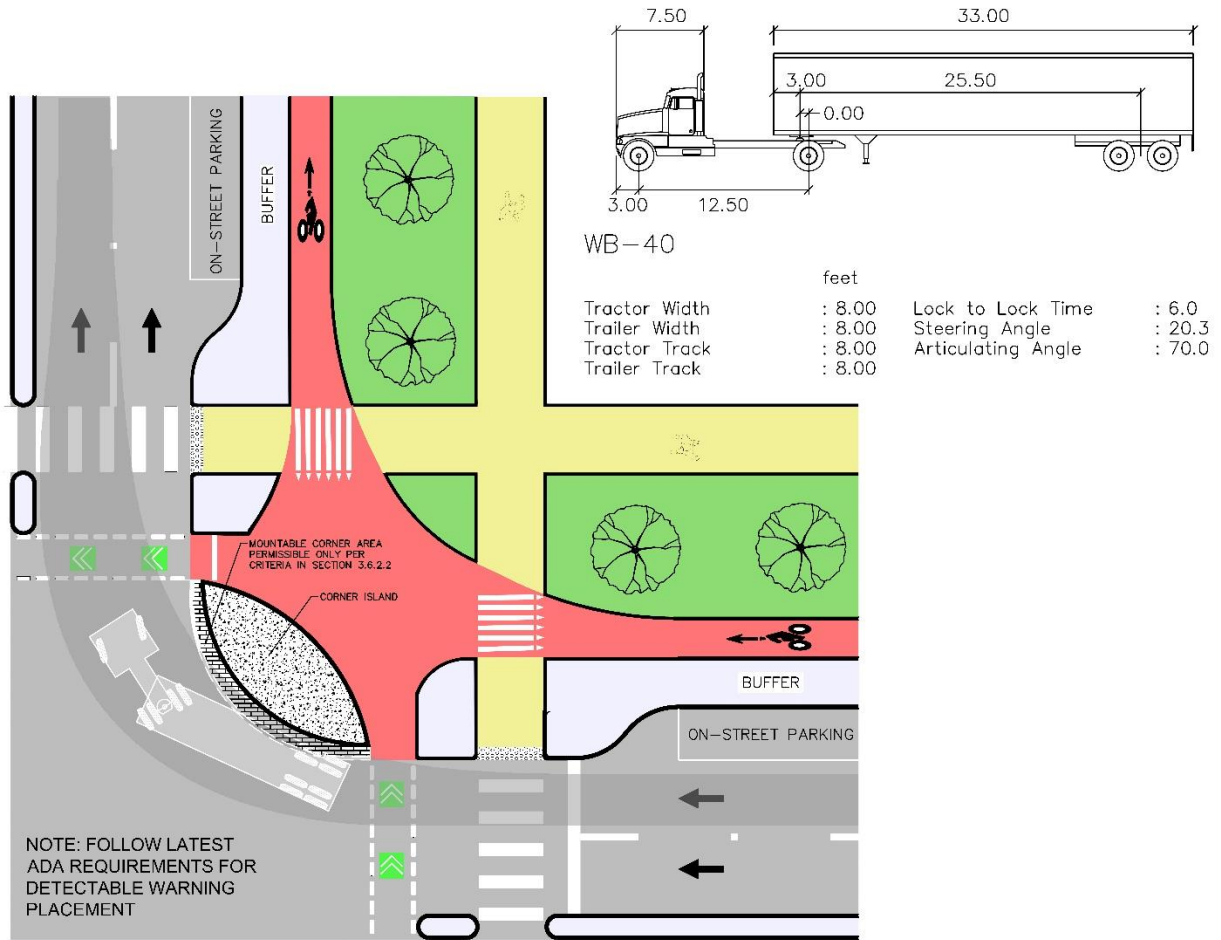


Figure 3-2 – Control Vehicle

NOTE: FOLLOW LATEST
ADA REQUIREMENTS
FOR DETECTABLE
WARNING PLACEMENT

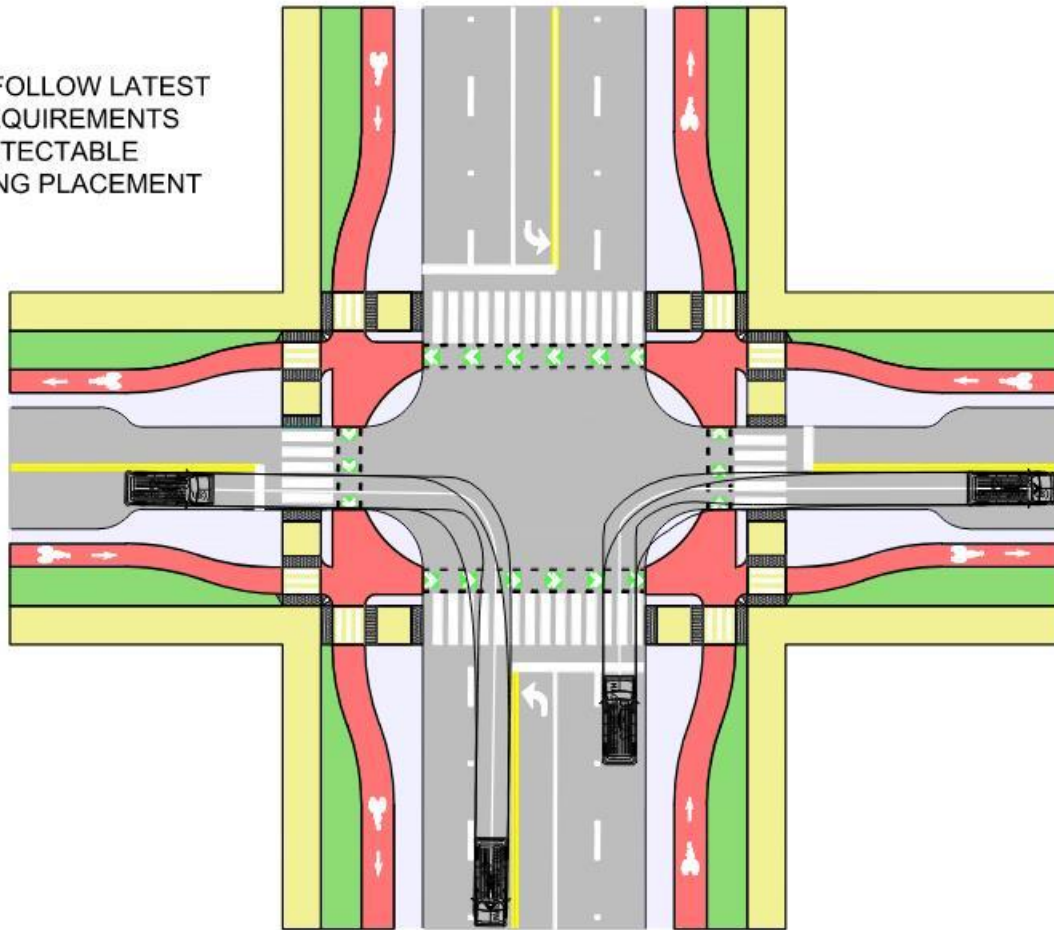
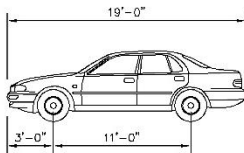


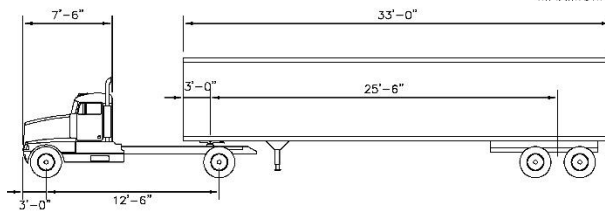
Figure 3-3 – Minor Intersection Swept Path Exhibit Example

PASSENGER VEHICLE



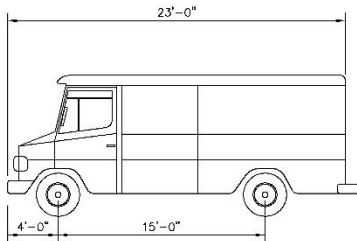
VEHICLE WIDTH: 7'-0"
MINIMUM *CTR: 21'
MAXIMUM STEERING ANGLE: 31.6°

WB-40 (INTERMEDIATE SEMITRAILER)



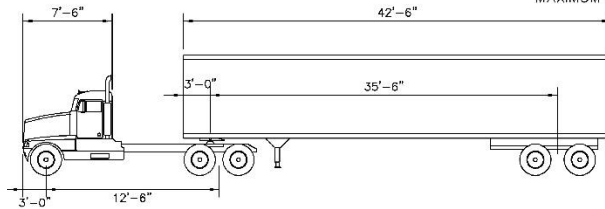
VEHICLE WIDTH: 8'-0"
MINIMUM *CTR: 36'
MAXIMUM STEERING ANGLE: 20.3°

DL-23 (COMMERCIAL TRUCK)



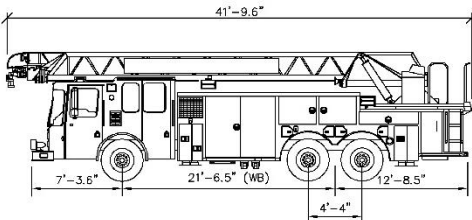
VEHICLE WIDTH: 8'-6"
MINIMUM *CTR: 41'
MAXIMUM STEERING ANGLE: 40.4°

WB-50 (INTERMEDIATE SEMITRAILER)



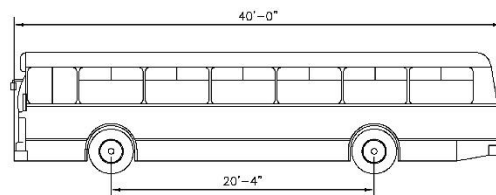
VEHICLE WIDTH: 8'-0"
MINIMUM *CTR: 46'
MAXIMUM STEERING ANGLE: 20.3°

FIRE TRUCK (100 AERIAL PLATFORM & BODY ASSEMBLY)

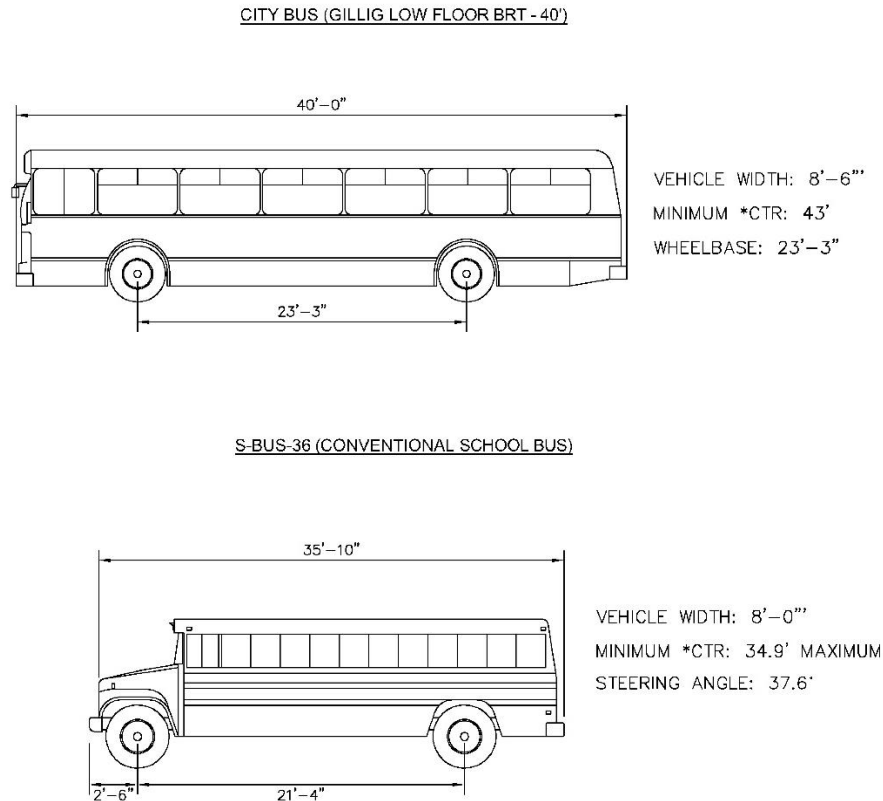


VEHICLE WIDTH: 8'-0"
MINIMUM *CTR: 49'-9"
MAXIMUM STEERING ANGLE: 34°

CITY BUS (METRORAPID NOVABUS - 40')



VEHICLE WIDTH: 8.5'
MINIMUM *CTR: 40'-10"
WHEELBASE: 20'-4"



- A. Prior to running turning simulations, the designer shall verify with applicable department what vehicle dimensions are currently accepted.
 - 1. Quint Fire Truck shall be simulations with loads showing the front bucket.
 - 2. Capital Metropolitan Transportation Authority (CapMetro) buses shall be simulated with bike racks down.
- B. Departments with vehicular fleets that shall be consulted for current design vehicles include:
 - 1. Austin Fire Department
 - 2. CapMetro

3.2.2 – Target Speed

The City of Austin uses target speed for design inputs. Target Speed refers to the speed at which vehicles should operate on a street in a specific context, consistent with the level of multimodal activity generated by adjacent land uses, to provide both mobility for motor vehicles and a safe environment for pedestrians and bicyclists.

Table 3-1 below provides guidance for selecting Target Speeds for each Street Level based on conflict density and activity levels. Before initiating design of new streets, capital improvement projects, or retrofits of existing streets, applicants must get pre-approval from the applicable department on selecting the appropriate Target Speed for the project to inform the geometric design features needed to achieve speeds at or below the Target Speed.

Table 3-1 – Street Level Target Speeds

Street Level	Street Context			
	High conflict density High activity	High conflict density Low activity	Low conflict density High activity	Low conflict density Low activity
Level 0	10 mph	10 mph	10 mph	10 mph
Level 1	20 mph or lower	20 mph	20 mph	20-25 mph
Level 2	20-25 mph	25 mph	25 mph	25-30 mph
Level 3	25-30 mph	30 mph	30 mph	30-35 mph
Level 4	30-35 mph	35 mph	35 mph	35-40 mph

- A. Activity level is determined by the level of potential pedestrian, bicycle, transit and stationary/public use on a street.

High activity streets include streets with any of the following characteristics:

1. Located on an Imagine Austin Activity Corridor or within Centers; OR
2. Located in the Urban Core (cite reference)
3. Located on the Transit Priority Network; OR
4. Located with a quarter-mile of a school or park; OR
5. Streets with primarily front-facing residential land use.

Low activity streets include all other streets.

- B. Conflict density is determined by the degree to which potential conflicts arise on a given street based on how much physical protection between modes the street offers and how closely spaced intersections and other crossing locations are.

High conflict density streets include all streets not defined as a low conflict street.

Low conflict density streets only include streets with ALL of the following characteristics:

1. Provides physical separation—including protected bicycle lanes or shared-use paths—for bicycles and micromobility devices; AND
2. Includes sidewalks or shared-use paths on both sides of the street; AND
3. No on-street parking or loading zones; AND

4. One or fewer intersections, driveways, curb cuts, or other crossing points per $\frac{1}{4}$ mile.
- C. After the target speed of the street has determined and approved, the target speed shall be used to select the design inputs outlined in the following sections.
 - D. On low conflict density, low activity streets the design of intersection sight distance, vertical curves, and horizontal curves shall be designed at 5 mph above the selected target speed in order to improve safety. By designing these street elements (curves and sight distance) to accommodate higher speeds, visibility should be improved for vehicles maneuvering into potential conflict points.

3.2.3 – Pavement Markings & Signs

- A. All signs and pavements markings shall comply with the latest edition of the TMUTCD.
- B. All plans with signs and striping in the City Right-of-Way must be approved by the **applicable department**.

3.3.0 – Designing for Speed Management

The operating speed of a street is the primary variable impacting the ultimate safety of the street. To achieve Vision Zero, speed must be managed carefully during the design of these streets. As outlined in **Section 3.2.2**, streets must be designed to the designated target speed so that lower operating speeds can be realized. Level 1 Streets are to operate at a speed of 20 mph and Level 2 Streets at a speed no greater than 30 mph. This is made possible through the application of various speed management techniques. These techniques also greatly improve pedestrian crossing safety and are to be used in conjunction with crossing locations as outlined further in **Section 4**.

This section outlines standardized speed management techniques for new Level 1 and Level 2 streets. Retrofits of existing streets with speed management devices shall be determined in consultation with applicable staff from the **applicable department** using the latest **administrative guidelines**. Alternative speed management techniques and associated design criteria are shown in Section 3.3.1 through Section 3.3.3. All speed management devices shall be installed per **City of Austin Standard Details**.

The following Figure 3-5 illustrates a toolbox of speed management design strategies on Level 1 and Level 2 Streets in the City of Austin.

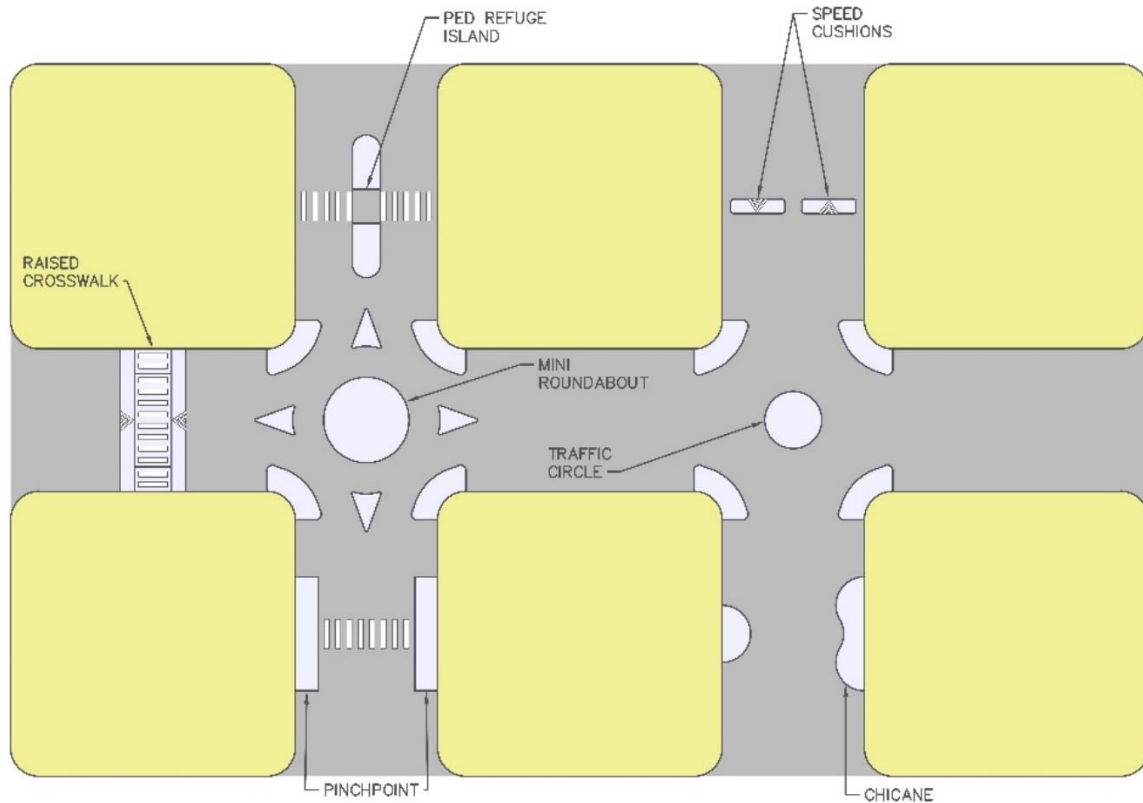


Figure 3-5 – Speed Management Strategies

Table 3-2 – Speed Management Spacing

Street Level	Maximum Spacing Between Treatments (ft)
Level 1	200
Level 2	300

- A. Speed management technique to be applied shall be approved prior to application by applicable staff of the applicable department if deviating from the following:
 - 1. The standard speed management device on Level 1 streets shall be a pinchpoint with 12 ft clear width. These shall be placed with spacing per Table 3-2 from another mid-block device or the nearest intersection with traffic circle, stop control, or raised intersection. **Section 2.8.2.2** includes Level 1 Street figures with speed management devices.
 - 2. The standard speed management device on Level 2 streets shall be a median island or painted median for horizontal deflection. These shall be placed with spacing per Table 3-2 from another mid-block device or at the intersection approach in tandem with a crosswalk. **Section 2.8.2.3** includes Level 2 Street figures with speed management devices.
- B. Speed management devices should be placed at least 5 ft from any driveway, entrance, curb cuts on Level 1 and 2 Streets except for median islands.
- C. Devices shall maintain a minimum spacing of 2 ft from manholes or utility poles or points of access.

3.3.1 – Vertical Deflection

Vertical deflection is an isolated increase in the normal pavement elevation that encourages the driver to slow vehicle speed. Raised crosswalks are the preferred method of vertical deflection on Level 2 Streets. Use of raised crosswalks encourages vehicle speeds to be slower at the point of conflict with pedestrians and bicyclists. When using vertical deflection, positive drainage shall be maintained to avoid ponding of water in the right-of-way.

3.3.1.1 – Speed Cushions

- A. Speed cushions shall be designed according to **City of Austin Standard Details**.

3.3.1.2 – Raised Crosswalk

- A. The raised crosswalk shall be from face of curb to face of curb in the traveled way.
- B. If bicycles operate in the street where a raised crosswalk is planned, bicycles shall transition across the raised crosswalk location with grades appropriate for their design speed. Maximum slope shall be 10% for ramps across a raised crosswalk when bicycles operate in the street.
- C. Raised crosswalks shall be designed so that the design vehicle does not bottom out traversing the raised crosswalk operating at 5 mph.

3.3.1.3 Speed Humps

- A. Speed humps shall be placed from lip of gutter to lip of gutter and designed to cause vertical deflection for vehicles passing through.

3.3.1.4 – Raised Intersection

Raised intersections include an effective speed hump from gutter to gutter at the approach from each direction resulting in a 3-6 in. deflection above street approaches in the intersection area. Raised intersections are applicable on Level 1 Streets.

3.3.2 – Horizontal Deflection

Horizontal deflection forces the driver to respond to a changing width or alignment of their anticipated travel path. This response typically results in a lowering of operating speed. Horizontal deflection can be implemented through the construction of a physical barriers or through the application of pavement markings with supplemental vertical devices. Pinch points and bulb-outs at pedestrian and bicycle crossings shall be used wherever possible in order slow vehicle speeds at pedestrian and bicyclist conflict points.

See **Section 3.5.2.2** for guidance on tapers when transitional shifts are used with either pavement markings or physical curbs.

3.3.2.1 –Median Island

For design of median islands, reference **Section 4**. For design of raised central islands at roundabouts, reference **Section 3.6.7**. Raised central islands and median islands are the preferred speed management techniques to require vehicle to shift horizontally from their travel path and typically results in reduced speeds.

3.3.2.2 – Pinchpoint / Bulb-Out

A Pinchpoint is a location with bulb-outs on both sides of the roadway typically at midblock locations that results in yield flow and significantly reduces speeds.

- A. Pinchpoints on Level 1 and 2 Streets shall maintain a minimum width of 12 ft between face of curb to face of curb and be designed for yield flow operation.

3.3.2.3 – Chicane

A Chicane slows drivers by alternating parking, bulb-outs, or pavement markings along the street. Chicanes deflect the horizontal path of a vehicle and are designed at the target speed or lower to induce reduced speeds.

3.3.2.4 – Lane Shift

A lane shift horizontally may be designed with striping or bulb-outs that deflects a vehicle's path.

3.3.2.5 – Diverter

A diverter is a device that limits through movements for motor vehicles in one or more directions. Some diverters cut across an existing intersection diagonally, while allowing passage for pedestrians and cyclists. Other diverter styles deny entry from a major street or only allow right in, right out movements. Diverters should only be used where the street network pattern is grid-like with a high connectivity index and nearby alternative routes. Traffic diversion can also be used on streets identified as Neighborhood Bikeways in the **Austin Bicycle Plan** to reduce traffic speeds and volumes to achieve an All Ages and Abilities bicycle facility.

3.3.2.6 – Traffic Circle

A traffic circle is central island, painted or raised with a vertical or mountable curb in the center of the intersection of two streets. Traffic circles paired with a visual obstruction through the intersection, such as a tree, increase the effectiveness of reducing speed. Traffic circles are intended to be yield operated intersections that cause a horizontal deflection in vehicle paths through the intersection.

3.3.2.7 – Mini-Roundabout

For the design of mini-roundabouts, reference **Section 3.6.7**. Mini-roundabouts are intended to be used as an alternative traffic control measure to a multi-way stop or a two-way stop and should be evaluated through Intersection Control Evaluation in **Section 3.7.0**. Mini-roundabouts differ from traffic circles in that they require deflection of vehicle paths prior to entry into the intersection, typically through the use of curbed or painted splitter islands.

3.3.3 – Visual Narrowing Techniques

Visual narrowing techniques utilize either physical objects, vertical street elements, or pavement markings to communicate to the driver a perceived narrowing of their anticipated path of permissible travel to reduce operating speeds.

3.3.3.1 – On-Street Parking

On-Street Parking, shown in **Section 9**, can be used as an effective way to narrow a street by creating friction for moving vehicles. On-Street Parking should be designed carefully if a street also has on-street bike facilities because of conflicts from the door zone of vehicles. In addition, on-street parking is particularly effective when coupled with pinchpoints and bulb-outs.

3.3.3.2 – Street Trees

Street Trees, shown in the cross sections in **Section 2** and required by the LDC help visually narrow the street. The visual narrowing effect is more pronounced the closer the trees are to the edge of travel way for vehicles. For specific criteria on street trees, see the **Environmental Criteria Manual**.

3.4.0 – Level 0 & 1 Street Design

This section applies to all new streets designed within sites that where the primary function of the street is access to lots within the property. All applicable criteria and references to other sections contained in this manual is listed below.

3.4.1 – Level 0 Streets

Table 3-3 specifies general design criteria for Level 0 Streets.

Table 3-3 – Level 0 Design Criteria

Target Speed	Typical Section	Min Grade – G (%)	Max Grade – G (%)	Design min K Value Sag Vertical Curve	Design min K Value Crest Vertical Curve
10	Refer to Section 2.8.2.1	0.6	8	26	12

- A. Level 0 streets shall not intersect with Level 2, 3, or 4 Streets.
- B. Level 0 streets shall not align with existing or future streets, except driveways on the opposite side of the street.
- C. Level 0 streets shall be perpendicular.
- D. Internal Level 0 street intersections shall consist of no more than three Level 0 residential street approaches
- E. The radius of Level 0 Streets pavement at street intersections shall be less than 15 ft At the intersection of two Level 0 Streets, the radius of the alley right of way is dependent upon the Level 0 Streets right of way intersection angle.
- F. If a Level 0 Street will serve Fire Department vehicles, consultation with the Fire Department must occur prior to approval for appropriate design.
- G. Parking is not allowed on Level 0 Streets.

3.4.1.1 – Turnarounds

- A. If a Level 0 Street terminates in a dead end and the City Transportation Engineer or applicable Director determines that the Level 0 street will not connect in the future, a turnaround must be provided. Details for the design of a turnaround are shown in Figure 3-6.

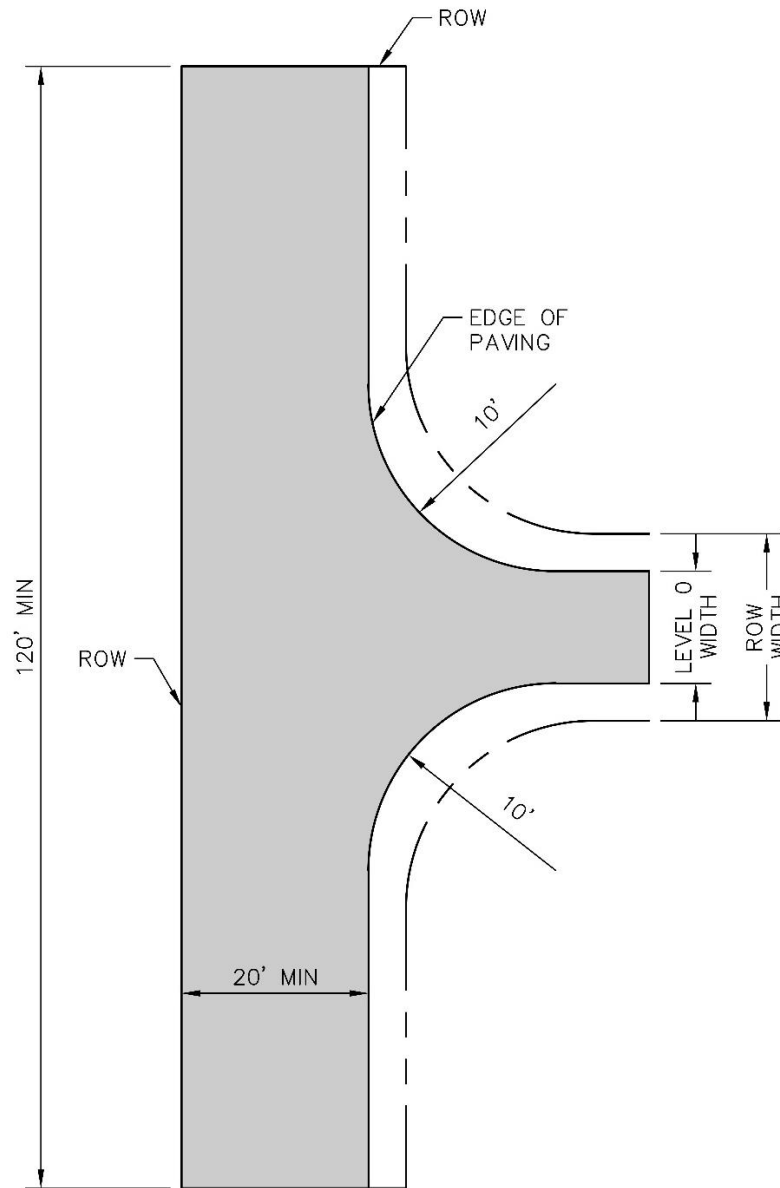


Figure 3-6 – Level 0 Turnarounds

3.4.2 – Level 1 Streets

This section covers design criteria for Level 1 Streets. Level 1 Streets provide connectivity to higher Level Streets. The design criteria shown apply to private streets in **Section 3.4.2.3**. Table 3-4 specifies general design criteria for Level 1 Streets.

Table 3-4 – Level 1 Design Criteria

Target Speed	Typical Section	Horizontal Radius (Measured at Inside Travel Way) (ft)	Min Grade – G (%)	Max Grade – G (%)	Design min K Value Sag Vertical Curve	Design min K Value Crest Vertical Curve	Maximum Tangent Length along Street Centerline
20	Refer to Section 2.8.2.2	200	0.6	8	26	12	1,000
25		350	0.6	8	37	19	1,500

3.4.2.1 – Intersection Design

This section governs design of intersections with Level 1 Streets. If intersection is with only Level 2 Streets or higher refer to **Section 3.6.0**. Crossings for street users outside the Motor Vehicle and Transit Zone must be highly visible to vehicular traffic and must be considered at every intersection. Refer to **Section 4** and **Section 5** for further guidance on pedestrian and bicycle crossings. Table 3-5 shows the allowable intersection controls for each intersection type with Level 1 Streets. Intersection controls shall be determined through an engineering evaluation considering anticipated intersection entering volumes and be approved by applicable staff.

Table 3-5 – Level 1 Intersection Controls

Level 1	Level 2	Level 3 or higher
Traffic circle, Multi-way ^B or two way stop control	Mini-roundabout ^A , multi-way stop control ^B , or Minor Street Crossing	Minor Street Crossing Traffic Signal ^C

^A Refer to **Section 3.6.7** for mini-roundabout design criteria.

^B Multi-Way stop warrants per the TMUTCD are recommended for existing intersections. New intersections may install multi-way stop control based on planning level analysis.

^C Signal warrants must be conducted and recommendation approved by the applicable department.

Figure 3-7 illustrates configurations of minor street crossings for both a separated pedestrian and bike facility and a shared use path crossing. Design criteria for these minor street crossings for Level 1 Streets are included in this section. **Figure 3-8** illustrates a turn restriction raised island device. These devices, if required to restrict turning movements, shall provide design provisions for bicycle and pedestrian access cut throughs to limit access restrictions to motor vehicles. For a grade profile of a minor street crossing, refer to **Section 5.2.1**.

Figure 3-9 illustrates a raised intersection at a Level 1 intersecting a Level 1 Street intersection.

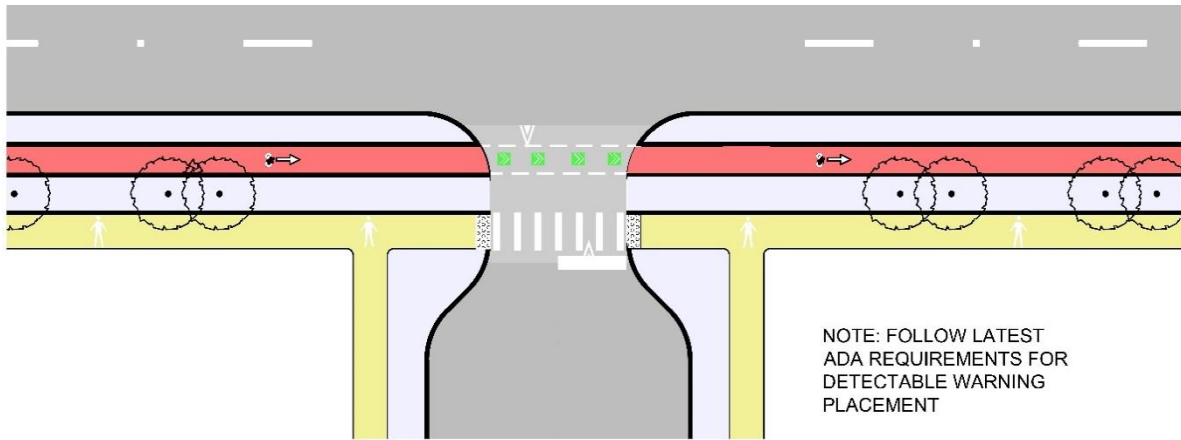


Figure 3-7 – Separated Bike and Pedestrian Minor Street Crossing

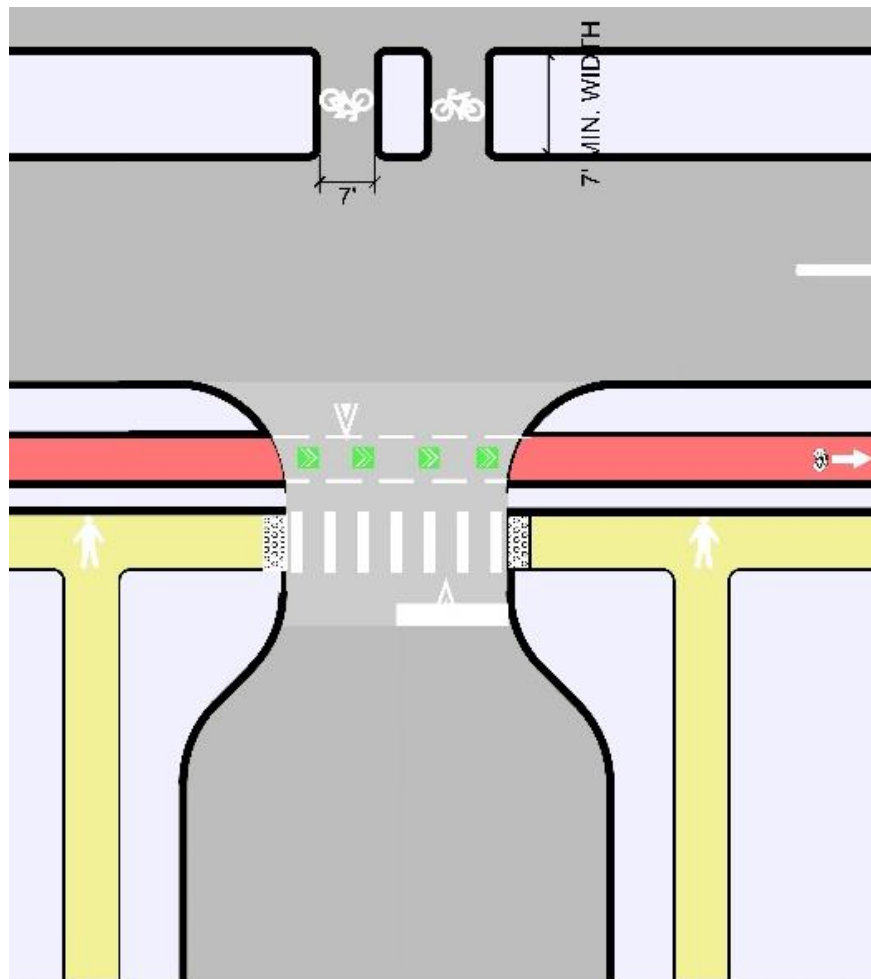


Figure 3-8 – Turn Restricted Movement with Bicycle Cut-Through Example

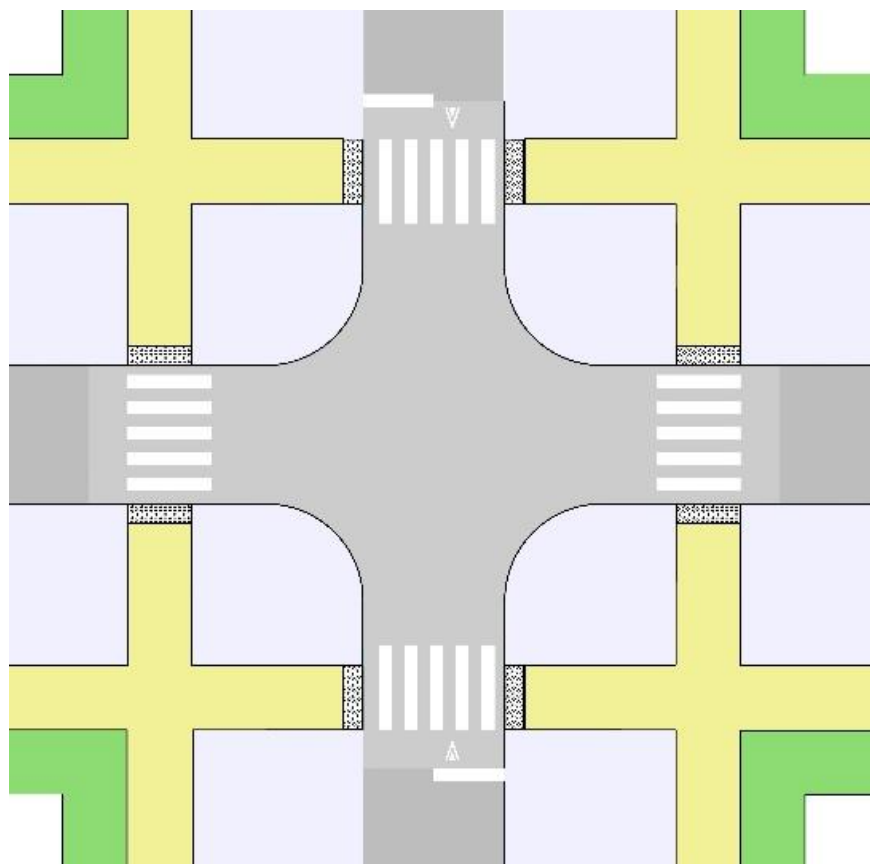


Figure 3-9 – Raised Intersection Typical Layout

Criteria Applicable at Level 1 to Level 1 Intersections

- A. Width between bulb-outs shall be 20 ft minimum.

Criteria Applicable at Minor Street Crossings (Level 1 to Level 2 or Higher Intersections)

- B. Width between bulb-outs shall be 24 ft
- C. Raised crossings of minor streets are required for all Level 1 intersections with Level 2 or higher streets. They enhance safety by reducing motor vehicle speeds and enhancing visibility for people walking and bicycling.
- D. Raised crossings shall be made of concrete for durability and maintenance. Reference **City of Austin Standard Details** for design requirements of raised crossings.
- E. Material and color of bicycle and pedestrian facilities along the major street shall continue through the minor street crossing.
- F. As necessary, use either inlets to catch water in advance of the raised crossing or use pass through rain gardens with bridges for bikeway and sidewalk.
- G. The maximum slope of raised crossing treatment is +/- 6% or +/- 4% from running street grade.
- H. Elevation of raised crossing shall be between 3 in. to 6 in. with 4 in. preferred height.
- I. Yield lines shall be used in conjunction with the raised crossing.

3.4.2.1.1 Intersection Sight Distance

Intersection sight distance (ISD) triangles are to be determined for all turning movements that are not controlled. ISD is the length of the sight triangle leg measured along the major street which a minor street is intersecting. Once the sight triangle has been determined for the turning movement, the triangle shall be clear of obstructions that restrict the vision of street users. Examples of potential visual obstructions include, but are not limited to the following: fences, walls, monument signs, trees, bushes, berms, or other manmade structures that impede view. Measurement of sight distance shall be from the location of a stopped vehicle or 6.5 ft from the edge of the outside lane edge, measured 8 ft from the front of the vehicle. Tables 3-6 through 3-8 identify minimum lengths of ISD. See **Section 11.2.1** for additional information about landscaping in sight triangles.

Table 3-6 – Minimum Intersection Sight Distance Length by Target Speed Case B1 (Left turn from stop)

Target Speed	Minimum Intersection Sight Distance (ISD)
20 mph	225 ft
25 mph	280 ft
30 mph	335 ft
35 mph	390 ft
40 mph	445 ft
45 mph	500 ft

Table 3-7 – Minimum Intersection Sight Distance Length by Target Speed Case B2 (Right turn from stop)

Target Speed	Minimum Intersection Sight Distance (ISD)
20 mph	195 ft
25 mph	240 ft
30 mph	290 ft
35 mph	335 ft
40 mph	385 ft
45 mph	430 ft

Table 3-8 – Minimum Intersection Sight Distance Length by Target Speed Case B3 (Crossing Maneuver)

Target Speed	Minimum Intersection Sight Distance (ISD)
20 mph	195 ft
25 mph	240 ft
30 mph	290 ft
35 mph	335 ft
40 mph	385 ft
45 mph	430 ft

- A. Minimum ISD in Tables 3-6 through 3-8 are determined using the default variables outlined in the AASHTO Green Book. Refer to the latest edition of the AASHTO Green Book if the default variables vary for turning movement being designed for.
- B. Based on the type of movements and intersection controls, the design shall provide the required ISD for given scenario described by the AASHTO Green Book.
- C. An analysis of the vertical profile within the area defined by the ISD horizontal profile value must also be completed to ensure oncoming traffic can be continuously seen and not obstructed by street grades or objects.
- D. An intersecting street or driveway may not be appropriate along a vertical curve when required sight distance from side street or driveway is not attainable. If it is essential that a side street or driveway intersect the major street along a vertical curve, then it may be necessary to reduce the vertical curve so that necessary sight distance is available.
- E. For streets with multiple through travel lanes in either direction and a speed of greater than 35 mph posted, left turns shall not be allowed from intersecting streets without a traffic signal or other operation to protect left turns from the intersecting street without City Transportation Engineer or applicable Director approval.

3.4.2.2 – Cul-de-sacs

The **LDC** defines when single access streets or cul-de-sacs will be permitted within the City and are prohibited without City Transportation Engineer or applicable Director approval. Cul-de-sacs shall be used sparingly as they violate the Comprehensive Plan goal for a “compact and connected” City. Design of these facilities is governed herein, when applicable. Single access streets have one point of access. Cul-de-sac streets are open at one end, with the closed end constructed to facilitate a turnaround for the appropriate design vehicle for the street. Figure 3-10 shows an illustration of single outlet streets and cul-de-sacs. Required radii and design vehicles based on Street Level are shown in **Table 3-9**.

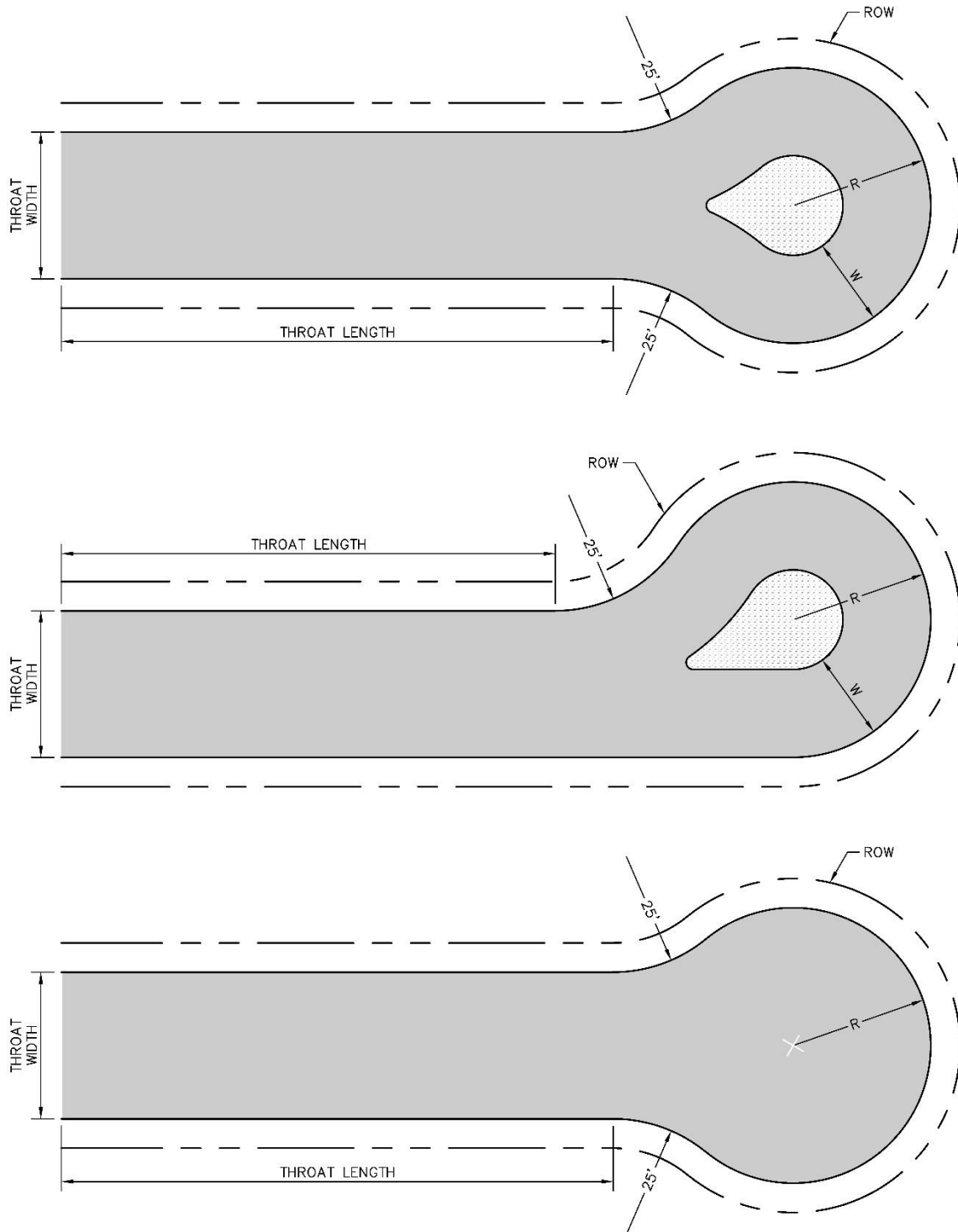


Figure 3-10 – Cul-De-Sac Geometry

Table 3-9 – Cul-De-Sac Design Criteria

Cul-De-Sac Throat Geometry				
	Level 1		Level 2	
Throat Width (ft)	30		36	
Throat Length (ft)	150 (min)	300 (max)	200 (min)	300 (max)
Cul-De-Sac Center Radius Geometry				
Design Vehicle	Center Radius (R) (ft)		Paving Width (W) (ft)	
Fire Truck (COA)	48		25	
WB-40 (Intermediate Semitrailer)	42		25	
WB-50	47		30	

- A. Single outlet streets that are not Level 0 Streets and have a face-of-curb to face-of-curb width of less than 40 ft or are undivided, are required to terminate in a cul-de-sac.
- B. Level 1 and Level 2 Streets shall be designed with one of the configurations shown in Figure 3-10.
- C. Level 3 and higher streets shall not terminate as a single outlet street unless it is a divided street with adequate space for a turnaround for the appropriate design vehicle, provided at a dead end signed for future connection.
- D. If the design vehicle differs from the vehicles listed in Table 3-9, swept path analysis shall be shown on plans for the design vehicle using computer aided design software. The proposed paving geometry shall allow the vehicle to maneuver within the paving limits.

3.4.2.3 – Private Streets

- A. A private street is a vehicular roadway under private ownership and maintenance which is not intended for use by the general public and may have its access controlled or restricted.
- B. Private streets are subject to City regulations in order to ensure:
 - 1. Safe movement of all street users from a private street to a public street system
 - 2. Adequate access to all buildings and lots by emergency and service vehicles
 - 3. Adequate construction standards in the event that private ownership becomes dedicated as public streets
 - 4. Adequate drainage and utilities
- C. Traffic control devices on private streets must conform with the Texas Manual on Uniform Traffic Control Devices (TMUTCD) latest edition per the Texas Transportation Code, Section 544.002.
- D. Right-of-way for a private street is not dedicated to the public; however, it may be designated as a "private street, drainage, and public utility easement."
- E. To discourage vehicular through traffic, private streets shall not form a direct link between two public streets that serve public through traffic, however direct links can be provided for sidewalks and shared use paths.

- F. Connection to two public streets to accommodate internal circulation is permitted.
- G. Should a private street with gated access become public, all security gates shall be removed, and the street must be brought to current acceptance criteria for a Level 1 Street.
- H. Within the City's zoning jurisdiction, permits for driveway and sidewalk construction along private streets will be required as for public streets.

3.4.2.3.1 – Conversion of Existing Private Streets to Public Streets

In certain cases, the City may allow existing private streets to be converted to public streets. In order to be accepted by the City as public streets, the following conditions must be met:

1. The streets must conform to the design criteria in **Section 3.4.2**, as well as the pavement design standards in **Section 14** and **Appendix B**. The owners of the private street must provide documentation verifying the cross-section construction of the private street.
2. There must be no outstanding unpaid taxes owed on the streets.
3. Existing building setbacks, lot widths, lot sizes, and yard sizes must conform to the requirements of the zoning district in which they are located, based upon the right-of-way lines established at an appropriate distance from the edge of the pavement.
4. A street deed must be prepared and processed through normal procedures to dedicate the right-of-way to the public, with the concurrence of all abutting property owners. The owners of the private street are responsible for surveying and conveyance of the right-of-way to the City.
5. Any covenants or other legal documents which created the private streets must be amended or terminated.
6. Any existing security gates, overhead rock entrance ways, speed bumps, special pavement treatments, and similar facilities which do not meet City design standards must be removed and the pavement repaired in an acceptable manner at the owner's expense, as determined by the Director of the Public Works Department.
7. Sidewalk construction must conform to **Section 4** and be brought into PROWAG or ADA compliance.
8. Private improvements left within the proposed right-of-way may require license agreements.
9. Street lighting, signals, and other street-related infrastructure must be acceptable to the applicable department.
10. The street must be inspected by the Public Works Department. All needed repairs or maintenance strategies identified during the inspection must be made and paid for by the owners of the private street prior to acceptance by the City. Repairs of maintenance strategies must conform to the same requirements and specifications as required for public streets. The City will have no obligation to repair, maintain, or reconstruct newly accepted private streets for a period of two years, unless required by emergency or safety reasons.
11. Designated off-street parking and garbage container areas will not become the responsibility of the City.

12. The City shall reserve the right to deny acceptance of the private street if current City street maintenance budgets are 90% or less of the current maintenance needs.

3.5.0 – Horizontal and Vertical Geometries

The following design criteria are intended to guide the selection of design inputs governing the horizontal, vertical, and cross-sectional dimensions along the street alignment. These inputs should be determined at the earliest stage of the design process. As these design inputs influence the ultimate performance of the street, careful attention must be taken to choose values that will result in a performance that will last throughout the design life of the street. This will reduce the need for reconstruction and speed management treatments after completion.

3.5.1 – Relationship to Target Speed

Once the target speed has been chosen for the street, horizontal and vertical design inputs can be chosen. All design variables in the following tables are to be chosen based on selected target speed. As explained in **Section 3.2.2.**, target speed aims to keep operating speeds at the posted speed of the roadway. For further explanation of the design variables that follow, refer to the latest edition of the design manuals listed in **Section 1.3.0.**

3.5.2 – Horizontal Geometry

The material covered in this Section governs the design criteria for horizontal geometry of the street. Horizontal geometry of the street dictates the left to right movement felt by the driver when traveling along the street alignment. A horizontal curve or transition must be introduced when tangent sections of the street are shifted laterally as a result of adjacent property lines, topographic features, narrowing or widening of the street, aligning with an existing street section, or as a form of speed management. Geometric changes can be influenced by both physical and visual cues along the street. Physical cues are encouraged in order to better influence driver behavior.

3.5.2.1 – Horizontal Curves

Figure 3-11 illustrates the measurement of a horizontal curve radius. Table 3-10 establishes the minimum horizontal curve radius based on target speed.

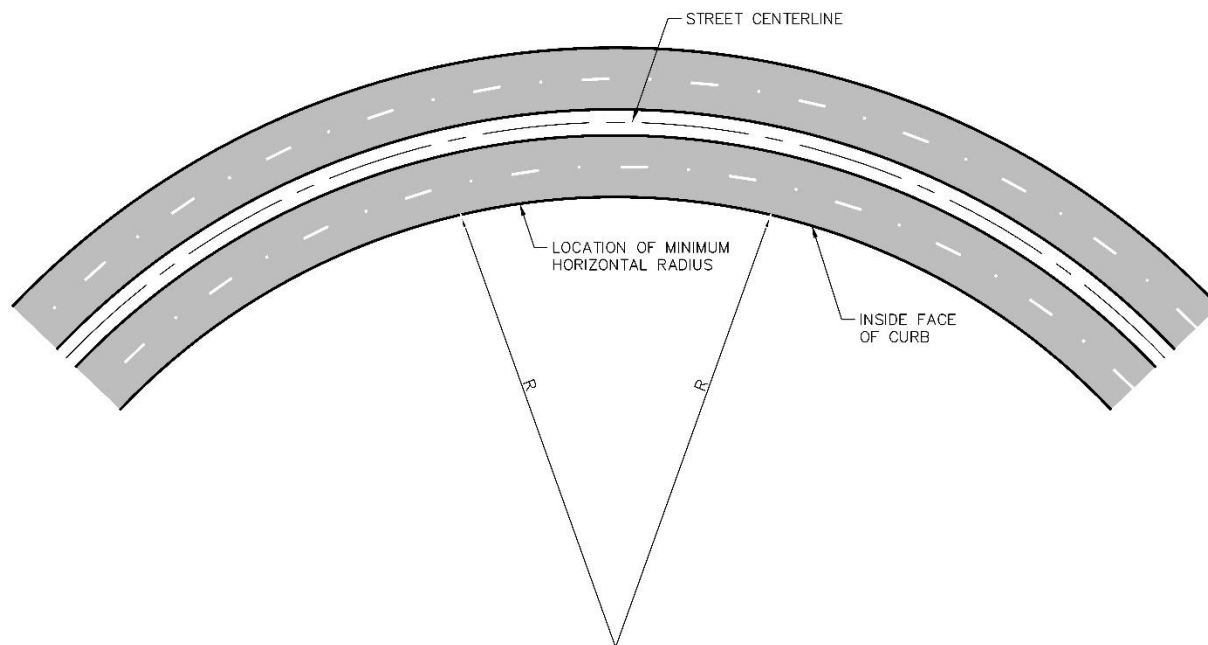


Figure 3-11 – Minimum Horizontal Radius Dimensioning

Table 3-10 - Minimum Horizontal Radius

Target Speed (mph)	Minimum Horizontal Radius (ft)
20	200
25	350
30	525
35	775
40	1050
45	1400

- A. The rounded horizontal radius was calculated using a superelevation rate, e , of -0.02. This equates to a 2% typical normal crown used on Level 1-4 Streets.
- B. Horizontal radii listed in Table 3-10 are measured along the inside of the inside travel way.
- C. Horizontal radii shall not be higher or lower than the values listed in Table 3-10 unless approved by staff member of applicable department.

3.5.2.2 – Tapers

The following section governs the design of tapers along a street. Tapers are typically used when designing transitions to add or remove through lanes in the direction of travel. Tapers may also be used for lateral shifts in roadway geometry for speed management purposes. Table 3-11 and Figure 3-12 show the design criteria for taper length based on target speed and modifications to taper length based on application of a taper in design for various scenarios.

Table 3-11 – Minimum Taper Lengths

Target Speed	Minimum Taper Length Equation
20	$L = W(S^2) / 60$
25	
30	
35	
40	

- a) L = Taper length (ft)
- b) S = Target speed (mph)
- c) W = Taper shift width (ft)
- d) Minimum desirable taper lengths vary depending on the taper shift width (W).
- e) For turn bay tapers refer to the TxDOT Roadway Design Manual.

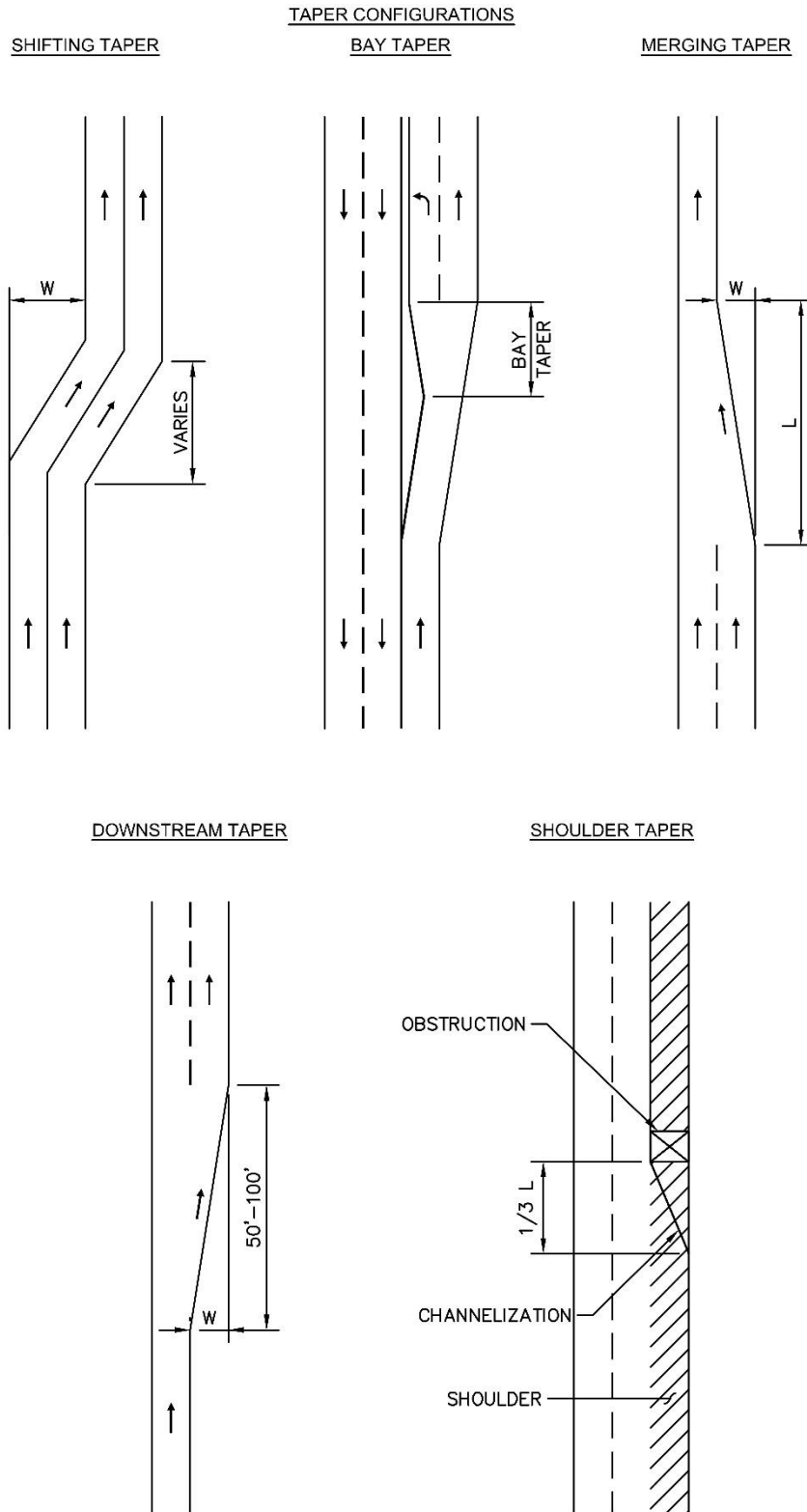


Figure 3-12 – Taper Types

- A. A Merging Taper (L) is defined as a pavement transition that results in a reduction of travel lanes at the prevailing speed, requiring vehicles to merge into adjacent traffic lanes
- B. A Shifting Taper is defined as a pavement transition where all approaching traffic lanes shifts laterally but does not require merging with adjacent traffic streams. Minimum taper lengths in **Table 3-11** may be used and divided in half (L/2) for speed management design in **Section 3.3.2**.
- C. A Downstream Taper (50 ft to 100 ft) is defined as a pavement transition that results in the widening of pavement or travel lanes
- D. Pavement transition design for permanent conditions shall be done in accordance with procedures outlined on the *AASHTO Green Book*.
- E. For a temporary condition, pavement transition shall be designed in accordance with the Texas Manual on Uniform Traffic Control Devices (TMUTCD) or with guidelines set forth in **Section 8** of this manual. Section 8 of the TCM shall control if guidelines are in conflict.
- F. In situations where more than one merging or shifting tapers are used in sequence between Level 3 Streets, the design must be reviewed by the City Transportation Engineer or applicable Director.
- G. If a taper is designed as back to back curves rather than a single tangent, curve radii shall be the same and meet the minimum requirement outlined in **Section 3.5.2.1**.

3.5.3 – Vertical Geometry

The content covered in this section governs design criteria for the vertical geometry of streets. The vertical geometry of the street pertains to the series of longitudinal grades along the street alignment connected by parabolic vertical curves to which the straight lines are tangent. Under all conditions, this line should be smooth flowing. Short, choppy grades are unsightly and disrupt operating conditions. The design of the vertical geometry of the street must align with the surrounding terrain to ensure existing drainage patterns are preserved while also balancing the safety and operations of adjacent properties and other users of the right-of-way.

Minimum grades are governed by ensuring drainage flows can be maintained and pass unrestricted to the outfall. Maximum grades are governed by the traversing abilities of control vehicles traversing the street. Grade transitions use vertical curves as shown in **Figure 3-13**, preferred grade strategies are shown in **Figure 3-14**, and preferred vertical curve design strategies are shown in **Figure 3-15**.

Design for crest vertical curves is governed by stopping sight distance and design for sag vertical curves is governed by headlight beam distance. Stopping sight distance measurement is shown in **Figure 3-16**.

Table 3-12 and accompanying Equations 3-1 through 3-5 shall be used for the design of vertical curves and grades. Equations are taken directly from AASHTO design criteria. If equations in this manual are in conflict, use the latest edition of the AASHTO Green Book for vertical curves and grades. These formulas may be updated by the City Traffic Engineer or applicable Director.

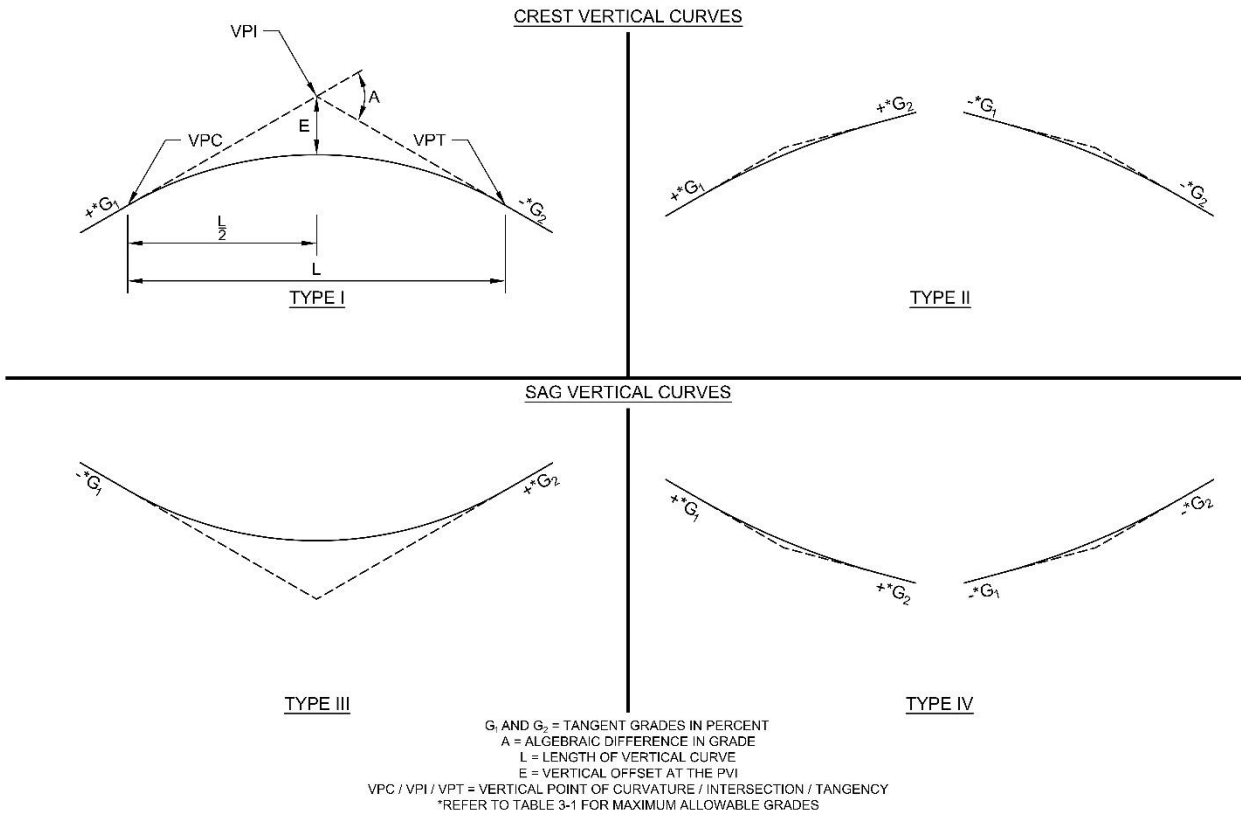
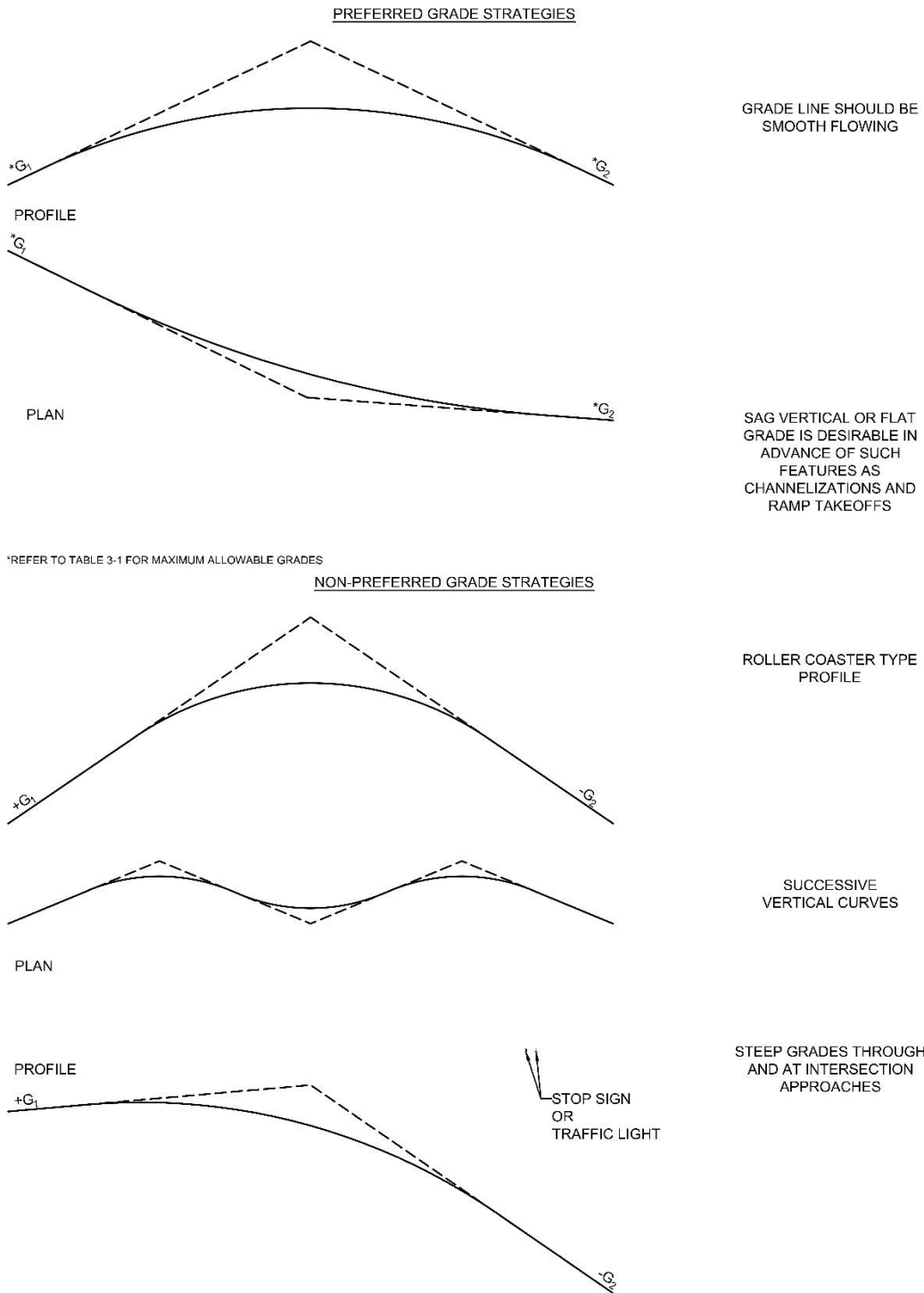


Figure 3-13 – Vertical Curve Types



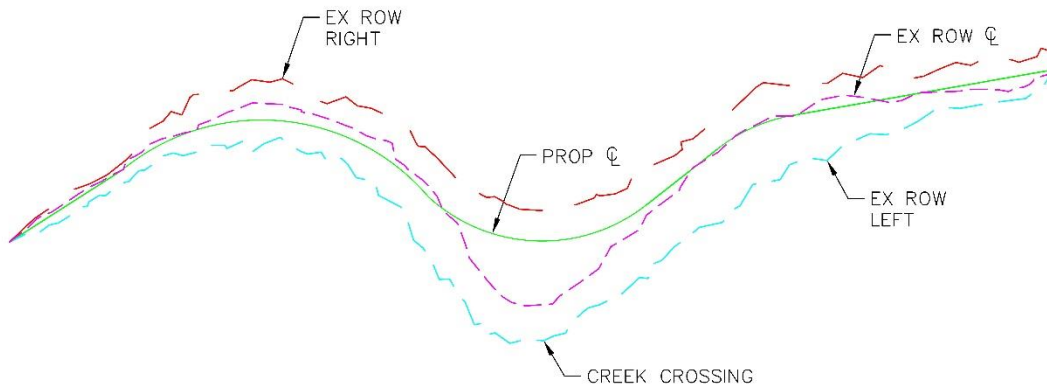


Figure 3-15 – Preferred Vertical Curve Design Strategies

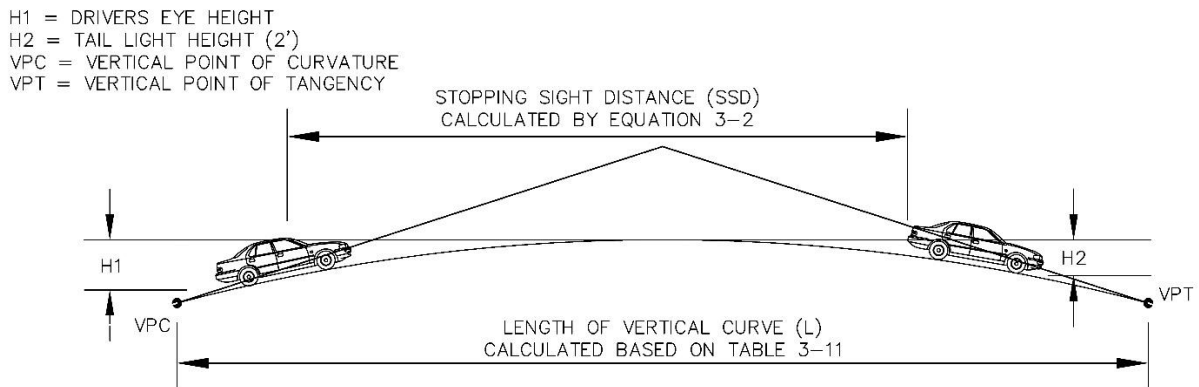


Figure 3-16 – Vertical Curve Stopping Sight Distance

Table 3-12 – Vertical Geometry Design Criteria

Target Speed (mph)	Min Grade - G (%)	Max Grade - G (%)	Stopping Sight Distance (ft)	Design min K Value Sag Vertical Curve	Design min K Value Crest Vertical Curve
20	0.6	8	155	26	12
25	0.6	8	200	37	19
30	0.6	8	250	49	29
35	0.6	6	305	64	44
40	0.6	4	360	79	61
45	0.6	4	425	96	84

Braking Distance in feet is determined from the formula:

Equation 3-1

$$BD = 1.075 \frac{V^2}{a}$$

BD = Braking Distance, ft

V = Target Speed, mph

a = deceleration rate, ft/s², per AASHTO Green Book

Stopping Sight Distance (SSD) in feet is determined from the following formula:

Equation 3-2 $SSD = 1.47Vt + BD$

SSD = Stopping Sight Distance, ft

V = Target Speed, mph

t = time gap for minor road vehicle to enter the major street (s), per AASHTO Green Book

BD = Braking Distance, ft

Rate of vertical curve grade change is determined as “K” in the following formula:

Equation 3-3 $K = \frac{L}{A}$

Minimum length of crest vertical curve length (stopping sight distance) is determined from the following formula:

Equation 3-4 $L = \frac{AS^2}{2158}$

Minimum length of sag vertical curve (headlight sight distance or stopping sight distance) is determined from the following formula:

Equation 3-5 $L = \frac{AS^2}{200(2 + S(\tan 1^\circ))}$

L = Minimum length of vertical curve (ft)

A = Algebraic difference in grades (G – G)

K = Rate of grade change along vertical curve (ft / 1%)

S = Stopping sight distance (ft)

- A. Climbing lanes shall be provided when grades exceed those in **Table 3-12** due to existing topography on all Level 3 and Level 4 Streets, and on non-curbed and guttered Level 2 Streets in the area defined in **Figure 2-2** in Section 2.
- B. For Level 5 facilities refer to the TxDOT Roadway Design Manual.
- C. A minimum grade of 0.5% shall be used where existing terrain allows. When 0.5% is determined to not be feasible by the design engineer, a minimum grade of 0.6% shall be used and approved by applicable staff.
- D. A maximum grade break of 1.5% may be used without a vertical curve for Level 0 – Level 2 Streets. For Level 3 – Level 5 Streets, the maximum grade break shall be 1.0% without the use of a vertical curve.

- E. Within the intersection physical area (**Section 3.6.4.1**), the street grade shall be above the minimum allowable grade and less than 2% to ensure pedestrian crossings meet ADA standards
- F. Where streets intersect, the grade of the smaller Level Street shall align with the cross slope of the larger Level Street, not to exceed 2%. Reducing the cross slope to 1% is encouraged to reduce vehicle vaulting across the intersection.
- G. When a street is designated as a truck route, grades shall not exceed 6%. If grades must exceed 6%, a climbing lane must be provided.
- H. In cases where horizontal curvature on a downgrade causes sight distance obstruction, a higher deceleration rate shall be used to account for difficulty of larger vehicles to stop adequately.

3.5.4 – Cross Sectional Elements

This section governs the cross-sectional elements within the Motor Vehicle and Transit Zone and the considerations that must be made during design. Cross sectional features relate to the widths and cross slopes experienced by driver as they navigate from side to side along street. Lane widths are the primary variable that influence driver comfort, while medians provide a barrier that separates opposing direction of traffic and provides for access management. Cross slope runs transverse to the street alignment and facilitates passage of surface drainage to curbside inlets or roadside ditches. Criteria contained within this section supplement the required widths of cross-sectional elements presented in **Section 2**.

3.5.4.1 – Lane Widths

Adjacent travel lanes going in the same direction are to be separated by pavement markings with the possible addition of retroreflective raised pavement markers. Lanes are the spaces within the street cross section that are to be used for safe passage of vehicular traffic. Chosen lane widths directly impact the normal operating speed of a street. Lane widths shall not be made wider or narrower than as specified in **Section 2**. The width of travel lanes is determined by the clear width provided. Figure 3-17 illustrates lane width measurements.

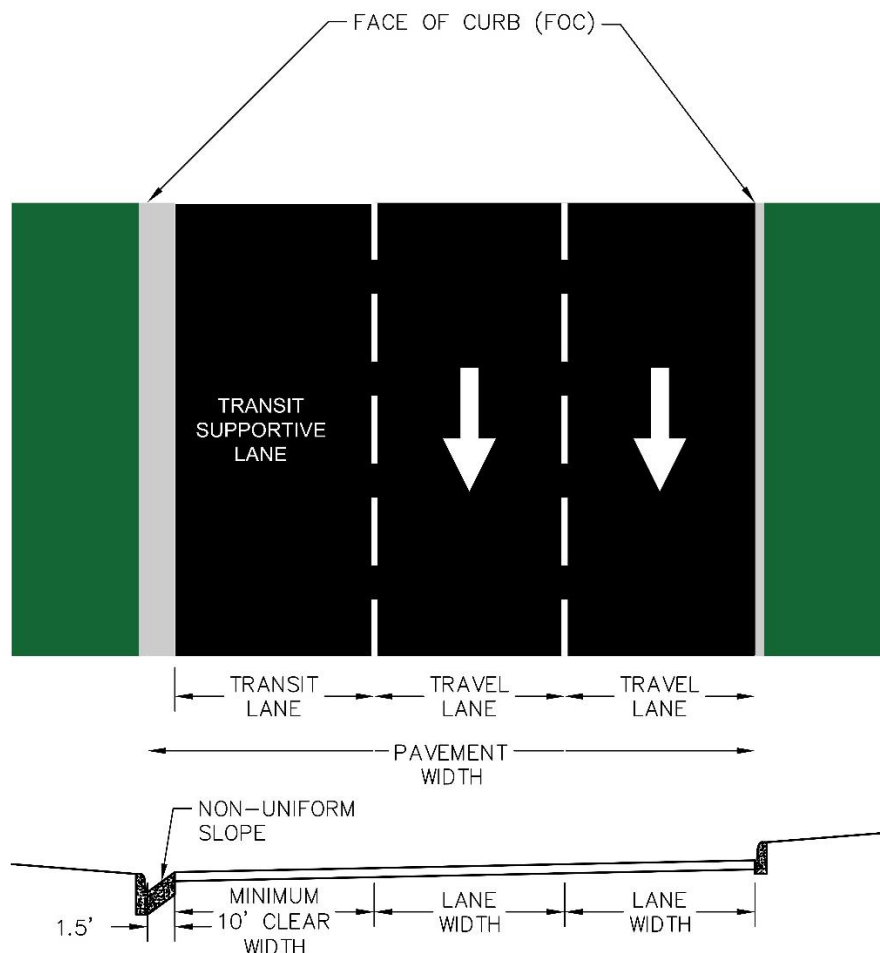


Figure 3-17 – Lane Width Dimensions and Edge Conditions

- A. Lane widths are measured as width from the face of curb or center of pavement marking. Reference **Table 2-2** for lane widths on curbed and guttered streets and **Table 2-3** for non-curbed and guttered streets.
- B. Level 2 Streets with transit traffic and Level 3 or higher streets shall have a clear width along the outside lane as shown in Figure 3-17

3.5.4.2 – Median Widths

This section is only applicable to Level 3 and 4 Streets, with the exception of use at entryways to subdivisions on Level 2 streets. The default treatment for lanes traveling in opposing directions is a physical curb with raised median. This treatment provides access control to manage turning conflicts and improve safety from all modes of travel. A physical curb and raised median are the safest treatment by separating travel directions and greatly reducing head on collisions while also providing space for errant vehicle redirection. Aside from the vehicular benefits, a raised median also improves safety for bicyclists and pedestrians by providing a protected space for crossing maneuvers by both users. Medians also provide a buffer for above and below ground utility placement. Landscaping and green street goals can also be accomplished within this space as well. Where a raised median cannot be provided, buffer space between opposing travel directions shall be provided with either a depressed median or pavement markings.

- A. If lane is next to a lane carrying traffic in the opposing direction, additional lane width may be required per conditions in **Section 2**.
- B. If a pedestrian crossing is provided through the median, see **Section 4** on sizing requirements for pedestrian island areas.
- C. Median width is measured at the mid-block typical section outside of turning lanes. The median width is intended to provide a recessed turn lane where possible.
- D. Signs shall not be placed in the median when the width of the median next to a turn lane cannot comply with offset criteria in **Section 11**.
- E. On streets that drain to the outside curbs, raised medians shall be built with 0.5 ft gutter pans to maximize utilization of the cross-sectional space while providing a small gutter as a reference elevation for future pavement maintenance.
- F. On streets where a median is proposed, consult with applicable staff on green street strategies planned for street as well as the Environmental Criteria Manual (ECM).
- G. The minimum width for a median adjacent to a turn lane is 1 ft as a back to back curb section. The minimum space required for a median turn lane, inclusive of back to back curb is 11 ft.

3.5.4.3 – Cross Slope

Cross slope is measured as the difference in grade perpendicular to the direction of travel, generally from the center or crown of the street to the edge of pavement. Figure 3-18 illustrates the required cross slopes by lane for divided and undivided streets. Examples of varied cross slope are the introduction of roadside gutter, curb, or variance from normal cross slope. **Figure 3-17** shows various edge and median conditions and how lane widths are to be measured in design.

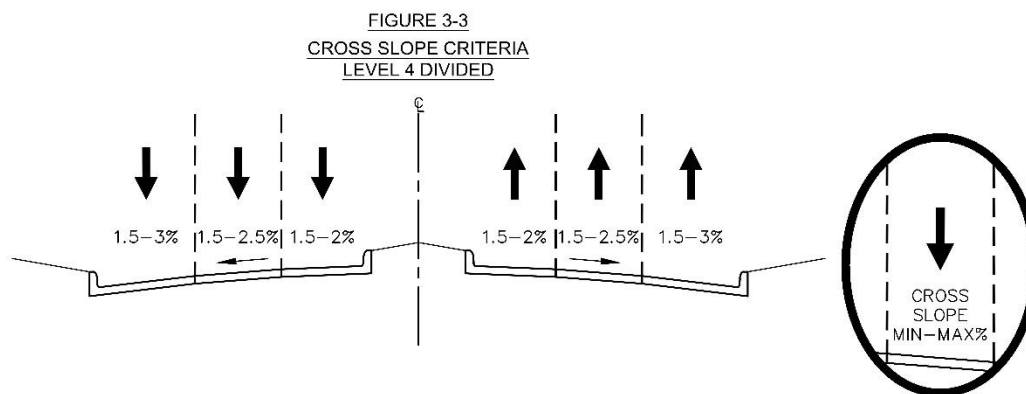


Figure 3-18 – Cross Slope

- A. On undivided streets with no center turn lane and passing maneuvers, drivers cross and re-cross the crown line and negotiate a total rollover or cross slope change of up to 4%. The maximum algebraic difference between cross slopes in adjacent lanes, main lanes and auxiliary lanes shall be 4% for a crown or crest slope break.
- B. On roadway sections that incorporate median islands, the difference in curb heights between the two interior curb lines may vary. In the area of intersections, median openings or possible median openings, the slope between the two interior curb tops should be no more than 2%.

- C. Median openings are to be held to the same standard as for cross slopes because driveway connections may be made to produce a three or four-legged intersection.
- D. At an intersection, the lower Level Street shall superelevate to meet the longitudinal slope of the higher Level Street.
- E. Within the intersection physical area (**Section 3.6.4.1**) it is desirable to reduce the cross slope of the street or super elevation the street in order to reduce minor street vehicles from vaulting as they cross intersection.
- F. Use of superelevation will require City Transportation Engineer or applicable Director approval.

3.5.5 – Additional Considerations

Application of the street design criteria contained in this document to new subdivisions and site developments must take into consideration all applicable drainage and environmental standards, including restrictions on cut and fill and development setbacks from waterways and critical environmental features. Requirements of the street design criteria shall not be considered as sole justification for variances from the Chapter 25-7 (Drainage) or Chapter 25-8 (Environment) of the **Land Development Code**. Conversely, requirements of these chapters shall not be considered as sole justification for variances from street design criteria. It is advisable to delineate all floodplains, erosion hazard zones, required setbacks and other applicable environmental protection measures prior to designing streets. Refer to **Title 30 of the City Code** for additional considerations outside the Full Purpose Limits of the City of Austin.

3.5.5.1 – Drainage Structures

The location of stormwater control measures such as drainage structures, inlets, catch basins, etc., should be consistent with the intended use of the right-of-way and in accordance with the **Drainage Criteria Manual**.

- A. Inlets or catch basins shall not be located within the corner radius or within 10 ft from the point of curvature of the corner radius or within 10 ft of driveways.
- B. A 5 ft clearance is needed to allow space for traffic control devices, utilities, and accessible pedestrian facilities

3.5.5.2 – Utility Assignments

Space is generally provided for above ground utilities and street lighting in the pedestrian zone as defined in **Section 2.6.0**. Placement of utilities above ground and below ground level shall be in accordance with the **Utilities Criteria Manual** and **Drainage Criteria Manual**. Below ground utilities are preferred for maximization of landscaping, street trees and space for street elements.

3.5.5.3 – Environmental Considerations

Deviations from the street design criteria may be applied for, on a case-by-case basis, in order to protect specific environmental features on severely constrained tracts provided that proposed deviations meet minimum safety standards, balance safety of all modes, and are approved by the City Transportation Engineer or applicable Director. General deviations may be pursued as stated in the **Section 1** of this Manual. See the **Environmental Criteria Manual** for environmental design standards.

3.6.0 – Intersection Design

This section governs design criteria for intersection designs of crossing streets that are Level 2 or higher. Refer to **Section 3.4.2.1** for intersection with Level 1 Streets, referred to as Minor Street Crossings. The goal of every intersection is to provide safe passage and crossing of all users of the street. Enhanced and clearly visible space for pedestrian and bicyclists, geometrics to reduce vehicular turning speed, clear sight lines for turning vehicles, and spacing along the street must all be considered and balanced during design of intersections. The intent of intersection design is to create a space that adheres to the guidelines set forth by Vision Zero, with a goal of achieving zero traffic related deaths in the City.

The intersection is a pivotal point where different street designs intersect – resulting in the most potential for conflicts between the trade-offs being considered. Intersections are also typically transition areas for Street Levels, where modal facility design often changes, and number of motor vehicle lanes may increase or decrease.

3.6.1 – Safety & Multi-modal Considerations

As non-vehicular traffic continues to rise along streets as part of the City's 50-50 mode split goal defined in the **ASMP**, intersections must not simply consider the crossing maneuvers of vehicles as the primary criteria for design. As outlined in NACTO's *Don't Give Up at the Intersection* guide, 43% of urban bicyclist fatalities occurred at an intersection. The primary components of improving safety for non-vehicular users consist of reducing turn speeds and improved visibility. Protected space must be reserved for both bicyclist and pedestrians queuing and crossings at all intersections.

As the diversity of street users changes the design of intersections must accommodate all street users. This section establishes standard treatments for how to transition and cross bicyclist and pedestrians at signalized and unsignalized intersections. These treatments are to be used for intersection design in new construction, reconstruction, and retrofit projects. Further guidance on pedestrians and bicyclist facilities within the right-of-way are covered in **Section 4** and **Section 5** respectively.

The design of bike lanes, sidewalks, or shared-use paths approaching and traversing through intersections must clearly communicate right-of-way to improve safety for these vulnerable non-vehicular users. The criteria listed in this section greatly reduce turning speeds and visibility when compared to intersection treatments historically applied to accommodate vehicles. For further criteria on visibility and sight distance at intersections refer to **Section 3.4.2.1.1**.

Refer to the **City of Austin Standard Details** for additional detail on the various example intersection design figures in this section.

3.6.1.1 – Bicycle & Pedestrian Transitions and Crossings

When non-vehicular modes of travel are separated prior to the intersection, protected intersections shall be the standard intersection design. Protected intersections physically separate people walking, bicycling, and motor vehicles, reduce motor vehicle turning speeds, create intermediate crosswalk waiting areas, and provide motorist yield zones using corner islands. These various features reduce the number of conflict points or reduce speed at conflict points. Protected intersections are compatible with streets with either protected bicycle lanes or legacy painted bicycle lanes through transitioning bicycle facilities behind curb. Figure 3-19 and Table 3-13 contain the protected intersection configuration, features, and required dimensions for each feature.

- B. Street Level bicycle facilities shall be transitioned to be behind a curb or edge of pavement prior to crossing an intersection.
- C. Vertical transitions shall be 4% slope per **Section 5.1.1.2**.

3.6.1.2 – Shared Use Paths at Intersections

When non-vehicular modes are not separated prior to the intersection or shared use paths are used for non-vehicular travel, crossings shall accommodate mixed flow of bicycles and pedestrians. Shared Use Path design criteria can be found in **Section 5**.

- A. Transitions for the non-separated bike lanes shall occur prior to the shared use areas.
- B. Transitions from separated pedestrian and bicycle facilities to shared use areas shall include a detectable warning surface extending the full width of the shared use area at the transition point. Standards for detectable warning surface details are located in the **City of Austin Standard Details**.

3.6.1.3 – Pedestrian Islands at Intersections

The design of this space must consider the vehicles that will be turning at the intersection to ensure a protected space for pedestrians. When pedestrian island areas are used at midblock crossings refer to **Section 4.2.4.2** for more guidance. Refer to City of Austin **Standard Details** for median nose construction and mountable details when used in design.

- A. Pedestrian islands shall be completely outside of the area of the emergency control vehicle swept path.
- B. Pedestrian crossings shall be placed as close to the intersection as possible and minimize horizontal deflection in pedestrian paths.
- C. When turning movement of control vehicles encroaches on median nose, mountable median treatments may be used.

3.6.2 – Intersection Geometrics

The geometric design of an intersection creates the space for vehicles, pedestrians, and bicyclists to traverse the intersection safely. The geometrics of the intersection influence the speeds of turning vehicles. Intersections must be designed as compactly as possible, in acknowledgement that they serve many modes and must consider safety as the highest priority at conflict points. Intersections are to be designed to provide protected space for pedestrians and bicyclists wherever outside of a travel lane. This is accomplished by a combination of bulb-outs and physical medians. Compact intersections slow traffic near conflict points, increase visibility of all users, and reduce pedestrian crossing distances. An additional benefit of compact intersections are reduced crossing times at signalized intersections, providing more efficient operation for vehicles.

- A. At intersections of rights-of-way, additional right-of-way shall be dedicated per the **ASMP**. In addition, intersections of rights-of-way shall be cornered with a radius matching the recommended curb radius per **Section 3.6.2.2** or a corner clip with the length along each right of way equal to the recommended curb radius.

3.6.2.1 – Bulb-outs

Bulb-outs shall be constructed into any cross-sectional street elements that contains parking to shorten pedestrian crossings, control vehicle speeds, and increase the visibility of crossings. Depending on the

presence of parking, the width of the street, and the Street Levels being intersected the configuration for bulb-outs can differ. Bulb-outs shall be located at intersections to slow turning movements. The geometry of the bulb-outs are to be designed around the turning movements of the normal traffic as discussed in Section 3.6.2.2. Further design guidance for bulb-outs is included in **Section 4.2.4.1**.

3.6.2.2 – Turning Movement Analysis

This section governs the analysis and use of vehicular turning movements to design intersections. Turning movement analysis using computer aided design software is required for intersection designs where control vehicle or turn behavior differ from the parameters in this Section. Exhibits documenting this analysis shall be submitted with all engineered design plans that deviate from the criteria in this Section. Turning movements design criteria are outlined in Table 3-14 and Table 3-15 and shall not be deviated from unless approved by applicable staff. Figure 3-20 illustrates different cases for turning movements shown in the remainder of this section and as referenced in Table 3-14 and Table 3-15. **Section 3.2.1** specifies how design and control vehicles should be used in design of streets. . See City published **administrative guidelines** which include turning templates used in development of these criteria .

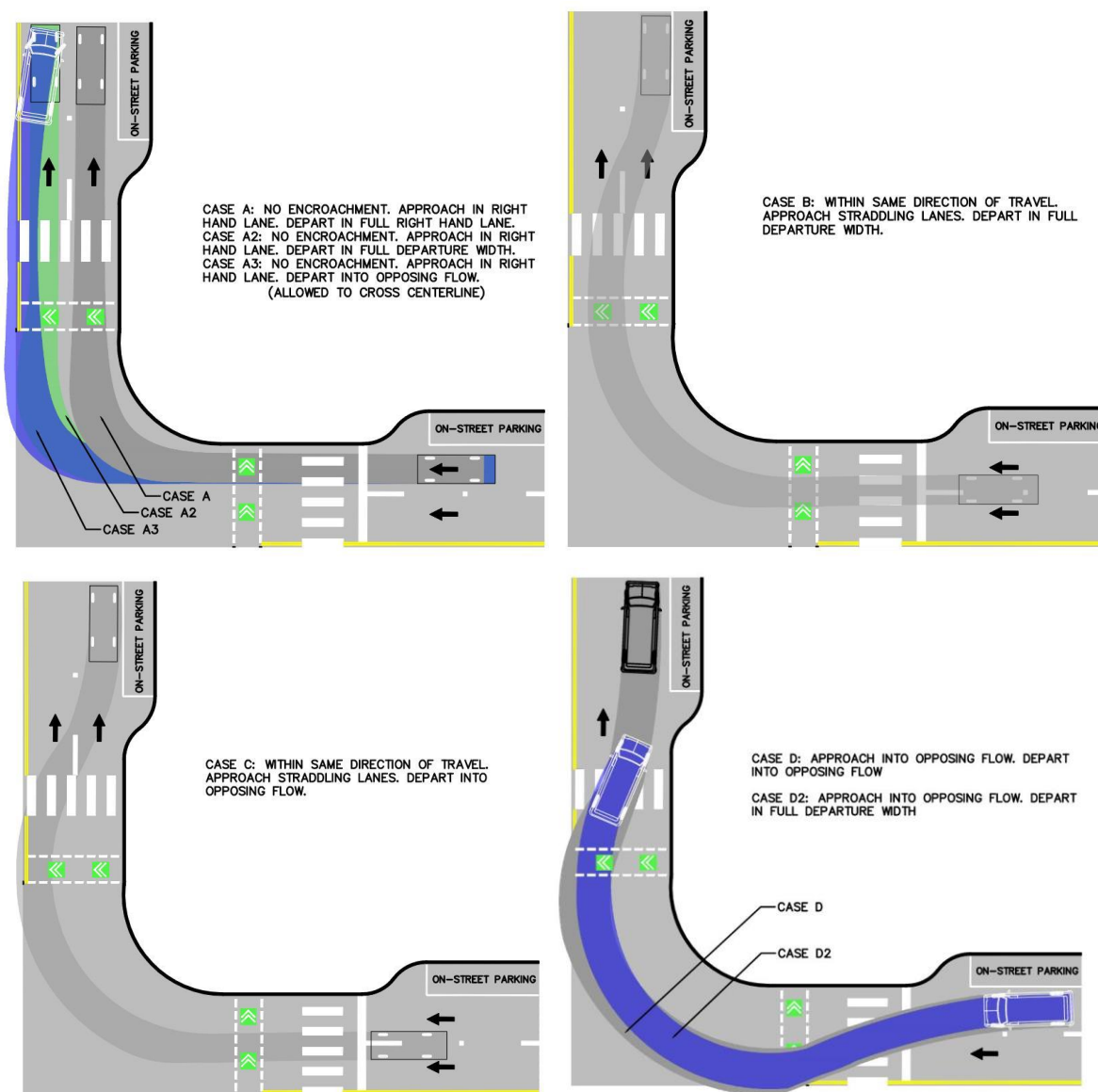


Figure 3-20 – Turning Movement Encroachment Cases

Table 3-14 – Control Vehicle & Case by Street Level

		Receiving Street Level			
		4/5 ^B	3 ^A	2	1
Departing Street Level	4/5 ^B	WB-50 (B) Quint (B)	WB-50 (B) Quint (B)	DL23 (A3) Quint (C)	DL23 (A3) Quint (C)
	3 ^A	WB-50 (B) Quint (B)	WB-40 (B) Quint (B)	DL23 (A3) Quint (C)	DL23 (A3) Quint (C)
	2	DL23 (A2) Quint (D)	DL23 (A2) Quint (D)	DL23 (C) Quint (D2)	DL23 (A2) Quint (D2)
	1	DL23 (D) Quint (D)	DL23 (D) Quint (D)	DL23 (D) Quint (D2)	Quint (D2)

^A Control vehicle can be changed to a smaller vehicle with a single lane Level 3.

^B These control vehicles are also to be applied to frontage roads and highways.

Table 3-15 – Recommended Effective Radii (Min – Max)^{A,C,D,F}

		4/5 ^B	3	2	1
Departing Street Level	4/5 ^B	30 ft (25-35 ft)	25 ft (25-35 ft)	15 ft (15-20 ft)	15 ft (10-20 ft)
	3	25 ft (25-35 ft)	20 ft (20-25 ft)	15 ft (15-20 ft)	15 ft (10-20 ft)
	2	15 ft (15-20 ft)	15 ft (15-20 ft)	15 ft (10-20 ft)	15 ft (10-15 ft)
	1	15 ft (10-20 ft)	15 ft (15-20 ft)	15 ft (10-15 ft)	15 ft (10-15 ft)

^A Radii are affected by angle of intersection. Values shown in this table assume generally orthogonal intersections. Values for skewed intersections will vary and need to be determined with turning simulation.

^B These recommended radii are desired for frontage roads and highways.

^C Presence of medians can result in different radii or mountability of median.

^D Actual radius may be smaller than the effective radius depending on receiving street width and presence of in-street bike lanes, parking, and bulb-outs.

^E Assumes a multi-lane Level 3 street. If designing single lane median divided street, turn design analysis required.

^F Corners where right turns are not permitted shall have radii of 5 ft or less.

- A. Design vehicle shall be a passenger car and turn using Case A, with the exception of an intersection of two Level 1 Streets when the turn shall be Case C.
- B. Control and design vehicle resulting radii may be modified at the discretion of the City Transportation Engineer or applicable Director. The lower end of the range shall be used unless larger radii is needed and analysis provided to justify the larger radius.
- C. When the following conditions are present for turning movements, the passenger car design vehicle shall be superseded by the stated design vehicle in these criteria and recommended curb radii do not apply for right turns:

1. On Transit Priority Corridors or where a designated transit route uses a right or left turn at an intersection, the design vehicle shall be a Standard City Bus using Case A2.
 2. Other than Level 1 Streets, where a school bus makes right or left turns as part of its regular route, the design vehicle shall be a school bus using Case A3.
- D. To accommodate a control vehicle, the following design strategies may be used with approval by applicable staff:
1. Stop bars may be setback from the intersection up to 30 ft
 2. Corners may be mountable for emergency control vehicles.
 3. Median noses and pedestrian or median islands may be mountable.
- E. Dual left turns shall not be permitted where there are 2 receiving lanes and the outside receiving lane includes a far side bus stop within 200 ft of the intersection, which may block vehicles from making the inside left turn.
- F. Dual left turns shall accommodate both lanes turning to the inside receiving lanes when more than 2 receiving lanes are present.
- G. Design vehicle turning movements are to be analyzed at 10 mph. If the recommended radius in Table 3-15 cannot be accommodated, the turning speed may be reduced to 5 mph.
1. Left turn speed may be analyzed at 15 mph if at a traffic signal, but may be reduced to 10 mph to allow a median nose or pedestrian waiting area.
- H. Control vehicle turning movements are to be analyzed at 5 mph. If the control vehicle cannot be accommodated at 5 mph, the turning speed may be reduced to 1 mph or alternative strategies used per criteria (D).
- I. For left turn movements, median noses shall be designed per City of Austin **Standard Details**. Deviations from the geometry shown in the standard details is allowed if it allows completion of design or control vehicle turning movement, such as use of a bullet nose median, and does not conflict with pedestrian or bicyclist crossings. For right turn movements, the curb return shall be designed to follow the vehicle wheel path.
1. Semicircular radii may be used on the noses of medians up to 6 feet wide. Compound medians nose treatments should be used for medians of greater width which gives enhanced opportunity for a median nose pedestrian waiting area.
- J. Compound curves shall be used for turning movement design to best fit the wheel path. Raised bulb-outs and medians shall be used to increase pedestrian waiting areas and reduce turning space.
- K. Areas where the apparatus body envelope of the control vehicle is anticipated to pass behind the face of curb or edge of pavement shall be clear of any vertical obstructions under 8 ft height.

3.6.2.2.1 Mountable Surface Placement

Intersection layouts shall incorporate the design control radius listed in **Table 3-15**. In scenarios where an existing intersection is being modified to include an additional turn lane or where right-of-way is constrained and the control radii in **Table 3-15** cannot be incorporated, implementation of mountable median noses may be used to maintain a raised barrier separating traffic.

- A. For streets with one travel lane in each direction and a center median, medians adjacent to a turn lane shall be either mountable surface or flush with the street pavement to allow for larger vehicles to make turns.
- B. Engineered mountable surfaces shall be placed between the edge of the design vehicle wheel path and the wheel path of the control vehicle. For left turns, standard median noses must be installed with a mountable curb.
- C. Figure 3-21 illustrates the profile of a mountable curb to accommodate a control vehicle. Refer to **City of Austin Standard Details** for additional design details on mountable median noses and mountable curbs.

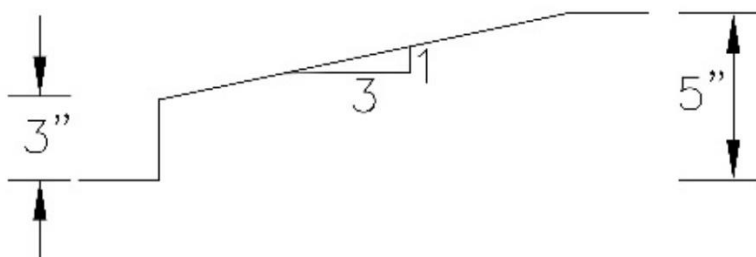


Figure 3-21 – Mountable Curb Profile

3.6.3 – Turn Lanes

This section covers the design of turn lanes on all new streets. While turn lanes improve intersection efficiency, they also introduce a conflict point between on street bicycle facilities and lengthen pedestrian crossing distances. Dedicated left and right turns shall only be provided along Level 2 and higher streets where turning volumes warrant their inclusion in street design. Turn lanes will not be considered unless volumes meet thresholds in **Table 3-16** determined through a Transportation Impact Analysis as defined in **Section 10**.

Table 3-16 – Turn Lane Thresholds

Turn Lane Type	Volume Threshold (turning vehicles per hour projected)
Right Turn Lane	200
Single Left Turn Lane ^A	150
Dual Left Turn Lane ^B	300

^A Threshold is not necessary if center turn lane or median with adequate width for a left turn lane per **Section 3.5.4.2** is present and access is approved by applicable department.

^B Shall only be considered where widening is feasible to accommodate and maintain minimum street element widths per **Section 2**.

- A. Turn lanes must provide sight distance for vehicular traffic to oncoming traffic and pedestrians and bicyclists. See **Section 3.4.2.1.1** for further guidance on intersection sight distance.

3.6.3.1 – Left Turn Lanes

Left turns shall be offset from adjacent travel lanes when sight distance is obstructed from opposing left turns or sight distance obstructions to maximize visibility for left turning vehicles. The typical configuration of the left turn offset in a median is shown in Figure 3-22. Two-way left turn lanes are strongly discouraged and should only be provided when approved as they introduce unprotected conflict points between drivers. Dual left turns create a number of impacts that need to be carefully considered and approved by applicable staff. Turn lane elements and dimensions are contained in Figure 3-23. **Table 3-17** contains design criteria for unsignalized left turn lanes. Signalized left turns shall be evaluated in a Transportation Impact Analysis per **Section 10**.

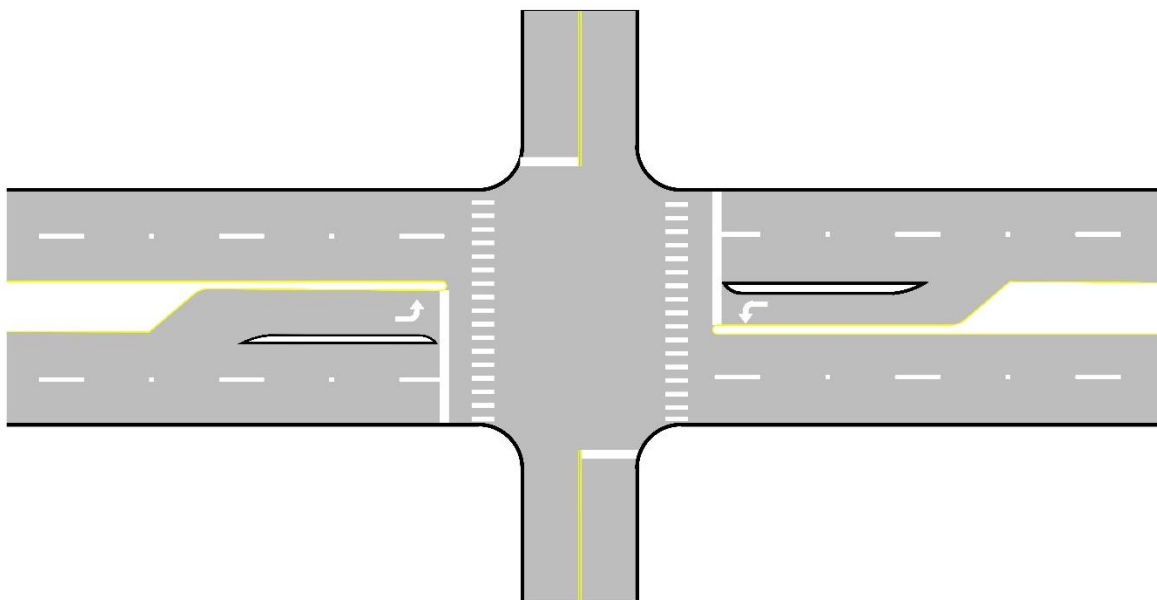


Figure 3-22 – Positive Offset Left Configuration

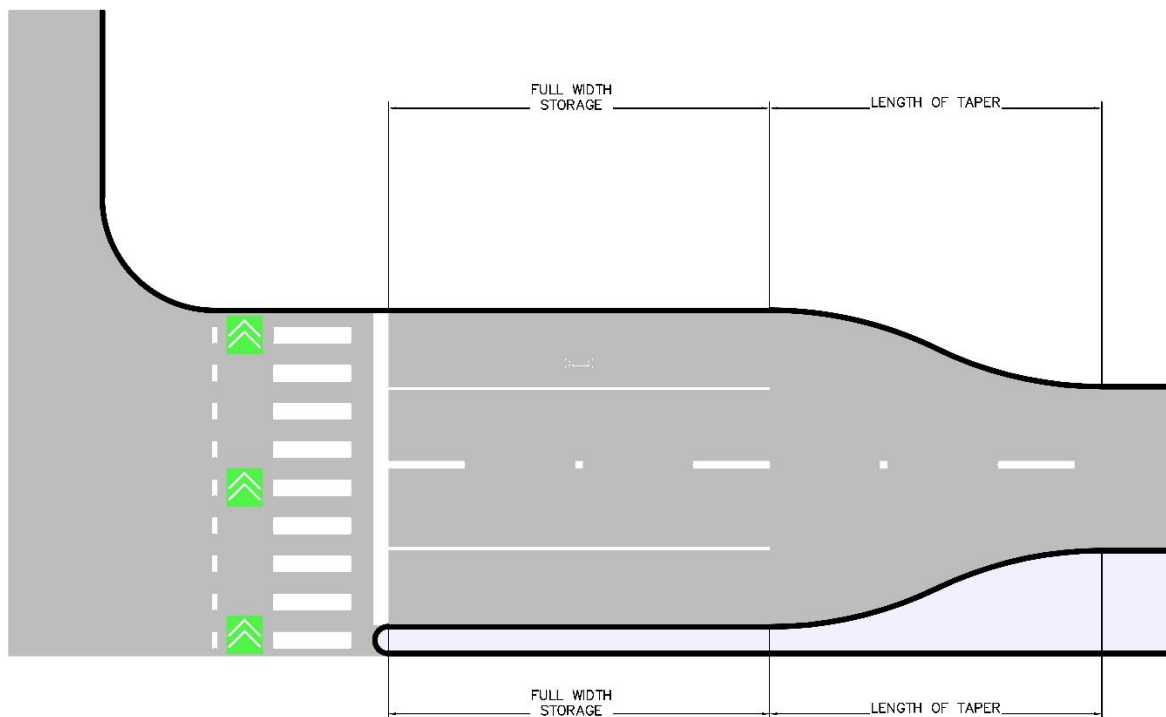


Figure 3-23 – Negative Offset Left Configuration

Table 3-17 – Unsignalized Left Turn Design Criteria

Level of Street On	Level of Street At	Turn Lane Width (ft)	Length of Full-Width Storage (ft)	Taper Specifications
4	4,3	10	250	200
3	4,3	10	150	200
4,3	2	10	150	100
4,3	1	10	100	100
4,3	Median Opening	10	150	100
2,1	4,3,2,1	10	100	100

- A. At left turn signalized intersections, the storage length shall be long enough to accommodate the projected 95th percentile queue length as determined by the *Highway Capacity Manual (HCM)*. At any left turn signalized intersection, a traffic study must be performed by a licensed professional engineer to determine the left-turn storage length, exclusive of taper, based on the number of turning vehicles likely to arrive in an average 2 minute period within the peak hour with each vehicle accounting for approximately 25 ft of storage. Turn lanes that exceed 400 ft must be approved by the City Transportation Engineer or applicable Director.
- B. To ensure proper deceleration length for turn lanes, the taper length plus storage length shall exceed deceleration length for a speed differential of 20 mph by at least 50 ft, per deceleration lengths in the latest edition of the TxDOT *Roadway Design Manual*.

- C. Dual left-turn lanes can be considered where traffic volumes exceed the capacity of a single lane and the cross-street is of sufficient width to receive 2 vehicles turning side by side.
 - i. Dual left-turn lanes are not permitted if only two receiving lanes are present with a bus stop within 200 ft of the intersection.
 - ii. Dual lefts require protected phasing that precludes permissive lefts / flashing yellow left signal operations.
 - iii. Dual lefts require exclusive pedestrian phases that depending on degree of pedestrian activity can affect theoretical signal benefits.
- D. Dual right-turn lanes are not permitted unless approved by staff member of the applicable department.
- E. If a turn lane falls in line with future through lane, width of turn lane shall match future through lane width.

3.6.3.1.1 Two-Way Left Turn Lane (TWLTL)

Refer to **Section 2** for permitted widths and applications of TWLTL. Due to the adverse safety impacts from head on conflict points that are created these turn lanes are highly discouraged. Where installed, raised medians are to be used where turning movements are not required to eliminate continuous TWLTL. This treatment is permitted as a retrofit application where high density access arises and is required for efficient operation of street.

TWLTL are not permitted for new construction projects unless approved by the City Transportation Engineer, applicable Director, or their designee.

3.6.3.2 – Right Turn Lanes

If a right turn lane is warranted per **Table 3-16**, it shall be designed as a smart right turn. Smart rights, by design, create a pedestrian island space prior to the turning vehicle path which reduces crossing distances and makes pedestrians highly visible to motorists. Smart rights facilitate the safe and orderly crossings between vehicles, pedestrians, and bicycles. Figure 3-24 illustrates a smart right turn lane and its features.

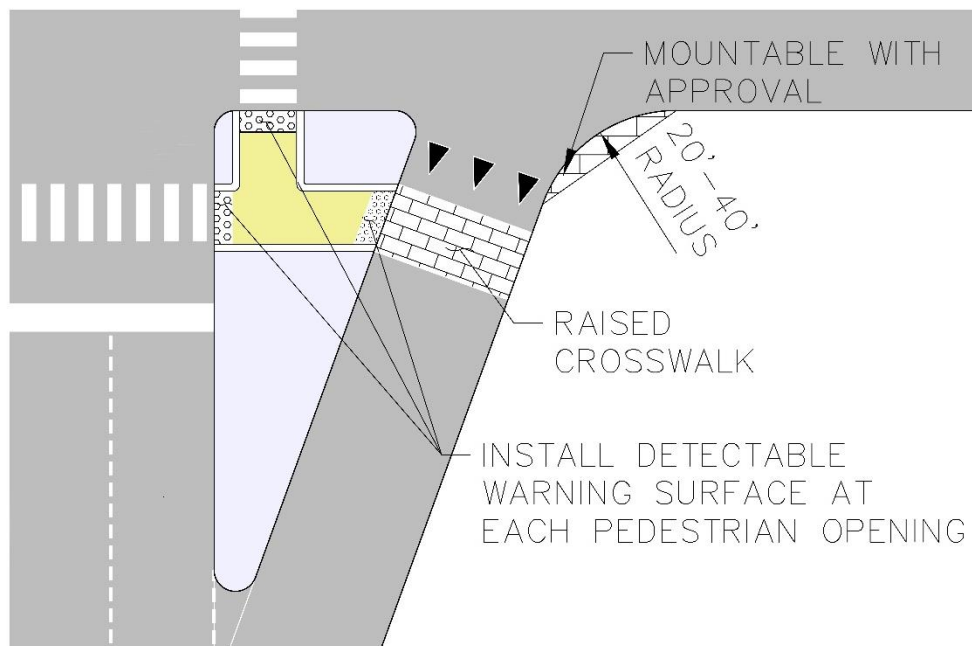


Figure 3-24 – Smart Right Turn

- A. Sight distance analysis shall be performed as outlined in **Section 3.4.2.1.1**.
- B. Pavement markings shall be used to supplement raised islands or other forms of physical separation of motor vehicles and other users of intersections and shall not be used as the only form of demarcation for channelizing right turns.
- C. Yield condition or stop sign must be provided at all smart rights. Uncontrolled turning movements are not permitted unless approved by staff member of applicable department.
- D. Pedestrian crossings for channelized right turns shall be a raised crosswalk.
- E. Smart right turn design entry and turning speed shall be at a target speed of 10 mph or less, for the appropriate design vehicle and control vehicle.
- F. Channelizing islands should include adequate space for accessible pedestrian paths and be compliant with ADA guidelines for design.

3.6.4 – Intersection Profile & Approach Design

Approaches to intersections serve to facilitate various maneuvers for road users such as lane shifts, merges, and turning movements. Approaches also serve the intersection by maintaining storage capacity for turning movements while vehicles wait for a safe opportunity to make a turning maneuver and not block lanes that are free flowing.

3.6.4.1 – Intersection Physical Area

The intersection physical area is defined by the area in which the intersecting roadways, driveways, pedestrian access routes and bikeways overlap and is shown in **Figure 3-25**. This area is primarily governed by vertical alignment, horizontal alignment, and minimum curb radius dimensions.

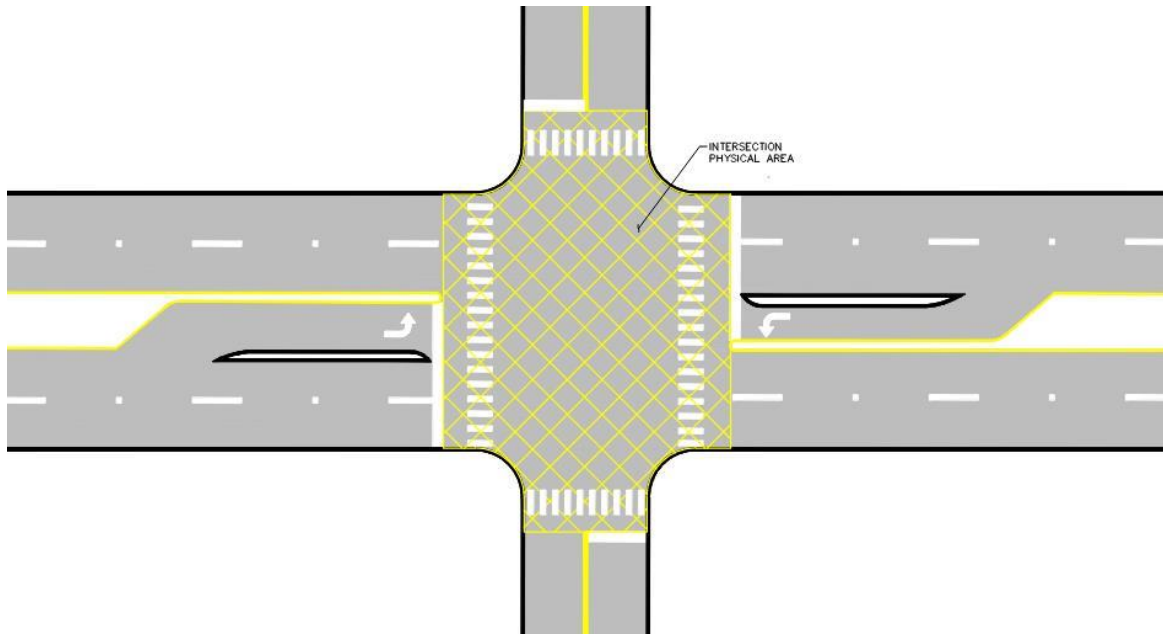


Figure 3-25 – Intersection Physical Area

3.6.4.2 – Intersection Alignments and Features

- A. In the intersection physical area, the target speed for motor vehicles for the higher level street at any intersection shall be maintained through the intersection approaches unless traffic calming and appropriate advance warning signage is used.
- B. The horizontal cross slope within the intersection physical area shall be a flat grade, where possible, that allows for street drainage. In situations where the terrain does not allow for flat grade, a maximum cross slope of 2% should be maintained for pedestrian access routes.

3.6.4.3 – Horizontal Alignment for Intersection Approach

Figure 3-26 illustrates the tangent length requirement for intersection approaches.

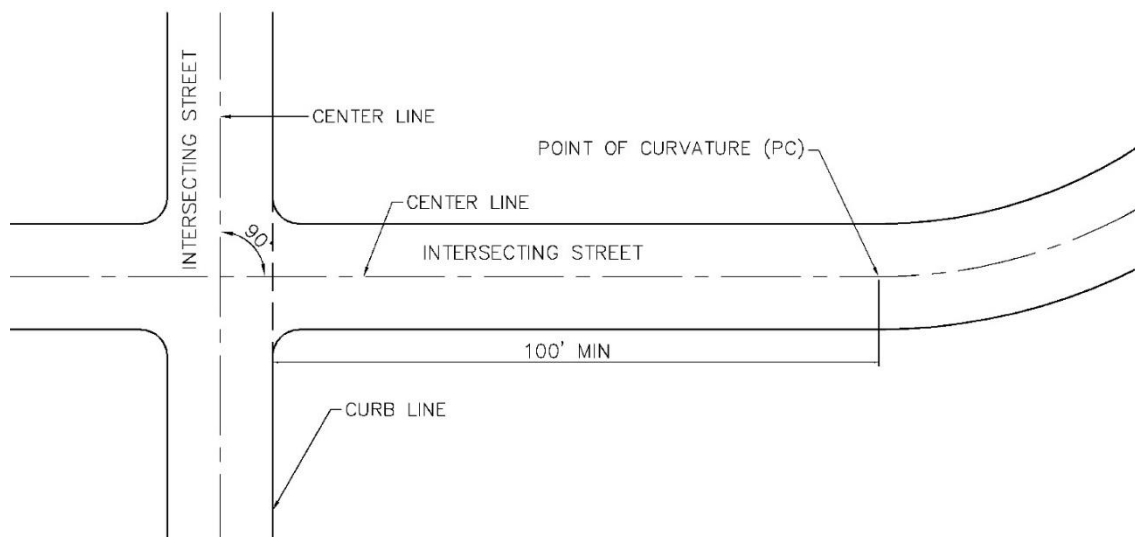


Figure 3-26 – Intersection Approach Geometry

- A. The horizontal approach to an intersection shall be tangent for a minimum length of 100 ft. Longer tangents are highly desirable.
- B. The tangent distance is measured from the curb line of the higher-Level street to the first point of curvature on the intersecting street. In this regard, radii greater or equal to 1,000 ft may be considered tangent.
- C. Intersections shall meet at approximately a 90-degree angle. Skewed intersections shall require City Transportation Engineer, applicable Director, or their designee's approval and in no case should the angle be less than 80 degrees or greater than 100 degrees.

3.6.5 – Access Spacing

This section governs spacing guidelines for placement of intersections and median openings along all streets. These criteria apply to new streets where access can be controlled and spaced prior to street construction. Planning access management for new projects is critical for a future well connected and safe street network. Spacing is to be planned in conjunction with adjacent development projects and zoning areas. New street intersections placement shall be placed in such a way to align with existing streets and minimize left turn conflicts. Median openings on new streets shall be placed at regular intervals to encourage a compact and connected street network. Access management shall be provided for in design of all Level 2 and higher streets. For placement of driveways in relations to median openings and intersections, see **Section 7**.

Table 3-18 shows the required access spacing based on target speed of the street being designed. Spacing requirements are further broken down by the level of activity along the street and if turn lanes are warranted at median openings. Where turn lanes are not required for access, median openings can be placed closer together. Figure 3-27 illustrates measurement of median opening spacing and **Section 7** elaborates further on driveway placements.

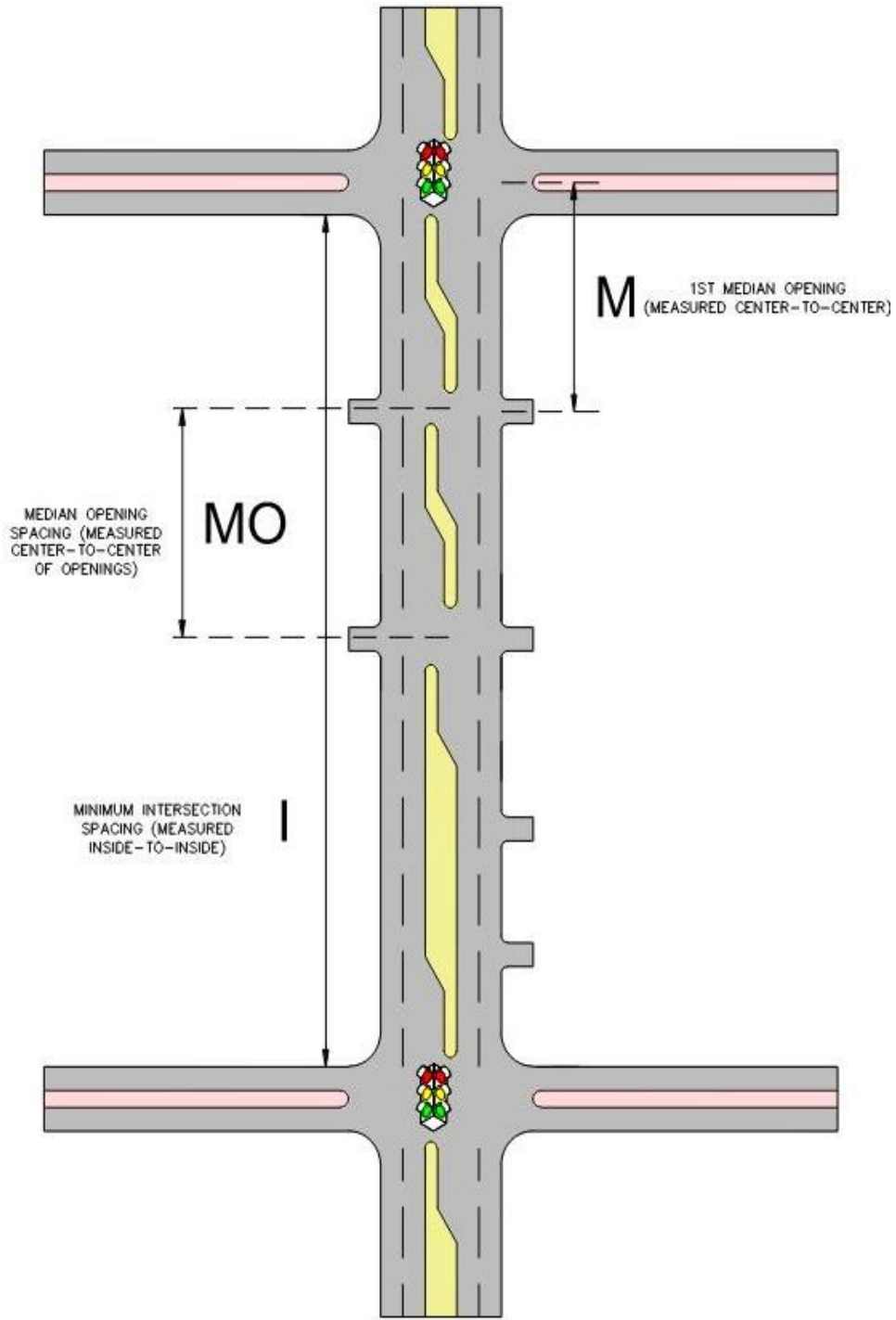


Figure 3-27 – Access Spacing

Table 3-18 – Median Opening Spacing Design Criteria

Street Level (mph)	Target Speed	Minimum Intersection – Intersection Spacing (ft) “I”	Minimum Intersection to Median Opening Spacing (ft) “M”	Minimum Median Opening – Median Opening Spacing (ft) “MO”	
				No Turn Lane Required	Turn Lane Required
Level 3 High Activity	25	600	300	150	300
Level 3 Low Activity	30	700	350	200	350
Level 4 High Activity	35	1,000	500	250	400
Level 4 Low Activity	40	1,000	500	350	500

- A. Median openings shall only be provided if minimum turn lane tapers and storage can be provided as outlined in **Section 3.6.3.1**. Median openings with substandard taper and storage length can only be provided with approval of staff member from the applicable department.
- B. Where minimum spacing requirements cannot be met along high-density corridors in urban areas, substandard spacing is permitted with approval of applicable staff. Median openings can be reduced to 300 ft minimum.
- C. Public streets shall be designed so that the centerline of the street is directly across from the centerline of another existing public street if left turns are permitted into or out of the public street.
- D. If an intersection is offset, they shall be located to avoid conflicting left turns and placed a minimum of 30 ft apart measured from the center line intersection of an intersecting roadway and the centerline intersection of the adjacent intersecting roadway, measured along the centerline of the intersected roadway.
- E. If an intersection is offset and left turns will conflict, access shall be restricted to right-in, right-out, with the exception of a hooded left-turn onto a street.
- F. Full-function median openings on Level 3 and higher streets shall be allowed only where the minimum spacings for signalized intersections are practicable. Practicable spacing outside the central business district are assumed to be 1,000 ft Consult with applicable staff for allowable spacing in the CBD.
- G. At intermediate locations along Level 3 and higher streets, limited-function openings may be provided at the spacings listed in **Table 3-18**.

3.6.6 – Traffic Signals

- A. Traffic signals shall be designed in compliance with the requirements set forth in the TMUTCD.
- B. All signal design shall conform to standard specifications and standard details as shown the **Standard Specifications Manual** and **Standards Manual**.
- C. All traffic signals shall be approved by the City Transportation Engineer or applicable Director.

3.6.7 – Roundabout Geometries

A roundabout is a form of circular intersection in which traffic travels counterclockwise around a central island and in which entering traffic must yield to circulating traffic. Roundabouts are a subset of circular intersections with specific design and traffic control features. These features include yield control of all

entering traffic, channelized approaches, geometric curvature, and features to induce desirable vehicular speeds.

Chapter 6 of NCHRP Report 672 should be used for geometric design of roundabouts, construction details, spacing between roundabouts, and traffic control plan phasing in the City of Austin. Key criteria that should be met include fastest path entry speeds, design vehicle movements, path overlap for entry and exit tangents, entry angles, entry and exit radii, maximum and minimum slopes and several other factors that are detailed in the NCHRP Report 672. Reference **Section 4.2.4.2** for Pedestrian island area minimum dimensions at roundabouts. Inscribed circle diameters should be designed as shown in **Table 3-19**. It is not preferred to apply signalized treatments to roundabouts.

Roundabouts can be one of many types: mini-roundabout, single lane roundabout, multi-lane roundabout, and roundabouts with bypass lanes. Roundabouts should be designed with the conditions shown in Table 3-19 for the appropriate category of roundabout based on available space, number of entering lanes and target speed, adapted from NCHRP Report 672. Typical configurations and features of each category of roundabout are shown in Figure 3-28 through Figure 3-31.

Table 3-19 – Roundabout Categories

Design Element	Roundabout Configuration		
	Mini-Roundabout	Single-Lane Roundabout	2 Lane Roundabout
Desirable entry target speed	15-20 mph	20 mph	20-25 mph
Maximum number of entering lanes per approach	1	1	2+
Central island treatment ¹	Hard Mountable	Raised (may have traversable truck apron)	Raised (may have traversable truck apron)
Central island pedestrian waiting area length	varies	6' minimum	8 ft minimum
Pedestrian / Bicycle Facilities	8 ft Shared Use Path	Separated sidewalk and protected bicycle lane OR 10 ft shared Use Path	Separated sidewalk and protected bicycle lane OR 12 ft shared Use Path
Pedestrian / Bicycle Crossings ²	Raised crossing with pedestrian warning signs	Raised crossings with flashing pedestrian warning signs	Grade separation or raised crossings with RRFB
Typical daily service volumes on 4-leg roundabout below which may be expected to operate without requiring a detailed capacity analysis (veh/day)	Up to approximately 15,000	Up to approximately 25,000	Up to approximately 45,000 for two lane roundabouts
Design Vehicle	Common Inscribed Circle Diameter Range*		
SU-30	45-90 ft	-	-
B-40	-	90-150 ft	-
WB-50	-	105-150 ft	150-200 ft (180-250 ft)
WB-67	-	130-180 ft	165-200 ft (180-300 ft)

¹ Hard mountable curb profile is 3 in. vertical and 2 in. additional at 3:1 slope.

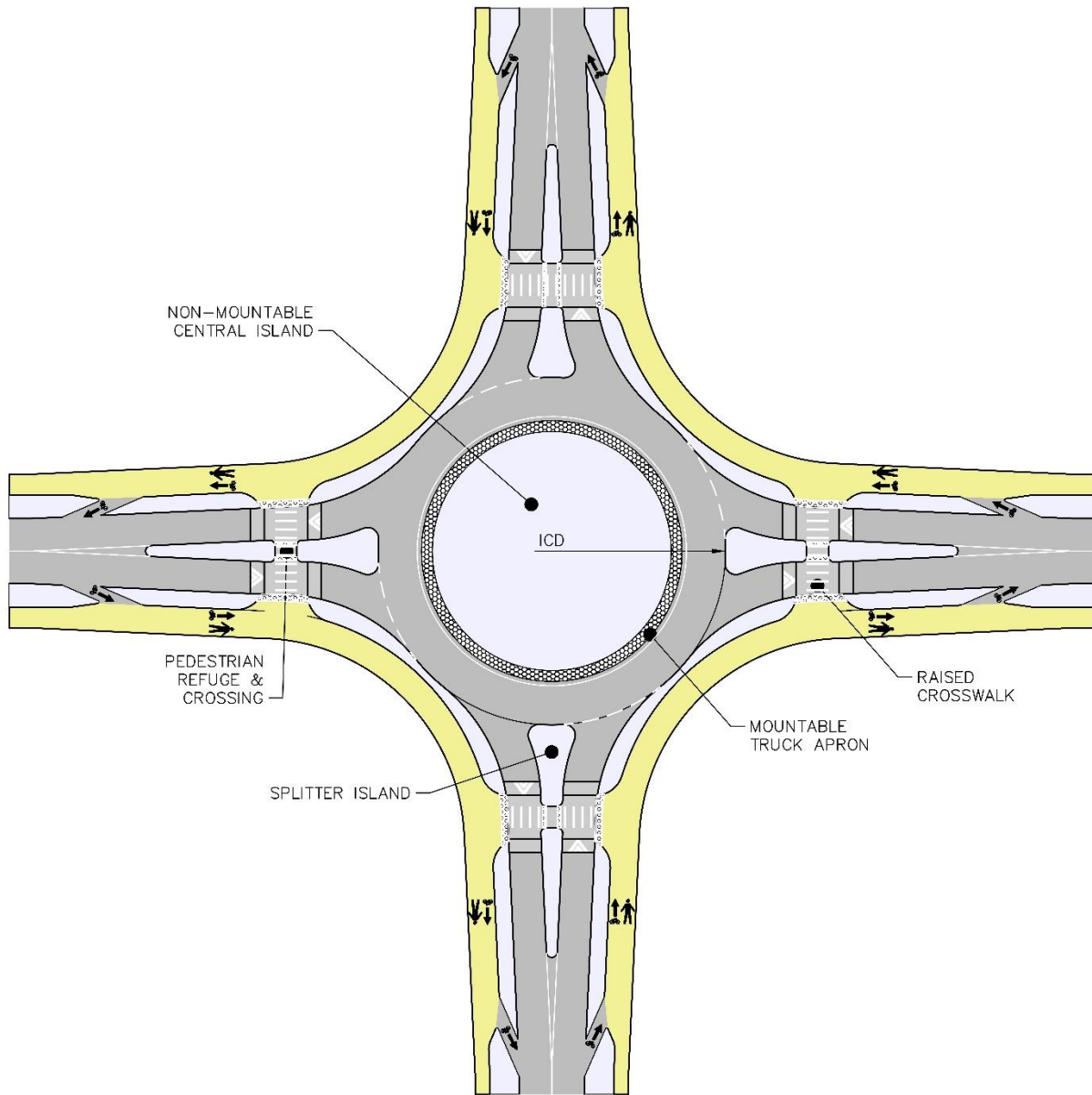


Figure 3-29 – Single Lane Roundabout Typical Features

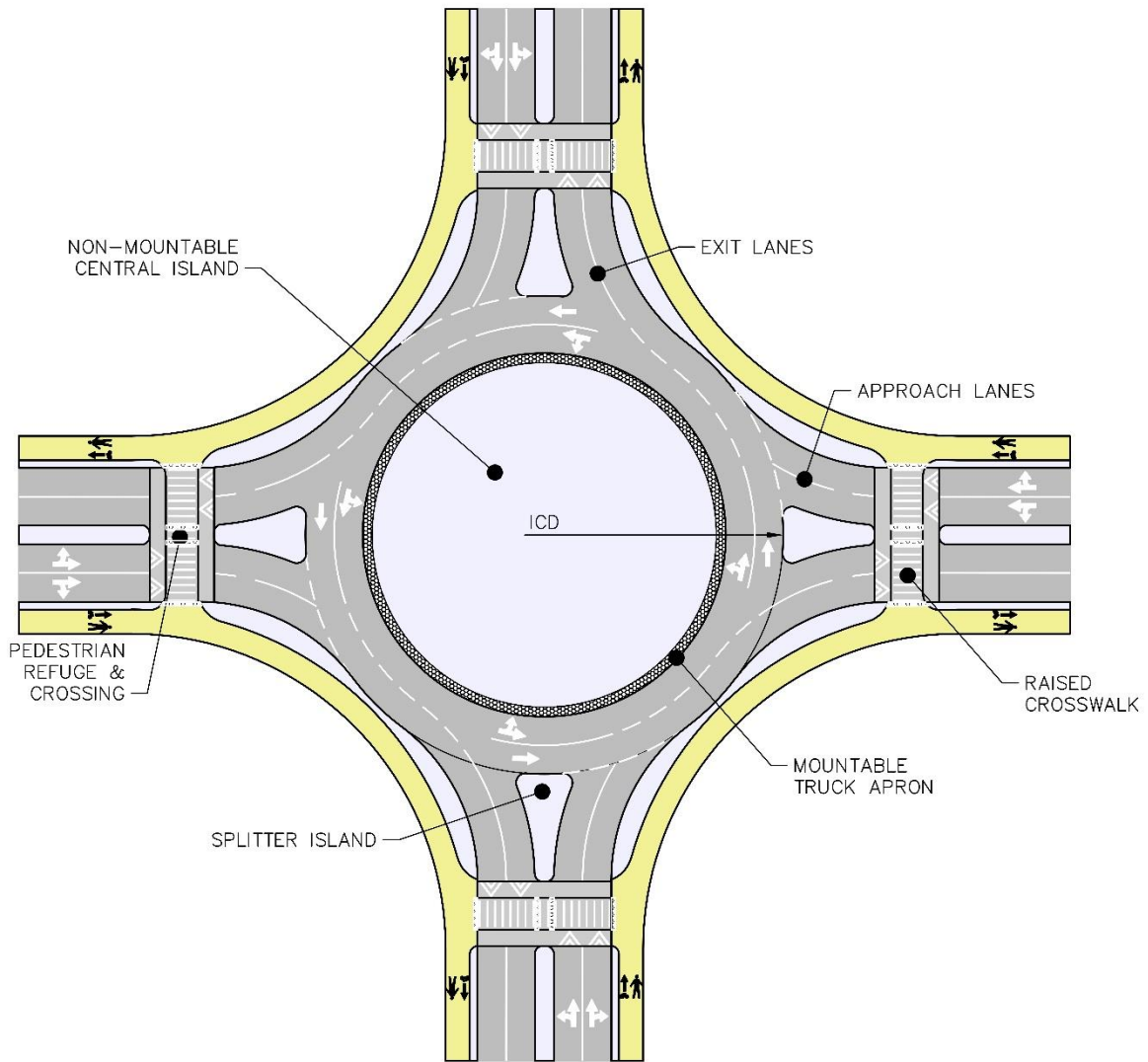


Figure 3-30 – Multi-Lane Roundabout Typical Features

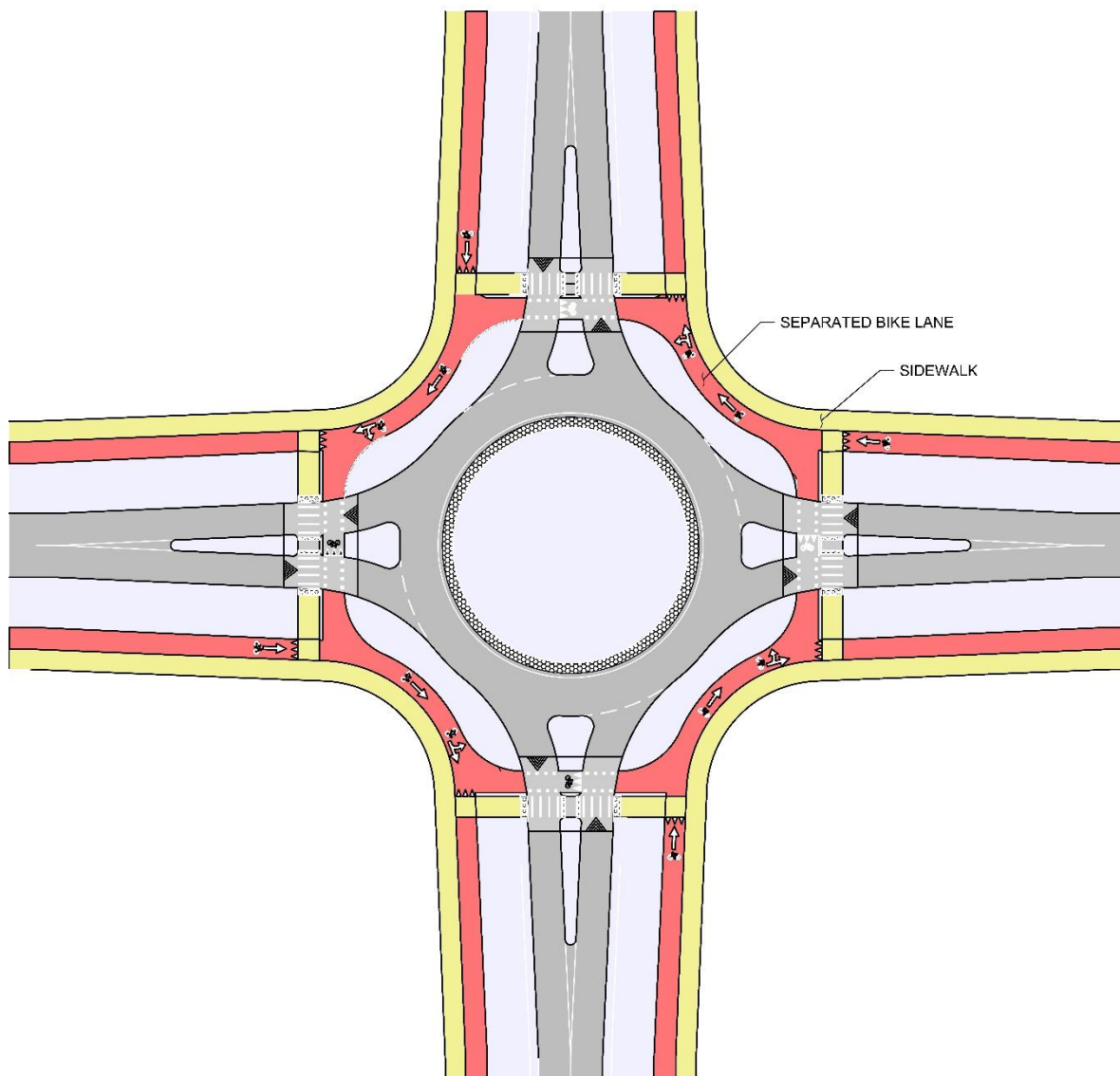


Figure 3-31 – Protected Bike Lane at Roundabout Typical Layout

- A. Protected bike lanes shall continue through roundabouts as a separated facility with marked crossings and not enter the inscribed circle area of a roundabout where motorists circulate. An example of a protected bicycle facility at a roundabout is shown in Figure 3-31.

3.6.8 – Additional Intersection Types

This section governs non-standard intersection geometries and control as determined by an Intersection Control Evaluation in **Section 3.7.0** for new and reconstruction projects. **Table 3-20** shows the various innovative intersection types and where to find design guidance on these intersection types (adapted from Florida ICE Manual, November 2017). These additional intersection types may be used in the ICE process and should be designed by a Professional Engineer licensed in the state of Texas with approval by the City Transportation Engineer or applicable Director, if deemed an appropriate solution through the ICE process.

Table 3-20 – Intersection Design Guidance Documents

Title	Description
FHWA-SA-14-069 Median U-Turn Intersection Informational Guide	PDF report providing guidance on median U-Turn (MUT) Intersections
http://safety.fhwa.dot.gov/intersection/alter_design/pdf/fhwasa14069_mut_infoguide.pdf	
FHWA-HRT-09-055 Displaced Left-Turn Intersection	PDF report providing guidance on displaced left-turn intersections
http://www.fhwa.dot.gov/publications/research/safety/09055/09055.pdf	
FHWA-SA-14-070 Restricted Crossing U-Turn Intersection Information Guide	PDF report providing guidance on restricted crossing U-turn (RCUT) intersections
http://www.fhwa.dot.gov/publications/research/safety/09055/09055.pdf	
FHWA-HRT-07-032 Traffic Performance of Three Typical Designs of New Jersey Jughandle Intersections	PDF report providing guidance on New Jersey Jughandle intersections
http://www.fhwa.dot.gov/publications/research/safety/09055/09055.pdf	
FHWA-SA-14-068 Displaced Left-Turn Intersection Informational Guide	PDF report providing guidance on displaced left-turn (DLT) intersections
https://safety.fhwa.dot.gov/intersection/alter_design/pdf/fhwasa14068_dlt_infoguide.pdf	
FHWA-SA-09-016 Continuous Green T-Intersections	PDF report providing guidance on continuous green T-intersections
https://safety.fhwa.dot.gov/intersection/innovative/others/casestudies/fhwasa09016/fhwasa09016.pdf	
FHWA-HRT-09-058 Quadrant Roadway Intersection	PDF report providing guidance on quadrant roadway intersections
http://www.fhwa.dot.gov/publications/research/safety/09058/09058.pdf	

3.7.0 – Intersection Control Evaluation

Intersection Control Evaluation refers to a decision-making process and framework to provide a more balanced and holistic approach to the consideration and selection of access strategies and concepts during transportation planning, project identification and initiation processes that contemplate the addition, expansion or “full control” of intersections. Traditional methods rely heavily upon the TMUTCD and its stop control and signal warrants without consideration of other alternative approaches to intersection control.

Section 3.4.2.1 offers some standard intersection control types for Level 1 streets within subdivisions that may be applicable as alternatives to traditional stop control.

3.8.0 – Shared Streets

A shared street is designed to emphasize pedestrian mobility. This facility still permits vehicular traffic, however, it is designed to encourage pedestrian activity by slowing traffic speeds using pedestrian volume, street design, landscaping, lighting, and material selections to help influence driver behavior and contribute to the quality of place. A shared street is the flexible use of right-of-way, allowing vehicles, pedestrians, and bicycles to share the street equally. Shared streets should only be used on streets with low volumes where 10 MPH or less can be attained through design and in areas where high multimodal activity exists and are

limited to Level 0 and Level 1 Streets. Figure 3-32 illustrates the different areas of a shared street. Shared streets shall have retractable bollards at entry points to the street and shall maintain a minimum clear width of 20 ft. A shared street must be approved by the City Transportation Engineer or applicable Director. Separately, streets that include temporary or permanent closure to vehicles for exclusive non-vehicular traffic shall be approved by the City Transportation Engineer or applicable Director.

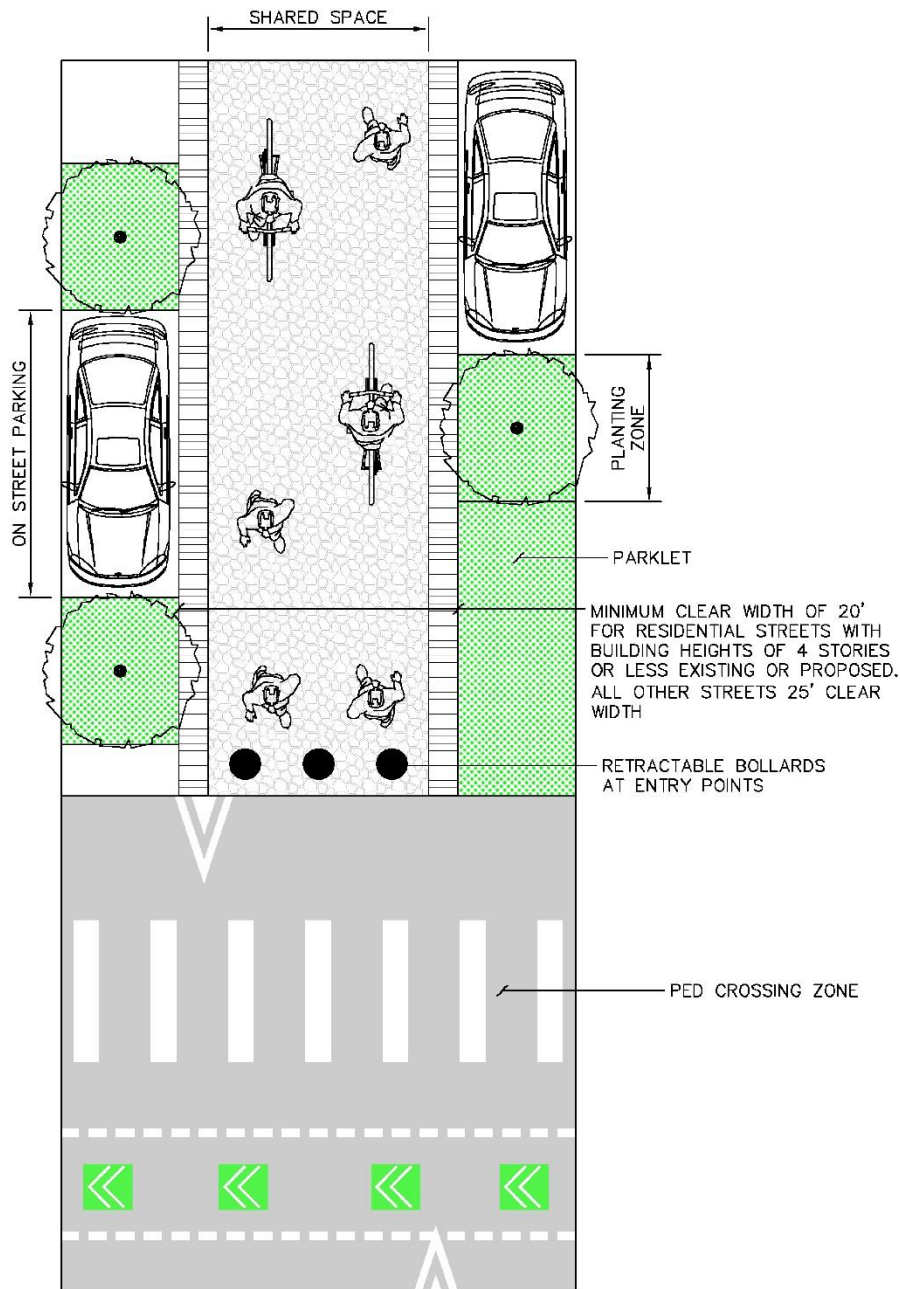


Figure 3-32 – Shared Street Typical Elements

SECTION 4 - PEDESTRIAN FACILITIES

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This Section covers design criteria related to pedestrian facilities. Pedestrian facilities occur along sidewalks, shared paths, and queuing areas such as transit stops. Pedestrian facilities also include areas where pedestrians cross the street.

Walking, as the most basic form of transportation, must be prioritized to provide a safe environment for all right-of-way users. Pedestrian facilities should be provided with shade wherever possible and frequent crossing locations that provide access to adjacent land uses. Pedestrian crossings should be highly visible and be combined with street design treatments that slow vehicle speeds near the pedestrian crossings.

The **ASMP**, Sidewalk Plan, and ADA Transition Plan are the guiding policy documents for completion and rehabilitation of the City of Austin's sidewalk network and should be referenced for guidance on Austin's vision for a complete pedestrian network. These plans highlight the importance of a connected network of sidewalks, proper intersection design, safe pedestrian crossings, and compliance with the current editions of the Americans with Disabilities Act (ADA), United States Access Board's Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG), and Texas Accessibility Standards (TAS) among other elements, as critical features of a safe and comfortable pedestrian network.

It is the intent of this Section to fulfill the ASMP goals and objectives to design streets and right-of-way to promote safe, comfortable, and convenient access and travel for people of all ages and abilities. It is also the intent of this Section to provide guidance to developers and development reviewers on facility and design requirements of pedestrian facilities and required spacing from other elements in the pedestrian zone.

4.1.0 – Pedestrian Zone

This Section covers design criteria for the design of pedestrian facilities occurring within the pedestrian zone. The criteria in this Section are to be followed for pedestrian facilities being designed for city streets and private streets.

A variety of elements may occupy the pedestrian zone, but it can generally be subdivided into two areas: 1) the tree and furniture zone and 2) the sidewalk (or shared use path in constrained Right-of-Way scenarios). This space includes sidewalks, shared use paths, boarding areas required for transit operations, street trees, and other street amenities that fall outside of the sidewalk or shared use path. This space is often shared with utilities above and below ground, which shall comply with the criteria in the **Utilities Criteria Manual**. Figure 4-1 illustrates the Pedestrian Zone in relation to the Bicycle & Street Edge Zone, as defined in **Section 2.6.0**, and the right-of-way line. The Pedestrian Zone includes a 6in width area for the curb when the zone is adjacent to the curb. **Section 2.7.0** contains criteria for widths of elements in the Pedestrian Zone.

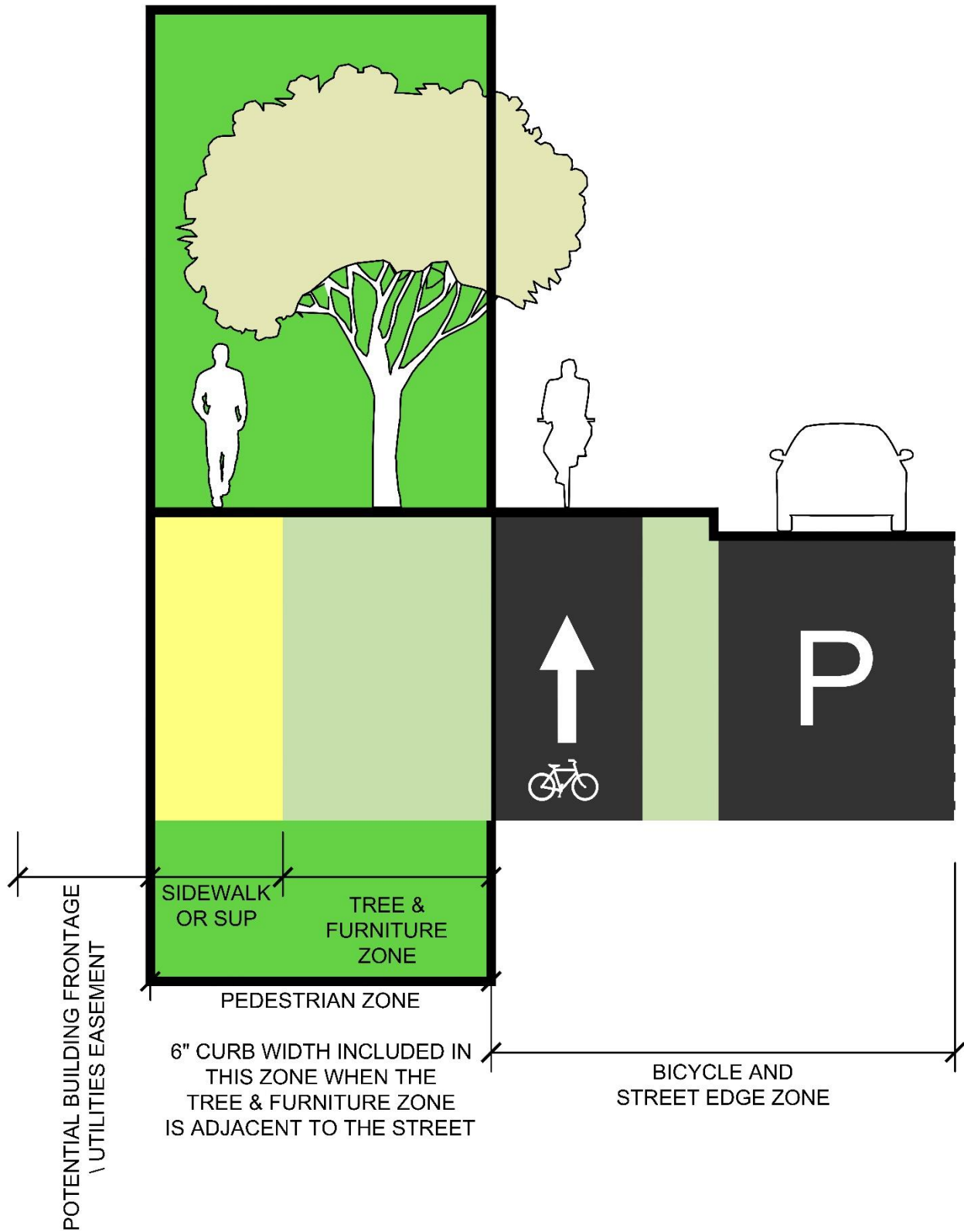


Figure 4-1 - Pedestrian Zone Elements

4.1.1 – Sidewalks

For sidewalk width and placement on Level 1 Streets, refer to **Figure 2-14**. For sidewalk width and placement requirements along Level 2, 3, and 4 Streets, refer to **Table 2-2 and Table 2-3**. For sidewalk width and placement requirements along Level 5 Streets, bridges, or temporary sidewalks, see **Section 4.1.4**. Typical placement of sidewalks within the pedestrian zone in relation to other streetscape furnishings is shown in Figure 4-2, with measurement of clear width illustrated as defined in Section 4.1.1 (A).

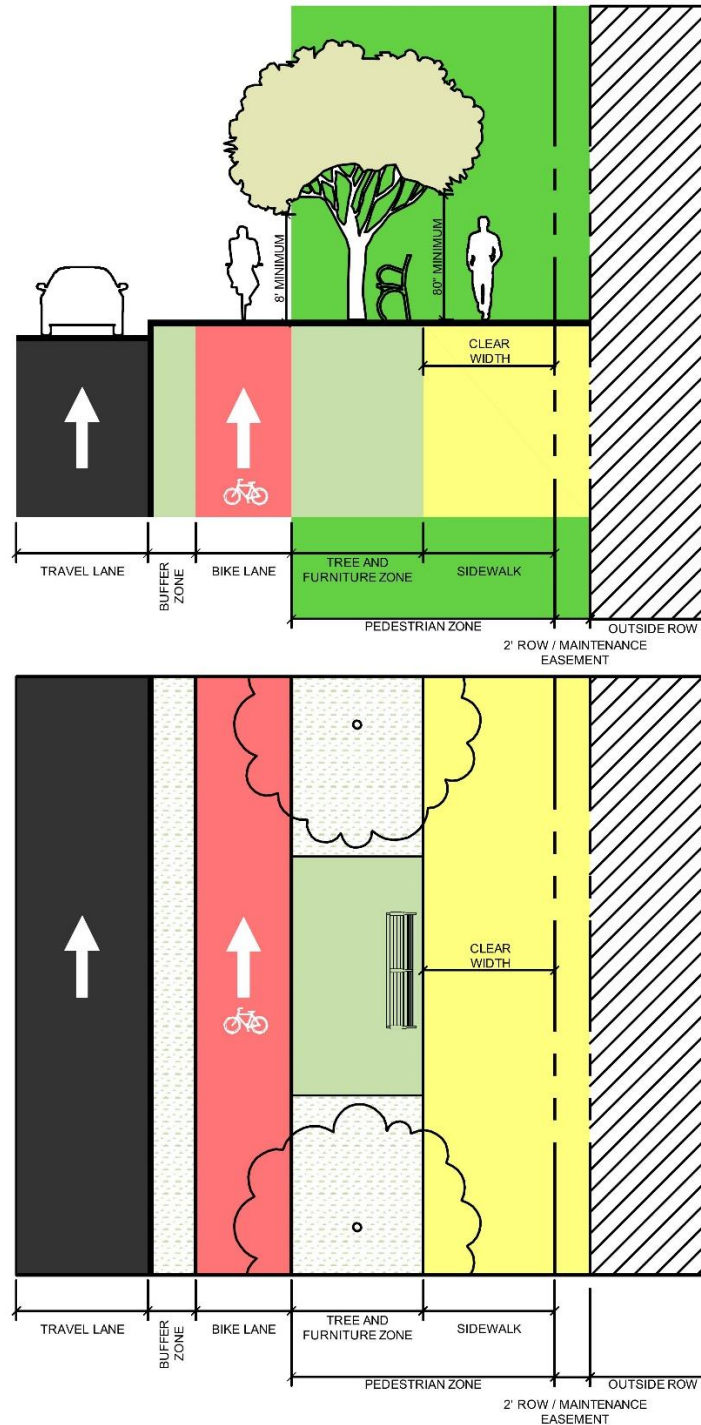


Figure 4-2 – Clear Width

- A. Sidewalk widths shall be consistent with the specifications in Table 2-2 and Table 2-3 in **Section 2.7.1** and shall be installed consistent with the requirements of the LDC and any applicable development approvals. Sidewalks must be ADA compliant. If a plan adopted by ordinance conflicts with these requirements, the strictest criteria shall be used. In areas with no other requirements, the minimum clear widths shall be 5 ft for Level 1 streets and 6 ft for all Level 2 and higher streets. Refer to **Great Streets Standards** for sidewalks in the area defined in **Figure A-2**.
 - 1. In situations where building lines are built up to the Right-of-Way line with 0 ft setback, an 18 in. clearance from the building face may not be counted as part of the 5 ft clear width requirement.
- B. The minimum clear width shall be unobstructed by any permanent or nonpermanent elements for accessible pedestrian travel and shall have a minimum vertical clearance of 80 in. Minimum vertical clearance for shared use paths is per **Section 4.1.2 (G)**.
- C. Sidewalks shall follow the shortest, most direct path along the roadway. If this path is not achievable, refer to **Section 4.1.3** for further guidance.
- D. Sidewalks or shared used paths shall be installed on both sides of all streets except where Fee-in-Lieu of Sidewalk Installation has been approved in accordance with the LDC and meeting requirements of **Section 4.1.6**.
- E. Sidewalks must be constructed between the curb line and the property line in the pedestrian zone, in an easement, or on adjacent dedicated parkland that creates a continuous path in front of adjacent properties.
- F. Except for zero setback properties, the standard alignment for the back edge of the sidewalk is 2 ft off the property line to allow sufficient space for maintenance. In constrained conditions, the back edge of sidewalk can be located within 2 ft of the property line with staff approval of an easement or other acceptable provisions to ensure sidewalk can be maintained. Where zero (building) setback lots exist adjacent to a pedestrian facility, sidewalks may be constructed for the entire width from the property line to the curb line, but shall conform to 4.1.1 (A) (1). See **Section 2** for additional detail on setbacks and typical cross sections.
- G. The side slopes of sidewalks within 5 ft parallel and on either side of the sidewalk shall not be steeper than 1V:3H.
- H. Sidewalks and streetscape furnishings shall be constructed in accordance with the City of Austin **Standard Details** and the City of Austin **Standard Specifications** and in accordance with current edition of PROWAG and TAS. Whenever these standards are in conflict, the strictest requirements shall apply.
- I. Sidewalk requirements of the **LDC** may be satisfied by existing sidewalks provided they meet the following criteria:
 - 1. The existing sidewalks comply with the requirements of the LDC and TCM; and
 - 2. The physical condition of the existing sidewalks, including curb ramps, meets or exceeds the requirements to be considered functionally acceptable (A or B rating) under the City of Austin functional classification system as outlined in the City of Austin Sidewalk Plan.

Applicants must take inventory of existing sidewalks adjacent to properties and determine the rating of the sidewalk per the methodology outlined in the City of Austin Sidewalk Plan.

- J. If a new sidewalk is constructed, street trees shall be provided, unless the street is a Level 1 Street with insufficient Right-of-Way to accommodate the minimum width of 6 ft required for street trees. Planting shall be in accordance with the **Environmental Criteria Manual**, and soil requirements for street trees are further specified in **Section 2.7.1.3**. Placement of street trees shall not conflict with utilities in accordance with design criteria in the **Utilities Criteria Manual**.

4.1.2 – Shared Use Paths

Shared use paths combine bike and pedestrian space into one path. To maintain safe operations for both modes of travel, the path must be wide enough to safely separate both users. Separated bike and pedestrian paths are the preferred design, as they are safer for both street users. Because of this, shared use paths are intended to be allowed when insufficient Right-of-Way exists per the typical cross sections identified in **Section 2.8.0** of the TCM and in special situations outlined below. A typical layout and application of a shared use path is shown in Figure 4-3.

In standard situations and with the approval of the applicable staff member, a shared use path may be substituted for a conventional sidewalk, provided access easements are provided and they are accessible to persons with disabilities as defined and required in the Americans With Disabilities Act. For capital improvement projects or corridor studies, one-way shared use paths may be installed as a phased approach to separated bike and pedestrian facilities as right-of-way is dedicated over time along a street, as shown in **Figure 2-20**.

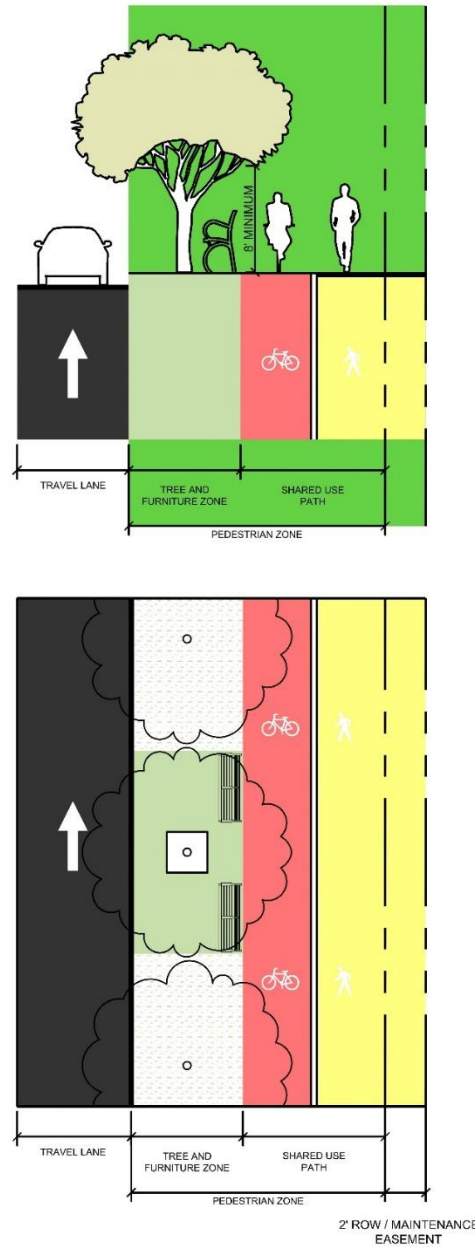


Figure 4-3 – Shared Use Path

- A. When pedestrian and bicycle facilities are combined into a shared use path, the shared use path shall be located between the Right-of-Way line and Tree & Furniture Zone as shown in Figure 4-3, unless placement in an easement is approved by applicable staff.
- B. The transitions between a shared use path and bicycle facility shall occur in advance of intersections, as detailed in **Section 5**.
- C. Shared use paths shall follow the shortest, most direct path along the street. If this path is not achievable, refer to **Section 4.1.3** for further guidance.

- D. Shared use paths are the recommended facility on Level 2, 3, and 4 Streets without curb and gutter. **Table 2-3** contains recommended and constrained dimensions for shared use paths based on street level.
- E. For streets with a curb and gutter, shared use paths shall only be approved with a waiver and facility widths followed per **Table 2-3** based on street level. The shared use path width will replace the combined width of the sidewalk and bicycle facility and bicycle facility buffer as shown in **Table 2-2**, when permitted.
- F. Grades and cross slopes for a shared use path shall conform with requirements for sidewalks as defined in the current editions of United States Access Board's Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG) and Texas Accessibility Standards (TAS).
- G. Minimum clear width shall be 8 ft for a shared use path that is one way for bicycles and 10 ft for a shared use path that is two-way for bicycles. Minimum vertical clearance for a shared use path shall be 8 ft. Other considerations may go into the required width of a shared use path, including likelihood of heavy pedestrian and bicycle use or a planning document such as the Austin Bicycle Plan or Austin Urban Trails Plan, at the discretion of the appropriate director.
- H. One-way shared use paths shall identify pedestrian and bicycle assignments utilizing pavement markings to separate pedestrians and bicycles with a solid line in the center of the path and pedestrian and bicycle pavement markings on either side of the line per Figure 4-3. Refer to City of Austin **Standard Details** for specifications on pavement markings for shared use paths. Markings and signs must be compliant with the latest edition of the Texas Manual on Uniform Traffic Control Devices (TMUTCD).
- I. Depending on the ultimate configuration of shared use paths they may be required to be fully or partially colored per **Section 5.1.3**.
- K. If a new shared use path is constructed, street trees shall be provided, unless the street is a Level 1 Street with insufficient Right-of-Way to accommodate the minimum width of 6 ft required for street trees. Planting shall be in accordance with the **Environmental Criteria Manual**, and soil requirements for street trees are further specified in **Section 2.7.1.3**. Placement of street trees shall not conflict with utilities in accordance with design criteria in the **Utilities Criteria Manual**.

4.1.3 – Flexible Design within the Pedestrian Zone

When constraints exist such as trees, grades, or other natural elements and additional easement or ROW is not possible to accommodate **Sections 4.1.1 (C) or 4.1.2 (C)**, sidewalks and shared use paths can be built in flexible ways to avoid impacts to the facility clear width and compliance with PROWAG and TAS requirements. Use of design strategies such as suspended sidewalks and meandering paths to avoid impacts is permissible with approval of applicable staff. Meandering paths should avoid sharp turns or transitions and gradually transition no more than 1 ft off path per 5 ft of sidewalk length and maintain a straight section no less than the width of the sidewalk between transitions, where able. Refer to the **City of Austin Standard Details** for design requirements for suspended sidewalks.

4.1.4 – Non-Standard Sidewalk Placement

This section covers criteria for sidewalk design and placement in locations with special conditions or subject to other jurisdictions' right-of-way in the City. Locations include but are not limited to; bridges, Texas Department of Transportation (TxDOT) facilities, and temporary sidewalks.

4.1.4.1 – Bridges

- A. When sidewalks are required on bridges, they shall match the sidewalk width of the adjacent roadway cross section or a minimum of 6 ft wide, whichever is greater (clear of bridge rail) plus a 3 ft wide buffer space of colored patterned concrete between the back of curb and sidewalk edge.
- B. In conditions where the appropriate facility on the bridge is determined to be a shared use path, minimum widths applied shall conform to requirements in **Table 2-3** based on street level, including a minimum buffer space of 3 ft of separation with a bridge rail.

4.1.4.2 – TxDOT Roadways

- A. Sidewalks or shared use paths are required on State-maintained highways except where prohibited by the Texas Department of Transportation.
- B. Shared use paths or sidewalks on State-maintained highways must be located in accordance with the requirements of the Texas Department of Transportation and as required by the Americans With Disabilities Act (ADA). Generally, shared use paths or sidewalks on State highways must be located within the right-of-way adjacent to the property line.
- C. For any State-maintained highways identified in the Bicycle Priority Network or Urban Trails Network of the ASMP, shared use paths are required in place of sidewalk requirements, conforming to minimum width requirements in this Section, recommended setbacks in **Section 2.8.2.6**, or minimum setbacks per AASHTO design guidance for shared use paths.

4.1.4.3 – Temporary Sidewalks

- A. During construction of permanent pedestrian facilities where pedestrian facilities previously existed and a reasonable alternate route is not available, temporary sidewalks shall be provided. Alternatively, a detour may be provided if approved by the **applicable department**. See **Section 8.3.2** for temporary traffic control for pedestrians.
- B. Temporary sidewalks shall comply with applicable ADA requirements.

4.1.5 – Appurtenances in Pedestrian Zone

This section covers placement requirements for city-maintained appurtenances in the pedestrian zone and spacing requirements from the sidewalk clear width. Appurtenances include, but are not limited to city utilities and bike, transit, and streetscape elements.

In City of Austin **Standard Details**, Code, ordinances, or other manuals from the City of Austin, "clear zone" when used to identify pedestrian paths is interchangeable with "clear width".

- A. Transit stops and associated amenities shall be placed between the curb or edge of pavement and the sidewalk clear width except as provided for in **Section 6** of this manual.

4.1.5.1 – Bike & Dockless Mobility Parking

See **Section 9.8.0** for guidance on placement of bike parking in the pedestrian zone, which shall generally be placed in the Tree & Furniture Zone of the right-of-way. **Section 9.9.0** additionally covers dockless mobility parking placement in the right-of-way.

4.1.5.2 – Streetscape

Streetscape furnishings are objects in the right-of-way available for public use that are intended to enhance the pedestrian experience and support pedestrian activity as a transportation mode. Typical placement of streetscape furnishings is in the Tree & Furniture Zone but may also be located at back of sidewalk with City Transportation Engineer, applicable Director, or their designee’s approval. Utility appurtenances also exist in the tree and furniture zone which include, but are not limited to, streetlights, fire hydrants, waste receptacles, and public utility equipment. Alternative placement in the sidewalk area of the Pedestrian Zone of a street is allowable with City Transportation Engineer, applicable Director, or their designee’s approval, if sidewalk clear width (see **Section 4.1.1 (A)**) is maintained and spacing between other appurtenances is maintained per this Section. For streetscape furnishings not specifically listed in this Section, the City Transportation Engineer, applicable Director, or their designee’s approval is required for placement. Within the Downtown area defined in **Figure A-2**, streetscapes shall be designed in compliance with the latest adopted version of the **Great Streets Master Plan**. Figure 4-4 illustrates the typical and alternative placement areas of streetscape furnishings with minimum spacing between objects.

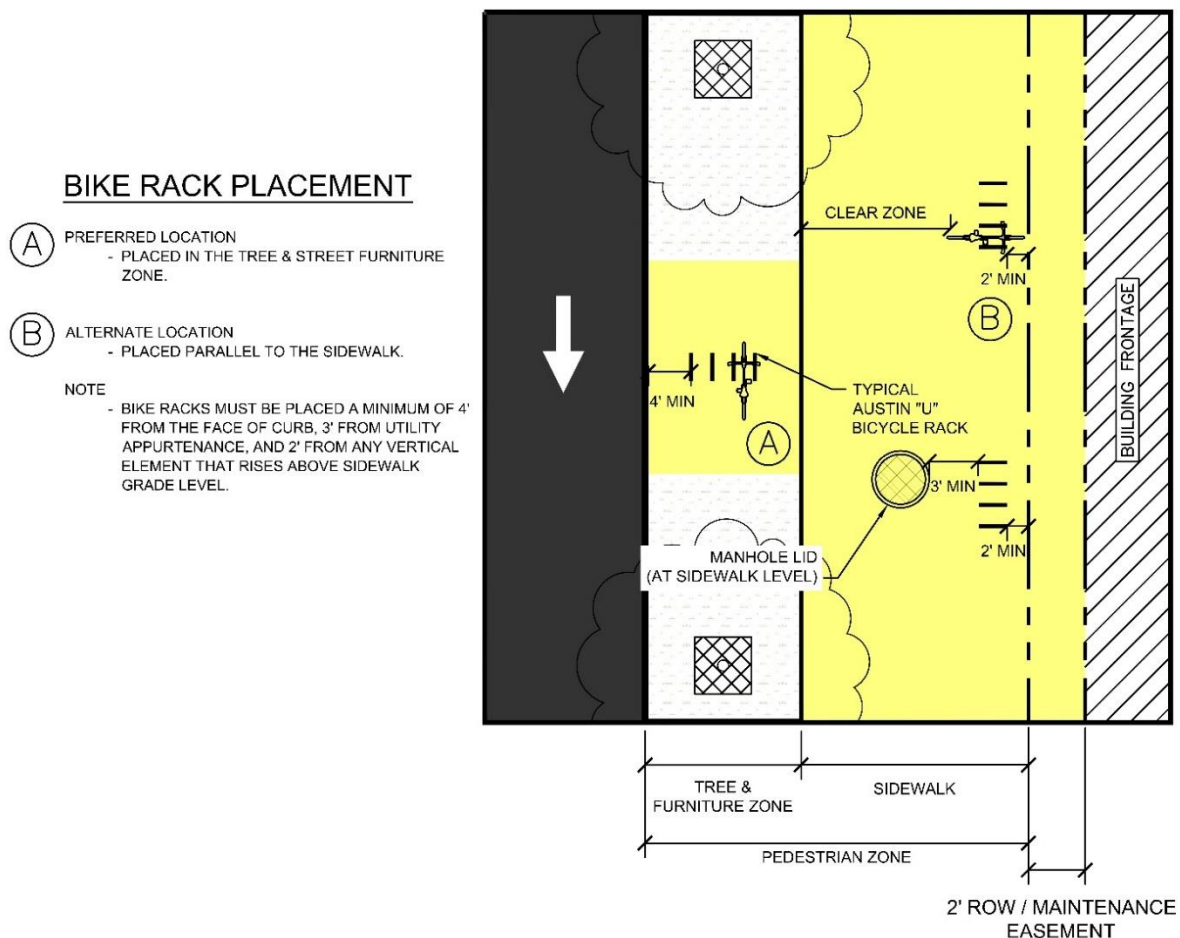


Figure 4-4 – Streetscape Furnishing Placement

- A. All criteria in **Section 4.1.1** shall be met when placing streetscape elements.
- B. Spacing between separate pieces of street furniture such as benches, utility appurtenances, tree well grates or edge of tree trunk, and trash receptacles shall be 2 ft minimum.
- C. Trash receptacles shall be within 50 ft of the entrance to food service establishments. Preferred placement of trash receptacles is within the Tree & Furniture Zone. Reference the City of Austin **Standard Details** for design of trash receptacles.
- D. In the Downtown area specified in **Figure A-2**, trash receptacles shall be located at intersections, adjacent to sidewalk curb ramps and follow **Great Streets Standards**. The trash receptacle shall be outside of the curb ramp limits, and directly next to the curb ramp no more than 1 ft away from the curb ramp and either within a sidewalk (not obstructing clear width in **Section 4.1.1 (A)**) or directly adjacent to the edge of a sidewalk.
- E. Benches are preferred to be placed in the tree and furniture zone per **Figure 4-2** and may alternatively be placed adjacent to building faces that abut the Right-of-Way line provided that clear width is maintained for the sidewalk per **Section 4.1.1**.
- F. Benches shall include space for wheelchair access adjacent to the bench. Reference the City of Austin Standard details for design of benches.
- G. Additional right-of-way or easements shall be required for shopfronts, galleries, or other extensions of the building face to maintain width of the Pedestrian Zone, per the **LDC**.
- H. Any encroachment into the Right-of-Way approved by the accountable official designated per the **LDC** shall not impede the clear width minimum in **Section 4.1.1 (A)** in any circumstance or diminish the minimum vertical and lateral clearances for pedestrian pathways as outlined in **Section 11** of this manual.

4.1.6 – Fee-in-Lieu of Sidewalk Construction

Per the LDC, when approved by the City Transportation Engineer or applicable Director, private applicants may pay a fee in lieu of constructing required on-site sidewalks and trails. Refer to the **sidewalk Ordinance** for latest fee schedule.

Paying Fee-In-Lieu of Sidewalk Construction approved in accordance with the **LDC** shall be made in accordance with actual land use (not zoning classification) per rates established on a website maintained by the City.

4.1.7 – Green Stormwater Infrastructure

Applicants shall consider methods of incorporating green stormwater infrastructure into the right-of-way, per **Imagine Austin**. Green stormwater infrastructure, as discussed in the Urban Street Stormwater Guide published by NACTO, supports the natural ecology and hydrology within the right-of-way. These strategies can be implemented to provide or supplement water quality benefits. Green stormwater infrastructure to consider are listed in 1.6.7.1 of the **Environmental Criteria Manual**.

These strategies are encouraged to be incorporated within the extension areas of the pedestrian zone created by curb bulb-outs at pedestrian crossing locations near intersections and midblock and through speed management design strategies that create opportunities for more green space behind a curb. The

landscaping types (trees and shrubs) listed in the **Environmental Criteria Manual** can be planted in the green stormwater infrastructure types in compliance with ECM 1.6.7.

- A. Private property may not use public Right-of-Way for treatment of site related stormwater runoff or for treatment of any stormwater runoff that is proposed to satisfy site development water quality credit requirements.

4.1.8 – Accessible Routes

- A. Pedestrian accessible routes are clear and unobstructed paths provided on a site that meet all Public right-of-way Accessibility Guidelines (PROWAG) as well as the current Texas Accessibility Standards (TAS). These routes shall be provided on all private sites to allow direct access to all accessible parking spaces on the site and building entrances. For pedestrian parking paths that do not serve accessible spaces, see **Section 9.3.3**. Accessible routes shall be created from one or more of the following facilities:
 - 1. Sidewalks
 - 2. Shared Use Paths
 - 3. Surface Parking Landscape Medians (includes 5 ft wide path)
 - 4. Crosswalks (raised at sidewalk level when connecting two sidewalk-height spaces)
 - 5. Footbridge
 - 6. Curb Ramp
- B. Accessible routes connect arrival points on the site to all accessible spaces. Arrival points are defined as locations where individuals begin their approach to an accessible facility. Accessible routes shall connect accessible parking spaces to all arrival points on a site. Examples of arrival points are as follows:
 - 1. Transit Stop
 - 2. Bike Rack
 - 3. Sidewalks
 - 4. Shared Use Path
 - 5. Street Pedestrian Crossing
 - 6. Parking Stall
- C. Accessible spaces on a site are defined as destinations or structures within a site that are along an individual's route or where an individual's route terminates. Accessible routes shall connect accessible parking spaces to all accessible spaces on a site. Examples of accessible spaces are as follows:
 - 1. Courtyards
 - 2. Exterior Drinking Fountains
 - 3. Parks
 - 4. Building Entrance

4.2.0 – Pedestrian Crossings

This Section covers design criteria for the design of pedestrian crossings at intersections and mid-block locations and any associated street features that accompany or supplement such crossings that assist in the safe crossing of a street.

- A. Crossings must be designed to be as short as possible, using techniques such as pedestrian islands per **Section 4.2.4.1** or bulb-outs per **Section 4.2.4.2** at intersections.
- B. Crossings must be highly visible to other users.
- C. As sidewalks, shared use paths, and trails transition to the Motor Vehicle & Transit Zone of a street, transitions and pedestrian crossings must be designed to be ADA compliant using curb ramps and detectable warning surfaces.
- D. The latest version of the ATD Pedestrian Crossing Guidelines, posted on a website maintained by the City, shall be used to determine the appropriate crossing treatment for a location.

4.2.1 – General Pedestrian Crossing Criteria

The following shall apply to all pedestrian crossings:

- A. All crossings shall be at controlled locations or where additional pedestrian crossing treatments are applied per the ATD Crossing Guidelines.
- B. Pedestrian crossing criteria shall be applied where pedestrian traffic is anticipated or encouraged in addition to retrofitting existing pedestrian crossings that are non-compliant.
- C. When recommended by ATD Crossing Guidelines, high-visibility continental crosswalks shall be installed between curb ramps on a street to delineate a defined, accessible pedestrian path compliant with the requirements of the latest edition of the Texas Manual on Uniform Traffic Control Devices (TMUTCD). Refer to **City of Austin Standard Details** for installation requirements.
- D. When possible, location of pedestrian crossings shall be designed to coincide with street lighting to better illuminate the treatment and increase the safety of pedestrians using the facility in poor lighting conditions
- E. Longitudinal and cross slopes in the street zone must meet ADA requirements along pedestrian crossings, with exception for street grades per PROWAG and TAS. Refer to **Section 3** for additional details on cross slopes.
- F. All the pedestrian crossing treatments in this section may be modified to support bicycle facility crossings of streets as required. See **Section 5.2.0** for additional details.

4.2.2 – Pedestrian Crossing Density

Pedestrian crossings shall be provided frequently to ensure safe pedestrian crossings, avoid crossing delay, discourage unsafe and illegal crossings, and promote walking as a chosen mode of transportation. Table 4-1 shows the desired pedestrian crossing maximum spacing by street Level and location along Transit Priority corridors as designated in the **ASMP**. These maximum crossing spacing distances are intended to identify gaps where a crossing may be needed, pending further engineering analysis, to create a complete pedestrian network. To link multiple modes of travel, wherever possible, pedestrian crossings

are to be placed at the same location as transit stops, bike parking, and in locations where high pedestrian volumes are present.

Refer to the latest version of the Pedestrian Crossing Guidelines on the City’s website for more details on how appropriate crossing treatments are determined. When pedestrians cross rail transit, Project Connect Design Criteria may supersede these standards, subject to the final approval of the City Traffic Engineer or applicable Director.

Table 4-1 – Pedestrian Crossing Spacing

Street Level	Context	Maximum Desirable Distance Between Marked Crossings (ft)
2	On Transit Priority Network	600
	All other streets	600
3	On Transit Priority Network	600
	All other streets	1,200
4	All	1,200
5	All	All vehicle crossings & every ½ mile maximum where vehicle crossings don’t exist
All	All	Within 100 of all transit stops

- A. Crossing density shall be at minimum every block or mid-block where blocks exceed the maximum spacing in Table 4-1.
- B. Marked crossing requirements at transit stops can be satisfied by providing new marked crossings at existing transit stops or by strategically relocating or consolidating transit stops such that they are located at existing marked crossings.
- C. While Table 4-1 shall be used as a guide for determining where a pedestrian crossing may be needed, the determination of the need for a new or upgraded crossing, including precise location of the crossing, shall be made by a City engineer based on criteria included in the ATD Pedestrian Crossing Guidelines, including:
 - 1. Existing or latent pedestrian demand;
 - 2. Vehicle volumes;
 - 3. Distance or number of lanes to cross the street;
 - 4. Observed speeds or posted speed limits, and
 - 5. Engineering judgement.
- D. Additional crossings may be recommended by a City engineer based on the above criteria, even if the maximum desirable distance between marked crossings in Table 4-1 are satisfied.

4.2.3 – Curb Ramps

- A. Sidewalks shall include a curb ramp wherever an accessible route crosses a curb.
- B. Curb ramps shall be designed and constructed in accordance with the City of **Austin Standard Details**, the City of Austin **Standard Specifications**, and the current editions of PROWAG and TAS. Where the City of Austin Standard Details are not applicable, the curb ramp design must meet criteria set forth in PROWAG. Where these standards conflict, the stricter design criteria shall apply and take precedent.
- C. Curb ramps shall be located so that they are not obstructed by parked vehicles and shall not intrude into vehicular traffic lanes. Curb ramps shall be located to provide a continuous accessible path of travel.
- D. The preferred alignment for new curb ramp construction is to be aligned with the shortest and most direct path across a street. In locations where this is not feasible due to existing features and above ground appurtenances, an alternative alignment shall be used. The alternative alignment shall be approved by applicable staff prior to installation.
- E. Curb ramps shall be designed and constructed to align across a street.
- F. The width of the curb ramp shall be at minimum the sidewalk clear width per **Section 4.1.1 (A)**, exclusive of flared sides or wings. When the pedestrian path is a shared use path, the width of the curb ramp shall be at minimum the full width of the shared use path and without sharp turns necessary to access the ramp, per AASHTO Guide for the Development of Bicycle Facilities. Flared wings shall be used where the curb ramp is adjacent to an area traversable by a pedestrian.

4.2.4 – Pedestrian Crossing Treatments

The degree of intervention necessary to achieve a safe all ages and abilities crossing of a street will vary depending on the characteristics of the street that include speed, number of lanes, and vehicle volumes. To determine the appropriate pedestrian crossing treatment to use at a location, follow the latest version of ATD Pedestrian Crossing Guidelines as provided on a website maintained by the City. Pedestrian crossings that count towards the required pedestrian crossing density are required conform to these guidelines. Refer to **Table 4-1** for required pedestrian crossing spacing.

4.2.4.1 - Pedestrian Islands

Pedestrian islands refer to the protected space provided for pedestrians between opposing travel lanes or between through lanes and a smart right turn. Placement must be considered during the design of the geometrics of an intersection as discussed in **Section 3**. These areas allow pedestrians more time to cross the street or operate as a two-stage crossing. These spaces must be highly visible, protected from encroachment of vehicular turning movements, and large enough to provide a comfortable waiting area for pedestrians.

Pedestrian islands shall be designed with minimum dimensions in Figure 4-5 and Table 4-2. The design shown in **Figure 4-5** is for a raised median with concrete curb, but may be substituted with a painted island area with vertical posts when approved by applicable staff. Refer to City of Austin **Standard Details** for specific sign, curb and gutter, and pavement marking requirements for pedestrian islands.

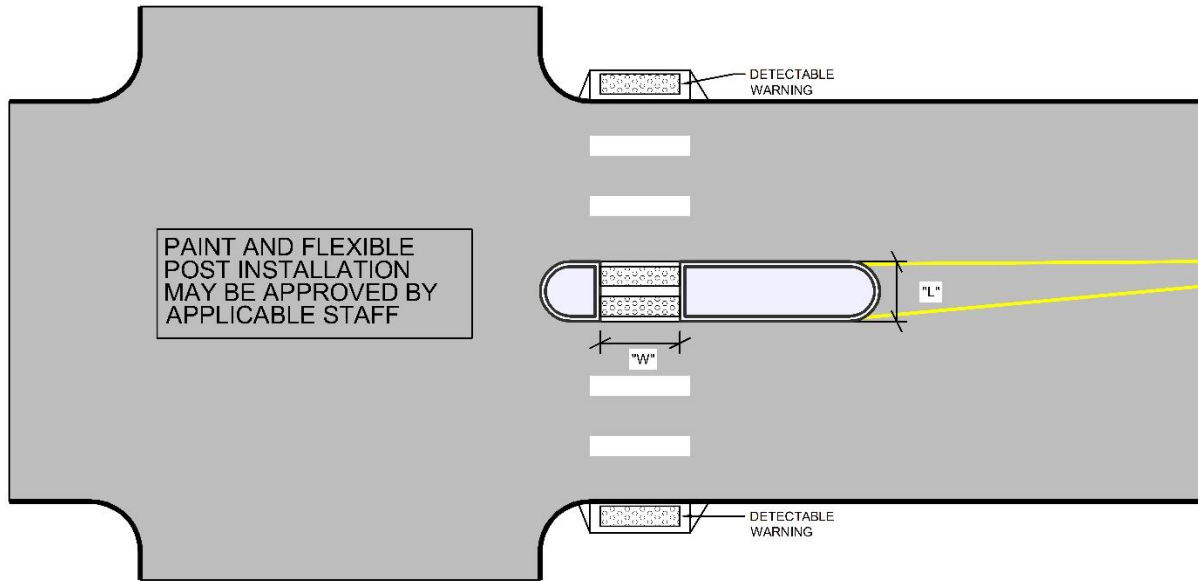


Figure 4-5 – Pedestrian Islands

Pedestrian Islands at approaches to roundabouts shall be designed with dimensions in Figure 4-7 and Table 4-2. Pedestrian islands that are not part of an isolated island, such as in a median along a street or between through lanes and a smart right turn shall be designed with dimensions in Figure 4-8 and Table 4-2.

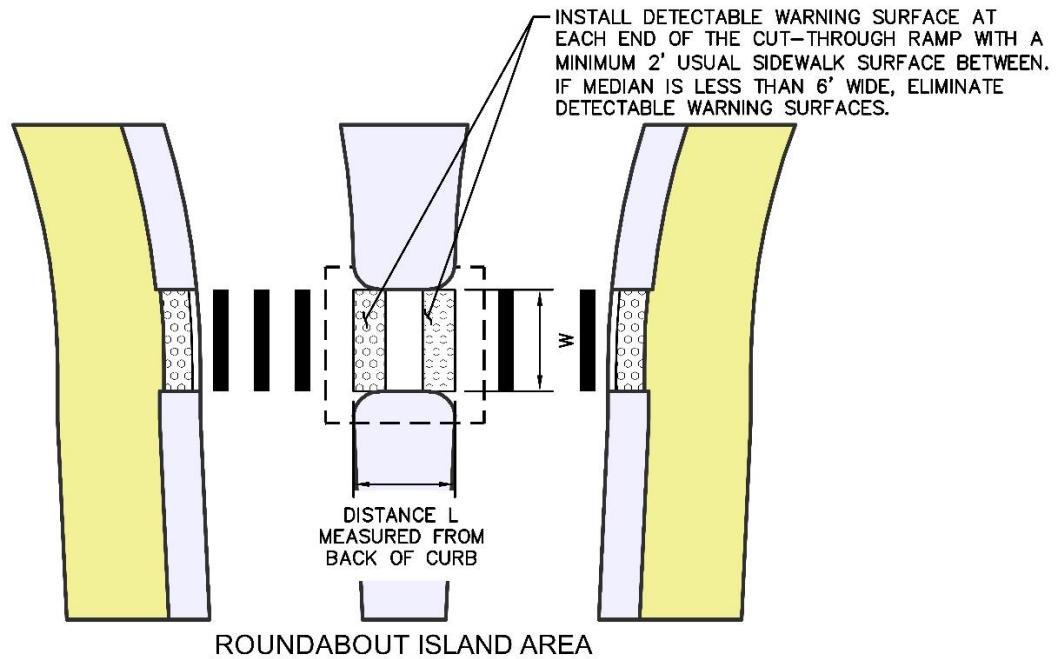
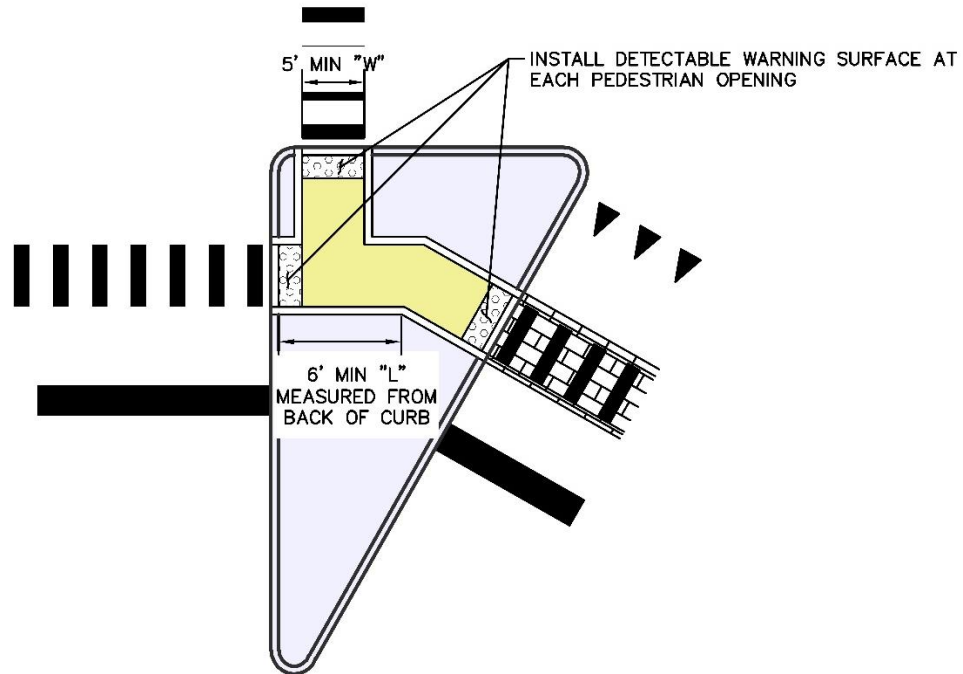


Figure 4-6 – Roundabout Pedestrian Island Area Dimensions



PORKCHOP TYPE ISLAND MEDIAN

Figure 4-7 – Smart Right Turn Pedestrian Island Area Dimensions

Table 4-2 – Pedestrian Island Area Dimensions

	Desired (ft)	Minimum (ft)
Length "L"	6	4
Width "W"	10	8

- A. Pedestrian islands shall be used at crossings on Level 2 and higher streets. They shall be used at signalized intersections whenever possible.
- B. When the associated pedestrian crossing is not raised, physical raised curbs shall be provided on all entry points to the island to shield pedestrians.
- C. The pedestrian island must match the elevation of the crossing path, whether at street elevation or top of curb elevation for raised street crossings.
- D. Pedestrian cut throughs shall be incorporated into all medians where pedestrian crossings intersect raised curbs.
- E. Either design of pedestrian islands shall provide a minimum width of 8 ft for the pedestrian path crossing through the island and a minimum median width of 4 ft.
- F. Pedestrian islands designed to accommodate bicycle or shared use path crossings shall be 8 ft minimum width and the cut through width shall be equivalent to the width of the shared use path and curb ramps.
- G. Length "L" in Figure 4-7 and Table 4-2 is measured from back of curb.

- H. Designated pedestrian island area shall not be placed within the turning envelope of the control vehicle (See **Section 3** for guidance on turning maneuvers and placement of pedestrian islands near intersections). If the speed of the turning maneuver can be lowered so that vehicles do not encroach, turning speed reduction shall be the treatment.
- I. Island areas shall include detectable warning surfaces prior to entering the street, except when less than 6 ft.
- J. When a pedestrian island area does not meet the Desired dimensions in Table 4-2, the crossing shall be timed as a single stage crossing and pedestrian area only serve as a cut through.
- K. Two-stage pedestrian crossings shall not be installed at new signalized pedestrian crossings.

4.2.4.2 – Curb Bulb-Outs

Curb bulb-outs or curb extensions shorten crossing distances, make pedestrians highly visible, and can be easily paired with all crossing treatments. As these spaces are adjacent to traffic and turning movements, the geometry is to be designed around the paths of vehicles that use the street. Refer to **Section 3** for further guidance on designing curb geometry around vehicle paths.

Figure 4-8 illustrates a typical application of a bulb-out for a pedestrian crossing. Pedestrian crossings shall be designed with curb bulb-outs to minimize crossing distances and allow for minimum acceptable curb to curb width for vehicular traffic per **Section 3.3.2.1**. Refer to City of Austin **Standard Details** for specific design requirements for curb bulb-outs.

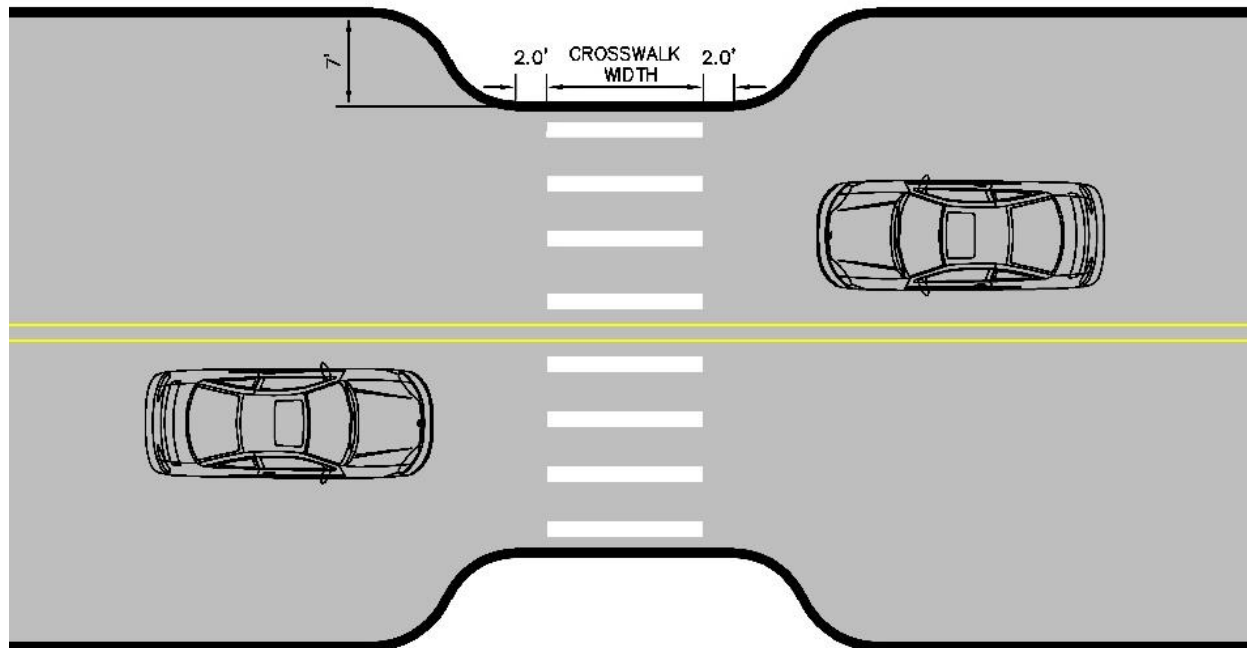


Figure 4-8 – Curb Bulb-Out Geometry

- A. Where on-street parking is present along the street, curb bulb-outs may be used with City Transportation Engineer or applicable Director approval in lieu of a pedestrian island.

- B. Bicycle facilities that are on-street shall be transitioned to be behind the curb prior to a bulb-out for pedestrian crossings unless parking is located between the bike lane and curb.
 - 1. If the bicycle facility is on a Level 2 or lower street and the pedestrian crossing is not raised for the full width of the street, bicycles may share space with vehicular lanes to traverse the pedestrian crossing.
- C. Bulb-outs shall provide for street drainage to pass through the pedestrian crossing or through inlets adjacent to the pedestrian crossing bulb-out to ensure surface drainage can still reach the outfall.
- D. Bulb-outs shall be 7 ft when on-street parking is present on Level 2 and higher streets.
- E. Bulb-outs are to be used as the preferred treatment rather than the inclusion of a turn lane at intersections in lieu of parking lanes. Turn lanes shall only be installed where turning movement volumes warrant, refer to **Section 3** for guidance on turn lanes.

4.2.4.3 – Raised Cross Walks or Speed Managed Cross Walks

Raised crosswalks are recommended at any free flowing or yield flowing street geometry where pedestrian crossings exist or are planned. Raised cross walks use a speed table to control vehicle speed to improve the safety and visibility of pedestrian crossings by reducing vehicle speed which in turn improves yielding compliance. Raised crosswalks shall be used when feasible to help encourage yielding by motorists and bicycles to pedestrians at midblock crossings. A typical application of a raised crosswalk is illustrated in Figure 4-9. Refer to **Section 4.2.4.1** for pedestrian island design.

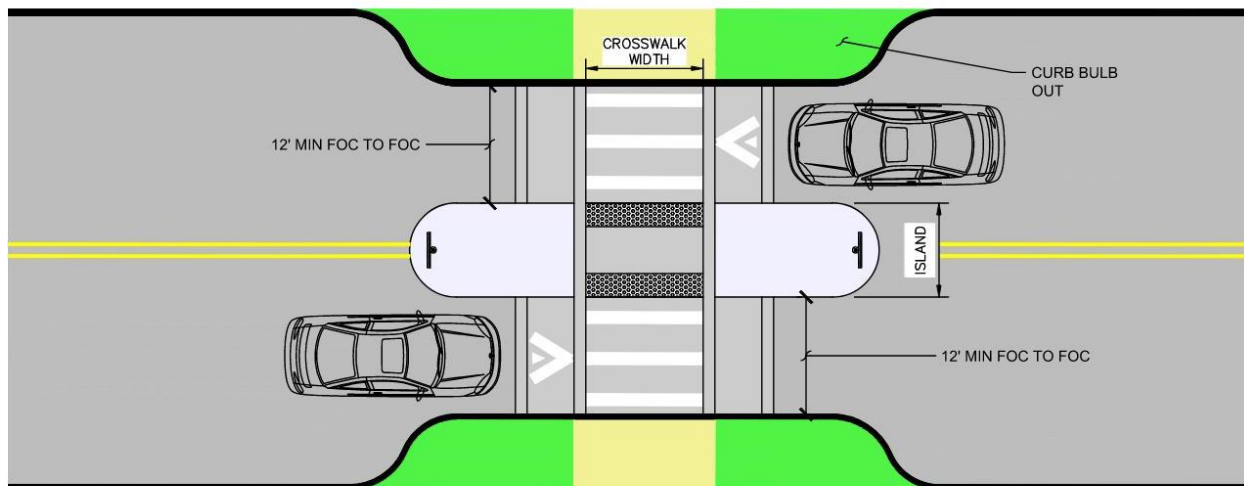


Figure 4-9 – Raised Crosswalk Application with Pedestrian Island

- A. Raised crosswalks shall be used at smart right turn lanes, roundabout crossings, and minor street crossings covered in **Section 3**.
- B. Raised crossings may be used at crossings of Level 2 Streets as appropriate based on attributes of the street such as traffic volume, consulted with applicable staff.

- C. Analysis shall be performed at raised crosswalk locations to ensure surface drainage can still reach the outfall.
- D. Where raised crosswalks are not feasible due to drainage or primary emergency response routes, speed cushions can be placed either upstream or downstream of the crosswalk for similar effect.

4.2.4.4 – Pedestrian Hybrid Beacons (PHBs)

Pedestrian Hybrid Beacons (PHBs) provide safe crossings at either uncontrolled intersections or midblock crossings of major streets and streets with sufficiently high traffic volumes, pedestrian demand, traffic speeds, and crossing distances, as determined by the Pedestrian Crossing Guidelines. PHBs shall be designed to conform with the requirements of the TMUTCD for operations, including signal indications, signs, and required pedestrian signal infrastructure design. An engineering study shall be performed prior to the installation of a PHB. A typical application of a PHB is shown in Figure 4-10.

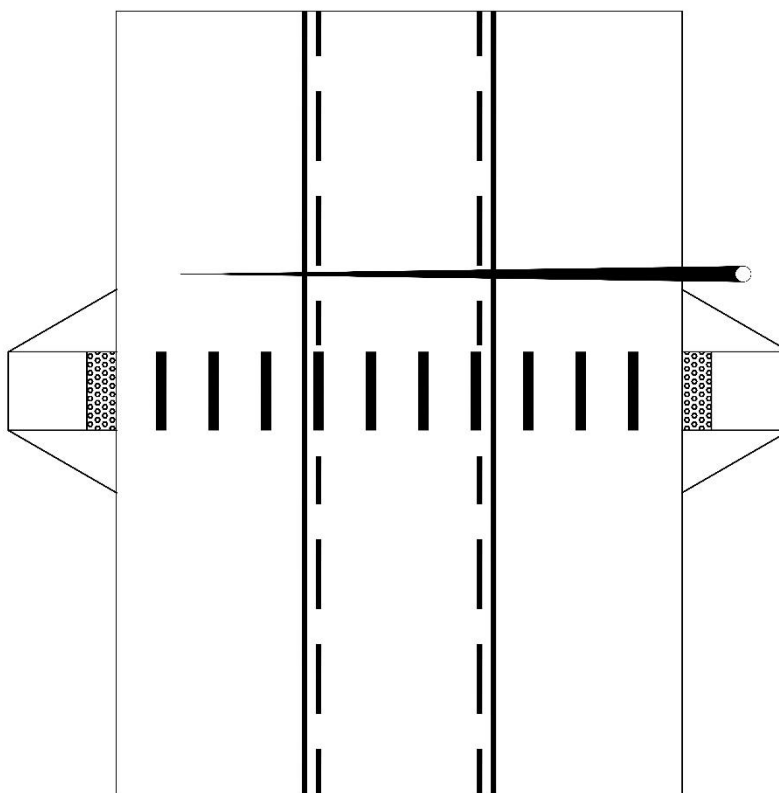


Figure 4-10 – Pedestrian Hybrid Beacon Typical Application

4.2.4.5 – Rectangular Rapid Flashing Beacons

Rectangular Rapid-Flashing Beacons (RRFBs) are a treatment for midblock crossings or uncontrolled intersections that bring greater attention to conflicting traffic than an unsignalized pedestrian crossing. The latest version of the Pedestrian Crossing Guidelines shall be used to determine situations where use of an RRFB is appropriate. A typical assembly for an RRFB device is shown in Figure 4-11 and shall include appropriate warning signs and accessible pedestrian push buttons and signs per the latest edition of the TMUTCD. An engineering study shall be performed prior to the installation of an RRFB.

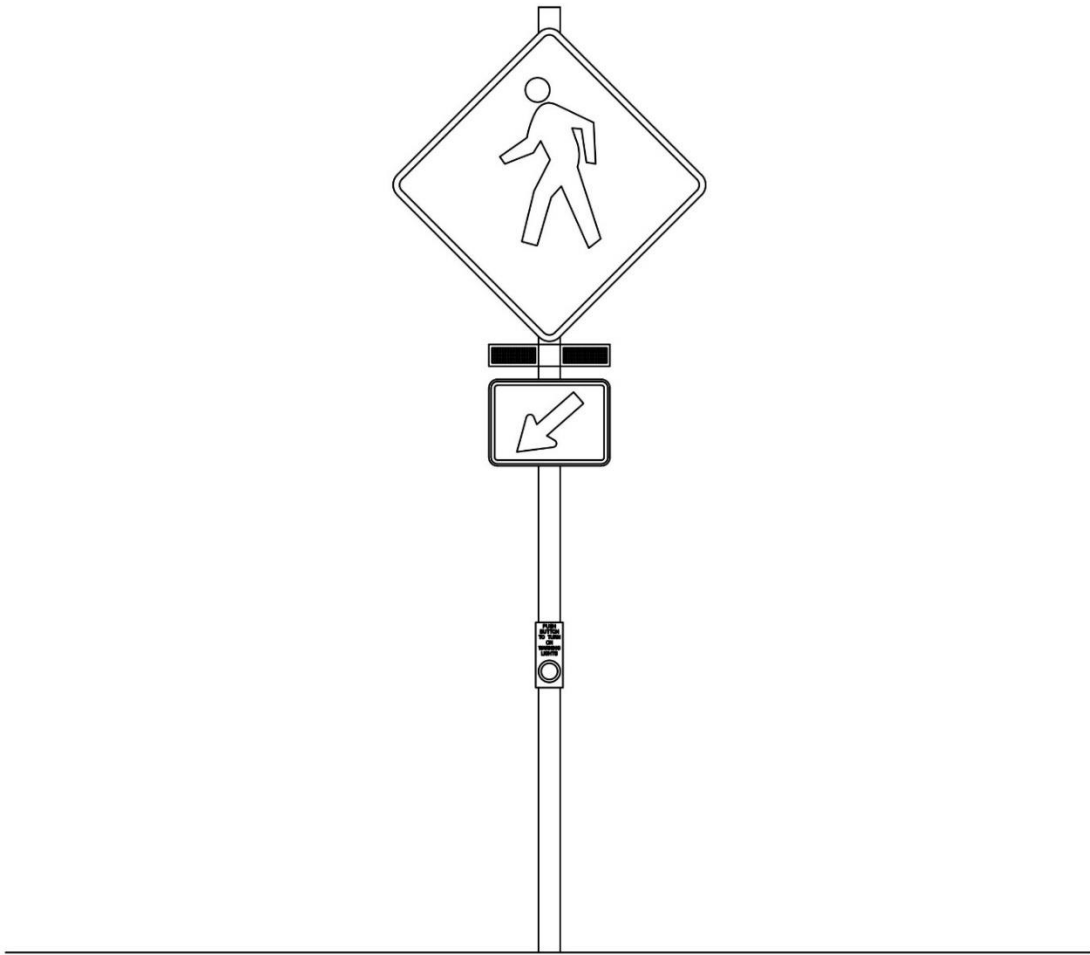


Figure 4-11 – Rectangular Rapid Flashing Beacon Assembly

SECTION 5 - BIKEWAYS AND URBAN TRAILS

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This section establishes clear and consistent design criteria that create a comprehensive, cohesive, intuitive, equitable, and comfortable bicycle and trail system. These criteria are intended to be used for the design of bicycle facilities and urban trails within the right-of-way or easements in the City of Austin.

The intent of the implementation of the bikeways and urban trails is to provide a network of safe and comfortable bicycle and trail facilities for people of all ages and abilities to encourage bicycling as a sustainable mode of transportation and to work to meet the City's mode share goals. To achieve this intent, bicycle and trail facilities that are physically separated from vehicles shall be designed and constructed wherever feasible. Painted bicycle facilities on the street shall only be designed and constructed in retrofit situations where existing conditions are constrained and do not make it feasible to construct physically separated bicycle and trail facilities. Urban Trails are defined in the **Land Development Code** as a citywide network of multi-use pathways that are used by bicyclists, walkers, and runners for both transportation and recreation.

The **ASMP** specifies policies related to completion of the bicycle and urban trails systems within the City of Austin, as well as the location of specific networks within each system. The Bicycle Priority Network within the ASMP or the Bicycle System Map in the **Bicycle Plan**, whichever is more recent shall be referenced for location of all ages and abilities bicycle facilities. The Urban Trails System Map within the ASMP or the Urban Trails Map within the **Urban Trails Plan**, whichever is more recent, specifies the location of Tier I and Tier II Urban Trails in the City of Austin. The Street Network Table and Map in the ASMP also includes identification of future bicycle facilities within existing and planned city streets.

5.1.0 – Bikeways

Bikeways are contained within the Bicycle and Street Edge Zone of a street as defined in **Section 2.6.0**. This zone within a street's cross section is composed of three separate components:

- A. *Bike Lane* – The space in which the bicyclists operate. This space is located between Tree and Furniture Zone (in the Pedestrian Zone, defined in **Section 4**) and the Buffer Zone.
- B. *Buffer Zone* – The street buffer that separates the bike lane from the vehicle traffic or parked cars.
- C. *Parking (where applicable)* – On-Street Parking (refer to **Section 9**)

The Bicycle and Street Edge Zone and its components are illustrated in **Figure 5-1**. Elements of bikeway design and urban trail design differ because bikeways have a street-based contact. As a result, bikeways must be designed in a way that gives bikes the clear right-of-way along streets. This is accomplished through protected wide spaces for bikes, highly visible colorized crossing areas, and transitions from bike facilities at intersections.

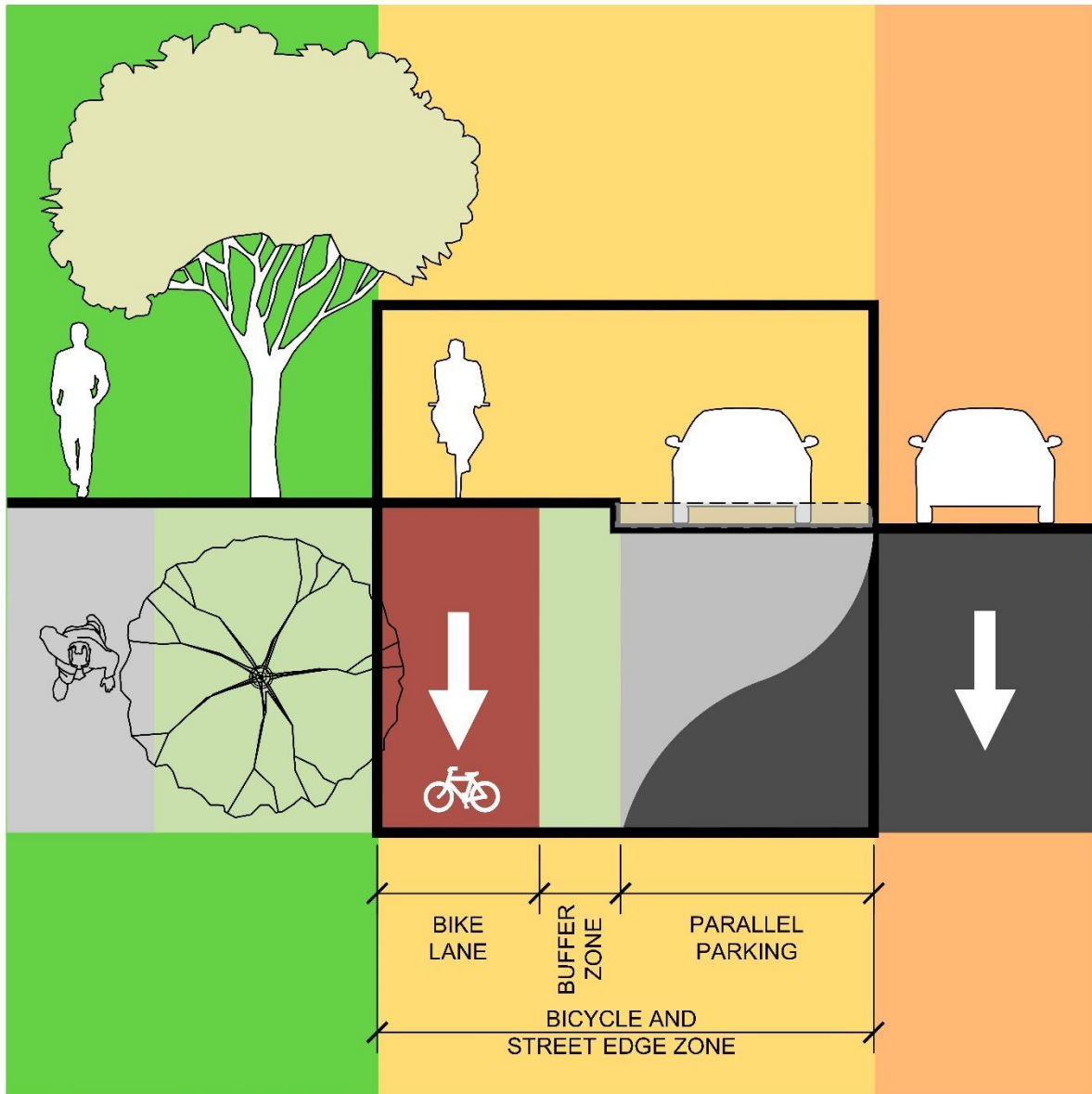


Figure 5-1 – Bicycle and Street Edge Zone Components

5.1.1 – Horizontal & Vertical Geometry

This section covers the design criteria for the horizontal and vertical geometry of a bike way. This requires careful consideration of the operating width, passing needs, horizontal and vertical curvature to maximize safety, comfort, and capacity of bikeway facilities.

5.1.1.1 – Horizontal Curves and Transitions

As with horizontal curves and transitions, vertical curves are important to consider for the safety and comfort of bicycle facilities. Vertical transitions shall be designed generally with curves or gradual transitions that are comfortable and stable at the design speed.

- A. Horizontal transitions shall be at a length of $WS/2$, where:
 W = width of horizontal transition, and;
 S = speed of bike
- B. Generally, curve-based transitions are preferred for smoothness and continuity, with sixty (60) ft minimum centerline radii curves. In unconstrained conditions, horizontal transitions should be minimized.
- C. The maximum vertical transition slope that shall be used is 5% and transitions between running slopes shall be smoothed or feathered.
- D. Bikeway, urban trail, and shared use path design shall treat a bicycle as the design vehicle and centerline transitions and curves shall be designed with a design speed. Refer to **Section 5.3.1.2** for the equation to calculate curve radius and **Table 5-4** for minimum radii.
 - 1. At locations where tight turns are necessary to facilitate intersection approaches, the minimum centerline radius is 10 ft This minimum is limited to turns from one street to another, not intersection approaches that may be used by cyclists continuing straight, which shall be designed for the full bicycle design speed.

5.1.1.2 – Design Speed

Context, such as elevation changes, shall be considered when choosing a bicycle design speed, as recommended by AASHTO. The presence of continuous downhill grades in the direction of travel allows for the consideration of bicycle design speeds in excess of 20 mph.

Table 5-1 – Bikeway Design Speeds Required

Bikeway Design Speeds (mph)		
Preferred	Minimum	Constrained
18	15	10

Bicycle facility design shall always treat a bicycle as a design vehicle, as defined by AASHTO. Turning simulation software can be helpful in determining if a bikeway or shared use path meets the requirements for design vehicle and design speed. Due to the design speed of bicycles, ramps between the raised bikeway level and Street Level should not be too abrupt, as this can lead to safety and comfort issues. Ramps that are for use on bikeways and shared use paths shall have a maximum slope of 4%. Increasing this to the maximum ADA slope of 8.33% shall only be allowed where constraints make this the only available option.

5.1.2 – Cross Sectional Elements

This section covers the design criteria of cross-sectional elements along a bikeway related to the operating space and areas on each side of the bikeway within the bicycle and street edge zone.

5.1.2.1 – Horizontal Clearances

Sign placement must meet minimum horizontal clearance distance requirements in Table 5-2. Horizontal clearance is defined as the distance from the outside edge of sign to the edge of the bicycle facility or Urban Trail. Depending on sign type and messaging, signage may be placed within the street buffer if sufficient width is provided. Traffic oriented signs may be placed closer than the dimensions in Table 5-2 when sufficient vertical clearance is provided.

Table 5-2 – Horizontal Clearance from Bicycle Facilities or Urban Trails

Horizontal Clearance	Object height < 36 in.	Object height 36 in. – 96 in.	Object height > 96 in.
Preferred	12 in.	18 in.	24 in.
Minimum	6 in.	12 in.	18 in.

- A. Horizontal clearances from vertical obstructions such as handrails and poles shall be 1 ft from operating clear width. In highly constrained conditions, 6 in. setbacks may be permitted with approval from applicable staff. A curb is not considered an obstruction.
- B. The object height is measured from the top of the sign to the ground elevation.

5.1.2.2 – Bikeway Width

Bike Lane widths are specified in **Table 2-2 and Table 2-3** in Section 2 with recommended and constrained widths. Constrained is defined as insufficient right-of-way and is explained in further detail in **Section 2.7.2**.

- A. The minimum width of a one-way protected on-street bike lane is defined in **Tables 2-2 and 2-3**. A constrained width of 5 ft with an 18 in. buffer and is only allowed for passage around obstructions as provided for in **Section 5.3.2.4**.
- B. The clear width area (defined as width excluding buffer) shall be demarcated with bicycle symbols as shown in the **City of Austin Standard Details** and use a colored surface treatment.
- C. Bikeway recommended width varies by Street Level but is recommended to be 7 ft to 8 ft wide to facilitate sweeping, passing, and social / side by side riding. In constrained conditions this width can be narrowed to 6.5 ft which is the minimum width that allow sweeping with City of Austin narrow sweepers and side by side.
- D. Bike lane width is measured from edge of pavement to edge of pavement when at sidewalk level and from face of curb or edge of pavement (if no curb) to center of separation device or pavement marking when on-street. Bike lane width is not inclusive of a buffer zone.
- E. In retrofit situations where bike lanes are on-street, effective bike lane width is reduced by gutter pans or drainage grates that exist at the edge of curb that are not a smooth operating surface. Effective bike lane width is defined as the space which a bicyclist can operate smoothly without obstruction.
- F. A minimum effective width of 5 ft is permitted for short distances (<100 ft) in order to navigate around transit stops, accessible parking spaces, or other obstacles.

- G. The recommended width of a two-way protected bike lane is 12 ft. In a constrained environment, a two-way protected bike lane is permitted to be 10 ft if it remains off-street. An effective width of 8 ft used for short distances (<100 ft) is acceptable in a retrofit condition in order to navigate around transit stops, accessible parking spaces, or other obstacles.

5.1.2.3 – Cross Slope

Bicycle lanes are not required to maintain ADA cross slopes though 2% is the preferred cross slope. Up to 4% cross slope is permitted which can be helpful in making grades when cross sections have elevation change.

5.1.2.4 – Pavement Markings and Signage

Refer to the **City of Austin Standard Details** for bicycle lane marking templates, placement, and material requirements.

5.1.3 – Bike Lane Surface & Color

A smooth surface is important for bicycle comfort and it is important for the surface to be durable and maintainable. Integral color concrete is the preferred material as it is a high-quality surface that requires little to no maintenance when used by bikes and has the ability to be colored to better define modal uses.

Uniform coloring of bikeway facilities helps to achieve cohesion throughout the bicycle network, aids in recognizability of bicycle facilities, and distinguishes between bicycle and pedestrian facilities.

- A. Refer to the **City of Austin Standard Details** for bike lane installation and color treatment specification.
- B. Asphalt shall only be used when approved by applicable staff.
- C. The standard concrete integral color for bikeway pavement is Terra Cotta Dark (Prism integral colors or equivalent). Alternate methods of coloring through colored asphalt, seal coat rock, paints, stains, or other surface treatments are subject approval by applicable staff. When in conflict the City of Austin Standard details will apply.
- D. Joints shall be designed to ensure a smooth riding surface. Expansion or construction joints shall be minimized, and control joints shall be saw cut or achieved through use of zip strips or comparable method. Tooled control joints are prohibited due to the bumpy finish.
- E. In retrofit situations, longitudinal seams shall be removed within the bike lane clear width by patching the surface material. Existing utility lids shall be adjusted to finished grade and examined on a case-by-case basis to determine if interventions are needed to reduce the risk of slipping.

5.1.4 – Bikeway Types

An All Ages and Abilities bicycle facility is defined as a facility that can be used by a bicyclist of all ages and abilities comfortably, which is intended to include separation from motorized road users and minimizes conflicts with other street users. The subsections that follow describe facilities that fit this definition and are appropriate for the Bicycle Priority Network as defined in the **ASMP**. This network establishes a system of bicycle facilities in the City that fulfill the desire for a connected City from the **Comprehensive Plan**. Selection of bicycle facilities that achieve All Ages and Abilities level of comfort varies by roadway context and shall conform to criteria in NACTO's Urban Bikeway Design Guide - Designing for All Ages and Abilities. Bicycle facilities in Table 5-3 that are in the "preferred" column are considered All Ages and Abilities bicycle

facilities while bicycle facilities in the Non-Preferred Bikeways column of Table 5-3 do not meet this definition or standard.

Table 5-3 – Preferred and Non-Preferred Bikeway Types

Preferred	Non-Preferred Bikeway Types
Protected Bike Lanes	Buffered Bike Lane
Shared Use Paths	No Buffer Bike Lane
Neighborhood Bikeways (Quiet Streets)	Shared Lane Markings

5.1.4.1 – Off Street Bikeways

This section covers the design of bikeways that are physically separated from the street and raised above the Street Level. These bikeway types are the preferred treatment as they provide a high degree of separation from other street users for bicyclists.

5.1.4.1.1 – Protected Bikeways

Protected Bike Lanes (also known as raised bike lanes, separated bike lanes, or cycle tracks) are exclusive bikeways that are typically at sidewalk level and use a variety of methods for physical protection from passing traffic and separation from pedestrian traffic as shown in **Figure 5-2** below. Protected bike lanes are a tool to make high-volume or high-speed streets comfortable for users of all ages and abilities. Protected lanes are more attractive to a wider range of bicyclists than striped bikeways on higher volume and higher speed roads. Protected bike lanes eliminate the risk of a bicyclist being hit by an opening car door and prevent motor vehicles from driving, stopping, or waiting in the bikeway. The protected buffer provides greater comfort to pedestrians by separating them from bicyclists operating at higher speeds.

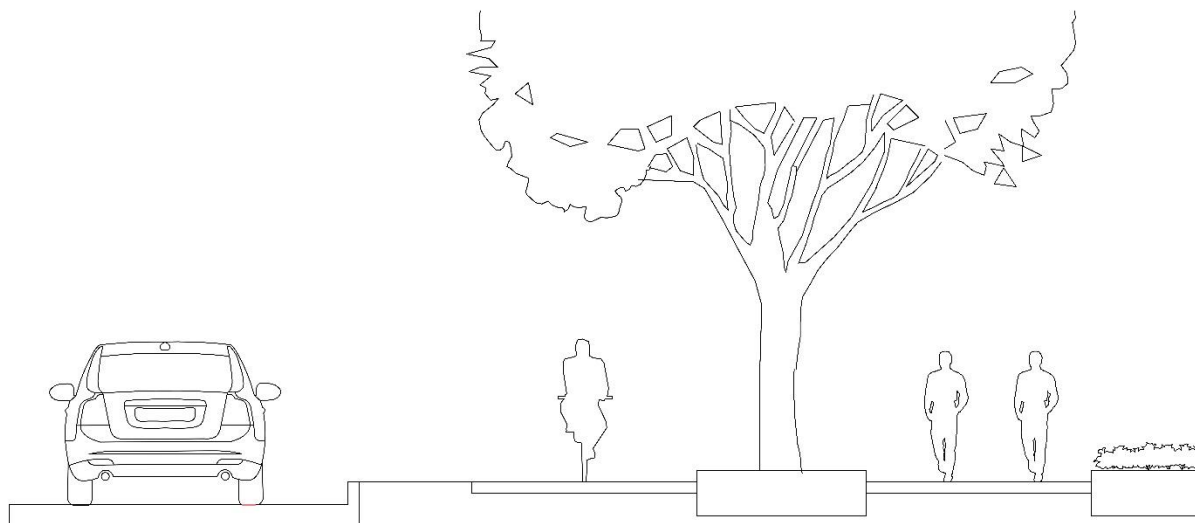


Figure 5-2 – Protected Bikeway Configuration Profile View

- A. A protected bikeway shall be raised to the same elevation of the sidewalk.
- B. The recommended buffer zone widths are defined in **Tables 2-2 and 2-3** in **Section 2.7.1**. The minimum width of a buffer zone between face of curb to edge of bike lane is 2 ft, though in retrofits more constrained buffer zones may be necessary.

1. Only hardscape shall be used in a buffer zone less than 2 ft in planted width. If hardscape is used it must contrast in color and texture with the material used for the bike lane (e.g. pavers or stamped integral colored concrete).
 2. Grass or planting strips are preferred in a buffer zone of 2 ft or more of planted width as a means of greening the street. Street Trees can be placed in the buffer zone if they are in accordance to the requirements in **Section 11.2.2.1**.
- C. A minimum offset of 1 ft shall be provided between any vertical objects in the tree and furniture zone or buffer zone and the bike lane. In highly constrained conditions, 6 in. setbacks may be permitted with approval from applicable staff.
- D. When a bicycle lane is adjacent to a sidewalk or pedestrian space, bicycle facilities shall be physically separated for the comfort of both pedestrians and cyclists. The sidewalk buffer discourages pedestrians from walking in the dedicated bicycle facility and discourages cyclists from riding on the sidewalk.
1. If no physical separated is provided, bicycle facilities shall be grade separated from sidewalks.
 2. Separated bike and pedestrian paths are the preferred design, as they are safer for both street users. However, when insufficient Right-of-way exists per the typical cross sections defined in **Section 2.8.0** of the TCM the bicycle lane and sidewalk may be combined into one path known as a shared-use path and described in **Section 4.1.2**.
- E. Streets where space is limited that may require provisions for emergency vehicles to use the bicycle lane area can have alternative equivalent facilities with mountable type curbs when approved by the City Transportation Engineer, applicable Director, or their designee.
- F. For protected bike lanes, the buffer zone shall be designed to maximize the safety and comfort of the bicyclist by physically separating these roadway users with a lateral separation from the curb or raised median.
- G. Areas in the buffer zone or bike lane designated for outrigger deployment for fire ground setup shall be made of reinforced concrete.

5.1.4.1.2 – One-way and Two-way Configuration

One-way protected bicycle lanes are the standard bicycle facility for streets in the typical cross sections shown in **Section 2.8.0**. One-way protected bicycle lanes follow the standard flow of motor vehicle traffic, result in simpler traffic operations, and result in more green time at signals for bicyclists.

Two-way protected bicycle lanes are also considered safe and effective and are more space efficient than one-way protected bicycle lanes. However operational complexities exist for two-way protected bicycle lanes such as bicycle operations at signals that operate in the opposite direction of vehicular traffic. Mitigations that are typically required include high visibility conflict markings and signage, protected intersection design, and dedicated phasing at signalized intersections.

- A. Two-way protected bicycle lanes may be used where one-way protected bicycle lanes do not fit due to right-of-way or existing infrastructure constraint or on one-way streets.
- B. Two-way protected bicycle lanes may be considered for connections and access to an urban trail or share used paths.
- C. Two-way bicycle lanes may also be permitted in lieu of one-way protected bicycle lanes by applicable staff.

5.1.4.1.3 – Shared Use Paths

A shared use path is a facility that supports multiple non-motorized transportation modes, typically including bicycles, pedestrians, and users who require an accessible path. Shared use paths are only suitable where bicycle and pedestrian volumes are expected to be low to moderate for the life of the facility, otherwise bicycles and pedestrians shall be split into separate facilities to manage conflicts. Generally, these paths follow the same design criteria as an urban trail but do have some variations, which are noted in **Section 5.3.0**. For pedestrian considerations when designing shared use paths, refer to **Section 4.1.2**.

Shared use paths with one-way bicycle operation and two-way pedestrian operation on both sides of a street can be a good interim option when limited ROW, constrained infrastructure, or limited scope do not allow for separate facilities but it should be noted that these are not a substitute for the combination of protected bicycle lanes and separate sidewalks per **ASMP** recommendations. These facilities are not permitted as an ultimate bicycle facility along streets except for streets or frontage roads under TxDOT jurisdiction. Figure 2-20 in **Section 2.8.2.4** illustrates a strategy to use interim shared use paths to achieve the ultimate protected bicycle lane and sidewalk condition for a phased investment approach.

5.1.4.1.4 – Protected Bikeways at Transit Stops

When protected bikeways and transit stops intersect in the Bicycle and Street Edge Zone, several design elements must be accommodated for both the transit stop and bicycle facility, which are covered in this Section. The preferred design approach to this situation is a floating bus stop, illustrated in Figure 5-3, where the bicycle lane transitions behind a transit stop located at the back of curb. Additional transit stop configurations and criteria for transit facilities are included in **Section 6**.

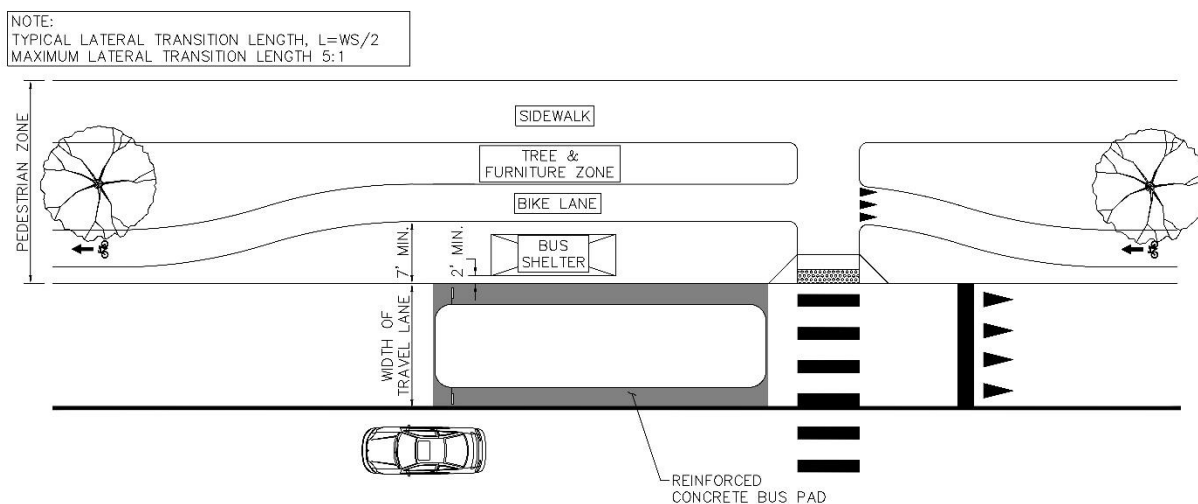


Figure 5-3 – Typical Floating Transit Stop Application

- A. Floating transit stops shall be a minimum of 7 ft in width and 25 ft in length and made of concrete. Longer bus stop lengths will be dictated by platform lengths as required in **Section 6**.
- B. A minimum 8 ft width by 5 ft length (measured along the street) area must be provided at transit stops for an accessible boarding area. Transit stops that are 8 ft or greater in width accommodate this area. For transit stops that are 7 ft in width, a flush transition between the boarding area and the bikeway or Shared Use Path must be provided to accommodate this accessible boarding area.
- C. Protected bike lanes transitioning behind a transit stop shall taper horizontally at 5:1 maximum with City Transportation Engineer, applicable Director or their designee's approval. Protected bike lanes must maintain minimum widths transitioning behind transit stops in compliance with **Section 5.1.2.2**.
- D. Shared Use Paths must transition with 60 ft minimum centerline radii curves around a transit stop and maintain a width of 8 ft minimum.
- E. In scenarios where back of curb to right-of-way line width is less than 15 ft, the bike lane or Shared Use Path may be flipped where the bike lane or Shared Use Path is located at back of curb. The surface between the bike lane or Shared Use Path may be flush with the transit stop, and a minimum of 5 ft in width must be provided for a transit shelter located at the right-of-way line.

5.1.4.2 – On-Street Bikeways

This section covers the design of bikeways that exist within the street zone. These bikeway types are not the preferred treatment as they do not give bicyclists clear right-of-way and can lead to conflicts between bicyclists and vehicles, which are less safe. On-street bikeways shall only be installed in locations where it has been determined that an off-street bikeway will not meet the criteria in **Section 5.1.4.1**.

5.1.4.2.1 – Neighborhood Bikeways (Quiet Streets)

Neighborhood bikeways are a tool to achieve all ages and abilities network connectivity on minor streets through design treatments. Neighborhood Bikeways achieve strict speed and volume criteria in NACTO's *Urban Bikeway Design Guide - Designing for All Ages and Abilities* through speed and volume management tools. Strategies for enhanced network connectivity utilizing minor streets shall not be a substitute for protected bicycle facilities on Level 2 and higher streets. **Figure 3-8** illustrates an intersection crossing treatment to restrict vehicle through movements on a minor street while allowing passage for bikes.

- A. Neighborhood Bikeways are applicable on Level 1 streets and low volume Level 2 streets, as approved by applicable staff.
- B. Wayfinding signage and directional shared lane markings shall be required for all turns along a designated bike route or bicycle facility identified as an All Ages and Abilities facility in the **ASMP**.
- C. Physical improvements to optimize designated Neighborhood Bikeways for bicyclists, and integrate them into the bicycle network, will include speed management devices for motor vehicles, per **Section 3.3.0**, intersection treatments to cross major streets, wayfinding signage and shared lane markings for bikes.
- D. In retrofit or constrained right-of-way situations, facilities with a lower degree of comfort may be used so long as they are not on the All Ages and Abilities network as defined in the **ASMP** or are approved per a variance.

5.1.4.2.2 – Protected On-Street Bike Lanes

Protected On-Street bicycle lanes are created by painting or otherwise creating a flush buffer zone between a bicycle lane and the adjacent travel lane. While buffers are typically used between bicycle lanes and motor vehicle travel lanes to increase bicyclists’ comfort, buffers can also be provided between bicycle lanes and parking lanes in locations with high parking turnover to discourage bicyclists from riding too close to parked vehicles. Figure 5-4 illustrates the layout of the buffer zone for a protected on-street bike lane with typical pavement markings, spacing and pavement markers.

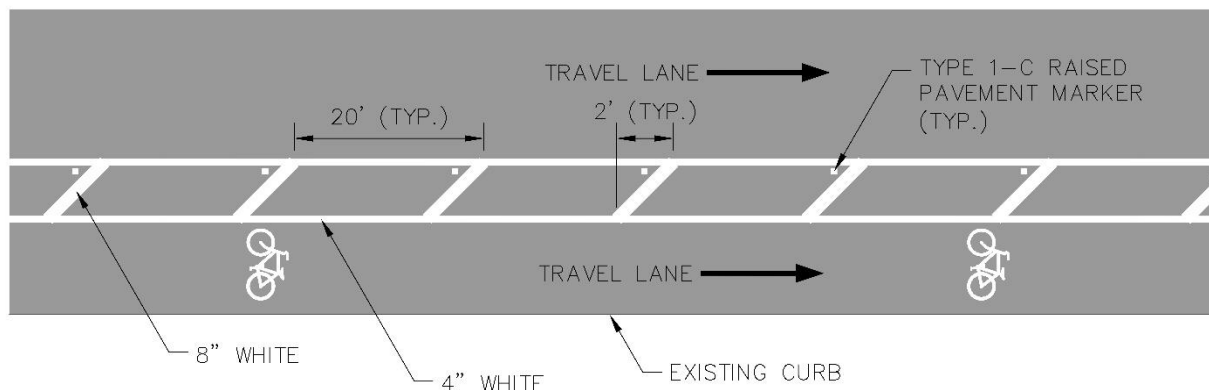


Figure 5-4 – Protected On-Street Bike Lane Buffer Zone Markings

Where the standard approach of raised protected bicycle lanes is not feasible, Street Level protected bicycle lanes may be permitted as an alternative. Cast concrete barriers, flex posts, planter boxes, concrete traffic buttons, and curb stops are required to provide a physical buffer between the street and bicycle lane in lieu of buffered bicycle lanes without protection.

When the buffer lane width is larger than the minimum of 2 ft, concrete barriers and planter boxes may be considered as vertical object treatments. **Figure 5-5** illustrates vertical objects in the street buffer and spacing requirements. As Street Level protected bicycle lanes are allowed only as an exception to standard raised bicycle lanes, physical protection type and spacing shall be chosen with the approval of applicable staff.

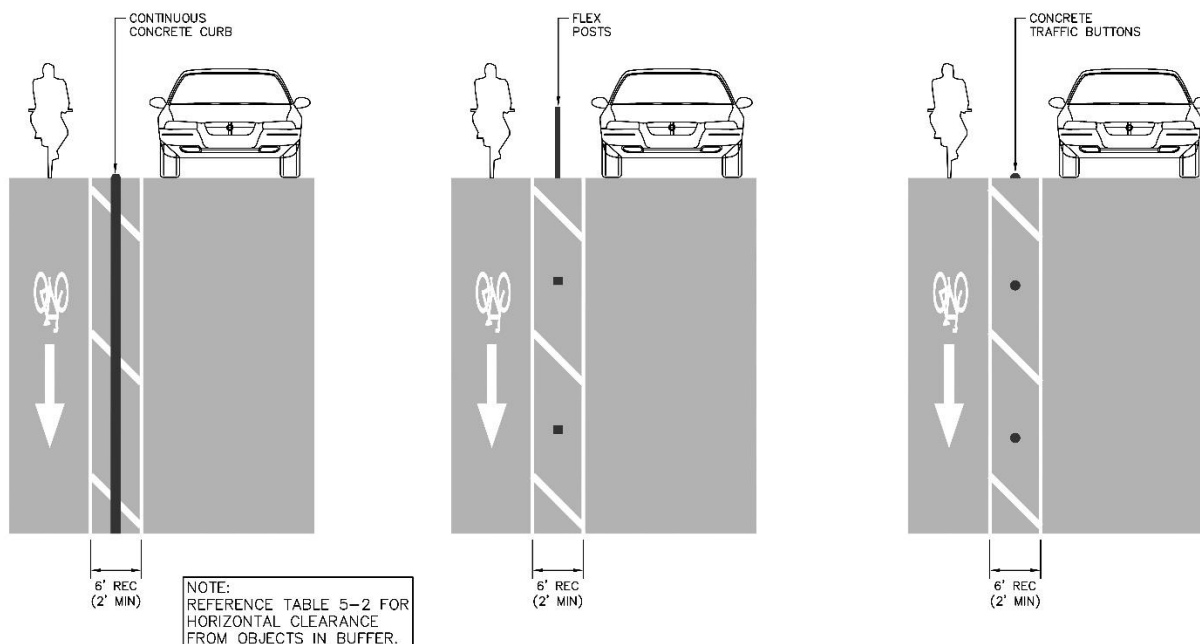


Figure 5-5 – Protected On-Street Bike Lanes

- A. When bicycle lanes on-street are raised from the roadbed, a curb with a minimum elevation difference of 2 in. shall be provided between the bicycle lane and the pedestrian area.
- B. For protected on-street bike lanes with a buffer, the buffer zone is on-street and striped with a diagonal cross-pattern.
- C. The recommended buffer width is 3-5 ft wide between bicycle lanes and adjacent traffic when on street. The minimum width of buffer is 2 ft for on-street bike lanes without approval from the City Transportation Engineer, applicable Director, or their designee.
- D. Crosshatching shall be used at a maximum distance of 40 ft measured center of stripe to center of stripe using 12 in. wide white stripes.
- E. Raised pavement markers shall be used at a spacing of 20 ft at the inside edge of the bike buffer.
- F. For protected on-street bike lanes, bike pavement markings shall be placed less than 600 ft apart. The bike lane pavement markings shall consist of a bike symbol and arrow indicating direction of travel.
- G. Objects within in the buffer shall consider **Table 5-2** design requirements. This does not include raised pavement markers and other typical traffic control devices.
- H. Refer to **City of Austin Standard Details** for guidance on installation of physical barriers.

5.1.4.2.3 – Bike Lane

Bike lanes without a buffer or physical separation designate an exclusive space for bicyclists using pavement markings and signage. They are typically on the right side of the street, between the adjacent travel lane and curb, road edge, or parking lane. Bicycle lanes also facilitate predictable behavior and movements between bicyclists and motorists.

- A. On-street bike lanes shall be 6 ft wide measured from center of stripe to face of curb.

- B. Striping shall be a 6-8 in. solid white line on the left side of the bike lane. When the street curb is not the right-side border of the bicycle lane, a 4 in. white stripe shall be used.
- C. Bike lanes without a buffer shall not be placed on any street other than Level 1 or Level 2 streets. If a bike lane is required on a higher-level street to provide interim connectivity it requires approval from applicable staff member.

5.2.0 – Crossing Treatments & Transitions

This section covers the design of bikeway crossings and transitions at intersections. As intersections are the main point of conflict for bicyclists and vehicles, crossings must be designed to make bicyclists highly visible and provide queuing space to await their crossing maneuver. With these locations coinciding with pedestrian crossings, both crossing modes must be coordinated. Refer to **Section 4.2.0** for guidance on pedestrian crossings and **Table 4-1** for when crossing treatments are recommended.

5.2.1 – Minor Street Crossings

Driveways (see **Section 7**) and Minor Street crossings (see **Section 3.4.2.1**) shall be designed to provide awareness and priority to the protected bike lane and sidewalk. Minor Street crossings include Level 0 and Level 1 streets, unless otherwise defined by the City Transportation Engineer or applicable Director as a Minor Street crossing.

Figure 5-6 shows the typical layout of a protected bicycle lane crossing a minor street as a raised crossing. Modified configurations are used when combined with continental crosswalks across minor streets. **Figure 5-7** illustrates the typical profile for a minor street crossing with a protected bike lane and sidewalk crossing.

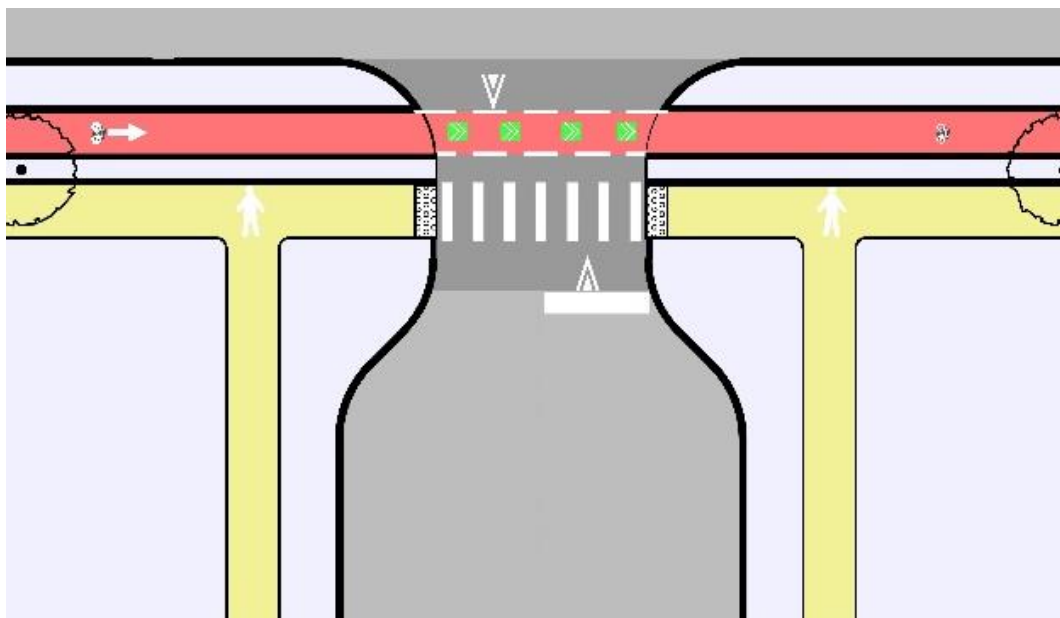


Figure 5-6 – Typical Minor Street Crossing

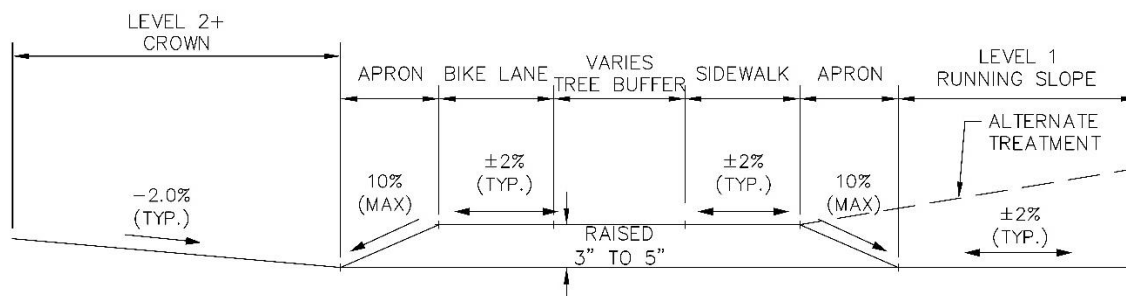


Figure 5-7 – Minor Street Crossing Grade Profile

- A. A raised crossing is the default treatment to be used at all minor street crossings.
- B. The design shall clearly communicate that bicyclists have the right-of-way by continuing the surface treatment of the bike lane across the driveway.
- C. The approach ramps to the raised crosswalk shall not exceed 5% for a minor street.
- D. For minor street crossings the bike lane and sidewalk can optionally be graded away from the higher-level roadway.
- E. Refer to **Section 3.4.2.1** for criteria for minor street crossings.

5.2.2 – Protected Intersections

Protected bike lanes shall be continued through stop controlled and signalized intersections as a protected intersection. A protected intersection eliminates the merging and weaving of bikes and vehicles. **Section 3.6.1.1** of the TCM shall be referenced for design criteria and geometry of bike lane transitions at protected intersections.

Bike boxes and two stage turn queues boxes are alternate tools when protected intersections are not feasible, described in sections that follow.

5.2.3 – Bike Boxes

An advanced stop bar, or bike box, is a designated area at the head of a vehicular lane at a signalized intersection that provides bicyclists with a safe and visible way to jump queued vehicles during the red signal phase. Bike boxes may be required at constrained locations where protected intersections are not feasible. A box formed by transverse lines shall be used to hold queuing bicyclists, 10 - 16 ft deep. **Figure 5-8** illustrates a typical layout of a bike box.

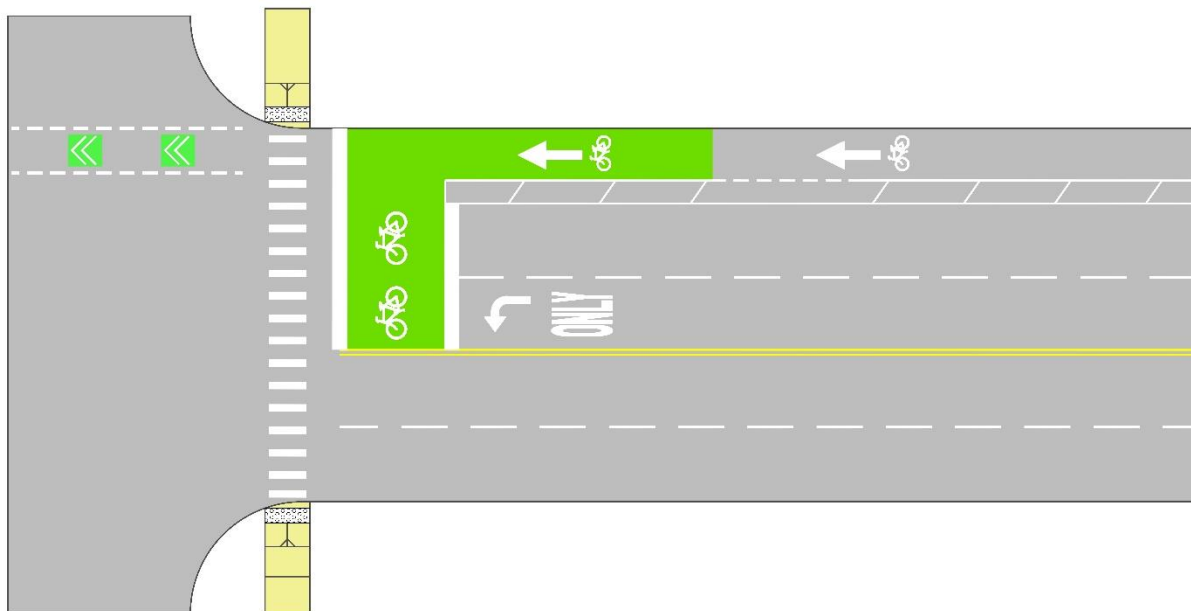


Figure 5-8 – Bike Box Typical Application

5.2.4 – Two-Stage Turn Queue Box

Two-Stage turn queue boxes offer guidance to people bicycling on how to make left turns without using a left turn lane where protected bicycle lanes are not feasible. At midblock crossing locations, a two-stage turn queue box may be used to orient bicyclists properly for safe crossings. A two-stage turn queue box, or a bike box shall be used at the intersection of two bicycle facilities requiring a left turn, when a protected intersection crossing is not provided. **Figure 5-9** illustrates a two-stage turn queue box configuration at an intersection.

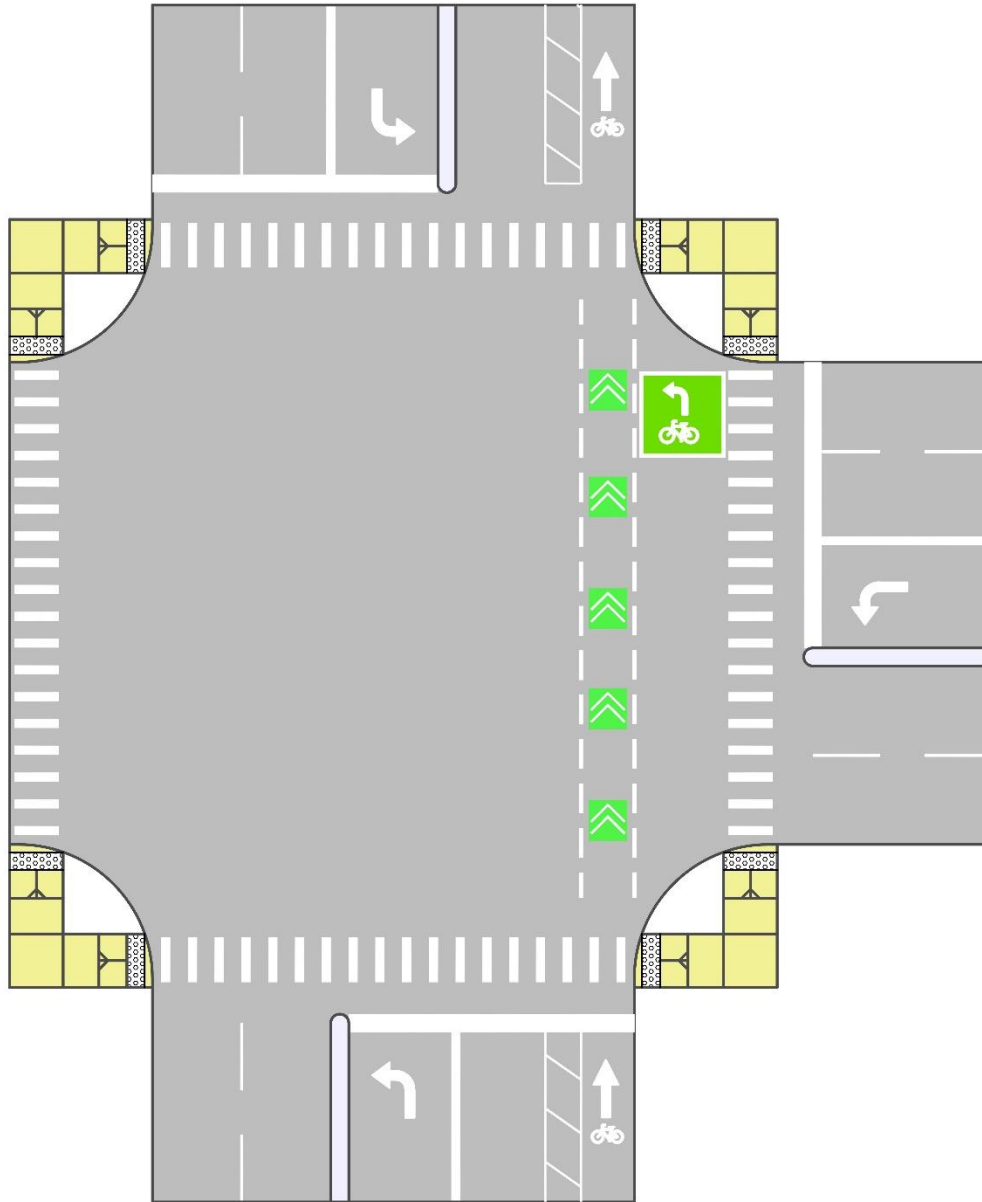


Figure 5-9 – Two-Stage Turn Queue Box Typical Application

5.2.5 – Transitions

Bicycle facility transitions shall be designed using the facility design speed and use Table 5-4 radii requirements and Table 5-5 for changes in grade slope requirements. Bicycle facility transitions to shared pedestrian facilities shall include ADA warning strips in advance of merging with a pedestrian facility, and warning strips shall be patterned perpendicular to direction of bike travel when merging with pedestrian areas. Typical transition zone configurations are shown in Figures 5-10 through 5-13 to address situations where facilities adjacent to a development are not the same as the facilities being designed. Refer to Figures 5-10 and 5-11 for typical transitions of one-way bicycle facilities and refer to Figures 5-12 and 5-13 for typical transitions of two-way bicycle facilities. Transitions shall meet criteria for tapers and centerline radii in **Section 5.1.1.1**. **Section 3.6.1** shows typical applications for bikes crossing intersections.

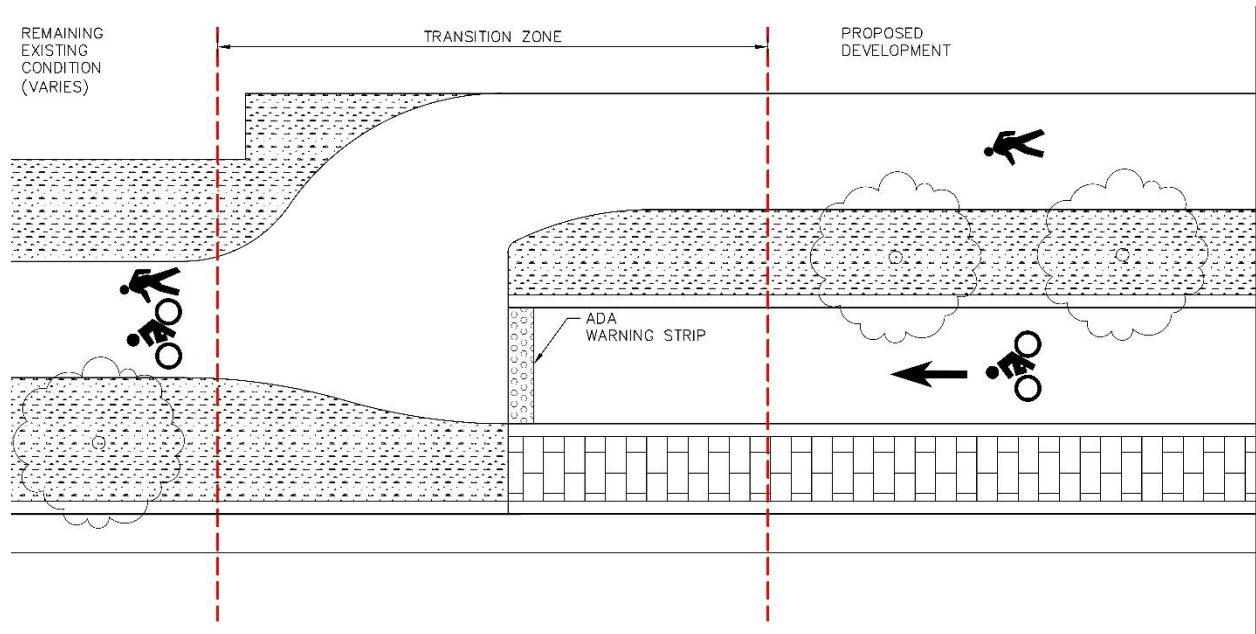


Figure 5-10 – Off-Street Merge to One-Way Shared Use Path

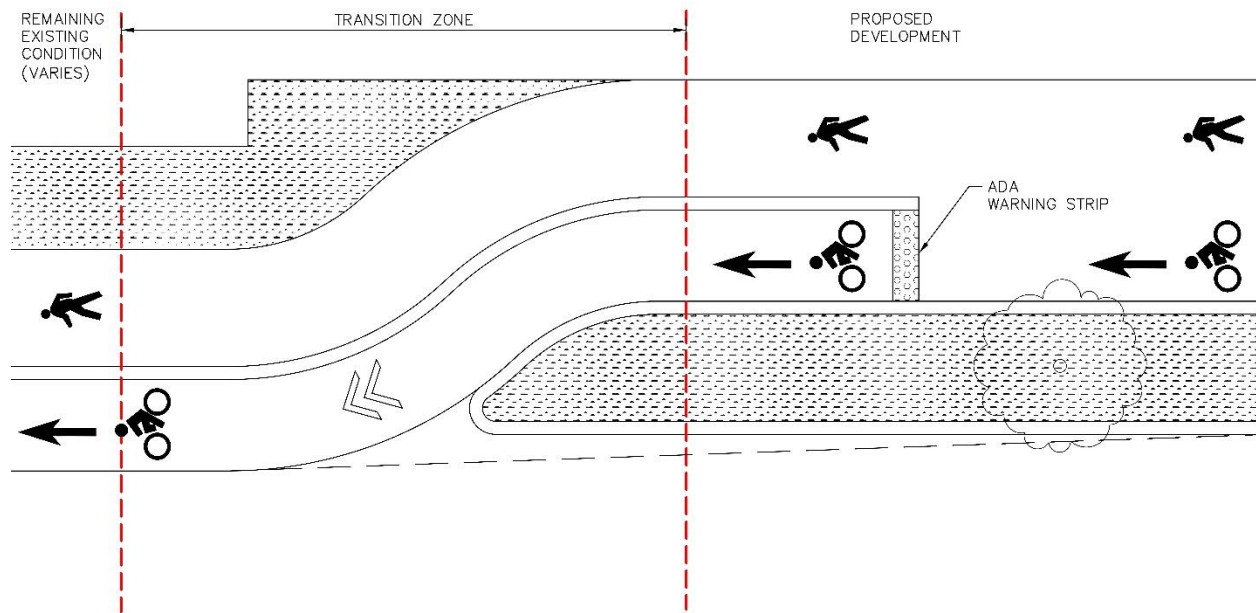


Figure 5-11 – Off-Street to On-Street One-Way Bicycle Transition

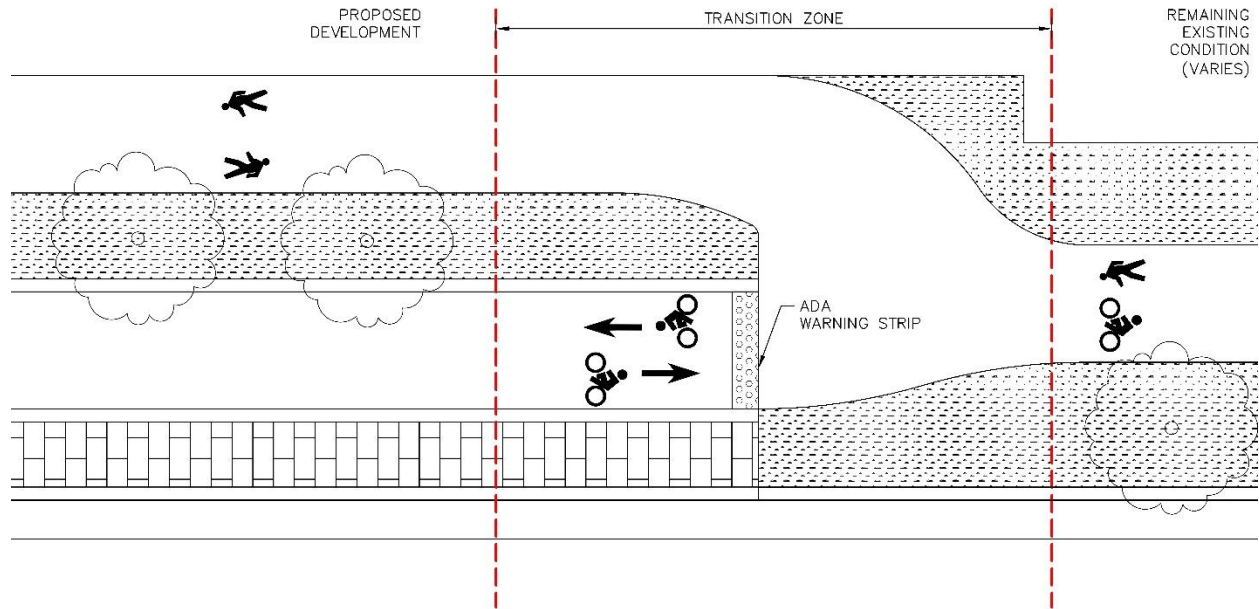


Figure 5-12 – Two-Way Shared Facility to Separate Facility Transition

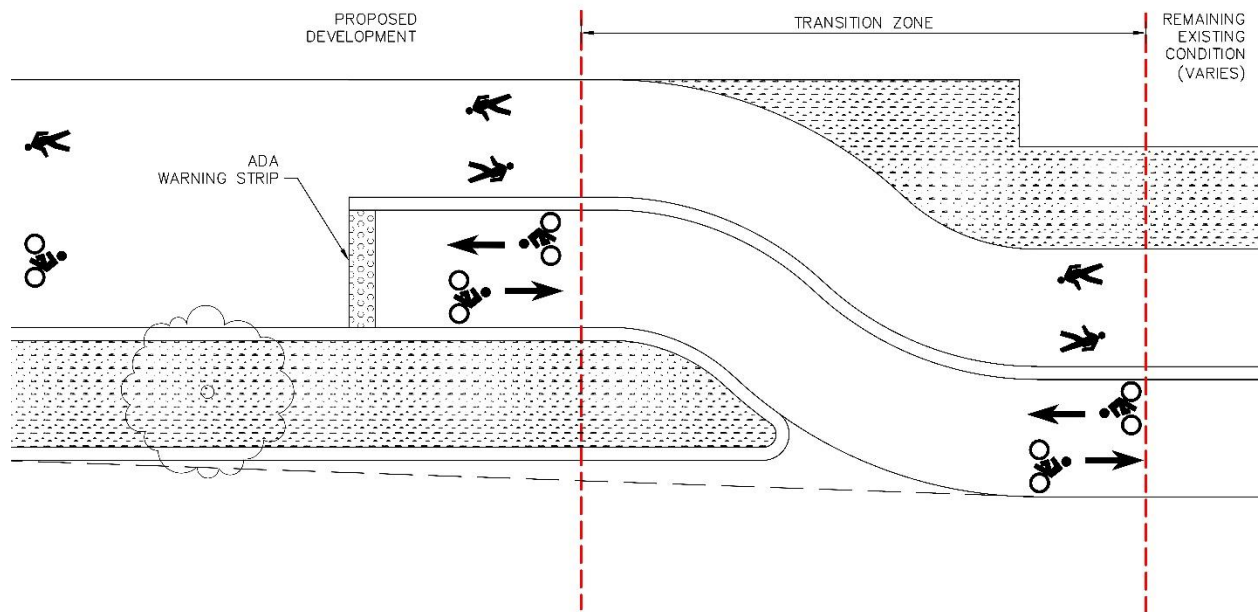


Figure 5-13 – Two-Way On-Street to Shared Transition

5.2.6 – Bicycle Signals

Bicycle signals are used to address identified safety or operational problems involving bicycle facilities or to provide guidance for bicyclists at intersections where they may have different needs from other road users. Bicycle signals are often required at signalized intersections where there are contraflow bicycle movements, the desire for a leading bicycle phase, or to manage conflicts with turning traffic. In the absence of dedicated bicycle signals, any signal heads that will be applicable to a bicycle facility shall be clearly visible to users on that bicycle facility.

TMUTCD standards shall be followed for bicycle signal design.

- A. Bicycle detection shall be automated through use of in-pavement loops, video, microwave, or other detection device unless approved by applicable staff.
 1. At locations where bicycle detection is used, a feedback indicator light and sign stating “Bicycle Detection” adjacent to the indicator shall be installed informing the bicycle facility user that they have been detected and are in the queue to receive a crossing signal.

5.3.0 – Urban Trail Design

The **LDC** requires installation or improvement of urban trails when identified in an adopted urban trail plan. The authority is designated to the Transportation Criteria Manual for design of these facilities. The following subsection addresses design of urban trails. This section applies to both Urban Trails and Shared Use Paths along roadways and in right-of-way or easements specified for Urban Trails.

Emergency access areas may be used as part of a trail connection or as a link in an existing future trail system if approved by the Austin Fire Department and Development Services Department.

5.3.1 – Horizontal & Vertical Geometry

This section covers the design criteria for the horizontal and vertical geometry of an urban trail. This requires careful consideration of the operating width, passing needs, horizontal and vertical curvature to maximize safety, comfort, and capacity of urban trail facilities.

5.3.1.1 – Design Speed

The design speed can fluctuate depending on the context of the trail, the user types expected, the trail terrain, and other trail characteristics.

- A. The City's design speed for urban trails shall be 24 mph, except where speed limits are set for trails in code or adopted plans, such as city parks.
 1. Trails can be designed for lower speeds in constrained scenarios. Engineering judgement will need to be applied on a case-by-case basis.
 2. In some circumstances, when environmental or physical constraints limit the geometry of the trail, design speeds slower than 12 mph may be applied when approved by applicable staff member.

5.3.1.2 – Horizontal Curves

Per AASHTO, horizontal curve radii are calculated from the following Equation 5-1 and specified for typical design speeds in **Table 5-4**.

Equation 5-1

$$R = \frac{0.067V^2}{\tan \theta}$$

Where:

R = Minimum radius of curvature (ft)

V = Design speed (mph)

θ = Lean angle from the vertical (degrees)

Table 5-4 – Minimum Radii

Design Speed (mph)	Minimum Radius (ft)
12	27
14	36
16	47
18	60
20	74
22	90
24	107

- A. The City’s desired minimum horizontal curve is 100 ft and when ample room exists, design shall include curves with radii greater than 100 ft.
- B. The trail alignment shall follow the contours of the land closely and, to the extent possible, preserve the natural terrain and vegetation. Design shall limit meanders in the trail unless they have a purpose (e.g. tree preservation).
- C. When the design speed is less than 18 mph, the section shall include trail widths of 12 ft or greater or curve widenings to let users navigate the effects of substandard curves. Design shall implement curve widening of 2-4 ft, with 2 ft curve widening as the standard. Curves with a resulting design speed less than 12 mph shall include signage instructing trail users of the operational speed of the curve. Table 5-4 shows minimum radii for typical trail design speeds.

5.3.1.3 – Grades

- A. When right-of-way is shared with a street, an urban trail or shared use path shall not exceed the general grade established for the adjacent street. When an urban trail has its own right-of-way or easement, urban trails shall not exceed 5% grade. Engineers should attempt to achieve a target grade of less than 2% when practical.
- B. In some circumstances, urban trails following the running grade of a street or 5% when in its own right-of-way or easement may not be possible due to physical or regulatory constraints. Physical constraints include existing terrain or infrastructure, right-of-way availability, and notable natural features. Regulatory constraints include federal, state, or local laws with the purpose of preserving threatened or endangered species; the environment; or archaeological, cultural, historical, or significant natural features that would be adversely affected by the additional gradient. Grades shown in Table 5-5 shall be provided when physical or regulatory constraints exist.

Table 5-5 – Maximum Running Slope and Segment Length

Running Slope of Trail Segment		Maximum Length of Segment (ft)
<i>Steeper Than</i>	<i>But Not Steeper Than</i>	
1:20 (5%)	1:12 (8.33%)	200
1:12 (8.33%)	1:10 (10%)	30
1:10 (10%)	1:8 (12%)	10

- C. If the terrain requires steep runs longer than the allowable distance shown in Table 5-5, resting intervals shall be provided at the top and bottom of each segment. Resting intervals may be provided within or adjacent to the trail. When the resting area is within the trail, it must be 5 ft long and at least as wide as the trail. When the resting area is adjacent to the trail, it must be 5 ft long and 3 ft wide and provide a minimum 4 ft by 4 ft turning space. The surface of the resting area cannot exceed two percent slope in any direction. The City's preferred minimum longitudinal grade shall be 0.5%.

5.3.1.4 – Vertical Clearance

Vertical clearance shall be 10 ft for Urban Trails with a minimum vertical clearance of 8 ft with applicable staff approval. If the passage of maintenance or emergency vehicles is necessary, a vertical clearance of 12 ft shall be provided. When overhead utilities (cables) exist, vertical clearance per the **Austin Energy Design Criteria Manual** (Section 1 of the **Utilities Criteria Manual**) is required.

5.3.2 – Cross Sectional Elements

This section covers the design criteria of cross-sectional elements along an urban trail related to the operating space and areas on each side of the trail.

5.3.2.1 – Width

- A. Urban trails shall be designed for two-way travel.
- B. Minimum trail width is 12 ft for off-street trails. Refer to **Section 4** for shared use paths on-street.
- C. If a portion of the urban trail is anticipated to exceed a peak hour volume of 300, considerations should be given for a wider facility or separated pedestrian and bike facilities. For each additional 100 peak hour urban trail users anticipated, the trail width should be widened by 2 ft, up to 24 ft.

5.3.2.2 – Shoulder

When space allows, a wider shoulder provides more space for incorporating furnishings and signage, gives users an area to stop alongside the trail.

- A. Shoulder width shall be 2 ft and shall have a recoverable cross slope of no steeper than 1V:6H on both sides.
- B. In situations where the trail is next to a street, the minimum offset from back of curb to edge of trail shall be 5 ft.

5.3.2.3 – Horizontal Offset

In locations where the trail is adjacent to parallel bodies of water (outside of the floodplain) or a downward slope of 1V:3H or steeper, the trail shall have an offset from the top of bank or hinge point. The edge of the shoulder shall measure 5 ft from the top of the bank/hinge point or the projected slope using **Table 5-6**, whichever is greater.

Table 5-6 – Offset Projected Slopes

Condition	Projected Slope from Bottom of Bank*
Bank in residual soils	1.5:1
Bank in fill soils	2.0:1
Bank in coastal plain soils	2.5:1
Bank in alluvial soils**	3.0:1

*Only valid if bank height is 15 ft or less. Anything greater than 15 ft shall be assessed individually.

**Assume this condition if no other information is available.

- A. Depending on the bank height and conditions at the bottom of the bank, a physical barrier, such as a fence, railing, or dense shrubbery, may be necessary. Engineering judgement should be applied to evaluate the risk of running off the trail versus the risk posed by the physical barrier.
- B. If a minimum 5 ft recoverable area (i.e., the distance between the edge of the trail and the hinge point) cannot be achieved, a physical barrier or rails are required.

5.3.2.4 – Cross Slope

The standard is to have the trail sloped in one direction.

- A. Maximum cross slope for the trail is 2%.
 - 1. The cross slope during design shall be 1.5% to account for minor deviations during construction and still be ADA compliant.
- B. If a center crowned typical section is needed, the maximum cross slope is 1%.
- C. The City’s desired cross slope for shoulders is 6H:1V.

5.3.2.5 – Pavement Marking & Signing

When used on trails, pavement markings provide guidance and information for the trail user. In some instances along a trail, pavement markings can be used to supplement signs. At critical stopping or turning points minimal pavement markings should be placed. These pavement markings can become slick to bicyclists when wet. A centerline is not required but should be considered in situations when delineation and indication of two-directional travel is needed to improve the safety and operation of the trail.

- A. Below are applicable situations for pavement marking use on trails:
 - 1. Trails with heavy two-way travel
 - 2. Along curves with restricted sight distance or design speeds less than 12 mph
 - 3. Along sections of trails that are unlit, or visibility is poor
 - 4. At intersections with streets or trails
 - 5. Underpasses or overpasses
- B. Pavement markings shall be retroreflective and strategically placed.

- C. A solid line shall be used when passing is prohibited and a dashed line when passing is permitted. The centerline shall be a 4 in. yellow line. Dashed lines shall be in 3 ft segments with 9 ft gaps in a repeating pattern. The City's preference is to not provide a centerline unless one of the situations above is applicable.
- D. A 4 in. yellow line shall be used to warn of an obstruction in the trail. Channelizing lines of appropriate color (e.g., yellow for centerline and white for all others) shall be used to guide the user away from the obstruction. For example, if a bollard is installed within the trail, a yellow diamond shall be installed around the bollard. Refer to Figure 5-14 (A) for pavement markings associated with a bollard or other vertical obstruction in the trail as shown in the Texas Manual on Uniform Traffic Control Devices (TMUTCD). For obstructions at the edge of the pathway, as shown in Figure 5-15 (B), Length of taper, L, shall be calculated with Equation 5-2.

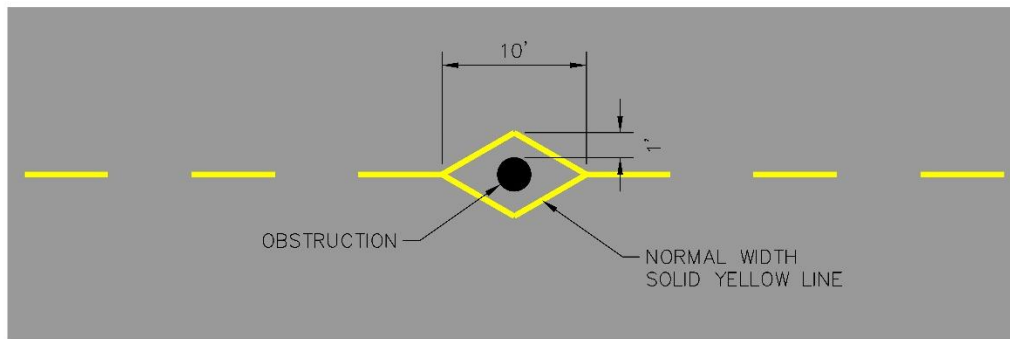
Equation 5-2 $L = WS$

Where:

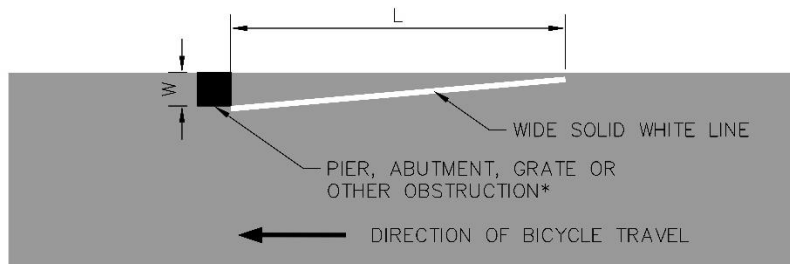
L = length of taper, in feet

W = width of obstruction, in feet (Note: add 1 ft to W in equation 5-2 when raised above trail surface)

S = bicycle approach speed, in mph



A—OBSTRUCTION WITHIN PATH



B—OBSTRUCTION AT EDGE OF PATH OR ROADWAY

L=WS, WHERE W IS THE OFFSET IN FEET AND S IS THE BICYCLE APPROACH SPEED IN MPH

*PROVIDE AN ADDITIONAL FOOT OF OFFSET FOR A RAISED OBSTRUCTION AND USE THE FORMULA L=(W+1) S FOR THE TAPER LENGTH

Figure 5-14 – Pavement Markings for Obstructions in Urban Trails

- E. Stop bars are not required on urban trails; however, stop bars should be considered in the following situations:
1. The trail intersects a heavily traveled roadway
 2. The trail intersects with a roadway and has minimal sight distance
 3. Any other need to help emphasize that the trail user must stop
 4. If added, the stop bar shall be a minimum of 12 in. wide, placed along the width of the trail, and be a minimum of 2 ft behind the truncated domes. Refer to Section 4.3.1 for crosswalk style requirements and refer to the TMUTCD for placement.
- F. Standard regulatory signage shall be retroreflective and follow Part 9 of the TMUTCD standards. Refer to Table 9B-1 in the TMUTCD for allowable trail signage dimensions. Regulatory signs warn users of various trail conditions, such as steep grades, sharp turns, or hazardous trail conditions. Signs shall be placed at least 50 ft in advance of the change or hazard. Sample typical signs used are shown with designation from TMUTCD in Figure 5-15.

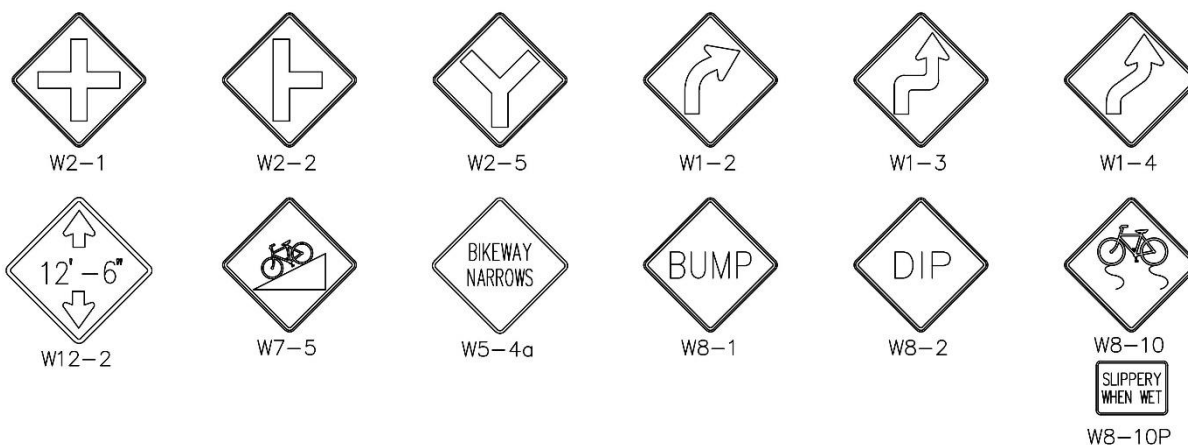


Figure 5-15 – Typical Signs for Urban Trails (TMUTCD)

- G. If a trail crosses a street, regulatory signage shall be added to the street to alert motorists of the crossing. Refer to the latest edition of the TMUTCD for recommended street signage.

5.3.2.6 – Pavement Design

Pavement design cross section for urban trails must be reviewed and approved. Standard Details for trails suggest a basic pavement design; however, this may need to be modified in thickness or to include subgrade stabilization in some cases.

5.3.3 – Urban Trail Surface

Refer to **City of Austin Standard Details** for urban trail surface specifications and installation requirements

5.3.4 – Lighting

Lighting improves visibility, enhances perceived safety, comfort, and increases the use of trails.

- A. Trail level lighting shall be provided unless there are sensitive environmental considerations and waived by City staff. If lighting is not provided, a 2 in. conduit shall be installed parallel to the trail to allow for lighting to be installed later if conditions change.
- B. Additional lighting shall be provided for the following locations along a trail:
 - 1. Near connections to transit stops, schools, universities, shopping, or employment areas
 - 2. Under vehicular bridges, underpasses, tunnels, and urban trail bridges
 - 3. Locations with limited visibility and sight distance
 - 4. Trail intersections with streets or other trails
 - 5. Trailheads
- C. The following guidelines shall be followed for lighting along a trail, in addition to requirements of the LDC:
 - 1. The illumination shall be adequate to identify a face up to 20 yards away.
 - 2. Full cut-off fixtures shall be used to reduce light pollution and comply with the International Dark Sky regulation.
 - 3. Electrical components need to abide by Article 862 of the National Electrical Code (NEC) in flood prone areas.
 - 4. Average horizontal illumination levels shall be between 0.5 to 2 foot-candles.
 - 5. LED lamps shall be used.
 - 6. Lighting shall be low voltage (e.g. LED) and low maintenance.
 - 7. Light fixtures shall be on poles at a minimum height of 12 ft and maximum height of 15 ft.
- D. Pedestrian lights can be solar powered or hard wired. Hard wired power sources are the standard for pedestrian lights. Solar powered pedestrian lights shall be allowed by variance when a utility collection is difficult or when alternative energy sources are desired. The amount of tree canopy shall be factored into the effectiveness of solar power.

5.3.5 – Amenities

Amenities along or at endpoints to urban trails shall follow Parks and Recreation Department (PARD) standards and specifications in the City of Austin. Maintenance and service of these amenities will be provided by the City in public right-of-way but will require a licensing agreement on private property or in easements. Standards are defined in the applicable department's Standard Park Amenities Manual per the LDC in the definition for "Standard Publicly Accessible Recreation Amenities".

5.3.5.1 – Water Fountains

- A. Water fountains shall be located near restrooms, trailheads, larger rest areas, and other public gathering places along the trail. Installation of water fountains will be dependent on available utility connections.
- B. Water fountains shall be a minimum of 5 ft from the trail edge and installed on a concrete pad.

- C. Water foundations shall be accessible by all trail users and be ADA compliant.

5.3.5.2 – Trash Cans and Recycling Bins

- A. Trash cans need to be accessible by all users and maintenance personnel.
- B. Trash cans shall be animal proof.

5.3.5.3 – Furniture

- A. Benches provided at trailheads shall be 4 ft in length. If bench is 6 ft in length it shall include a center placed armrest.
- B. Benches shall be a minimum of 3 ft from the trail edge.
- C. Benches shall be placed at trailheads and along the urban trail where appropriate. If benches are placed along the trail, ½- to 1-mile spacing is recommended.
- D. Benches shall be placed at interesting views, close to interpretive elements, or in areas with shade or sheltered from seasonal winds.

5.3.6 – Landscaping

Landscaping can enhance the experience on an urban trail and can provide shade, shelter, and serve as a natural privacy screen. Trails are to be designed and constructed to protect, preserve, and maintain the existing native vegetation and follow the LDC for existing tree impacts and removals. If the native vegetation is impacted or was sparse, trees and shrubs can be planted in logical places along the trail. The only vegetation along the shoulder should be grass.

- A. All trees and shrubs shall be planted at 10 ft offset from outside edge of the trail shoulder. Native species will be more tolerant and require less maintenance. The topography and existing soils will affect the type of plants chosen.
- B. Shrubs adjacent to the trail shall be a maximum of 24 in. in height as to not obstruct the line of sight.
- C. Trees shall be trimmed to provide a minimum of 8 ft of vertical clearance and be placed as to not obstruct trail lighting if installed.

5.3.7 – Trailheads and Access Points

5.3.7.1 – Trailheads and Intersections with Streets

Trailheads provide a transition between motorized and nonmotorized transportation and recreational systems.

- A. Trailheads shall also include trail wayfinding signs per Section 5.4.0. Providing access to a trail shall be required at existing public facilities such as schools, libraries, and parks.
- B. Trailheads adjacent to streets, shall have removable bollards at the street interface. Bollard should not be placed in the clear zone of the roadway. Refer to **City of Austin Standard Details** for installation requirements.

5.3.7.2 – Neighborhood & Destination Access

Trailhead access points to neighborhoods and popular destinations are to be considered along all new trail designs per requirements of the LDC requiring public multi-use trail easements.

- A. Neighborhood and destination access points shall not be considered an alternative to trail heads as mentioned in **Section 5.3.7.1**.
- B. Neighborhood access shall be ADA compliant, with provisions for a variance if existing terrain limits the type of access.

5.3.7.3 – Reference Location Markers

Reference location markers shall follow Parks and Recreation Department (PARC) standards and specifications in the City of Austin.

5.4.0 – Bicycle Routing / Wayfinding

Bicycle routes and wayfinding signs may be implemented by the City with guidance on preferred signs and markings in administrative guidelines or **City of Austin Standard Details**.

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When designing a street or when developing a complete street network system, consideration should be given to the existing or potential future use of the right-of-way by transit vehicles and customers. Designs that support transit operations can improve the speed and reliability of transit service, helping transit move more people more quickly and safely, with more consistent travel times. While the following design standards and criteria focus largely on transit buses, they may also be applicable to other transit vehicles, including paratransit, streetcar, and light rail systems.

This Section incorporates and adapts national best practices as well as guidance published by Capital Metropolitan Transportation Authority (CMTA) for use in street design in the City of Austin. The intent of this Section is to cover general elements of street design for incorporation of transit facilities and vehicles into street design. This Section also includes design criteria for on-site development that accommodates transit.

Published or approved national references as listed in **Section 1** and CMTA design standards shall be referenced when developing facilities to accommodate transit, as those resources may provide more detailed design guidance for planners and engineers beyond the scope of this manual. Proposed developments along a current or planned transit corridor are to be designed in coordination with CMTA and the applicable department at the City of Austin. Project Connect Design Criteria may supersede the requirements of this manual, subject to final approval by the City Traffic Engineer or applicable Director and shall be consulted when a development is located adjacent to the alignment of a transit line per the latest adopted Project Connect System Plan. Existing transit stop access must be maintained during construction. If an existing transit stop needs to be temporarily relocated during construction, it is the applicant's responsibility to coordinate with CMTA and the City of Austin to find an appropriate location and to provide the appropriate facilities.

6.1.0 – Transit Operations

Transit can be provided through a variety of services in order to match the mobility needs of customers and travel demands of a corridor. Transit operators address these differing needs by strategically deploying specific transit modes, vehicles, and service patterns on each travel corridor. Table 6-1 summarizes the different transit services provided by CMTA, which shall be superseded by the latest fleet information and typical service schedules in effect:

Table 6-1 – Capital Metro Transit Services

Service	Mode	Headways	Network Role
Local Bus	Bus	30min	Local circulation, network connections, coverage, trip completion
High-frequency local bus	Bus (includes articulated bus)	15min	Core frequent network
MetroRapid	Bus	10min	Network spine, sub-regional travel
MetroExpress	Bus	30min	Longer-distance travel
MetroRail	Commuter Rail (DMU)	35min	Network spine, regional travel

Source: Capital Metro, 2015

In planning for the different types of existing and potential future transit service it is important to consider the transit vehicle and corresponding infrastructure necessary to serve it. Table 6-2 documents CMTA fleet

characteristics and vehicle dimensions that must be accommodated into the planning and design of transit corridors and facilities.

Table 6-2 – Transit Fleet Characteristics

Service	Vehicle Dimensions		Vehicle Seating Capacity	Vehicle Standing Capacity	Total Vehicle Capacity
	Length (ft)	Width (ft/in.)			
MetroAccess/Neighborhood Circulators (Shuttle bus)	23	7.4	14 (+2)	--	14(+2)
MetroBus (Typical Bus)	35-40	8.4	29-36	24-31	60
MetroRapid (Typical Bus & Articulated)	40-60	8.4	30-46	30-70	60-115
MetroExpress (Coach Bus)	45	8.4	39-57	--	39-57
MetroRail (DMU)	134		108	122	230

Source: Capital Metro, 2015

- A. Buses operated by CMTA at time of document writing are 40 ft Gillig, New Flyer and NOVA buses, 45 ft MCI, and 60 ft NOVA buses (articulated). Specific design criteria shall be adjusted to accommodate vehicles in operation at time of design.
- B. **Section 3.2.1** includes criteria for design vehicles and where buses are applicable design vehicle.

6.2.0 – Transit-Supportive Guideways

Making transit work for cities means designing streets to accommodate and facilitate safe, reliable, and efficient transit service. The following subsections cover the street design strategies, tools, and requirements to support and prioritize transit. Elements of this guidance may be applied to transit corridors across the city and will be particularly critical for the successful implementation of the Transit Priority Network, including priority treatments that will improve the speed, reliability, and efficiency of public transportation. Project Connect Design Criteria may supersede the requirements of this manual, subject to final approval by the City Traffic Engineer or applicable Director and shall be consulted when a development is located adjacent to the alignment of a transit line per the latest adopted Project Connect System Plan.

6.2.1 – Non-dedicated Guideway

Allocation of space in the right-of-way shall consider existing and future transit service where identified in the **ASMP**. Transit routes spend a significant amount of each trip navigating mixed-flow travel lanes, in which transit vehicles share the lane with private automobiles, trucks, and possibly non-motorized users. Mixed-traffic lanes do not give priority to any roadway user and may be adequate for transit operations if travel conditions do not impede transit vehicle movements or reduce transit performance.

Generally, buses are accommodated through 11 ft wide travel lanes, exclusive of gutter pan, and through provision of adequate space at stops to be accessible and allow boarding and alighting of passengers. High-capacity transit modes like light rail have different space requirements depending on the mode and supporting facility type, such as a rail station, which are specified in the Project Connect Design Criteria. **Section 2.7.0** of the TCM specifies lane widths that shall accommodate transit vehicles in the outside lane of streets and left turns.

6.2.1.1 – Transit Priority

Transit priority treatments in mixed-flow or non-dedicated guideway environments refers to various in-street lane treatments that provide transit vehicles with advantageous travel conditions to increase travel speed and reliability, as well as reduce conflicts with other modes. The scope of these treatments may vary, from long segments to specific spot improvements, as well as different operating conditions and periods.

6.2.1.1.1 – Transit Priority Lanes

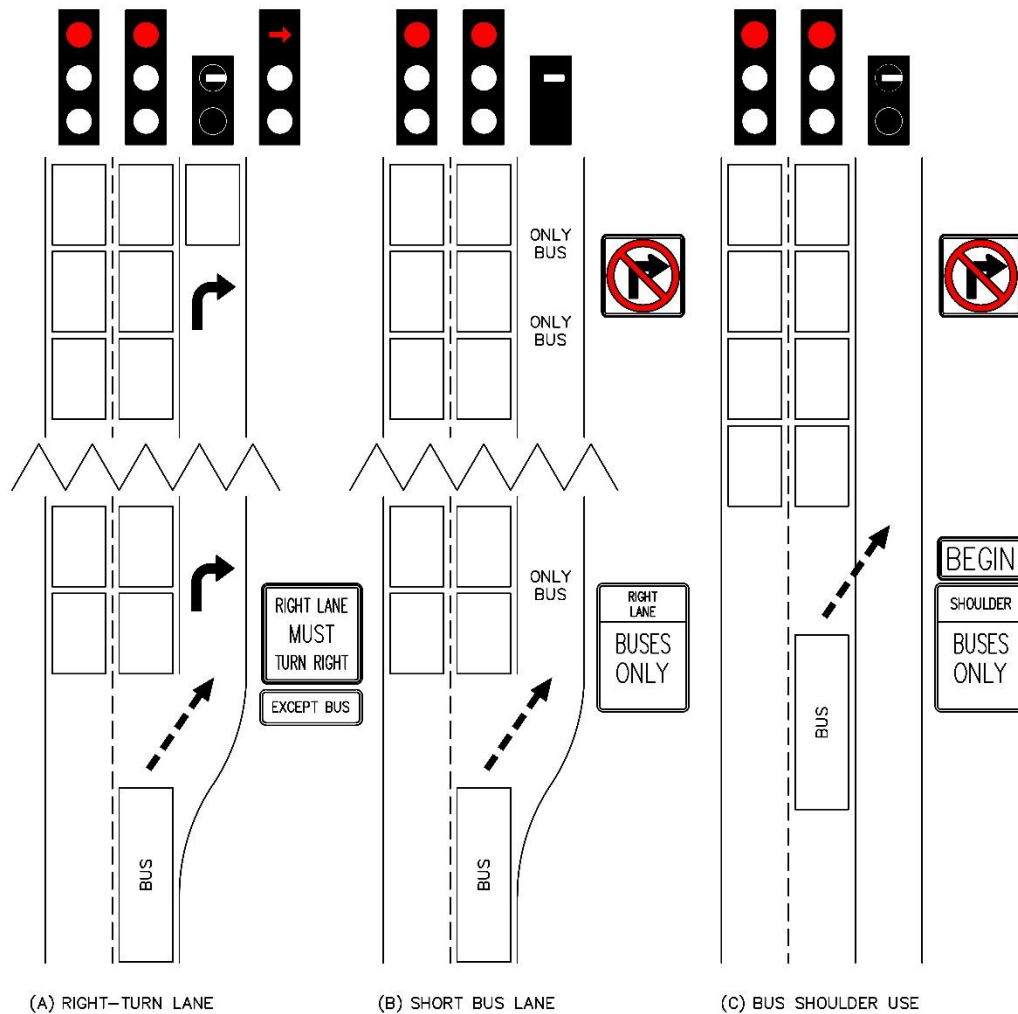
Transit Priority Lanes are street segments designated by signs and markings for the use of transit vehicles, sometimes limited use by other vehicles.

- A. Transit Priority Lanes can be flexible, operating either full time or during limited hours, and may be dedicated to transit use only, allow designated users (e.g. bicycles) to share the lane, or allow other vehicles to enter the lane exclusively to make local access turning movements.
- B. **Section 6.3.3** specifies markings and color treatment, and signage for transit priority lanes.

6.2.1.1.2 – Transit Queue Jump/Bypass Lane

Transit queue jumps or bypass lanes may be used in coordination with shared right-turn, short bus lanes, and shoulder bus lanes to allow buses to preemptively bypass intersection queues in adjacent mixed-flow travel lanes. Figure 6-1 illustrates each of these three applications of transit queue jump/bypass lanes as well as the associated transit signal heads.

- A. Transit signal heads shall comply with the latest edition of the Texas Manual on Uniform Traffic Control Devices (TMUTCD) for Light Rail Transit (LRT) signal heads found in Part 8 of the TMUTCD.
- B. Design of transit queue jump lanes shall include reinforced concrete pavement for the full width of the queue jump lane per the cross section for bus pads illustrated in **Section 6.3.3**.
- C. AASHTO *Green Book* recommends that “1.5 to 2 times the average peak-period queue length be used in designing turn lane storage lengths, which approximate 85th and 95th-percentile queues, respectively.”
- D. The queue jump / bypass lane shall be designed so that an arriving bus would be able to access the queue jump lane unimpeded by queue spillback 95% of the time.
- E. A traffic analysis is required to determine the 95th percentile queue length for lanes adjacent to a transit queue jump lane and therefore the length of the transit queue jump lane.



Adapted from NACTO Transit Street Design Guide

Figure 6-1 – Queue Jump Treatment Options

6.2.2 – Dedicated Guideway

The purpose of dedicated guideways is to separate transit vehicles from mixed-flow traffic to improve the operational efficiency of transit services. This strategy is often employed in congested corridors with high traffic volumes and substantial existing or potential transit demand. Dedicated guideways may include at-grade facilities, which have some interface with street-level traffic, or aerial or underground structures that offer complete grade separation between transit vehicles and other roadway users. This manual is limited to at-grade facilities for bus vehicle applications, and additional criteria that may supersede this manual, subject to final approval of the City Traffic Engineer or applicable Director, are included in the Project Connect Design Criteria for other dedicated guideway transit applications.

6.2.2.1 – Transit-Only Lane Requirements

When a corridor study or City Capital Improvement Plan (CIP) project is being designed, transit-only lane conversions on existing streets and inclusion of transit only lanes on new streets or widened streets shall be considered as part of the project development process. Conversion of existing travel lanes with a mix of

automobile and transit vehicle use shall be evaluated when the person carrying capacity of the lane exceeds that of the person carrying capacity of vehicles using the lane. Table 6-3 establishes the vehicle capacities and estimated headways of each service type offered by CMTA in a person carrying capacity calculation for this evaluation. Conversion of parking lanes to transit-only lanes or addition of transit-only lanes outside of existing vehicular travel lanes shall be approved by the City Transportation Engineer or applicable Director.

Table 6-3 – Transit Only Lane Person Capacity Calculation Basis

Service	Vehicle	Capacity per Vehicle (seated & standing)	Assumed Peak Period Headway	Person Carrying Capacity (per hour)
MetroBus	Standard bus	60	30 min	120
Metrobus High-frequency	Standard bus	60	15 min	240
MetroRapid	Standard Bus	60	10 min	360
	Articulated Bus	115	10 min	690
MetroExpress	Coach bus	57	30 min	115
Metrorail (Commuter Rail)	DMU railcars (3)	230	35 min	400

Source: Capital Metro, 2015

- A. Capacity will be evaluated for the peak hour and is based on the capacity of each transit vehicle multiplied by the number of vehicles arriving in 1 hour for each route.
- B. To determine the person carrying capacity of a lane, the sum of all capacities of transit routes using the street in a single direction shall be calculated.
- C. Transit routes may be existing routes or in an approved plan by CMTA or the City of Austin.
 - 1. For routes in an approved plan, consideration in the calculation shall be given to whether the planned service route will replace an existing route, for which the existing route should be removed from the calculation.
- D. **Section 6.3.3** specifies markings and color treatment, and signage for transit only lanes.
 - 1. Signage must be used for each block adjacent to the designated lane to convey restricted use to different classes of road users. All signage should be compliant with the TMUTCD.
- E. Manage or prohibit turns across transit facilities to reduce transit delays and minimize conflicts with pedestrians, bicyclists, and other traffic per example configurations in Figure 6-2.
- F. Transit Only Lanes should be designated using a single or double white line and a stenciled “BUS ONLY” marking in the lane being used, per TMUTCD.

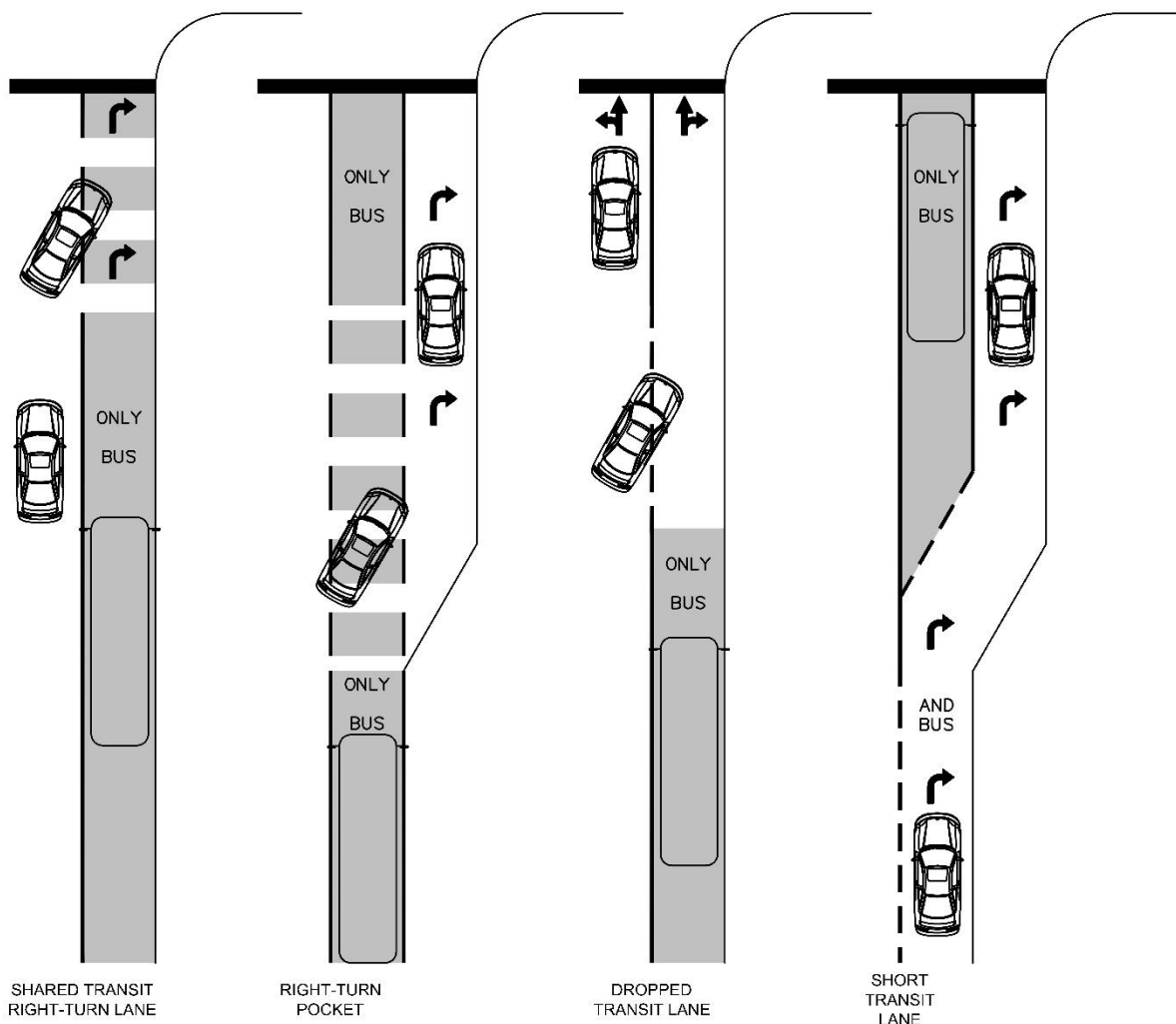


Figure 6-2 – Intersection Approach Bus Lane Transitions

6.2.2.2 – At-Grade

At-grade dedicated guideways offer enhanced transit capacity on existing thoroughfares by providing exclusive use of lanes to transit vehicles. Although these transit-only lanes promote separation of transit vehicles from mixed-flow traffic, design of these facilities must consider different points of conflict between modes at intersections.

6.2.2.2.1 – Side-Running

Side-running dedicated guideways offer the enhanced capacity and flow of fully separated transitways while enabling pedestrians to board directly from the sidewalk. Design considerations include:

- A. All intersections with pedestrian, bicycle, or motor vehicle traffic must be signalized.
- B. To avoid conflicts with transit vehicles, left- and right-turning traffic across the transitway must be either prohibited or accommodated using turn lanes with dedicated signal phases.
- C. If parking is located next to a transitway, 4 ft of clear width must be available adjacent to the parking lane to accommodate loading.

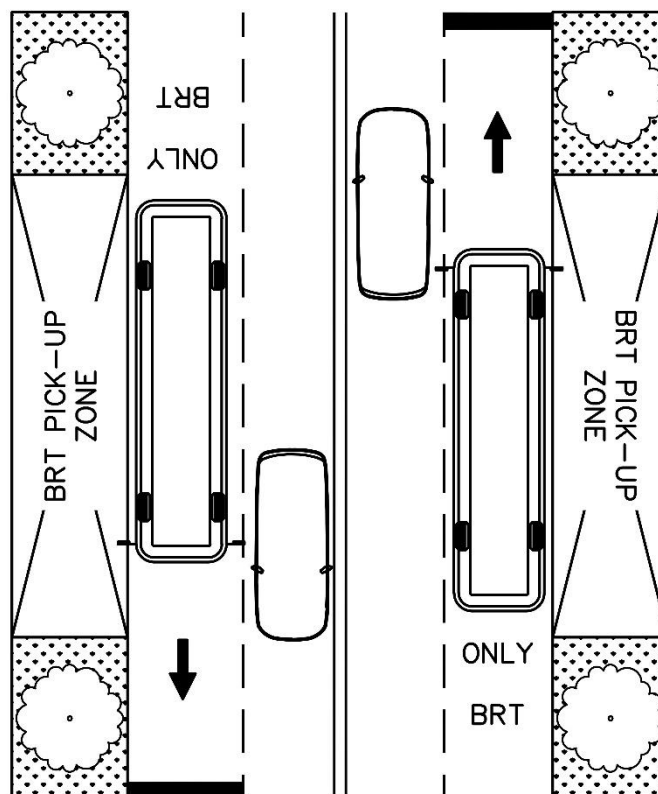


Figure 6-3 – Side-Running Guideway Typical Application

6.2.2.2.2 – Center-Running

Center-running guideways are located in the roadway median. This alignment is advantageous in corridors with high-quality, frequent bus or rail service on very large streets. They provide strong protection from traffic-related delays and offer the highest running speeds for at-grade facilities.

- A. Median boarding islands must be fully accessible and lead to safe, controlled crosswalks or other crossings.
- B. Right-boarding stations (Figure 6-3), permit the use of typical rolling stock, while center platforms require transit vehicles with left-boarding. Center platforms (Figure 6-4 and Figure 6-5) are advantageous in constrained corridors because they require less width.
- C. To avoid conflicts with center-running transit vehicles, left turns must be either prohibited or accommodated using left-turn lanes and dedicated signal phases.
- D. Transit signal heads shall be used at signalized intersections to give transit vehicles priority and avoid driver confusion with general traffic signals.

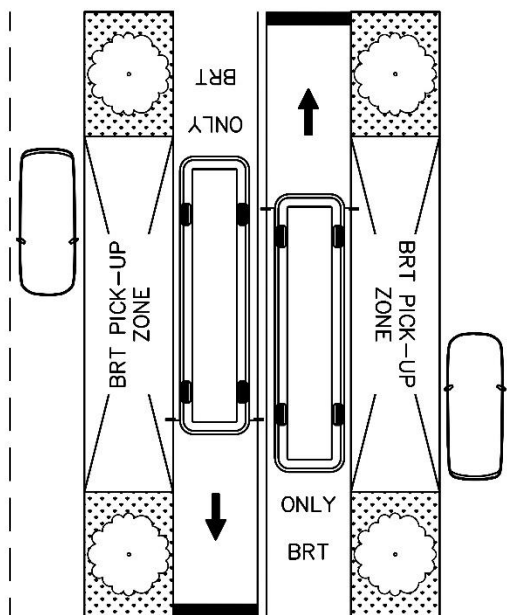


Figure 6-4 – Center-Running, Side Platform Guideway Typical Application

6.2.3 – Multimodal Interface with Transit Guideway

Connected and consistent pedestrian and bicycle networks can reduce conflicts among modes, enable a comfortable trip from beginning to end to maximize transit use, and encourage higher levels of walking, bicycling, and riding for users of all ages and abilities. Uncomfortable intersections, and difficult mid-block crossings must be addressed to allow pedestrians and bicyclists to safely access transit stops and other destinations.

6.2.3.1 – Stop/Station Access

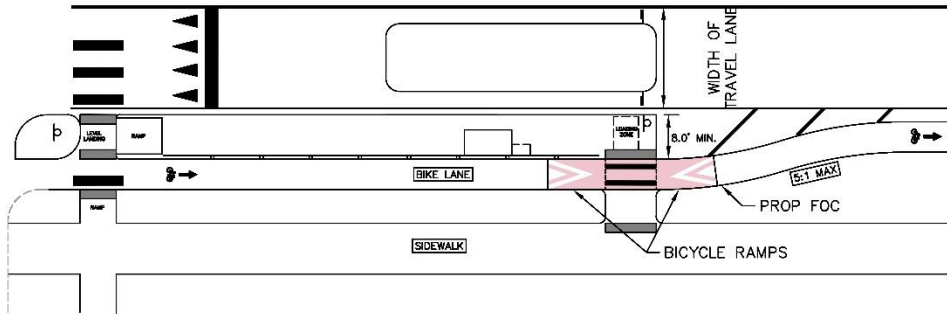
Access to and from the station or bus stop shall be provided along a clear path of travel for each mode, serve all users, and provide a sense of comfort. Stop/station access shall adhere to a strict access hierarchy that prioritizes the most vulnerable users—pedestrians and bicyclists—over motorized traffic.

To successfully integrate different modes at transit stops, the preferred configuration is a floating bus stop and raised or separated bicycle lanes. The floating bus stop layout and criteria for a Tier 1 transit stop are specified in **Section 5.1.4.1.4**. Alternatively, where floating stops are not feasible, it is preferred that transit stops be placed outside of merging areas for bike lane and transit only lanes per the Tiers in Table 6-4. An example of a Tier 2 configuration is shown in **Figure 6-5**. A Tier 3 configuration is shown in **Figure 6-6**.

Table 6-4 – Preferred Transit Stop Configurations for Multimodal Integration

Tiers	Configuration Descriptions
Tier 1	Floating bus stop where buses, bicycles, and peds all have separate space.
Tier 2	Bus still stops in lane, but either bike lane ramps up to shared platform or a shared-use path passes in front of or behind shelter
Tier 3	Bikes and buses share space at the stop and buses block bike lanes.

- A. Bicyclists should be separated from bus-only access roads and driveways on the stop or station site, where possible, by providing protected bicycle routes per **Section 5.1.4.1.4** of the TCM.
- B. Where separation is not feasible, sidewalks should be wide enough to accommodate both bicyclists and pedestrians safely with widths of 8 ft for one-way travel and 10 ft for two-way travel, at a minimum.
- C. Stop or station design should comply with Federal accessibility standards as adopted by U.S. DOJ and U.S. DOT to support users of all abilities.
- D. In the context of a one-way street, on-street or protected bicycle facilities operating in two directions may be located on the left side of the street to reduce bus and bike conflicts.
- E. For facilities design as Tier 3, per Table 6-4, bikes shall transition to share the lane with buses per configuration and markings in Figure 6-6.
- F. Refer to **Table 5-2** regarding clearance between bikeway and fixed objects.



NOTES

1. RAMP LENGTH VARIES DEPENDING ON SLOPE OF ROAD.
2. USE 1" WIDE REINFORCED CURB ALONG TRAFFIC EDGE OF PED RAMP.
3. INSTALL LIMITS ON EITHER SIDE OF BICYCLE RAMP AS NEEDED. SET CROSSWALK AREA ACROSS BICYCLE LANE AT SIDEWALK LEVEL. USE ASPHALT OR COLORED PAVEMENT WITHIN BICYCLE LANE.

Figure 6-5 – Teir 2 Example Bus Stop with Bicycle Ramps

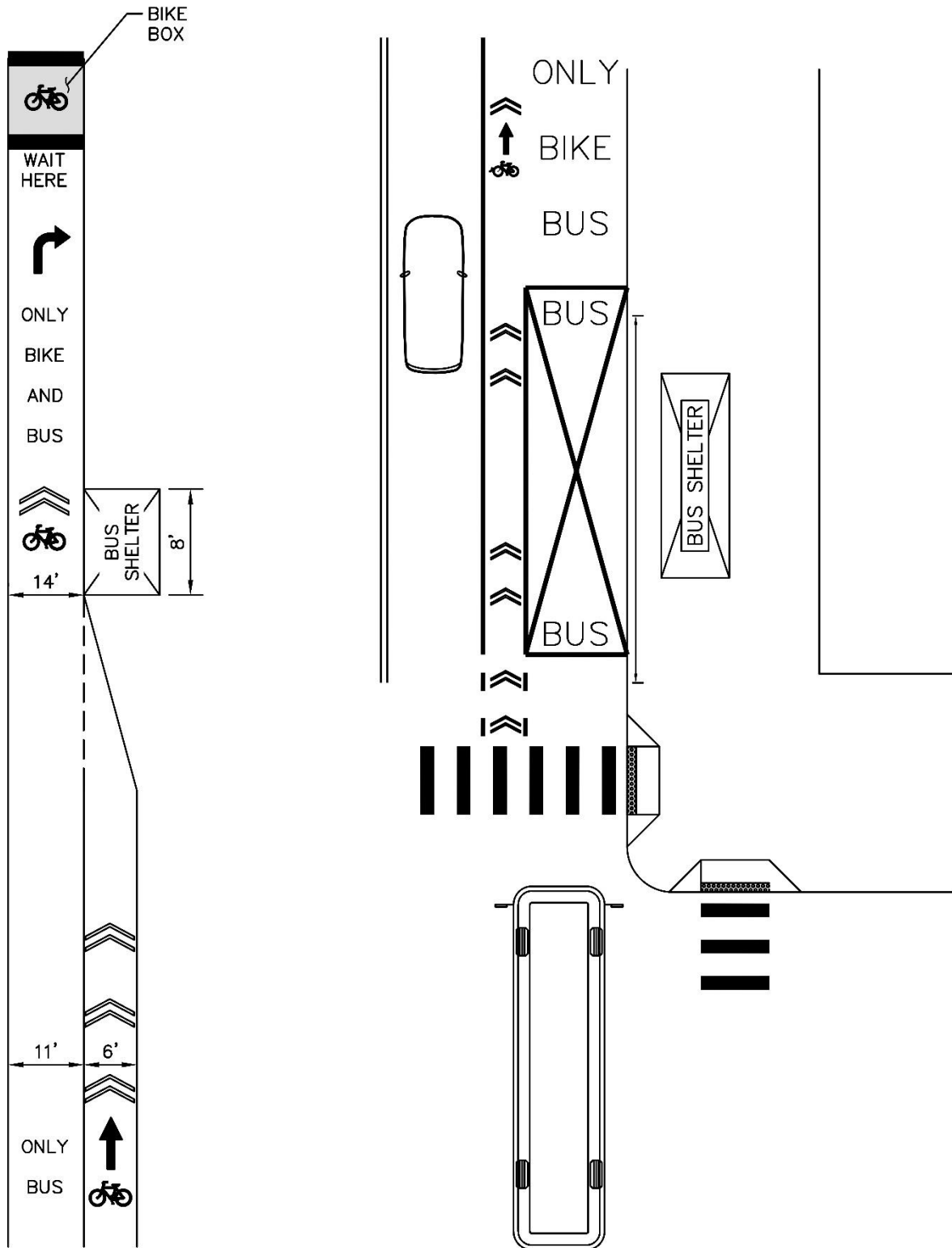


Figure 6-6 – Tier 3 Shared Bus-Bike Lane Transitions at Transit Stop

6.2.3.2 – Bicycle Storage

- A. Stations shall provide sufficient parking for bicycles and shared mobility devices in concurrence with **Section 9.7.0** and **Section 9.8.0** of this manual.
- B. Bicycle racks shall be placed in locations permitted in **Section 9**, or within transit stop area.

6.2.3.3 – Driveway Access Management

- A. Driveway access management in relation to transit operations shall be performed in concurrence with **Section 7** of this manual.
- B. Driveways shall be designed so as not to conflict with bus stops and other transit facilities.
- C. Driveway consolidation may be considered as a part of transit stop or station placement and approved by an City Transportation Engineer, applicable Director, or their designee.

6.2.3.4 – Rail Crossings

- A. At-grade rail crossings shall conform to the latest edition of the TMUTCD standards and are subject to the required US DOT approval process.
- B. Slopes to at-grade crossings shall comply with grades to curb ramps and crossings shall be 12 ft or 16 ft wide depending on ridership and constructed of precast concrete panels.
- C. The crossing shall extend from the face of one platform to the face of the opposite platform at the same elevation as the top of rail.
- D. The platform shall be depressed to the crossing at a rate that does not exceed 8 in. rise for 16 ft of run.
- E. Signalized crossings shall be provided at locations where two or more tracks are crossed; gates at crosswalks shall not be allowed at these locations.
- F. Cross track boarding is to be avoided and warning signals should be provided at all existing at-grade crossings.
- G. The number of at-grade crossings is based on the platform length and the maximum distance between at-grade crossings is 405 ft.

6.3.0 – Transit Facilities

Determining where to locate transit stops and stations is one of the chief governing factors of effective transit operations. Facility placement involves a balance of user safety, accessibility, comfort, and operational safety and efficiency. Stops should optimally be placed at signalized crossings to maximize pedestrian safety, be compatible with adjacent land use, and minimize adverse impacts on the built and natural environment. Stop configurations, including placement in relation to intersection, as well as curb access should optimize transit vehicle and customer access and safety.

6.3.1 – Stop Location

Transit stop frequency, size, and configuration shall be designed to accommodate all users in an accessible manner and service the demand and vehicle type using the stop or station. Specific considerations that

factor into stop/station placement and design include: (1) Center vs. side-running operations; (2) intersection configurations; and (3) curb access, including right or left-boarding configurations.

6.3.1.1 – Stop Spacing

Stop spacing is determined based on several factors including customer convenience, ridership demand, and service type. Customer convenience involves a trade-off between proximity to stops and travel time. Closely spaced stops reduce customer walking distance but result in slower transit speeds, reducing operating efficiency and cost effectiveness. Few stops spaced further apart increase walking distance but result in faster, more reliable service. Table 6-5 defines recommended stop spacing ranges.

Table 6-5 – Recommended Minimum Distance Between Bus Stops

Area Type	Stop Spacing Range (Min/Max) (ft)*
Stops on Transit Priority Network, within Centers or along Corridors and on Level 3 Streets	800 - 1,600
Other areas or Level 4 Streets	1,200 - 2,500

**Shorter spacing distances are permitted with approval from the City Transportation Engineer or applicable Director*

6.3.1.2 – Far-side Stop

Far-side stops occur when the bus stops after proceeding through the intersection. These stops are preferred at most intersections, including at intersections in which buses make left turns and intersections with a high volume of right turning vehicles. Far-side stops are also preferred on corridors with transit signal priority (TSP) and encourage pedestrians to cross behind the bus.

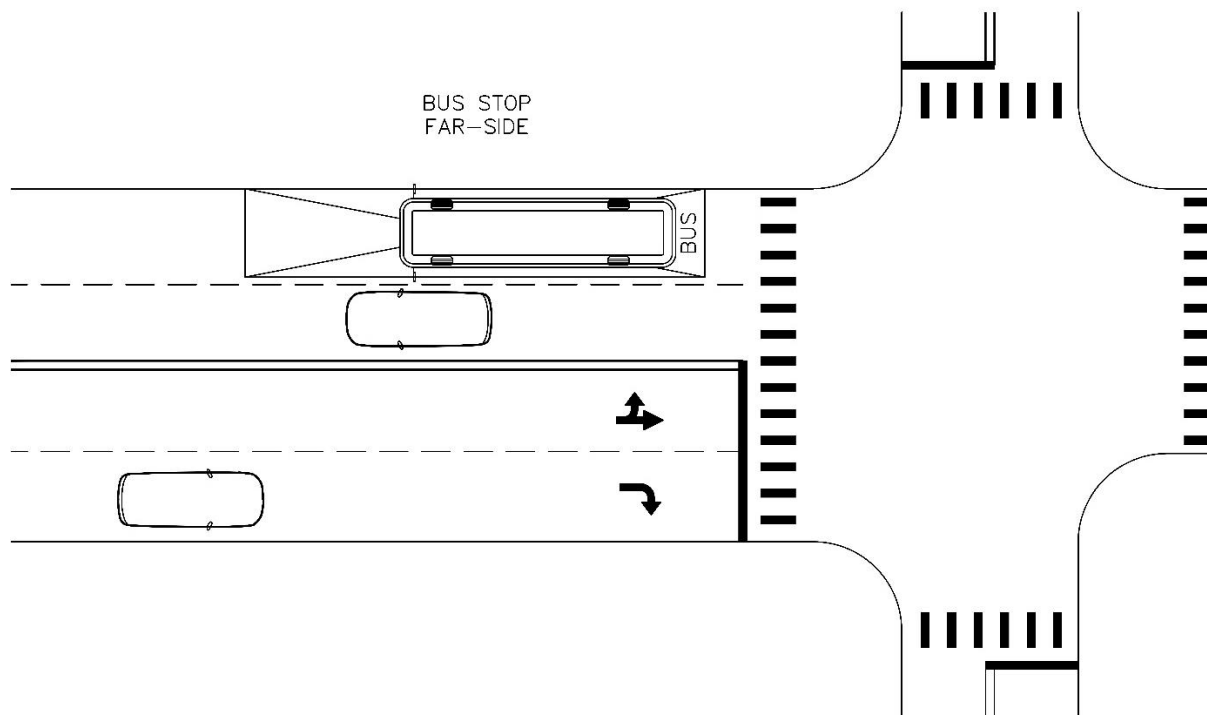


Figure 6-7 – Far-side Bus Stop Platform

6.3.1.3 – Near-side Stop

Near-side stops occur when the bus stops before the intersection. Near-side stops are discouraged where they have an impact on the ability of an intersection to process traffic and cause noticeable drops in intersection capacity. Typical application of a near-side bus stop is shown in Figure 6-8.

- A. Near-side stops should be set back at least 10 ft from the edge of the intersection crosswalk, or at the end of the turn radius, whichever is further from the intersection.

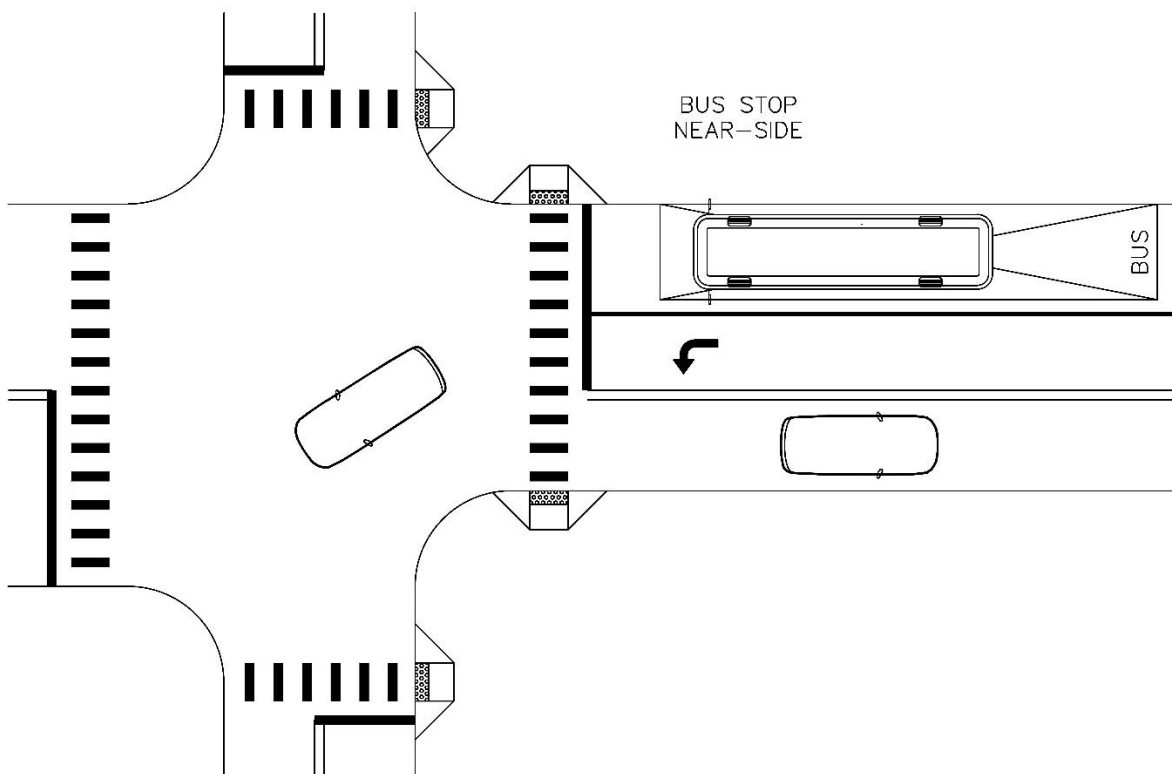


Figure 6-8 – Near-side Bus Stop Platform

6.3.1.4 – Mid-block Stop

Mid-block stops occur when the bus stops in between intersections, usually in a well-defined area. Mid-block stops should be placed where a controlled, mid-block pedestrian crossing can be installed in tandem with the transit stop. If pedestrian crossings are not present, options for the installation of a pedestrian hybrid beacon, pedestrian crossing islands, or other pedestrian crossings must be installed with transit stop design. Figure 6-9 illustrates a typical application of a mid-block stop, with the stop located on the far side of the crosswalk.

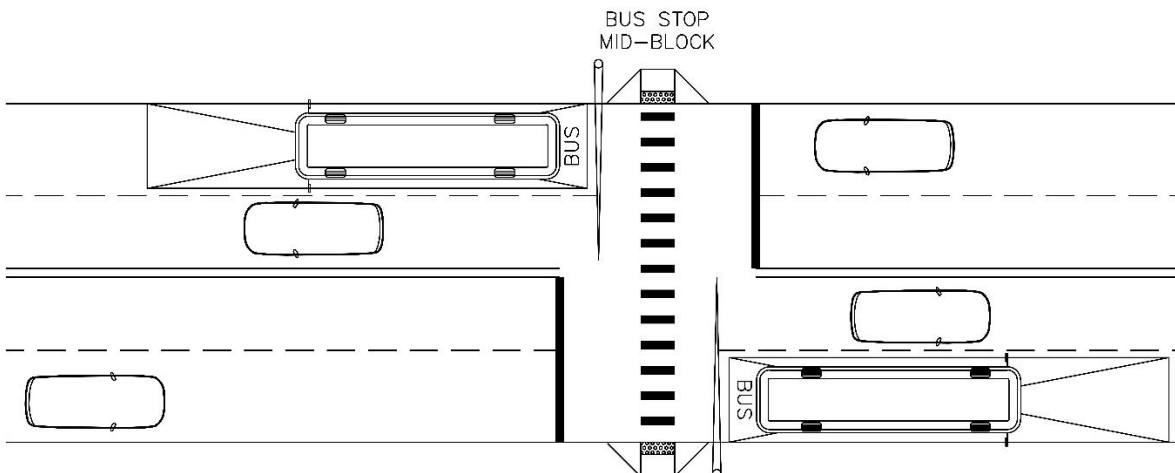


Figure 6-9 – Mid-block Bus Stop Platform

6.3.1.5 – Off-street Transit Facilities

Generally, transit facilities and supporting infrastructure located outside the public right-of-way is expected to adhere to the same requirements and guidelines as they would if located within the public right-of-way.

6.3.1.5.1 – Infrastructure Outside Right-of-Way

- A. Transit infrastructure located outside the public right-of-way shall be configured and sited in close proximity to adjacent transit services.
- B. Amenities provided for the transit service shall be located on the site in such a way that accessible pedestrian paths are provided between the transit stop or station and the amenities.
- C. Bicycle facilities shall be extended onto the site to locations for bicycle parking associated with the transit stop or station.
- D. In situations where open space is provided on site, applicable provisions of the **LDC** shall be followed, including placing open space to adjoin, extend and enlarge the adjacent transit station.
 1. Transit infrastructure provided on site shall connect to open space with accessible pedestrian paths and bicycle facility extensions.

6.3.1.5.2 – Stops Outside Right-of-Way

Transit stops provided outside the Right-of-Way shall conform to the applicable provisions of this Section as it relates to connectivity, access, and handling of multi-modal conflicts.

6.3.2 – Curb Access

Curb access refers to the horizontal and vertical alignment of the curb space at transit stations in relation to transit vehicle use. This section summarizes options and corresponding design implications for curb access.

6.3.2.1 – In-lane Stop

In-lane bus stops are the most common type of bus stop that has the least impact on bus operations and should be used in most contexts. The desired location for an in-lane bus stop platform in relation to an intersection or pedestrian midblock crossing is illustrated in Figure 6-10. Table 6-6 specifies platform lengths based on location on a street block and expected largest transit vehicle serving the stop.

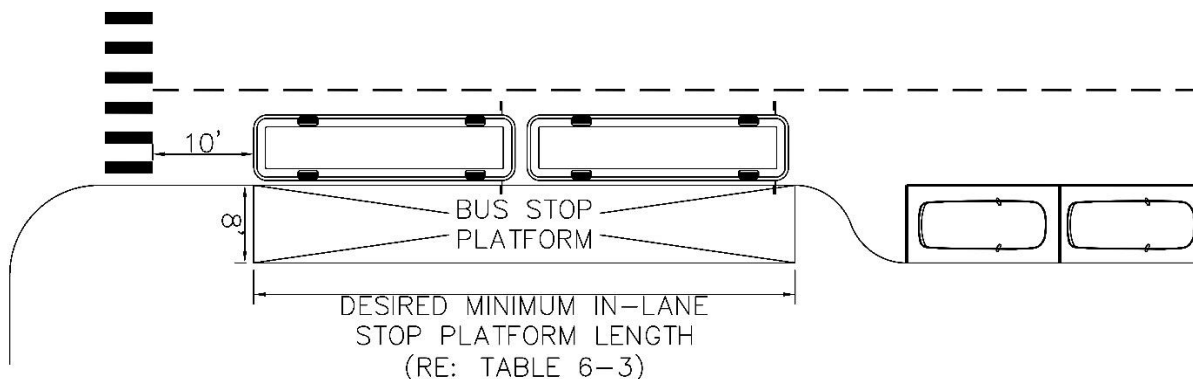


Figure 6-10 – In Lane Bus Stop Platform

Table 6-6 – In-Lane Stops: Minimum Platform Length by Bus Length (ft)

	Length of Bus			
	40 ft Bus	60 ft Bus	2 x 40 ft	2 x 60 ft
Platform Length	35	50	80	115

6.3.2.1.1 – Bulb-out In-Lane Stop

A bulb-out (or “bus bulb”) is a modification of the curb and sidewalk to extend the bus loading/waiting area out to the edge of the parking lane, allowing the bus to stop in the travel lane.

Table 6-7 – Bus Bulb-Out Dimensions

Vehicle	Vehicle Length (ft)	Doors Served	Bulb Length (ft)*	On-Street Parking Displaced**
Standard Bus / Trackless ¹	41.5	2	30	2 Spaces
Articulated Bus/Trackless	60.75	2-3	50	3 Spaces

¹ Standard design unless larger vehicles are assumed in adopted plan

*Plus 10 ft intersection buffer from the crosswalk

**Assuming 20 ft length per parking stall, rounded up to the next stall

Source: DVRPC, 2012

- A. Bus bulbs serving 40 ft buses shall be minimum 25 ft in length (in constrained environments).

- B. On-street parking is a prerequisite for bus bulbs, as bulb-outs are constructed within the area used by the parking lane.
- C. Bulb-out stops are applicable in both dedicated and mixed-traffic conditions.
- D. The bus bulb-out shall be designed to accommodate the largest vehicle using a specific bus stop.
- E. Further details on bulb-out design are in **Section 4.2.4.1**.

6.3.2.2 – Pull-out Stop

Pull-out stops require different spacing requirements to accommodate the maneuvering of a bus into and out of the pullout. In calculating the total curb space required for bus access to pull-out stops, both the length of the bus and the pull-out entering speed must be considered. The length of the bus pull-out taper and deceleration and acceleration zone is dependent on the bus speeds, as shown in Table 6-8. Figure 6-11 illustrates a typical layout of a far-side bus pull-out stop.

Table 6-8 – Bus Pull-out Dimensions

Design Speed	Entering Speed	Suggested Taper Length (ft)	Minimum Deceleration Length (ft)	Minimum Acceleration Length (ft)
30 mph	20 mph	150	120	50
35 mph	25 mph	170	185	250
40 mph	30 mph	190	265	400
45 mph	35 mph	210	360	700
50 mph	40 mph	230	470	975

Source: Pace Transit, 2013

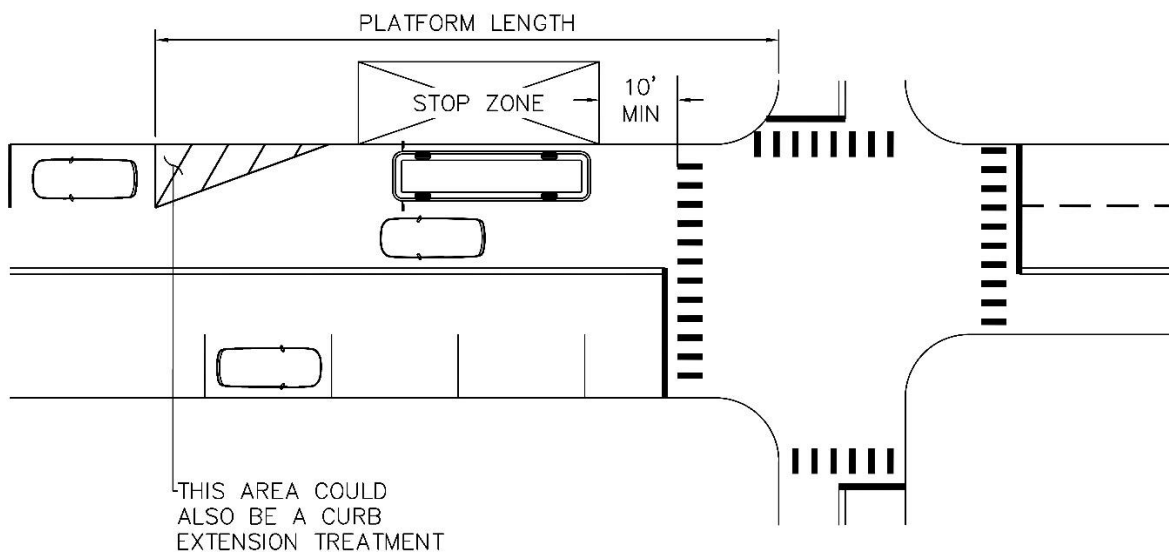


Figure 6-11 – Far Side Pull-Out Bus Stop

In scenarios where a stop is located on the near side of an intersection and a queue jump is desirable, platform location and queue jump configuration should match the typical layout in Figure 6-12.

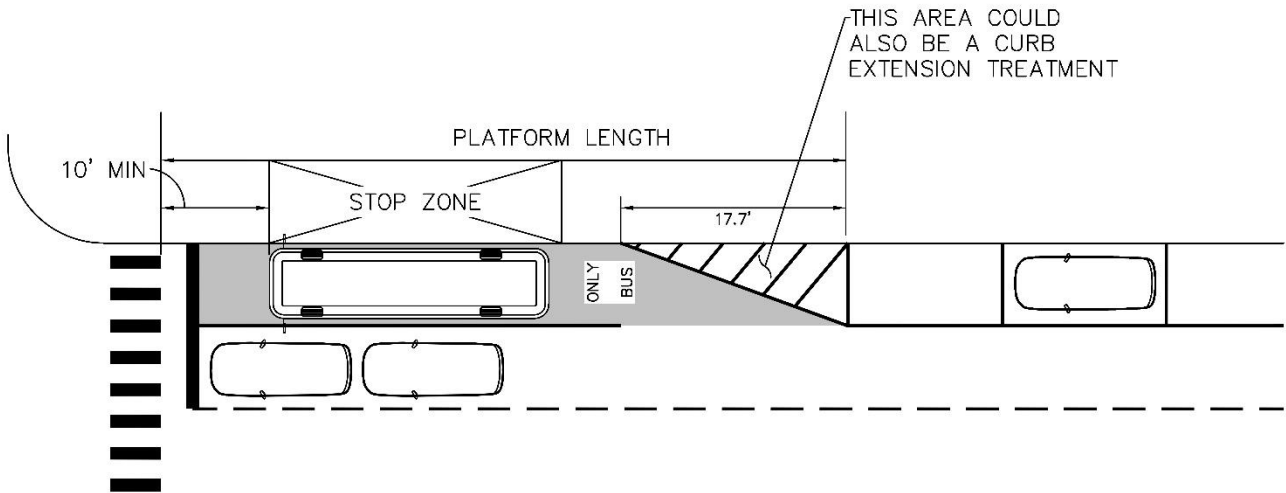


Figure 6-12 – Near Side Pull-In Bus Stop Platform with Queue Jump

6.3.2.3 – Roadway Median Stop

Boarding islands are dedicated waiting and boarding areas for transit users that can improve transit speed and reliability while reducing conflicts with other modes by enabling in-lane stops separate from bike lanes or right-turn lanes. Figure 6-13 illustrates a typical layout for an in-street, interior boarding island.

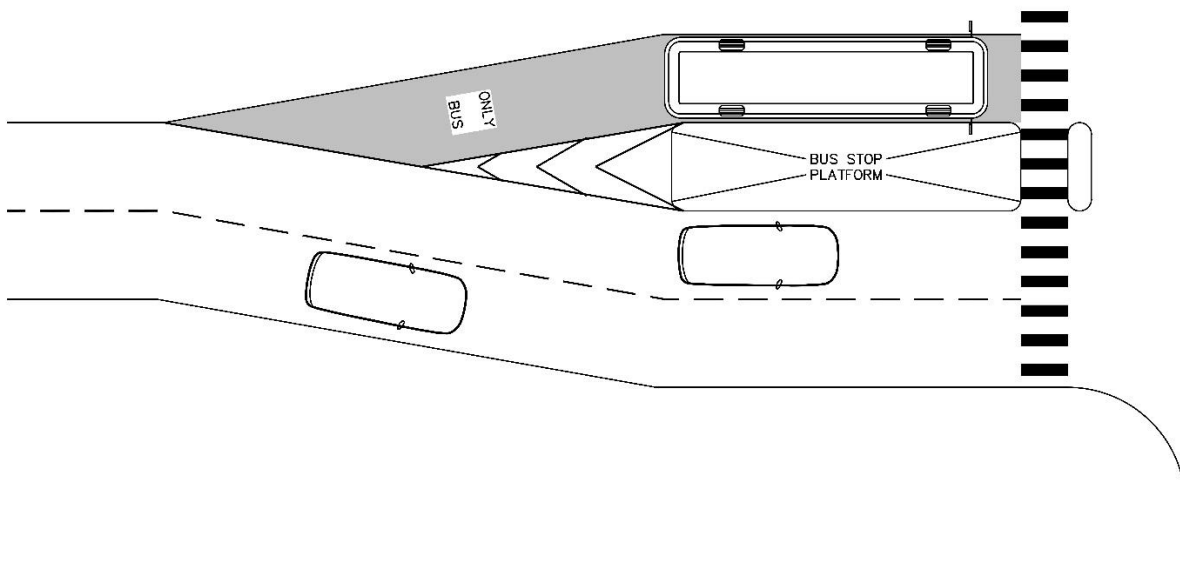


Figure 6-13 – In-Street, Interior Boarding Island

- A. Boarding island platforms must provide the minimum required ADA clear area and an accessible route to other pedestrian paths.

- B. Detectable warning strips must be placed on both sides of every flush pedestrian crossing.
- C. At intersections, install median island tips at least 6 ft wide to provide pedestrians protection in the crosswalk.
- D. Interior boarding islands shall only be placed on streets with a target speed of 30 mph or less.
- E. Strategies for accommodating bicycle traffic when designing boarding islands are discussed in the NACTO *Transit Street Design Guide*.

6.3.2.4 – Near-level or Level Boarding

The curbside boarding level affects ease of boarding, with implications for both vehicle access and route efficiency. Typical sidewalk/curb heights in an “unimproved” condition are approximately 4-6 in., whereas the bottom step of the bus is over 12 in., in an upright position and 9 in., in a kneeling, lowered position. Adjusting curb heights to allow near-level or level boarding can provide seamless vehicle entry/exits and save stop times by not requiring a bus ramp or the bus itself to be lowered.

- A. Level boarding requires that the height of the curb aligns vertically with the typical 12-14 in. floor height of transit vehicles. Near-level boarding requires platform heights of approximately 8-11 in., within the range of the vehicle floor height when in a lower position.
- B. Detectable warning strips with widths of at least 24 in. must be placed along the full length of the platform edge.
- C. Access to raised boarding platforms and curb space shall adhere to ADA accessibility requirements, including ramp design and slope.

6.3.3 – In-street Treatments

In-street treatments cover the pavement used at transit stops, pavement markings, and signage associated with transit stops.

6.3.3.1 – Pavement

Pavement material selection shall be considered for outside travel lanes when designing streets with multiple transit routes or high frequency routes to minimize roadway damage caused by transit vehicles and life cycle costs. Though the first cost of heavy-duty rigid concrete pavements are now fairly competitive with flexible asphaltic pavements; concrete is more durable, stronger, deforms less, and lasts longer on transit routes. Thus, concrete will typically have a lower life cycle cost than asphalt particularly in warm weather locales. Further guidance for pavement material selection is provided in **Section 14 – Pavement Design**.

6.3.3.1.1 – Bus Pad

A bus stop’s road surface shall be durable enough to withstand heavier loads than typical traffic due to pavement damage from braking buses. Roadway pavement design must be assessed using the methodology outlined in **Section 14** of this manual. Roadway design must also conform to particular soil and climate conditions, which have a significant effect on pavement performance. Figure 6-14 illustrates a typical bus pad location in relation to a transit stop.

- A. A concrete pad is required for bus stop areas where multiple routes or higher frequency routes (with headways of 15 minutes or less) exist or are planned for service.

- B. For in-lane bus stops, the bus pads shall extend across the full width of the travel lane. For pull-out bus stops, the bus pad shall be provided for the full length of the clear curb zone.
- C. The seam of the concrete bus pad should be placed on either side of a bicycle lane (if present), as seams and cracks pose a hazard to bicycle wheels. Where practical, concrete bus lanes or bus pads will extend uninterrupted to the curb often including bike lane pavement to avoid excessive joints and pavement type changes.
- D. At a minimum, ensure that the cross-slope of the bus pad does not exceed 2%.
- E. In curbed areas, construct the bus pad of concrete at least 14 in., in depth. In uncurbed shoulder areas, an engineered or structural asphalt bus pad is acceptable.
- F. Bus pads shall span a minimum of 10 ft to accommodate both wheels of the bus. In locations where precision loading may be challenging, the bus pad width should be expanded.
- G. Bus pads shall end before reaching a crosswalk. In instances where spanning the crosswalk is necessary, the bus pad should extend across the full width of the crosswalk to prevent lateral or longitudinal pavement seams.

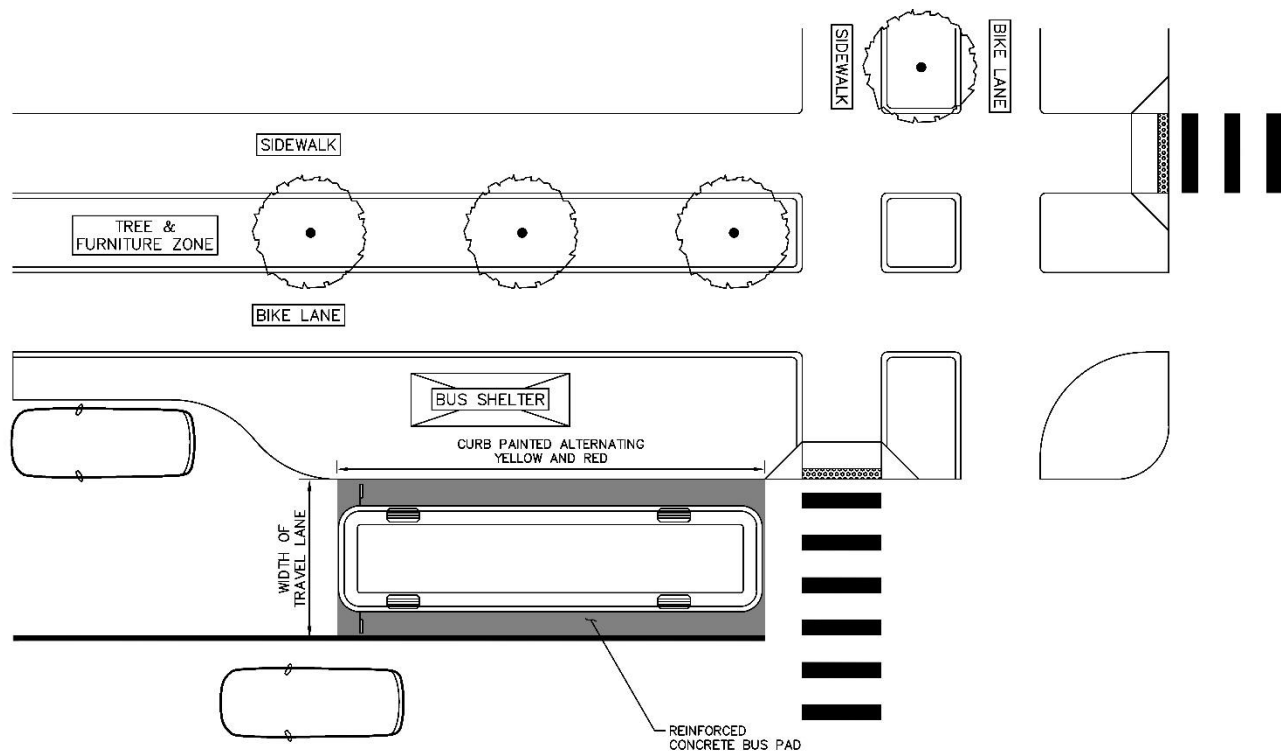


Figure 6-14 – Bus Pad Location

6.3.3.2 – Markings

- A. Colored pavement shall be considered anywhere a travel lane is reserved exclusively or primarily for buses and shall be applied consistently between signalized intersections. Coloring application depends upon factors such as climate, use and stress, and age and condition of pavement. See

NACTO Transit Street Design Guide for more information on the use of these materials and comparison of their benefits.

- B. The TMUTCD provides guidance on specific configurations and uses for signs, signals and markings standards and shall be complied with.

6.3.3.3 – Signage

- A. Signage must be present to orient roadway and transit users, but also strategically located to convey critical travel and operational information without overwhelming users.
- B. The TMUTCD provides guidance on specific configurations and uses for signs, signals and markings standards and shall be complied with.

6.3.4 – Station Design

The size and scale of a stop/station will vary depending on the level of service that is provided at that location. The platform design process shall consider the location of intersections, shelters, points of public access, and parking areas.

- A. Platforms shall provide a clear path to direct commuters to and from the platform and shall be designed to provide accessible routes into train cars.
- B. In developing platform dimensions for each mode, it is necessary that the length of the platform adequately supports boarding/alighting of transit vehicles.
- C. Depending on station activity and transit vehicle frequencies, the curb length may require accommodation of multiple vehicles at one time.

6.3.4.1 – MetroAccess

MetroAccess shuttles, which typically provide paratransit services, do not operate on fixed routes. Due to the reduced size of the MetroAccess transit vehicles and flexible routes, it is unnecessary to establish unique infrastructure design requirements. The primary requirement, shared by other transit services, is the presence of an 8 ft x 5 ft landing space for ADA-accessible boarding and alighting.

6.3.4.2 – Bus Transit

Bus Transit stops shall meet size and placement requirements of **Section 6.3.2**. Refer to **CMTA Standard Details** for bus transit station design.

6.3.5 – Stop/Station Amenities

All amenities provided shall be contained within the platform area and shall provide minimum unobstructed widths for accessible paths per PROWAG guidelines. Spacing of utility appurtenances and trash receptacles from other amenities shall match those outlined in **Section 4**. Stop/Station amenities will vary based on the level of service that is provided at the location.

- A. Placement of all bus stop / station amenities shall be in the Pedestrian Zone and an unobstructed clear, accessible pedestrian path shall be maintained with a minimum width as required in **Section 4.1.1** of this manual.

- B. Placement of amenities shall comply with the spacing requirements throughout **Section 4** of this manual and generally be placed in the Tree and Furniture Zone portion of the Pedestrian Zone or in the buffer area of the Bicycle and Street Edge Zone, maintaining required lateral and vertical clearances as defined in **Section 11**.
- C. Generally, placement of bus stop / station amenities shall follow the layout in **Section 4.1.5.2**.
- D. Capital Metro's Service Guidelines and Standards detail specific requirements that should be met for the provision of certain amenities, such as bus shelters, benches, and litter containers. Bus stops generating at least 15 boardings per weekday qualify for a bench.
- E. Bus stops generating 50 boardings per weekday qualify for a shelter. All bus stops with shelters or benches shall also have a trash receptacle.
- F. Bicycle racks may be installed at stops in areas of high demand or in concert with other local entities, per requirements in **Section 9.8.0** of this manual.

6.3.5.1 – Signage/Wayfinding

Wayfinding signs shall be provided to locate facilities, operations, as well as remote signage to direct transit users to the facilities. Wayfinding shall follow CMTA's branding standards.

6.3.5.2 – Shelters

Shelters protect passengers from weather conditions while waiting and should be constructed of durable, architecturally sound materials to withstand heavy use and continual exposure to the elements.

- A. Shelters shall be oriented to protect against exposure to the elements as best as possible during peak demand periods.
- B. Shelters shall not interfere with pedestrian clear zones and shall be oriented toward the path that leads to the bus entrance.
- C. Passengers waiting in the shelter must be able to easily see arriving transit vehicles and must be readily visible to operators if transit vehicles stop only on demand.
- D. Include lighting in the shelter or locate shelters in a well-lit area.
- E. Ensure the shelter can be seen from outside by using perforated panels or open design for any structure walls.

6.3.5.3 – Seating

Stops should offer a variety of seating options to transit patrons; this may include benches, leaning rails, and low masonry walls. Facility seating shall take into consideration expected duration of wait times, boarding volumes, passenger characteristics, and weather impacts. The amount of seating should match the average number of commuters simultaneously occupying the stop, given that it does not impede access to the buses or to other pedestrian facilities. Seating is warranted for stops with relatively high use by the elderly or children, as well as stops with longer wait times or high volumes of travelers.

- A. The recommended minimum length for a bench is 6.5 ft. It is recommended that benches include arms to aid people with mobility challenges.

- B. Benches near transit stops or stations shall be placed in a manner where seating is oriented towards the bus boarding location for visibility for buses.
- C. Placement of benches for transit shall be in the Tree and Furniture zone and maintain spacing of 2 ft to litter trash receptacles and 3 ft from utility appurtenances or other amenities for appropriate access. Additional requirements for benches are outlined in **Section 4.1.5.2** of this manual.
- D. Leaning rails shall be placed at a height of 2.5 ft.
- E. Employ bench design and materials that can mitigate weather impacts, such as water pooling and surface materials that retain heat (i.e. metal surfaces).

6.3.5.4 – Waste Receptacle

Trash receptacles should be placed at the far side of benches with at least a 2 ft spacing from benches, wherever present near a transit stop.

6.3.5.5 – Lighting

Areas around stops should be kept adequately lit at night and during darker conditions. Specifications for stop lighting include:

- A. Pedestrian scale lighting shall include lamps less than 25 ft high.
- B. An average level of 1.3 foot to 2.6 foot horizontal candles (f.c.) or 13 to 26 lux shall be provided to cover all bus stop amenities and signage and extend 5 ft beyond the length of the boarding area for the full width of the pedestrian zone.

6.3.5.6 – Information Technology

Kiosks or other information technology devices shall be placed in the Pedestrian Zone in a manner that does not impede an unobstructed, accessible pedestrian route and shall be placed in an accessible location that complies with the applicable provisions of PROWAG.

6.3.5.7 – Fare Vending

Fare collection and boarding can be time consuming, accounting for half to a third of vehicle revenue time. Strategies that streamline fare collection and allow for multi-door boarding can dramatically speed up passenger boarding time, reducing dwell time and total run-time. Fare Vending shall be located per CMTA Standard Details.

SECTION 7 – DRIVEWAYS

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The authority for standards for driveway design in the Transportation Criteria Manual is given by the **Land Development Code** (LDC). This section provides minimum and desirable design criteria, provisions, and requirements for safe and convenient access to abutting properties along streets and highways. The purpose of this section is to assist City staff and private sector street design professionals in applying a consistent approach to driveway design.

7.1.0 – Designing for Safety

Driveway placement shall ensure access is provided to properties while minimizing the number of driveways needed to maintain efficient vehicular access, which in turn reduces the number of conflicts for pedestrians and bicycles along a street. Managing access ensures minimum interference with the free and safe movement of pedestrians, bicycles, vehicles, and other modes of travel. Safety shall be held paramount to all other interests per the **ASMP**. To this end, the intent of this section is to provide access, while designing driveways with the lowest width and corner radii feasible for the necessary design vehicle, leading to slower turns, safer maneuvering, and safer pedestrian and bicycle facilities.

7.2.0 – Design Controls

The driveway is defined as the area between the edge of the vehicular travel lanes and the property line. See **Figure 7-1** for area marking this defined area for a driveway. The subsections that follow in this Section outline the driveway design criteria to be used on driveway access connections in the City of Austin. For driveways on TxDOT facilities, TxDOT shall be consulted as part of the driveway permitting and approval process.

7.2.1 – Design & Control Vehicles

To balance the needs of vehicular and non-vehicular users at each driveway, careful attention needs to be placed on which type of vehicles require access to each site. Vehicle types are broken into two categories similar to **Section 3.2.1**, design vehicles and control vehicles. The design vehicle is a frequent user accessing the site and serves as the primary vehicle for which driveway geometries are determined. The control vehicle is an infrequent user accessing the site that must be accommodated while maintaining safety for pedestrian and bicycle users. Control vehicle turning movements can be made possible by the installation of mountable curbs and surfaces at the curb radii only if compliant with provisions in **Section 3.6.2.2**.

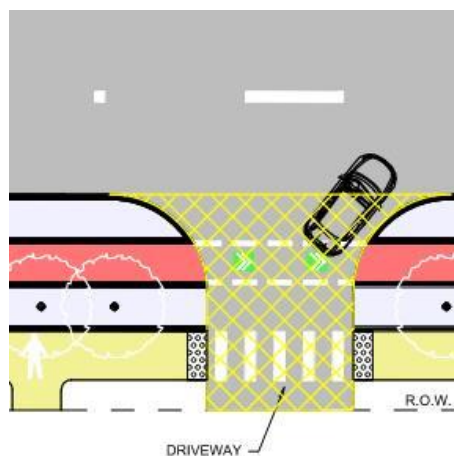


Figure 7-1 – Driveway Area

7.3.0 – Driveway Access Types

Regardless of driveway access type, all driveways shall be designed to maximize safety and reduce conflicts between all road users. Driveways along a street provide access to varying land uses which require different design criteria for each access type. Driveway access types are separated into two primary categories, minor and major driveways. Each access type category as well as sub-categories are explained in further detail below. For driveways on streets with multiple through travel lanes in either direction and a posted regulatory speed of greater than 35 mph, left turns exiting the driveway shall not be allowed from intersecting driveways without a traffic signal or other operation to protect left turns from the intersecting driveway without City Traffic Engineer, applicable Director, or their designee's approval.

7.3.1 – Minor Driveway

- A. Defined as driveways providing access to the following developments:
 - 1. Single Family Residences
 - 2. Duplex
 - 3. Multi-Family units made up of 4 or fewer units
- B. Minor driveways shall be built to Type I driveway construction standards in the **Standards Manual**.
- C. Minor driveways shall be prohibited from taking access to Level 3 and Level 4 streets.

7.3.2 – Major Driveway

Defined as driveways providing access to the following developments:

- A. Commercial – Office, retail, service station or institutional building
It should be expected that these developments will require access by emergency as well as routine delivery and refuse vehicles.
- B. Mixed Use Developments (Residential & Non-Residential)
- C. Multi-Family units made up of greater than four units
- D. Industrial
Will require truck movements accessing an industrial, manufacturing, warehouse, or truck terminal facility to load and unload goods.
- E. Other non-residential uses

Major driveways shall be built to Type II driveway construction standards in the **Standards Manual**.

7.3.3 – Special Access Types

- A. Access to Level 0 Streets requires approval by the City Transportation Engineer or applicable Director. Access to and from unimproved Level 0 Streets is not allowed. If an applicant wishes to have access to an unimproved Level 0 Street, they must obtain approval by the City Transportation

Engineer or applicable Director and improve the Level 0 Street to current City Standards. The decision to access a Level 0 Street is optional and any improvement will not be credited toward Rough Proportionality as defined in **Section 10**.

- B. Areas used as motor vehicle service stations or parking lots shall have a 6 in. raised curb along the entire street frontage except at the driveway approaches and curb ramps.
- C. For driveways that are designated as fire access only, roll curbs shall be used as standard and driveways shall be at sidewalk elevation. Fire access only areas may be used as part of a trail connection or as a link in an existing or future trail system if approved by both Austin Fire Department and Development Services Department.

7.4.0 – Driveway Design Types

Land use types vary and change along a street over time, which results in different access needs and requirements for how each access point shall be designed. The benefits of each driveway type should be considered when planning new access points or retrofitting existing access points along a street, with the safety of non-vehicle users as a primary consideration. The three primary driveway types are shown in Figure 7-2 and are listed in this section with their intended use explained in greater detail.

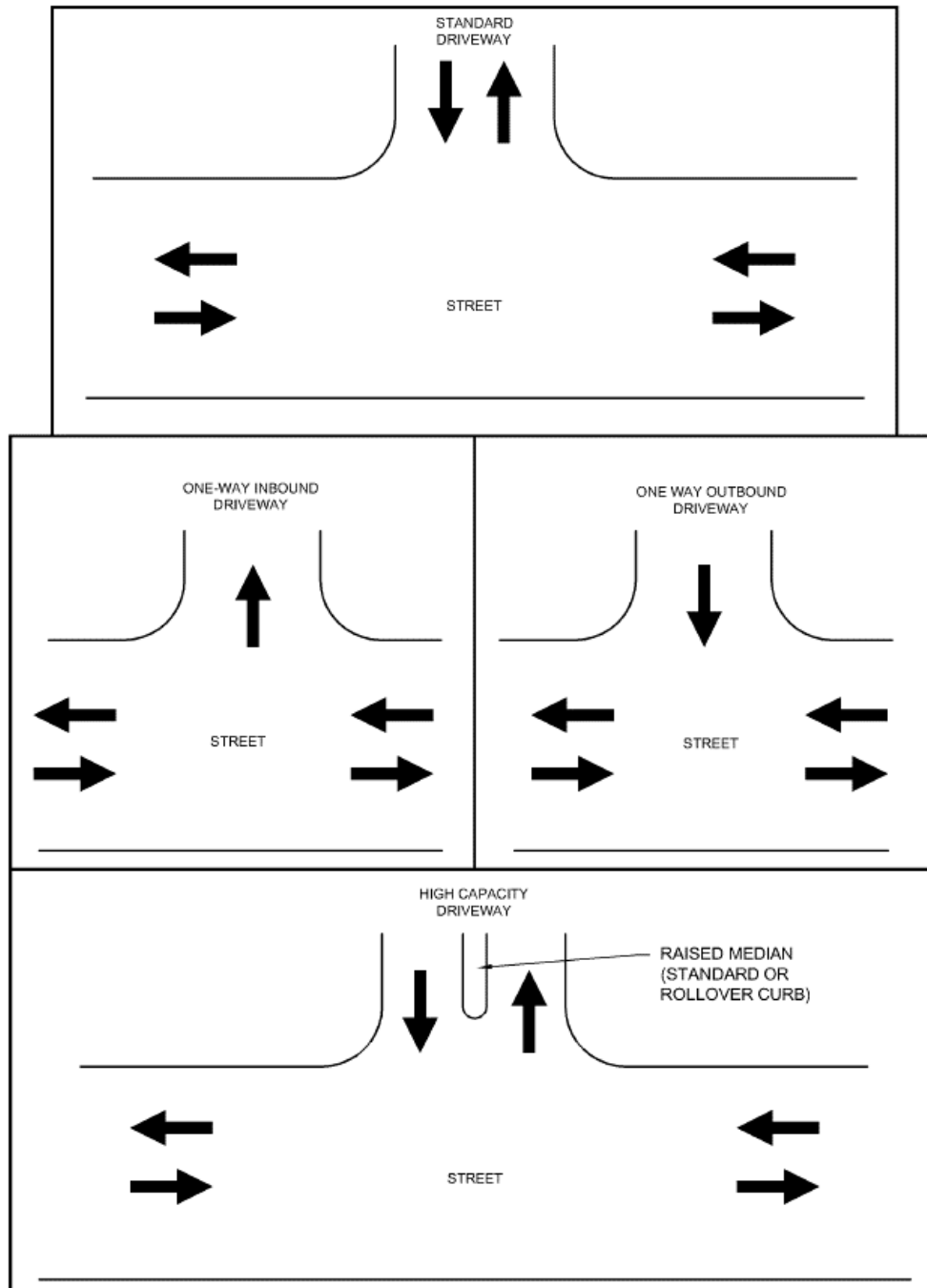


Figure 7-2 – Driveway Types

7.4.1 – Standard Driveway

A standard driveway provides two-way access at a single, undivided curb opening. Dimensions will vary based on access type and Street Level of abutting street per **Section 7.5.0**. This includes minor driveways, which will be narrower with smaller turning curb radii.

7.4.2 – One-Way Driveway

One-way driveways provide only inbound or outbound access. On-site circulation must be provided to ensure that vehicles can safely and efficiently access both the inbound and outbound access points.

7.4.3 – High Capacity Driveway

High capacity driveways provide two-way access separated by a raised median at a single curb opening, except when the driveway directly accesses a parking garage. Geometric modifications such as increased width of the driveway opening, increased curb radius, and a raised median to separate traffic shall only be considered if they do not negatively affect pedestrian or bicyclists' safety.

- A. High capacity driveways may only be used in locations where peak hour volumes are expected to exceed 50 vehicles in any peak hour based on the latest edition of the ITE Trip Generation Manual.
- B. Special consideration shall be given to designing for both design and control vehicles in **Section 7.2.1** by utilizing means such as mountable surfaces while preserving safety for pedestrians and bicyclists.
 - 1. Increasing the curb radius beyond **Section 7.5.1.1** maximums will only be considered if the applicant can demonstrate the maximum allowable curb radii cannot accommodate design and/or control vehicles and that the larger radii do not negatively impact safety.
- C. The raised median on a high capacity driveway shall include pedestrian waiting areas or cut throughs per **Section 4.2.4.2**, which shall be properly designed to meet ADA requirements and **Section 4** of the TCM.
- D. When high capacity driveways serve a garage across a zero lot line pedestrian zone, accommodations shall be made to increase visibility and awareness of street users crossing the driveway to drivers exiting the garage.

7.5.0 – Driveway Geometric Design Criteria

The geometry of a driveway will 1) determine how a vehicle transitions from the through lanes of the abutting street and traverses the driveway to the subject site, and 2) should serve to maximize safety for all users. The geometric design criteria set forth in this section shall be followed on new and existing driveways. Figure 7-3 illustrates the features of a driveway.

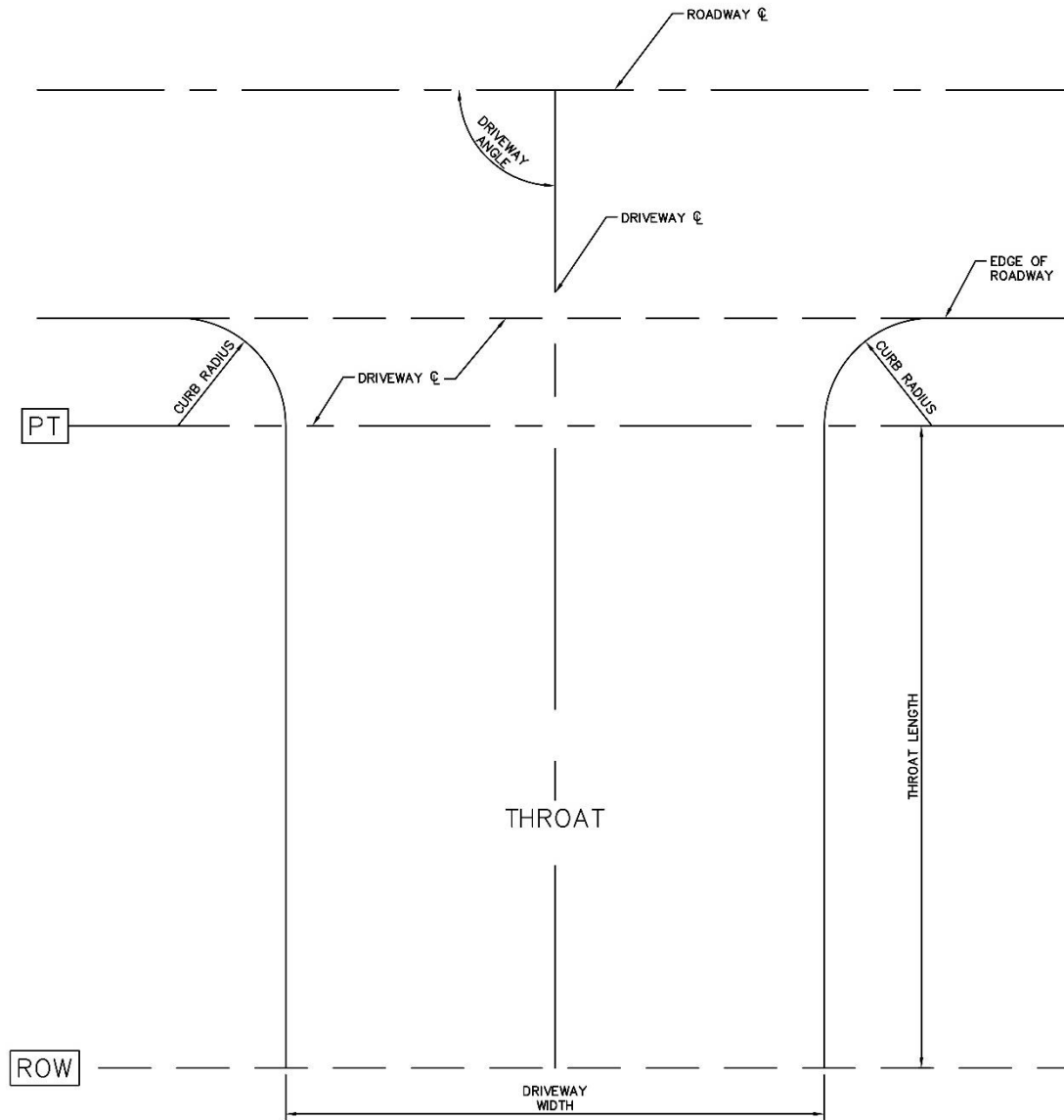


Figure 7-3 – Driveway Geometric Features

- A. If deviating from the criteria in this Section, vehicle swept path analysis shall be run with computer aided design software to ensure the proposed driveway geometric configuration allows the design vehicle to maneuver the driveway geometry without off tracking.
 - 1. The design engineer shall also provide a swept path analysis for control vehicles and shall make provisions to accommodate control vehicles while maintaining safety for pedestrians and all other users.
- B. Refer to **City of Austin Standard Details** for construction standards for driveways.

7.5.1 – Driveway Approach

7.5.1.1 – Driveway Curb Radius

The curb radius of a driveway refers to the curb return or transitional area between the through lanes of the street and the throat of the driveway. The primary purpose of the curb radius on a driveway is to balance access and safety for entrance and departure from a site. A larger curb radius allows vehicles with a larger turning radius to enter or exit a site without encroaching beyond the curb radius. There is a direct correlation between the radius and the speed at which vehicles can complete a turn. Therefore, minimizing curb radius for design vehicles, defined in **Section 7.2.1**, is the priority when designing driveways to reduce speed.

Table 7-1 below lists the curb radii that shall be used on driveway designs depending on Street Level and land use. In scenarios where a design vehicle cannot navigate a turn into a driveway without encroaching across the curb radii listed in Table 7-1, the design engineer shall demonstrate this and make provisions for control vehicles such as delivery, refuse, or emergency vehicles while maintaining safety for pedestrians and other users.

Table 7-1 – Driveway Curb Radius Criteria

Street Level ³	Typical ¹	Fire Access ²	Industrial ⁴
Level 1	10	15	15
Level 2	10	15	15
Level 2 – 3 lane (center turn lane)	15	15	25
Level 3 Single Lane Median	15	20 (In) 25 (Out)	25 (In) 50 (Out) ⁶
Level 3-4 Multi- lane	15	15	20

1. Major driveways without fire access or industrial / commercial access with heavy large trucks. Minor driveways shall be designed per Type I driveway standards in the **Standards Manual**.
2. Serves as a fire access lane.
3. Street Level refers to the street type that vehicles use to access a site.
4. As defined in **Section 7.3.2 (D)**.
5. Driveway design shall allow design vehicles to safely traverse a turn without encroaching on pedestrian or bicycle space outside the traveled way. Bulb-outs, setback stop bars and other strategies may be used as defined in **Section 3**.
6. Driveway turn radius within the Downtown area in **Figure A-2** shall follow **Great Streets Master Plan** standards. Driveway turn radius within the University Neighborhood District Overlay (UNO) shall follow UNO standards.
7. When large design vehicles are expected, the use of a compound curve rather than a simple radius design or a mountable median may be used to reduce pavement required.
8. Areas where the apparatus body envelope of the control vehicle is anticipated to pass behind the face of curb or edge of pavement shall be clear of any vertical obstructions under 8 ft height.

7.5.1.2 – Driveway Widths

The driveway width defines the width of the driveway throat as shown in **Figure 7-4**, measured from face of curb to face of curb or edge of pavement to edge of pavement. Driveway width will vary depending on the land use being accessed as well as the vehicles that are forecasted to use the driveway. Access

requirements of the site must be identified when determining the number of lanes required. Table 7-2 specifies the driveway widths. Driveway widths shall be minimized as much as possible to shorten crossing distances and decrease exposure for vulnerable users crossing the driveway.

Table 7-2 – Maximum Driveway Width (Throat Width)^{5,6}

Street Level ³	Typical ¹	Fire Access ²	Industrial ⁴
Level 1	20	20	25
Level 2			
Level 2 – 3 lane (center turn lane)		25	
Level 3 Single Lane Median			
Level 3-4 Multi- lane			

1. Major driveways without fire access or industrial / commercial access with heavy large trucks. Minor driveways shall be designed per Type I driveway standards in the **Standards Manual**. As defined in **Section 7.3.2** (A) through (C).
2. Serves as a fire access lane.
3. Street Level refers to the street type that vehicles use to access a site.
4. As defined in **Section 7.3.2** (D).
5. Driveway widths listed above for two-way driveways only include one lane in each direction.
6. High capacity driveways serving a parking garage may have a driveway width of 32' maximum to accommodate 3 lanes of travel for ingress and egress operations.

7.5.1.3 – Driveway Angle

The angle of the driveway refers to the angle the centerline of the driveway makes with the centerline of the street. Driveways shall be 90 degrees to the through lanes. Angles less than 90 degrees are not allowed as they encourage faster turning speeds which are not desired for safety on pedestrian facilities. Angles that deviate from 90 degrees also negatively affect the sight line of departing vehicles.

7.5.2 – Driveway Grades

A driveway grade is defined as the vertical change per foot at the centerline of a driveway. Sidewalks and bikeways shall have raised crossings at driveways, maintaining their elevation for a safer crossing that increases visibility and encourages yielding by turning vehicles. Driveways shall maintain the minimum and maximum driveway grades, diverting storm water flow, and meet all ADA requirements. Figure 7-4 illustrates how driveway grades are to be applied to driveway design and **Table 7-3** outlines driveway grade criteria.

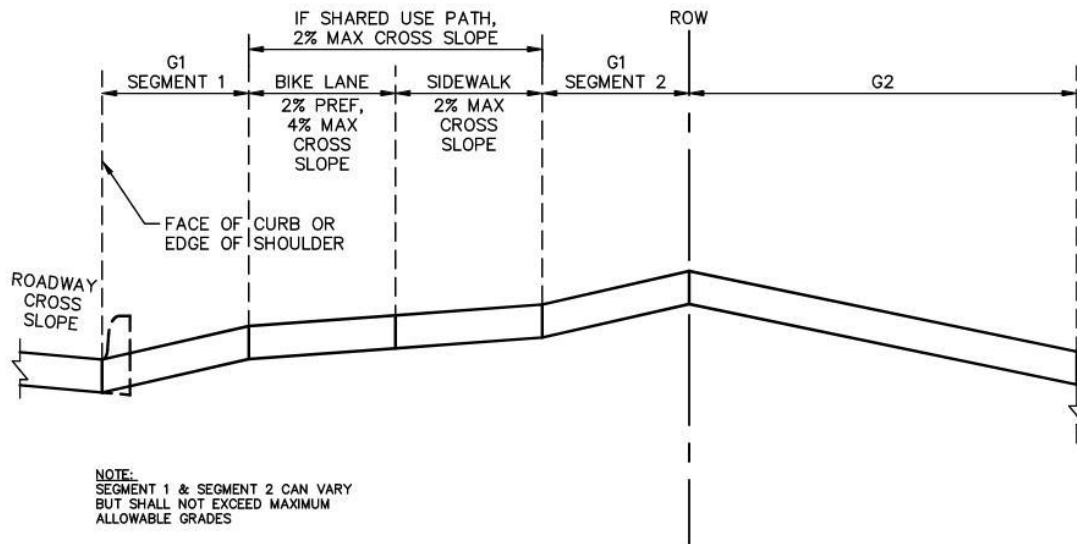
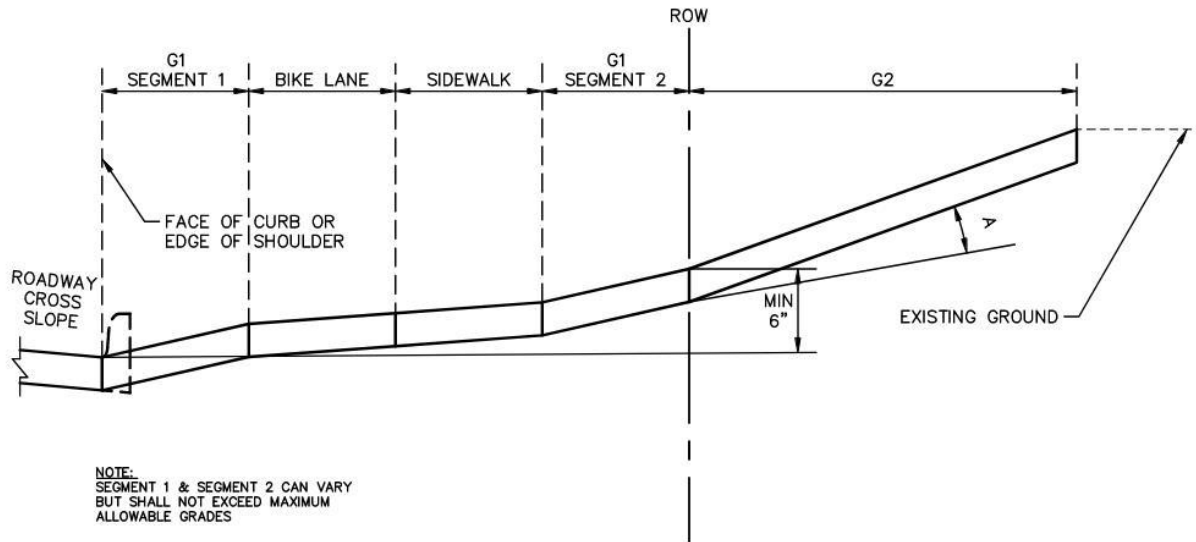


Figure 7-4 – Driveway Grades

7.5.2.1 – Driveway Grades Design Criteria

Table 7-3 –Allowable Driveway Grades⁵

		G₁ (Segments 1 and 2)	G₂
Major	Commercial²	2 - 10%	Max 12%
	Industrial	2 - 10%	Max 12%
Minor¹		2 - 12%	Max 15%

1. As defined in **Section 7.3.1**.
 2. As defined in **Section 7.3.2(A)** through 7.3.1(C).
 3. G₂ is determined by the design engineer based on site conditions and end user requirements.
 4. Maximum allowable grade change of 13.3% between G₁ Segment 1 and intersecting street and G₁ Segment 2 at G₂ to prevent bottoming out or high centering of vehicles.
 5. Reference latest **Standard Details** for grades, which may supersede this manual, subject to final approval by the City Traffic Engineer or applicable Director.
- A. Figure 7-5 reflects the acceptable driveway profile intended to limit abrupt changes in grades. The value of G₁ is limited by street cross slope or behind curb elevation profile. G₁ shall not exceed 6% for major driveways and 12% for minor driveways.
 - B. The driveway grade shall meet all state and federal ADA requirements for accessibility through the pedestrian crossing area.
 - C. All sidewalk and bicycle lane crossings of driveways shall maintain the elevation of the sidewalk and bicycle lane in a raised crossing.
 - D. Driveway elevations at the ROW line of a public street shall be a minimum of 6 in. above the street gutter. A minor driveway that intersects a Level 0 Street shall be a minimum of 3 in. above the edge of the Level 0 Street pavement at the ROW line.
 - E. Driveway grade change in a fire lane shall not exceed 6%.
 - F. Vertical clearance along utilities in the driveway shall meet utility clearance and access requirements per the **Utilities Criteria Manual**.

7.6.0 – Access Management

Access Management is a term used to describe how access to varying land use contexts are regulated and designed along a street. Criteria for how land can be accessed must differ depending on the context and the intended mobility of each street. Access management, future land use and roadway network planning are all connected, and if managed properly, will lead to safe and efficient street operations for all street users. Current and future access requirements must be considered for the property in consideration and adjacent properties during the planning and design phase, as it will allow the entire street network to operate most efficiently.

The primary goals of access management criteria are to minimize conflicts between all street users, improve safety, and maximize the efficiency of each driveway along the street. There is a direct correlation in the number of driveways along a street and the amount of traffic delay and conflict points. Best practice is to consolidate driveways with the use of joint use driveways during the redevelopment of existing property

and the new development of vacant land. Joint use driveways are discussed in further detail in **Section 7.6.4.**

Proposed driveway access shall be identified in an applicant’s Transportation Impact Analysis per **Section 10.**

7.6.1 – Property Frontage Driveway Requirements

Each property’s frontage length will vary along a street and access requirements will vary as well. Table 7-4 outlines the allowed number of driveways based on property frontage available.

Table 7-4 – Maximum Site Access Connections

Property Street Frontage (ft)	Maximum Number of Allowable Driveways
< 300	1
300 - 600	2
>600	3

Driveways on adjacent sites must be considered and driveway must be placed in accordance with spacing requirements outlined in Section 7.6.2. Sight distance requirements per **Section 3.4.2.1.1** shall be considered for placement of new driveways or when changing use of existing driveways.

7.6.2 – Driveway Placement

Driveways operate together along a street and their placement affects the safety and efficiency of a street to move vehicles through and to adjacent properties. Several factors must be considered when determining the placement of the driveway:

1. Street Level that the driveway draws access from;
2. Target speed of the street;
3. Level of non-motorized vehicle activity;
4. Amount of site frontage available to be accessed;
5. Approach directions of traffic in need of accessing the development;
6. Location of existing cross streets and traffic signals;
7. Traffic signal coordination requirements;
8. Proximity to other proposed and existing driveways; and
9. Intersection sight distance per **Section 3.4.2.1.1.**

Table 7-5 defines minimum spacing based the Level of the street access is being taken from and driveway access type. Spacing driveways per criteria in Table 7-5 with respect to other driveways and intersections will maximize the traffic safety, flow, and operations of the street. The dimensions in Tables 7-5 for spacing between driveways should be increased whenever possible so that the number of driveways can be reduced. Dimension control for applying the criteria in Tables 7-5 is shown in Figure 7-5.

Table 7-5 – Minimum Driveway Spacing¹

Street Level ²	Minor Driveway	Major Driveway
4	N/A	280
3	N/A	200
2	75	150
1	50	75

1. Distances are measured from inside edge of pavement of each driveway or the edge of the intersecting street travel lanes as in Figure 7-5.
2. Street level refers to the street that vehicles are using to access the site. Level 5 streets do not have driveways.

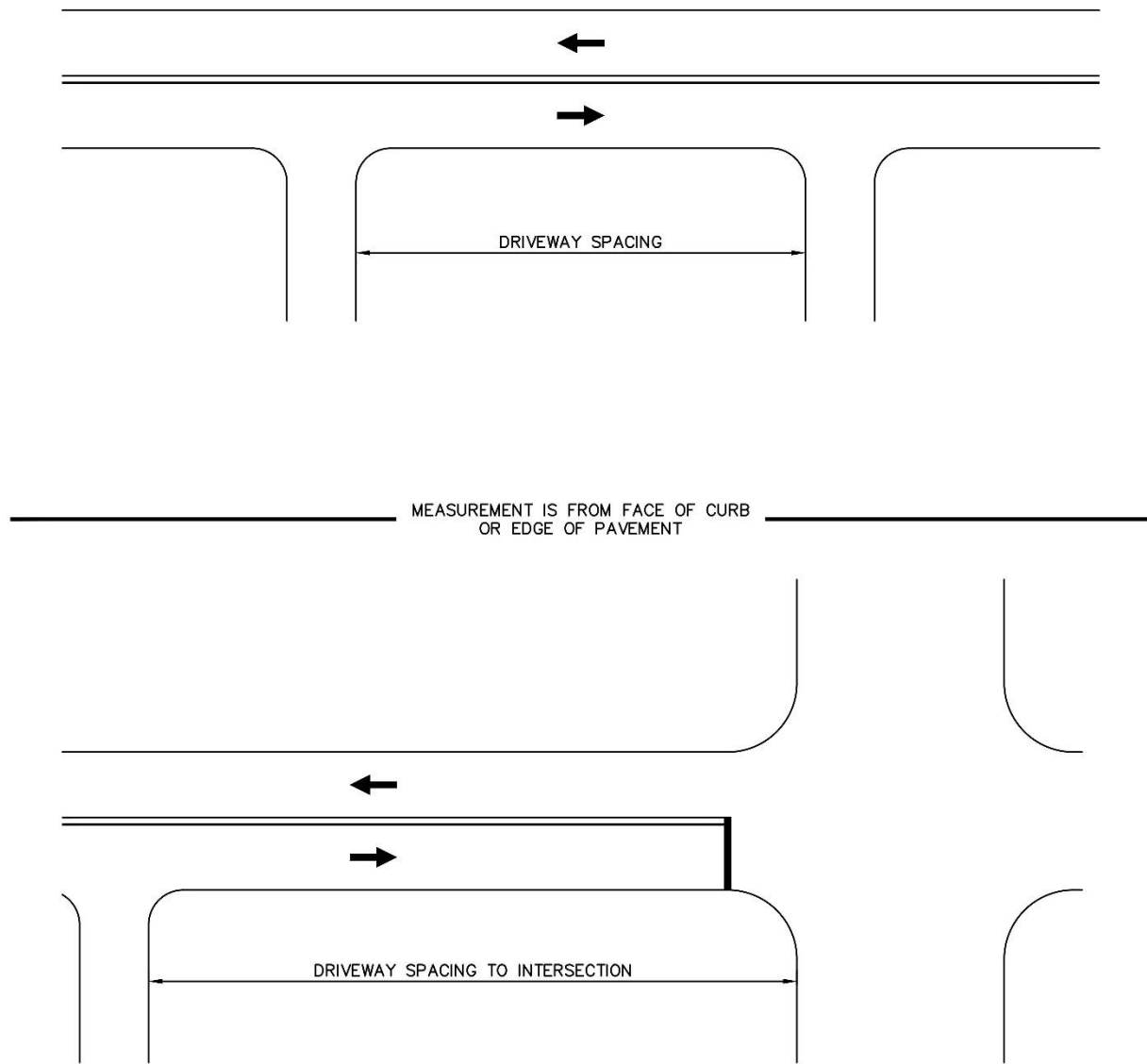


Figure 7-5 – Driveway Spacing

- A. When a property is at the corner of two streets, access shall be provided along the intersecting street with the lower Street Level unless property frontage exceeds 200 ft on the higher Level street (or shortest frontage exceeds 200 ft when both streets are the same Level) or multiple points of access are required for the site due to **Fire Code** or the **LDC**.
- B. When a property is in a mid-block location and only accessing one street, preferred placement is the midpoint of the property or midpoint between driveways on adjacent properties to maximize driveway spacing along the street.
- C. If a curb inlet is present, there shall be 10 ft between the inlet opening edge and the driveway point of tangency with the street.
- D. All driveways must be constructed within the street frontage of the subject property, as determined by projecting the side property lines to the curb line. Neither the driveway nor the curb returns shall encroach upon this projected line or onto adjacent property frontage without written approval from the adjacent property owner.
- E. Alignment of driveways with opposing streets at signalized intersections shall be approved by the City Transportation Engineer or applicable Director. If such a design is approved, the driveway approach may be constructed without an apron and the maximum driveway widths as shown in **Table 7-2** may be increased to match the cross-section of the opposing street. Construction of these driveways shall be built as new street intersection leg and signal modification costs shall be borne by the applicant and not be credited towards Rough Proportionality as defined in **Section 10**.
- F. Driveways shall not be permitted in the taper area of any right-turn lane or any part of a right-turn lane.
- G. Driveways that intersect at a mid-block median opening shall have the driveway centerline intersect with the midpoint of the median opening (measured nose-to-nose)
- H. Full access driveways shall not be permitted where it is necessary for left turning vehicles coming out of the development to cross an existing left turn lane.
- I. Additional driveway placement design criteria are contained in **Section 7.6.1**.

7.6.3 – Opposing Driveways with Offsets

Driveways on opposing sides of an undivided street with offsets can result in conflicting movements in and out of driveways and within the street.

- A. If left turning paths into driveways on opposing sides of a street cross each other (offset left), access shall be restricted to right-in, right-out, with the exception of a hooded left-turn into one driveway.
- B. If left turning paths into driveways on opposing streets do not cross each other (offset right), the driveways shall be located to avoid conflicting left turns out of the opposing driveways and placed a minimum of 80 ft apart measured from the throat edge of an intersecting driveway and the throat edge of the opposite intersecting driveway.

7.6.4 – Joint Use Driveways

Joint use driveways provide direct access to adjacent properties through a single driveway. This method of driveway placement is recognized as driveway consolidation and should be used as much as possible. Driveway consolidation reduces the potential of traffic delays and traffic conflicts; it minimizes curb cuts, resulting in a safer and more comfortable sidewalk environment for pedestrians and bicyclists. General principles for joint use driveway placement are illustrated in Figure 7-6.

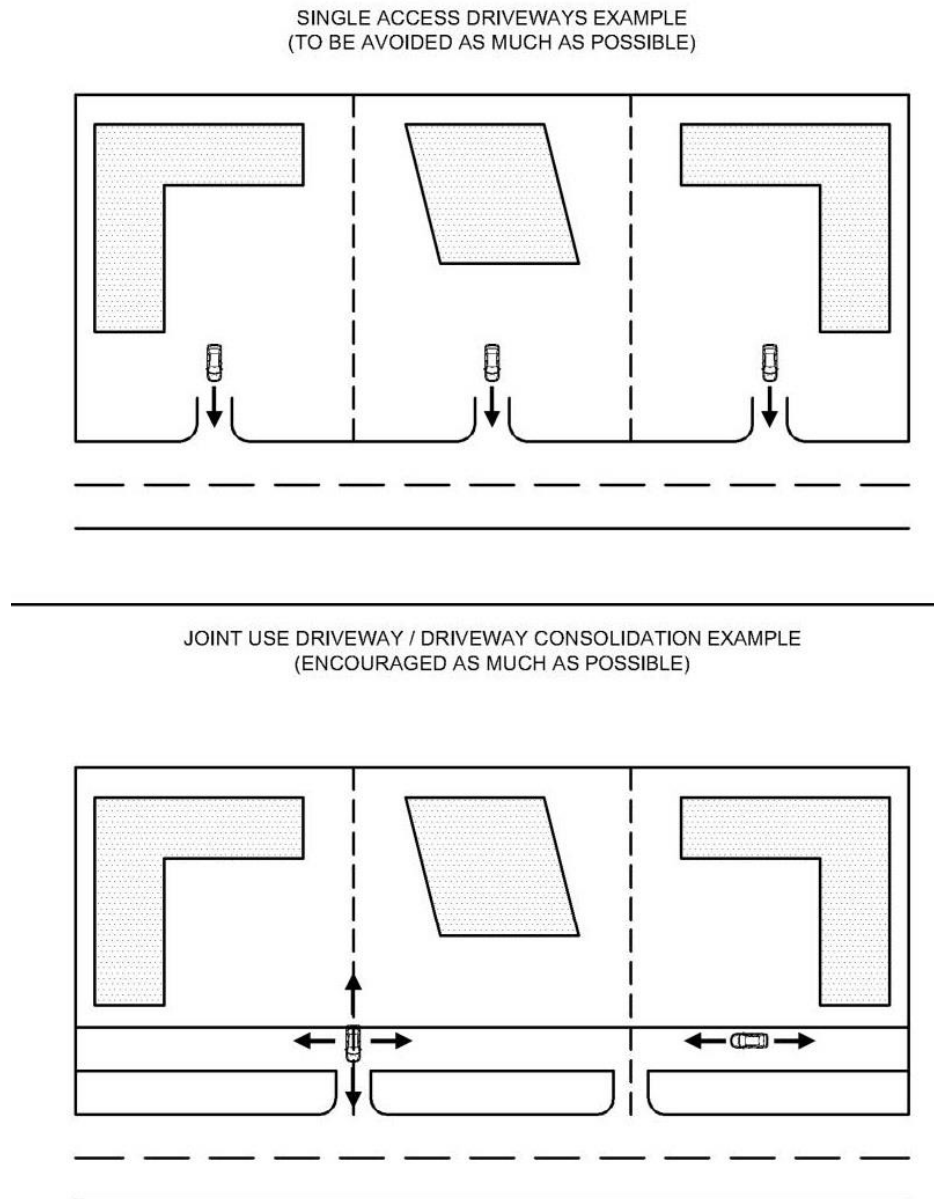


Figure 7-6 – Single Driveways and Driveway Consolidation Examples

- A. Design of joint-use driveways is subject to the same design criteria as minor and major driveways.

- B. New joint use driveways are encouraged and will require a permanent joint use access easement and/or unified development agreement. The easement language will require that maintenance of the joint use driveway shall be the responsibility of the lot owners served by the joint use driveway. The authority allowing for use of shared driveways is provided in **LDC**. If more than 3 dwelling units are to be served by a single joint use driveway, the following requirements apply:
 - 1. The applicant must post fiscal surety for the construction of the joint use driveway prior to plat approval and must construct the driveway during the construction of the streets within the same subdivision, or within the term of the fiscal instrument if no public or private streets are to be constructed within the subdivision. The driveway construction shall be subject to City inspection and obtain City approval before fiscal will be released.
 - 2. The applicant must obtain a written signature from the area fire service providers acknowledging their approval of the proposed joint use driveway.
 - 3. The area for the shared driveway may be required to be dedicated as a public utility easement and may be required to be used for drainage and public utility purposes. If the area will serve multiple purposes, then separate easements for public utilities and drainage will be required. In those cases where the joint use access easement is to be combined as a public utility and/or drainage easement, the access agreement for the driveway must include a clause indicating that the driveway may be used by public service personnel and equipment for servicing public utilities.
 - 4. If the applicant does not use a restrictive covenant to require homeowners to park all vehicles off the joint use driveway surface, then the joint use driveway surface must be at least 24 ft wide.
 - 5. The applicant must erect signs indicating "private driveway" at the driveway entrance.
- C. Refer to the **LDC** for additional criteria on the development of joint use driveways.
- D. Flag lots shall have a joint use access easement for a driveway accessing the lot if the lot frontage is 15 ft per the **LDC**. No other driveway may be approved for access.

7.6.5 – Temporary Driveway

A temporary driveway approach (Type III driveway) is intended to provide vehicular access to a lot or parcel of land, such access being from a roadway not yet constructed to permanent lines and grades or a roadway not having curb and gutter.

- A. Temporary Type III driveways shall be reconstructed under the respective minor and major driveway standards within 60 days after construction of the abutting street to permanent line and grade with concrete curb and gutter.
- B. Parking shall be prohibited in a temporary driveway if Austin Fire Department will need to use the driveway in the event of an emergency.
- C. Placement and spacing of temporary driveways are subject to same standards as permanent driveways.

- A. Temporary construction entrances shall be prohibited on commercial lots and residential lots with more than 4 residential units on Level 1 Streets.
- B. Approval from the City Traffic Engineer, applicable Director, or their designee is required for temporary construction entrance change in location after the site plan has been approved.

7.6.7 – Limited Movement Driveway Islands

- A. If channelized islands for limited movement driveways are approved, the applicant shall establish a maintenance agreement with the City.
- B. Where a sidewalk, walkway, or an accessible path of travel, crosses a limited movement driveway island, it shall meet all state and federal ADA requirements for accessibility and comply with applicable requirements of **Section 4** of this manual.

7.7.0 – Driveway Permitting

The above standards and criteria specify the placement and design of driveways to build a driveway that accesses a site. A right-of-way construction permit must be granted for the driveway approach to be built. Refer to the **LDC** for permitting requirements.

SECTION 8 – TEMPORARY TRAFFIC CONTROL

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8.1.0 – General

8.1.1 – Applicability

The provisions set forth in this section shall apply to all persons performing activities on any portion of the public right-of-way (ROW) in the City of Austin and includes city employees and contractors, utilities, and all persons whose work requires them to obtain a permit under **Chapter 14-11** of the City Code or other applicable sections of the City Code. For all construction in the right-of-way, the City Traffic Engineer, applicable Director, or their designee must inspect construction and the construction must be accepted by the **applicable department**.

8.1.2 – Design References

- A. The Texas Manual on Uniform Traffic Control Devices (TMUTCD) is hereby incorporated by reference. The most recent edition of the TMUTCD shall be consulted for the design and implementation of work zones within the City of Austin, unless otherwise stated in this manual. When the TMUTCD and this manual conflict, the stricter of the two shall apply.
- B. The director may publish Mobility Guidelines that expand upon requirements and processes regarding ROW use that cannot always be encapsulated in City Code or these rules, which are intended as a more static framework. Mobility Guidelines are available on a website maintained by the City and will provide further technical explanation of ROW requirements that are left to the director's discretion.

8.2.0 – Permits

Permits are defined in the Austin City Code **Chapter 13**, **Chapter 14**, and **Chapter 25**. The following are specific criteria required to obtain permits within the public ROW.

8.2.1 – Permit Required

Any person wishing to perform any work within the public ROW or cause the interruption of normal flow of street users within the public ROW must obtain the proper permit(s) prior to starting such activity, as required by **Chapter 14-11** of the Austin City Code.

If work is required within the ROW as a result of an emergency requiring immediate maintenance, proper permit is not required prior to beginning work; however, a permit must be applied for no later than 12 pm (noon) the next business day. Reference **Section 8.4.11** for additional information in emergency situations.

8.2.2 – Time and Work Restrictions

To minimize travel delay, activities in the ROW will be restricted as follows in Table 8-1.

Table 8-1 – Restricted Work Times in the ROW

Street Level ^B	Right-of-Way Activity Restricted Times
Level 1	No restrictions
Level 2 ^A	6am-9am and 4pm-7pm
Level 3 ^{A, C, D, E}	6am-9am and 4pm-7pm
Level 4 ^{C, D, E}	6am-9am and 4pm-7pm
Level 5	Consult with TxDOT or applicable agency

^A Work is permitted during these times on Level 2 and 3 streets that do not require a lane closure.

^B Refer to **Section 2.4.1** for Street Level Definitions.

^C Double lane closures in the DAPCZ, defined in **Figure A-2** are prohibited Monday through Friday.

^D Work Zones will not be permitted within 1,500 ft of an established work zone.

^E No bus/transit priority lane restrictions per **MG-03**.

- A. The director or designee may modify restriction hours on a case-by-case basis based on the unique context of a particular closure. For example, closures around schools may be restricted to only take place outside of school hours.
- B. The restriction hours above are promulgated only in the interest of traffic mitigation – other laws and regulations may also restrict the times that certain activities can take place, such as laws relating to decibel limits for construction machinery. A permit holder is responsible for ensuring their activity will not violate laws and regulations separate from the TCM or any chapters of the City Code.
- C. Further restrictions may be established by the director or designee to minimize conflicts with special events or other similar activities.
- D. Activity during overnight hours must be reviewed by the City.
- E. Full closures are generally prohibited Monday through Friday.

8.2.3 – Types of Permits

A current list of permits managed by the Right-of-Way Management Office can be found here:

<https://austintexas.gov/page/right-way-management-approval-network-rowman>

8.2.4 – Permit Requirements

- A. The director may establish permit requirements needed for the safe and expeditious handling of traffic, which may vary from requirements of a general nature to those that take into account specific site or work circumstances and may not be contemplated in the TCM.
- B. Permit requirements found in City Code include but are not limited to the following:

1. Downtown project coordination (**14-11-167**)
 2. Utility coordination (**14-11-165**)
 3. Construction near moonlight towers (**14-11-201** through **14-11-205**)
 4. In addition, for the purposes of additional considerations made by the director under section **14-11-173 (B) (13)**, applicants must also coordinate with:
 - i. The Corridor Program Office, if the permit impacts a Corridor Program route
 - ii. The Capital Metropolitan Transportation Authority (CMTA), if the permit impacts a CMTA route or stop
 - iii. The Texas Facilities Commission and State Preservation Board, if the permit impacts the Capitol Complex
 - iv. The Austin Fire Department, if the permit impacts an alley
 - v. The Austin Resource Recovery Department, if the permit impacts an alley in the CBD
 - vi. The Parking Division (Mobility Group)
 5. The appropriate jurisdictional authority, if the permit impacts another jurisdiction
 6. The appropriate school official, if the permit impacts a posted school zone or street immediately adjacent to a school
 7. The appropriate official, if the permit impacts a restricted parking zone
- C. Issuance – a permit may be issued once a customer has cleared the applicable requirements outlined above, has satisfactorily coordinated with all conflicting activities, and the proposed activity is in compliance with city ordinance.
- D. Extension – a permit may be extended once a customer has cleared the applicable requirements outlined above, has satisfactorily coordinated with all conflicting activities, and the proposed activity is in compliance with city ordinance.

8.2.5 – Construction Entrances

A construction entrance is a temporary egress/ingress from a construction site to the ROW.

- A. Construction entrances may use either existing driveways or be constructed according to a site plan or other construction documents approved by the City.
- B. A construction entrance, whether it be an existing driveway or stabilized construction entrance, shall have on either side for approaching traffic an orange construction warning sign with the text “Construction Entrance Ahead” to warn traffic to expect large trucks, backing maneuvers, and other activities that occur at construction sites. Refer to **Standard Details** for Construction Entrance Ahead standard sign. A permit is not required to place “Construction Entrance Ahead” signs when the construction entrance is shown on a site plan or uses an existing driveway, unless excavation or removal of part of the street, curb, or sidewalk is needed, in which case an excavation permit is required.

- C. A permit is required for any construction delivery activities that will occur in the ROW. Construction delivery activities include loading or unloading of any materials in the ROW or when any portion of delivery vehicle or equipment is stationary in the ROW for the purposes of delivery of materials. Vehicles exiting the construction site must not track debris into the street.
- D. Construction entrance ahead signs must be placed on all approaches to the construction entrance.

8.3.0 – Traffic Control Plans

A traffic control plan or appropriate traffic control standard detail is required to obtain a ROW permit. A traffic control plan provides the method by which street users will be warned, guided, and protected through a temporary traffic control zone. It also protects workers from traffic. A City of Austin standard detail, TxDOT standard detail, TMUTCD typical application, or City of Austin typical application may be used when the proposed activity aligns with the figure and notes. Otherwise, a traffic control plan must be designed to meet the specific requirements of the activity and be signed and sealed by a professional engineer licensed in the State of Texas.

8.3.1 – Plan Requirements

Engineered traffic control plans must meet the requirements established in this section. A sample traffic control plan template can be found on a website maintained by the city.

- A. Drafting Standards
 - 1. A traffic control plan shall include:
 - i. A cover sheet or title bar that identifies the project name, sponsor, and engineer, site plan or other development permit number;
 - ii. Page numbers that are sequential and start with the first page numbered 1, followed by 2, 3, 4, etc.; and
 - iii. A legend that includes symbols that are used in the plan; the legend shall not include symbols that are not used in the plan.
 - 2. A traffic control plan shall be a high resolution, to scale drawing representing the existing street conditions and geometrics, including:
 - i. Curb and gutter or edge of street, raised/painted medians and islands;
 - ii. Location of asphalt or rubber speed cushions;
 - iii. All traffic lanes, including turn lanes and bays, bike lanes, and other preferential lanes;
 - iv. Properly represented pavement markings, including lane lines, stop and yield bars, crosswalks, gore areas, and edge lines;
 - v. Lane movements/assignments, driveways, sidewalks, including beaten pedestrian pathways, bus stops, and parking spaces;
 - vi. Lane widths of any impacted lanes measured from face of curb to the center of the lane line or center of lane line to center of lane line. A lane includes traffic lanes, preferential lanes, bus lanes, bike lanes, turn lanes, and parking lanes;

- vii. Accurate representation in a distinct color or shading of adjacent or overlapping projects and how the other closure(s) will interact with the proposed work zone
 - viii. A uniform north arrow on all sheets;
 - ix. All streets labeled with the correct name and traffic flow arrow direction;
 - x. Match lines shall be used whenever a plan spans more than one page, and match lines shall be labeled and properly aligned on the plan sheet to show the separation of work by station;
 - xi. Unnecessary elements shall be removed;
 - xii. Be drawn to a uniform scale that conveys an appropriate level of detail. The scale shall be shown on the plans;
 - xiii. Baseline/skeleton drawing shall consist of CAD drawing. Aerial images are not sufficient to be utilized as base drawings;
 - xiv. Right-of-Way lines. If Right-of-Way pertains to other jurisdictions, the appropriate jurisdiction shall be shown on the respective Right-of-Way; and
 - xv. Dimensions of advance warning signs and tapers.
- B. Standard Notes and Barricading Summary Table – traffic control plans shall include the ROW Standard Notes and Barricading Summary Table, which can be found on a website maintained by the City. The Barricading Summary Table shall be completed, and any field left blank shall have a note explaining why a field is blank.
- C. Submittal Requirements
- 1. Traffic Control Plans shall be submitted electronically as a PDF on 11 in. x17 in. (tabloid) size sheet size in a landscape orientation.
 - 2. The PDF shall not have security features that prevent markups from being added to the document.
- D. Expiration – if a traffic control plan has completed the review process but does not commence implementation within 1 year from the approval date, it will be considered expired. If the plan's impacted area falls within the DAPCZ, the boundary of which is defined in **Figure 8-1**, it will be considered expired 6 months from the approval date, if implementation has not commenced. Expired plans are subject to additional review to confirm that field conditions have not changed, and the plan may still be safely implemented.
- E. City of Austin **Standard Details** – the director may publish Standard Details for use as traffic control plans in the City of Austin. When a proposed activity conforms with the Standard Details, a permit holder shall not be required to develop a separate traffic control plan with staff approval. The Director's Standard Details can be found on a website maintained by the City.
- F. The design engineer shall select the most appropriate detail from the City of Austin Standard Details, TxDOT Standard Details, or TMUTCD typical application, if applicable.

- G. Temporary Work Zone speed limits (both regulatory and advisory) may be used per the provisions of Section 6C.01 of the latest edition of the TMUTCD.

8.3.2 – Pedestrian Considerations

- A. Public Right-of-Way Accessibility Guidelines (PROWAG), latest edition, are hereby incorporated by reference for use in work zones within the City of Austin.
- B. TMUTCD Chapter 6D and Typical Applications Standards, latest edition, shall be followed for crosswalk closures and pedestrian detours.
- C. Vehicles shall be detoured, on-street parking temporarily removed, or lanes and other street elements narrowed for a TTC plan prior to consideration of pedestrian detours.
- D. Covered Walkway – a pedestrian covered walkway shall be installed in accordance with the International Building Code, section 3306, whenever that code requires a covered walkway. The requirements for setup of a covered walkway are shown in the **Standard Details**. The walkway shall be maintained in good, clean condition, free of any debris, and fresh in appearance at all times.
- E. An engineered, alternate covered walkway may be acceptable upon approval from the applicable director. The design must be sealed by a Structural Engineer licensed in the State of Texas.
- F. Audible Pedestrian Signals (APS) – shall be used to warn and guide visually impaired pedestrians when sidewalks are closed, and pedestrians are detoured into a path that crosses vehicular traffic paths. Messaging and devices shall be placed in compliance with TMUTCD and shall not conflict with existing traffic signal operations or other APS units.
- G. Detectable warning surfaces – are required when pedestrians are channelized to a location where pedestrians share the space with other street users.
- H. Positive Protection – When pedestrian routes are created in the street, consideration must be given to the deflection of devices into the pedestrian pathway. Longitudinal channelizing devices shall only be used when the regulatory speed is below 30 mph and the duration of work is less than 14 days. If the duration of work is 14 days or longer and the regulatory speed of the street meets or exceeds 30 mph, then water filled or ballasted positive protection barriers shall be used. For walkways on bridge sections or drop-offs greater than 10 ft, the TxDOT Positive Protection Manual requirements shall be used with a concrete barrier for pedestrian walkways.
- I. Pedestrian pathways – pathways, including temporary sidewalks, must be a minimum width of 5 ft, except for covered walkways. Detours should not exceed 660 ft and crossings should be made at existing crosswalks. If an existing crosswalk is closed due to ongoing work, a temporary crossing shall be installed that meets all guidelines set forth in **Section 4**.

8.3.3 – Bicyclist Considerations

- A. Any regulations and guidelines under the TMUTCD and other superseding regulatory standards shall be considered when accommodating bicyclists in or around work zones.
- B. For work zones impacting any bicycle lane facilities, the following accommodations shall be prioritized as follows:

- i. Provide a dedicated temporary bike lane with a minimum 5 ft clear width for a one-way bicycle lane and 8 ft clear width for a two-way bicycle lane and channelizing devices to delineate a pathway from both traffic and work zones. Any street elements that can be adjusted to accommodate a temporary bike lane shall be considered, such as temporary removal of on-street parking or the narrowing or closure of vehicular travel lanes. Engineering judgment shall also be used when considering positive protection, including duration of the project, volume of traffic, the posted speed limit, and site conditions
 - ii. A “Shared Roadway” condition can be considered when all of the following conditions are met:
 1. Merging cyclist and adjacent traffic travelling in the same direction with channelizing devices around the work zone;
 2. Low-volume roadway with average daily traffic (ADT) of 5,000 or less (or AADT/24 is less than 100 – which accommodates peak hour flow);
 3. Posted speed limit of 30 MPH or under (a temporary reduction in speed limit can be considered so long as the ADT is under 5,000 and the maximum proposed reduction in speed is 10MPH);
 4. The impacted facility is not an existing protected bicycle lane in the City’s All Ages and Abilities Network (AAA, as defined in the **ASMP**) or does not impact such a facility for more than 14 calendar days; and
 5. Engineering judgment, including the following factors:
length of work zone, grade, and surface conditions.
 - iii. Provide a temporary shared use path for a minimum clear width of 8 ft for one-way bicycle travel, or 10 ft for two-way bicycle travel.
 - iv. When no other alternative is feasible, provide a full bicycle lane closure and detour. Conditions for this detour route should match or exceed the existing accommodations of the existing impacted bicycle facility, such as the width of the facility, directionality of the facility, and presence of protection for the bike lane. Engineering judgment should also be used when considering alternative bicycle detour routes, including the following factors: length of detour, grade, surface conditions, volume of traffic and posted speed limits.
- C. Bicyclist should not be directed into a sidewalk intended for pedestrian use and the implementation of dismount zones are strongly discouraged as a method of temporary traffic control.
- D. Any temporary bike lanes or shared use paths shall be clear and free of any debris, obstructions, and have a minimum 8 ft vertical height clearance.
- E. Trails are not permitted to be closed without Director or their designee’s approval.

8.3.4 – Positive Protection Considerations

- A. Regulations and guidelines adopted under the TMUTCD, TxDOT, and Federal Highway Administration (FHWA), including 23 CFR Part 630, shall be considered in regard to the appropriate use and minimum requirements for work zone positive protection.
- B. Positive protection devices can offer the highest degree of safety for pedestrians, cyclists, and workers from motorized traffic. The following operations shall consider the use of positive protection:

- a. Mobile and Short Duration Operations (1 hour or less):
 - i. Locations with high-speed roadways (45MPH or greater) or locations with no means of escape (bridges, tunnels, narrow medians) shall consider Truck Mounted Attenuators (TMA) as a method of temporary positive protection for mobile operations and/or emergency work. TMAs must be placed in advanced of the work zone and the appropriate standard lane closure devices and signage shall be utilized.
- b. Stationary Operations:
 - i. Locations with high-speed motorist (45MPH) that have pedestrians, cyclists, or workers present within one travel lane width of traffic shall consider the use of stationary positive protection
 - ii. Locations with no means of escape (examples include areas such as bridges, tunnels, or narrow medians) where work will occupy an area for more than 24 hours, or multiple day/night setups totaling more than 24 hours shall consider the use of positive protection
 - iii. Locations with long duration setup (14 days or more) shall consider the use of positive protection
- C. There are additional factors outside of the operations mentioned above that can warrant the use of positive protection based on an engineering study. Those factors are included below:
 - a. High-Volume Traffic and/or High-Speed Traffic
 - b. Unique roadway geometrics that may increase the likelihood of errant vehicles (this can include abrupt lane transitions/closures, or obstructions in sight distance caused by existing site conditions or construction equipment)
 - c. Any length and/or depth of pavement drop-offs (this can include trenching operations)
 - d. Exposure to any work zone hazards (equipment or materials stored within the public right-of-way)
- D. The type of positive protection devices to be used shall be determined by an engineering study. The most common types of positive barriers and their applicable situations are outlined below:
 - a. Ballast or Water filled barriers may be warranted for projects located within urban areas with low traffic speed or low impact angles. Additionally, ballast or water filled barriers can be used for projects where space is limited and heavy equipment to place concrete barriers not feasible
 - b. Temporary concrete barriers (TCB) and the appropriate end treatments may be warranted for high-speed roadways (45MPH or greater), projects with long duration (14 days or more), and work zones where special hazards exist on a consistent basis, such as pavement drop-offs. Additionally, TCBs can be anchored to minimize impact deflection.
- E. All positive protection devices must meet crashworthiness requirements outlined in the Manual on Assessing Safety Hardware (MASH), the National Cooperative Highway Research Program (NCHRP) Report 350, and any superseding documentation. Positive protection devices must be installed and maintained per the manufacturer's requirements and routinely inspected for defects.

8.3.5 – Transit Considerations

In no instance shall a lane with bus service be reduced below 11 ft from center of stripe to a longitudinal joint in the pavement for a gutter or to any vertical barrier. The city shall require coordination and approval from CMTA for work affecting bus stops, bus lines, rail stations, and rail lines.

8.3.6 – Temporary Signals

- A. Temporary signals may be installed to control traffic in a work zone lasting 6 or more months provided that the installation of such a signal is coordinated and approved by the applicable department, to include any additional insurance or bonding requirements above that required to obtain a ROW permit.
- B. The permit holder shall be fully responsible for the installation and maintenance of temporary signals. The City will not be responsible for installation or maintenance of temporary signals, but will operate temporary signals as required. The permit holder shall restore temporary traffic signals to working conditions within 2 hours.

8.4.0 – Work Zones

8.4.1 – Notification

- A. 311 Notification – the permit holder is responsible for contacting 3-1-1 in advance of ROW closures. Notification must be made at least 3 business days in advance of planned closures and can be performed by calling 3-1-1 or using the 3-1-1 mobile application. Emergency closures shall be reported promptly upon discovery of the emergency. Notification is required as follows:
 - 1. For sidewalks within the DAPCZ
 - 2. For travel and bike lanes on all Level 3 and Level 4 Streets
 - 3. For full street closures on all streets and alleys
- B. Portable Changeable Message Signs (PCMS) – closures on Level 3 and Level 4 Streets that will restrict traffic by 50% or more in any one direction shall be preceded by notification by PCMS for at least two weeks prior to the closure. The message at a minimum shall indicate the extent of the closure, start date, and anticipated duration. Placement of PCMS shall comply with the TMUTCD and not obstruct the required width of any street user path.
- C. Door-hangers/mailings – closures on any street that will restrict driveway access to residential or business lots shall be preceded by targeted notification to the affected addresses with advanced notification requirement following **Section 8.4.4 (A)**. Targeted notification may include door-hangers and/or mailed notices. Such notification shall include the nature of the work, start date, duration, times that driveway access will be restricted, and contact information for the contractor performing the work.
- D. Provide a construction notice sign 14 days in advance of commencement of work including the nature of the work, start date, duration, and contact information for the contractor performing the work.

8.4.2 – Setup and Phase Changes

- A. It shall be the responsibility of the permit holder for private activities or the job supervisor for public projects to ensure that all policies, procedures and requirements set forth in this manual, **City of Austin Mobility Guidelines**, TxDOT regulations, TMUTCD, and any other regulatory requirements are met. Each work site shall have a designated competent person responsible and available on the project site or in the immediate area to ensure compliance with the traffic control plan and the provisions of this manual and any applicable regulatory requirements.
- B. Initial setup and major phase changes shall be coordinated and organized by the permit holder to ensure that appropriate devices and workers, both in terms of quality and quantity, are on hand to complete the setup or phase change without delay. Setups and phase changes should not extend into hours where work activities are prohibited per **Table 8-1** except with approval from the applicable director. Any long-term setups should occur during low-volume traffic hours, such as during weekends.

8.4.3 – Maintenance of Work Zones

8.4.3.1 – Excavation

- A. Backfill – backfill of excavated areas shall be performed in accordance with Section 5.8.0 of the **Utilities Criteria Manual** unless otherwise approved by a construction inspector or professional engineer with City concurrence.
- B. Steel Plates – steel plates shall be used in accordance with Section 5.7.8 of the **Utilities Criteria Manual** unless otherwise approved by a construction inspector or professional engineer with City concurrence.
- C. Refer to Positive Protection Requirements per TxDOT for any excavations.

8.4.4 – Access Management

- A. Public and Private Property - Access shall be maintained to all properties on all streets during construction and maintenance activities at all times. The Temporary Traffic Control (TTC) Plan shall provide for access to all sidewalks, driveways, Level 0 Streets, and areas of ingress and egress outside the limits of construction. If access cannot be maintained, the contractor, utility, department or supervisor shall notify the affected property owner, resident or tenant a minimum of 7 days in advance of the pending work unless the work is of an emergency nature. For emergencies, the affected party shall be notified as soon as possible. Access shall, in all cases, be restored as soon as possible. To ensure this, the contractor or work crew shall only perform the work affecting the restricted access areas while access is not maintained.
- B. Emergency Service Facilities - Access to fire stations, hospitals, EMS facilities and police stations shall be maintained at all times on all streets during construction and maintenance activities. The Temporary Traffic Control (TTC) Plan shall provide for access to all sidewalks, driveways, Level 0 Streets, and areas of ingress and egress.
 - 1. If access cannot be maintained, the contractor, utility, department or supervisor shall request closure from the director and provide an engineering reason why access cannot be maintained. The affected emergency service facility shall be notified a minimum of 14

days in advance of the pending work unless the work is of an emergency nature. For emergencies, the affected party shall be notified as soon as possible. Access shall, in all cases, be restored as soon as possible. To ensure this, the contractor or work crew shall only perform the work affecting the restricted access areas while access is not maintained.

8.4.5 – Traffic Control Devices

- A. Identification of Devices - Temporary traffic control devices that are placed in the public ROW shall be marked or affixed with a sticker, in a manner that will not interfere with the normal operation of the device, clearly identifying the name, and telephone number of the individual or company responsible for the device. This shall include all signs, sign mounts, cones and other channelizing devices, barricades, positive protection, arrow boards, portable message boards, barrier or any other traffic control device used in the public ROW.
- B. Quality – the ATSSA publication ‘Quality Guidelines for Temporary Traffic Control Devices’, City of Austin **Standard Details** and **Standard Specifications**, and TMUTCD shall be referenced when determining whether or not a traffic control device is fit for use. It shall be the responsibility of the permit holder to ensure work zone devices are of sufficient quality to be used in the ROW, to include retro reflectivity, legibility, and free from color degradation and graffiti. The final determination shall be made by the City inspector, who may direct that a device be removed from use and replaced according to standards.
- C. Crashworthiness – Devices used in the ROW shall be crashworthy according to MASH testing and NCHRP Report 350 requirements for the appropriate use case.
- D. Impoundment of Devices – a city official may impound a traffic control device that is placed in the ROW without a permit or where it poses a hazard to traffic. The city may also impound devices left in the ROW after work performed under a permit is completed and they are no longer needed. Impounded devices may be reclaimed pursuant to **City Code Chapter 9-1**. Devices that are not identified within 30 days will become property of the City of Austin to be re-used, sold, or disposed of.
- E. Automated Flagger Assistance Devices – the city will consider the use of AFADs in accordance with the TMUTCD, provided that their use is shown on a traffic control plan sealed by a professional engineer.

8.4.6 – Temporary Pavement Markings

- A. Any use of the temporary pavement markings shall be made compliant with the **City of Austin Standards Details and Specifications**, TMUTCD, and shall be installed per the manufacturer’s requirements.
- B. Prior to the installation of any temporary pavement markings, the street surface should be clear and dry to allow maximum surface adhesion. Temporary pavement markings shall be routinely inspected daily to identify any deficiencies. Any deficiencies must be corrected as provided for by section 14-11-222 of the City Code.
- C. Obliteration of any temporary and permanent pavement markings can lead to pavement scarring (ghost markings). Removal techniques that minimize and avoid any pavement scarring must be considered. Grinding of pavement markings will only be allowed on pavement that is to be completely replaced. Any pavement scarring that is visibly noticeable after construction and

conflicts with any pavement markings must consider street resurfacing and restriping to correct the deficiency. Additionally, black paint or spraying with asphalt over pavement markings is not considered an acceptable method of removal or obliteration. Removable, non-reflective, preformed block-out/masking tape that approximately matches the same color as the pavement surface may be used to temporarily remove lane markings.

- D. Long-term stationary work (defined as work occupying a location for more than 3 days) shall have all conflicting pavement markings removed or obliterated and the appropriate temporary pavement markings shall be installed.
- E. Intermediate-term stationary work (defined as work occupying a location more than one daylight period up to 3 days, or any nighttime work lasting more than 1 hour) should temporarily block-out/mask any conflicting permanent pavement markings. When it is not feasible to temporarily block-out/mask any markings with conflicting information, a clear and well-defined temporary pathway shall be established. The engineer may consider implementing reduced longitudinal spacing (no more than 10 feet) between channelizing devices to help establish a clear and well-defined temporary pathway.
- F. Refer to the **City of Austin Standard Details and Specifications** regarding use of temporary pavement markings. The following types of temporary pavement markings are commonly used. Engineering judgment shall be used to decide the appropriate temporary pavement markings for each work zone:
 - 1. Traffic Paint – A quick dry paint that may be used on roadways. The engineer may consider using traffic paint as a method of temporary pavement markings within the limits of construction where the roadway will be resurfaced and restriped in order to avoid pavement scarring during removal. Temporary traffic paint markings are not allowed on final pavement surfaces. To improve reflectivity, glass beads are required.
 - 2. Temporary Raised Pavement Markers (RPM) – There are two common types of temporary RPMs, temporary buttons and temporary plastic tabs. Both types of RPMs have an adhesive backing and typically have a higher reflectivity than other applications, making it ideal for nighttime applications and poor-visibility conditions. The engineer can consider using temporary RPMs on low-volume roadways since it is not impact resistant as other methods. On high-volume roadways, temporary RPMs may be supplemental device to improve lane delineation during night-time applications and times of poor-visibility.
 - 3. Temporary Pavement Marking Tape – Preformed tape which can stick to the pavement surface. The engineer may consider using temporary pavement marking tape to delineate temporary traffic lanes or changes to traffic patterns during construction (e.g. lane shifts, cross overs, etc.). Note that temporary pavement marking tape does not typically hold during high-volume traffic conditions. Wet reflective tape should be considered to improve traffic lane guidance during times of poor-visibility.
 - 4. Thermoplastic Markings – a highly durable temporary pavement marking. The engineer may consider using thermoplastic markings on high-volume roadways where the same traffic pattern will be in place for a long duration, typically longer than 1 year. Thermoplastic can be used within the limits of construction where the roadway will be resurfaced and restriped.

5. Temporary Rumble Strips – A type of temporary strip that adheres to the roadway surface. The engineer may consider using temporary rumble strips on high-speed roadways as a supplement to warn motorists of impending stop conditions (e.g. temporary traffic signals, flaggers).
- G. Refer to City of Austin **Standard Details** and **Standard Specifications** and/or TMUTCD Standards for restoration of striping.

8.4.7 – Worker Safety

Those employed in work zone activities shall wear appropriate safety attire, which at a minimum will include an ANSI certified traffic safety vest as required by the TMUTCD. Additional personal protective equipment may include a hard-hat to mitigate overhead dangers, safety-toe footwear, fireproof clothing, and electrically insulated gear. When certain occupational dangers require personal protective equipment that does not meet TMUTCD requirements for traffic safety, the relative dangers should be weighed against each other and the appropriate equipment selected (e.g. fireproof clothing that is not high-visibility per the TMUTCD should be worn when there is a risk of fire, such as from a gas leak).

8.4.8 – Inspection and Enforcement

- A. Contractor Self-Inspection Checklist – the permit holder is responsible for ensuring the ‘Contractor’s Self-Inspection Checklist’ is completed. The form and instructions can be found on a website maintained by the City.
- B. Vehicle Staging – a permit holder shall ensure that vehicles, including construction machinery, do not stage or loiter in the ROW. Construction machinery such as tractors and excavators may operate in the ROW as allowed by the Texas Transportation Code; however, any machinery that is used to carry live loads shall not operate in City of Austin ROW outside of the approved closure area and shall be confined to the limits of construction.

8.4.9 – Existing Infrastructure

- A. Traffic Signals, PHBs, and flashing beacons - If maintenance or construction activities require excavation in the vicinity of a signalized intersection, the applicable department shall be notified at least 14 days prior to commencing work activities. Any damage to the traffic control devices or associated equipment, resulting from the maintenance or construction activity, will be repaired and restored to City of Austin **Standard Details** and **Standard Specifications** by the contractor performing the work under inspection by the City and all costs associated with repairs and restoration shall be paid by the contractor, utility, agency or department causing the damage. Emergency repairs may be performed by the City or its approved contractor with reimbursement for the cost of the repairs and restoration paid by the contractor, utility, agency or department causing the damage.
- B. Lane changes at traffic signals – if lanes will be removed from operation or lane assignment or location changed, notification shall be provided 14 days in advance of such changes to the applicable department to adjust signal timing or traffic signal head operations. This applies to all work including that of short duration.
- C. Traffic Signs and Permanent Devices - All traffic control or street name sign posts adjacent to construction or maintenance work sites shall be protected from damage. If removal of such signs is necessary, contact the applicable department for review and coordination as required. All

regulatory and/or warning signs that are applicable to traffic shall remain visible to the motorist unless otherwise addressed by the TTC plan. The contractor shall relocate existing signs on to temporary mounts as needed to facilitate construction activities. Any existing sign that conflicts with an approved TTC plan must be covered and or removed for the duration of the approved TTC plan and or project. Any sign or support damaged by the construction or maintenance activity shall be repaired and restored by the contractor at-fault or by the applicable department and the cost of such repairs and restoration will be paid by the contractor, utility, agency or department causing the damage.

- D. Parking Meters - All metered parking spaces shall be maintained open for parking at all times unless other actions are authorized by the applicable department and appropriate permits for the use of the city ROW have been obtained. Multi space and single space parking meter removal, relocation or re-installation shall be performed by the applicable department and the contractor shall also be responsible for final restoration. 48 hours' advance notification is required when meters need to be removed or installed and for temporary signs on meters for reservations. The contractor shall be required to provide barricades and no parking signs to block off parking spaces. Work within ADA parking spaces shall be prohibited in order to maintain public accessibility. Should work require the occupation of ADA parking spaces, the applicable department shall review the engineering reason for the request.

8.4.10 – Special Events

Special events are planned and coordinated interruptions of normal operations of the public ROW for purposes other than construction or maintenance. These can include closures for street festivals, music festivals, block parties, parades, sporting events, and others. Special events are handled through the applicable department and require a special permit distinct from those issued under **City Code Chapter 14-11**.

8.4.11 – Emergency Situations

Work may begin immediately to address an imminent health and safety hazard. Appropriate traffic control measures must still be taken as per the City of Austin and TMUTCD to safeguard workers and the public. A permit application must be submitted by noon the following business day for the emergency operation. Once the initial work to address the emergency stops and the site is vacated, any further work, such as restoration, is not considered an emergency.

8.5.0 – Deviations

- A. The director may grant a variance from these requirements for good cause. Good cause may include, but is not limited to, minimizing traffic disruption, accelerating work schedules to avoid conflicts or other delays, and to minimize costs and inconvenience to the public.

SECTION 9 – PARKING AND LOADING

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9.1.0 – General

The principal design objectives for any parking facility are the provision of safe customer service and convenience coupled with minimal interference to street traffic flow. Specific ordinance requirements for parking facilities and required parking calculations are provided in the **LDC**. The requirements for parking facilities are dependent on a site's zoning, principal uses, and accessory uses. Depending on zoning and land use, parking minimums, maximums, or prohibitions may apply and shall be determined by the **LDC**.

The following criteria aid in designing parking facilities in conformance with accepted principles of traffic engineering and safety. The following criteria address requirements for off-street parking design and general principles for on-street parking placement within the right-of-way. Loading zones are also addressed for both on-street and off-street facilities in this Section. Various components of parking areas both within the right-of-way and on public or private properties are defined in **Figure 9-1**.

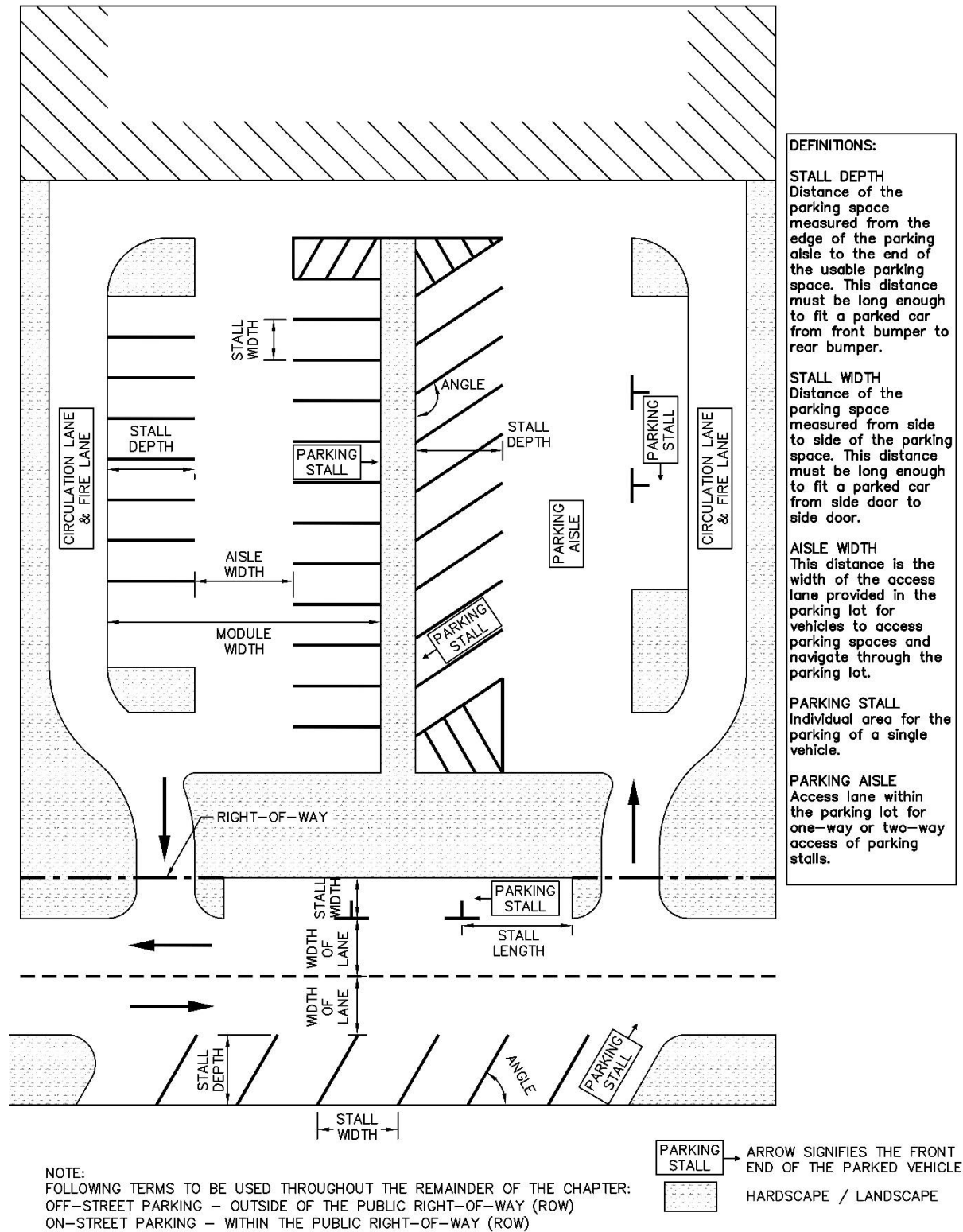


Figure 9-1 – Parking Overview

9.2.0 – Parking Design (On-Street)

Parking is defined as on-street parking when it has direct access to vehicular travel lanes in the right-of-way. Stationary vehicles parked along the corridor act as a speed management technique in appropriate contexts, per **Section 3.3.3.1**. On-street parking can facilitate the application of bulb-outs, which can reduce motor vehicle speeds, reduce impervious cover, allow for additional street trees, and reduce pedestrian crossings.

- A. Where on-street parking is desired without adequate right-of-way, a dedication of right-of-way shall be required.
- B. On-street parking shall not count towards required parking unless it is approved by the City Transportation Engineer or applicable Director.
 - 1. On-street parking counted towards parking requirements remain open to the public and may not be reserved for sole usage of the adjoining development.
 - 2. The adjacent on-street parking may be removed at any time for any reason and the developer counts the spaces at their own risk. There will be no compensation for the removal of on-street parking, commercial zones, or loading areas.
- C. Pavement design for any on-street parking shall be consistent and compatible with the general street structure. This will most often be the same cross section as the surrounding pavement; however, it may have a different design recommended which must be approved based on its projected use. Any such pavement must comply with **Section 14** Pavement Design.

9.2.1 – On-Street Parking Types

On-Street parking may be provided as parallel or back-in angle parking. Parallel parking shall be the configuration of all on-street parking unless approved by the City Transportation Engineer or applicable Director. Parking is not permitted on Level 4 streets. Head-in angled parking is prohibited as an on-street parking type.

The following are descriptions of the types of on-street parking configurations:

- a) Parallel – Side of the vehicle is parallel to the curb when parked
- b) Angle (Back-In) – Vehicle backs into the stall at an angle to the roadway

9.2.1.1 – On-Street Parking Alternate Space Uses

- A. On-street parking can be converted to sidewalk cafes or street patios for use by adjacent properties, at the request and expense of the adjacent property owner and by approval of the City Transportation Engineer or applicable Director. Reference **Sidewalk Café and Street Patio Handbooks** for more information on design of these facilities and the **Standards Manual**. A license agreement is required for a parklet for maintenance by the adjacent property owner. Parklets serve as an extension of the pedestrian zone by providing a protected space for pedestrian use or as a sidewalk cafe. Reference **Sidewalk Café and Street Patio Handbooks** for more information on design of these facilities and the **Standards Manual**.

- B. On-street parking spaces may be converted to bike or dockless mobility parking spaces with approval by the City Traffic Engineer, applicable Director, or their designee. Refer to **Section 9.8.0** for bicycle parking and **Section 9.9.0** for dockless mobility parking criteria.
- C. To enhance the pedestrian zone and safety of the bicycle and street edge zone, street trees and landscape elements can be provided in bulb-outs, if sight distance is maintained at intersections and horizontal and vertical clearances for landscaping are maintained per **Section 11** of this manual.

9.2.2 – General Design Criteria

For the following on-street parking design criteria, if there are conflicts between the **Land Development Code, Building Code, Fire Code**, or this Section, the stricter shall apply:

- A. On-street parallel parking stalls width shall be measured from the edge of the traveled way to the face of curb. The combination of travel and parking stall next to one another shall be no less than 18 ft. In areas adjacent to transit routes, the minimum shall be 19 ft. Parking is assumed to be 8 ft in width.
- B. On-street angled parking stalls shall be 8.5 ft minimum width, measured from center of stripe or face of curb.
- C. Individual parallel parking stall lengths shall be 20 ft in length.
- D. On-street parking is only permitted in cul-de-sac areas where demonstrated control vehicle can make turns without conflicting with parked cars. Refer to **Section 3.4.2.2** for criteria on cul-de-sacs.
- E. On-street angled parking shall be constructed in accordance with the dimensions in **Table 9-1**.
- F. A construction joint shall be provided on concrete roadways to delineate the parking lane edge.
- G. On-street parking shall be prohibited on streets with target speeds 35 mph or greater.
- H. If the sidewalk abuts the end of the angled parking stall, a 2 ft overhang shall not be counted towards the required clear width for sidewalks.
- I. On-street parking shall not be placed on Level 4 or Level 5 facilities.
- J. Except for streets that specify on-street parking in the Street Network Table in the **ASMP**, right-of-way shall be dedicated by applicant for on-street parking at the applicant's request.
- K. On-street parking shall be the lowest priority when determining the roadway cross section. Due to the large variance in right of way required between the two parking types, angled parking shall only be allowed if all other right of way zone elements are included with their minimum widths being met.
- L. Accessible parking shall meet current PROWAG and Texas Accessible Standards (TAS).
- M. Time-Restricted On-Street Parking – These are considered 5-minute standing zones. Vehicles shall have their hazards lights flashing and always be attended by the driver. These are allowed on Level 0, 1, 2, and 3 streets in specifically designated spaces. Time limits shall be signed for these spaces and conform to City of Austin Standards and be approved by the City Traffic Engineer, applicable Director or their designee.

Table 9-1 – Minimum Dimensions for Angled On-Street Parking Stalls

Angle	Stall Width	Stall Depth (Perpendicular to Curb)	Minimum Width of Adjacent Lane	Curb Overhang
45	8 ft-6 in.	17 ft-8 in.	12 ft-8 in.	2 ft
50	8 ft-6 in.	18 ft-3 in.	13 ft-3 in.	
55	8 ft-6 in.	18 ft-8 in.	13 ft-8 in.	
60	8 ft-6 in.	19 ft-0 in.	14 ft-6 in.	
65	8 ft-6 in.	19 ft-2 in.	15 ft-5 in.	
70	8 ft-6 in.	19 ft-3 in.	16 ft-6 in.	

9.2.3 – On-Street Parking Placement

On-street parking and bike lanes make up the bicycle and street edge zone, as outlined in **Section 2**. Where both are present along the same corridor, their placement in relation to each other defines the operations and safety for each user within the bicycle and street edge zone. Users of bicycle facilities are to be given the priority over vehicles within this zone. Elements typically placed in the pedestrian zone can be extended into the bicycle and street edge zone (e.g. street trees, bike racks) in strategic locations to intermix the two zone uses which can have a positive effect on the feel and usage of the street.

9.2.3.1 – General Placement Criteria

- A. A 1.5 ft offset from the curbside of a parking stall shall be provided to all obstructions such as parking meters, poles, trees, etc.
- B. Parking shall be prohibited within 15 ft of either side of fire hydrants. Refer to **Figure 9-2**.
- C. The nearest edge of a parking stall shall be a minimum of 30 ft from the curbside of a crosswalk. Refer to **Figure 9-2**.
- D. The nearest edge of a parking stall shall be a minimum of 30 ft from the approach to an intersection. Intersections do not include driveways
- E. **Texas Transportation Code 545.302** specifies prohibitions for parking of vehicles. **Figure 9-3** illustrates spacing from a controlled intersection with a crosswalk.
- F. If transit service is provided, no parking shall be permitted in the platform areas as defined in **Section 6** of this manual to allow for loading and unloading of passengers.

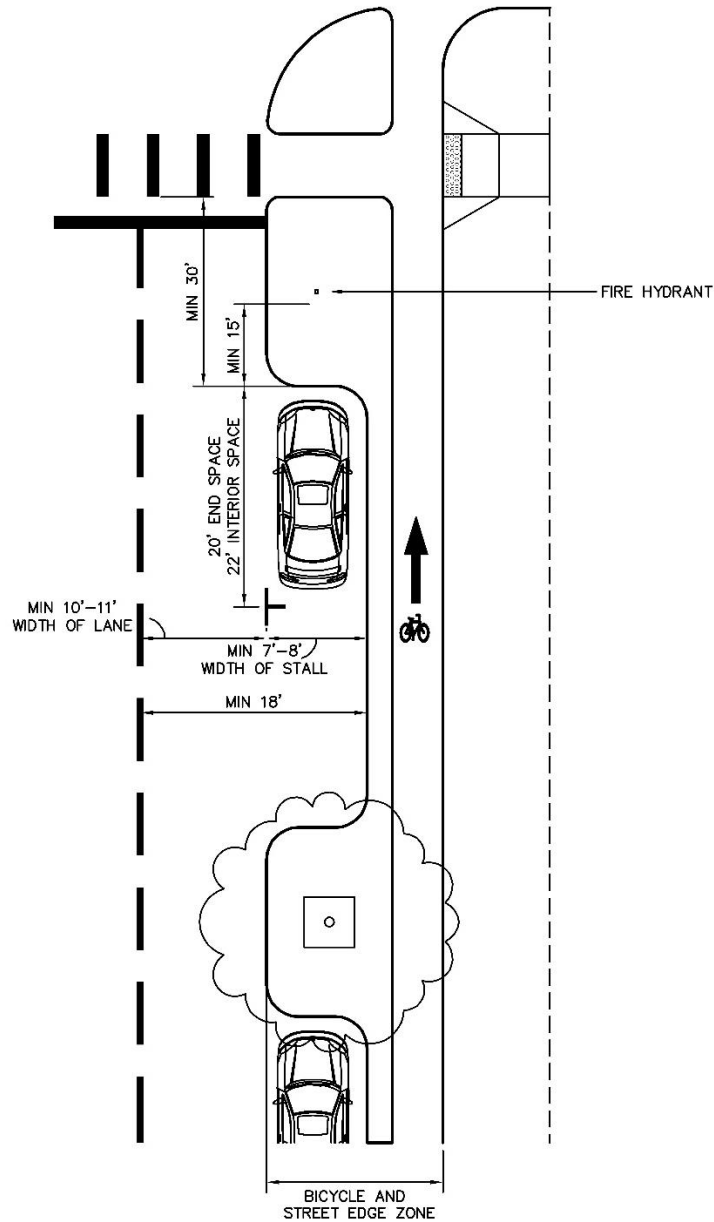


Figure 9-2 – Bulb-out Usage and Parking Placement

9.2.3.2 – Bike Lane Interactions with Parking and Loading

Figures 9-3 through 9-6 below illustrate proper placement of bike lanes, on-street parking stalls and on-street loading stalls when included on the same street. The figures below illustrate the treatment of protected and buffered bike lanes as well as bike lane transitions for recessed loading stalls.

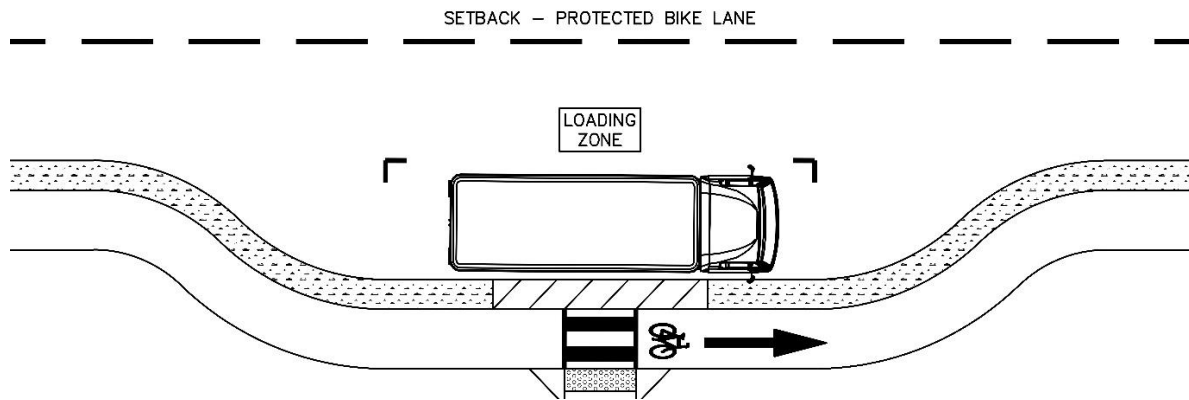


Figure 9-3 – Protected Bike Lane with no On-Street Parking

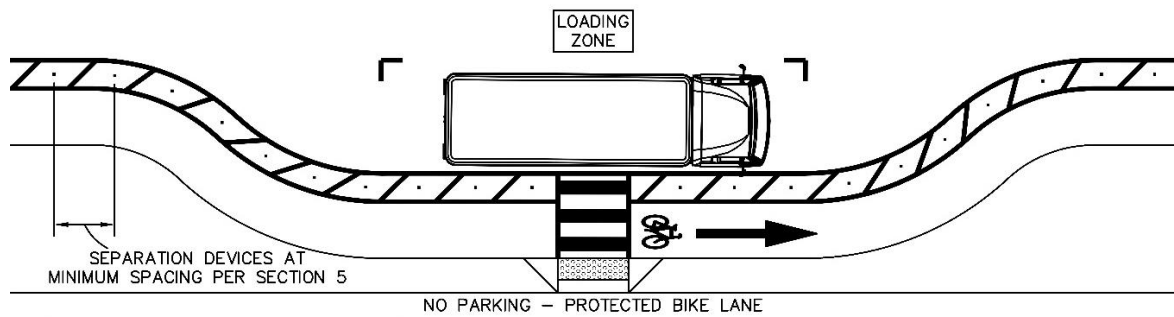


Figure 9-4 – Buffered Bike Lane with No On-Street Parking

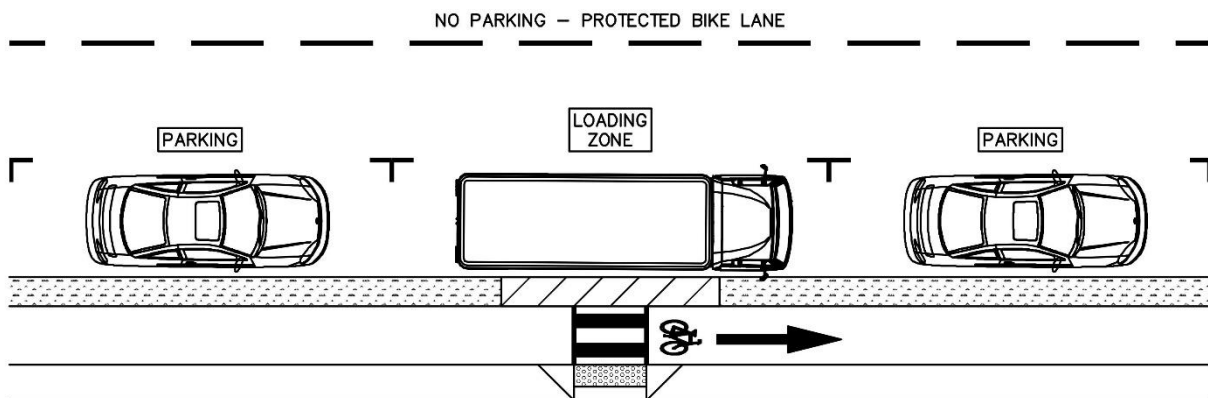


Figure 9-5 – Protected Bike Lane with On-Street Parking

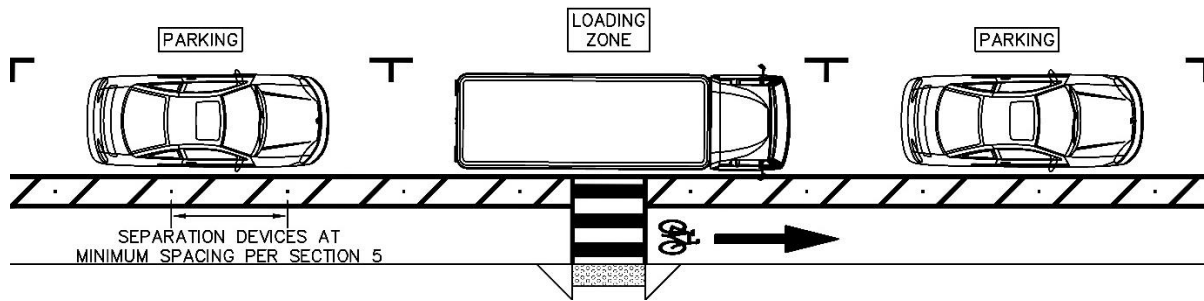


Figure 9-6 – Buffered Bike Lane with On-Street Parking

- A. A minimum 3 ft buffer shall be provided between the edge of parallel on-street parking and a bike lane. The buffer ensures that opening car doors will not encroach in the protected bike lane.
- B. Protected or buffered bike lanes with vertical separation elements in the buffer shall be provided on the pedestrian zone side of on-street parking.

9.3.0 – Parking Design (Off-Street)

Parking is defined as off-street parking when it is placed outside of the public right-of-way (refer to **Figure 9-1**).

9.3.1 – Off-Street Parking Types

- A. Parallel – Side of the vehicle is parallel to the curb when parked
- B. Angle (Head-In) – Front of the vehicle pulls into the front of the parking stall at an angle
- C. Perpendicular – Front or back of the vehicle is 90 degrees to the parking aisle

9.3.2 – General Design Criteria

- A. Parking stalls shall be constructed in accordance with the dimensions in **Table 9-2** for surface parking and with dimensions in **Table 9-3** for structured parking.
- B. Compact parking stalls shall not exceed 30% of the required parking spaces for a site. Compact parking stalls may be used for additional parking provided beyond the minimum parking required, after all parking reductions have been accounted for.
- C. Parking stalls may only be installed in 100-year or 25-year floodplains if the requirements of **LDC** are met.
- D. For parking structures, columns may encroach into the head end of parking stalls, provided that the columns do not reduce the total (double-loaded) module width by more than 2 ft and the columns do not encroach into more than 25% of the spaces. Columns may not encroach into the side of parking stalls; stall width must be measured from the face of the column.
- E. The angle and design of parking stalls and aisles shall be relatively consistent throughout a unified development. If both structured parking and surface parking exist in a development, the angle and design of parking stalls shall be consistent within the structured parking and consistent within the surface parking. One-way angled parking aisles shall be designed to alternate the direction for adjacent aisles. Proper signs and markings shall be required to reinforce traffic circulation and flow.
- F. Each parking stall shall be independently accessible and shall have a vertical clearance as specified in the **Building Criteria Manual**.
- G. Tandem parking stalls (one car behind another, so that one car must be moved before the other can be accessed) are allowed for residential uses and for commercial uses that operate exclusively as a valet service following requirements of **Chapter 13-5** of the City Code. Tandem parking is also allowed for additional parking provided in excess of the required parking, after reductions applied, for employees only working the same shift and shall be signed and marked as employee parking only. Both stalls in tandem must be standard size per **Table 9-2**; no compact or accessible tandem stalls are permitted. When tandem parking stalls are provided for residential uses, the following must be included as a note on the site plan:
 - 1. The stalls must be reserved and assigned to dwelling units which are required to have 2 or more parking stalls per unit (i.e. units with two or more bedrooms).

2. At least one of the stalls must be located within an enclosed garage or carport for residential uses with 4 or fewer dwelling units.
 3. When the residential use includes 10 or more parking stalls, except in the downtown area as defined in **Figure A-2** and for structured parking garages, at least 10% of the total parking stalls on the site must be unassigned stalls which are available for the use of visitors, shall not be in tandem, and do not count towards the total parking required after all parking reductions are applied.
- H. Each parking and loading stall shall have adequate drives, aisles and turning and maneuvering areas for access and usability.
- I. Parking and loading facilities accessed from a low volume, high volume, or temporary driveway approach shall be surfaced and maintained with asphaltic concrete or other permanent hard surfacing material sufficient to prevent mud, dust, loose material, and other nuisances. Materials may allow for infiltration of stormwater but must be included as impervious cover. For lots at least one acre in size, gravel surfacing is permitted for a single-family residence. With the approval of the City Transportation Engineer or applicable Director gravel surfacing may be permitted in other locations when deemed necessary to protect trees.
1. In such cases, the gravel surfacing must be limited to parking stall areas within the critical root zone of the trees and must be confined by curbing or other barriers to prevent it from being carried into public roadways and drainageways. Gravel surfacing will not be permitted on slopes greater than 5%, within accessible parking spaces, or along accessible pathways between accessible parking and the building entry. Gravel used for parking must be crushed, angular stone, with a minimum $\frac{3}{4}$ in. aggregate size, and must be included as impervious cover.
- J. Safety barriers, fencing, wheel stops, curbs or other restrictive barriers and directional markers shall be provided to assure safety, efficient utilization, protection to landscaping and to prevent encroachment onto adjoining public or private property.
- K. No more than 10 percent of all the stalls should be located in the service areas at the rear of shopping centers and other locations with poor pedestrian access to the building entrances.
- L. Visibility of and between pedestrians, bicyclists and motorists shall preserved when circulating within a parking facility and when entering and exiting a parking facility. Landscaping and other objects within the parking lot shall remain outside of the visibility sight triangle. Refer to **Section 3.4.2.1.1** for sight triangle criteria.
- M. At least 40% of the required parking stalls at land uses with fueling stations shall be stalls which do not abut air, water, or vacuum facilities.
- N. Design speed for internal circulation routes in parking lots or structures shall be 10 mph or less and accommodate a SU-40 design vehicle for all turns.
- O. Parking bays (rows of parking spaces separated by parking tree islands) shall be no more than 200 ft in length or 20 parking stalls long, whichever is less. Cross-aisles or turnarounds should be provided in order to avoid long dead-end aisles. This criteria does not apply to structured parking.

- P. End islands should be used to delineate primary traffic aisles and to protect cars parked at the end of parking bays from turning vehicles. Concrete islands in lieu of painted areas should be provided in order to prevent vehicles from parking in such areas and thereby obstructing sight distance triangles. Refer to **Figure 9-7** for perpendicular parking and **Figure 9-8** for angled parking end island configurations. This criteria does not apply to structured parking.
- Q. Accessible parking stalls shall meet current PROWAG and Texas Accessible Standards (TAS).
- R. Accessible parking stalls shall be located on the shortest accessible route of travel from adjacent parking to an accessible building entrance. Accessible parking stalls shall be dispersed among the various types of parking facilities provided. In parking facilities that do not serve a building, accessible parking stalls shall be located on the shortest route to an accessible pedestrian entrance to the parking facility. Where buildings have multiple accessible entrances with adjacent parking, accessible parking stalls shall be dispersed and located near the accessible entrances.
- S. Parking spaces within an automotive repair facility or service station may be counted as required parking spaces as long as they are independently accessible.
- T. Traffic control signs and marking used in parking areas, except for structured parking garages, must conform to the latest edition of the **Texas Manual for Uniform Traffic Control Devices (TMUTCD)**.
- U. If a site is located along a Corridor, as defined in the **LDC**, off-street parking shall not be placed between the building façade and the Corridor per **LDC**.
- V. Refer to the **LDC** for landscape requirements in parking lots.
- W. Refer to **LDC** for the required number of accessible parking stalls for a site.
- X. Refer to the **LDC** for allowed use of off-site parking to satisfy off-street parking requirements.

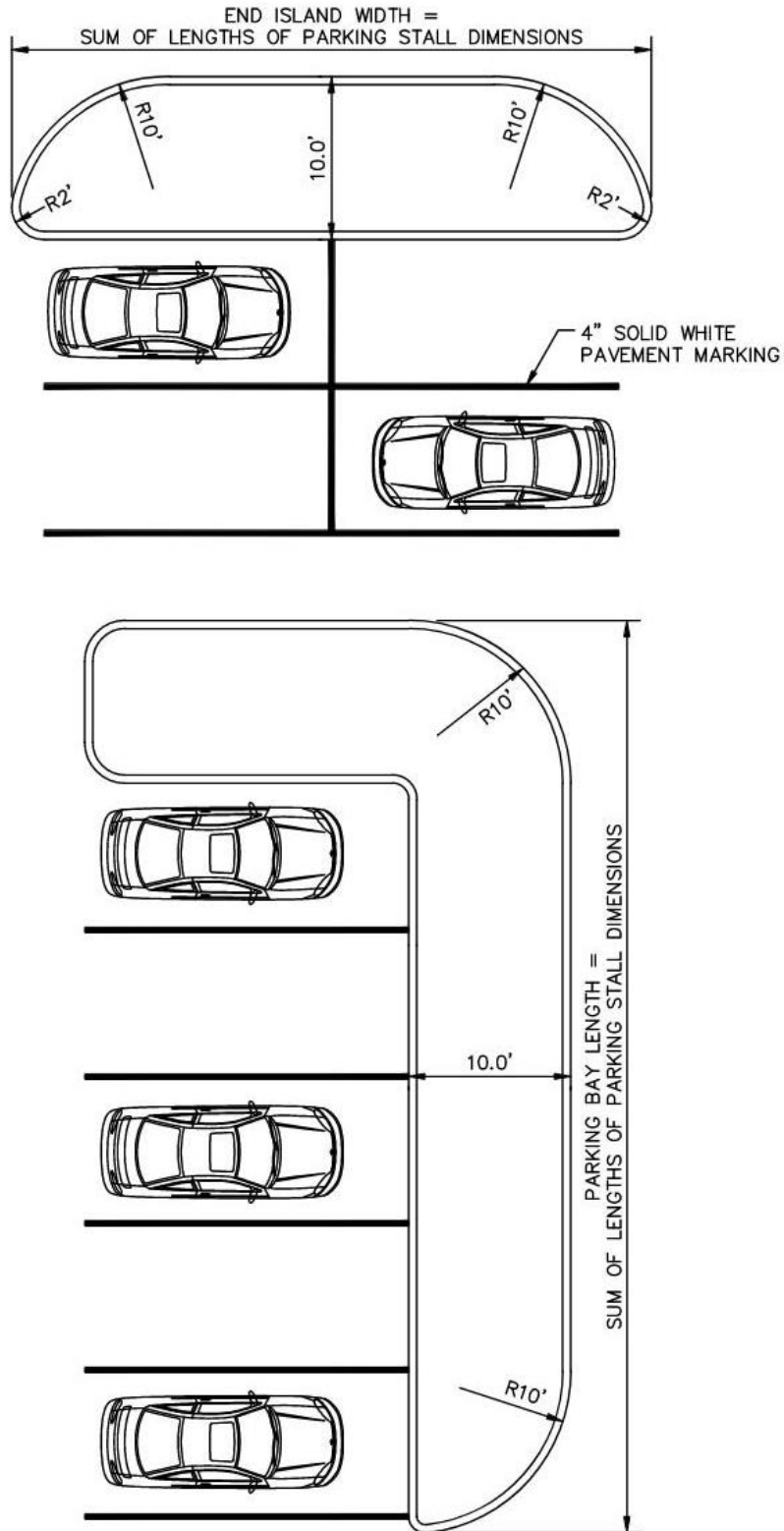


Figure 9-7 – Typical Parking Bay and End Island Geometry for Perpendicular Surface Lot Parking

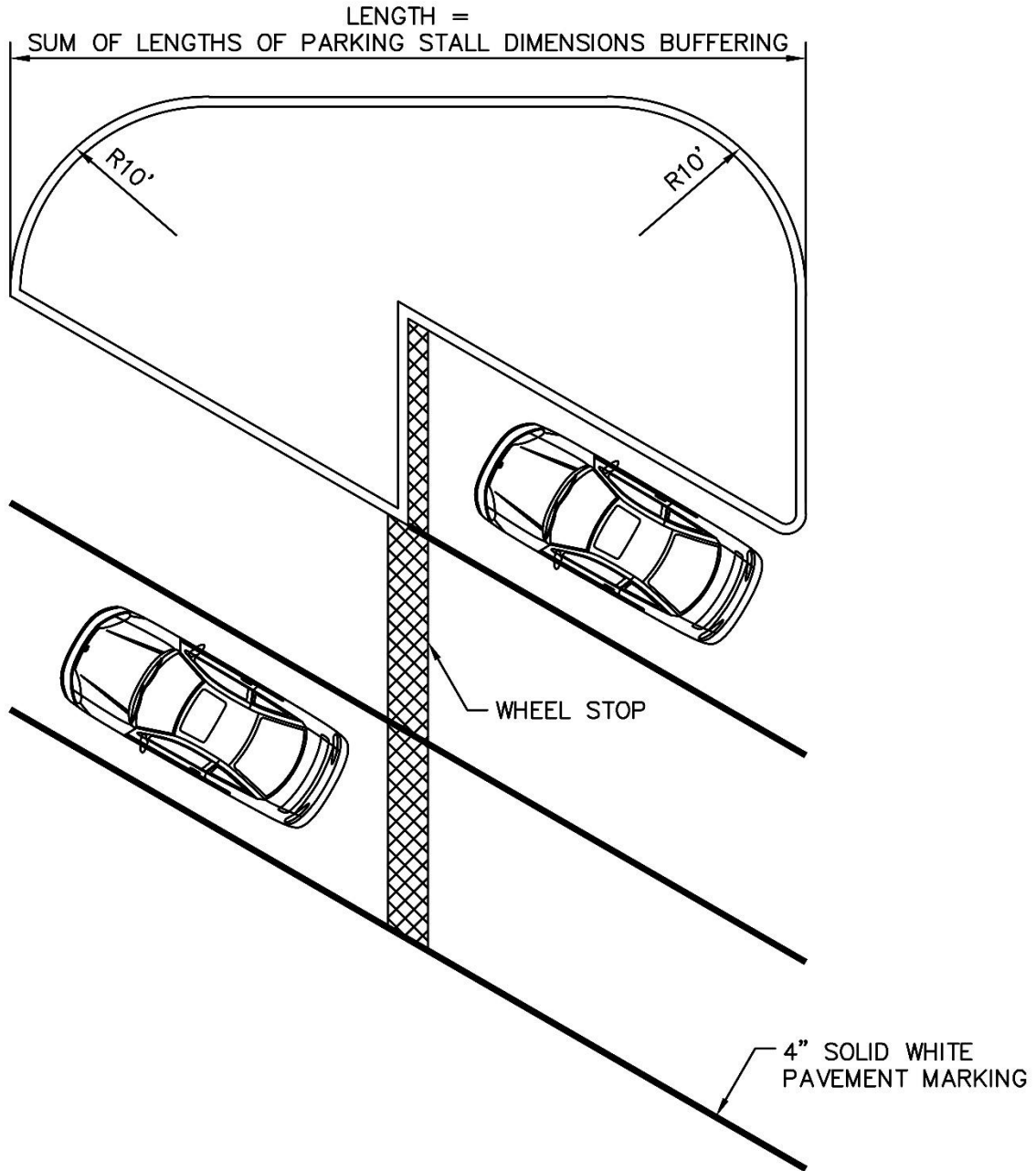


Figure 9-8 – Typical End Island Designs for Angled Surface Lot Parking

Table 9-2 – Surface Lot Parking Criteria

Angle of Parking (degrees)	Width of Stall	Depth of Stall 90° to Aisle	Width of Aisle		Module Width
			One Way	Two Way	
Standard Parking Stalls					
30	8 ft-6 in	16 ft	12 ft	-	Depth of Stall + Width of Aisle
45	8 ft-6 in	17 ft	14 ft	-	
60	8 ft-6 in	18 ft 6 in	16 ft	-	
75	8 ft-6 in	18 ft 6 in	18 ft	-	
90	8 ft-6 in	17 ft 6 in	-	25 ft	
Compact Parking Stalls					
45	7 ft-6 in	15 ft 11 in	13 ft	18 ft	Depth of Stall + Width of Aisle
60	7 ft-6 in	16 ft 8 in	18 ft	-	
75	7 ft-6 in	16 ft 6 in	18 ft	-	
90	7 ft-6 in	15 ft	-	18 ft	
Parallel Parking Stalls					
0	8 ft-6 in (Width)	22 ft (Length)	12 ft 6 in.	25 ft	-

Table 9-3 – Structured Parking Criteria

Angle of Parking (degrees)	Width of Stall	Depth of Stall 90° to Aisle	Width of Aisle		Module Width
			One Way	Two Way	
Standard Parking Stalls ¹					
30	8 ft-6 in	16 ft	11 ft	-	Depth of Stall + Width of Aisle
45	8 ft-6 in	17 ft	13 ft	-	
60	8 ft-6 in	18 ft 6 in	15 ft	-	
75	8 ft-6 in	18 ft 6 in	17 ft	-	
90	8 ft-6 in	17 ft 6 in	-	24 ft	

¹ Compact Parking Stalls per Table 9-2 may be used in Structured Parking

9.3.3 – Pedestrian Paths from Parking Areas

9.3.3.1 – Accessible Routes

- A. Refer to **LDC** for required number of accessible parking spaces.
- B. Pedestrian accessible routes are clear and unobstructed paths provided on a site that meet all Public right-of-way Accessibility Guidelines (PROWAG) as well as the current Texas Accessibility Standards (TAS). An accessible route shall be located so that a person using the route is not required to travel in a traffic lane or behind a parked vehicle (except the vehicle the person operates or in which the person is a passenger). Refer to **Section 4.1.8** for specific requirements for accessible routes.

9.3.3.2 – Pedestrian Parking Paths General Criteria

In order to provide parking facilities that are conducive to pedestrian safety, pedestrian parking paths shall be provided that do not require a person using the route to travel in a traffic lane or behind a parked vehicle

(except the vehicle the person operates or in which the person is a passenger). These can be accomplished through the use of optional landscape medians as well as providing perimeter sidewalks around the edge of a surface parking lot. These criteria do not apply to structured parking garages.

- A. A pedestrian parking path shall be provided for 50% of on and off-street parking and loading facilities. Accessible routes shall be provided to every accessible parking stall.
- B. Accessible routes terminating at a parking lot shall be accessible by every accessible parking stall and pedestrian loading zone provided in the parking lot.
- C. Accessible routes shall be shown with circulation direction arrows and limits clearly defined on all submitted site plans for review by the applicable city review department.
- D. Provided accessible routes shall be clear to all individual users of a parking lot. The accessible route shall be a clear path for exiting the parking lot. If the route is not clearly identified and recognizable to all individuals exiting the parking lot, it shall be identified using pavement markings and signage at the discretion of the applicable city review department.
- E. Accessible routes serving accessible parking stalls shall be clearly marked with the use of cross hatched pavement markings. The extents of the route from the accessible parking to the termination at the accessible elements on the site shall be delineated with cross hatched pavement markings. Refer to **Figure 9-9**.
- F. Accessible routes serving accessible parking stalls shall be placed along one side of the accessible parking stall to allow the unobstructed loading and loading of passengers. Refer to **Figure 9-9**.
- G. Bike paths shall not be used as an accessible route.
- H. Pedestrian parking paths that do not serve accessible parking spaces may be composed of alternative surface materials that are not smooth or ADA compliant such as crushed granite.

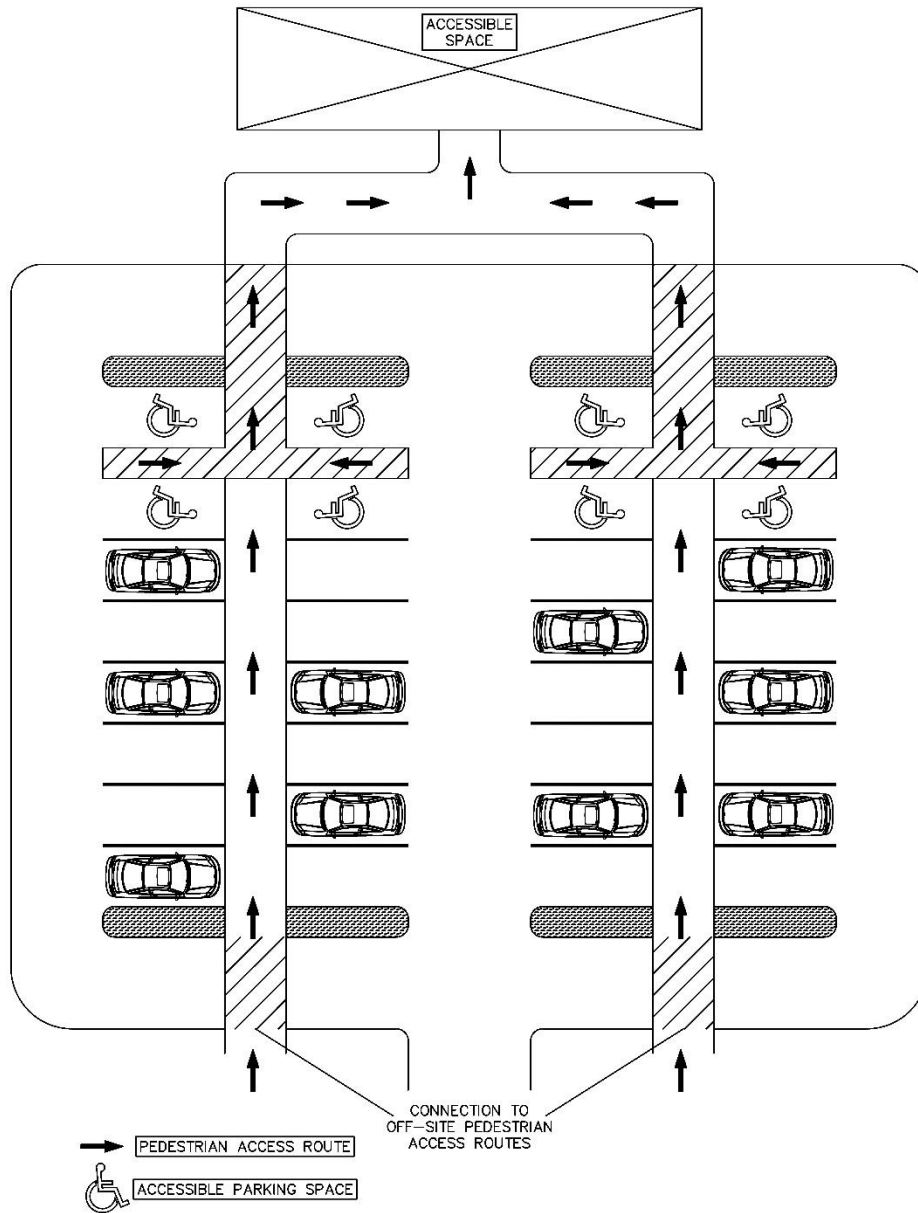


Figure 9-9 – Desired Pedestrian Parking Paths Layout

9.3.3.3 – Design Strategies

The criteria set forth in this Section shall be followed for all design of pedestrian parking paths. Listed below are several design strategies that shall be evaluated to counteract negative conditions affecting pedestrian safety along pedestrian parking paths. These strategies shall be evaluated for existing conditions as well as conditions that are forecasted to occur after parking is open for operation.

9.3.3.3.1 – Raised Crosswalks

In parking lots with commercial or retail land uses where internal circulation routes do not encounter a stop sign for distances of 200 ft or greater, raised crosswalks shall be used to cross the internal circulation lanes to improve the visibility of pedestrians and slow down traffic.

9.3.3.3.2 – Pavement Markings

Where pedestrian parking paths cross internal circulation lanes, crosswalk markings shall be used that are high visibility continental or “ladder” style and be accompanied by pedestrian crossing warning signs per the TMUTCD, latest edition. By outlining the pedestrian path within the parking lot, pedestrians can be deterred from walking directly in areas that experience high vehicle conflicts.

9.3.3.3.3 – Create Buffers

In parking lots that experience high turnover of vehicles and high volumes of traffic, providing the pedestrian route between parked cars creates a natural buffer between moving vehicles and pedestrians. Pedestrian routes shall be placed between rows of parking stalls that are back to back wherever possible.

9.3.3.3.4 – Illumination

Lighting within parking lots shall be placed and oriented to provide the highest lighting intensity at conflict points between pedestrians and vehicles and at marked crosswalks.

9.3.4 – Queuing & Internal Circulation Routes

9.3.4.1 – Queuing

Adequate storage space shall be provided for queuing on-site in order to prevent queues spilling into the right-of-way. Queuing area requirements for drive-through facilities are as follows:

- A. Queuing spaces or queuing areas shall be designed in accordance with the following criteria for uses and as required by **LDC**.
- B. Queue spaces or queuing areas may not interfere with parking spaces, parking aisles, loading areas, internal circulation, or driveway access.
- C. Each queue space shall consist of a rectangular area not less than 10 ft wide and 25 ft long with a vertical clearance as specified in the **Building Criteria Manual**. Queue spaces are not interchangeable with parking spaces.
- D. A 12 ft by-pass lane may be required adjacent to queue lines to allow vehicles an opportunity to circumvent the drive-through activity and exit the site.
- E. Queue areas and drive-through facilities shall be clearly identified with the appropriate signing and marking.
- F. Queuing areas for service station islands and fuel dispensing pumps shall be designed according to **Figure 9-10**. The minimum queuing requirement dimension is measured from the ends of the service island or protective bollards. By-pass lane(s) are required to provide on-site circulation. Parallel adjacent islands with 3 or more pumps on each island shall maintain a circulation aisle between queuing spaces or other obstructions. Specific requirements may vary based upon

individual site design. Consult with the City Transportation Engineer or applicable Director for specific requirements prior to site design.

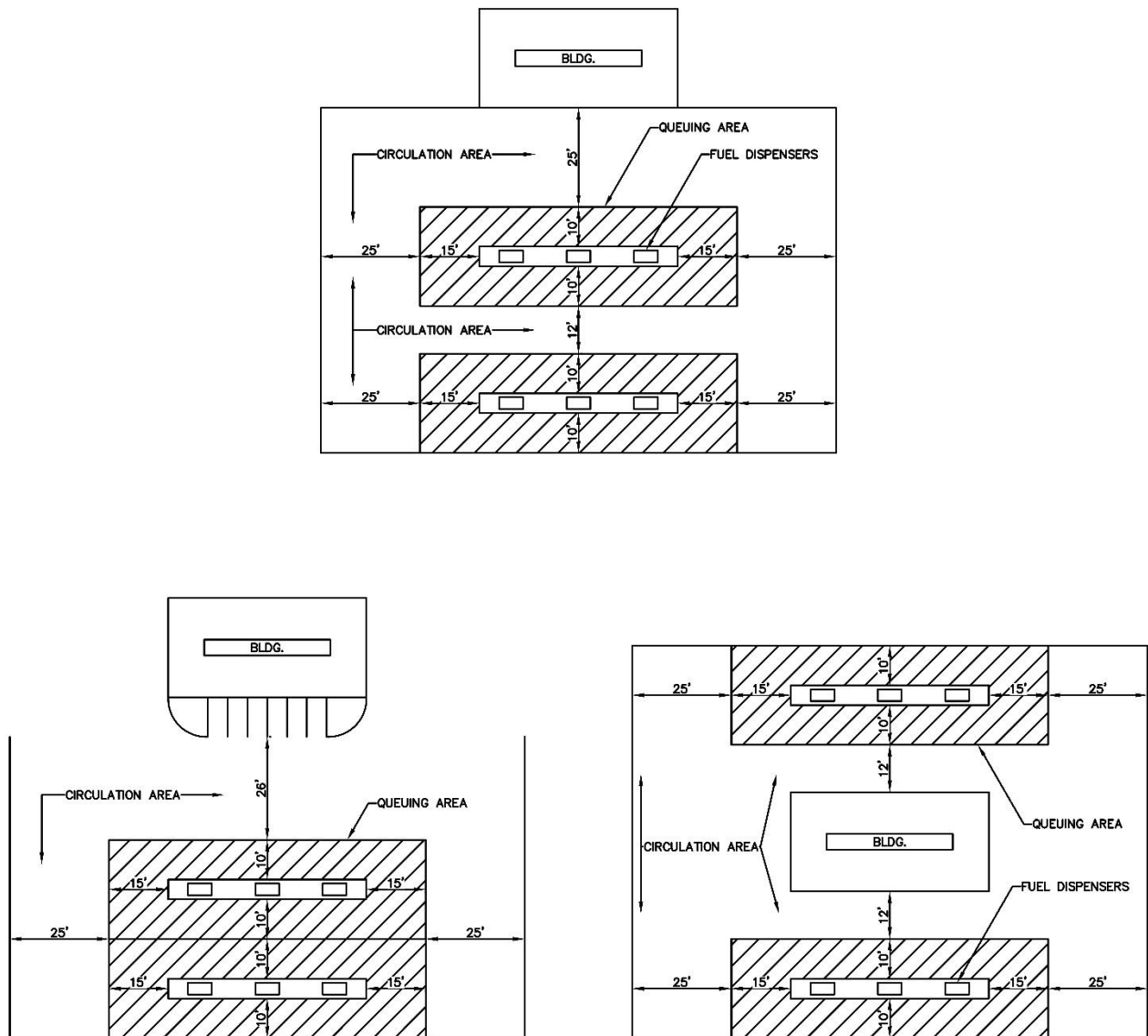


Figure 9-10 – Service Station Queuing & Internal Circulation Layout

- G. Refer to **Figure 9-11** for calculation of queue length required for a drive through facility.
- H. Refer to **Figure 9-12** for layout of queuing area and internal circulation routes on a site providing a drive through facility.
- I. School sites with a gate at school driveways must be open for drop off and pick up for 1 hour prior to the start of the earliest class until 30 minutes after the start of the latest class and 1 hour prior to the end of the earliest class until 1 hour after the end of the latest class.
- J. The provided queue area on site shall be able to accommodate the peak AM or PM hour queue length for a facility. The peak queue length shall be calculated as follows, unless otherwise required

by the City Transportation Engineer or applicable Director to follow the procedure in **Section 9.3.4.1.1**:

1. Expected peak hour queue is assumed to be 10-15% of all arriving vehicles during the AM or PM peak hour, whichever generates the higher number of trips. Refer to **Table 9-4** for example calculations of queue length.
2. The 10-15% AM or PM peak hour arriving vehicle shall be calculated using the current version of the ITE Trip Generation Manual. “AM Trips In” or “PM Trips In”.

Table 9-4 – Queue Length Samples from ITE Method

Land Use (ITE Code)	Fast Food (934)	Car Wash (948)	Coffee (937)	Bank (912)	Pharmacy (881)
10% of ITE Trip Generation (AM/PM Peak)	6	2	14	6	7
15% of ITE Trip Generation (AM/PM Peak)	9	3	20	9	11

All numbers based on 10th Edition of ITE Trip Generation Manual. Use Latest Edition.

9.3.4.1.1 – Alternative Queuing Analysis

In lieu of the method identified in **Section 9.3.4.1(J)**, the expected peak hour queue shall be calculated through observation of a comparable land use and building size for 3 sites within the City Limits. Observation and memorandum documenting results shall be done by a professional engineer licensed in The State of Texas.

Once expected peak hour queue has been determined, queuing area shall be sized to accommodate the full length of the expected AM or PM peak hour queue using the following formula:

Equation 9-1 $\text{Expected AM or PM Peak Hour Queue Length} = \text{Expected Queue} \times 25 \text{ feet}$

(25 ft is the assumed space for one queued vehicle)

The following Figure 9-11 illustrates the queue length calculation concept for a straight line queue, and Figure 9-12 illustrates the queue length concept for a drive through facility type with a “building wrap-around” configuration.

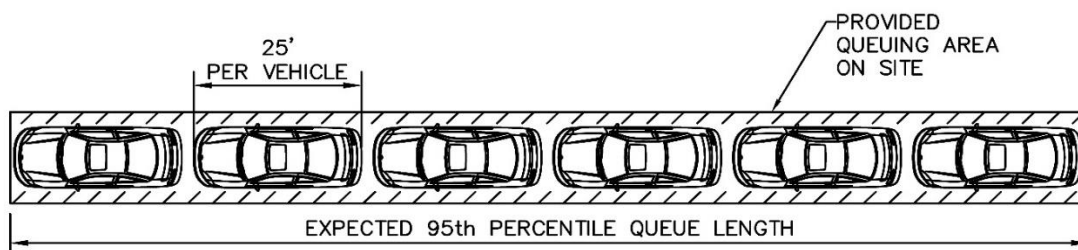


Figure 9-11 – Area for the 95th Expected Queue

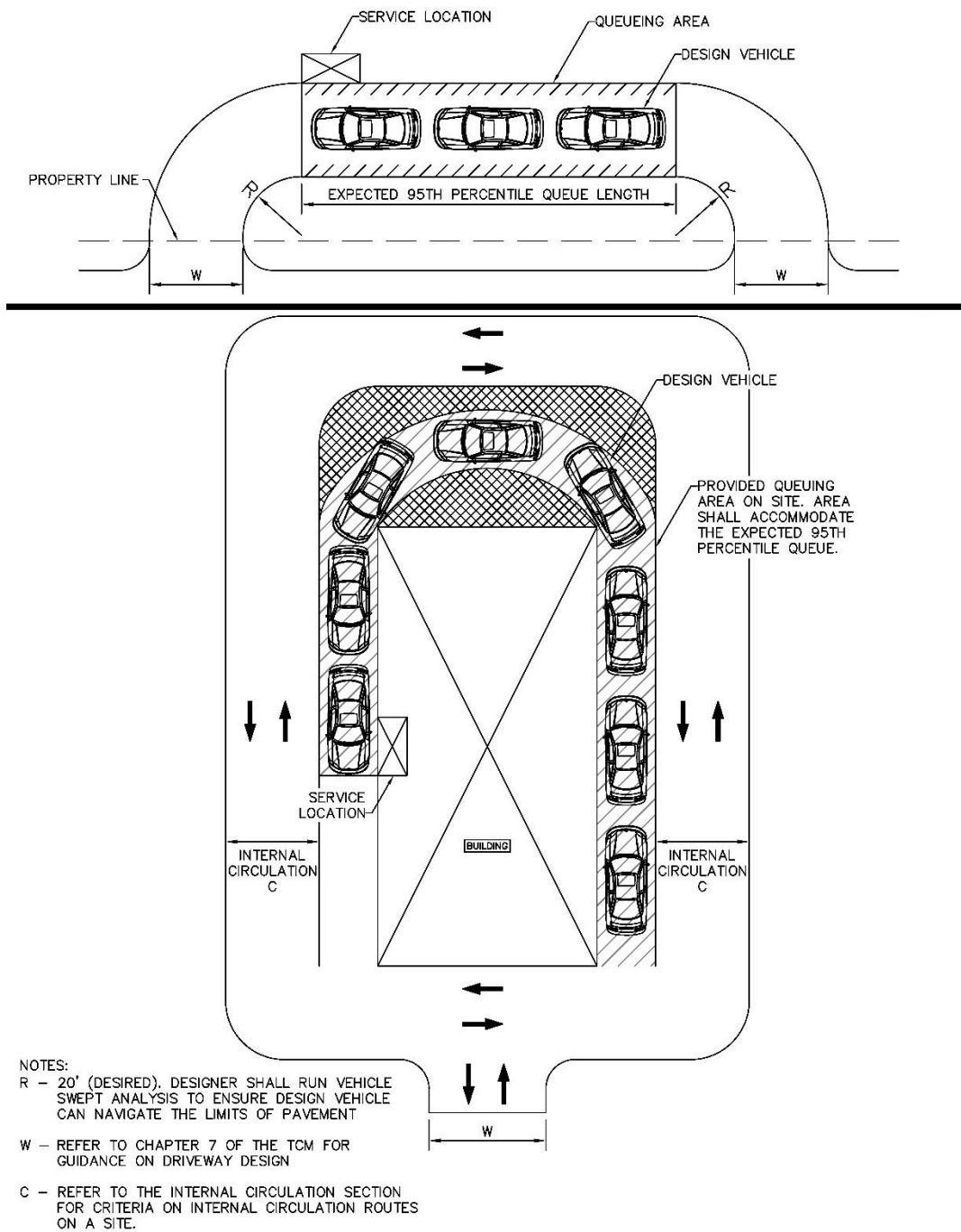


Figure 9-12 – Semicircular Drop-off Driveway & Drive Through Facility Queuing with Internal Circulation Layout

- F. All semicircular drop-off driveways shall be designed to operate in 1 direction only. **Figure 9-12** provides specific design criteria for semicircular drop-offs.
- G. All internal circulation and queuing areas must be designed to accommodate the turning radii of the vehicles that will be using the site. Design criteria are provided in **Section 3.2.1** for various design vehicles.
- H. The minimum width for an internal drive or circulation aisle with no parking is 20 ft for two-way traffic and 10 ft for one-way traffic. Additional width, up to 25 ft for two-way traffic and 15 ft for one-way traffic, may be required where traffic volumes are heavy or where obstructions or circuitous alignment necessitates a wider drive for clearance of turning vehicles. Fire Department access criteria must also be met.
- I. On-street parallel and head-in angle parking are allowed on an Internal Circulation Route, subject to compliance with fire access standards. If the Internal Circulation Route is intended to accommodate bicycles, head-in and angle parking is not permitted.

9.3.4.3 – Driveway Throat

The driveway throat is the section beyond the driveway into the site. This area of the driveway is used for storage of vehicles accessing and departing the site. The geometry of this area is highly dependent on the access capacity the property requires. The components that make up the driveway throat can be found in **Figure 7-4** and are explained in greater detail in the sections that follow.

9.3.4.3.1 – Throat Storage Length

The throat storage length for high volume access driveways is directly related to the number of parking spaces accessible by the driveway. To determine the throat storage length, the total number of parking spaces shall be divided by the number of driveways and refer to **Table 9-5**. The calculation shall be used on the proposed number of parking stalls for an overall development or the number of parking spaces for an individual lot, whichever provides the more conservative ratio of parking stalls to driveways. This will ensure all departing cars can be stored adequately while waiting to exit the site.

Table 9-5 – Minimum Throat Storage Length

Parking Spaces Per Driveway	Storage Required (ft)			
	Multi-Family or Commercial Land Use		Industrial Land Use	
	Left Turn Allowed			
	No	Yes	No	Yes
<25	25	25	25	25
25-50	25	40	25	40
51-100	25	40	40	40
101-200	40	80	40	60
More than 200	100	150	40	100

- A. Throat length is measured from the property line to an interruption point.
 - 1. An interruption point consists of the first intersecting aisle, internal driveway, or parking stall.

- B. For minor driveways that do not access a parking lot, the length of the driveway must fully incorporate the length of one parked vehicle or 20 ft.
- C. For sites with structured parking, the throat length may be reduced to 0 ft if queuing areas are demarcated to prevent turning conflicts for queued vehicles.

9.4.0 – Loading Zones

Loading zones are defined as spaces used to load and unload pedestrians, goods serving public and private properties, and waste materials. These areas must include proper signage and pavement markings to clearly define the limits of the loading zone and convey the required use of space to all users of the public right of way.

9.4.1 – Off-Street General Loading Requirements

Refer to **LDC** for requirements for off-street loading facilities. If requirements of the LDC are in conflict with these criteria, the LDC supersedes these criteria. Additional design criteria are provided in the remainder of this subsection.

- A. Each off-street loading zone shall consist of a rectangular area not less than 12 ft wide and 25 ft long, with a vertical clearance of not less than 15 ft.
- B. Loading area dimensions – shall be based on the design vehicle, which is the vehicle with the predominant use.
 - 1. Loading Stall Length = loading vehicle length plus 5 ft clearance
 - 2. Loading Stall Width = 2 ft clear on either side of vehicle, minimum 12 ft.
- C. Freight loading and trash collection facilities should be designed and located to minimize intermixing of truck traffic with other vehicular and pedestrian traffic on site. Such facilities shall be located off the main access and parking aisles and away from all pedestrian corridors, except for commercial alleys.
- D. Maneuvering areas for loading facilities shall not conflict with parking spaces or with the maneuvering areas for parking stalls. Public right-of-way shall not be used for maneuvering. All maneuvering shall be contained on-site.
- E. Rear-loading freight docks are preferred to side-loading docks. For such rear-loading docks, truck circulation patterns and dock positions should be designed for left-side, back-in maneuvers to allow for better driver visibility. The apron space should be adequate to allow the truck to back and pull-out in 1 maneuver. Where semitractor/trailer combinations are expected, the critical maneuvering and circulation areas shall be designed to accommodate trucks with a WB-62 design, except for the Downtown Austin Area as defined in **Figure A-2**, where a WB-40 truck design may be used. SU-40 truck design may be used for design via an administrative variance if loading is restricted to this type of vehicle or smaller.
- F. Land uses where fuel is dispensed must provide an adequate maneuvering and unloading area for fuel delivery vehicles. Such facilities or areas shall be designed to enable trucks to deliver fuel without interfering with on-site parking, queuing areas, internal circulation, or driveway access.

- G. For sites meeting the requirements for off-street loading in **LDC** with greater than 100,000 square ft of gross floor area, one of the following shall apply:
1. An analysis shall be performed by an engineer licensed in the State of Texas as part of a Transportation Impact Analysis, per **Section 10**, if required per **LDC**, to determine the number of required loading spaces based on arrival schedules for deliveries to the site. The amount of loading spaces provided shall ensure that adequate spaces exist for the peak loading times.
 2. If a Transportation Impact Analysis is not required, then loading spaces shall be provided per the **LDC**.
- H. Loading spaces may be shared by multiple land uses or a single building as a common loading space if the City Transportation Engineer or applicable director determines that the loading space can adequately serve each use.
- I. Common loading zones, which are shared by several properties along the corridor shall be provided whenever loading zone demand allows. Maximum frontage that may share a common loading zone shall be limited to 600 ft of shared frontage between adjacent properties.

9.4.2 – On-Street Loading

This section defines criteria that shall be followed for on-street loading zones. On-Street loading zones shall not be allowed without applicable staff approval and a waiver. There will be no compensation for the removal of on-street loading. On site loading zones shall be provided unless applicable staff determine it is not feasible and allow for on-street loading or shared loading zones with adjacent sites.

9.4.2.1 – Types of On-Street Loading Zones

- A. Commercial – for commercial service delivery vehicles that meet the definition in **Chapter 12-5-5 of the City Code**. These zones are limited to 30 minutes. These are allowed on Level 0, 1, 2, and 3 streets in designated loading spaces. Time limits for loading shall be signed for these spaces and conform to City of Austin Standards and be approved by the City Traffic Engineer, applicable director, or their designee.

9.4.2.2 – On-Street Loading Zone General Criteria

- A. Loading zone widths shall be a minimum of 8 ft, if placed adjacent to on-street parking stalls they shall be the same width. Loading zone spaces shall be a minimum 25 ft in length.
- B. Passenger loading zones shall comply with all Public Right-of-Way Accessibility Guidelines (PROWAG) as well as the current Texas Accessibility Standards (TAS). If a loading zone is desired for an adjacent land use, additional right-of-way must be dedicated by applicant to accommodate access aisles and curb ramps provided for access to spaces.
- C. Wherever Level 0 Streets are behind a site, loading activities may take place on the Level 0 Street with applicable waiver.
- D. An accessible pedestrian path per Section 9.3.3, compliant with PROWAG and TAS shall be provided between the site and loading zone.

9.4.2.3 – On-Street Loading Zone Placement

Loading zones shall be clearly marked and identified within the right of way. This ensures that all users of the right of way can clearly differentiate between loading and non-loading zones. The criteria below shall be followed for the placement of on-street loading zones.

9.4.2.3.1 – Curb Side Loading Zone Placement Criteria

- A. The loading zone shall be placed outside of the adjacent moving lanes of traffic. Where on-street parking is present, loading areas can be created by restricting the parking in these areas.
- B. Loading zones shall be placed at the start or end of on-street parking stalls along the street if applicable.

9.4.2.3.2 – Loading Zone Placement in Relation to Bike Lanes

- A. Loading zones shall not be placed within the limits of a designated bike lane. Bike lanes shall remain clear of obstructions as not to require bike lane users from maneuvering into traffic lanes.
- B. If approved, loading zones shall be placed between vehicular travel lanes and bike lanes.

9.5.0 – Shared-Use Parking

Shared-use parking shall be applied for and evaluated through a Transportation Demand Management (TDM) Plan as a component of such studies required for site development. For applicants desiring to reduce off-street parking or loading requirements through shared-use parking on a site which does not require a TDM Plan, the applicant may submit a TDM plan for the site per the procedures identified in **Section 10** of this manual.

9.5.1 – General Requirements

9.5.1.1 – Site Plan

All requests for shared parking must be accompanied by a site plan and include sufficient information to identify the type and intensity of the uses which are proposing to share parking.

For projects which are subject to site plan review only because of a request for shared parking, the City Transportation Engineer or applicable Director may modify the normal site plan submittal requirements if some material is determined to be unnecessary.

9.5.1.2 – Ownership

When first approved, the shared parking facility must be under common ownership or under the control of a single site plan. All requirements and conditions imposed upon the shared parking facility shall be listed on the site plan and shall be binding upon all subsequent purchasers.

9.5.1.3 – Time of Submittal

All requests for shared parking must be submitted in writing at the same time as an application for site plan review. For Commission-approved site plans, any supplemental information required by the staff in order to complete the review must be submitted at least 18 working days prior to the date on which the project is scheduled for consideration by the Planning Commission.

9.5.1.4 – Review Criteria

All requests for shared parking shall be reviewed by the City Transportation Engineer or applicable Director in accordance with this Section or applicable requirements of a TDM Plan in **Section 10**. The City Transportation Engineer or applicable Director shall determine whether shared parking is feasible at the proposed site and specifying the reasons for approval or disapproval.

9.5.2 – Suitable Applications of Shared Parking

9.5.2.1 – Uses

The project must contain at least 2 of the following uses which are functionally and physically related:

1. Office
2. Retail
3. Restaurant
4. Cinema
5. Residential
6. Hotel
7. Cocktail Lounges
8. Religious Institutions
9. Recreational
10. Financial Institutions
11. Public Primary or Secondary Educational Facility

For projects which: 1) contain other land uses or 2) have operating hours which do not overlap, shared parking may be considered if the applicant furnishes reliable data signed by a professional engineer registered in the State of Texas or other state-licensed professional with training or experience in the design of parking facilities and/or shared parking documenting: 1) the appropriateness of shared parking in similar situations or 2) modifications to the ULI methodology. Nevertheless, site plan characteristics, public transit availability, adequacy of roadways and access, the methodology in **Section 9.5.3**, the design strategies in **Section 9.5.4** below and the land uses selected are the primary variables used in determining the appropriateness of shared parking.

9.5.3 – Methodology

9.5.3.1 – Responsibility

The preparation of a proposal for shared parking shall be the responsibility of the applicant. A preapplication consultation with Transportation Review staff is encouraged. A shared parking proposal must be prepared by a professional engineer registered in the State of Texas or other state-licensed professional with training or experience in the design of parking facilities and/or shared parking.

9.5.3.2 – Analysis Methodology

A proposal for shared parking shall be based upon the current edition of Urban Land Institute's (ULI) "Shared Parking" Report or upon other methodologies approved by the City Transportation Engineer or applicable Director. Applicants should refer to the Shared Parking report for a complete discussion of the variables analyzed. Any methodology other than the ULI procedure shall be thoroughly documented in a similar level of detail by a professional engineer registered in the State of Texas prior to review of the parking analysis by the staff. The City Transportation Engineer or applicable Director shall determine the appropriateness of other methodologies for each specific application.

9.5.3.3 – Total Parking Reductions

Regardless of the methodology, City of Austin parking requirements contained in **LDC** shall be the minimum acceptable rates for calculating peak parking requirements for each use. Refer to **LDC** for criteria on allowable reductions to the parking requirement for a site before performing a shared parking plan or TDM Plan including shared parking. Reductions in the total parking requirement may be made to reflect different hours of operation; different hourly, daily, or monthly peaks; interaction among land uses; or incentives for use of transit or carpooling, as outlined in ULI "Shared Parking Report".

9.5.4 – Shared Parking Plan Requirements

The following are required to be demonstrated as part of a plan designating parking spaces for shared use between different land uses.

9.5.4.1 – Distribution of Spaces

All shared parking facilities shall be accessible to all land uses and adequately distributed on the site to provide the required parking for any use within the site. To be considered shared parking, an accessible pedestrian route per the provisions of PROWAG and TAS must be provided from parking to all land uses.

9.5.4.2 – Reserved Spaces

Parking stalls which are reserved for employees or other individuals shall not be included in shared parking unless hours of use are such that parking is available for others to use at different hours.

9.5.4.3 – Fees and Access Controls

Any parking fees and any access controls to a parking area (such as gates or attendants) shall be identified in the shared parking plan.

9.5.4.4 – Hours of Operation

For projects using the ULI report, the hours of operation shall be consistent with the ULI peak hour methodology.

9.5.4.5 Accessible Parking

Spaces designated for accessible use shall be provided in a quantity equal to the sum of the minimum requirements for each individual use in the mixed-use development as set forth in the **LDC**. Accessible parking stalls may not be included in parking stalls designated as shared.

9.5.5 – Shared Parking Plan Revisions

9.5.5.1 – Change in Uses

After a shared parking facility has been approved, any subsequent change, addition, or deletion in the type or intensity of the original mixed land uses which results in an increase in the parking requirement shall require an updated shared parking plan or TDM plan demonstrating accommodation of the increased parking demand as part of the change in use. No certificate of occupancy for the new or changed uses shall be issued without site plan approval for the revised shared parking facility or, absent such approval, the provision of sufficient parking stalls to match the sum of the minimum requirements for each individual use.

9.5.5.2 – Change in Operations or Design

After a shared parking facility has been approved, any subsequent change in operations affecting hours of operation by a change of 1 hour or more or design impacting accessible routes or use of parking stalls deviating from the plan, shall require administrative approval by the City Transportation Engineer or applicable Director. In approving such revisions, the City Transportation Engineer or applicable Director must determine that the circumstances and conditions applicable at the time of the original approval remain valid, and that the changes would not affect the suitability of the site for shared parking. The City Transportation Engineer or applicable Director will determine submittal requirements for each revision based upon the nature of the change requested.

9.5.6 – Monitoring

In order to ensure adequate parking capacities and establish a database for better evaluating the adequacy of shared parking, all projects approved for shared parking will be required to conduct a follow-up evaluation of the actual utilization of the parking facility. Such an evaluation shall be signed by a professional engineer registered in the State of Texas or other state-licensed professional with training or experience in the design of parking facilities. The study shall be performed in accordance with standards established by the City Transportation Engineer or applicable Director, as outlined in this section. The evaluation shall be conducted following completion and occupancy, of the project within a time period specified at the time of approval, depending on phasing, project size, occupancy and utilization. The study shall take into account any variations due to building occupancy rates and hourly, daily, or monthly peaks in parking utilization.

In the event that the evaluation is not submitted within the agreed-upon time frame or identifies a deficiency in the number of parking spaces needed to satisfy the demand, the City Transportation Engineer or applicable Director will notify the owner that no additional permits will be issued for changes in occupancy until the parking supply is brought into compliance with the demand. The owner may correct the deficiency through provision of additional parking spaces, a change in the tenant mix, changes in the operating hours or use of other strategies approved by the City Transportation Engineer or applicable Director.

9.5.6.1 – Procedures for Monitoring of Shared Parking

A follow-up evaluation of an approved shared parking application shall contain the following elements:

- A. A site plan including an inventory of all parking provided on the site, identifying the quantity of stalls in each parking area.

- B. An inventory of all uses on the site as shown on the site plan, identifying gross square footage of floor area, type of business, normal operating hours, and any unoccupied floor space at the time of the inventory.
- C. An hourly count of all vehicles parked on the site, beginning one hour before the earliest opening hour of a business within the project and ending one hour after the latest closing hour, with the condition that no counts need be taken before 6:00 a.m. or after 12:00 midnight. To substantiate the peak day, these counts must be taken on three different weekdays and on one Saturday as specified by the City Transportation Engineer or applicable Director. Counts must not be taken on days with inclement weather. The data must identify the number of vehicles which are illegally parked outside designated parking stalls (within right-of-way, in aisles, in loading zones, etc.).
- D. Documentation of any existing transit usage or ridesharing programs.
- E. Adjustment of the empirical data to represent the peak hours, days, and months, using the factors contained in the current edition of the Urban Land Institute's Shared Parking report, as well as compensation for transit usage. Adjustments for internal capture or auto occupancy may be made only if supported by empirical data.
- F. An assessment of the adequacy of the available shared parking at the peak periods identified in the Shared Parking report for the uses contained in the project.
- G. Recommendations for addressing any deficiencies identified in the parking supply.

9.6.0 – Calculation of Parking Requirements

The final parking requirements on a site shall be determined by the **Land Development Code** and any applicable reductions allowed for through a TDM plan or shared parking analysis, per **Section 9.5.0** and shall comply with the criteria outlined in this manual. **LDC** establishes parking requirements for all land uses based on the applicable zoning in the City of Austin. **LDC** establishes parking reductions allowed for within the City of Austin. In addition to **LDC**, a TDM Plan, described in **Section 10** of this manual, may further reduce parking required on a site. Maximum parking allowed for specific zoning is calculated prior to any applicable parking reductions in the **Land Development Code** or this manual.

9.6.1 – On-Street Parking Counted Towards Parking Requirement

The minimum off-street parking requirement shall be reduced by one stall for each on-street parking stall located adjacent to the site in a public street right-of-way. Refer to **Section 9.2.0** for on-street parking criteria. On-street parking counted towards parking requirements remain open to the public and may not be reserved for sole usage of the adjoining development. The adjacent on-street parking may be removed at any time for any reason and the developer counts the spaces at their own risk.

9.7.0 – Parking Lifts

9.7.1 – Parking Lifts Types

- A. A mechanical lift or vehicle elevator is defined as an automated mechanism that lifts parked vehicles to create additional parking space below.
- B. A robotic parking system is defined as an automated lift using an elevator system that moves vehicles from an entrance area to a separate storage area within the parking facility.

9.7.2 – Parking Lifts General Criteria

- A. Parking lifts may be used to meet the parking requirements for a site for the following land uses:
 - 1. Multifamily Residential
 - 2. General Office
 - 3. Industrial Park
 - 4. Commercial (Hotel)
 - 5. Automotive
 - 6. Institutional
- B. The location of mechanical lifts shall be located within an enclosed parking facility. All lifts and equipment shall not be visible from public view from outside of the facility.
- C. Mechanical parking lifts shall not be used for accessible parking spaces.
- D. Use of mechanical parking lifts shall be approved by the City Transportation Engineer or applicable Director prior to being installed in a parking facility. To be approved, an application shall be submitted by a professional engineer licensed in The State of Texas. Application shall include the following information:
 - 1. Operation plan, hours of operation, number of staff members for vehicle drop off and retrieval, and plan for maintenance and emergency support.
 - 2. Layout of mechanical lift placement within the parking structure and provided vehicle queueing area for stacking of vehicles during vehicle drop-off and retrieval.
 - 3. Vehicle drop-off and retrieval efficiency during the expected peak hour shall be provided.
- E. Mechanical parking lifts shall not encroach into the limits of internal circulation lanes or adjacent parking stalls.
- F. Parking lifts adjacent to parking stalls shall maintain adequate clearance from parked vehicles at all times.
- G. All parking lifts shall be designed to prevent lowering of the lift when a vehicle is parked below the lift.
- H. All mechanical parking systems, including lifts, elevators and robotic systems, must be inspected and certified as safe and in good working order by a licensed mechanical engineer at least once per year and the findings of the inspection shall be summarized in a report signed by the same licensed mechanical engineer or firm.

9.8.0 – Bicycle Parking

Bicycle parking standards ensure that required bicycle parking is easy to access, convenient and secure. The standards allow for a variety of bicycle parking facilities which may serve a wide range of uses. Bicycle parking space supply and location shall not conflict with requirements of the **LDC**. Additional measures to enhance connectivity to bicycle parking shall be provided as required by **LDC**. For detailed specifications

of bicycle parking equipment, see the **Standards Manual**. Table 9-6 specifies how to determine the amount of short- and long-term bicycle parking based on land use as a proportion of total bicycle parking required by the **LDC**.

The bicycle parking standards specified in this section refer uniquely to bicycle parking for privately owned bicycles and do not refer to shared micromobility or dockless mobility parking. Dockless mobility parking placement shall follow **Section 9.9.0** of this manual.

Table 9-6 – Short- and Long-term Bicycle Parking Spaces by Land Use

Use Classification	Percentage of Overall Required Bicycle Parking	
	Short-term bicycle parking	Long-term bicycle parking
Residential	30% - 50%	50% - 70%
Commercial		
Commercial, general	70% - 100%	0% - 30%
Business and professional offices	10% - 30%	70% - 90%
Industrial	-	-
Civic		
Civic, general	70-100%	0% - 30%
College and university facilities	60% - 80%	20% - 40%
Public or private primary and secondary educational facilities	70% - 90%	10% - 30%
Agricultural	-	-

9.8.1 – Bike Parking Locations

Bicycle parking locations and placement are split into short-term and long-term bicycle parking categories. The amount of each type of parking shall be determined based on building use and available data, including trip generation rates, employees per square footage, number of residential units, and visitation rates and in compliance with the **Land Development Code** bike parking required.

The following criteria apply to all bicycle parking:

- A. Provide enough space between bike rack locations to adequately accommodate a bicycle locked in every spot. One “U” rack provides two bike parking spots.
- B. The standard required bicycle space is 2 ft wide, 6 ft long and 3 ft 4 in. tall. See **Figure 9-14**. If larger styles of bicycles such as cargo or electric bicycles are anticipated, the design shall accommodate the footprint of these bicycles as the design bicycle (up to 3 ft wide by 10 ft long).
- C. Bike parking shall be accessible by the street and at Street Level.
- D. Bike parking locations shall be outside of the travel lanes, loading zones and bike lanes
- E. Bicycle parking may be installed in the pedestrian zone or bicycle and street edge zone wherever feasible, and if applicable, within the tree and furniture zone. Bicycle parking must allow a pedestrian path clearance per **Section 4.1.1 (A)** when bikes are locked to the racks per intended design use. The accessible pedestrian path shall meet current PROWAG and Texas Accessibility Standards (TAS). **Figure 9-15** illustrates permissible locations for bike rack placement.
- F. Bike racks may be installed parallel, perpendicular or at a 45-60-degree angle to the curb, as appropriate. **Figure 9-16** and **Figure 9-17** illustrate required bike rack spacing.

- G. When it is not possible to locate bicycle parking in the pedestrian zone, parking areas shall be separated from motor vehicle traffic with either a raised curb or bollards.
- H. Bike rack placement in the pedestrian zone shall meet permissible spacing criteria as shown in **Section 4**.
- I. Must be located in a well-lit area.
- J. Must be at Street Level. Bike parking shall not be installed on elevated sidewalks or in other topographically challenging scenarios and be accessible from the nearest bike facility.
- K. All bicycle parking shall have an accessible pedestrian path connecting bicycle parking spaces to the entrance of a development per requirements of **LDC**.
- L. If bicycle parking is provided outside of public right-of-way or easements or provided in a structured parking garage, an accessible path to bicycle parking from the site entrance shall be provided.

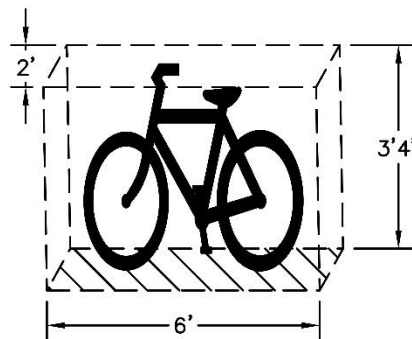


Figure 9-14 – Standard Bicycle Space

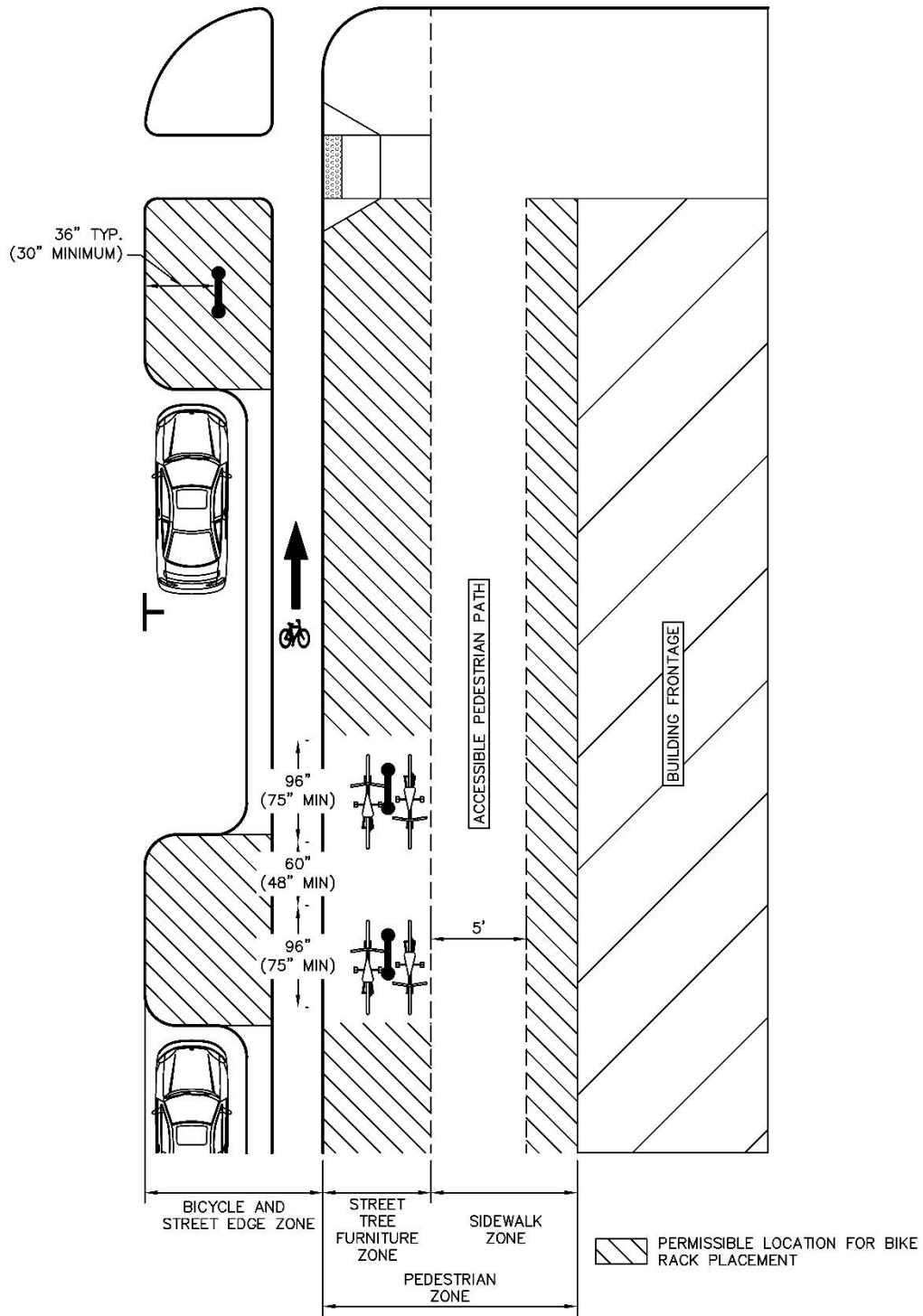


Figure 9-15 – Permissible Locations for Bike Rack Placement

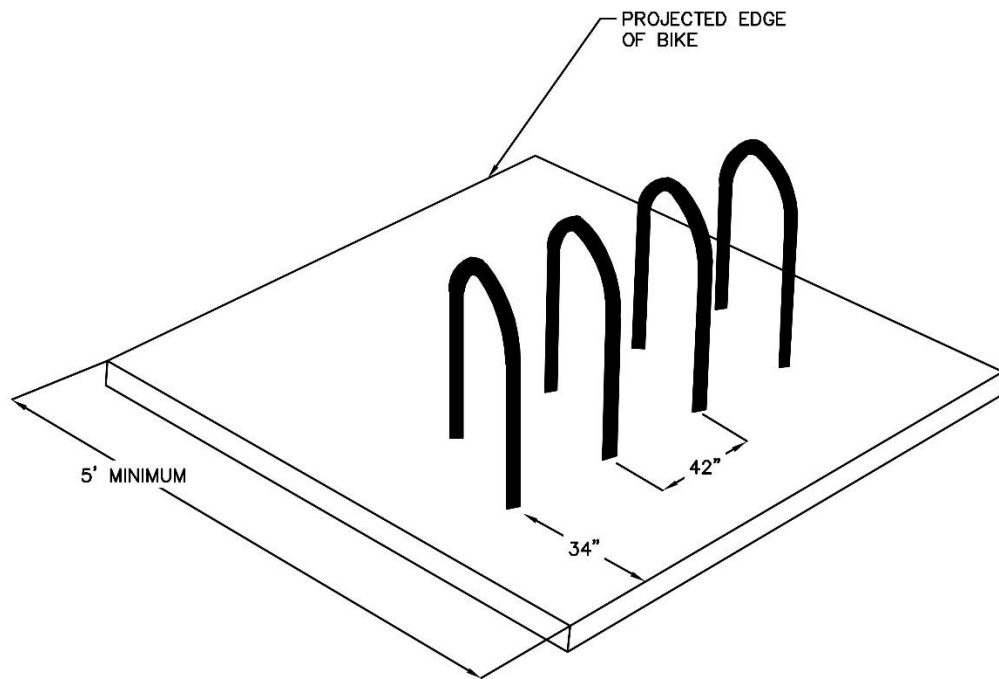


Figure 9-16 – Bike Rack Spacing (Away from Vertical Obstructions)

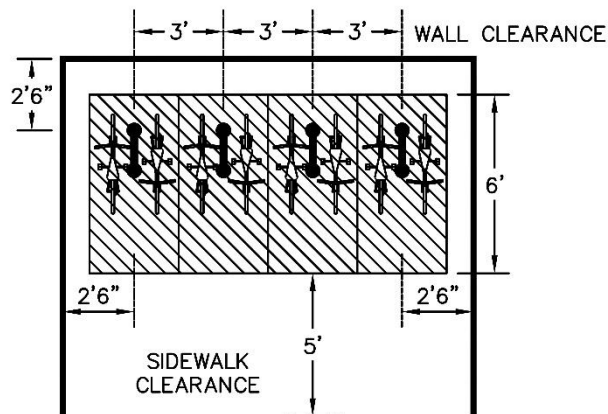


Figure 9-17 – Bike Rack Spacing (Near Vertical Obstructions)

9.8.2 – Short-term Bicycle Parking

Short-term bicycle parking serves people who park their bicycles for less than 4 hours in a publicly accessible and convenient location. This type of bicycle parking encourages shoppers, customers, patients, and other visitors to use bicycles as a mode of transportation by providing visible, convenient, and secure parking.

Required short-term bicycle parking must meet the following standards:

- A. Shall be located at ground level within 50 ft of the principal building entrance.
 - 1. For sites with more than one primary building, the required bicycle parking shall be dispersed at principal entrances of all primary buildings.
- B. Shall be publicly accessible.
- C. Shall be visible from the lobby or windows of the building.
- D. Shall not compromise pedestrian access or mobility.
- E. If possible, protected from severe weather, including full sun or rain, by existing structures, such as overhangs or awnings, or by natural elements such as tree canopy.
- F. All public entrances must have at least 2 bicycle parking spaces unless this exceeds the total requirement from the **Land Development Code**.
- G. Short-term bicycle parking is typically placed within the right of way, near the curb or near building entrances. Good bike parking placement allows for easy access to the parking by bicyclists without impeding other users of the right of way and without placing the bike or bike rack in undue risk from moving traffic. See **Figure 9-15** for permissible bike rack placement in the right-of-way.

9.8.3 – Long Term Bicycle Parking

Long-term bicycle parking serves people who park their bicycle for 4 or more hours and requires more secure parking. This type of bicycle parking encourages residents, transit users, employees, and students to use bicycles as a mode of transportation by providing secure, convenient, and weather-protected parking.

Required long-term bicycle parking must meet the following location criteria

- A. Shall be located in a secure location within 250 ft in a walked path of building entryways, or within a building, or in a covered motor vehicle parking space within 250 ft in a walked path of a Street Level entrance without use of an elevator
- B. Long-term bicycle parking must be no farther than the closest motor vehicle parking space in that location, excluding accessible parking spaces.
- C. At least 50% of required long-term bicycle parking must be provided as standard U racks or spaces on lower level of stacked bicycle parking racks that do not require lifting or upper level of stacked bicycle parking racks with lift assist. See **Figure 9-18** for example layout of a bike locker room. See **Figure 9-19** for a typical layout of a two-tier lift assist rack.
- D. All long-term bicycle parking shall be covered to provide weather-protected parking.
- E. A detail of the bicycle rack designs, locations, and accessible path must be included on site plans.
- F. Bicycle Cages and Bicycle Storage Room parking areas must be easy to access to a person walking, not carrying, a bicycle, including:
 - 1. No heavy or sprung doors that must be held open for access, and
 - 2. No stairs that would require bicycles to be lifted to access the area, and

3. No blocked or restricted areas that would be cumbersome to walk a bicycle through, for example bicycle racks, pull-out trays that block entrances, or hairpin corners, and
 4. No bicycle racks or pull-out trays that interfere with the operation of an adjacent rack, and
 5. Bicycle parking must be located in a well-lit area with a minimum average illumination level of 200 lux (recommended light levels from the US General Services Administration for public areas including stairwells, pedestrian tunnels and elevator lobbies).
 6. Provide electrical outlets for electric bicycle charging.
 7. Consider designing at least 5% of required spaces for large bicycles, such as cargo, recumbent, tandem, electric and bicycles with trailers. The larger bicycle footprint design is typically 3 ft by 10 ft.
 8. The bicycle cage or storage room may be secured by key, smart card, fob, or code access. If so, the bicycle parking area shall be accessible to designated users at all times.
- G. Mobility hubs, as defined by Capital Metro Transit Authority (CMTA), shall provide weather-protected, high security parking such as bike lockers, bike shelters or bike cages.

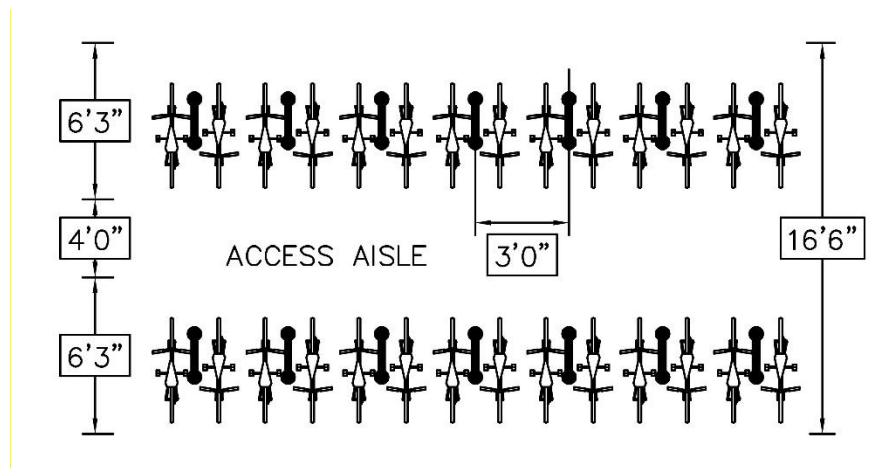


Figure 9-18 – Typical Bike Room Layout

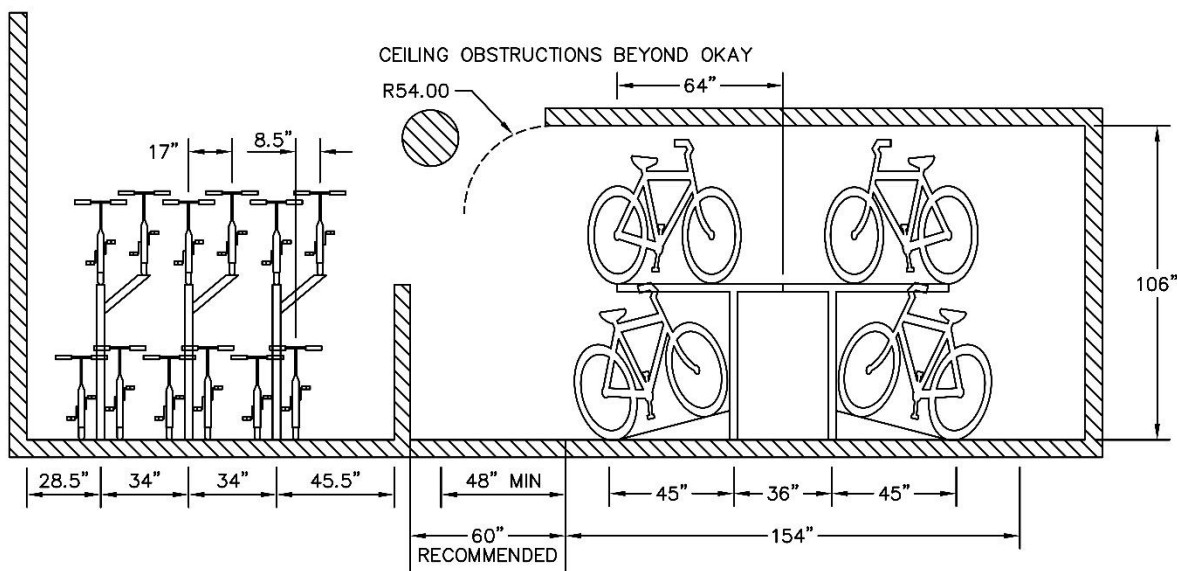


Figure 9-19 – Typical Two-Tier Lift Assist Rack Layout

9.8.4 – Bike Parking Equipment and Installation Requirements

The City of Austin hereby adopts the latest edition of the Association of Pedestrian and Bicycle Professionals (APBP) Bicycle Parking Guidelines. The following criteria apply to all bicycle parking:

- A. Bicycle racks, lockers or other parking types must be securely anchored with the appropriate fastener according to ground or wall surface material.
- B. Bicycle parking installed on concrete, such as the standard “U rack”, shall be securely anchored with tamper-resistant hardware, preferably a tri-groove security nut or a crimp anchor.
- C. Area devoted to bike parking shall be hard surfaced.
- D. If the bike rack is a horizontal rack, it shall support the bicycle at two points, including the frame of the bicycle.
- E. A detail of the appropriate bike rack shall be included on the site plan.
- F. Install bike storage structures per **City of Austin Standard Details**.
- G. Artistic bike parking may be permitted after review by applicable staff.

9.8.5 – Permissible Bicycle Parking Types

When bicycle parking is short-term parking, the following parking types shall be used:

- A. A “U rack” – an inverted u-shaped rack that provides parking for up to two bicycles. Typically, U racks are installed on concrete, in which case the tri-groove security nut is the recommended tamper resistant hardware. For specifications for the standard U rack see City of Austin **Standard Details**.

When bicycle parking is long-term parking, the following parking types, or short-term parking types, shall be used:

- A. A bike locker – a fully enclosed and secure box enclosure which can hold one individual bicycle that may be accessed with a key or code. Bike lockers may be located at transit centers, parking garages or outside of buildings. See **Figure 9-20** for bike locker typical layout. Additional specifications are included in the City of Austin **Standard Details**.
- B. Locked storage rooms and cages – include a variety of configurations where a secured room provides dedicated, shared space for high volume bicycle parking. Typical access control to these rooms or cages is with a key, keypad or cardkey. These are typically located in a private office building, multifamily residential building, or mobility hubs. Bicycle racks may be standard U racks or two-tiered, vertical racks. Two-tiered racks must include a lift assist mechanism. See **Figure 9-18** and **Figure 9-19** for examples of bike rooms and two-tier lift assist racks

When bicycle parking is non-standard bicycle parking using creative bicycle racks, applicable staff must provide approval on submitted design. Creative bicycle rack submitted designs must, at a minimum, include material and finish, dimensions, installation method including tamper-resistant hardware, and an image of the proposed design. The following additional design criteria apply to creative bicycle racks:

- A. Must be detectable by visually impaired person using cane to navigate
- B. Must not obstruct pedestrian clear width per **Section 4**.
- C. Must be lockable using a standard U-lock with the rack
- D. Must be able to rest the bicycle frame against rack at two points of contact.
- E. Minimum height of 32 in.
- F. Standard width is 20-24in, but this may be altered with applicable staff approval
- G. Advertising, such as a company name or logo, is not allowed

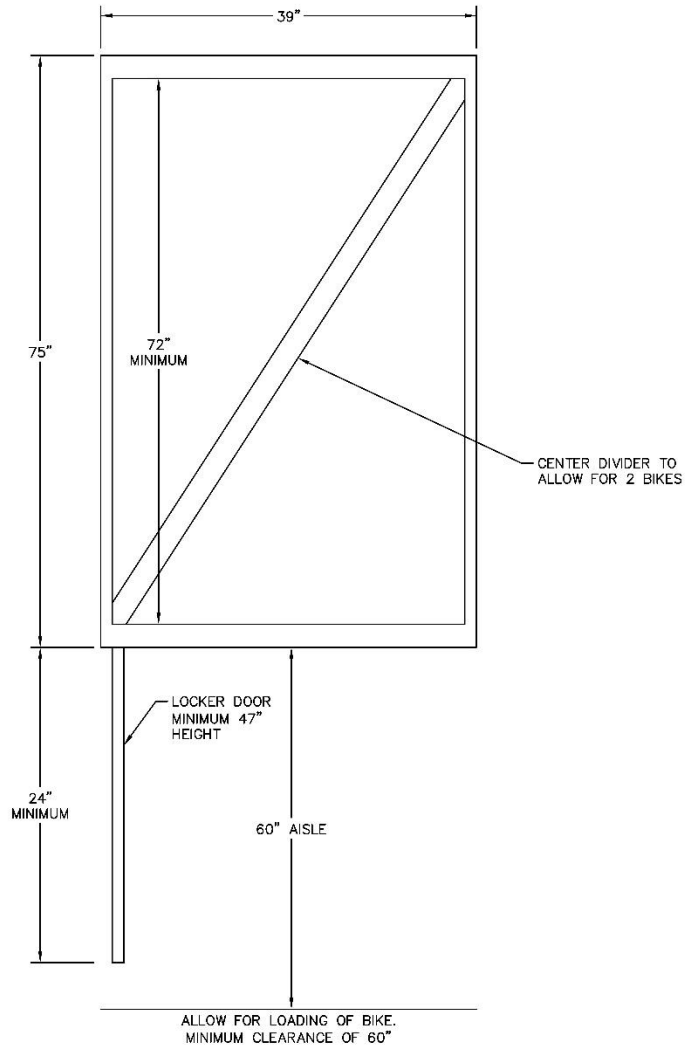


Figure 9-20 – Bike Locker Typical Layout

9.9.0 – Dockless Mobility Parking

In general, the applicable requirements of **Section 9.8.1** shall apply for placement of dockless mobility parking areas within public right-of-way or easements, maintaining an accessible path from parking to site entrances and spacing from other objects in right-of-way and easements per **Section 4.2.2** of the TCM for location of streetscape furnishings. City of Austin Standard Details should be referenced for layout and installation of dockless mobility parking areas.

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10.1.0 – General

This Section provides requirements for studying transportation impacts of a site development within the City of Austin (the City). Per the **LDC**, developments within the extraterritorial jurisdiction of Austin in Travis County shall follow established transportation requirements of **City Code Title 30** instead of this manual. Other counties within the extraterritorial jurisdiction of Austin shall follow the requirements of their respective Interlocal Agreements (ILAs).

The two primary components involved in studying transportation impacts are a Transportation Demand Management (TDM) Plan and a Traffic Impact Analysis (TIA). A TDM Plan includes a sustainable modes analysis and a determination of TDM points credits and trip reductions for vehicle travel based on proposed TDM measures. A TIA assesses impacts of new vehicle trips and identifies potential options to mitigate impacts for safety and site adjacent impacts separate from Roadway Capacity Plan improvements identified in the latest adopted Street Impact Fee Study and **ASMP**. The remainder of this Section covers requirements for TDM Plans and TIAs performed in the City of Austin, as well as their relationship to determination of proportionality of transportation improvements, right-of-way dedication and improvements, street impact fees, and transportation infrastructure mitigations in the **LDC**.

Administrative guidelines may be adopted to supplement this Section for preferences in TDM Plan and TIA submissions as well as presentation of information to meet the criteria outlined in this Section.

10.2.0 – Traffic Impact Analysis Determination

Traffic Impact Analysis (TIA) Determination shall be required of all developments. The TIA Determination shall include the following, with documentation of items A-E (if required, per **LDC**) included in development applications for an applicant submitting a site plan, or zoning change request:

- A. Unadjusted trip generation anticipated by the development, as follows:
 1. The latest edition of the Institute of Transportation Engineers (ITE) Trip Generation Manual, or;
 2. Other sources of trip generation publications, such as the National Cooperative Highway Research Program (NCHRP) Report 684, may be proposed in the TIA determination only if the trip generation information is not available in the ITE Trip Generation Manual.
 3. Trip generation counts conducted by an applicant may not be used for the purposes of TIA determination.
 4. Data related to ITE's 'dense city core' designation may not be used without review and approval from the applicable department.
- B. Determination of what traffic studies may be required, if any, to assess the impacts of a proposed development on adjacent transportation system and identify transportation mitigations to address the impacts. Transportation mitigation, defined in **LDC 25-6-101**, may be included per mitigation requirements identified in **Section 10.4.4**. If required, a traffic study would include one of the following per **Section 10.2.1**:
 1. Transportation Assessment (**Section 10.4.1.1**)
 2. Full TIA (**Section 10.4.1.2**)

3. Neighborhood Traffic Analysis (**Section 10.4.3.2**)
 4. Zoning Transportation Analysis (**Section 10.5.0**)
- C. Transportation Demand Management (TDM) Plan points goal (if > 2,000 unadjusted trips). TDM Plan Points goal is defined in **Section 10.3.4.2**.

The City will adopt a TIA Determination Worksheet (TIA Worksheet) documenting these items to aid in the administration of these criteria. An applicant or applicant's consultant shall submit a TIA Worksheet to the applicable department for review prior to beginning the scoping process for a new or updated TDM Plan and/or TIA. The TIA Worksheet shall be described in published **administrative guidelines** and include required development information for filling out the TIA Worksheet. Documentation of the above items, whether by an adopted worksheet or other means acceptable to staff, shall be signed by applicable staff. Documentation of the following may be required if a waiver is granted from performing a TDM Plan or Traffic Impact Analysis (TIA) or neither is required by the **LDC**:

- D. List of required transportation mitigation per requirements of **Section 10.4.4**, with commitment to fund or construct identified improvements. The default mitigation is to construct improvements and commitment to only fund improvements requires approval by applicable staff. These mitigations may be determined in consultation with applicable staff or through a Sustainable Modes Analysis per **Section 10.3.4.1** and shall be creditable towards the Street Impact Fee if included in the Street Impact Fee Roadway Capacity Plan. Per the **LDC**, a credit agreement must be in place for improvements or funds to be creditable towards Street Impact Fees.
- E. Measures to limit transportation demand, as well as any reporting requirements associated with measures to limit transportation demand.

Granting of a TDM Plan waiver or TIA waiver is the sole discretion of the City Transportation Engineer or applicable Director. Waivers granted for TDM Plans or TIA requirements are independent of any street impact fees for transportation improvements, as enabled by Chapter 395 of the Texas Local Government Code, per the **LDC**. Waivers granted for a TDM Plan or TIA shall not diminish the requirements of any fees established nor shall such waivers affect the roughly proportionate impact of the development on the transportation system as described in the LDC and **Section 10.4.5**.

10.2.1 – TDM and TIA Requirement

The results of the TIA Determination will determine the requirement to perform a TDM Plan and/or TIA, based on the unadjusted trips anticipated from a site in **Section 10.2.0 (A)**. Per the **LDC**, all sites are subject to a street impact fee for implementation of the Roadway Capacity Plan in the **ASMP** regardless of trip generation amount, unless specifically exempted in the **LDC**. The following criteria shall apply based on TIA Determination:

- A. If a site generates less than 2,000 unadjusted trips, no TDM Plan or TIA is required. The City may require transportation mitigation as identified in **Section 10.4.3** and any measures to limit transportation demand and reporting requirements as identified in **Section 10.3.5**. An applicant may still implement measures to limit transportation demand for reductions in the anticipated Street Impact Fee, per the **LDC**.
- B. If a site generates 2,000 or more unadjusted trips, but less than 5,000 unadjusted trips, a Transportation Assessment and TDM Plan shall be required. The City Transportation Engineer, applicable Director, or their designee may expand the scope of a Transportation Assessment to

include additional intersections as allowed for in **Section 10.4.1.2.1** for a Full TIA if substantial impacts are anticipated from site traffic at an intersection.

C. If a site generates 5,000 or more unadjusted trips, a Full TIA and TDM Plan shall be required.

The following flowchart in **Figure 10-1** illustrates the criteria established in this section for when TDM and TIA are required for developments based on their associated TIA Determination. Additional terms and requirements identified in the flowchart are further described in subsequent sections.

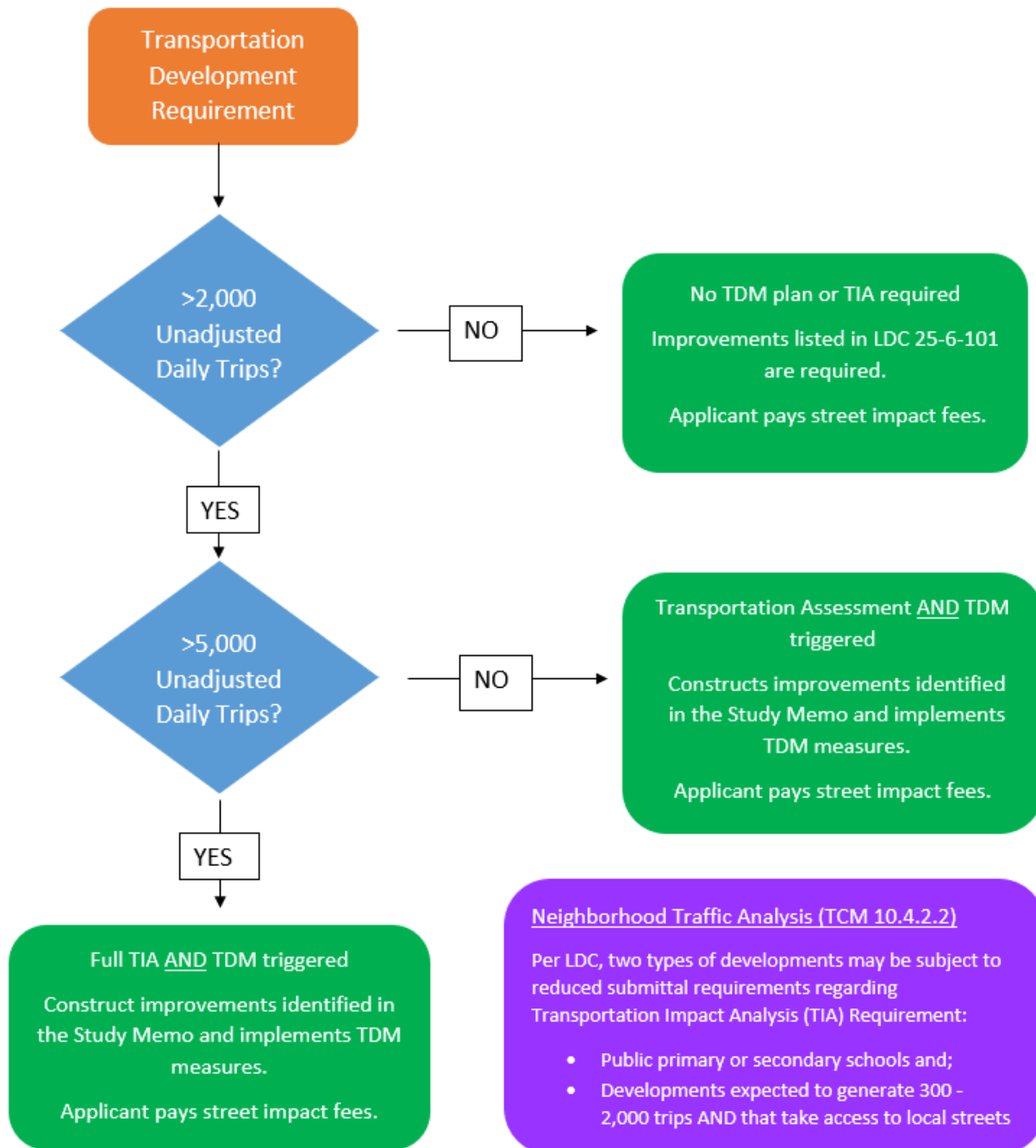


Figure 10-1 – TDM & TIA Requirement Flowchart

10.3.0 – Transportation Demand Management

This subsection sets forth the requirements for Transportation Demand Management (TDM).

10.3.1 – Intent of TDM

The term Transportation Demand Management (TDM) describes a range of measures designed to mitigate roadway traffic congestion by reducing vehicle trips and/or vehicle-miles traveled, especially in locations and during times that experience high travel demand. Encouraging the use of sustainable travel modes and increasing the number of travelers in each vehicle are the primary objectives sought by TDM measures in pursuit of this goal. Additional objectives include removing trips entirely (e.g. teleworking) and reducing the distance of trips taken. Additional benefits of effective TDM include:

- A. More reliable access to goods and services, provided when TDM results in more consistent travel times across all travel-mode options.
- B. More equitable access to goods and services, provided when TDM results in diverse travel-mode options that reduce reliance on personal-vehicle access for effective transportation.
- C. More resilient access to goods and services, provided when TDM results in redundant travel-mode options for meeting common travel needs, allowing travelers to meet these needs in circumstances when their primary mode choice may not be available.
- D. Reduced carbon emissions and improved air quality, provided when TDM increases the share of trips completed by more sustainable and fuel-efficient travel modes.
- E. Increased capacity for sustainable population growth and economic expansion, provided when TDM results in reduced per-person rate of trip-generation and vehicle-miles-traveled.
- F. Increased capacity for complete-streets applications and interventions, provided when TDM increases the share of trips completed by active modes and higher-occupant vehicles

The intent of TDM is to leverage the trip-mitigation impacts of TDM to further sustainable growth and development across the city and to support the City in meeting its goal to reduce drive alone mode share to 50% drive alone by 2039 as outlined in the **ASMP**.

10.3.2 – Applicability

- A. Applicability of TDM requirements shall be determined by outcomes of a development's TIA Determination Worksheet as per **Section 10.2.1**.
- B. An applicant may apply to complete a TDM plan at zoning. If a TDM plan is completed at zoning, the following apply:
 - 1. TDM plans approved with zoning applications shall satisfy the TDM requirement at site plan.
 - 2. For TDM plans completed at zoning, compliance monitoring and reporting shall not commence until after site plan approval.
- C. An applicant may petition for director approval to use an existing TDM plan for a site.
 - 1. If an existing TDM plan is being used, the site must fund or construct improvements identified in the existing TDM Plan's sustainable modes analysis (**Section 10.3.4.1**).

2. Programs and Incentives Measures API-1, API-2, or API-3 must be complied with (**Section 10.3.5.3**)
 - D. Approved TDM Plans are valid for 5 years from date of approval. Previously approved TDM Plans may be used when projected number of trips changes, so long as the number of unadjusted trips has not increased more than 10%.

10.3.3 – TDM Administrative Guidelines

The City shall adopt, and maintain via periodic updates, a TDM administrative guidelines document to the TDM Toolbox or Framework containing the point values and associated trip reductions for various TDM measures. The TDM administrative guidelines shall be updated, as deemed appropriate by the City, to reflect best practices in the field of Transportation Demand Management.

- A. When preparing, adopting, or updating the TDM administrative guidelines, the City shall consider the intent of TDM, per **Section 10.3.1**.
- B. The TDM Administrative guidelines shall provide flexibility to developers to achieve the purposes of TDM in a way that best suits the circumstances of each site and development proposal.
- C. The TDM administrative guidelines shall include a Toolbox of approved TDM measures known to reduce single-occupant vehicular trip generation when maintained by a property developer, owner, or key tenant.
- D. Each of the identified measures shall be assigned a percent-reduction level, reflecting the estimated level of trip-reduction impact for the measure, in isolation of other factors.
- E. Each measure shall be based upon documentation from reliable research sources, local data collection, best practice research, and/or input from relevant, recognized expert opinion, as described in the TDM administrative guidelines.
- F. In each of the first four years following the effective date of TDM, the City shall prepare a report analyzing the implementation of TDM and describing any changes to the TDM administrative guidelines.
- G. After this period, this report shall be prepared by the City every four years.

10.3.4 – TDM Plan Requirements

A required TDM Plan shall include the following components in this subsection. A TDM plan may be performed by a licensed professional engineer in the state of Texas, a licensed American Institute of Certified Planners in the state of Texas, or another certification that is approved by the City Transportation Engineer or applicable Director.

10.3.4.1 – Sustainable Modes Analysis

A Sustainable Modes Analysis shall be completed to initiate a TDM Plan development process. Following the processes required to initiate a site plan review for a proposed development, the property owner shall:

- A. Submit a description of the characteristics of the proposed development, including site location and characteristics, development scale, land use programming, and any unique site amenities or conditions that may affect travel choices to or from the site.

- B. Initiate a Sustainable Modes Analysis by:
 - 1. Identifying/confirming a list of priority improvements to sustainable-mode access and connectivity (walk, bike, transit, ride-share, and emerging mobility modes and services) for the proposed development's TDM Plan.
 - 2. Identifying transit infrastructure upgrades, including added amenities such as benches or shelters.
 - 3. Identifying potential transit stop relocations.
 - 4. Analyze the need for transit-only lanes adjacent and internal to the site on public streets per the methodology outlined in **Section 6.2.2.1**.
- C. Complete the Sustainable Modes Analysis by confirming a final set of improvements approved for the proposed development's TDM Plan, including approved TDM Plan points and trip-reduction measures for each.

10.3.4.2 – TDM Plan Requirement and Associated Trip Reductions

The TIA Determination Worksheet will determine the requirement of a TDM Plan. As part of the TDM Plan, the applicant will need to meet a minimum points requirement that would be conducive to a specific percent reduction in vehicular trips. The intent of the points system is to reduce vehicular trips and achieve the 50/50 mode split goal of the **ASMP**. This is more readily measured and described by anticipated trip reductions that result from implementation of TDM measures for a site. The context areas in this section correspond with effectiveness of TDM measures, and rough ratios of points to percent trip reductions are described in the criteria in this section. Reference **administrative guidelines** for specific values of points for each TDM measure and implementation level.

Calculation of points and associated vehicular trip reduction for a TDM plan shall follow the criteria and associated minimum and maximum point ratios by category established in this section. These baseline requirements will be adjusted if the proposed on-site parking supply is considered excessive, as described in **Section 10.3.4.2.1**. The TDM administrative guidelines shall have a link to a worksheet for this calculation provided on a website maintained by the City. The following criteria shall be met when establishing points and vehicular trip reduction requirements, also summarized in **Table 10-1**:

- A. When anticipated trip generation is greater than 2,000 unadjusted trips but less than 5,000 unadjusted trips the TDM Plan must include measures with summary point values of at least 20. Associated trip reductions required by context area are further described in item (C) and summarized in Table 10-1.
- B. When anticipated trip generation is greater than 5,000 unadjusted trips the TDM Plan must include measures with summary point values of at least 30. Associated trip reductions required by context area are further described in item (C) and summarized in **Table 10-1**.
- C. Trip reductions associated with points required in A & B vary based on context of the development. Context Areas correspond to the service areas defined in Chapter 25-6 of the **Land Development Code**, Article 9. The following are context areas established for associated trip reduction values for TDM Measures defined in **Section 10.3.4.4**:
 - 1. Downtown – defined as the area bounded by the Colorado River, Interstate 35, Martin Luther King Boulevard, and Lamar Boulevard, where associated trip reductions are roughly

equivalent to a 2% trip reduction: 1-point ratio as illustrated in **Table 10-1**. This context area also includes the University Neighborhood Overlay (UNO District);

2. Urban (“Inner Loop”) – defined as the area bounded by US 183, SH 360, and SH 71, but excluding the area defined as Downtown where associated trip reductions are roughly equivalent to a 1% trip reduction: 1-point ratio as illustrated in **Table 10-1**; and
 3. Urban Transition (“Outer Loop”) – defined as the area outside the Downtown and Urban context areas, where associated trip reductions are roughly equivalent to a 0.5% trip reduction: 1-point ratio as illustrated in **Table 10-1**.
- D. TDM Measures are grouped into the following categories for determination of points requirements:
1. **Contextual Trip Reduction:** Reduced trips generated by the proposed development by mixing land uses or by virtue of proximity to Transit Priority corridors as defined in the **ASMP**.
 2. **Parking:** Parking supply and management measures that mitigate against the trip-generation impacts of abundantly supplied and underpriced parking.
 3. **Programs, Incentives, and Amenities:** Programs that support the use of sustainable modes of travel, or deferring trips altogether, to reduce the trip-generation impacts of the proposed development.
 4. **Sustainable Mode Improvements:** Measures that implement improvements to walk, bike, transit, ride-share, and/or use emerging mobility modes and services as identified as Priority Improvements in the project’s approved Sustainable Modes Analysis. Points and associated trip reductions associated with these improvements shall be determined in the Sustainable Modes Analysis.
- E. TDM Plans submitted for approval must include measures with a combined points-total that meets or exceeds the TDM Plan’s overall TDM Plan points requirement, while also including a balance of measures across all four categories in item (D), so that:
1. Measures from any single category account for no more than 50% of the TDM Plan points requirement.
 2. Measures from (D)(2) account for at least 10% of the TDM Plan points requirement
 3. Measures from (D)(3) account for at least 10% of the TDM Plan points requirement
 4. Measures from (D)(4) account for at least 10% of the TDM Plan points requirement
- F. Trip reductions are established in the TDM administrative guidelines and may be updated on an annual basis based on observed trip reduction trends from implementation of TDM measures. Trip reductions associated with a TDM plan are set at the time of TDM Plan approval and are valid for the period specified in **Section 10.3.7.1**.
- G. Measures identified in **Section 10.3.4.2 (D) (4)** shall be presented in a Sustainable Modes Analysis with associated trip reductions for improvements identified.
- H. Trip reductions shall be capped at maximum percentages as shown in Table 10-3 by TDM measure category and context and be applied after any reductions given in the LDC.

Table 10-1 – TDM Plan Points and Associated Trip Reduction Requirements

Context Area	Points Requirement (2,000 – 5,000 unadjusted trips)	Associated Trip Reduction	Points Requirement (> 5,000 unadjusted trips)	Associated Trip Reduction
Downtown	20	40%	30	60%
Urban		20%		30%
Urban Transition		10%		15%

10.3.4.2.1 Increased Requirements for Excess Parking Supplies

The LDC identifies ratios of parking supplies required relative to development intensity as well as applicable parking reductions. These ratios do not represent a requirement to provide any parking, but rather a benchmark for identifying proposed parking supplies, referred to as the Standard Parking Supply Ratio. The Standard Parking Supply Ratio shall be defined as the required ratio from the LDC after parking reductions allowed for by the LDC. The TDM Plan points requirement will be increased for proposed developments that propose excess parking beyond the Standard Parking Supply Ratio, as shown in **Table 10-2**.

Table 10-2 – TDM Plan Points Requirement Adjustment for Excess Parking

Proposed Parking Supply	TDM Plan Points Requirement (and Associated Trip Reduction) is Increased By		
	Downtown	Urban	Urban Transition
Context Area			
101% - 110% of the Standard Parking Supply Ratio	3	2	1
110% - 130% of the Standard Parking Supply Ratio	5	4	3
130% - 150% of the Standard Parking Supply Ratio	7	6	5
150% or more of the Standard Parking Supply Ratio	10	8	7

10.3.4.3 – TDM Plan Trip Reduction Maximums

TDM Plans are required to meet a threshold for points that are associated with trip reductions as described in **Section 10.3.4.2**. However, an applicant may commit to and perform additional TDM measures beyond their requirement. The resulting trip reductions by context area shall be capped at the maximums in Table 10-3 and follow associated criteria for application to the Rough Proportionality Determination in **Section 10.4.5**.

Table 10-3 – Maximum TDM Trip Reduction Allowed

Maximums by TDM Measure Category	Downtown & UNO	Urban	Urban Transition
Contextual Trip Reduction ¹	40%	30%	25%
Parking	20%	10%	5%
Programs and Incentives	20%	10%	5%
Sustainable Modes Improvements	60%	40%	20%
Overall Maximum by Context Area	100%	60%	30%

¹ – Internal Capture shall be maximum 20% trip reduction for all areas, includes Transit Proximity

- A. Resulting Trip Reductions from an approved TDM Plan, capped at the maximums shown in Table 10-3, may be applied as a credit towards the Rough Proportionality Determination.

10.3.4.4 – TDM Measures Implementation Levels

A set of TDM measures shall be identified, selected from an approved Sustainable Modes Analysis and/or from the City's TDM administrative guidelines as described in **Section 10.3.3**. All measures shall include their proposed implementation level and associated points and trip-reduction value, with the sum of points from all TDM measures implemented being sufficient to meet the minimum points required for TDM Plan approval. All measures shall also include commitment to reporting and compliance monitoring, as required by **Section 10.3.8**.

10.3.5 – TDM Measures Implementation Criteria

The following subsections include a description of TDM measures, implementation criteria to receive credit for TDM points and any associated trip reductions, and reporting requirements to satisfy criteria outlined in **Section 10.3.8**. Each category of TDM measure is presented in tabular format in a table, with the exception of Section 10.3.5.1 – Contextual Trip Reduction and **Section 10.3.5.4** – Sustainable Mode Improvement Measures. Point values and trip reductions for each TDM measure shall be identified in administrative guidelines for TDM as adopted by the City.

10.3.5.1 – Contextual Trip Reduction

- A. Internal Capture shall be calculated using the latest edition of the ITE Trip Generation Handbook to determine Contextual Trip Reductions for mixing of land uses.
- B. The resulting percentage trip reduction for Internal Capture shall be capped at 20%.
- C. Consideration of Transit Priority Network Proximity may also be used to determine the Trip Reduction percentage for the Contextual Trip Reduction TDM Category.
- D. Trip reductions for this category shall be calculated independently of other TDM Measure Categories. The resulting Trip Reduction shall be added to the calculated trip reduction from other TDM measures, for a development's total trip reduction.

10.3.5.2 – Parking (Vehicle) Measures

Table 10-4 includes criteria to receive points or trip reductions for various TDM measures to reduce parking in vehicles on site. These measures include inclusion of pricing for parking for residents, tenants, or visitors to incentivize use of other modes of travel.

Table 10-4 – Parking Measures Criteria

TDM ID	Measure Description	Implementation Criteria	Pre-Occupancy Requirements	Post-Occupancy Requirements
P-1	Reduced Parking Supply	<ul style="list-style-type: none"> Provide fewer parking spaces than the required Standard Parking Supply Ratios on site. 	Site inspection to confirm on-site parking supply	Submission of photos that confirm that the parking supply remains unchanged
P-2	Unbundled Parking	<ul style="list-style-type: none"> All resident/tenant parking is offered as an optional amenity that is priced separately from the cost of associated building leases or housing-unit purchases; and Supporting documentation required to be included for the proposed rate/credit for debt service on parking spaces and/or IRS limits on pre-tax parking purchases; and Supporting documentation required to be included for the rates as compared to the area parking rates for visitors 	<ul style="list-style-type: none"> Copies of all informational materials about parking cash out and current rates for all residents / tenant-employees at the site; and Copy of residential/office lease and parking contract 	<ul style="list-style-type: none"> Copies of all informational materials about parking cash out and current rates for all residents / tenant-employees at the site; and Copy of residential/office lease and parking contract
P-3	Daily Tenant Parking Rates	<ul style="list-style-type: none"> All criteria for P-2 are met; and All unbundled parking is priced at an hourly or daily rate, no monthly or annual permits are offered; and Supporting documentation required 	Copies of all informational materials about parking rates for all tenant parking options	Copies of all informational materials about parking rates for all tenant parking options
P-4	Visitor Parking Pricing	<ul style="list-style-type: none"> All criteria for P-2 are met; and All visitor parking is priced at an hourly and/or daily rate and/or visitor parking is priced at a higher rate during the hours of 7-10am and 4-7pm Monday through Friday or other peak land use travel demands as identified in the TDM Plan and approved by applicable staff 	Copies of all informational materials about parking rates for all parking options	Copies of all informational materials about parking rates for all parking options

10.3.5.3 – Amenities, Programs, and Incentives Measures

Table 10-5 includes criteria to receive points or trip reductions for various amenities, programs, and incentives TDM measures. These measures include programs implemented and incentives offered by the property owner to tenants or residents that encourage use of other travel modes or result in removing trips entirely.

Table 10-5 – Amenities, Programs, and Incentives Measures Criteria

TDM ID	Measure Description	Implementation Criteria	Pre-Occupancy Requirements	Post-Occupancy Requirements
API-1	Transportation Management Association (TMA) Membership	<ul style="list-style-type: none"> Documentation of membership in a TMA, or similar organization is included in a TDM Plan 	Documentation confirming pending or active membership	Documentation confirming active membership
API-2	Designated Mobility Coordinator	<ul style="list-style-type: none"> The name and contact information of the property's Mobility Coordinator is identified in the TDM Plan 	Contact information for mobility coordinator, documentation confirming staff position, roles, and responsibilities that conform to this measure's requirements	Contact information for mobility coordinator, documentation confirming active staff position, roles, and responsibilities that conform to this measure's requirements
API-3	Marketing and Information	<ul style="list-style-type: none"> A marketing and information program is defined, including frequency of proposed actions, estimated costs, funding allocations, and staffing committed for implementation is included in a TDM Plan; and All criteria for TDM Measure PI-1 and PI-2 must be met 	Copies of all promotional materials and welcome packets to be distributed to employees and/or residents as part of their annual monitoring and reporting update	Copies of all promotional materials and welcome packets, plus documentation identifying distribution to employees and/or residents
API-4	Parking Cash-Out	<ul style="list-style-type: none"> The majority of trips projected by TIA determination (Section 10.2.0) are projected for proposed non-residential uses; and Parking Cash-Out program is defined for tenant employers, inclusive of level of benefit, terms of eligibility that match those linked to a parking benefit is included in a TDM Plan 	Copies of all promotional or informational materials on this benefit, to be distributed to all tenant employees	<ol style="list-style-type: none"> Copies of all promotional or informational materials on this benefit, plus documentation identifying distribution to all tenant employees; and Verifiable data about participation in this incentive
API-5	Universal Transit Pass or Mobility Wallet	<ul style="list-style-type: none"> A Universal Transit Pass or Mobility Wallet benefit is defined for property tenants, inclusive of level of benefit, eligibility, and committed funding levels, is included in a TDM Plan; and All criteria for TDM Measure PI-1 and PI-2 must be met 	Copies of all promotional or informational materials on this benefit, to be distributed to all residents/tenant-employees	<ol style="list-style-type: none"> Copies of all promotional or informational materials on this benefit, plus documentation identifying distribution to all residents/tenant-employees; and

TDM ID	Measure Description	Implementation Criteria	Pre-Occupancy Requirements	Post-Occupancy Requirements
				2. Verifiable data about participation in this incentive
API-6	Ride-Home Benefit	<ul style="list-style-type: none"> • A Guaranteed Ride Home benefit is defined for property tenants, inclusive of level of benefit, eligibility, and committed funding levels, is included in a TDM Plan; and • All criteria for TDM Measure PI-1 and PI-2 must be met 	Copies of all promotional or informational materials on this benefit, to be distributed to all residents/tenant-employees	<ol style="list-style-type: none"> 1. Copies of all promotional or informational materials on this benefit, plus documentation identifying distribution to all residents/tenant-employees; and 2. Verifiable data about participation in this incentive
API-7	Internet Access Amenity	<ul style="list-style-type: none"> • Evidence of a commitment to provide publicly accessible free, high-speed, broadband service - such as a service-provider contract/invoice, marketing materials that promote this amenity, or other -- is included in a TDM Plan; and • All criteria for TDM Measure PI-1 and PI-2 must be met 	Copies of all promotional or informational materials on this amenity, to be distributed to all residents	Copies of all promotional or informational materials on this amenity, plus documentation identifying distribution to all residents
API-8	Telecommuting Work Option	<ul style="list-style-type: none"> • Evidence of a commitment to provide options to employees for telecommuting at least 1 day per week must be included in a TDM plan 	Copies of all promotional or informational materials on this benefit, to be distributed to all tenant-employees	<ol style="list-style-type: none"> 1. Copies of all promotional or informational materials on this amenity, plus documentation identifying distribution to all employees; and 2. Verifiable data about participation in this incentive
API-9	On-site Daycare or School	<ul style="list-style-type: none"> • Submitted plans that identify ground-floor space designed to accommodate the proposed facility, and that complies with all State, County, and City requirements, including provisions within the LDC; and • Submitted plans identify a commitment to ensure the space will be occupied by a childcare facility or school. 	Identification of appropriate space within submitted site/building plans	Inclusion of contact information for a representative who can verify ongoing childcare/school occupancy and operations
API-10	Delivery-Supportive Amenities	<p>Submitted plans identify either of the following building amenities:</p> <ul style="list-style-type: none"> • Lockers or other storage facility for laundry, packages, or other “dry goods”; or 	Site inspection to confirm amenities are in place	Submission of photos that confirm that the amenities remain in place and unchanged

TDM ID	Measure Description	Implementation Criteria	Pre-Occupancy Requirements	Post-Occupancy Requirements
		<ul style="list-style-type: none"> • Temperature-maintaining or refrigerated storage device for groceries 		

10.3.5.4 – Sustainable Mode Improvement Measures

Criteria for various sustainable mode improvement measures are listed below as a baseline requirement to receive points or trip reductions. These measures will be identified in the Sustainable Modes Analysis (**Section 10.3.4.1**) as improvements that enhance site access and connectivity for sustainable travel modes. Transportation mitigation required by the LDC may receive credit towards TDM points or trip reductions as TDM measures under this category. The following criteria shall be satisfied to receive credit towards a TDM points requirement and associated trip reductions:

- A. Improvements identified and agreed upon to be constructed in an approved Sustainable Modes Analysis (**Section 10.3.4.1**) are included in a TDM Plan.
- B. Improvements shall be constructed by the applicant and accepted by the City prior to occupancy.
- C. Improvements shall improve access and connectivity for the following:
 - 1. Pedestrian travel
 - 2. Bicycle travel
 - 3. Transit travel
 - 4. Rideshare travel (including carpool, vanpool, school-pool, or other shared travel that reduces drive alone trips)
 - 5. Emerging mobility travel – other travel modes that reduce drive alone trips (including scooters, bike share, or other modes not included in pedestrian, bicycle, or transit travel)

Measures included in a TDM plan that fall in this category shall not require compliance monitoring or reporting after initial occupancy. Guidance on points for different sustainable modes improvements as well as associated trip reductions are included in the TDM administrative guidelines document.

10.3.6 – TDM Submittal Requirements

- A. TDM review fees shall be paid before the TDM review begins by applicable staff. The applicant shall submit the appropriate TDM review fee based on the City of Austin’s latest fee schedule. The fee schedule can be found on a website identified in the adopted administrative guidelines.

10.3.7 – TDM Plan Approval

- A. Compliance with the TDM Plan, shall be included as a Condition of Approval of the proposed development. The property shall be subject to the TDM administrative guidelines in effect at the time of its Site Plan approval. If the City has issued revised TDM administrative guidelines subsequent to the date of the property’s Site Plan approval, the property owner may elect to have the property be subject to the requirements of the later-approved TDM administrative guidelines in lieu of guidelines at Site Plan approval.

- B. The City Transportation Engineer, applicable Director, or their designee shall approve TDM plans at Site Plan approval. A memo for approval shall include the property's final TDM Plan and detailed descriptions of each TDM measure. A final TDM Plan may be modified, upon application of the property owner or as required by the City.
- C. Property owners shall pay administrative fees with the application, periodic compliance review, and voluntary update review of their TDM Plans, as set forth in the applicable department's latest adopted fee schedule.

10.3.7.1 – Duration of Approval

Because of the ever-changing conditions that will impact the effectiveness of a TDM Plan, a plan for a site shall be considered valid for no more than five years. If five or more years have passed since the approval of the TDM plan and the site has not been fully developed according to the site plan, an updated TDM plan shall be required to be prepared and submitted for approval for the site development permit to remain in effect. If a project's development is to be completed in distinct phases, a required TDM Plan shall only be approved for the phases to be completed within five years, as defined in the approved Site Plan.

10.3.8 – Compliance Monitoring and Reporting

Prior to the issuance of a first certificate of occupancy, City staff shall confirm via site inspection that all physical improvement measures in the approved TDM Plan are present and installed appropriately and in accord with the TDM Plan. City staff shall also review provided documentation that all approved programmatic measures in the approved TDM Plan have been implemented. The process and standards for determining compliance are specified with specific TDM measures in **Section 10.3.4.4**.

For 5 years after the TDM Plan is approved on an annual basis, the property owner shall:

- A. Submit compliance checklist as required by the City's TDM administrative guidelines.
- B. Maintain and identify a single point of contact for all coordination with City staff related to compliance with the approved TDM Plan.
- C. Allow City staff access to relevant portions of the property to conduct compliance-monitoring activities, which may include:
 - 1. site visits,
 - 2. surveys,
 - 3. physical improvement inspections,
 - 4. data collection
 - 5. in-person interviews
- D. Provide appropriate contact information to City staff to conduct phone, and/or e-mail or web-based interviews with residents, tenants, employees, and/or visitors.

City staff shall provide advance notice of any request for access and shall use all reasonable efforts to protect personal privacy during visits and in the use of any data collected during this process.

If a development is found to be out of compliance for any TDM measures that are not associated with physical improvements inspected at first certificate of occupancy during reporting, a TDM Plan update shall

be required to identify new measures to achieve the TDM points goal for the site. Alternatively, mitigation or funds toward mitigation not to exceed the dollar value of the associated trip reduction for the measures out of compliance may be constructed or paid in lieu of a TDM Plan update. The dollar value shall be calculated as the trip reduction associated with non-compliant TDM measures multiplied by the Rough Proportionality Determination of the site at the time of previous TDM Plan approval.

10.4.0 – Traffic Impact Analysis Studies

A TIA is required to assess the transportation aspects of a proposed development that has the potential of generating new trips and exceeds the threshold identified in the LDC for unadjusted trips and determined during TIA Determination per **Section 10.2.1**. Trips assessed in a TIA shall include all new vehicular trips and trips by other modes of travel. New developments and re-developments change the travel patterns in and adjacent to the development site, affecting all travel modes.

The requirements contained herein shall be present in the TIA. Administrative guidelines for performing specific elements of a TIA may be adopted by the City as a supplement to the contents of this Section.

10.4.1 – TIA Scoping

The applicable department will perform and sign the TIA Determination Worksheet and, if applicable, based on **Section 10.2.1**, direct the applicant to submit either a Transportation Assessment scope or a Full TIA scope according to other provisions of this Section or as described in the adopted administrative guidelines. All appeals to a TIA Determination Worksheet will be made to the City Transportation Engineer, applicable Director, or designee. A signed Transportation Assessment scope or a Full TIA scope must accompany a Transportation Assessment or Full TIA submitted for review.

10.4.1.1 – Transportation Assessment Scope

The scoping requirements for a Transportation Assessment Scope are applicable to both a Transportation Assessment and a Full TIA Scope as identified in **Section 10.4.1.2**.

10.4.1.1.1 – Project Information

- A. The proposed project location, land use, and proposed development intensity must be identified.
- B. The proposed development's site access locations and functionality are to be identified.
- C. Build out date of the development shall be identified.
 1. If the project is split into phases, the phasing breakout is to be identified with corresponding build out dates for each phase.
- E. If there is an existing land use, the existing land uses must be identified with intensity for each use.

10.4.1.1.2 – Definition of Study Area

- A. The study area shall include all site driveways and street intersections within the site.
- B. If an intersection falls within ¼ mile of the site boundary and 100 or more peak hour trips (either AM or PM peak) pass through the intersection, staff may request inclusion of the intersection in the Transportation Assessment.

10.4.1.1.3 – Trip Generation

The proposed development's daily and peak hour trip generation must be presented. Trip generation rates must be obtained following criteria in **Section 10.2.0 (A)**. When presenting trip generation information, the following must be considered:

- A. Documentation of pass-by trips, based on the Institute of Transportation Engineers latest edition of *Trip Generation Handbook*, or other sources as described in administrative guidelines
- B. Documentation of and calculations for internal capture, if applicable
- C. Trip Generation, less pass-by trips and internal capture, by phase of development, if the development is anticipated to be built in phases.
- D. If a zoning change is requested, a comparison of the existing zoning trip generation versus the proposed zoning trip generation is required.
- E. When a TDM Plan is required for site, the anticipated resulting trip reduction percentage may be applied uniformly across all land uses for an adjusted trip generation value for use in the study and shall be identified in the scope, per **Section 10.4.3.1**.

10.4.1.1.4 – Trip Distribution

An estimate of the directional distribution of site traffic entering and exiting the proposed development must be presented. The directional distribution of the development must be based on:

- A. Existing traffic patterns, supported by data from traffic counts;
- B. Proposed site access locations;
- C. Anticipated local traffic patterns for the land uses within the development; and
- D. Future study area streets network, if future streets are identified to be built in the City's Capital Improvement Plan or in an approved TIA memo by another development

A directional distribution figure must be provided to clearly communicate distribution assumptions for the study area where streets intersect the Study Area boundary and at each intersection and access drive identified for study in the Study Area. The figure must also distinguish between entering and exiting trips. Multiple directional distribution figures may be needed for phased developments to reflect changing traffic patterns resulting from additional land uses and access points in subsequent phases.

10.4.1.1.5 – Background Growth

Based on the anticipated Build Out year, or phasing of the development, an annually compounding growth rate must be assumed to project background traffic. This growth rate must be considered based on historical data near the study area. Acceptable historical data sources include:

- A. [TxDOT Traffic Count Database System \(TCDS\)](#)
- B. Raw traffic count data obtained from previously approved TIAs
- C. Traffic count data provided by the City
- D. Established compound growth rates that may be adopted by the City for specific areas of the City in its administrative guidelines

10.4.1.1.6 – Other Developments Near the Study Area

Prior to submitting the study scope, the applicant is to inform the applicable staff of the proposed development study location. If applicable staff determine that site traffic from other planned developments should be accounted for in the TIA, then ATD is to provide a list of the studies to be considered.

10.4.1.1.7 – Special Site Considerations

If the preparer of the study has any site-specific topics that are desired to be addressed in the study, they must be included in the scope. These topics may include, but are not limited to:

- A. Proposed road closures or right-of-way abandonment.
- B. The proposed addition, removal, or modification of on-street parking.
- C. Internal circulation procedures for schools or sites with heavy truck traffic

10.4.1.2 – Full TIA Scope

All requirements of **Section 10.4.1.1** – Transportation Assessment Scope apply to Full TIA Scopes, with additional requirements contained within this Section.

10.4.1.2.1 – Definition of Study Area

For a Full TIA scope, this section replaces the requirements of **Section 10.4.1.1.2**. The study area intersections and roadways to be analyzed, in addition to the site drives, must be identified. The following outlines study area requirements:

- A. All existing and planned intersections of streets in the **ASMP** within $\frac{1}{4}$ mile of the site boundary or along the site boundary.
 - 1. When adjacent to a Level 5 Street, the study area shall terminate at the furthest Level 4 Street frontage road intersection from the site.
 - 2. Additional intersections may be added to the study area if the intersection is within $\frac{1}{2}$ mile of the site boundary and 50 or more peak hour trips (either AM or PM peak) pass through the intersection at the discretion of staff.
- B. All existing and planned school sites, transit routes/stops, trails, sidewalks, and bike facilities within $\frac{1}{4}$ mile of the site boundary must be identified.

10.4.2 – TIA Submittal Requirements

- A. TIA review fees shall be paid before the TIA review begins by applicable staff. The applicant shall submit the appropriate TIA review fee based on the City of Austin's latest fee schedule. The fee schedule can be found on a website identified in the adopted administrative guidelines.
- B. The applicant's consultant shall contact any other appropriate agencies (e.g. TxDOT, Travis County, etc.) for their submission requirements. Incomplete TIA's will not be reviewed. The applicant is tasked with providing all necessary and required information at the time of submittal for a permit. Incomplete submittals will be returned for completion.

10.4.2.1 – Data Collection Requirements

- A. Turning movement counts at all study intersections shall be collected, at a minimum, between the hours of 7-9am and 4-6pm, unless a specific land use justifies different hours of collection and analysis per the TIA scope.
- B. All existing signal timings shall be obtained from either the City of Austin or the jurisdiction which operates and maintains the existing signal.
- C. Plans for transportation capital improvement projects shall be obtained and considered as part of the site's build year analysis.

10.4.2.2 – Projected Volumes Analysis

The purpose of a Projected Volumes Analysis is to assess whether internal streets or Level 1 Streets adjacent to the site should be classified as a Level 2 or higher street when the street network is undefined within or adjacent to the site boundary in the **ASMP**.

- A. Daily traffic volumes shall be estimated for post-development conditions on internal streets and Level 1 Streets adjacent to the site. Based on this analysis, the Street Levels shall be recommended for Level 1 Streets adjacent to the site and internal streets, if not identified in the **ASMP**.
- B. Cross sections identified shall include the behind-curb facilities for pedestrians and bicycles as well as buffers and planting zones as a baseline. These facilities should match the improvements for the appropriate Street Level, identified in **Section 2** and the **ASMP**.

10.4.2.3 – Safety & Sight Distance Requirements

- A. A proposed development shall not create a public safety hazard condition for any mode of travel. The TIA shall include a documentation of all site access locations, showing proposed access points, planned driveway layouts with appropriate crossing facilities that meet requirements of **Section 7**, and demonstrate adequate sight distance exists for newly created intersections per the procedures outlined in **Section 3**.
- B. In addition to determining adequate sight distance and proper configuration of driveways or access points to the site, turning movement analysis shall be evaluated at site driveways to determine the need for right turn deceleration lanes, acceleration lanes, and in some cases, auxiliary lanes for significant turning movements into and out of the site across multiple access points.
- C. If a turning movement is deemed unsafe from a proposed access point, the TIA shall document restricted turning movements at each site driveway location and propose measures to limit turning movements that would create a safety hazard at the applicable access point.

10.4.2.4 – Signal Warrant Analysis

- A. Signal warrant analysis shall accompany any proposed new signals that result from the TIA analysis as mitigation for the site per the methods in the latest edition of the Texas Manual on Uniform Traffic Control Devices (TMUTCD). If a study intersection is projected to have an entering volume of greater than 1,000 vehicles in any peak hour in the site build year of any phase of development, a signal warrant analysis shall be performed at the study intersection identified in the TIA scope.

10.4.2.5 – Turn Lane Analysis

- A. Turn lane analysis shall be provided at site driveways for left and right turn lanes based on projected peak hour volumes from the proposed development. Analysis shall assess warrants for new turn lanes based on turn lane volume thresholds included in **Section 3.6.3**.
- B. Queueing of existing and proposed turn lanes shall be provided to evaluate storage lengths per **Section 3.6.3**.
- C. When turn lane warrants are met or storage is insufficient, new or extended turn lanes are required as mitigation for safety per **Section 10.4.4**.

10.4.2.6 – Access Management and Queuing Analysis

- A. Access Management Analysis shall be conducted to ensure safe and effective access for the site's operations. For certain uses where on-site queuing is probable, such as drive-through restaurants or schools, a queuing analysis may be required. A queuing analysis should identify the project's queues and ensure that on-site storage can contain the queue generated by the development using the methods described in **Section 9** for on-site circulation requirements. Driveway spacing and design shall follow the spacing requirements in **Section 7**.

10.4.3 – Generalized Study Contents and Valid Period

A Transportation Assessment or a Full TIA shall:

- A. Be signed by a licensed professional engineer in the state of Texas with demonstrated experience in transportation engineering;
- B. Assess and recommend dedication or reservation of Right-of-Way based on the latest adopted **ASMP**;
- C. Provide information on the projected traffic generated by a proposed development;
- D. Provide traffic data and turning movement counts per **Section 10.4.2.1** at locations and times approved by the applicable department
- E. Assess the effects of the proposed development on the surrounding transportation system and recommend measures and/or improvements to mitigate adverse effects on traffic operations;
- F. Identify operational, geometric, and safety impacts, and recommend actions to address these concerns; and
- G. Include, but not be limited to, capacity analysis, safety, and geometric analysis, and conceptual plans or designs to support recommended mitigation.

An approved Transportation Assessment or Full TIA will be valid for a period up to 5 years from the date of the approved final study memo, or the date of assumed final build out, whichever is earlier.

10.4.3.1 – Trip Reductions from TDM Plan

TDM measures shall be covered in a TDM Plan per **Section 10.3.0**, submitted separately or concurrently, and shall be referenced in the Transportation Assessment or Full TIA for determination of trip reductions. Trip reduction percentages resulting from a TDM Plan shall apply to both daily trip generation and peak hour trip generation for the purposes of the TIA study.

10.4.3.2 – Neighborhood Traffic Analysis

A Neighborhood Traffic Analysis (NTA), which includes the requirements covered in **Section 10.4.3**, may be required for some schools and developments below the Transportation Assessment threshold impacting residential neighborhoods per the **LDC 25-6-114**. An NTA shall:

- A. Provide information on the projected traffic generated by a proposed development;
- B. Provide traffic data at locations and times approved by the applicable department;
- C. Provide an access management plan and queuing analysis as required by the applicable department;
- D. For projects impacting residential neighborhoods, site trip distribution, driveway locations, and a Sustainable Modes Analysis to identify transportation mitigation items in the LDC is required.
- E. Recommend measures and/or improvements to mitigate adverse effects on traffic operations limited to transportation mitigation items in the LDC.

10.4.4 – Determination of Mitigations

If an applicant is required to submit to the City a TIA Determination per **Section 10.2.0** as a condition of development review as required by the LDC, determinations of transportation mitigation shall be made. Required mitigations identified in the Transportation Assessment or Full TIA are subject to review and development approval and may be conditioned upon construction, dedication of right-of-way, TDM measures as identified in a TDM Plan, and phasing agreements for the timing of improvements per LDC.

Applicant shall be responsible for the entire cost to design and construct site-related facilities for a new development. System improvements such as street and intersection improvements adjacent to or extending beyond the site boundary of a new development may be required to be constructed based upon the submitted determination of required infrastructure from the Transportation Assessment or Full TIA, subject to the Rough Proportionality Determination and requirements outlined in the LDC.

The **LDC** defines system improvements that may be required of any development. System improvements must maintain a nexus to be a condition of development approval and be applicable for the associated land use. **Table 10-6** assigns criteria that must be met to require each item listed as a system improvement, which establishes a nexus. For any non-adjacent system improvements, the City will be responsible for right-of-way acquisition. The City may offset the street impact fee for the improvements or funding for construction of any system facility included on the roadway capacity plan as detailed in the **25-6-669 of the LDC**.

Table 10-6 – Criteria for System Improvements

System Improvement, as defined in Section 10.2.0 (D)	Transportation Assessment Nexus Standard	Full TIA Nexus Standard
Sidewalks and curb ramps	For residential developments, connections to schools within the study area may be required to complete a gap in the sidewalk connectivity or upgrade existing facilities. Alternative designs may be permitted to provide	Must be on a path to a school, transit stop, public space, on facilities designated Level 2, 3, 4 or 5 in the ASMP , and be within study area and necessary to complete a gap in sidewalk connectivity or upgrade existing facilities.

System Improvement, as defined in Section 10.2.0 (D)	Transportation Assessment Nexus Standard	Full TIA Nexus Standard
	pedestrian connectivity on an interim basis.	
Traffic signs, markings, upgrades to signal infrastructure	Must be included as an intersection in the study area	
Traffic calming devices	Must be on a street adjacent to the site.	Must meet eligibility requirements per the City's Speed Management Program or its successor.
Bike lanes or upgrades to bike facilities	Must be: (1) on a path in the All Ages and Abilities network to a school, bus stop, public space, or Level 3, 4 or 5 facilities, as designated in the ASMP ; or (2) be within the study area to complete a gap in bike connectivity	
Bike-share stations and public bicycle racks	Must be directly adjacent to the property line of the site for bike-share station. Public Bicycle racks shall be per requirements of the LDC for bike parking.	
Rectangular Rapid Flashing Beacons	Must be within the study area	Must be: (1) recommended by study approved under the TCM; or (2) located between the site and a school, transit stop, or other significant pedestrian generator in the study area.
Pedestrian islands and bulb-outs	Must be at an intersection within the study area	
Pedestrian Hybrid Beacons (PHB's)	Must be directly adjacent to the property line of the site.	Must be: (1) recommended by study approved under the TCM; or (2) located between the site and a school, transit stop, or other significant pedestrian generator.
Urban Trail or Improvements	Must be: (1) designated in the Urban Trails Plan as a Tier 1 or Tier 2 facility, complete an existing gap of 500' or less in the trail system, and be within the study area	Must be: (1) designated in the Urban Trails Plan as a Tier 1 or Tier 2 facility and required to complete an existing gap of 1,000' or less in the trail system in the study area; or (2) provide connection to an existing street.
Right-of-Way Dedications	Must be: (1) full width of ROW required by the ASMP , if the facility is new; or (2) ½ of the ROW from the centerline of the existing street alignment.	
Safety improvements, including acceleration and deceleration turn lanes	Must be at site driveways or intersections within the study area	
Traffic Signals	Must be at site driveways or intersections within the study area	
Transit Stop Relocations	Must be (1) accessible by the site and (2) be within the study area	
Transit infrastructure upgrades, including adding amenities such as benches or shelters	Must be (1) accessible by the site and (2) be within the study area	

10.4.5 – Proportionality of Transportation Improvements

As a condition of approval for a new development, the City may require applicants to construct, dedicate or contribute towards transportation facilities. The City shall determine Rough Proportionality in accordance with state law and the **LDC** by comparing the required system infrastructure facilities' supply to the demand created by the new development. The LDC defines eligible improvements, in addition to Right-of-Way dedications, that are applicable to supply provided by a development. Any contributions toward a Street Impact Fee, as defined in the LDC, shall be applicable to supply provided by a development. Nexus standards for required improvements are identified in **Section 10.4.4**.

Demand generated by the development shall be based on the unadjusted trips generated by a development per the TIA Determination in **Section 10.2.1** multiplied by the average trip length in the City for each associated land use, resulting in vehicles of demand generated or VMT. Demand may be reduced by the percentage resulting from an approved TDM plan, as specified in **Section 10.3.4.3**. The supply and demand will be compared in dollars based on cost per VMT. Unless the supply calculated exceeds demand generated, then the required transportation improvements will be considered roughly proportionate in the rough proportionality determination. If the supply calculated exceeds demand generated, the City must reduce the requirements of the development to be roughly proportionate. The rough proportionality determination does not prohibit the City from requiring minimum adequate infrastructure to serve the new development.

10.4.5.1 – Appeal of Rough Proportionality Determination

An applicant may appeal the City's Rough Proportionality determination to the City Council. The Applicant must deliver a written notice of appeal to the Director of the applicable department. The Director of the applicable department will schedule the date of the appeal before the City Council. The Director of the applicable department may attempt to resolve the appeal with the applicant before the hearing before the City Council.

At the hearing before the City Council, the applicant and City staff may present testimony and other evidence and cross examine witnesses. The City Council must uphold, reverse, or modify the Rough Proportionality Determination made by the City within 30 days following the final submission of any testimony or other evidence. All applicable appeal procedures of the **LDC** shall be followed.

10.5.0 – Zoning Transportation Analysis

Zoning Transportation Analysis shall be performed at zoning where anticipated trips are anticipated to exceed 2,000 unadjusted trips to satisfy the LDC requirement for a TIA, but does not diminish the authority to require an updated Traffic Impact Analysis at site plan. A Zoning Transportation Analysis shall be limited to the following scope components of TIA:

- A. Trip Generation for most intensive use proposed by Zoning
- B. TDM Plan measures anticipated
- C. Projected Volumes Analysis, per requirements in **Section 10.4.2.2**
- D. Site driveway access analysis, including requirements in **Section 10.4.2.3**
- E. Assessment of Right-of-Way needs, if determined necessary by the City Transportation Engineer or applicable Director per the LDC
- F. Dedication of Right-of-Way, per the LDC, if this is known at time of zoning

SECTION 11 – OFFSETS & RAILS

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The purpose of this section is to provide design criteria for establishing a clear zone and lateral offsets, landscaping requirements, and the selection and installation procedures for guard rails. Landscaping requirements in the University Neighborhood Overlay and Great Streets Master Plan standards for the Downtown area per **Figure A-2** shall supersede the requirements of this manual.

11.1.0 – Clear Zone Offset & Lateral Offset

Providing a full, unobstructed clear zone offset is often not practical in urban and suburban environments, which are generally streets with curbs that have a vertical element, exclusive of ribbon curbs. In these contexts, a lateral offset may be used if certain criteria are met. For comparison, Figure 11-1 shows the areas where lateral offsets are applicable, which are smaller in width and less restrictive than clear zones.

Lateral offsets shall be used on curbed streets. **Section 11.1.1** and **11.1.2** outline the concepts of lateral offset and clear zone offset, respectively.

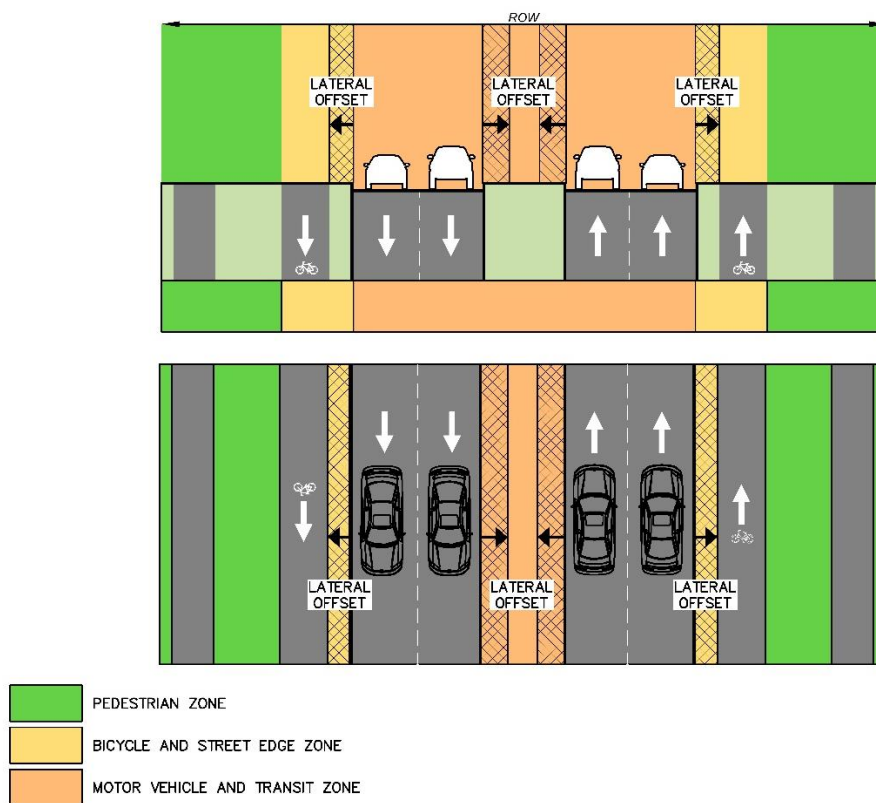


Figure 11-1 – Lateral Offset in the Right-Of-Way

The clear zone offset criteria applies to non-curbed streets, with the exception of ribbon curbs (no vertical element to redirect errant vehicles). This section provides guidance on the clear zone offset. The clear zone offset is used to designate the unobstructed, recoverable area provided beyond the edge of the traveled way for the recovery of errant vehicles.

Clear zone offset and lateral offset criteria apply to the areas within the public right-of-way that are not designated for vehicular travel including the bicycle and street edge zone, pedestrian zone, and median. The offsets are not an additional street zone but rather a theoretical overlay of these street zones that must

remain clear of unprotected obstructions that pose a collision risk for vehicles. **Figure 11-2** shows the areas within the right-of-way where clear zone offsets are applicable.

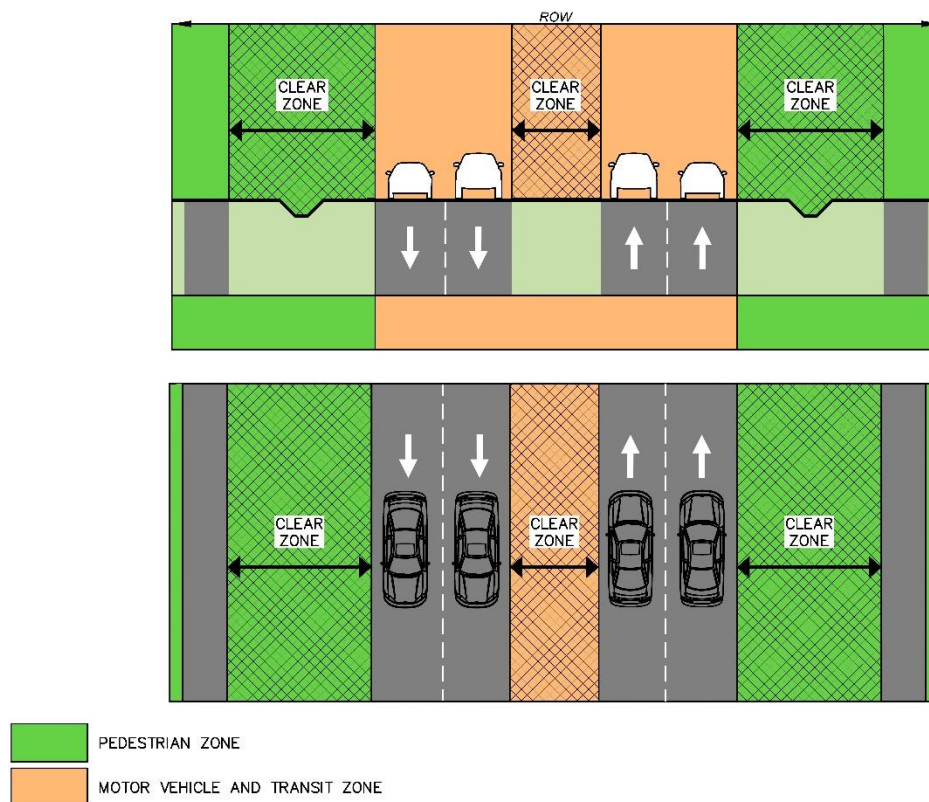


Figure 11-2 – Clear Zone Offset in the Right-Of-Way

11.1.1 – Lateral Offset

Providing a full clear zone offset is often not practical or desirable in environments that operate in a constrained right-of-way or along streets that operate at low speeds or low volumes. The lateral offset shall be provided to ensure street operations can be maintained and roadside structures do not encroach or are not contacted by vehicles in the travel way or parking lane. The lateral offset only applies to streets that have a vertical curb. If a vertical curb is not present, offsets shall meet the minimum clear zone offset outlined in Section 11.1.2

The lateral offset is measured from the face of curb to the street side edge of the object, unless otherwise stated in this section, and is illustrated in **Figure 11-3**.

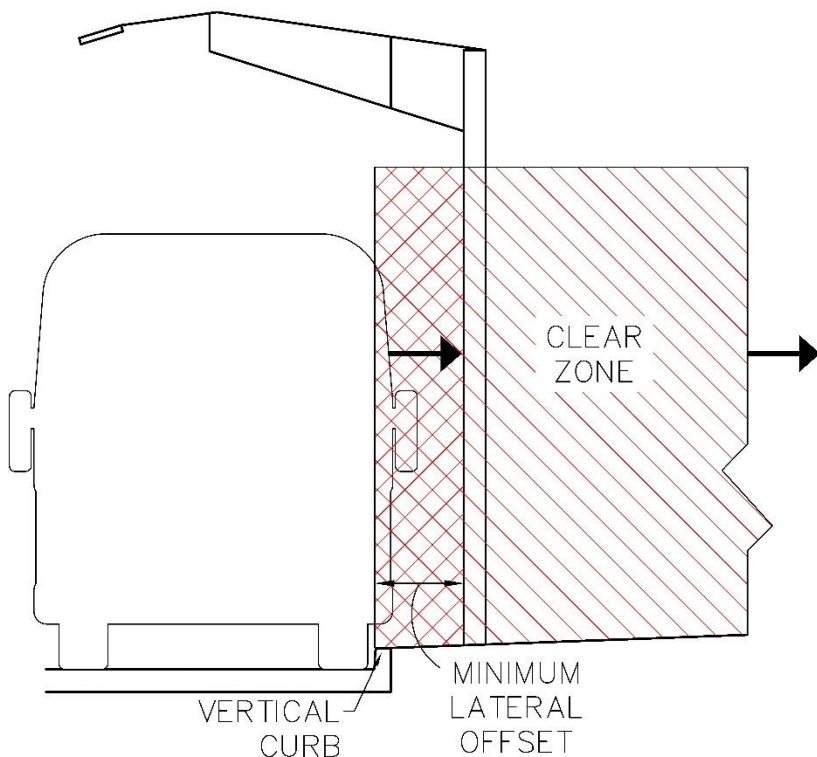


Figure 11-3 – Minimum Lateral Offset

- A. All objects shall have minimum 18 in. lateral offset.
- B. Objects at driveways and intersections shall have minimum 3 ft lateral offset
- C. All newly planted trees shall have a minimum 4.5 ft lateral offset to center of trunk, unless in the Downtown area per **Figure A-2** or in the University Neighborhood District Overlay (UNO), where streetscape standards from the **Great Streets Master Plan** shall be used.
- D. Standard placement for pedestrian appurtenances shall have minimum 4 ft lateral offset (refer to **Section 4.2.0** for criteria on pedestrian facilities and **Section 9.8.0** for criteria on bike facilities).

11.1.1.1 – Curb Space Object Placement Criteria

- A. Objects installed along the curb line shall be placed outside the lateral offset as defined in **Section 11.1.1** of this manual. The minimum lateral offset is 18 in.
- B. If a bike lane is present, installed objects shall not be placed in the bike lane or in the bike lane buffer, except when the bike lane buffer is adjacent to the edge of the vehicular travelway, where lateral offsets from **Table 5-2** apply.
- C. Installed objects shall not be placed within the minimum clear width of the sidewalk per **Section 4.1.1 (A)**.
- D. Refer to **Figure 11-4** for permissible zones for curb side object installation.

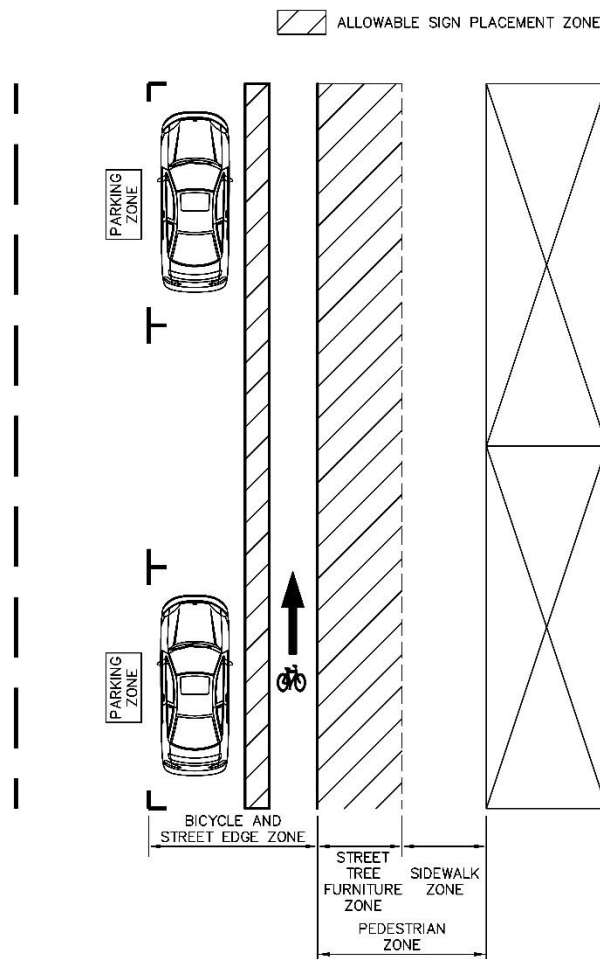


Figure 11-4 – Permissible Curb Side Object Installation Zones

- E. Parking signs shall be installed under the approval and direction of the City of Austin Traffic Engineer or applicable Director.
- F. Parking meters shall be installed under the approval and direction of the City of Austin Traffic Engineer or applicable Director.
- G. Irrigation and other private utility lines shall be placed a minimum of 4 ft from face of curb to be clear of any signs or sign foundations.

11.1.2 – Clear Zone Offset

The clear zone offset is dependent on the target speed of the roadway, the anticipated or observed average daily traffic and the slopes present adjacent to the travel way. The clear zone offset increases as the target speed, measured/anticipated traffic volumes, and fore slopes increase. **Figure 11-4** illustrates the relationship between edge of pavement, clear zone offset and Right-of-Way and where non-compliant objects must be protected or removed. Table 11-1 and 11-2 below outline minimum clear zone offsets for curbed and non-curbed streets. The clear zone offset must be graded at a slope that allows for recovery and redirection of an errant vehicle that leaves the travel way. Further guidance on roadside slopes is

Table 11-1 – Minimum Clear Zone Offset for Non-Curbed Streets

Target Speed	Average Daily Traffic (ADT) ²	Roadside Slope ¹		
		1V:6H or Flatter	1V:5H to 1V:4H	1V:3H ³
25-40	Under 750	10	10	N/A
	750-1,500	12	14	
	1,500-6,000	14	16	
	Over 6,000	16	18	
45-50	Under 750	12	14	N/A
	750-1,500	16	20	
	1,500-6,000	18	26	
	Over 6,000	22	28	
55	Under 750	14	18	N/A
	750-1,500	18	24	
	1,500-6,000	22	30	
	Over 6,000	24	32	
60	Under 750	18	24	N/A
	750-1,500	24	32	
	1,500-6,000	30	40	
	Over 6,000	32	44	
65	Under 750	20	26	N/A
	750-1,500	26	36	
	1500-6,000	32	42	
	Over 6,000	34	46	

Table 11-1 Notes:

1. All distances measured from the edge of the travel way (edge of pavement or outside lane stripe). If there are multiple slopes adjacent to the street the steeper of the two slopes shall be used to determine the clear zone offset, as shown in Figure 11-7.
 2. ADT shall be the anticipated value based on historical data or counts, if available. In the absence of data, the highest value shall be used.
 3. This slope is deemed as non-recoverable. See **Section 11.1.3** for further guidance.
- A. The clear zone offset shall be used by errant vehicles to redirect onto the street and shall be free of any of the obstructions listed below. If any of the listed obstructions are present within the clear zone offset, they shall be a crashworthy/break away type. If obstructions cannot be made crashworthy, they shall be removed or relocated outside the clear zone offset or be protected against with a crashworthy barrier. Refer to **Section 11.3.3** for guidance on the use of crashworthy traffic barriers, such as guard rails.
1. Trees
 2. Poles & Other Fixtures – luminaires, traffic signals, signs, fire hydrants
 3. Retaining Walls
 4. Vertical drop-offs and non-traversable fore slopes (steeper than 1V:3H) (refer to **Section 11.1.3** for an overview of fore slopes)

5. Stormwater Infrastructure - sag curb inlets, area inlets, headwalls, box culverts
 6. Bridge structures – piers, abutments, railing ends
 7. Permanent bodies of water
 8. Utility Boxes (franchise and city owned)
- B. If the use of a crashworthy barrier is not feasible and obstructions cannot be removed or relocated outside the clear zone offset, drivers shall be alerted of the presence of objects that violate the clear zone using highly visible illuminated signs.

11.1.2.1 – Clear Zone Offset on Horizontal Curves

Sections of the street that are located along a horizontal curve require a larger clear zone offset than straight sections. To prevent an increase in roadside collisions, increasing the clear zone offset will result in less obstructions near the travel way. Table 11-2 below outlines adjustment factors to clear zone offsets along horizontal curves.

Table 11-2 – Clear Zone Adjustment Factors for Horizontal Curves

Horizontal Curve Radius (ft)	Target Speed (mph)			
	25 – 40	45-50	55	65
3,000	1.1	1.1	1.2	1.2
2,500	1.1	1.2	1.2	1.2
2,000	1.1	1.2	1.2	1.3
1,500	1.2	1.3	1.3	1.4
1,000	1.2	1.4	1.5	1.5
750	1.3	1.4	1.5	N/A
500	1.4	1.5	N/A	N/A
250	1.5	N/A	N/A	N/A

Table 11-2 Notes:

1. To determine the adjusted clear zone offset, multiply the clear zone value obtained from Table 11-1 by the adjustment factor obtained in Table 11-2 for the minimum clear zone on horizontal curves.

11.1.3 – Roadside Slopes

This section outlines the difference between fore slopes and back slopes and the street types where they can be found outside the edge of pavement.

11.1.3.1 – Backslopes

Backslopes are slopes that fall toward the roadway and are typically present on curbed streets to facilitate drainage within the right-of-way or on-streets that are lower than the surrounding natural ground. Errant vehicles traveling on backslopes naturally redirect to the travel way. Thus, recoverable and traversable slope limits are not defined or required in excess of other City requirements in other manuals or City code related to slope requirements. Refer to Figure 11-7 for an illustration of a backslope.

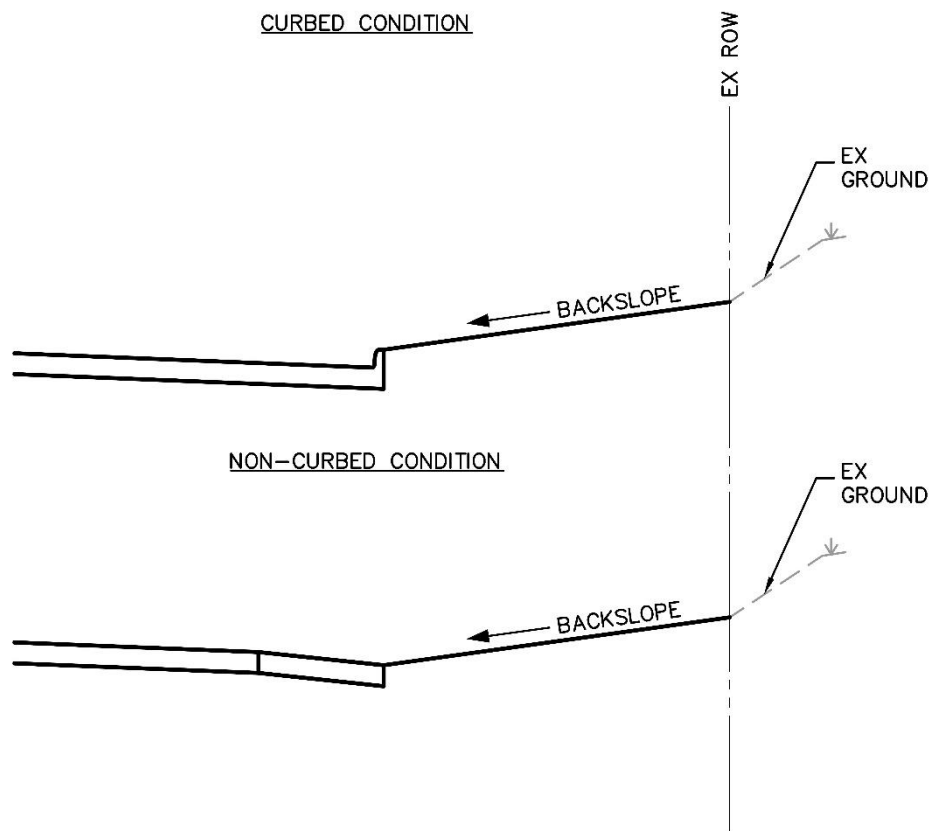


Figure 11-6 – Backslopes

- A. Clear zone widths in Tables 11-1 and 11-2 shall apply when a backslope exists.
- B. Backslopes shall be made at the flattest slope practicable that allows for conveyance of drainage without ponding or standing water.

11.1.3.2 – Fore Slopes & Ditch Sections

Fore slopes and ditch sections (fore slope and backslope adjacent to each other) are slopes that fall away from the roadway and are typically present on non-curbed streets to facilitate drainage. They are also present when the roadway is higher than the surrounding natural ground line. Extensive research has been done on their effect on errant vehicles and how vehicle handling is impacted when driving on this slope type. The fore slope steepness has a direct correlation to the minimum clear zone offset. Refer to Figure 11-6 for an illustration of fore slopes.

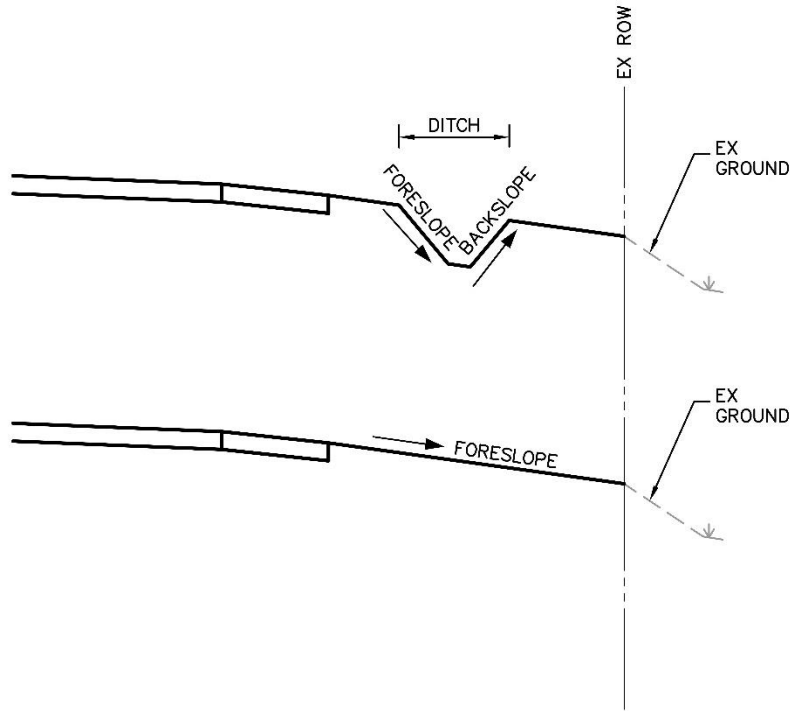


Figure 11-7 – Fore Slope

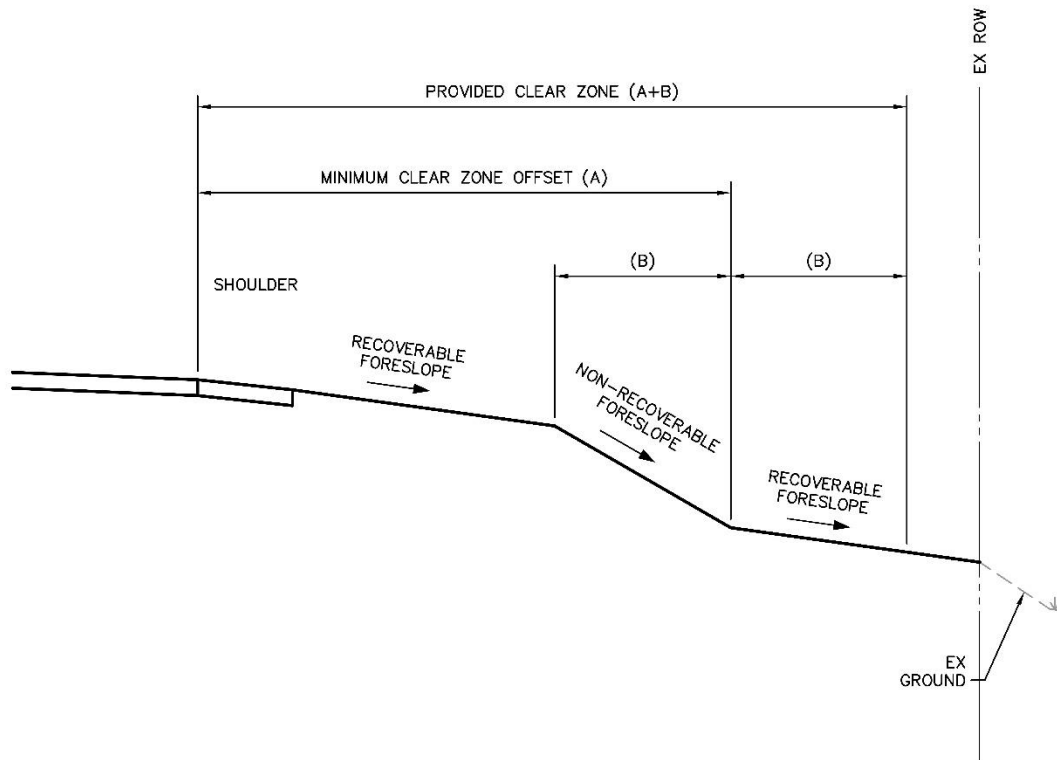


Figure 11-8 – Clear Zone Offset on Recoverable & Non-Recoverable Fore Slopes

- A. Fore slopes are deemed either recoverable/traversable, non-recoverable/traversable or non-recoverable/non-traversable. The following are the slope limits for each category:
- a) Flatter than 1V:3H – Recoverable & Traversable
 - b) 1V:3H – Non-Recoverable & Traversable
 - c) Steeper than 1V:3H – Non-Recoverable & Non-Traversable
- B. Fore slopes of 1V:3H are considered traversable but non-recoverable and objects shall not be present at the bottom of these slopes as the vehicle will likely continue to the bottom of the slope. If a non-recoverable fore slope falls within the clear zone offset, it does not count toward the clear zone offset requirement. Additional recoverable area shall be provided to meet the clear zone offset as illustrated in Figure 11-7.

Non-recoverable slopes shall not count towards the clear zone offset width, if a non-recoverable slope falls within the clear zone offset. Additional clear zone width shall be provided until the clear zone offset is met (refer to Figure 11-7, “A” represents the minimum clear zone offset obtained from Table 11-1 and “B” represents the width of the non-recoverable slope and the corresponding additional clear zone offset that shall be provided).

If the clear zone offset requirement cannot be met, a guardrail shall be installed per the criteria in **Section 11.3.3**.

11.2.0 – Landscaping Requirements

The criteria in this Section outline the height and vertical clearance requirements for landscaping in the right-of-way to provide sight distance and clear passage of street users.

Safety shall be the foremost consideration in the placement and selection of plant material in the City's right-of-way. The focus of these criteria is the prevention of traffic hazards that can be created by the placement of landscaping which restricts sight distance or creates obstacles to mobility. The following addresses acceptable criteria for landscaping and planting in the Bicycle and Street Edge Zone or Pedestrian Zone, within a median, and near intersections.

Landscaping is defined as the following:

- small trees (mature tree height of 30 ft or less)
- large trees (mature tree height of greater than 30 ft)
- small shrubs (maximum mature height of between 2 ft and 4 ft)
- large shrubs (maximum mature height of greater than 4 ft)

A listing of tree species and their mature heights are shown in Appendix F of the Environmental Criteria Manual (ECM). Landscaping size requirements are intended to maximize sight distance and minimize safety hazards for errant vehicles.

11.2.1 – Landscaping Vertical Clearance Requirements

Sight triangles shall be analyzed at conflict areas along the street such as driveways, intersections, and horizontal curves. Requirements for sight triangle analysis is presented in **Section 3.2.2** of this manual.

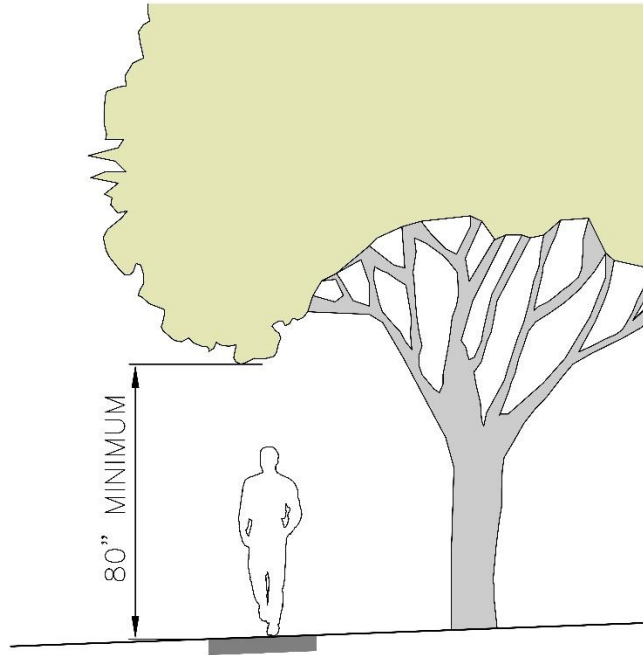


Figure 11-9 – Landscaping Vertical Clearance Above Sidewalks

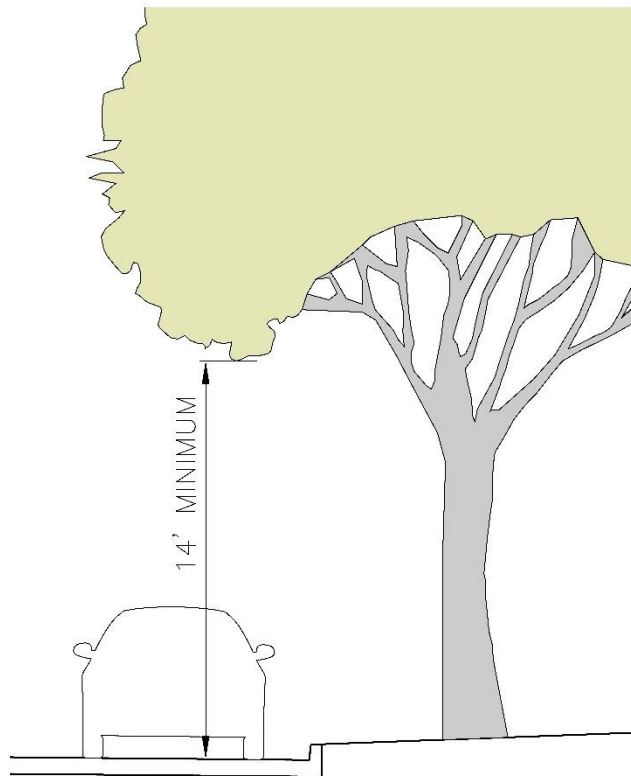


Figure 11-10 – Landscaping Vertical Clearance Above Streets

- A. A minimum clearance height of 80 in. above the sidewalk level must be provided and maintained for all existing and newly planted landscaping as shown in Figure 11-8. Refer to **Section 4** for width of path requirements.
- B. A minimum clearance height of 14 ft above the Street Level must be provided and maintained for all existing and newly planted landscaping as shown in Figure 11-9.
- C. Within sight triangle limits, large shrubs, as defined in the ECM, are not permitted. Small shrubs and ground cover shall be maintained to the height of 2 ft or less. If canopy of landscaping is present within sight triangle it shall meet the requirements of A and B of this list.

11.2.2 – Location Specific Landscaping Requirements

The following sections outline location-specific criteria for the placement of landscaping in the right-of-way.

11.2.2.1 – Street Trees

This section covers criteria for trees planted within the right-of-way. These trees are referred to as “street trees” throughout this manual. As shown in **Section 2**, street trees can be located in either the tree and furniture zone or the median, when a raised median is provided. All other median landscaping requirements are discussed later in this section. Street tree placement by Street Level is as follows:

- shall be planted on all Level 2 and greater streets
- shall be planted on Level 1 streets if the project fronts a Level 2 or greater street

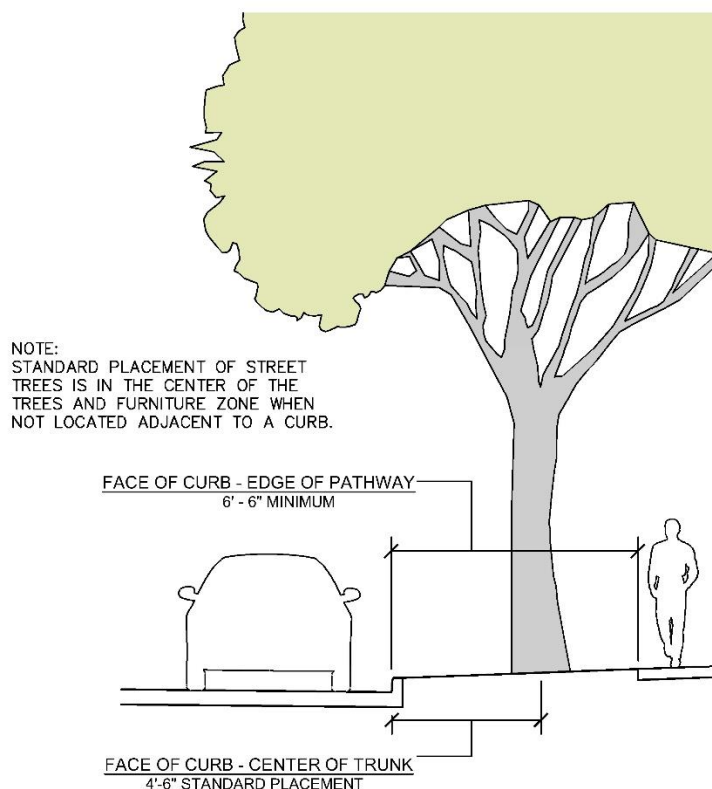


Figure 11-11 – Tree & Furniture Zone Horizontal Clearances

- A. The center of tree trunks shall be located 4 ft 6 in. from the face of curb, unless in the Downtown area per **Figure A-2** or in the University Neighborhood District Overlay (UNO), where streetscape standards from the **Great Streets Master Plan** shall be used.
- B. Street trees shall be planted on average 30 ft on center per the illustration in **Figure 11-11**, unless in the Downtown area per **Figure A-2** or in the University Neighborhood District Overlay (UNO), where streetscape standards from the **Great Streets Master Plan** shall be used.
- C. Street trees shall not be placed in areas that are required to be free from obstruction for sight distance reasons unless canopies are above vertical clearance requirements in **Section 11.2.1**.
- D. Near intersections, street trees should be placed strategically to minimize impacts to sight distance.
- E. See **Section 2.7.1.3 (K)** for criteria on-street tree quality soil requirements.
- F. Street trees should be sited for adequate lighting and protection from summer heat.
- G. Street trees require license agreements per **Section 11.2.3.2**.

11.2.2.2 – Median

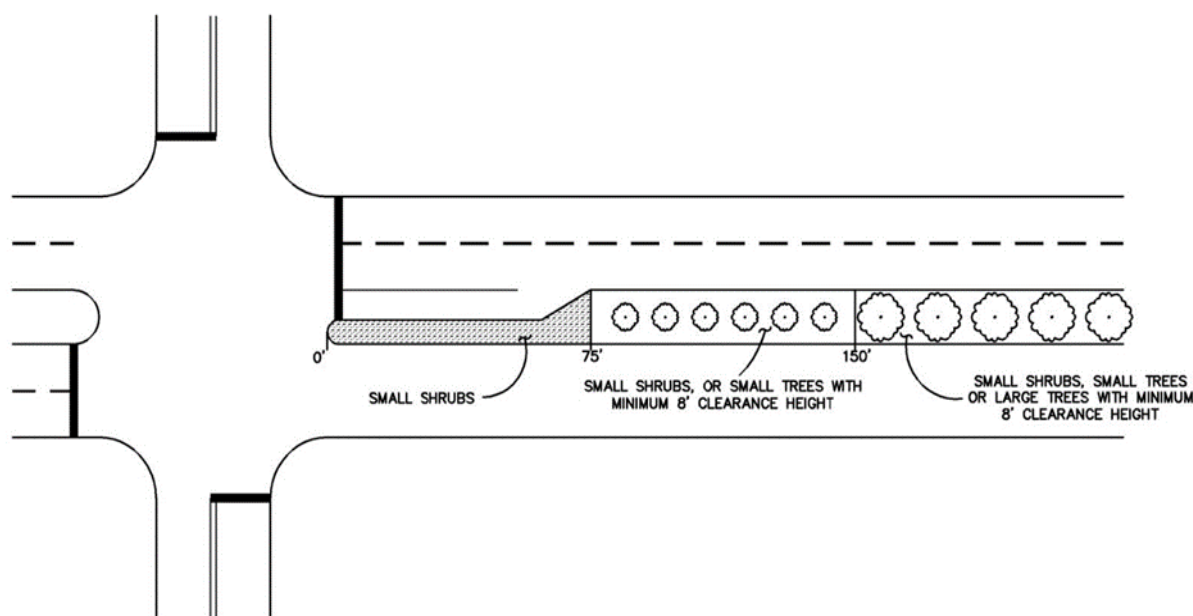


Figure 11-12 – Median Landscape Placement Requirements

- A. Ground covers or small shrubs with no more than 24 in. in height and small trees are recommended in the area from a point 75 ft to 150 ft from the nose of the median. This results in better sight distance visibility at intersections due to less visibility blockage, and reduced safety hazard for errant vehicles. (see **Figure 11-1**).
- B. In the area beyond 150 ft from the nose of the median, any planting shall be allowed as long as the requirements of **Section 11.2.1.C** are met.

- C. Street trees in a median shall be placed in the center of the median and shall not be placed in medians narrower than 9 ft from back of curb to back of curb.

11.2.2.3 – Railroad Crossings

Only small shrubs or ground cover maintained to a height of 2 ft or trees with canopies maintained to be greater than 8 ft above sidewalk level or 14 ft above Street Level are allowed within on 100 ft of an uncontrolled railroad crossing.

11.2.2.4 – School Crossing

Only small shrubs or ground cover maintained to a height of 18 in. or trees with canopies maintained to be greater than 8 ft above sidewalk level or 14 ft above Street Level are allowed within 150 ft of an uncontrolled school crossing.

11.2.2.5 – Traffic Control Devices

Tree canopies must be maintained and clear from a height of 7 ft to a height of 14 ft within a 25 ft radius of any existing or proposed traffic signal, regulatory or warning sign, or other traffic control device. If this is not feasible, maintenance must, at a minimum, clear vegetation from blocking visibility for the stopping sight distance (calculated from the Equation in **Section 3**) of traffic signal indicators, regulatory or warning signs, or other traffic control devices and provide a 2 ft buffer around extents of these objects.

11.2.3 – Landscaping Responsibilities

This Section outlines the protocol that shall be followed for landscaping maintenance and license agreements within the right-of-way.

11.2.3.1 – Landscaping Maintenance

- A. The adjacent property owner(s) shall maintain the landscaping located between curb or edge of pavement and the property line. The adjacent property owner shall also be responsible for trimming tree limbs from trees located on private property, which cause an obstruction of the right-of-way.
- B. The City reserves the right to prune or remove any vegetation, at the cost of the adjacent property owner(s), as determined necessary for visibility and ease of maintenance.

11.2.3.2 – Landscaping License Agreements & Removal

- A. Where limited right-of-way or the necessity for planting would result in less clearance than what is required within the remainder of **Section 11.2.0**, special exception may be justified. Such an exception must be approved by the City Transportation Engineer or applicable Director.
- B. Any landscaping that is not in compliance with the requirements outlined throughout **Section 11.2.0** or has been planted without an approved License Agreement from the City shall be removed by the property owner(s) at their cost. The required License Agreement may be obtained from the applicable department.
- C. Appeals dealing with street trees shall be reviewed by City Arborist.

11.3.0 – Railing

This section covers the requirements of the City of Austin relative to pedestrian and bicyclist railing, bridge railing, and guard rails along streets. To maintain consistency and safety to the general public, the latest edition of the Texas Department of Transportation's (TxDOT) "Bridge Railing Manual" (BRM) is hereby included by reference as a requirement within the jurisdiction of the City of Austin. The City of Austin's TCM will provide supplementary and complementary information and requirements to the TxDOT document. When there are differences between BRM and TCM, the more restrictive or conservative of the two shall be required.

11.3.1 – Pedestrian & Bicyclist Railing

- A. On pedestrian access routes, a pedestrian railing may be required if side slope is inconsistent with City of Austin Manuals, Specifications, or Details or applicable building codes.
- B. On pedestrian access routes, a pedestrian railing may be required if there is or will be a vertical drop-off of more than 10 in. anywhere in the area of influence. The area of influence is defined in **Section 4**.
- C. For projects proposing the installation of publicly maintained improvements in the right-of-way or easements, pedestrian railing shall conform to a current TxDOT standard drawing or a railing approved by a Professional Engineer registered in the State of Texas or City of Austin **Standard Details**. Responsibility for the appropriate selection and application of these standard railings remains with the Professional Engineer registered in the State of Texas who specifies them.
- D. For bridges with a design or operating speed above 45 mph, a separator railing is required to shield pedestrians from vehicles. Refer to **Section 11.3.2** for railing requirements along the outside edge of bridges.
- E. Any bridge that is designated for bicycle use shall meet the requirements in the latest edition of the TxDOT BRM.

11.3.2 – Bridge Railing

- A. For construction by site permit or for new subdivision construction, bridge railing shall be required at all bridges. For capital improvement projects on any roadways, bridge railing shall be required for all bridges. Responsibility for the appropriate use of a crash tested bridge railing such as TxDOT approved standard bridge railings remains with the professional engineer registered in the State of Texas who specifies them.
- B. When a bridge railing is to be specified on a bridge with a pedestrian access route and a combination railing is deemed inappropriate (e.g. design speed too high for combination railing alone), then the pedestrian railing shall be used in conjunction with a non-combination bridge railing.
- C. When transitions from bridge railing on the bridge to other railing on the street cannot be accommodated with guard rail (e.g. driveways), then suitable end protection (energy absorbing devices) shall be specified for the exposed ends of the bridge railing. Refer to **Section 11.3.3** for criteria on the use of guard rail.

11.3.3 – Guard Rail

Guard rail is a longitudinal barrier used to protect vehicles against non-crashworthy obstructions, drop-offs, or excessive slopes outside of vehicular travel lanes. The purpose of guard rail is to deflect up to 2 ft while redirecting vehicles which have left the travel way. Thus, allowing the vehicle to regain control and preventing them from striking a non-crashworthy object, drop-off, or slope that would be less forgiving than hitting the guard rail itself.

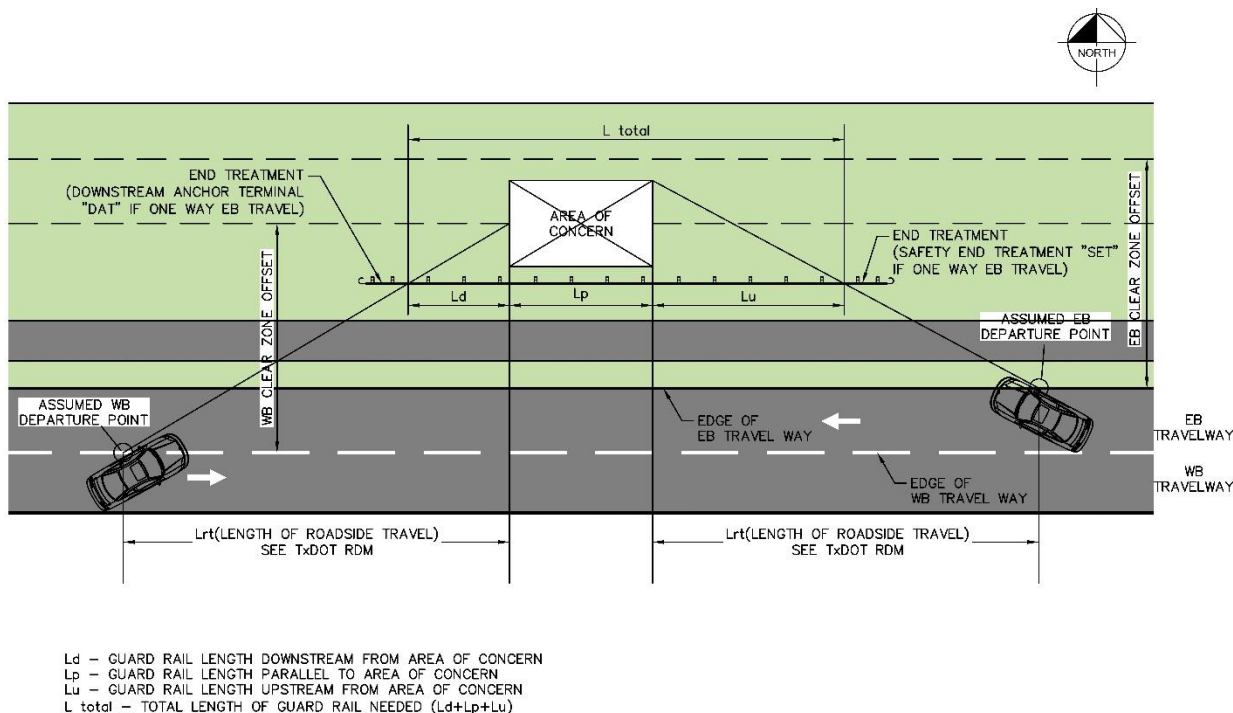


Figure 11-13 – Guard Rail Length Requirements

- A. Refer to the TxDOT Roadway Design Manual (RDM) for an outline of the components needed to protect roadside obstructions with guard rail (area of concern, guard fence length needed upstream, downstream, and parallel to the traffic flow) within the clear zone. Figure 11-12 illustrates the components involved in guard rail design. Refer to the TxDOT RDM for all design values and further discussion associated with each component shown in the figure.
- B. If a non-crashworthy obstruction is located within the minimum clear zone offset or lateral offset, consideration shall be made as to whether guard rail is used to protect against the non-crashworthy obstruction. Refer to **Section 11.1.1** for examples of non-crashworthy obstructions and criteria on the required minimum clear zone offset.
- C. Guard rail shall be installed if the result of a vehicle striking the guard rail will be less severe than the result of the vehicle striking the unprotected non-crashworthy obstructions.
- D. When the total length of required guard rail (see Figure 11-12) cannot be accommodated for protecting against non-crashworthy roadside obstructions (e.g. driveway openings falling within total length of guard rail needed) an alternative form of protection is the use of suitable end protection (energy absorbing devices) to protect against oncoming traffic or wrapping the guard rail around the driveway opening to shield the side of the obstruction.

SECTION 12 – SMALL CELL NETWORK FACILITIES IN THE RIGHT-OF-WAY

No change to Section 12 of the TCM proposed

SECTION 13 – STRUCTURES IN THE RIGHT-OF-WAY AND IN EASEMENTS

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13.1.0 – General

This section presents structural design criteria for retaining walls, bridges, culverts, headwalls, junction structures, screening walls, and stormwater drainage pipe to be constructed in the right-of-way, easements, and any City property. Structures, such as retaining walls, that are located on private property will also be subject to these requirements if the failure of the structure impacts City property. Structural design of electric utility infrastructure and mass transit facilities and hydraulic design of structures for stormwater drainage facilities are presented in other Criteria Manuals. Drainage facilities, referred to as stormwater control measures, include but are not limited to headwalls, open channels, storm drains, area inlets, easements, detention ponds, retention ponds, water quality controls, and their appurtenances. Applicable sections where these are applied include:

- 13.1.0 – General
- 13.2.3 – General Requirements, paragraphs 3 and 6,
- 13.2.4 – Wall Location and Layout, paragraph 1,
- 13.2.7 – Internal Drainage, paragraph 1,
- 13.2.8 – External (Surface) Drainage,
- 13.2.14 – Construction Drawings, paragraphs 2 and 3.
- 13.3.0 – Bridges
- 13.4.0 – Culverts

At a minimum, all structures shall be designed using the current standards and guidelines as adopted by the City and shall meet the applicable local, state, and federal standards. For other standards not specifically adopted by the City, the latest edition of that standard or guideline shall be utilized.

13.2.0 – RETAINING WALLS

13.2.1 – Definitions

A. Conditional/Incomplete Design

In a "conditional" design, the designer defers essential elements of the design to someone else. An example of conditional design is one in which, by a note on the drawings, the designer makes the contractor responsible for determining whether the subsurface materials will support the applied wall footing loads. An "incomplete" design does not address all of the requirements in this section. An example of incomplete design is one in which the designer checks only internal wall stability, with the implication being that someone else will check external stability.

B. Construction Waiver

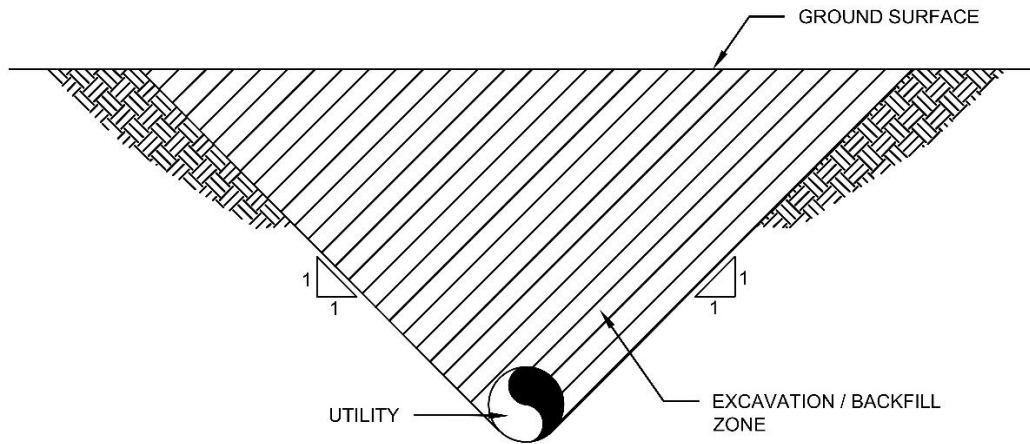
A construction waiver grants the owner of abutting private property permission to construct, in the right-of-way, a minor structure that is non-standard or is of benefit only to that property. The waiver attaches to the property, being recorded with the county record of deeds. Construction waivers exempt the City from maintaining the structure and from financial liability for property damage or personal injury associated with the structure. It also requires the complete removal of the structure, at the owner's expense, if required by the City.

C. Minor Structure

A minor structure is defined as a retaining wall less than 2 ft in height in accordance with **Figure 13-3**, stairs, or level-ups (less than 2 ft in height). Minor structures also include driveway or ramps.

D. Excavation/Backfill Zone

The excavation/backfill zone for utilities and other structures shall meet all applicable OSHA regulations and the respective utility's criteria and shall be defined in the following Figure 13-1 and Figure 13-2.



UTILITY EXCAVATION /
BACKFILL ZONE DIAGRAM

Figure 13-1 – Utility Excavation/Backfill Zone

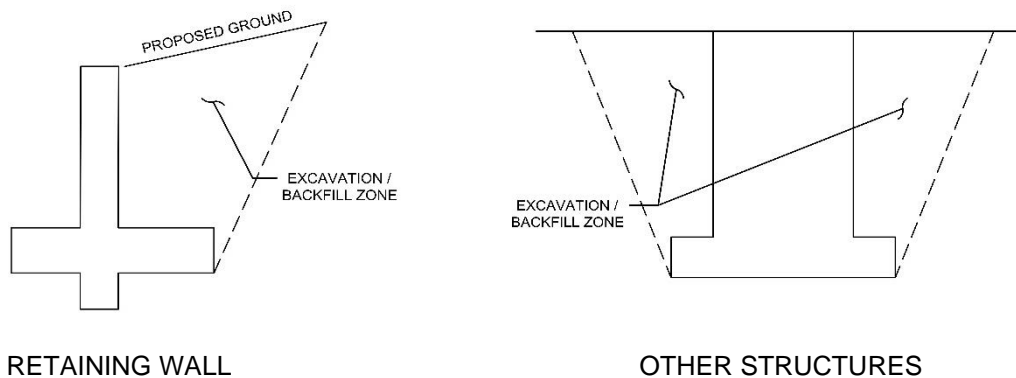


Figure 13-2 – Structure Excavation/Backfill Zone

All shoring and excavation plans for structures shall be designed by a licensed professional engineer in the State of Texas.

E. Fascia Wall

A fascia wall is constructed over the face of a stable slope to enhance its appearance or to protect the slope from degradation due to weathering. The slope may be stable naturally or may be made stable by nailing or other forms of reinforcement. Fascia walls do not contribute to the overall stability of the slope.

F. License Agreement

A license agreement grants a second party, such as an individual private property owner, homeowners' association or corporation, permission to use public right-of-way for a temporary structure that requires maintenance or that poses unusual risk to the city. It further contains a 90-day revocability clause. If the structure must be permanent, an Encroachment Agreement shall be

required. The license agreement exempts the city from maintaining the structure and from financial liability for property damage or personal injury associated with the structure.

G. Encroachment Agreement

An encroachment agreement authorizes a private structure to permanently encroach the right-of-way. An encroachment agreement authorizes use of public right-of-way as long as the encroachment allowed under the agreement continues. City Council must approve an encroachment agreement.

H. Mechanically Stabilized Earth (MSE) Retaining Wall

A mechanically stabilized earth retaining wall is composed of facing units and metal strips or geosynthetic (geogrid) reinforcement connecting to the facing units and extending behind the wall into special backfill. The design of these walls shall at a minimum consider the interaction of the facing units, strips or geogrid, and backfill, acting as a system, as well as global stability, foundation stability (bearing capacity) and internal shear. When using these wall types, easements shall be considered for the zone of influence behind the wall.

I. Non-Standard Retaining Wall

A non-standard retaining wall is any wall not meeting the definition of a standard wall.

J. Product-Specific Information

Product-specific information describes the behavior, performance characteristics or qualities of a material or interacting materials or components and is based on results of standardized tests.

K. Retaining Wall

A retaining wall is a structure used to support a soil or rock embankment, slope, or cut in a vertical or near-vertical configuration in which it would otherwise be unstable because of gravitational forces or applied loads.

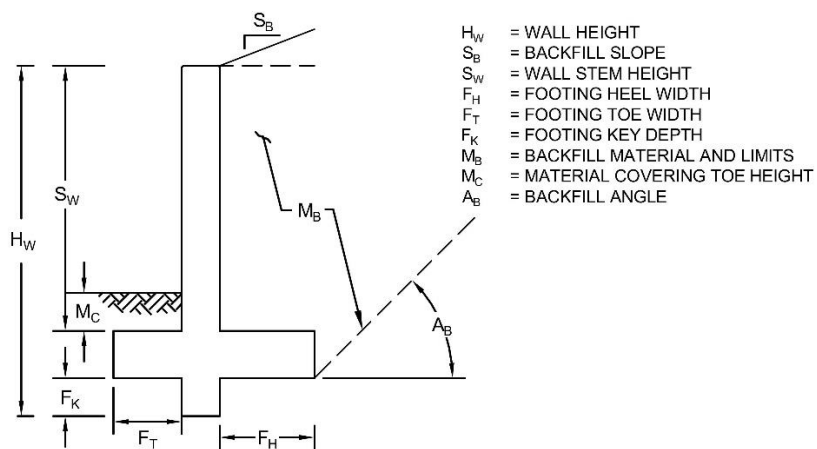


Figure 13-3 – Retaining Wall Geometry

L. Tie-backs, Soil or Rock Nail

Tie-back retaining walls generally refer to walls that consist of post-tensioned anchors, that have been placed in pre-drilled holes, and then grouted in place. Nailing is the reinforcement of slopes by installing anchors in horizontal or near-horizontal, pre-drilled holes in the soil or rock, usually followed by shotcreting of the slope face. The anchors shall be proof tested and performance tested to confirm the efficiency of the anchor/grout/soil or rock interaction. A fascia wall usually covers the shotcrete surface. Frequency of proof and performance testing as well as specific locations shall

be included as a part of the design submitted to the City for review. When using these wall types, easements shall be considered for the zone of influence behind the wall.

M. Standard Retaining Wall

A standard retaining wall is a free-standing, cantilever or counterfort wall consisting of cast-in-place, reinforced concrete designed according to AASHTO *Standard Specifications for Highway Bridges*, latest edition. Wall details at a minimum may also comply with TxDOT standard wall design details but use of these details must be validated through submittal of calculations and geotechnical information.

N. Tiered Walls

Retaining walls constructed one behind the other, each wall creating a bench or step, resulting in a terraced slope.

O. Utility Assignments

The pre-assigned horizontal and vertical positions of the utilities in the street right-of-way or easement.

P. Wall Height

The wall height dimension for structural design shall be taken as the vertical distance from the bottom of the footing to the top of the wall as defined by **Figure 13-3**. A retaining wall is considered to have potential influence on the right-of-way if it is located behind the right-of-way, easement, or setback behind property line within a distance equal to or less than the wall height.

Q. Wall Systems

Retaining walls whose performance relies on multiple components acting together as an integral unit. Examples are mechanically stabilized earth retaining walls and walls of any type with underdrains, filter media and porous backfill.

R. Zone of influence

The zone of influence for a retaining wall in general is defined as the area behind the wall that includes footings, mechanical straps, soil nails, rock anchors, tiebacks, or similar appurtenances. It is also defined as the area containing select backfill material whichever is greater. Improvements shall not be permitted within the zone of influence without specific approval. **Figure 13-4** illustrates the zone of influence.

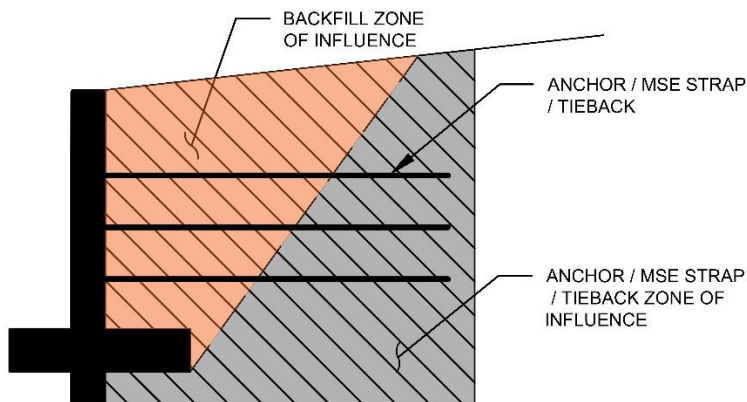


Figure 13-4 – Retaining Wall Zone of Influence

13.2.2 – Use of Standard/Non-Standard Walls

Standard retaining walls, necessary for city sponsored public construction, will be permitted in the street right-of-way or easement when necessary, provided the requirements in this section have been satisfied. Retaining walls proposed solely to facilitate private development designs may not be placed in the right-of-way or within a distance from the right-of-way such that the wall's movement or failure would impact the right-of-way. Non-standard walls will be considered on a case-by-case basis and may be permitted by the Director, depending on wall type, wall height and layout, proximity to buried utilities, industry acceptance, availability of test data covering characteristics and performance of the proposed materials and documented long-term performance of similar walls in similar applications. Retaining walls are often necessary; however, grading and design layout shall avoid walls in or near the right-of-way wherever reasonably practicable.

13.2.3 – General Requirements

Retaining walls, except for those less than 2 ft in height, regardless of type, must be designed by engineers licensed in the State of Texas, using current industry standards and accepted engineering practices. Retaining walls, regardless of type, must be constructed of materials meeting City of Austin **Standards Manual** and **Standard Specifications**, where applicable, or ASTM or AASHTO materials and test specifications. Walls for which there are no published, nationally recognized, design criteria or for which there are no ASTM or AASHTO materials or test specifications will not be permitted.

Conditional or incomplete designs will not be accepted. All aspects of design must be addressed and clearly conveyed in the drawings and specifications.

Tiered (perched) walls and back-to-back walls will be permitted only under special circumstances and only with the approval of the Director. When approved, additional information must be submitted for review to include but not be limited to global stability calculations and verification of compliance with applicable industry standard and guidelines for factors of safety.

Retaining walls must be designed for external and internal stability. The design must include, as necessary, the effects of water or wastewater line breaks, the effects of inundation and rapid drawdown resulting from flooding or stormwater detention or retention, including hydrostatic pressures, internal erosion, scour, and alteration of engineering characteristics and behavior of foundation and backfill materials. The walls must be designed to support, where applicable, surcharge loads from traffic or structures and lateral loads from nearby guardrail or streetlight foundation footings.

Walls consisting of pre-cast segmental units, whether these units are facing or structural elements, must have a coping or capstone at the top of the wall. The coping may be pre-cast or cast in place. The coping or capstone must extend above the adjacent ground at least 4 in. (100 millimeters). If cast in place, the coping must be reinforced and must have control and expansion joints to accommodate differential movements in the wall. Pre-cast coping and capstone must be affixed to the upper layer of segmental wall by using epoxy, non-shrink grout or other methods or material as recommended by the manufacturer, appropriate for the material and installation, and approved by the City.

Walls constructed using flexible facing elements, such as welded or woven wire, will be permitted only in drainage channel applications not affecting or related to roadway embankment. Metal prefabricated modular walls will not be permitted.

Where retaining walls are used as the exterior walls in stormwater retention structures, the walls must be cast-in-place reinforced concrete made watertight by using approved waterstops in joints and using underdrains behind the walls, as necessary. Where retaining walls are used as the exterior walls in stormwater detention structures and the walls are not watertight, then the walls must be designed to provide free drainage of the backfill following drawdown.

TxDOT standard details may be used. In such cases, the engineer must submit validation in the form of calculations showing that the correct wall type was selected and that backfill type and geometry as shown on the details conform to design criteria. If any modifications to the standard details are necessary, the engineer must modify those details as appropriate and notate the details as a “MOD” detail. Engineer must sign and seal the MOD details as a part of the design package.

All wall designs must be accompanied by a geotechnical investigation specific to the retaining wall design unless the wall height is less than 2 ft high. Wall designs shall conform to the design criteria as outlined in the geotechnical investigation.

Materials must meet the requirements for the City of Austin where applicable. Otherwise, they must meet the requirements of TxDOT’s Departmental Materials Specifications (DMS) approved list, ASTM and/or AASHTO requirements.

13.2.4 – Wall Location and Layout

A. General

The city will assume maintenance responsibility only for those walls that are necessary to facilitate a city sponsored public project or support channel slopes in drainage easements. Retaining walls that facilitate private property development must be built on private property and must be privately owned and maintained. Designers must fully consider topography of parcels proposed for private development in their preliminary planning and design and develop sites such that any retaining walls necessary are located fully within private property and at locations where if the wall were to move or fail, the right-of-way would not be affected. Only in special cases approved by the Director will retaining walls that facilitate private property development be allowed in public right-of-way or drainage easement. License agreements or Encroachment agreements will be required for all retaining walls in the right-of-way or drainage easement that support private property.

Utility mains and service lines must not pass through or under a retaining wall unless the utility is installed in an encasement pipe meeting the approval of the affected Utility. The encasement pipe must extend beyond the retaining wall a sufficient distance to insure that future excavation to expose the ends of the casing will not endanger any external structural component of the wall, will not threaten the stability of the wall itself and will not encroach upon any components of the wall system, including backfill. For utility services, the encasement pipe must extend from the main to the property line and must be large enough to pass valves, connections, couplings and other components that are integral parts of the service.

In street right of way, a minimum of 36 inches (1 meter) of protective soil or rock cover must be provided over the upper layer or row of external structural components such as geogrid, strips, bars, tie bars or buried pre-cast units.

In general, trees and large shrubs shall not be permitted near retaining walls and other structures. Any proposed landscaping within the zone of influence of a retaining wall or structure as defined by **Figure 13-4** shall not be permitted without approval. Similarly, no retaining walls or other structures shall be constructed in the vicinity of existing trees, large shrubs, and other landscaping without approval if the trees and/or shrubs will fall within the proposed zone of influence as defined by **Figure 13-4**.

B. Proximity to Right-of-Way and/or Easements

Any development including retaining walls that may adversely affect the public right-of-way or public infrastructure is highly discouraged. If the distance measured from the wall to the nearest easement or Right-of-Way, D_1 , is less than or equal to wall height, H_1 , as shown in Figure 13-5, then the retaining wall is subject to the criteria of Section 13 of the TCM.

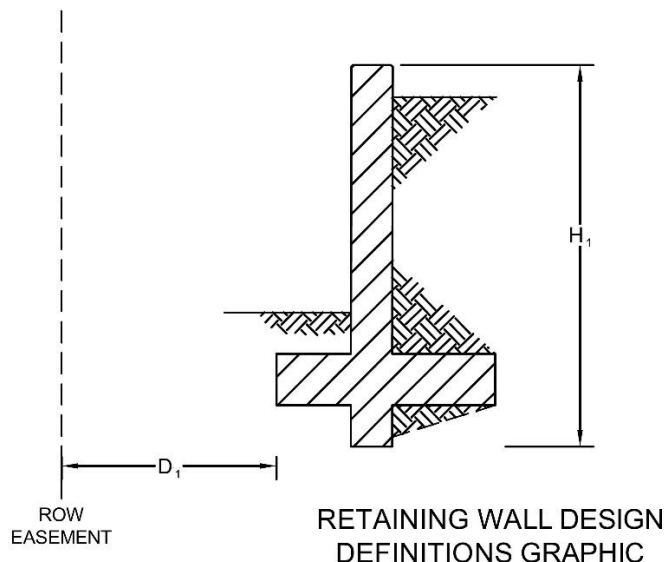


Figure 13-5 – Measurement to Right-of-Way or Easement

C. In Streets and Utility Easements

Utilities, utility appurtenances, and pavements have priority over retaining walls in street right-of-way and utility easements. Retaining wall layout must take into account utility assignments in addition to allowing for future utility installation and future excavation for utility maintenance and repair, including mains as well as services. No component of the retaining wall that is essential to the stability of the wall or wall system (such as footings, underdrains, strips, geogrid, bars, tie bars, or buried pre-cast units) can be within the excavation / backfill zone of any utility main or service regardless of the type of utility. The wall or wall system must be stable under any scenario involving utility excavation in the excavation / backfill zone. External components of the retaining wall, such as geogrid, anchors, strips, tie bars or buried pre-cast units, which are essential to stability of the wall, cannot extend beyond the back of curb, under the street, or into utility easements unless the external components are at least 10 ft (3 meters) below the street surface and at least 3 ft (1 meter) below the deepest utility.

The distance between the street-side face of the wall and the back of curb must be such that sidewalk and ramps can be accommodated, but in no case can this distance be less than 5 ft (1.5 meters), with provisions for pedestrian and vehicular railing, as needed. The wall must be located outside the right-of-way.

13.2.5 – Structural Requirements

Retaining walls must be designed according to Division I Section 5 of AASHTO *Standard Specifications for Highway Bridges*, latest edition. The following additional requirements apply, depending on type of wall. TxDOT standard details may be used as described in **Section 13.2.3**.

A. Design Life

Design must be based on a 100-year service life that, from a structural standpoint, is essentially maintenance-free. Walls subject to City maintenance must be designed to withstand full hydrostatic pressures.

B. Cast in Place Concrete

Cast in place concrete must have a minimum compressive strength of 3,600 psi. Joints, including waterstops where applicable, must be provided according to the latest addition of *ACI Manual of Concrete Practice* Standard 224.3R Chapter 8. Waterstop type and use may be selected from TxDOT's latest approved Departmental Material Specifications (DMS) list for waterstop. Waterstop type and specific locations must be listed on the plans.

C. Conventional Segmental Gravity Walls (without mechanically stabilized backfill)

Internal stability of segmental gravity retaining walls without mechanically stabilized backfill (mortared or dry-stack rock, boulders or pre-cast concrete units) must be analyzed according to *NCMA Design Manual for Segmental Retaining Walls*, latest edition. The minimum factor of safety for internal shear capacity must be at least 1.5 if product-specific information is available. If the 1.5 factor of safety is used based on product-specific information, then no substitution of materials or product will be allowed without a revised design being approved. Otherwise, it must be at least 4. External and overall, or global, stability shall be analyzed according to *AASHTO Standard Specifications for Highway Bridges*, latest edition.

D. Tie-backs, Soil and Rock Nailing

Tie-back, soil, and rock nail anchor walls must be designed according to the latest edition of the following guidelines:

FHWA Geotechnical Circular for Ground Anchors and Anchored Systems.

PTI, Recommendations for Prestressed Rock and Soil Anchors, latest edition.

FHWA Geotechnical Circular for Ground Anchors and Anchored Systems.

FHWA *Manual for Design & Construction Monitoring of Soil Nail Walls* and the University of Texas Center for Transportation Research Report 1407-1F, *Rock Nail Design Guidelines for Roadway Cuts in Central Texas*.

Steel anchors must be corrosion-protected by epoxy coating or by encapsulation. Steel anchors protected only by grouting will not be permitted. In all cases, rock nails must be used in conjunction with shotcrete and a fascia wall.

Surface drainage must be prevented from infiltrating behind the wall or flowing over the wall by installing an interceptor ditch behind the top of the wall. To control groundwater seepage, composite geosynthetic face drains must be installed on the exposed rock face before shotcreting. The face drains must extend the full height of the wall and must connect to a base drain that discharges from behind the wall in a manner that water is not directed onto the adjacent sidewalk or into the street.

Temporary tiebacks and soil nails in vicinity of utilities may not be steel or concrete and must be easily removable for excavation equipment. Materials must be submitted for approval prior to construction.

No tiebacks or soil nails are permitted within the zone of influence as defined in **Figure 13-4**. In situations where utilities are located within the zone of proposed soil nails or tiebacks, special approval must be obtained prior to design.

13.2.6 – Material Requirements

Materials must meet City of Austin **Standard Specifications**, where applicable. Otherwise, they must meet the requirements of the applicable Sections in Division II of *AASHTO Standard Specifications for Highway Bridges*, latest edition.

13.2.7 – Internal Drainage

- A. Retaining wall backfill must be free-draining, non-expansive material that is non-aggressive to external structural or drainage components unless wall geometry or backfill constraints limit this use. In such cases, Wall design must accommodate higher backfill soil and hydrostatic pressures.
- B. Wall design must accommodate higher backfill soil and full hydrostatic pressures. Backfill must meet the requirements outlined in the geotechnical investigation.
- C. Underdrains or weep holes must be provided. Geotextile fabric or graded granular filters must be provided as necessary to prevent migration of fine-grained soil particles from the surrounding soils into the backfill and drainage media. The fabric or granular filter must be designed not only to prevent migration of fine-grained soil particles but also not to become clogged by those particles. Underdrains and weep holes must not discharge where drainage can flow onto adjacent sidewalk or into the street. When french drains are used as underdrains, cleanouts must be provided to allow periodic cleaning of the drain. Install cleanouts at 100 ft on center and at least 1 cleanout per 135 degree change of direction. Use 2 45-degree elbows at locations where the system bends 90 degrees to promote ease of cleaning. The plans must indicate party responsible for annual maintenance and cleaning of underdrains and weep holes.

13.2.8 – External (Surface) Drainage

Surface runoff that flows toward the retaining wall from the retained slope must be collected in a vegetated or paved interceptor ditch behind the wall and transmitted to a stormwater inlet or let-down structure to prevent water from flowing over the wall, collecting in low points behind the wall or eroding the slope at the ends of the wall.

13.2.9 – Maintenance Provisions

A 20 ft (6 meters) wide truck-accessible maintenance access zone must be provided at the base of walls higher than 10 ft (3 meters) that support roadway embankment. The maintenance access zone must be free of obstacles to vehicles, relatively smooth and level, all-weather accessible, and able to support loads from maintenance vehicles. The maintenance access zone may consist of easement or right-of-way, or both.

13.2.10 – Safety Provisions

Safety rail (vehicular and pedestrian specific as appropriate) must be provided on any wall that supports roadway embankment adjacent to sidewalks and roadways in accordance with PROWAG, ADA, and AASHTO requirements. Safety rail must also be provided on any wall not supporting roadway embankment if the ground surface behind the wall slopes toward the wall and this surface is part of a park, playground, single or multi-family residence. A chain link fence may be preferable to and substituted for safety rail in many of these installations with approval.

Roadside barriers such as metal beam guardrail or concrete barrier rail must be designed according to the latest editions of AASHTO Roadside Design Guide and AASHTO *Standard Specifications for Highway Bridges* regardless of street classification. In locations where design speed is lower than what standards provide, the minimum design speed for barrier design shall be used.

13.2.11 – Warning Devices

Walls supporting roadway embankment and having structural components (geogrid, strips, tie bars, or pre-cast units) extending behind the wall must have plaques placed in the coping or capstone along the top of the wall at intervals not exceeding 100 ft (30 meters). The plaques must be made of durable metal, at least 5 in. (125 millimeters) by 8 in. (200 millimeters), with 0.5 in. (12.5 millimeters) raised lettering that reads "Do not excavate between the retaining wall and street/No excave entre el muro de contención y la calle." The plaque must have at least two studs attached

to the back so it can be mounted flat against the coping or capstone by inserting the studs into holes drilled into the side or top of the coping or capstone. The plaque must be set in epoxy or non-shrink grout covering the mounting surface and filling the holes.

Walls not supporting roadway embankment, but having structural components (geogrid, strips, tie bars, or pre-cast units) extending behind the wall must have warning plaques as described above but which say "Do not excavate behind the wall within _____ ft/No excave detrás del muro de contención dentro de una distancia de _____ meters."

Warning tape must be placed 6 in. (150 millimeters) above the uppermost layer of geogrid or strips used in MSE walls. The tape must be placed in a crisscross pattern on 24 in. (600 millimeters) spacing.

13.2.12 – Supplemental Construction

Conduits must be installed adjacent to retaining walls that support roadway embankment wherever geogrid, tie bars, rods or pre-cast units extend behind the wall. Two 4 in. (100 millimeters) diameter, Schedule 40 polyvinyl chloride (PVC) pipes must be provided between the retaining wall and street, parallel to the back of curb along the entire wall, to provide for future installation of utilities such as communications cables. Pull-boxes must be installed at the ends of the pipe and at intermediate points, as appropriate, but in no case shall the distance between pull-boxes exceed 200 ft (60 meters).

13.2.13 – Geotechnical Information

A geotechnical investigation must be performed for retaining walls, higher than 2 ft measured from the base of the footing to the top of the wall for walls with flat backfill. For walls with sloping backfill, top of wall shall be taken as top of slope measured at the back of the footing heel. Refer to **Figure 13-3**.

13.2.14 – Construction Drawings

- A. The drawings must contain the design assumptions, material properties and all actual, calculated factors of safety and reduction factors compared to the recommended values or criteria in the AASHTO, NCMA or FHWA design criteria, whichever applies, and in the project geotechnical report. Design criteria such as, but not limited to, factors of safety for sliding, overturning, bearing capacity, and global stability, as well as code references for loading, and material strengths.
- B. The retaining wall and any external structural elements, such as geogrid, tie bars or pre-cast units, must be shown on the plan and profile sheets for street, drainage and utility construction and on the site plan for drainage structures so that the location of the retaining wall and related components will be obvious to anyone reading the drawings. For walls designed with drainage to be collected behind the wall, plans shall show entire conduit location from the wall to the approved storm drain connection or discharge point.
- C. The drawings must contain a separate plan and profile sheet for the wall itself, drawn to a 1 in. = 30 ft (1 to 400), or larger detail plan view and 1 in. = 3 ft (1 to 40), or larger detail profile view. The plan view drawing must show all buried utilities, structures and other constructed features, both existing and proposed, within a horizontal distance of 2 times the wall height. The following must be included: wastewater mains, services and manholes; stormwater drainage pipe, inlets, junction boxes and manholes; water mains, services and hydrants; electrical lines and services; gas mains and services; communications and entertainment lines and services; pavement curb and gutter; sidewalk; guardrail, pull boxes, sign footings, street light footings, and the limits of geogrid, strips, tie bars or nail tendons or rods and other features as required.

- D. The profile view drawing must include the top of wall elevations, footing elevations, locations of changes in top of wall; locations of warning plaques; the elevations of each layer of geogrid, strips or tie bars, if used; the existing ground line at the base of the wall; the proposed ground line at the back of wall; all utilities shown on the plan view, and other features as required. Exact locations of existing utilities must be provided, based on "pot holing" if necessary.
- E. The drawings must contain cross-sections of the wall at points where the wall height is maximum, where drainage structures penetrate the wall, where the utility excavation/backfill zone is most critical and where structures behind the wall fall within the zone of geogrid, strips, tie bars or pre-cast units, if used. The cross sections must be drawn to scale and must show utilities, utility excavation/backfill zone, sidewalks, pavements, wall units, backfill, filter fabric, handrail, guardrail, geogrid, strips, or tie bars, inlets, headwalls, the existing ground line, and other features as required.
- F. Typical sections of the wall must be provided, showing all components necessary to construct the wall and appurtenances.
- G. Control joint and expansion joint locations must be shown on the drawings. Details for each joint must be shown. At a minimum, spacing must conform to that outlined in TxDOT details.
- H. Details of appurtenances such as handrail, guardrail and headwalls, must be included in the drawings.

13.2.15 – Technical Specifications

- A. Technical specifications must describe all materials that comprise the wall, using City of Austin *Standard Specifications* where applicable. Specific—rather than generic—products, brands, models or styles should be referenced, if possible, and locally produced materials should be specified by producer and product designation, listing alternative sources and products. Alternately, materials may be specified by their composition and physical and chemical properties and characteristics, in which case, the design engineer and the City must approve each product, based on the contractor's submittals including the requisite test results and certifications.
- B. The specifications must state that the contractor, producer or manufacturer are responsible for quality control testing during production or manufacture of the materials and for testing of materials for the purpose of demonstrating, before construction, that they meet the project specifications. The specifications must also require that a Texas-licensed professional engineer certify that the materials meet the project specifications. Test results, including a summary comparison of the tests to the project specifications, must be submitted with the certification. The certification must be accepted by the City before construction. This testing and certification is to be performed at no cost to the City and is separate from and precedes quality control testing performed by the City during construction.
- C. All materials that comprise the wall appurtenances, such as guardrail and safety rail, must be described.
- D. The specifications must state that chipped, cracked or honeycombed pre-cast concrete units, and marred or damaged geosynthetic, metal straps, tie bars or other components must not be incorporated into the project.

13.2.16 – Shop Drawings/Materials Tests

The specifications must require submittal of shop drawings, concrete mix designs, and other technical and material information, as required, for all wall components and materials, geogrid, strips, tie bars, waterstop, filter fabric, and other components.

13.2.17 – Changes in Design or Materials

Material substitutions or changes in wall components, design or configuration are not permitted after the City has issued a development permit unless revised drawings and, if required, revised technical specifications are submitted for City review and approval before construction.

13.2.18 – License Agreements/ Encroachment Agreements / Construction Waivers

License agreements are required for all temporary retaining walls facilitating private site development, if allowed, that are proposed in the right-of-way. An encroachment agreement is required if the structure is permanent. Construction waivers may be granted for retaining walls less than 2 ft high and not supporting roadway embankment.

13.3.0 – BRIDGES

Bridge design shall meet the following criteria in this section in addition to coordinating with the **Environmental Criteria Manual** for design standards for Critical Water Quality Zones. Also refer to **Drainage Criteria Manual** for hydraulic considerations.

13.3.1 – Structural Requirements

Bridges, bridge rail, and bridge-class culverts must be designed according to the latest edition of AASHTO *Standard Specifications for Highway Bridges* or AASHTO *LRFD Bridge Design Specifications*. In addition, design must conform to the TxDOT Bridge Design Manual – LRFD, and the TxDOT Bridge Railing Manual.

Railing for bridges must conform to the latest MASH/NCHRP standards as well as the TxDOT Bridge Railing Manual. See **Section 11.3.0** for additional details.

13.3.2 – Material Requirements

Materials must meet the requirements in City of Austin *Standard Specifications*, where applicable. Otherwise, they must meet ASTM and/or AASHTO requirements.

Reinforcing steel must be of domestic origin.

13.4.0 – CULVERTS

Culverts and Stormwater Drainage Pipe shall meet the following criteria in this section, in addition to coordinating with the **Environmental Criteria Manual** for design standards for Critical Water Quality Zones. Also refer to **Drainage Criteria Manual** for hydraulic considerations.

13.4.1 – Structural Requirements

Culverts must be designed according to the latest edition of AASHTO *Standard Specifications for Highway Bridges* or AASHTO *LRFD Bridge Design Specifications*.

Railing for culverts must conform to the latest MASH/NCHRP standards as well as the TxDOT Bridge Railing Manual.

13.4.2 – Material Requirements

Materials must meet the requirements in City of Austin **Drainage Criteria Manual** and **Standard Specifications**, where applicable. Otherwise, they must meet the requirements of TxDOT's Departmental Materials Specifications (DMS) approved list, ASTM and/or AASHTO requirements.

13.5.0 – INSPECTIONS

Plans must indicate required inspections including City and code related special inspections (ACI, IBC, etc.) as well as post inspections.

A project video survey shall be taken pre and post construction of utility lines as well as surface site to document conditions. Any damage identified in post construction video shall be repaired at the expense of the contractor.

SECTION 14 – PAVEMENT DESIGN

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14.1.0 – General

This section details the criteria for all pavement designs which must meet City of Austin design requirements. The pavement design process, procedures, and tools are completely described in **Appendix B** to this Transportation Criteria Manual. These criteria were developed by a study completed by HVJ Associates' Austin Office in June 2017. The study was sponsored by the Capital Area Pavement Engineering Council (CAPEC) which includes the City of Austin as a primary partner.

The City has observed premature distress on many of the heavily traveled streets and on streets built on clay subgrade soils with high plasticity indices ($PI >20$). A map is provided within the design criteria appendix that represents the general soil PI distribution within the Austin area for illustrative purposes. Use of this map does not relieve the designer's responsibility to provide a geotechnical report and to design to the site-specific soil condition. Furthermore, the minimum pavement standards included in this Transportation Criteria Manual do not relieve the design engineer from the responsibility of designing a cross section with materials that are appropriate for the soil conditions and meet the required design life. Pavement designs that are appropriate for soil conditions must result in pavements that are maintainable over the entire useful life of the pavement structure. This is often achieved with proper stabilization of subgrade soils that may necessitate using a combination of modification techniques for the subgrade soils: such as, but not limited to removal of objectionable soils, reinforcement strategies, and/or subgrade moisture control features described in the appendix.

14.1.1 – Pavement Design Study

The primary member agencies of the Capital Area Pavement Engineering Council (CAPEC) consist of the City of Austin, Travis County, Williamson County, and the City of Pflugerville. CAPEC also had significant participation from Associate Members and guests at the CAPEC meetings and workshops. Associate Members included industry representatives, professional associations, TxDOT, geotechnical and materials engineering firms, and civil design firms. CAPEC sponsored this study to develop new pavement design criteria based on the current state of the practice in pavement design.

HVJ Associates was the consultant selected to complete the pavement design study effort and was led by Frank Carmichael, PE, Pavement Practice Leader; Linda Barlow, PE, Project Manager; Reuben James, PE, Website Management; and Michael Hasen, PE, Geotechnical Practice Leader. HVJ Associates also recognized the contributions of sub-consultants including PaveTex, Rodriguez Engineering Laboratories, and Dr. Robert Gilbert and Dr. Jorge Zornberg of the Department of Civil Engineering at the University of Texas at Austin. The support of the Texas Department of Transportation was especially appreciated for supporting the basic research and testing associated with the fundamentals of swelling soils at The University of Texas at Austin Center for Transportation Research (CTR).

Transportation Criteria Manual “Appendix A”

Definitions

AAA – All Ages and Abilities bicycle network

ACCESS – The ability of drivers, pedestrians, and cyclists to enter and use facilities in the right-of-way such as sidewalks, bike lanes, streets, bus stops, etc. Also, the ability of persons to enter and use facilities in private and public properties such as buildings, parking lots, loading areas, etc.

ADT - Average Daily Traffic: Average number of vehicles that pass a specified point during a 24 hour period.

ALLEY – Public right of way which affords a secondary means of vehicle access.

ASMP – The Austin Strategic Mobility Plan (ASMP) is the City’s new transportation plan, as referenced in the Land Development Code (LDC). It guides our transportation policies, programs, projects, and investments for the next 20+ years. The ASMP covers all the ways we get around Austin. This includes: driving, walking, bicycling, and taking public transportation like buses and trains.

ATSSA – American Traffic Safety Services Association

BICYCLE - A device having two (2) tandem wheels propelled exclusively by human power upon which any person may ride.

BICYCLE FACILITIES – A general term used to denote improvements and provisions to accommodate or encourage bicycling. These include bicycling parking facilities, bikeways, shared roadways, etc.

BICYCLE LANE - A portion of roadway which has been designated for preferential or exclusive use by bicycles. It is distinguished from the portion of the roadway for motor vehicle traffic by a paint stripe, curb or other similar device.

BICYCLE PATH - A path or trail, separated from the roadway, which is for the exclusive use of bicycles or, in some instances, for combined bicycle and pedestrian use.

BIKE STREET - A roadway which is officially designated, signed and marked as a bicycle route but which is open to motor vehicle travel and upon which no bicycle lane is designated.

BIKEWAY - A travel way specifically designed and marked for bicycle travel.

BLOCK FRONTAGE – All of the property along one side of the street measure between two adjacent intersecting streets.

BREEZEWAY – A roofed passageway, open at two sides, connecting two or more primary structures on a single property.

BUILDING SET BACK LINE - A line beyond which buildings must be set back from the right of way line.

CBD – Central Business District - the zoning designation for an office, commercial, residential, or civic use located in the Downtown Austin Area as defined in **Figure A-2**.

CLEARANCE - Lateral distance from edge of traveled way to a roadside object or feature.

CLEAR ZONE - That roadside border area, starting at the edge of the traveled way, available for safe use by errant vehicles. Establishment of a minimum width clear zone implies that rigid objects and certain other hazards with clearances less than the minimum width should be removed, relocated to an inaccessible position or outside the minimum clear zone, remodeled to make safely traversable or breakaway, or shielded.

CONFLICT POINT – The point at which two or more vehicle paths cross.

CONSTRAINED DESIGN CRITERIA – Recommended guidelines used when the right-of-way is not sufficient or adequate to accommodate typical design dimensions.

CONTRACTOR - Any individual, association or corporation engaged in the business of installing or altering walks, driveway approaches, curbs, gutters or pavements or appurtenances on public property. This term shall also include those who represent themselves to be engaged in the business whether or not actually doing the work.

CMTA – Capital Metropolitan Transportation Authority, the local transit agency in Austin

CROSSWALK – A marked pedestrian area for crossing a street or internal drive.

CUL-DE-SAC - A turnaround to the reverse direction point of a street or network of streets.

CURB BASIS - The distance between the right of way or property line and lip of gutter as indicated in design criteria.

CURB, CONCRETE RIBBON (LAYDOWN) - A concrete curb flush and contiguous with the pavement which strengthens and protects the pavement edge and clearly defines the pavement edge to vehicle operators.

CURB, STANDARD - A vertical or sloping structure located along the edge of a roadway, normally constructed integrally with the gutter, which strengthens and protects the pavement edge and clearly defines the pavement edge to vehicle operators (see Standard Detail No. 430-1, City of Austin Standard Details).

DAPCZ – Downtown Austin Project Coordination Zone, an area roughly bounded by Martin Luther King, Jr. Boulevard and Enfield Road to the north, Mopac/Loop 1 to the west, Chicon Street to the east, and Oltorf Street and Barton Skyway to the south. **Figure A-1** illustrates the DAPCZ Boundary.

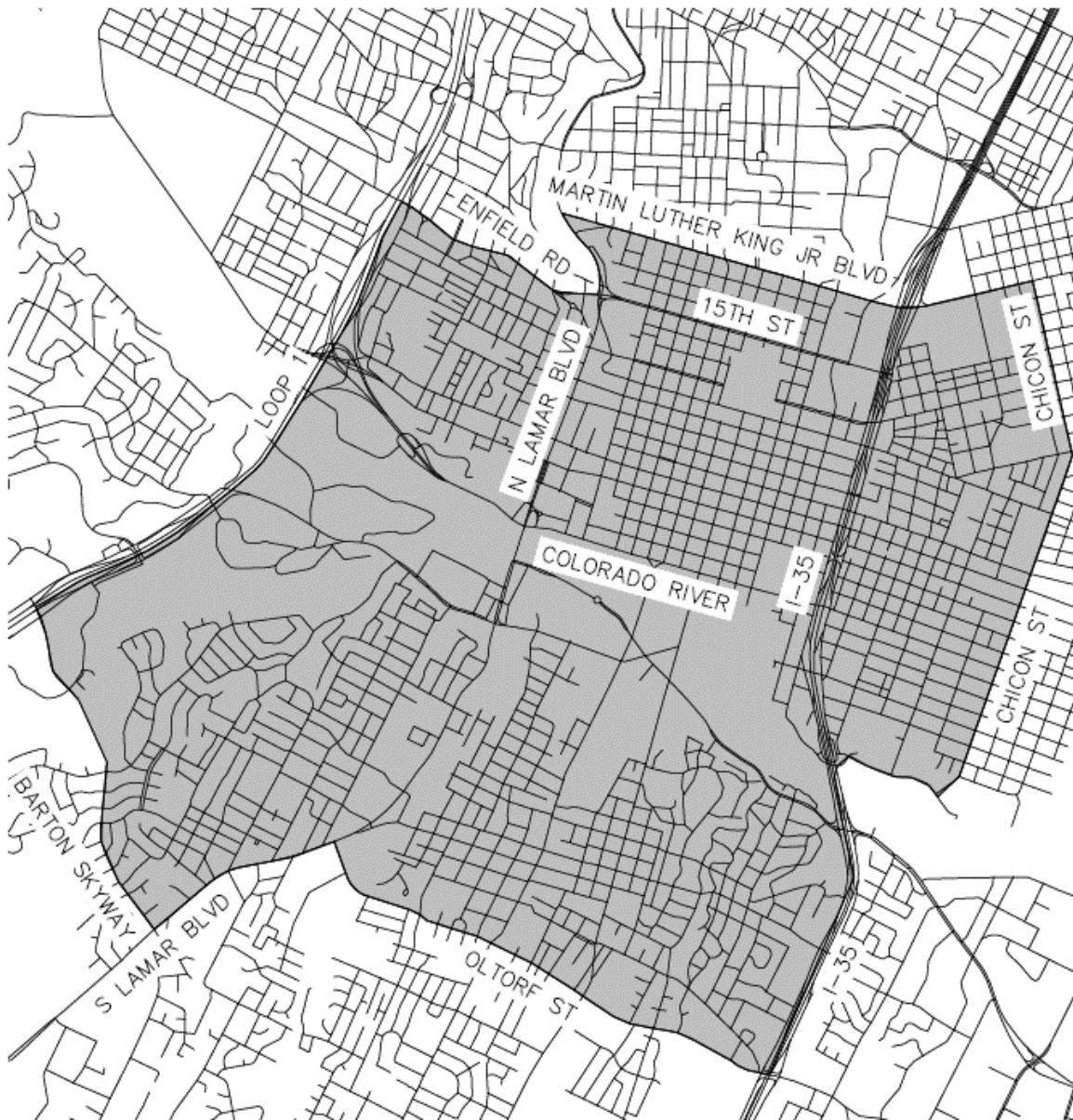


Figure A-1 – DAPCZ Boundary

Downtown Austin Area – area bounded by Martin Luther King Jr. Boulevard to the north, Interstate Highway 35 to the east, Lady Bird Lake to the south, and Lamar Boulevard to the west. The Downtown Austin Area boundary is shown in **Figure A-2**.



Figure A-2 – Downtown Austin Area Boundary

DESIRABLE - A condition which should be met when attainable. Desirable values will normally be used where the social, economic or environmental (S.E.E.) impacts are not critical.

DIRECTOR - Refers to the Director of the appropriate department.

DRIVEWAY – An unobstructed paved area providing vehicular access from a street to a developed property.

DRIVEWAY APPROACH – The section of a driveway located in the right-of-way built between the edge of pavement and the property line.

DWELLING UNIT – A single unit providing complete, independent living facilities for one or more persons.

EASEMENT – An area authorized by a property owner to be used for a specified purpose by a government agency, utility company, or the public.

EOP - Edge of Pavement: used for determining roadway width where standard curb and gutter does not exist.

ENCROACHMENT - Any structure or device positioned within, over or upon right of way, that is not the property of the City of Austin.

FEE-IN-LIEU – Payment required of a property owner as a substitute for a specific physical improvement.

FOC - Face of Curb: used for determining roadway widths.

FLAT TERRAIN - Topography conducive to generally long sight distance potential with little or no construction difficulty or major expense.

GRADE - The change in elevation between two (2) points along the vertical alignment of a roadway. Usually expressed as the change per 100 feet or percent.

GUTTER - A generally shallow waterway adjacent to a curb used or suitable for drainage of water.

HILLY TERRAIN - Condition where the natural slopes consistently rise above and fall below the road or street grade and where occasional steep slopes offer some restriction to normal horizontal and vertical alignment.

IMPERVIOUS SURFACE – A hard surface area which does not readily absorb or retain water.

INTERSECTION - The common area embraced between the projected lines of the edge of two or more roadways which join at any angle whether or not one such street crosses the other. **Figure A-3** illustrates the intersection area definition.

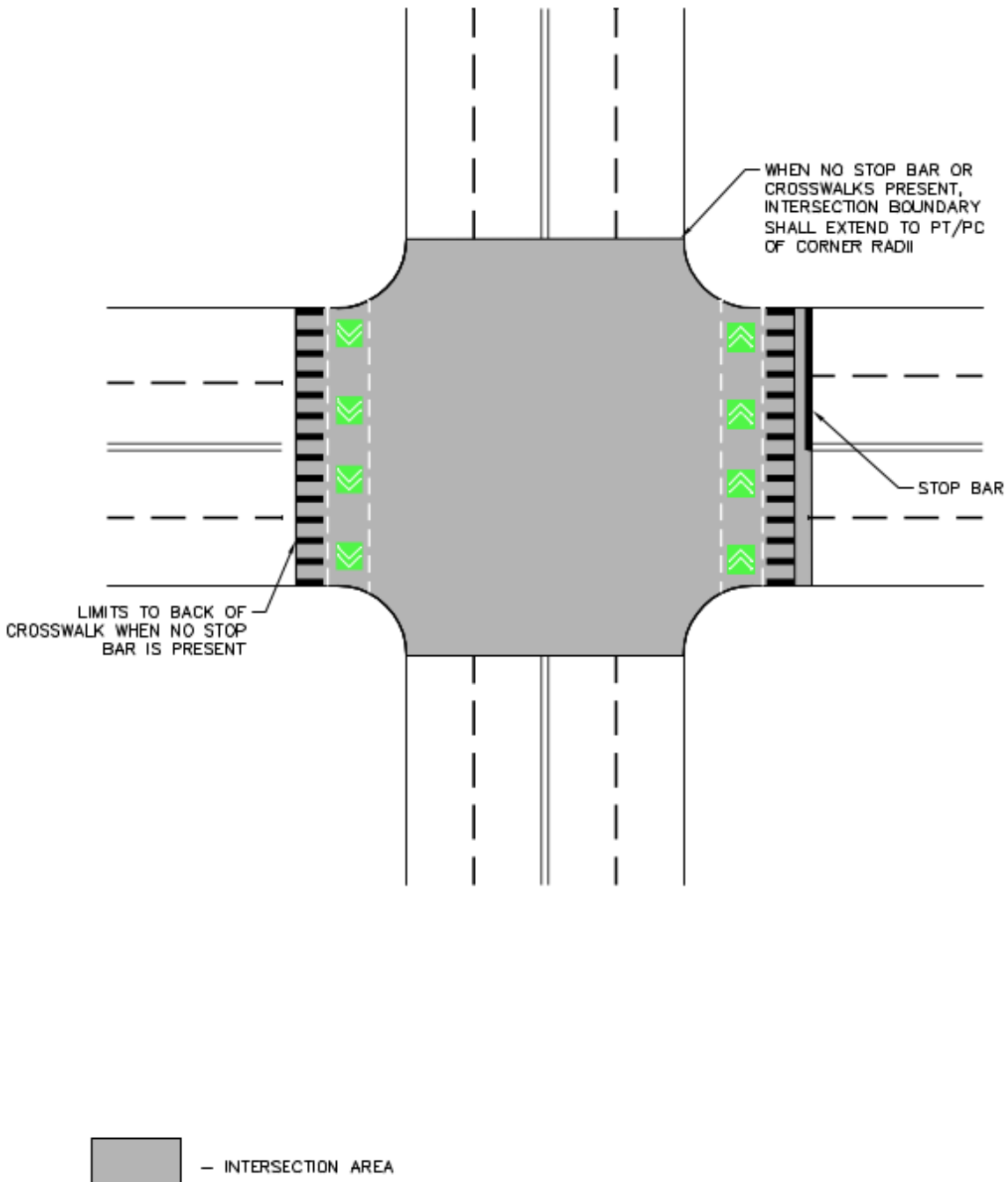


Figure A-3 – Intersection Area

JOINT USE DRIVEWAY – A driveway shared by two or more adjoining lots for providing ingress and egress to a public or private street.

LAND USE – Description of how land is designated or used as identified in the LDC.

Live Loads - refer to the dynamic forces from occupancy and intended use. They represent the transient forces that can be moved through the structure or act on any particular structural element.

STREETSCAPE – Amenities used to improve the fabric of the street.

LOG - Lip of Gutter: used for determining roadway widths.

LOT – A legally subdivided parcel of land or a tract of land with a legal lot determination.

MAY - A permissive condition. No requirement for design or application is intended.

MIXED USE - A single development containing two or more significant land uses which are functionally and physically integrated and are developed under a coherent plan.

MOTOR VEHICLE – A vehicle that is self-propelled designed primarily for the transportation of persons and goods.

PARKING LOT – A paved outdoor area where motor vehicles are stored for the purpose of temporary or daily off-street parking.

PARKING STRUCTURE - A structure of two or more stories, whether privately or publicly owned, used for parking motor vehicles.

OFF-SITE PARKING - Parking facilities that are not located on the same lot as the principal land use.

PEDESTRIAN WAY - A travel way designed primarily for pedestrians.

Point of Curve – the point where the curve begins; where a curb transitions from a straight line to a curve

PRIVATE STREET - A vehicular access way under private ownership and maintenance.

PUBLIC STREET - A vehicular access way designated or acquired for public use and accepted for ownership and maintenance by a governmental agency.

ROW - Right of Way: Land dedicated for public streets and related facilities which include utilities and other infrastructure. As defined in Chapter 14-11 of the City Code.

ROW WIDTH - The shortest horizontal distance between the lines which delineate the right of way of a street.

ROADWAY - A paved area within the right of way ordinarily used for vehicular traffic movement. With curbs and gutters, the pavement width is measured from the lip of gutters; without standard curbs and gutters, pavement width is measured from the edge of the pavement, excluding any required shoulders or ribbon curbs.

ROUNABOUT - Roundabouts are intended to be used as an alternative traffic control measure to an all-way stop or a two-way stop. Roundabouts differ from traffic circles in that they require deflection of vehicle paths prior to entry into the intersection, typically through the use of curbed or painted splitter islands.

SCENIC ARTERIAL - A roadway designated as a Scenic Arterial in the City of Austin's Zoning Ordinance.

SCREENING - Facilities created with landscaping or a decorative two-dimensional structure to visually conceal an area.

SHADOWING - Area of roadway protected from through traffic, i.e., left-turn bay or wide median opening.

SHALL - A mandatory condition. Where certain requirements in the design or application of the guidelines are described with the "shall" stipulation, it is mandatory that the requirements be met.

SHARED PARKING - Parking that can be used to serve two or more individual land uses without conflict or encroachment.

SHOULD - An advisory condition. Where the word "should" is used, it is considered to be advisable usage, recommended but not mandatory.

SHOULDER - A portion adjacent to the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use and for lateral support of sub-base, base and surface courses.

SIDEWALK - A paved area within the street right of way or sidewalk easement specifically designed for pedestrians and/or bicyclists.

Street User – Vehicle or bicycle traffic that is traveling along the section of the street in question.

STREET LEVEL – Classification of roadways identified in the ASMP Street Network Map.

TCP – Traffic Control Plan

TIA - Traffic Impact Analysis; as defined by City Code Chapter 25-6, Article 3.

TRAFFIC CIRCLE - A traffic circle is a circular travel way with a central island, painted or raised with a vertical or mountable curb in the center of the intersection of two streets. Traffic circles are intended to be yield-operated intersections that cause a horizontal deflection in vehicle paths through the intersection.

TRANSPORTATION MITIGATION – Necessary improvements for upgrading the components of the roadway infrastructure.

TRAVEL WAY - The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

TRANSIT - A public mass transportation system including buses, light-rail, and associated elements.

TTC – Temporary Traffic Control

TYPE I DRIVEWAY APPROACH - A concrete driveway approach designed and intended to serve as access from a roadway to a lot or parcel of land which is a location for a one (1) or two (2) family residence.

TYPE II DRIVEWAY APPROACH - A concrete driveway approach designed and intended to serve as access from a roadway to a lot or parcel of land used for any development or purpose other than one (1) or two (2) family residences.

TYPE III DRIVEWAY APPROACH - A driveway approach intended to provide vehicular access to a lot or parcel of land, such access being from a roadway not yet constructed to permanent lines and grades or a roadway not having curb and gutter.

TYPICAL - A common condition; not to be used as sole basis for establishing criteria or classifications.

WAIVER – An administrative variance processed and coordinated by authorized city staff.

APPENDIX B - PAVEMENT DESIGN GUIDELINES

Appendix B of the Transportation Criteria Manual contains the pavement design requirements, design guidance, and specifies the necessary pavement design programs to comply with Section 14 Pavement Design of this manual.

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Attachment B.1 - Sample USDA SOILS REPORT Output

Attachment B.2 - Sample TxDOT FPS21 Output

Attachment B.3 - Sample StreetPave12 (now PavementDesigner) Output

1 General

The Capital Area Pavement Engineers Council (CAPEC) formed by local governments funded the development of a unified approach to pavement design in central Texas. Based on historical discussions at monthly CAPEC meetings over the last few years, the critical issues to each of the members were documented as follows:

- Variety of pavement design procedures used in central Texas area
- Common swelling clay soils problems need to be addressed
- Increase in traffic loading and stop/go patterns contribute to pavement failures
- Current technology needs to be implemented to minimize pavement failures
- Increase in initial construction costs may be offset by lower maintenance cost/longer pavement life
- Numerous material mix designs are used throughout central Texas areas
- Design of low volume roads, such as residential streets, have different issues than highways
- Utility trenches and utilities in the pavement
- Multiple different subgrade characteristics
- Required construction sequencing

The goals of this pavement design approach are to update the pavement design program, consider entire pavement life cycle, update pavement design criteria, and consider analysis of existing expansive soils' problems in the area. The design programs are based on modern design methodologies, mechanistic components, and alternative design considerations. The pavement life cycle is addressed with a life cycle cost analysis that includes initial construction cost, maintenance costs, and user costs. The design criteria take into account the development patterns of expanding into areas of poor subgrade support and addresses truck traffic, including consideration of construction traffic. Multiple alternatives and a combination of strategies are considered to address expansive soils.

Pavement designs that are appropriate for both traffic and soil conditions result in pavements that are maintainable over the entire useful life of the pavement structure. This is achieved with proper modification of subgrade soils as needed to meet the required performance criteria. The designer is responsible for providing a geotechnical investigation to design to site specific soil conditions. Any representative pavement sections included herein do not relieve the design engineer from the responsibility of designing a cross section that is appropriate for the site-specific soil conditions to meet the required design life.

The following sections discuss the resulting design methodology recommended for implementation by member agencies.

1.1 Balanced Pavement Design Approach

The design methodology utilizes a "Top Down" design based on traffic loading and a "Bottom Up" design to obtain an improved foundation, as depicted in the figures below.

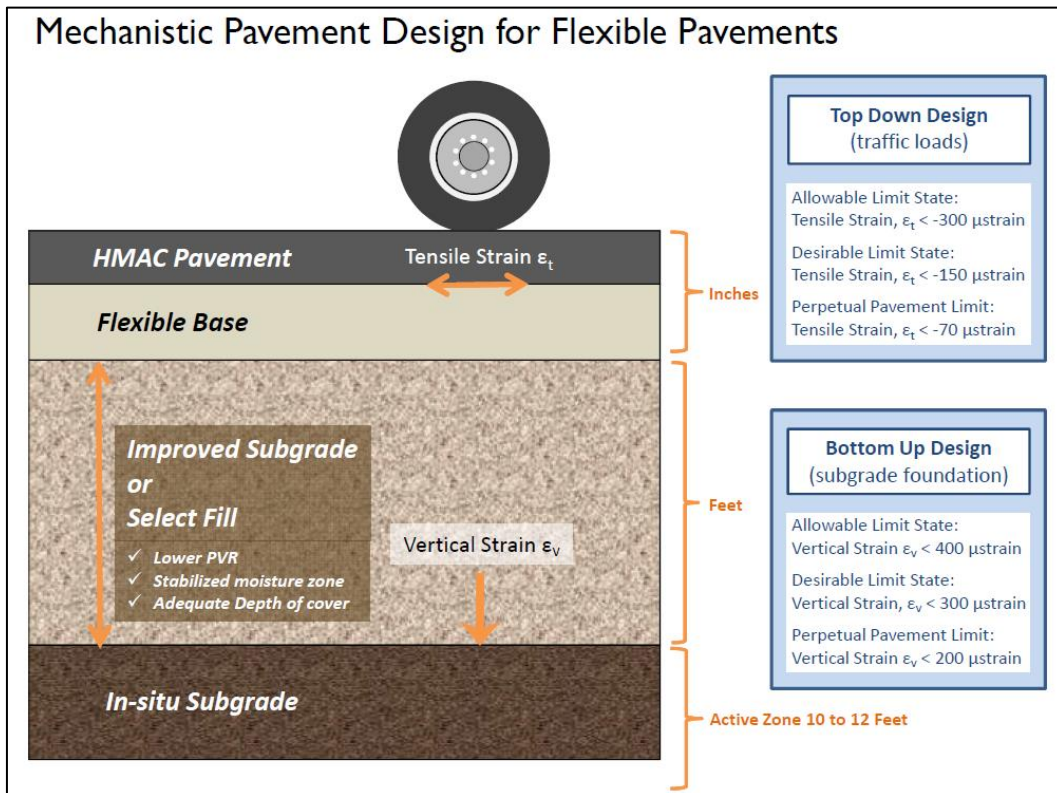


Figure 1.1 Top Down and Bottom Up Pavement Design – Flexible Pavement

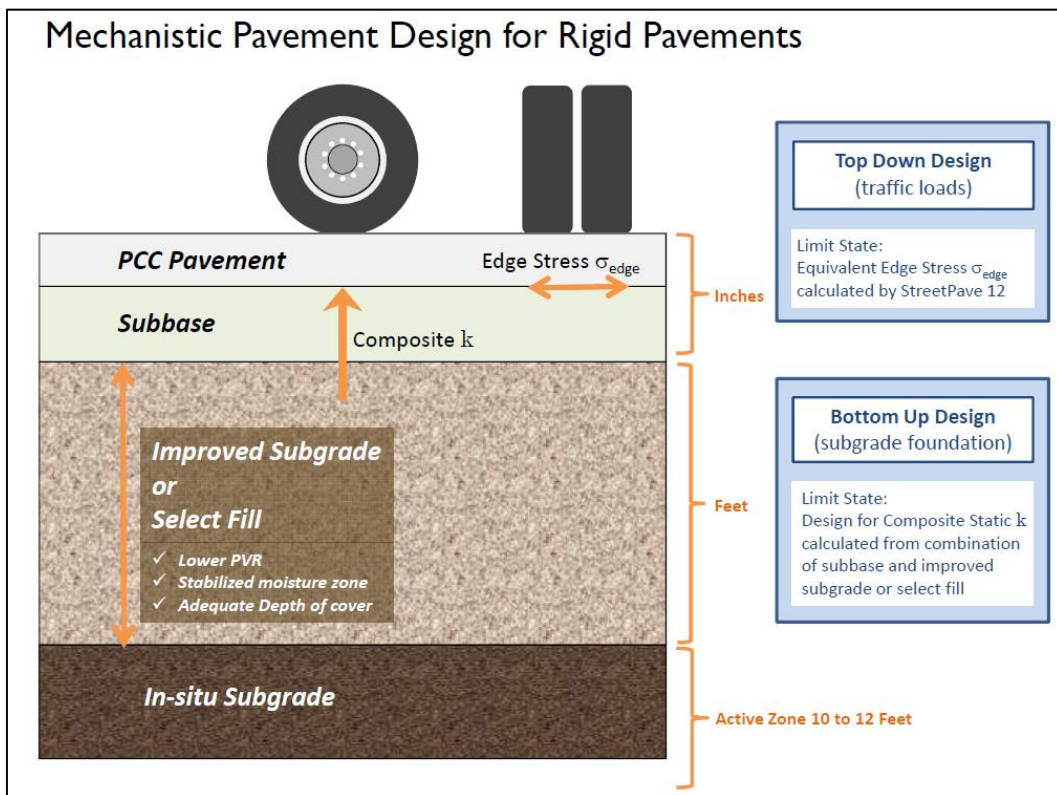


Figure 1.2 Top Down and Bottom Up Pavement Design – Rigid Pavement

The two-step design process includes an initial pavement thickness design based on traffic loads and a secondary subgrade improvement design to address environmental loads. The thickness design of both flexible and rigid pavements for traffic loading (Top Down Design), including suggested input parameters needed for the procedure, are defined herein, as are the subgrade design procedure (Bottom Up Design).

The design methodology includes a balanced pavement design to provide for longer pavement performance life. The balanced pavement designs require that the engineer:

- Design for Crack Resistance
 - Consider Environmental Stresses (Shrink/Swell) in High PI Soils
 - Consider Fatigue Cracking Criteria (Thicker Surface Layers)
 - Consider Thinner Base Layers to Offset Cost
- Develop Subgrade Improvement Strategies
 - Consider Subbase Layers
 - Recommend Combination Strategies

Base layers exceeding 14” in thickness may not be a cost-effective treatment to reduce stresses/strains in the pavement. The stresses at the bottom of the base layer do not justify the thick layer of very stiff base material. Improved subgrade or select fill is a better investment and a more effective layering of materials of progressively reducing stiffness in the pavement design. It is important to balance constructability, consistency and level of complexity and use an optimization process to find the most cost-effective solution.

The general steps are illustrated in the design flow chart in Figure 1.3.

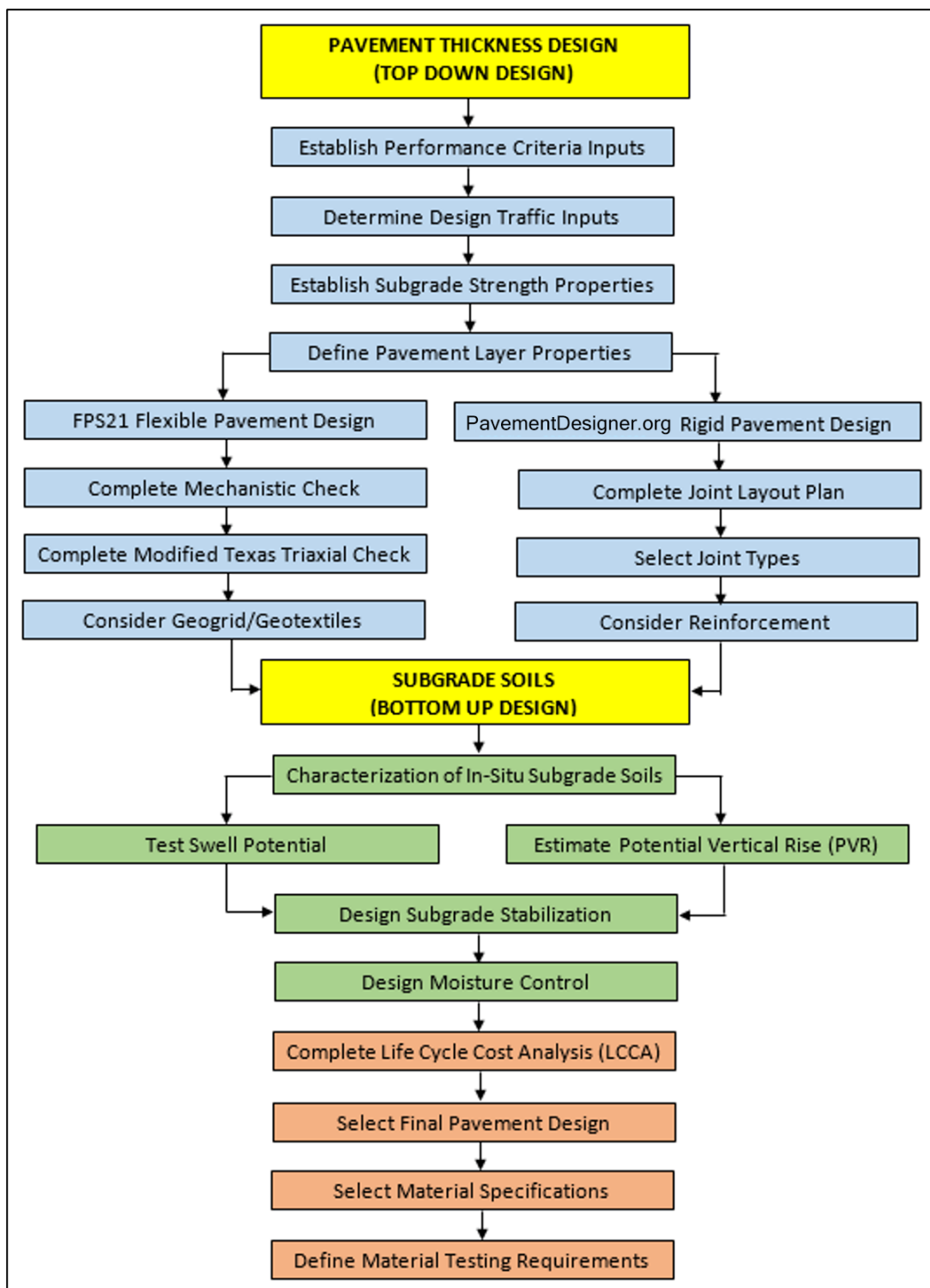


Figure 1.3 Flow Chart for Pavement Design Process

1.1.1 Top Down Pavement Design - General

The Top Down structural design is to be performed using modern, evolving, well-supported applications and is discussed in more detail in Section 2.

1.1.1.1 Flexible Pavement Design

The required flexible pavement design procedure is the Texas Department of Transportation's (TxDOT's) FPS21, developed with TxDOT by Texas Transportation Institute (TTI). It is available for free download here: <http://pavementdesign.tamu.edu/fps21.htm>. As per the FPS21 User's Manual (Ref 1):

“The Flexible Pavement System (FPS) is a mechanistic-empirically (M-E) based design software routinely used by the Texas Department of Transportation (TxDOT) for: (1) pavement structural (thickness) design, (2) structural overlay design, (3) stress-strain response analysis, and (4) pavement life prediction (rutting and cracking).

The FPS design approach is based on a linear-elastic analysis system, and the key material inputs are the back-calculated modulus values of the pavement layers. For in place materials, these are obtained from testing with the Falling Weight Deflectometer and processing the data with back-calculation software such as MODULUS 6.1. For newly placed materials, realistic average moduli values for the main structural layers in typical Texas pavements are supplied based on user experience, with recommended values also available in TxDOT's online pavement design guide. The FPS design process is comprised of the following two steps: (1) generate a trial pavement structure with proposed FPS design thicknesses, and (2) check this design with additional analysis routines, which include mechanistic performance prediction. The FPS system has an embedded design equation relating the computed surface curvature index (difference of the W1 and W2 deflections) of the pavement to the loss in serviceability (as defined in the original AASHO Road Test). As described below the design checks are principally based on either mechanistic design concepts, which computed fatigue life and subgrade rutting potential, or the Modified Texas Triaxial criteria, which evaluates the impact of the anticipated heaviest load on the proposed pavement structure.”

The FPS21 design software and associated design input values were established based on collaboration with CAPEC member agencies and are discussed in detail in Section 3.

1.1.1.2 Rigid Pavement Design

The required rigid pavement design procedure is the American Concrete Pavement Association's (ACPA's) PavementDesigner. This program is available as a web-based program at www.pavementdesigner.org. A free personal user account is recommended for ease of use and being able to store your work in progress. An online site account and login is useful, but it is not required to use the web application. The site combines numerous design types including jointed plain concrete pavements (JPCP), Roller Compacted Concrete (RCC), Continuously Reinforced Concrete Pavement (CRCP), concrete overlays, and composite cement-based bases.

The concrete street (JPCP) design portion of PavementDesigner is based on the 1960's Portland Cement Association method and is tailored for streets and roads (not highways or interstates) with the failure models being cracking and faulting. PavementDesigner looks at the stresses at the edge of the slab generated by the traffic loads. The equation uses equivalent moment, which is different for a single, tandem or tridem axles (with and without edge support), which is dependent on concrete modulus, Poisson's ratio, thickness, and pavement support k-value. Included in the equivalent edge stress calculations are adjustment factors for the effect of axle loads and contact area, adjustments for slabs with no concrete shoulder, adjustment for the effect of truck wheel placement at the slab edge, and adjustment to account for an approximate 23.5% increase in concrete strength with age after the 28th day and reduction of one coefficient of variation to account for materials variability.

PavementDesigner limits the stress ratio to achieve a desired number of design repetitions. The program increases the thickness of the slab to bring the stress ratio low enough to achieve a certain number of traffic repetitions as illustrated in Figure 1.4 and calculated as follows:

$$\text{Stress Ratio (SR)} = \frac{\text{Stress}}{\text{Concrete Strength}}$$

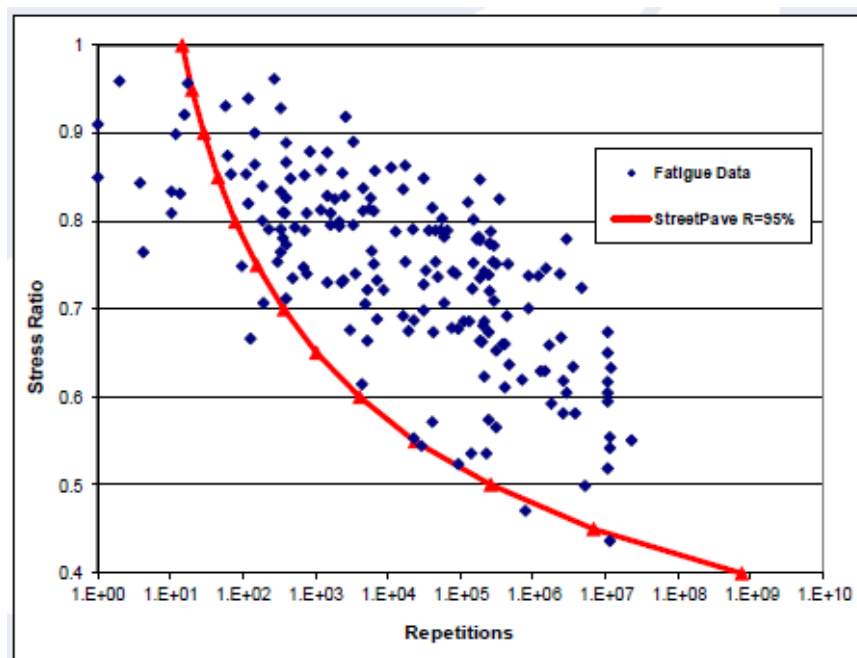


Figure 1.4 Example of the Stress Ratio Consideration in PavementDesigner

Figure courtesy of 2014 TxDOT/CCT Concrete Conference, September 30, 2014, Robert Rodden, P.E. (Ref 35)

PavementDesigner design software and associated design input values are established based on collaboration with CAPEC member agencies and are discussed in detail in Section 4.

1.1.2 Bottom Up Pavement Design - General

The bottom up pavement design is based on in-situ soils investigation, laboratory testing and analyses and is discussed in more detail in Section 5. The bottom up design is intended to primarily address shrink/swell potential resulting from basic soil characteristics and environmental changes (primarily moisture content) by designing a reduction in potential vertical rise (PVR) to acceptable limits. Subgrade performance criteria required for the bottom up design, based on general street classification, are as follows:

- Provide an adequate depth of cover or modification of subgrade layers to limit the potential vertical rise, considering a 15 foot depth, to the following criteria:
 - Arterial / Collector PVR $\leq 2.0''$
 - Local / Residential PVR $\leq 3.0''$

1.2 Design Life and Performance Expectations

Level of service (LOS) or street condition is a function of numerous factors including, but not limited to: initial design, construction quality, preventive maintenance, repairs, agency budgets, traffic, weather, public expectation, and safety. To this end, the pavement design approach includes performance criteria and life cycle costs, in addition to pavement thickness/subgrade design (top down and bottom up designs), to assist in final pavement design selection.

1.2.1 Performance Criteria

The design life and performance criteria for ride quality and distresses detailed in the following tables must be met.

Table 1.1 - Design Life/Failure Criteria

Pavement Type	<u>Flexible</u>	<u>Rigid</u>
Design Life	20 years: 20 yr min to first overlay 10 yr min between overlays	30 years
Failure Criteria	Fatigue cracking: maximum tensile strain at bottom of all HMA layers 70 μ -strain	Faulting: If faulting criteria is not met, Pavement Designer will recommend dowel bars
	Rutting: maximum compressive strain at top of subgrade 200 μ -strain	Cracking: 15% of slabs for Arterials and Collectors 25% of slabs for Locals

Table 1.2 Minimum Cracking and Loss of Ride Quality (Serviceability)

Criteria	Acceptance/Warranty Period	
	Flexible	Rigid
Cracking	Minimal cracking; less than 10 LF/LM	
Other Criteria	No noticeable roughness from new condition measured during construction with 10-ft straightedge test*	No noticeable roughness from new condition measured during construction with 10-ft straightedge test**

* Maximum 1/8" per foot parallel to centerline and 1/4" perpendicular to centerline (COA Specification Item 340)

** Maximum 1/8" per foot (COA Specification Item 360)

The initial Present Serviceability Index (PSI) and the Terminal Serviceability Index (TSI), as defined in the AASHTO Road Test are key inputs to the pavement design software. The difference between these two values represents the service life of the pavement from the time of initial acceptance of the construction until the time when major structural rehabilitation or reconstruction is needed.

Table 1.3 Serviceability Indices and Associated Ride Quality

Street Classification (see Table 1.3)	Initial Present Serviceability Index (PSI)	Terminal Serviceability Index (TSI)
Urban Arterial High Traffic	4.2 - 4.5	3.0
Urban Arterial Low Traffic	4.2 - 4.5	3.0
Rural Arterial	4.2 - 4.5	3.0
Urban Collector High Traffic	4.2 - 4.5	3.0
Urban Collector Low Traffic	4.0 - 4.2	2.5
Rural Collector	4.0 - 4.2	2.5
Urban Local	4.0 - 4.2	2.0
Rural Local	4.0 - 4.2	2.0

Because CAPEC represents both cities and counties, street classifications considered should be general in nature but able to be further subdivided based on the governmental agency's street network system. The general guidelines for the classifications used herein are shown in the following table. Further clarifications may be provided by the governing agency.

Table 1.2 General Street Classifications for CAPEC Member Agencies

General Description	CAPEC Member Agency			
	City of Austin	Travis County	City of Pflugerville	Williamson County
Urban Arterial High Traffic	Major Arterial	Freeways, expressways and highways / Major Arterial	Freeways/ Expressways	Major Thoroughfare
Urban Arterial Low Traffic	Minor Arterial	Minor Arterial	Arterial	Urban Arterial
Rural Arterial	n/a	n/a	n/a	Rural Arterial
Urban Collector High Traffic	Primary/ Industrial Collector	Collector	Collector	Urban Collector
Urban Collector Low Traffic	Residential/ Neighborhood Collector	n/a	n/a	Urban Collector
Rural Collector	n/a	n/a	n/a	Rural Collector
Urban Local	Local	Local	Local	Urban Local
Rural Local	n/a	n/a	n/a	Rural Local

1.2.2 Other Performance Related Pavement Design Considerations

Other design considerations include but are not limited to: special attention to utility construction; lateral restraint (i.e. curb and gutter, ribbon curbs for ditch drainage, vertical barriers, etc.); maximum slopes for embankment/ditches; paved shoulders; and others. These design considerations will help address moisture control in the pavement subgrade and are discussed in more detail in Section 5.7.

1.3 Life Cycle Cost Analysis (LCCA)

All pavement designs must be submitted with a Life Cycle Cost Analysis (LCCA) as defined in section 6. The LCCA period shall be a minimum of 40 years to adequately compare the various alternatives with significantly different design lives and maintenance profiles.

FHWA report FHWA-SA-98-079, Life-Cycle Cost Analysis in Pavement Design defines LCCA (Ref 3) as:

“...an analysis technique that builds on the well-founded principles of economic analysis to evaluate the over-all-long-term economic efficiency between competing alternative investment options. It does not address equity issues. It incorporates initial and discounted future agency, user, and other relevant costs over the life of alternative investments. It attempts to identify the best value (the lowest long-term cost that satisfies the performance objective being sought) for investment expenditures.”

LCCA is typically used as a decision support tool to select pavement type, determine structure and mix type (for flexible pavements), construction methods, as well as maintenance and rehabilitation strategy. LCCA includes first cost, long term costs as well as asset renewal. The initial construction cost (first cost) is based on developer contribution and/or agency (re)construction. Long term costs include routine repairs, preventative maintenance, rehabilitation, and salvage value. Each agency will need to provide agency specific assistance and guidance on maintenance unit costs and typical timing (i.e. agency specific maintenance profile). Asset renewal is reconstruction that starts the cycle again. LCCA is discussed in more detail in Section 6.

1.4 Pavement Design Report

Pavement design analyses conducted as per the criteria and procedures herein shall be documented in an engineering report prepared by a Texas Licensed Professional Engineer. In addition to the basis of the pavement design, the engineering report shall contain the following:

- Geotechnical boring logs for borings minimum 15-ft deep, or 1 foot into rock, spaced at 500 ft up to a maximum of 1000 ft for homogeneous conditions. Shorter spacing shall be used for nonhomogeneous conditions. Boring spacing shall be justified by geotechnical engineer.
- Results of sampled and tested subgrade soils for the following:
 - Atterberg Limits (Liquid and Plastic Limits) (ASTM D4318),
 - Percent Passing No. 200 Sieve (ASTM D1140)
 - In-situ moisture content,
 - Standard Proctor (ASTM D698) for maximum density,
 - pH and sulfate content,
 - Unconfined Compressive Strength (ASTM D2166),
 - Modified Texas Triaxial Classification (Tex-117-E “Triaxial Compression for Disturbed Soils and Base Materials” Ref. 5),
 - Subgrade strength tests,
 - Proposed PVR analysis methodology (e.g., Free Swell Test ASTM D4546 or Tex 124-E),
 - Proposed treatment strategy, presence of sulfates and impact to design.
- Basis of design traffic including the Average Daily Traffic (ADT) before and after the proposed development, as well as estimates of construction traffic and truck percentage. Identify heavy loads that are expected and how the design traffic accommodates these loads.
- Life cycle cost analysis detail and results for the pavement design alternatives considered. The basis of life cycle strategies must be documented as well. Each agency will need to define the requirements for roadway acceptance for maintenance to be reflected in the life cycle cost analysis documentation.

- Recommended pavement structure and basis of recommendation, including considerations in addition to the life cycle cost analysis, such as historical performance of previous designs and construction, constructability, sustainability, etc.
- Recommended material specifications.

1.2 Construction Procedures, Specifications and Materials Testing

Quality control is a key factor in the success of the pavement performance. As such, it is critical to adequately define the required specifications and testing to be followed during construction as well as thorough inspections at critical points during construction. Material specifications and testing requirements are currently being updated by the various agencies and need to be agency specific. The CAPEC Phase 1 report summarized TxDOT and COA specifications which are related to pavement construction quality and therefore good long-term performance. All CAPEC reports are available on the CAPEC website at www.capectx.org.

All materials shall be sampled and tested by an Independent Testing Laboratory in accordance with the construction documents approved by the relevant agency. Certified copies of these test results shall be furnished to the relevant agency. Any material which does not meet the minimum required test specifications shall be removed and re-compacted or replaced unless alternative remedial action is approved in writing from the owner agency.

The following material design properties are critical inputs to the pavement design procedure and to pavement performance, however, are not historically included in the pavement construction material specifications and required testing:

- 1) Hot Mix Asphalt Concrete (HMAC)
 - a) Resilient Modulus of HMAC layers
 - b) Resilient Modulus of Base/Subbase layers
 - c) Resilient Modulus of Subgrade
- 2) Portland Cement Concrete (PCC)
 - a) Flexural Strength of PCC
 - b) Resilient Modulus of PCC
 - c) K-value of subbase layers
 - d) Resilient Modulus of Subgrade

It is recommended that material specifications consider these tests either by required testing during construction or by establishing relationships at the time of mix design preparation to allow confirmation during construction that the basis of design is being met.

2 Top Down Design

The structural design of a pavement system requires as primary design parameters, traffic loading and subgrade support strength. These two parameters are discussed below.

2.1 Design Traffic

For new roadways or existing roadways being widened for added capacity, traffic data must be developed based on a variety of factors usually depicted with Traffic Impact Analyses (TIA) that predict the type and volume of future traffic; however, rather than peak hourly volumes, it is necessary to have full spectrum 24-hour traffic volumes and percent trucks also required/reported. For rehabilitation or reconstruction of existing roadways, traffic counts may be obtained to collect current traffic data that may then be analyzed to predict future volumes. It is important that the traffic projection consider complete build-out of subdivisions and any future development that will be served by a specific street.

2.1.1 Consideration of Heavy Loads

Adequate consideration must be given to heavy loads such as transit or school busses, fire trucks, solid waste trucks, as well as construction traffic. To appropriately incorporate these loads in design, a review should be made of: existing and/or planned bus routes, fire stations in the vicinity, schedule of solid waste and/or recycling trucks, etc.

The construction of streets basically consists of three phases: rough grading (or removal of existing pavement), fine grading (which includes sub-grade preparation), and construction of the pavement structure. Compaction is also a major element including compaction of basic fill/subgrade, stabilized subgrade, aggregate base, and hot mix asphalt. A rough calculation based on typical types of equipment required for street construction is summarized in the following table.

Table 2.1 Typical Roadway Construction Equipment for Consideration

Construction Activity	Example Equipment	Assumed Weight, lbs.	Calculated Load Equivalency Factor	Assumed Number of Operations per Day	Additional ESALs per Day of Construction
Excavating existing asphalt pavement	Asphalt Milling Machine	40,550	3.44	10	35
	Road Reclaimer	53,900	10.89	10	109
Rough grading	Motor Grader	58,250	0.95	20	20
	Excavator	22,050	2.23	20	45
	Backhoe	27,110	0.50	20	10

Construction Activity	Example Equipment	Assumed Weight, lbs.	Calculated Load Equivalency Factor	Assumed Number of Operations per Day	Additional ESALs per Day of Construction
Compacting	Vibratory Steel Drum	15,950	0.12	20	3
	Pneumatic Tired Roller	30,600	0.05	20	2
Paving	Paving Machine	43,000	2.20	20	44
	Dump Truck (For Hot Asphalt)	80,000	4.02	20	81
	Concrete Redi-Mix Truck	61,000	6.28	20	126
Miscellaneous	Bulldozer (non-track)	58,250	0.95	10	10
	Rear end/Belly Dump Trucks	80,000	4.02	30	121
	Water Trucks	56,000	5.99	20	120
Total Potential Additional ESALs per Day of Construction:					726

If this mix of construction equipment was involved in the roadway construction for 30 days, the resulting additional ESALs is 21,780. If this mix of construction equipment operated for 90 days, the total added ESALs is 65,340. These are only representative examples, each design site location will have specific conditions, which need to be estimated by the design engineer.

Depending on the mix of construction equipment and the duration of the construction, the additional ESALs can be very critical for pavement design considerations especially local roadways, for which design traffic is typically underestimated. Examples include new subdivisions for which the roadways are first constructed, then expanded as each phase of the subdivision is built out. Homes constructed lot by lot for these new subdivisions as well as new apartment/condo buildings also add structural building construction traffic not considered in the roadway construction traffic in the previous table.

In summary, it is critical to increase traffic projections to account for the addition of construction traffic during the development of the design traffic for the roadway, either as added daily trucks, increased percentage of trucks or added ESALs based on similar calculations to the Table 2.1.

2.1.2 Required Traffic Data

The flexible and rigid pavement design methodologies vary somewhat regarding what is required to calculate design traffic. Required traffic parameters include the following: average annual daily traffic (AADT), number or percentage of truck volume in the ADT, design life, growth rate, directional distribution, and design lane distribution.

These parameters are used to calculate the 18 kip Equivalent Single Axle Wheel Loads (ESALs) in one direction, which is the traffic input for FPS21 flexible pavement design.

Rigid pavement design with PavementDesigner focuses on a traffic spectrum rather than the direct input of ESALs. PavementDesigner has predetermined traffic spectrums and counts; however, custom traffic spectrum should be used based on specific traffic developed for the street being designed.

There are also other types of traffic inputs, such as: axle type and load or total vehicle weight, tire load and tire pressure, which can either be used directly in the design procedure to calculate a truck factor required to calculate ESALs, or to calculate stresses/strains in pavement due to a specific load.

If both flexible and rigid pavement design alternatives are being considered, the design traffic needs to be reviewed to confirm the ESALs considered for designs are equivalent. Since calculated ESALs are one of the outputs in PavementDesigner, it becomes an iterative process whereby the AADT and % trucks inputs are changed to obtain the predicted ESALs.

Traffic data may be available from agency planning departments. Site specific justification for design traffic inputs is required. Traffic data for adjacent/similar roadways and/or traffic generators within the site may be considered. Classification counts are the preferred type of traffic count to be obtained to have a breakdown by the thirteen Federal Highway Administration (FHWA) vehicle types. Additionally, transit busses and special vehicles should be added to the standard FHWA vehicle type counts. This additional data may come from external sources such as transit schedules and facility logistics data. Average daily bus counts of transit busses shall be broken down by BRT (bus rapid transit/extra heavy bus types), 40' (standard), and 30' and smaller busses.

2.1.3 Traffic Calculations

The pavement engineer collects basic traffic data and calculates the 18 kip Equivalent Single Axle Wheel Loads (ESALs) required for pavement design. In general, the following information is needed to forecast the cumulative Equivalent Single Axle Wheel Loads (ESALs) input value needed for pavement design:

- Two-Way Average Annual Daily Traffic (AADT)
- Two-Way Vehicle Classification Breakdown/Percentage of Trucks
- Traffic Growth Rate for the Design Period
- ESAL Factors for Each Vehicle Type
- Directional and Design Lane Distribution Factors

There are a few sources for Two-Way AADT volume. The Capital Area Metropolitan Planning Organization (CAMPO, <https://data.austintexas.gov/Transportation-and-Mobility/Traffic-Count-Study-Area/cqdh-farx>) has links to count data provided by the City of Austin, TxDOT, and other local agencies, if site specific current or forecasted traffic count data is not available for the specific street under design. Additionally, as mentioned previously, PavementDesigner has predetermined traffic spectrums and counts; these predetermined spectrums as designated for “residential”, “collector”, “minor arterial” and “major arterial” general designated street classifications.

A specific 24-hour traffic count that includes vehicle classification breakdown is preferable as it provides current traffic data and percent trucks for the location in question. However, should the roadway’s geometry be changing, e.g. widening to add capacity, or narrowing to add bicycle lanes or parking, these counts will need to be adjusted to a projected traffic level and number of lanes appropriate for the geometry changes. Additionally, if the roadway is a proposed roadway along a new alignment, the anticipated traffic must be estimated for pavement design.

In addition to the truck loads based on traffic counts, other heavy loads such as fire trucks (most likely not included in count data) especially if there is a fire station located along the street being designed, as well as construction traffic (for either nearby construction projects or for a new phased subdivision) should be considered, as previously discussed. Depending on the repetition of these heavy loaded vehicles, the overall ESALs being considered for design may significantly increase.

Another traffic parameter required is growth rate. Based on input from current CAPEC member agencies, the following growth rates were defined for the CAPEC designated street classifications.

Table 2.2 Recommended Growth Rate

Street Classification	Growth Rate, %
Urban Arterial High Traffic	4.0
Urban Arterial Low Traffic	4.0
Rural Arterial	4.0
Urban Collector High Traffic	4.0
Urban Collector Low Traffic	3.5
Rural Collector	3.5
Urban Local	3.0
Rural Local	3.0

There are two additional factors included in traffic calculations, directional distribution and lane distribution. Directional distribution is typically considered 50% in each direction, unless the street is a one-way street for which the directional distribution factor is 100%. If the traffic data projections conclude a different split, the higher of the two should be used in the traffic calculations. The lane distribution factor is depending on the number of travel lanes included on the road. The recommendations are summarized below.

Table 2.3 Recommended Lane Distribution Factor

Number of Lanes in Each Direction	% Traffic in Design Lane
1	100
2	80 – 100
3	60 – 80
4	50 – 75

2.1.3.1 Additional Traffic Inputs - Flexible Design

Beginning ADT: This input is for the Average Daily Traffic at the beginning of the analysis period. It is expressed as total vehicles per day in both directions. This parameter is used to estimate the user delay cost during overlay at the end of each performance period (see Section 6. Life Cycle Cost Analysis).

End ADT: This input is for the Average Daily Traffic at the end of the analysis period which is generally for 20-year period. It is expressed as total vehicles per day in both directions.

18 Kip ESAL (1 direction): The 18 Kip Equivalent Single Axle Load repetitions is expressed in millions and is calculated using the following equations.

$$ESALs = \sum AADT \times GF \times 365 \text{ days/year} \times \% \text{ truck} \times TF \times DDF \times LDF$$

Where,

AADT=Average Annual Daily Traffic

TF= Truck factor

DDF=Directional Distribution Factor

LDF=Lane Distribution Factor

$$GF = \frac{\left((1 + GR)^{DL} - 1 \right)}{GR}$$

GR= Annual growth rate, %

2.1.3.2 Additional Traffic Inputs - Rigid Design

Trucks per Day: This input is a two-way daily estimate of trucks at the beginning of the analysis period. The number of trucks per day may be measured in a traffic count collected for a street or calculated based on the percent trucks of the expected initial daily traffic.

PavementDesigner calculates 18 Kip ESALs based on three different methods, which are listed in order of preference: 1) traffic counts including classification, 2) user input traffic distributions for the specific functional class of pavement, or 3) predetermined traffic spectrums. As mentioned previously, utilization of traffic counts is the preferred method of calculating ESALs. The truck factors used in PavementDesigner calculation of 18 Kip ESALs are internal to the program and are not user input.

2.1.4 Representative Traffic Data by Street Classification

These representative values were estimated based on a review of existing COA criteria and actual traffic data from COA and Travis County for various street classifications. Representative ESALs were selected, as well as ranges of ADT, percent trucks, and trucks per day, for the suggested general street classifications and summarized in Table 2.4. Note that the street classifications defined here do not directly reflect the traffic categories in PavementDesigner. These values may be used for general review of pavement designs or to develop general construction cost estimates for funding considerations. The projected traffic for pavement design must be estimated based on specific site conditions for the roadway(s) being designed.




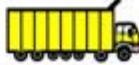














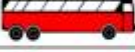




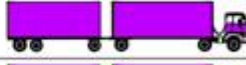

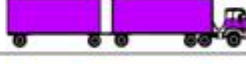








Table 2.4 Representative Traffic Data by Street Classification

Street Classification	Representative ESALs	General Range in ADT	General Range in % Trucks	General Number of Trucks/Day
Urban Arterial High Traffic	9,000,000	4,000 - 25,000	4% - 15%	160 - 3,750
Urban Arterial Low Traffic	2,500,000	6,000 - 9,000	4% - 15%	240 - 1,350
Rural Arterial	1,000,000	2,000 - 9,000	7% - 15%	140 - 1,350
Urban Collector High Traffic	2,100,000	2,000 - 8,000	3% - 10%	60 - 800
Urban Collector Low Traffic	700,000	2,000 - 4,000	3% - 10%	60 - 400
Rural Collector	600,000	2,000 - 8,000	4% - 10%	80 - 800
Urban Local	150,000	200 - 3000	6% - 10%	12 - 300
Rural Local	350,000	500 - 4000	4% - 10%	20 - 400

Figure 2.1 depicts the FHWA vehicle classification system and vehicle classifications 4 thru 13 have the greatest impact to pavement design. Truck factors for central Texas and CAPEC use are based on a TxDOT study of weigh-in-motion data along the IH35 corridor (Ref 6), as shown in Table 2.5.

Table 2.5 Summary of Equivalency Factors from TxDOT Weigh Stations

Vehicle Class	Truck Factor		
	Station 513 - South of San Antonio	Station 516 - South of Salado	Factor Selected
1	n/a	n/a	0.00002
2	n/a	n/a	0.008
3	n/a	n/a	0.01
4	0.66	0.54	0.60
5	0.03	0.04	0.04
6	0.47	0.46	0.47
7	0.96	1.19	1.08
8	0.38	0.34	0.36
9	1.06	1.16	1.11
10	n/a	n/a	1.16
11	1.89	1.53	1.71
12	n/a	n/a	0.68
13	n/a	n/a	1.94

Class 1 Motorcycles		Class 7 Four or more axle, single unit	
Class 2 Passenger cars		Class 8 Four or less axle, single trailer	
			
			
			
Class 3 Four tire, single unit		Class 9 5-Axle tractor semitrailer	
			
			
Class 4 Buses		Class 10 Six or more axle, single trailer	
			
		Class 11 Five or less axle, multi trailer	
Class 5 Two axle, six tire, single unit		Class 12 Six axle, multi-trailer	
			
		Class 13 Seven or more axle, multi-trailer	
Class 6 Three axle, single unit			
			
			

Source: Federal Highway Administration.

Figure 2.1 FHWA 13 Vehicle Classification

2.2 Design Subgrade Properties

The primary subgrade design parameter is strength in terms of resilient modulus. However, a number of other soils properties may be used to develop and/or confirm an appropriate value to be used for design. Historical data may be reviewed for the area in which the street is located or specific field/laboratory tests may be conducted. These methods are discussed in the following sections.

2.2.1 Historical Data from USDA Soils Map

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) operates web soil survey at the website <http://websoilsurvey.nrcs.usda.gov/app/>, which provides soil maps and data information for more than 95 percent of the nation's counties. This source may be used to identify the soil types included in the proposed roadway alignment. The user can define the specific area of interest to produce a soil map and the associated metadata. Specific soil information may be obtained for the defined area of interest such as soil engineering properties including Unified Soil Classification, percentage passing various sieve sizes, liquid limit (LL), plasticity index (PI), and chemical properties including pH level, and amount of gypsum with depth, an indicator of sulfates.

The steps to retrieve the engineering and chemical properties are as shown below.

- Zoom to the area of interest using either the navigation toolbar or the quick navigation search tabs
- Once zoomed in to the desired extents, click the AOI button to define the area of interest (AOI) using either a rectangular shape or polygon.
- Click the "Soil Map" tab to view or print the soil maps.
- Click the "Soil Data Explorer" tab and again click the "Soil Reports" tab.
 - Click "Soil Chemical Properties" tab. Click the "View Soil Report" underneath the tab. The report can then be added to the Shopping Cart to be included in the report.
 - Similarly, as above, add all reports under soil physical properties (engineering properties, particle size and coarse fragments and physical properties) to your Shopping Cart.
- Using Shopping Cart tab, user can get the free custom printable report immediately or download it later.

A sample of the USDA soils report output is shown in Attachment B.1. Subgrade strength ranges may be estimated based on the Unified Soil Classification and other data obtained from the report. (See section 2.2.2.4) The USDA soils data report is for reference only and does not replace the need for a project specific geotechnical investigation.

2.2.2 Assessment of Subgrade Support

The subgrade design strength parameter for both flexible and rigid pavement design is modulus. Subgrade modulus shall be obtained by direct laboratory testing, field testing and analysis/correlations, as well as correlations with other laboratory test values. Variations such as, in-situ moisture content, changing geological formations and strata, and sample depth relative to the final design grade, will impact the results of field or laboratory testing and should be taken into consideration during the determination of subgrade support for design.

2.2.2.1 Direct Laboratory Testing for Subgrade Soil Modulus

The Resilient Modulus test is a repeated load Triaxial compression test that measures the material's stiffness under different conditions such as moisture, density and stress level. It is determined in accordance with AASHTO T 307-99 Determining the Resilient Modulus of Soils and Aggregate Materials. (Ref. 7)

2.2.2.2 Field Testing and Analyses for Subgrade Soil Modulus

Direct field tests that are recommended to develop subgrade strength design parameters are: 1) Non-Destructive Deflection Testing (NDT) and 2) Dynamic Cone Penetrometer (DCP). Alternative test methods are: Plate Load Tests for K-Value or CBR.

Non-Destructive Deflection Testing (NDT) - For existing roadway pavement being evaluated for reconstruction or rehabilitation, non-destructive deflection test data may be collected on the existing pavement with equipment including the Falling Weight Deflectometer (FWD) or Heavy Weight Deflectometer (HWD). The test procedure is ASTM D4602 - 93(2015) Standard Guide for Nondestructive Testing of Pavements Using Cyclic-Loading Dynamic Deflection Equipment. (Ref. 9) The NDT data is analyzed to estimate existing subgrade strengths using the TxDOT back calculation program MODULUS (Version 6.1) considering existing pavement thicknesses, typically confirmed with pavement cores and borings.

Dynamic Cone Penetrometer (DCP) - The Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications is ASTM D6951/D6951M - 09(2015). (Ref 19) The Dynamic Cone Penetration Test provides a measure of a material's in-situ resistance to penetration. The test is performed by driving a metal cone into the ground by repeated striking it with a 17.6 lb. weight dropped from a distance of 2.26 feet. The penetration of the cone is measured after each blow and is recorded to provide a continuous measure of shearing resistance up to 5 feet below the ground surface. Test results can be correlated to California Bearing Ratios, in-situ density, resilient modulus, and bearing capacity. See section 2.2.2.4 for correlations to modulus.

Plate Load Test for K-Value – AASHTO T 222-78 Plate Load Test method (Ref 10) covers the making of non-repetitive static plate load test on subgrade soils (compacted or the natural state), base materials and flexible pavement components. See section 2.2.2.4 for correlations to modulus.

Plate Load Test for CBR – ASTM D4429-09 Standard Test Method for CBR (California Bearing Ratio of Soils in Place) (for Soil in place in field). (Ref. 11) See section 2.2.2.4 for correlations to modulus.

2.2.2.3 Laboratory Testing

Laboratory tests that are recommended to develop subgrade strength design parameters for rigid pavement design are: California Bearing Ratio or K-Value. Laboratory tests required for flexible pavement design include Modified Texas Triaxial Test and either Unconfined Compressive Strength Test or California Bearing Ratio for estimated strength values based on correlations.

California Bearing Ratio – It measures the penetration resistance of the subgrade or base course relative to a standard crushed rock. It is an empirical test developed by California Department of transportation. The CBR test can be done in accordance with ASTM standards D1883-16 (Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils) (for laboratory prepared samples) (Ref. 12) and AASHTO T193 (Standard Method of Test for the California Bearing Ratio). (Ref. 13)

K-Value – The TxDOT laboratory test procedure for Determining Modulus of Sub-Grade Reaction (K Value) is Tex-125-E. (Ref. 14)

Texas Triaxial Classification – Evaluating a material for its Texas Triaxial Classification is covered in “Tex-117-E, Triaxial Compression for Disturbed Soils and Base Materials.” (Ref 5) This method determines the shearing resistance, water absorption and expansion of soils and/or soil-aggregate mixtures.

Unconfined Compressive Strength Test – This test determines the shearing resistance of the cohesive soil which may be undisturbed or remolded soils. It is determined in accordance with ASTM D2166/D2166M-16 (Standard Method for Unconfined Compressive Strength of Cohesive Soil) (Ref 15) and AASHTO T208 (Standard Method for Unconfined Compressive Strength of Cohesive Soil). (Ref. 16)

2.2.2.4 Modulus Correlations

Correlations have been researched with various other types of field and laboratory tests. Although there are numerous correlations for various soil test parameters, the table below summarizes suggested correlations to be used in establishing the subgrade soil strength modulus.

Table 2.6 Suggested Subgrade Strength Correlation Equations

Basis of Correlation	Equation	Origin	Comments
CBR to M_R	$M_R = (1500)(\text{CBR})$	Heukelom & Klomp (1962) (Ref 17)	Only for fine-grained non-expansive soils with a soaked CBR of 10 or less.
	$M_R = 2555 \times \text{CBR}^{0.64}$	NCHRP 137A (Ref 18)	A fair conversion over a wide range of values.
DCP Test to CBR	$\text{CBR} = 292/\text{PR}^{1.12}$	ASTM D6951 (Ref 19)	PR is penetration rate, mm/blow from DCP test
	$\text{CBR} = 1/(0.002871)(\text{PR})$	Webster, Brown and Porter, 1994 (Ref 20)	For high plasticity clay soil (CH); PR is penetration rate, mm/blow from DCP test
	$\text{CBR} = 1/[(0.017019)(\text{PR})]^2$	Webster, Brown and Porter, 1994 (Ref 20)	For low plasticity clay soil (CL); PR is penetration rate, mm/blow from DCP test
Unconfined Compressive Strength (UCS) to M_R	$M_R = 143.33(\text{UCS}) + 4283.5$	Hossain & Kim (2014) (Ref 21)	N/A
Texas Triaxial Classification (TTC) to M_R	$M_R = 2161.2(\text{TTC})^2 - 26263(\text{TTC}) + 81981$	1993 AASHTO Guide (Ref 22)	N/A

2.2.2.5 Typical Ranges of Strength Values by Soil Type

Various sources were reviewed to obtain typical ranges of strength related test values for various subgrade soil materials. Ranges are summarized below for general guidance only and shall not be used in lieu of testing. The ranges below are always a function of moisture content, void ratio and density.

Table 2.7 Typical Subgrade Soil Strength Ranges

Material (USC given where appropriate)	CBR	K-Value (pci)	UCS (psi)	Elastic or Resilient Modulus (psi)
Gravel and Gravelly Soils (GW, GP, GM, GC)	20 – 100	200 - 300+	110-250	20,000 – 40,000
Sandy Soils (SW, SP, SM, SC)	10 – 40	200 - 300	19-180	7,000 – 30,000
Silty Soils (ML, MH)	8 – 15	200 - 300	5-110	5,000 – 20,000
Clay Soils, Low compressibility LL<50 (CL)	5 – 15	100 - 200	5-40	5,000 – 10,000
Clay Soils, high compressibility LL>50 (CH)	1 - 5	50 – 100	1-5	2,000 – 5,000

3 Flexible Pavement Design – TxDOT FPS21 Guidelines

3.1 Basic Design Criteria Input Variables

3.1.1 Length of Analysis Period

Length of analysis period is the time over which each design alternative is analyzed. The length of analysis period is required to be 40 years for flexible pavement.

3.1.2 Minimum Time to First Overlay

The minimum time to first overlay can be selected by each county and agency based on their previous experience, policies, budgetary constraint and other general guidelines. 20 years is the required input as a minimum time to first overlay.

3.1.3 Minimum Time Between Overlay

This parameter will be based on agency practices. Unless otherwise directed, the minimum time between overlay shall be set to 10 years.

3.1.4 Design Confidence Level

Design confidence level takes into account the uncertainty due to variability in estimating traffic, material strength and construction practices to ensure that the pavement will last for design period. The confidence level shall be selected based on the functional classification of the road. Table 3.1 shows the alphabetic code used by FPS21 for the appropriate design confidence level.

Table 3.1 Required Design Confidence Level

Street Classification*	Representative ADT Range**	Representative ESALs at 20 Years**	FPS21 Code	Design Confidence Level (%)
Urban Arterial High Traffic	4,000 - 25,000	9,000,000	C	95
Urban Arterial Low Traffic	6,000 - 9,000	2,500,000	C	95
Rural Arterial	2,000 - 9,000	1,000,000	C	95
Urban Collector High Traffic	2,000 - 8,000	2,100,000	C	95
Urban Collector Low Traffic	2,000 - 4,000	700,000	B	90
Rural Collector	2,000 - 8,000	600,000	B	90
Urban Local	200 - 3000	150,000	B	90
Rural Local	500 - 4000	350,000	B	90

* Street Classification will be based on the platted street designation and clarification by the governing agency.

** Not intended to be used in lieu of traffic calculations

3.1.5 Present Serviceability Index

The Present Serviceability Index refers to the condition of the pavement ride quality. The selection of the suitable initial serviceability index can be made from the ranges provided in Table 3.2 considering the number of factors such as reconstruction/widening vs new construction, control of grades/profiles, ditches types and other construction constraints. Table 3.3 provides the required terminal serviceability index values by street classification.

Table 3.2 Initial Serviceability Index Range

Surface Type	Allowable Initial Serviceability Index Range
Surface Treatment	4.0
Thin HMAC ($\leq 4''$)	4.0 - 4.2
HMAC $> 4''$	4.2 - 4.5

Table 3.3 Terminal Serviceability Index

Street Classification	Representative ESALs	Terminal Serviceability Index
Urban Arterial High Traffic	9,000,000	3.0
Urban Arterial Low Traffic	2,500,000	3.0
Rural Arterial	1,000,000	3.0
Urban Collector High Traffic	2,100,000	3.0
Urban Collector Low Traffic	700,000	2.5
Rural Collector	600,000	2.5
Urban Local	150,000	2.0
Rural Local	350,000	2.0

3.1.6 District Temperature Constant

This input represents the susceptibility of the asphalt binder to thermal cracking under traffic load. The default value for the central Texas is 31.

3.1.7 Subgrade Elastic Modulus

See Section 3.4 for discussion of this input parameter.

3.1.8 Interest Rate (%)

This parameter is a required input, however, is only used in the life cycle cost analysis which is not being utilized with FPS21. (See Section 6 for discussion of the required Life Cycle Cost Analysis (LCCA) software RealCost 2.5). A value of 7% may be input for the program to run.

3.2 Program Controls

Max Funds in Dollars per Square Yard, Initial Construction: \$99.0/SY

[Note: 99.0 is default value; however, FPS21 is not be to used for life cycle cost analyses; see Section 6 for more discussion]

3.2.1 Max Thickness, Initial Construction:

99.0 inches

[Note: 99.0 is default value; if there are limitations on the depth of construction, it may be included here, however if too thin, there may be no acceptable solution]

3.2.2 Max Thickness, All Overlays:

6.0 inches

[Note: 6.0 is default value]

3.3 Construction and Maintenance Data/Detour Design

These input parameters are used for life cycle cost analyses which will not be utilized with FPS21 (See Section 6 for RealCost 2.5 discussion). However, FPS21 will require several of these inputs to run, whether or not the cost is considered. Inputs required, but not utilized are: overlay construction time, asphalt density and production time, lane width, and detour design inputs. See discussion below regarding inputs.

3.3.1 First Year Cost for Routine Maintenance (\$/lane-mile)

This is a life-cycle costs parameter that will not be utilized. Set this number to 0.

3.3.2 Annual Incremental Increase in Maintenance Cost

This is a life-cycle costs parameter that will not be utilized. Set this number to 0.

3.3.3 Overlay Construction time, Hours/day

This input is used to evaluate traffic delay costs as a result of overlay operations required at the end of a performance period. Daily construction time typically ranges from 8-12 hrs.

3.3.4 ACP Production Rate, Tons/Hour

Typically, the value ranges between 150–300 tons/hr.

3.3.5 Detour Model Selection for Future HMAC Overlays

The FPS21 program has 5 different models for handling traffic during overlay operations, each one generating a unique user-delay related cost. Unfortunately, the built-in help screen only addresses three of the five models. The model number (1-5) is entered in this field.

CAUTION: Use of the incorrect detour model can result in excessive user delay costs or cause the program to crash, particularly when insufficient lanes are allotted for very high ADT inputs.

A short description of each model is given here.

- Model 1. Highway cross section consists of two driving lanes (one each direction) with wide (8-10 ft.) shoulders. Paving operations will block one lane at a time, with traffic in the paving direction using the shoulder or lane in that direction as the detour. Traffic in the non-paving direction is relatively unaffected, although slowing will probably be required.

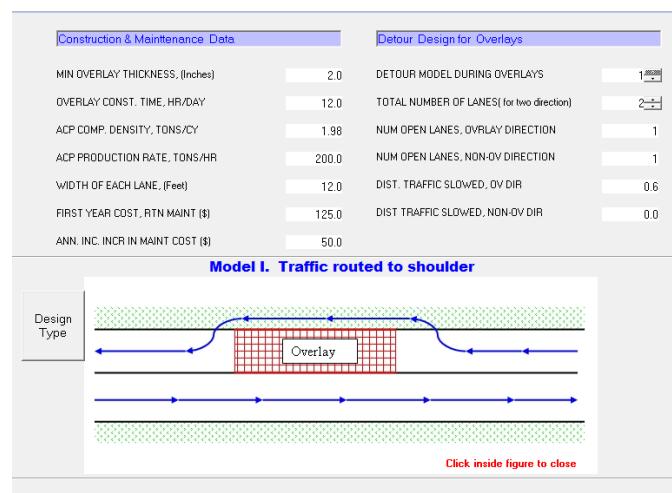


Figure 3.1 FPS Detour Model 1

- Model 2. Highway cross section consists of two driving lanes (one each direction) with narrow shoulders. Paving operations will block one direction at a time, with traffic in the paving direction being diverted into the on-coming lane using an escort. Traffic in the non-paving direction will be required to stop when traffic is escorted from the opposite direction.

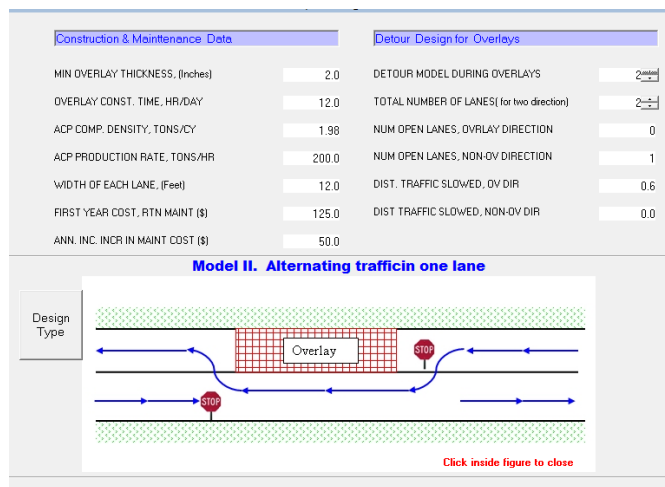


Figure 3.2 FPS Detour Model 2

- Model 3. Highway cross section consists of two or more driving lanes in each direction. Paving operations will block one driving lane at a time, requiring traffic in the paving direction to channel down into fewer lanes. Traffic in the non-paving direction may be completely unaffected if the highway is a divided facility.

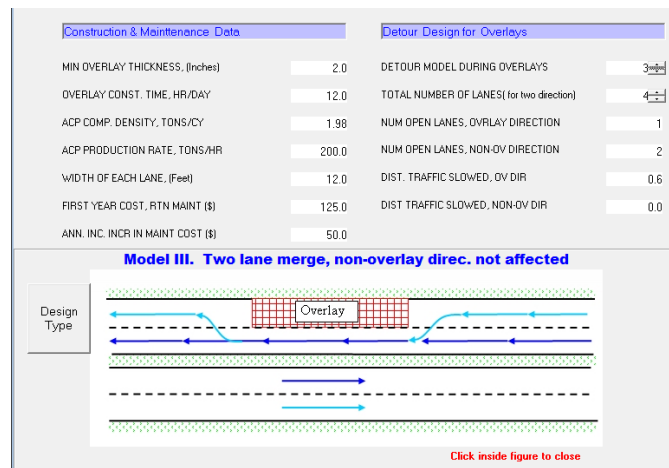


Figure 3.3 FPS Detour Model 3

- Model 4. Highway cross section consists of two or more driving lanes in each direction. Directional traffic flow in the paving direction is completely blocked, with traffic diverted to at least one lane in the opposite direction. Traffic in the non-paving direction must be channeled down into fewer lanes to accommodate opposing traffic.

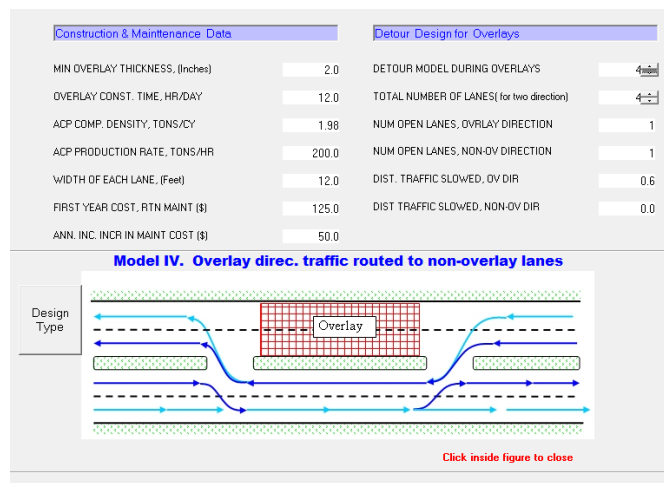


Figure 3.4 FPS Detour Model 4

- Model 5. Highway cross section consists of two or more driving lanes in each direction. Directional traffic flow in the paving direction is completely blocked, with traffic diverted around the overlay zone by special detour, alternate route, or combination of these. Traffic in the non-paving direction may be completely unaffected if the highway is a divided facility.

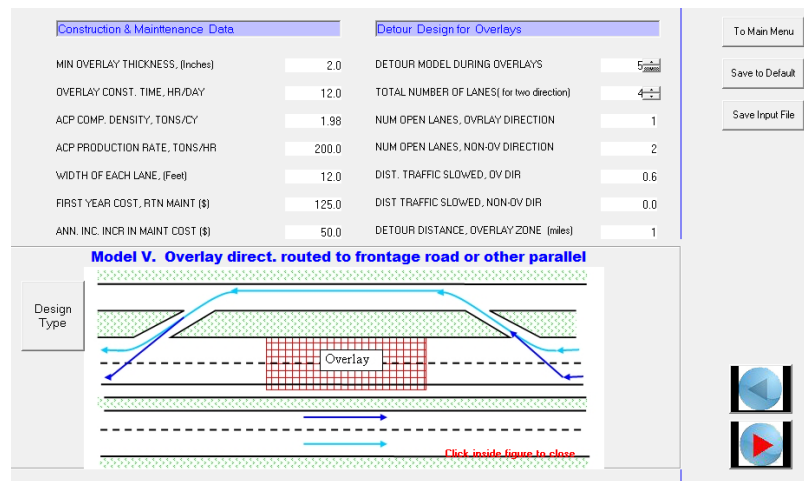


Figure 3.5 FPS Detour Model 5

For low to medium volume highways, the TxDOT Pavement Design Task Force (PDTF, 2009) recommended removing the possible cost bias in accounting for these user costs by simply selecting detour model 3 and entering the posted approach speed for all traffic speed entries in the detour area. This recommendation is supported for comparisons of flexible pavement design alternatives.

3.4 Paving Materials Information

3.4.1 Subgrade Soil Characterization Input Variables

FPS21 utilizes elastic modulus in ksi as the strength input for subgrade strength. See Section 2.2 for more discussion. Additionally, Poisson’s Ratio value of 0.40 shall be used for subgrade.

3.4.2 Pavement Layer Characterization Input Variables

FPS21 utilizes elastic modulus for the various pavement layer strengths. Based on the Austin District Pavement Design Standard Operating Procedure (Ref 23) that was developed to reflect central Texas paving materials, the following values are suggested:

Table 3.4 Typical Pavement Layer Characteristics

Material Properties	Typical Design Modulus	Poison's Ratio	Other Considerations
Natural Subgrade	Back-Calculated Moduli from FWD or DCP	0.4	Historical FWD data in the area can be used, if the new construction is in close proximity and the same soil formation/classification.
			Typical range is 8 to 20 ksi. DCP or FWD data must be obtained to apply a modulus outside this range
Lime Stabilized Subgrade	3 times the modulus of the natural subgrade or 20 ksi whichever is greater	0.3	Must have a UCS \geq 100 psi for structural credit. Otherwise, all lime treated layers are not given structural credit
			Minimum of 6 inches for construction purposes.
			Typical thickness range of 8 to 18 inches
Cement Stabilized Subgrade	40 ksi	0.3	Must have a UCS \geq 100 psi for structural credit. Otherwise, all cement treated layers are not given structural credit.
			Typical thickness range of 6 to 12 inches.
Cement Stabilized Base	150 ksi	0.25	Typical thickness range of 8 to 12 inches.
Flexible Base	40 ksi	0.35	Typical thickness range of 8 to 16 inches

Material Properties	Typical Design Modulus	Poisson's Ratio	Other Considerations
Mechanically Stabilized Flexible Base (Geogrid Reinforced)	>40 ksi (varies)	0.35	Minimum 6 inch flexible base
Seal Coat	200 ksi	0.35	Do not assign structural credit to seal coats if used as underseal.
Dense Graded HMAC	500 ksi (≤ 4 " Total HMAC)	0.35	Minimum total dense graded HMAC thickness of 4 inches when placed on flexible base. Use only for Intermediate, Level-up or Base HMAC courses. Do not specify as surface course. Minimum Layer Thickness: Type B: 3.0" Type C: 2.5" Type D: 1.5"
	650 ksi (> 4 " Total HMAC)		
Thin Overlay Mixtures (TOM)	500 ksi	0.35	Use "User Defined" pavement design type in FPS21, select "Performance Mix" from material type menu when using TOMs. Use $\frac{3}{4}$ " to 1"

3.4.3 Cost per Cubic Yard

The cost per CY for all new materials proposed is an input for life cycle cost analysis, for which FPS21 is not being utilized. A value of 0 may be input for each pavement layer.

3.4.4 Salvage Percentage

The salvage value for the original cost of the material that may be recovered at the end of the analysis period is related to life cycle cost analysis, for which FPS21 is not being utilized. However, a value must be input for the program to run. Therefore, the default values for the materials selected are recommended.

3.5 Design Output

The FPS21 solutions that meet the design criteria will be provided, including alternatives based on variable thicknesses (as per thickness ranges input) for the designated material layers. Each alternative will indicate the predicted life in years, based on the traffic data input.

3.6 Mechanistic Check

Mechanistic design check will provide an estimate of expected fatigue life of the HMA layers and the full depth rut life of the structure based on the critical responses of the pavement.

FPS21 runs elastic linear analysis to calculate stress and strain at critical locations which are the critical tensile stress at the bottom of HMA and the compressive strain at the top of the subgrade. These values are then used in the performance models to compute the number of load repetitions to either cracking or rutting failure.

The estimated number of ESALs repetitions to failure in fatigue and rutting is compared with the estimated cumulative ESALs to the end of the first performance period and if either of the rutting life or fatigue life is less than the estimates cumulative ESALs to the end of the performance period, then the FPS option could be under designed and need to be adjusted to accommodate the design traffic.

3.7 Modified Texas Triaxial Check

The Modified Texas Triaxial (Ref 5) check establishes the total combined thickness of the pavement required to prevent the shear failure in the subgrade based on the heaviest wheel load, percentage tandem axle and the Texas Triaxial class of the subgrade. The input for the Modified Texas Triaxial check are shown below:

3.7.1 The Average Ten Heaviest Wheel Loads Daily (ATHWLD)

The ATHWLD is the load carried by the dual tires at each end of the drive or trailer axles or a single wheel load on each tire of the steering axle, or the tire load on drive or trailer axles equipped with wide-base radials. Table 3.5 provides the suggested ATHWLD based on the design ESALs.

Table 3.5 ATHWLD as per ESALs

ESAL Ranges	ATHWLD
< 0.9 Million	10,000
0.9 to 10 Million	11,500
10 to 50 Million	13,500
> 50 Million	14,000

3.7.2 Percentage of Tandem Axles

In FPS21 Modified Texas Triaxial Check, the percentage of tandem axle is categorized into two categories: % Tandem Axles > 50 and % Tandem Axles < 50. When % Tandem Axles is greater than 50%, the design wheel load is increased by 30% in FPS21 software. The TxDOT Pavement Design Task Force (PDTF, 2009) recommends a factor of 1.0 be used for all designs where traffic loading is below 5 M ESALs. Thus input the % Tandem Axles as < 50% for this design condition. For Industrial Streets in the Urban High Collector Traffic classification, >50% Tandem Axles shall be used unless data to support less Tandem Axles is provided.

3.7.3 Modified Cohesimeter Value (C_m)

Modified cohesion value is required to account for the reduction in the overall pavement thickness requirement due to the presence of better material above the subgrade. The good material above the subgrade will protect the subgrade from the shear failure. Table 3.6 shows the approved cohesimeter values for different materials.

Table 3.6 Cohesimeter Values

Material Type	Cohesimeter Value (C _m)
Lime Treated Base greater than 3" thick	300
Lime Treated Subgrade greater than 3" thick	250
Cement Treated Base greater than 3" thick	1000
Cold Mixed Bituminous Materials greater than 3" thick	300
Hot Mixed Bituminous Materials greater than 6" thick	800
Hot Mixed Bituminous Materials 4" to 6" thick	550
Hot Mixed Bituminous Materials 2" to 4" thick	300
Untreated Materials	100

3.7.4 Subgrade Texas Triaxial Class

The Subgrade Texas Triaxial Class (TTC) can be selected using three different options:

Option 1: Input based on TEX-117-E

Option 2: Enter soil PI to estimate TTC

Option 3: Select TTC based on predominate soil type

3.7.5 Modified Triaxial Check Results

If the required overall thickness of the pavement with the Modified Texas Triaxial criteria is equal to or less than the resulting section being checked, the section meets the criteria. If the required overall thickness of the pavement with the Texas Triaxial criteria is more than the section being checked, the design solution needs to be re-run to obtain an overall thickness to meet the criteria. Changes in layer thicknesses or materials which can increase the cohesiometer value may be considered.

3.8 Representative Cross Sections by Classifications

Based on the representative traffic values presented previously for the various street classifications, representative cross sections are included in the following tables for three subgrade conditions: moderate swell, high swell, and very high swell. An example FPS21 output can be found in Attachment B.2.

Table 3.7 Representative Sections by Street Classifications and Subgrade swell

Street Classification	Moderate Subgrade Swell (Subgrade Strength of 10 ksi)		High Subgrade Swell (Subgrade Strength of 5 ksi)			Very high Subgrade Swell (Subgrade Strength of 2 ksi)		
	Representative Thickness of HMAC Surface Course (in.)	Representative Thickness of Flexible Base Course (in.)	Representative Thickness of HMAC Surface Course (in.)	Representative Thickness of Flexible Base Course (in.)	Representative Thickness of Stabilized Subgrade (in.)	Representative Thickness of HMAC Surface Course (in.)	Representative Thickness of Flexible Base Course (in.)	Representative Thickness of Stabilized Subgrade (in.)
Locals								
Urban Local	2.0	14.0	2.0	8.0	10.0	2.0	12.0	12.0
Rural Local	2.0	14.0	2.0	9.0	10.0	2.0	14.0	12.0
Collectors								
Rural Collector	3.0	14.0	3.0	9.0	10.0	3.0	14.0	12.0
Urban Collector Low Traffic	3.5	14.0	3.0	10.0	10.0	3.5	14.0	12.0
Urban Collector High Traffic	5.0	14.0	6.0	10.0	10.0	6.0	14.0	12.0
Arterials								
Rural Arterial	5.0	14.0	4.5	10.0	10.0	4.5	14.0	12.0
Urban Arterial Low Traffic	5.5	14.0	6.5	10.0	10.0	6.5	14.0	12.0
Urban Arterial High Traffic	9.5	14.0	9.5	14.0	10.0	10.5	14.0	12.0

4 Rigid Pavement Design – PavementDesigner Guidelines

4.1 Input Variable Descriptions

The input variables and outputs for PavementDesigner are organized under the following:

(1) PROJECT LEVEL Page

Traffic Spectrum, Truck Data, Traffic Distributions

(2) PAVEMENT STRUCTURE Page

Surface Concrete Properties, Subgrade Soil Strength, and Subbase Layers

(3) SUMMARY Page

Design Thickness, Joint Spacing, extensive sensitivity charts, analysis, and guidance

4.2 (1) PROJECT LEVEL Page

4.2.1 TRAFFIC inputs

PavementDesigner calculates 18 Kip ESALs based on either predetermined traffic spectra with counts or user input traffic distributions for the specific functional class of pavement for which a design is being calculated. The predetermined load spectra are identified by street classifications: Residential, Collector, Minor Arterial, and Major Arterial; ACI 330 categories: Categories A through E; and also allows for entering your own Custom Traffic Spectrum. The Custom Traffic Spectrum may be entered by identifying the axle load by single, tandem and tridem axle type and number of axles per 1000 trucks. These traffic spectrums establish the truck factors to be used in the ESAL calculations, which are internal to the program.

The truck traffic is then determined for the pavement design life by providing the following inputs: Design Life in years, Trucks per Day (initial two-way), Traffic Growth Rate in % per year (Table 2.2), Directional Distribution, and Design Lane Distribution (Table 2.3). From these inputs and the load spectrum chosen or defined, the Average Trucks per Day and Total Trucks in the Design Lane over the Design Life is calculated and used in the thickness design. Some representative traffic data by street classifications is summarized in Table 2.4 and includes ESALs, ranges of ADT, percent trucks, and trucks per day.

4.3 (2) PAVEMENT STRUCTURE Page

4.3.1 SURFACE LAYER inputs

4.3.1.1 Concrete Material Properties

The 28-day flexural strength and the Modulus of Elasticity of Concrete are required for the rigid pavement design. Typical 28-day flexural strength ranges from 500-700 psi. City of Austin Item 360 requires minimum compressive strength of 4,500 psi at 28 days for concrete mix design. As per the ACPA concrete strength converter (<http://www.apps.acpa.org/apps/StrengthConverter.aspx>), a compressive strength of 4500 psi is correlated to flexural strength range of 503 to 637, based on various sources as follows:

English (psi)	Source
637	MEPDG
627	Mindess, Young, and Darwin; Raphael
503	ACI 318
627	ACI 330*
537 to 671	Yoder and Witczak; Huang

Figure 4.1 ACPA Concrete Strength Converter Calculation

Additionally, the use of “macrofibers” may also be included for consideration of fiber-reinforced concrete mixtures. However, if macrofibers are selected for consideration in the design, additional documentation with requirements for the fiber-reinforced concrete mix design and construction specifications must be provided with the design report.

4.3.1.2 Edge Support

The critical load location on a concrete slab is at an unsupported edge, hence additional support will result in reduced pavement thickness. Edge support can be accomplished by specifying a concrete curb and gutter, tied concrete shoulder, or widened lane. A widened lane consists of a lane edge stripe that

is placed a minimum of 1 ft. from the pavement edge. If edge support is to be provided, that should be selected on the design input screen.

4.3.1.3 Macrofibers in Concrete

The use of macrofibers in concrete adds to the reliability of the concrete slabs through crack control, resistance to some specific modes of failure, and potentially strength. This is a simple toggle for yes or no for the existence of fibers in the concrete. See Concrete Material Properties above for more details.

4.3.2 SUBGRADE input

4.3.2.1 Composite Modulus of Subgrade Reaction (Static k-value)

The properties of subbase such as the modulus of elasticity and the layer thicknesses are used to calculate the composite static k-value. This value estimates the support of the layers below concrete pavement slab(s). This value may be directly measured in the field; however, it is more typically calculated based on the thickness and layer strengths.

The subgrade modulus, MRS_G, can either be given as a direct input or calculated through correlations to the CBR or R-value of subgrade. The equations developed from NCHRP 128, "Evaluation of the AASHTO Interim Guide for the Design of Pavement Structure" (Ref 25) are used to estimate the subgrade modulus. Refer to Table 2.7 for more details on subgrade modulus and k-value ranges based on soil type.

The subbase material types included in PavementDesigner are: Cement-Stabilized Subgrade; Lime-Stabilized Subgrade; unstabilized subbase (e.g. sand/gravel, crushed stone); Cement-Treated Subbase (CTB); Lean Concrete Subbase (LCB, Econocrete); Asphalt-Treated Subbase (ATB); and Hot-Mix or Warm-Mix Asphalt Subbase.

The layer thickness and layer modulus of elasticity is input for each subbase layer and the composite k-value is thus calculated. Background details on the calculations of composite k-value are included in 1993 AASHTO Guide for Design of Pavement Structures (Ref 22) in Section 3.2.1. PavementDesigner's allowable range of modulus values for each material type is generally equivalent to the material strengths included in Table 3.4. The subbase material directly under the concrete shall be non-erodible material, therefore an unstabilized subbase shall not be considered.

4.3.3 GLOBAL Inputs

The global design parameters required are reliability and percent of slabs cracked at end of design life.

4.3.3.1 Reliability

The primary global design input is Reliability. Reliability depends on the type of roadway that is being designed. A relatively high reliability is used for high traffic, high speed roadways, while low traffic, low

speed roads typically need a low level of reliability. The reliability required by street classification is shown in Table 4.1.

Table 4.1 Required Design Reliability

Street Classification	Representative ESALs	Design Reliability (%)
Urban Arterial High Traffic	9,000,000	95
Urban Arterial Low Traffic	2,500,000	95
Rural Arterial	1,000,000	95
Urban Collector High Traffic	2,100,000	95
Urban Collector Low Traffic	700,000	90
Rural Collector	600,000	90
Urban Local	150,000	90
Rural Local	350,000	90

4.3.3.2 Percent of Slabs Cracked at End of Design Life

This input reflects the allowable percent of concrete slab that are cracked at the end of the design life of pavement. This number could correspond to the percent of slabs that are intended to be replaced in determining future rehabilitation of pavement for life cycle cost analysis. Typically for arterials and collectors, the recommended percent of concrete slabs cracked at the end of the design life is 15%; for local roads that percentage is 25%. These percentages of cracked concrete slabs are based on studies such as FHWA-RD-97-131 “Common Characteristics of Good and Poorly Performing PCC Pavements” (Ref 24).

Conservative pavement designs might use a value as low as 10% cracked slabs to minimize the allowable damage for more critical infrastructures. Fortunately, even selecting a more conservative value here typically does not excessive drive up the thickness of the design and may be desirable.

4.3.4 STRUCTURE inputs for Subbases

Upon entering the type and thickness of any desired subbase or multiple subbases the application will automatically calculate an appropriate composite K-value unless the manual Override is checked.

4.4 SUMMARY – design output

When the design solution is run, the PavementDesigner outputs the Rigid ESALs over the design life along with the minimum required concrete thickness for doweled and undoweled condition, with an indication of the controlling failure criteria noted. Regardless of the PavementDesigner output value, the minimum concrete pavement thickness allowed for public streets shall be 6 inches.

Note, rigid pavement designs must include proper jointing plans and joint types to provide for successful construction and long-term performance. Standard guidance is provided in ACI 325.12R-02 Guide for Design of Jointed Concrete Pavements for Streets and Local Roads (Ref 26), by ACI Committee 325, American Concrete Institute, Reapproved 2013 and ACI 330R-08 Guide for the Design and Construction of Concrete Parking Lots (Ref 27) also provides additional details which are helpful for on-street parking areas. These ACI guides will help to prevent cracking due to improperly located and constructed joints. PavementDesigner provides guidance regarding maximum joint spacing and dowel bar recommendations for jointed plain concrete pavement. An example PavementDesigner output is included in Attachment B.3.

4.5 Representative Cross Sections by Classification

Based on the representative traffic values presented previously for the various street classifications, representative cross sections are included in the following tables for three subgrade conditions: moderate swell, high swell, and very high swell.

Table 4.3 Representative Sections by Street Classifications and Subgrade Swell

Street Classification	Moderate Subgrade Swell (Subgrade Strength of 10 ksi)			High Subgrade Swell (Subgrade Strength of 5 ksi)			Very high Subgrade Swell (Subgrade Strength of 2 ksi)		
	Representative Thickness of PCC Surface Course (In.)	Representative Thickness of HMAC Base Course (In.)	Representative Thickness of Stabilized Subgrade (In.)	Representative Thickness of PCC Surface Course (In.)	Representative Thickness of HMAC Base Course (In.)	Representative Thickness of Stabilized Subgrade (In.)	Representative Thickness of PCC Surface Course (In.)	Representative Thickness of HMAC Base Course (In.)	Representative Thickness of Stabilized Subgrade (In.)
Locals									
Urban Local	6.0	--	--	6.0	--	10.0	6.0	--	12.0
Rural Local	6.0	--	--	6.0	--	10.0	6.0	--	12.0
Collectors									
Rural Collector	6.0	4.0	--	6.0	4.0	10.0	6.5	4.0	12.0
Urban Collector Low Traffic	6.0	4.0	--	6.0	4.0	10.0	6.5	4.0	12.0
Urban Collector High Traffic	6.0	4.0	--	6.5	4.0	10.0	7.0	4.0	12.0
Arterials									
Rural Arterial	6.5	4.0	--	7.0	4.0	10.0	7.5	4.0	12.0
Urban Arterial Low Traffic	7.0	4.0	--	7.5	4.0	10.0	7.5	4.0	12.0
Urban Arterial High Traffic	7.5	4.0	--	8.0	4.0	10.0	8.5	4.0	12.0

5 Subgrade Soils (Bottom Up Design)

Figure 5.1 shows why subgrade evaluation is critically important in the central Texas area. Soils conditions are highly variable and many of the existing subgrades are highly expansive. These conditions are all along the IH-35 corridor and exist in other major Texas urban areas including the Dallas-Fort Worth and San Antonio metropolitan areas.

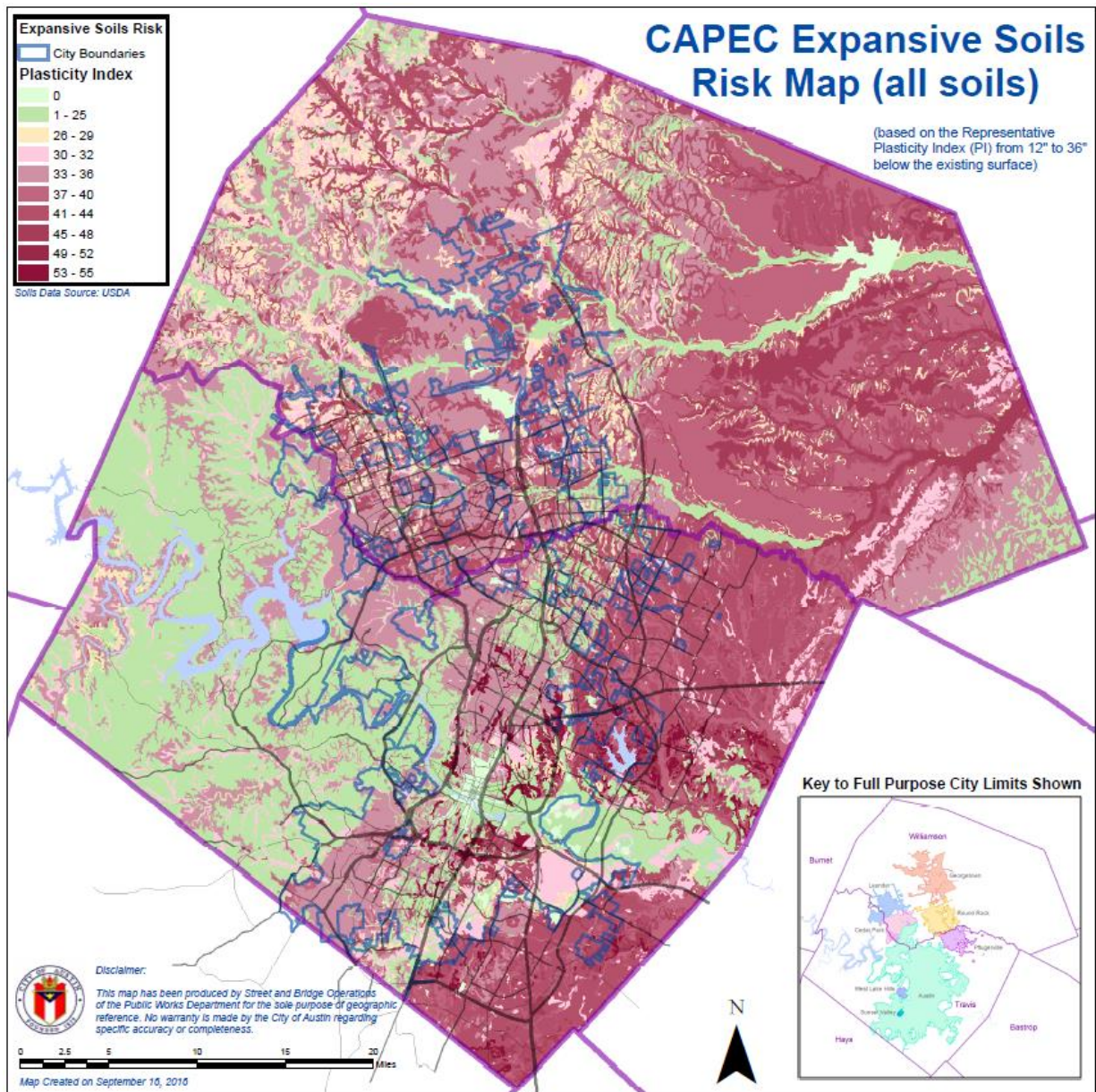


Figure 5.1 CAPEC Area Soils Map (provided by Edward A. Poppitt, PE, City of Austin)

5.1 Characterization of In-situ Subgrade Soils

It is critical to establish the properties of the subgrade soils for the Bottom Up design effort. In addition to the strength of the soil to define the subgrade support for traffic loading, other critical properties to assess the shrink/swell nature of a soil include: Liquid Limit (LL) and Plasticity Index (PI), moisture content, minus 40 and 200 sieves, and sulfate content. Based on these laboratory test results and other specialized testing, it is possible to estimate subgrade shrink/swell and determine improvement/stabilization requirements for design. Subgrade soils considered to be high swell generally have the following characteristics: PI greater than 35, LL greater than 60, and greater than 50% passing the minus 200 sieve.

5.2 Methods to Estimate Subgrade Shrink/Swell

There are several methods to estimate the shrink/swell impacts of subgrade. The required testing procedures in priority order are:

- 1) Free Swell Test as per ASTM4546 – 14 (Ref 28) to calculate PVR for actual soils samples.

or

- 2) Traditional Potential Vertical Rise (PVR) calculations as per Tex 124E for an approximation.

Other procedures have been developed by The University of Texas at Austin including centrifuge testing (Test Method 6048A and 6048B), and forced ventilation accelerated swell/shrink test. These optional tests may also be used to support design calculations.

Sample selection and laboratory testing shall consider proposed final grades, i.e. depth of cut and fill. All geotechnical boring logs shall include accurate vertical and horizontal location.

5.2.1 Free Swell Test Model (ASTM D4546 -14 Standard Test Methods for One-Dimensional Swell or Collapse of Soils)

The free swell test (ASTM D4546 -14 Method C) will provide a good design benchmark criterion for swelling clay behavior under variations in moisture content. The free swell test method (ASTM D4546 -14 Method C) also provides an estimate of the stress applied to the pavements in addition to the “free swell”.

In order to estimate the amount of swell in a profile, it is understood that the swell is a function of the overburden pressure over the depth of interest, normally modeled to 15 feet with a vertical effective stress of up to about 2,000 psf. Free swell test Method B only gives the total swell due to inundation at zero effective stress. It is helpful to determine the swell pressure in addition to the free swell particularly since this gives the pavement designer a feel for the stresses the pavement will experience due to high PI swelling clay. The swell pressure is the effective stress required to hold the sample at

zero deflection. This swell pressure can be determined by running Method C of ASTM D4546 -14, whereas free swell alone is Method B.

A single sample taken from near the ground surface may not give a good representation of the soil behavior over the depth of the active moisture zone. It is preferable to run the test on three samples at each location – one in the upper 5 feet, another in the middle 5 feet, and a third in the lower 5 feet, based on changes in the soil classifications. However, 1 or 2 tests per location may be adequate to characterize more highly uniform soils based on the geotechnical engineer’s judgement. These should be Shelby tube samples of the in situ soils. It is preferred to keep the samples sealed in the tubes until they reach the lab, and then extrude immediately prior to running the tests. The tests can also run tests on soils mixed with stabilizing agents to determine the effect and percentage of stabilizing agent required. Bulk samples can also be used for this testing.

Figure 5.2 shows an example calculation based assumed existing soil layer swell test results.

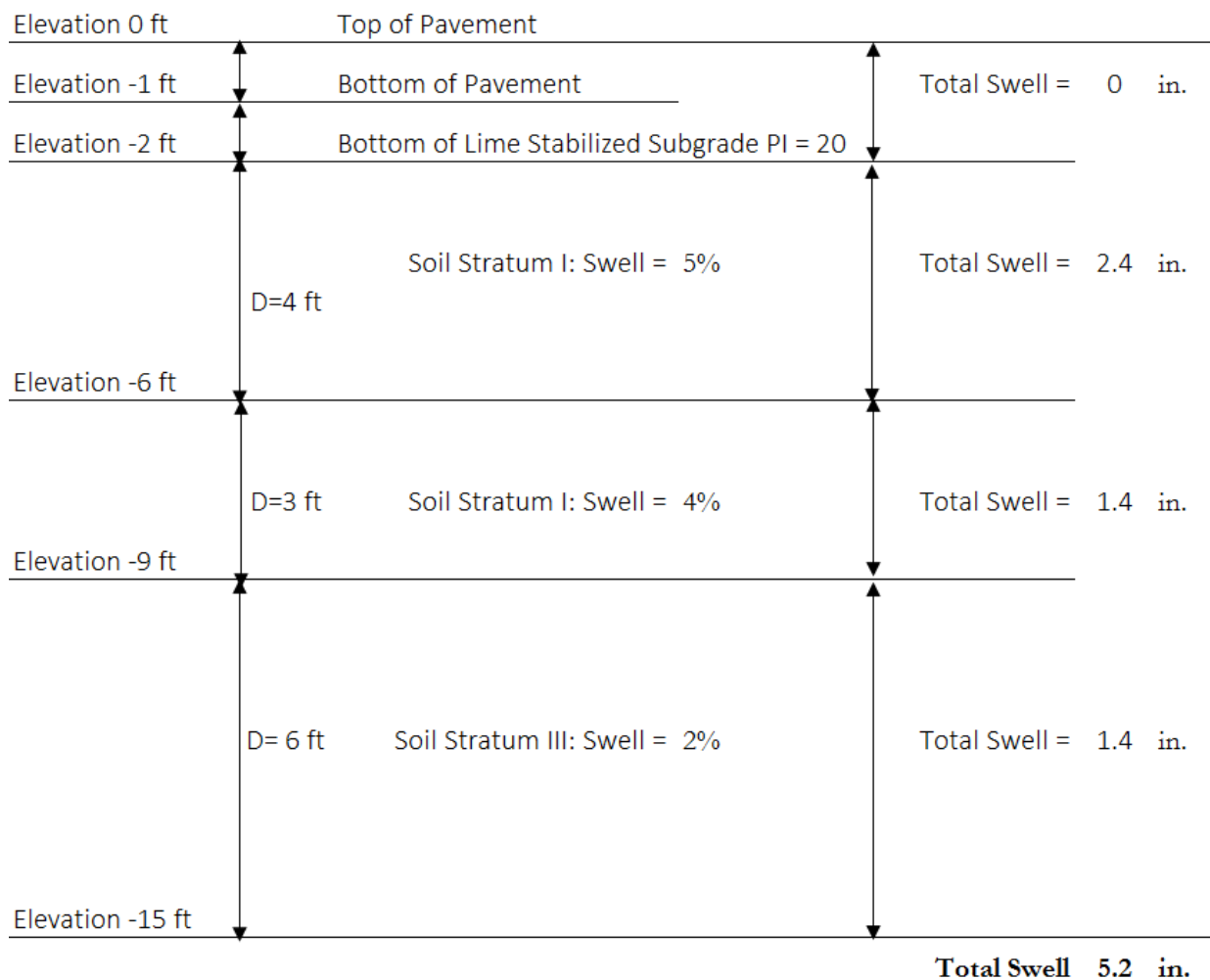


Figure 5.2 Example of PVR Calculation from Swell Testing

5.2.2 Potential Vertical Rise (PVR) Model (TxDOT Tex-124-E)

This traditional method to estimate the swell potential of fine-grained clay soils is based on the historical work of TxDOT and uses correlations of Plasticity Index (PI) to develop an estimate of swelling. It is based on McDowell's 1959 method (Ref 29, 30) and is based on a "free swell" conversion ratio. The required data inputs from laboratory soils testing are:

ω = Moisture content

LL = Liquid Limit

PI = Plasticity Index

% < No. 40 Sieve = Fine Grained

A sample output for the Tex-124-E is included in Figure 5.3. The spreadsheet can be downloaded from the TxDOT website.

This model estimates the cumulative potential vertical rise (PVR) of the pavement section based on the CAPEC required 15 feet of material. The required inputs for Tex-124-E are layer thickness, w (moisture content), γ (unit density), Liquid Limit (LL), Plasticity Index (PI), and % passing No.40 sieve. When using the spreadsheet, the pavement design thicknesses resulting from FPS21 or PavementDesigner shall be included as the top layer with an assumption of no swell, i.e. Inputs for liquid limit, Moisture content, percent < No. 40, and PI are set to zero.

As provided in Section 1, subgrade performance criteria required for the bottom up design to be considered for PVR are as follows:

- Provide an adequate depth of cover to limit the potential vertical rise:
 - Arterial / Collector PVR $\leq 2.0''$
 - Local /Residential PVR $\leq 3.0''$

If calculated PVR exceeds the criteria provided, adjustments should be made to the design of the subgrade as per sections 5.4 and 5.5 to meet the required criteria, unless otherwise directed by the agency.

PVR Data BH

Depth to Bottom of Layer [ft]	Average Load [psf]	Liquid Limit (LL)	Dry 0.2LL+9	Wet 0.47LL+2	Percent Moisture	Dry Avg Wet	Percent -No.40	Plasticity Index (PI)	Percent Volume Swell	Percent Free Swell	PVR [in] Top of Layer	PVR [in] Bottom of Layer	Differential Swell [in]	Modified -No.40 Factor	Modified Density Factor	PVR in Layers [in]	Total PVR [in]
0.0	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.70
1.0	0.5	9.0	9.0	2.0	-	Dry	0.0	0.0	0.0	0.0	0.00	0.00	0.00	1.00	1.00	0.00	3.70
2.0	1.5	40	17.0	20.8	26.1	Wet	50.0	20	1.4	4.1	0.00	0.12	0.12	0.50	1.00	0.06	3.64
3.0	2.5	74	23.8	36.8	26.1	Dry	100.0	62	15.6	19.3	0.74	1.42	0.68	1.00	1.00	0.68	2.96
4.0	3.5	74	23.8	36.8	26.1	Dry	100.0	62	15.6	19.3	1.42	2.04	0.62	1.00	1.00	0.62	2.35
5.0	4.5	74	23.8	36.8	26.1	Dry	100.0	62	15.6	19.3	2.04	2.60	0.56	1.00	1.00	0.56	1.79
6.0	5.5	74	23.8	36.8	26.1	Dry	90.0	62	15.6	19.3	2.60	3.10	0.51	0.90	1.00	0.46	1.33
7.0	6.5	62	21.4	31.1	18.7	Dry	90.0	47	13.5	17.1	2.70	3.07	0.38	0.90	1.00	0.34	0.99
9.0	8.0	47	18.4	24.1	18.7	Dry	85.0	47	13.5	17.1	3.07	3.71	0.63	0.85	1.00	0.54	0.45
12.0	10.5	47	18.4	24.1	19.3	Dry	85.0	35	9.6	12.9	2.55	2.81	0.26	0.85	1.00	0.22	0.23
15.0	13.5	47	18.4	24.1	19.3	Dry	85.0	35	9.6	12.9	2.81	3.08	0.28	0.85	1.00	0.23	0.00

Fields are chart inputs

Fields are final answers per layer

Final Total PVR for the borehole

Note: PVR calculations are based on future pavement grade being the same as present grade. Bold numbers are interpolated and extrapolated values.

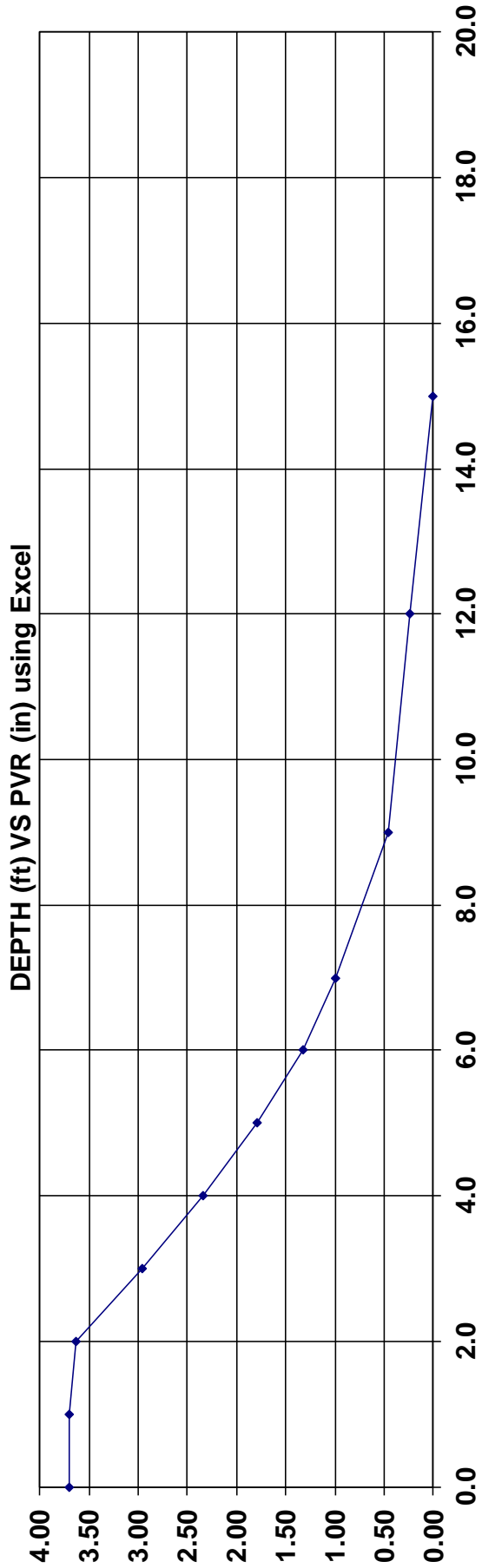


Figure 5.3 Sample Tex-124-E PVR Calculation Spreadsheet

5.2.3 University of Texas Centrifuge Test Method 6048A and 6048B

Method UT 6048A is based on the use of an available database of swell test results on central Texas clay materials (Ref 32 and 33). Results of the TxDOT testing completed and published in March of 2013 were for clay soils from five select sites around Austin in Travis County, including:

- a) Eagle Ford Clay from Intersection of Hester's Crossing and IH 35 in Round Rock
- b) Black Taylor Clay from excavation research project in Manor
- c) Tan Taylor Clay from Intersection of SH 71 and Riverside Drive in Austin
- d) Houston Black Clay from Highway 79 in Hutto
- e) Soil 5 (Generic Backfill Material) from a TxDOT Austin District project site

Reference 33 contains a database spreadsheet which includes 138 test results for the clay soils cited above and may be reviewed to evaluate the swell potential and calculate PVR for soils matching the fundamental laboratory properties provided in the table. Test Method 6048A is soil-specific (suitable for preliminary prediction) and 6048B is project-specific (suitable for final design).

Method UT 6048B uses project-specific sampled materials and requires three laboratory centrifuge tests, which has been developed for TxDOT use. This test method directly measures the PVR value. Use of Method UT 6048B would require the local testing laboratories to have a centrifuge, which is not common at this time.

5.2.4 Forced Ventilation Accelerated Swell/Shrink Test Model

The Forced Ventilation Accelerated Swell/Shrink Test Model is based on the work of Dr. Robert Gilbert, PE, at The University of Texas at Austin (ref 39). This method uses an air drying method to evaluate the shrink-swell potential of the subgrade sample. The resulting test specimen shows the types of cracks that form in the subgrade material due to shrinkage. It may provide a good visualization of the type of distress that we are trying to minimize/eliminate in the flexible pavement design.

Four (4) Austin Chalk samples and nine (9) Navarro and Taylor clay samples were initially tested with repetitive cycles of sample swelling and shrinking and published at 2006 ASCE Fourth International Conference on Unsaturated Soils. Normal stress is applied to the soil corresponding to in-situ stress. Swelling is accomplished by inundating the specimen with water. Shrinking is accomplished by using forced ventilation (air circulation under a nominal pressure of 5 psi).

This test is intended to provide a practical indicator of vertical displacement under the limit of possible moisture conditions. It complements the conventional swell test in the following ways:

- It captures the drying cycle, which is where most structural distress tends to occur.
- It attempts to mimic realistic conditions by allowing the soil to crack when drying under the overburden stress (meaning that the change in void volume during drying is not entirely manifested

as a change in vertical displacement as it is in a conventional swell test during swelling since the sample in a swell test is initially fit snug within the oedometer ring).

- It is insensitive to the moisture content of the soil at the time of sampling, in contrast to a swell test where the amount of swell measured is going to be affected by the initial water content at the start of the test (e.g., if an undisturbed sample is obtained when the soil is at its wettest state, then theoretically no swell would be measured in a swell test).

5.3 Subgrade Design Parameters by Swell Category

Ranges in various subgrade soil properties are provided in the following table as general guidance, however not intended to replace any soils testing on site specific locations.

Table 5.1 General Range of Subgrade Soil Properties

	Low Swell	Moderate Swell	High Swell	Very High Swell
Soil Classification	Rock, Gravels, Sands, Silt	Lean Clay, Clayey Sands, Sandy Clays	Lean Clay, Fat Clay, Shale	Fat Clay, Shale
Range in PI (%)	NP < PI < 20	20 ≤ PI < 35	35 ≤ PI < 45	PI ≥ 45
Range in LL (%)	0 - 45	45 - 60	60 - 70	> 70
Range in -200 sieve (%)	0 - 100	30 - 100	50 - 100	80 - 100

5.4 Selection of Subgrade Improvement Methods

These following strategies, which may be combined to be effective, include, but are not limited to the following:

- Lime Stabilization
- Portland Cement Stabilization
- Lime Cement Stabilization
- Lime or Cement-Fly Ash Stabilization
- Chemical Stabilization
- Subgrade Moisture Treatment
- In-situ mixing with lower PI materials to reduce swell characteristics
- Removal and replacement with lower PI materials
- Use of Geosynthetics

TxDOT flow charts shown in Figure 5.4 (Ref 38) and Figure 5.5 (Ref 37) have been thoroughly researched and developed for use to evaluate and guide soil stabilization. These guidelines shall be considered for the CAPEC pavement designs process. Additional factors to consider when selecting subgrade improvement method(s) include: pH values, construction time, rehabilitation vs new construction, confined construction area, utility depths, use of moisture barrier, and multiple methods to minimize variability in the improved materials.

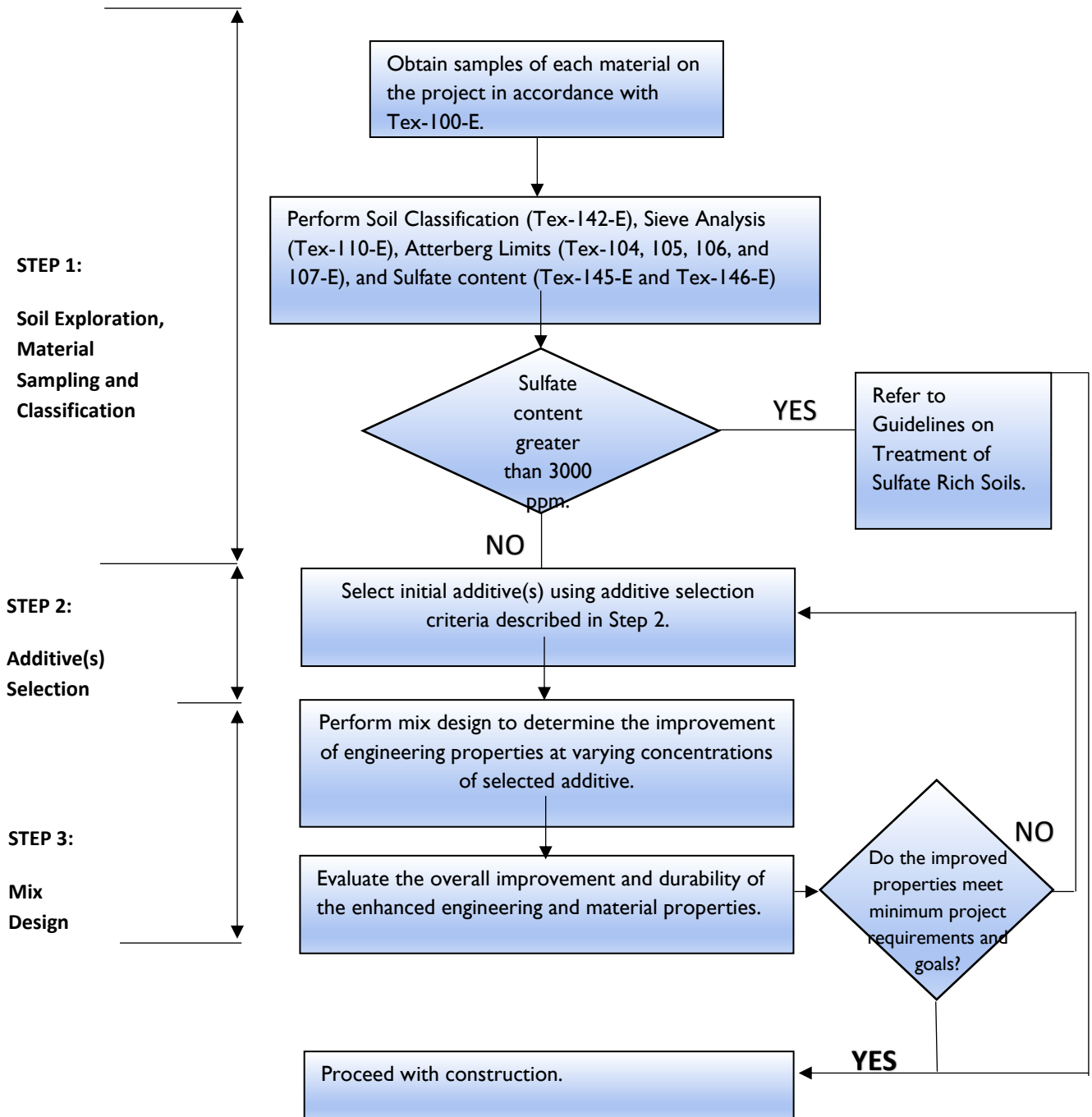


Figure 5.4 TxDOT Flowchart for Subgrade Soil Treatment

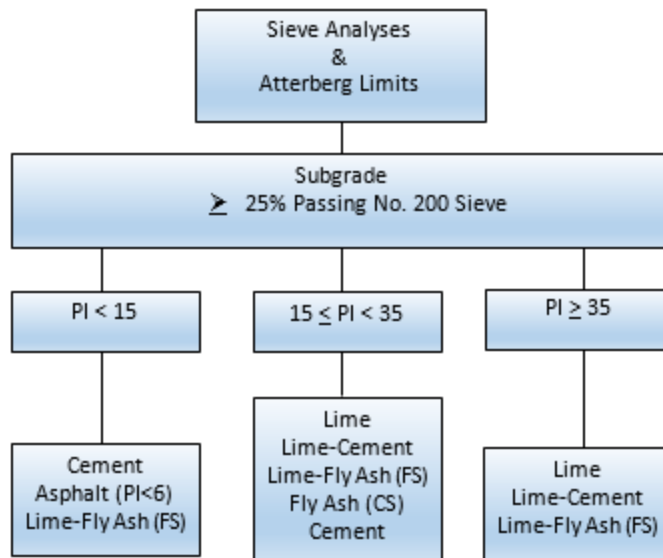


Figure 5.5 TxDOT Flowchart for Subgrade Stabilization Alternatives

5.5 Traditional Stabilization Methods

5.5.1 Lime Stabilization

The TxDOT “Guidelines for Modification and Stabilization of Soils and Base for use in Pavement Structures” (Ref 38) provides guidance on when to select lime stabilization and describes the steps necessary for determining the correct % of lime for the specific soil.

Tex-121-E Test Procedure for Soil-Lime Testing, Part III describes the mix design procedure. The test indicates the soil-lime proportion needed to maintain the elevated pH equal to 12.4 or greater, necessary for sustaining the reactions required to stabilize a soil.

Field tests at the time of construction must be completed on the site-specific soils to determine what construction process to follow. Finally, the resulting free swell should be less than 1%. If higher strength is desired cement can also be added and unconfined compressive strength is typically to be 160 psi or greater.

5.5.2 Cement Stabilization

The TxDOT “Guidelines for Modification and Stabilization of Soils and Base for use in Pavement Structures” (Ref 38) recommends that Portland cement alone can be considered if the PI is < 35. The PCA “Guide to Cement-Modified Soil (CMS)” provides guidelines for: Silt-clay classified materials, which are defined as soil/aggregate mixtures containing more than 35% percent material passing a No. 200 sieve, and Granular classified soil materials, which are defined as soil/aggregate mixtures containing less than 35% percent material passing a No. 200 sieve.

High levels of sulfates or chlorides negatively affect the use of cement stabilization for high PI swelling clay subgrade soils and the guidelines are the same as for lime stabilization as described above. Mix designs should be prepared for the specific in-situ soil which is being considered for stabilization. Typically, a PI reduction and a minimum unconfined compressive strength are specified. A maximum unconfined compressive strength should also be specified for thinner HMA pavements to prevent reflection cracking.

Cement stabilization is not recommended under normal circumstances when addressing swelling soils; however, if other performance requirements dictate stabilization for strength, cement may be considered. There will be a significant increase in mechanical work required to blend the cement with high swell soils.

5.5.3 Lime-Cement Stabilization

Lime and cement in combination may also be utilized for stabilization of high plasticity soils ($PI > 35$). In this approach the lime is used first to obtain a more friable and workable mixture and reduce the plasticity of the material. Portland cement is then used to provide rapid strength gain. It is important to maintain the correct moisture content during curing of the stabilized layer to ensure desired strengths are achieved.

5.5.4 Lime or Cement-Fly Ash Stabilization

Fly ash is a by-product of coal combustion and its components and properties depend on the specific coal and combustion process used. The TxDOT Guidelines for Modification and Stabilization of Soils and Base for Use in Pavement Structures identifies two classes of fly ash: Class FS and Class CS. Class FS requires the use of an activator such as lime or cement for a pozzolanic reaction to occur. Class CS can bind materials together without lime or cement. Fly ash provides a longer and slower strength gain than Portland cement. Its use as a stabilizing agent is proven, however a specific mix design must be developed to determine whether or not to use it in combination with lime or cement or to use it independent of other stabilizing agents.

This material can be seasonally unavailable since its production is dependent on the level of activity at the local coal burning power plants and when production is slowed, availability is impacted in the two plants located in the central Texas area, Deely Plant in San Antonio and the Fayette Plant in La Grange. Additionally, availability may be impacted if TxDOT has a large highway construction project utilizing fly ash from the local producers. Finally, in the future the electrical generation industry is moving away from coal fired power plants, which may also affect availability.

5.5.5 Chemical Stabilization

Chemical soil stabilizers are liquid agents which must be distributed into the soil to affect a change in behavior. There are two predominant means of distributing stabilization chemicals into soils: pressure injection and mixing after soil pulverization. A significant, lasting change in a clay soil's swell potential requires a thorough distribution of any stabilizing agent. It is for this reason that chemical injection has had very mixed and sometimes poor results in the clay soils of Central Texas. Thus, chemical injection has not been looked upon very favorably here for use in clay soils due the difficulty in thoroughly distributing a liquid agent throughout an extremely low permeability soil mass. Alternatively, chemical distribution by spreading and mixing after soil pulverization is much more likely to be evenly and thoroughly distributed, easily controlled and observed, and more readily tested for consistency. Mixing should be more effective and reliable and have a much lower risk for the agency. These advantages make soil mixing the preferred method of liquid-based chemical stabilization with clay soils.

The effectiveness of any proposed chemical agent must be demonstrated by adequate testing and documentation. Independent studies and independent laboratory test results are highly desired as part of this documentation. Unfortunately, liquid stabilizers may provide little more than a temporary change in swell potential similar to that of moisture conditioning with water if they cannot provide a proven chemical change. Therefore, the swell reduction mechanism of the active chemical agent must be clearly disclosed and adequately proven.

The proprietary nature of any chemical product must also be carefully considered by public agencies. Many of the available stabilization alternatives are non-proprietary and do not require special justification for their specification, purchase, and use. Proprietary products must be able to document superior performance, reliability, and efficiency to be justified over the numerous non-proprietary alternatives.

5.6 Mechanical Modification Methods

There are various mechanical stabilization methods to be considered to address subgrade shrink/swell, such as: moisture treatment, in-situ blending with lower PI materials, removal and replacement, addition of gap graded or other low-cost subbase layer, addition of geogrid, etc.

5.6.1 Moisture Treatment

Moisture treatment of high PI soils is another technique which has been successfully used to mitigate shrink/swell potential. The concept is to compact the high PI fat clay materials at 3 to 6% above optimum, based on the Standard Proctor moisture density relationship. Compacting and establishing the soil moisture content slightly above the optimum moisture level, reduces the soil affinity for additional moisture. Deep treatment can be accomplished by injection, but the results are less controlled and are more variable and must be proven prior to use.

Swelling soils are pre-swelled to prevent further expansion after paving. This assumes a moisture barrier of some type is provided to protect/retard the soil material from natural wetting and drying cycle. Moisture treatment can minimize roadway distortion and post-construction longitudinal and edge cracking if the moisture can be stabilized. The process can be expensive due to the amount of mechanical work required and the difficulty in capping off the layer once the desired moisture content is achieved.

The depth of moisture treatment is determined as a function of the free swell test or modeling the soils as “wet” in the Tex-124-E PVR spreadsheet. Establishing and maintaining moisture control in the critical zone of moisture fluctuation is important.

5.6.2 In-Situ Blending with Lower PI Material

Mechanical mixing with lower PI materials has been used in the past to reduce the average shrink/swell characteristics of the in-situ subgrade foundation materials. This process can be cost effective if there are readily available lower PI materials within the limits of construction and blending effectively reduces the PVR to acceptable levels.

5.6.3 Removal and Replacement

Complete removal and replacement of high PI materials may be a cost-effective alternative depending on a number of factors such as haul distance for the replacement materials, haul distance for the disposal of the high PI materials, cost of replacement materials, and construction labor, equipment and fuel considerations.

5.6.4 Adding Gap Graded or Other Low-Cost Subbase Layer

Available non-standard subbase materials may be considered where the cost of higher quality materials makes their use unaffordable. These materials shall not be used under the pavement asphalt or concrete surface but may be considered in the lower layers of the pavement section to address subgrade improvement. For example, flexible base materials can be considered under TxDOT Item 247 Type D or E Grade 4 where the engineer specifies the gradations on the plans.

5.6.5 Geosynthetics (Geogrids and/or Geotextiles)

Historically, geotextiles have been widely used to control the movement of fine materials and to provide moisture barriers. Before the development of geogrids, these products were widely used to encapsulate in situ subgrades. Geotextiles were also used to retard the reflection of underlying rock, utility trenches, and cracked pavement. By including a geotextile separator/filter (see TXDOT DMS 6200 Filter Fabric) at

the subgrade interface to prevent upward migration of fines, fines reduction is possible, thus greatly increasing the overall drainage and performance of the pavement section.

Geogrid has been used in the Austin area for base layer thickness reduction and pavement structural enhancement. Additionally, it has been used over high plasticity clay soils (especially in areas with high sulfate content) to minimize reflective cracking caused by post-construction environmental shrink/swell, or as a factor of safety to extend pavement service life.

TxDOT experience and research (Ref 31) has shown that geogrids are effective at controlling environmental cracking and should be considered at the base/subgrade interface when the $PI > 35$, i.e. high swelling soils. The grid holds the unbound material in a tight matrix allowing the shrinking subgrade to move and limit subgrade cracking from propagating to the pavement surface. Available material specifications that can be reviewed for applicability include, but are not limited to, TxDOT Departmental Material Specification (DMS) DMS 6240 - Geogrid For Base/Embankment Reinforcement provides material property requirements only; TxDOT does not currently allow structural contribution for geogrids meeting the DMS 6240 minimum material properties. More recently, triaxial (triangular) geogrids have also been introduced as a structural enhancement for flexible pavements for which specifications are under development. The engineer should strongly consider geogrids in high PI soils in combination with other treatments as summarized herein to enhance performance life. For information related to geogrid material requirements for specific design conditions, industry representatives should be consulted.

Geosynthetics, which include both geogrids and geotextiles, encompass a large variety of products, quality of products, with many different design functions and design procedures. A full analysis of these diverse pavement enhancement products was not possible in the initial phases of the CAPEC study. Pavement designers are expected to evaluate the functional needs of the pavement section, select the appropriate solutions, design and specify them correctly. Appropriate justifications for the selection, use, and design of geosynthetics must be included in the pavement design submittal. Despite these concerns, the appropriate use of one or more geosynthetics products is encouraged as part of the solution to smoother, long-lasting pavements with limited cracking on expansive soils.

The general approach to approving the use of any geosynthetic should be based on its intended function and justified with an appropriate selection process and/or design procedure. The primary functions of these products is typically mechanical stabilization, aggregate stabilization, aggregate confinement, or similar, drainage, moisture control, separation, or a combination of these. Each should be appropriately designed and clearly justified for its functional purpose(s).

One geogrid design approach is to reduce the base layer thickness rather than incorporating a thicker layer of material that has low volume change potential. This is an important advantage since there will be specific situations that limit the overall depth of the pavement section, and will necessitate considerations of geogrid to offset the required additional base thickness. For CAPEC designs the reduction in crushed stone base thickness when considering geogrid enhancement, stabilization, mechanical stabilization, or similar must be supported by calculations submitted with design report. The

reduction shall be limited to a maximum of 4 inches of flexible base thickness (but in no case will the enhanced, stabilized, mechanically stabilized, or similar flexible base thickness be less than the minimum in Table 3.4), unless supported by independently validated performance data that is submitted for review and approval by the City.

Although there are other products and product research in the marketplace, the consideration of requiring any proprietary products or design procedures could not be supported. The pavement design engineer must provide convincing justifications for the selection of proprietary products for use in the final design. Preference should be given to geosynthetic pavement reinforcement products which have the following:

- 1) Full-scale laboratory and in-ground testing of pavement structures reinforced with the specific product being proposed.
- 2) Design method utilized for incorporating the product being proposed must have undergone a full calibration and validation with the specific product.
- 3) Testing methods, performance testing, and products used must have been reviewed by a third party recognized by AASHTO as a pavement engineering services firm.
- 4) Third party must validate that the products being proposed and the methodology used are in full compliance with AASHTO R50-09 Geosynthetic Reinforcement of Aggregate Base Course of Flexible Pavement Structures, set proper boundary conditions, and provide design predictions that correspond to performance testing validation results.
- 5) Validation testing conducted must have been performed at an Accelerated Pavement Testing (APT) Facility in the United States in accordance with NCHRP Report 512 guidelines.
- 6) Assessment report by the third-party validator shall accompany the submittal along with a qualifications summary of the third-party reviewer.

The use of geogrid alone is not expected to completely eliminate cracking and distortion but is expected to help to manage pavements on expansive clays and potentially on subgrades with poor bearing capacity. Geogrids should limit crack widths and minimize differential distortion by spreading out both subgrade swelling forces and occasional pavement overloads on softer spots. However, stabilization and moisture control strategies are highly encouraged in addition to the consideration of the use of a geogrid product meeting the appropriate specification. Geogrids do not provide layer separation (to control migration of fines) nor do they provide a moisture barrier. These functions may be provided by geotextiles or stabilized layers.

The recommended design approach for using a geogrid is as follows:

- 1) Develop pavement thickness (criteria) with standard procedures.
- 2) Determine enhanced structural layer coefficient for mechanically stabilized layer (MSL).
- 3) Find geogrid optimized section equivalent to unreinforced section.

- 4) Document design procedures and software used to include in pavement design report.
- 5) Check severity of swelling soils and serviceability criteria.

5.6.6 General Guidelines for Stabilization Methods

Subgrade treatment alternatives are summarized in Table 5.3.

Table 5.3 Subgrade Treatment Alternatives

Subgrade Treatment Alternative	Low Swell	Moderate Swell	High Swell	Very High Swell
Admixture Stabilization Methods:				
Lime Stabilization		√	√	√
Portland Cement Stabilization	√	√	*	*
Lime - Cement Stabilization		√	√	√
Lime - Fly Ash Stabilization	√	√	√	√
Mechanical Modification Methods:				
Geogrids/Geotextiles	√	√	√	√
Subgrade Moisture Treatment		√	√	√
Blending with Lower PI Select Fill Material			√	√
Replacement With Lower PI Materials			√	√
Adding Low Cost Subbase Layer			√	√

**Cement stabilization is not recommended under normal circumstances when addressing swelling soils; however if other performance requirements dictate stabilization for strength, cement may be considered. There will be a significant increase in mechanical work required to blend the cement with high swell soils.*

5.7 Design to Control Moisture Fluctuation

The following moisture control design strategies, which may be combined to be more effective, include, but are not limited to the following: address/account for poor drainage, use of curb and gutter and ribbon curbs for ditch drainage, sidewalk adjacent to back of curb, paved shoulders, maximum ditch slopes, etc. The design objective of these control measures is to minimize the moisture content from fluctuating in the moisture critical zone which is 10 to 15 feet in central Texas.

Horizontal or vertical moisture barriers of sufficient width or depth to minimize moisture migration into and out of the subgrade soils.

- Although 4 foot vertical barriers may be adequate, vertical barriers of 6 to 10 feet are often required to be effective. Vertical barriers could be constructed of slurry walls at the back of curb

- Contiguous sidewalks and driveways placed at the time of roadway construction are highly desirable and is considered a horizontal barrier.
- An acceptable design with moisture barriers must be used in combination with at least one other strategy discussed herein.
- Manufactured plastic tree root barriers between tree wells and pavement have been effective in the urban environment.
- Plastic sheeting [polyethylene] could be considered, although it may not be durable, therefore may have a limited life.
- Polyester film or plastic sheeting might be considered under the curb to back of sidewalk, if the sidewalk is offset from the curb, to potentially provide a horizontal barrier.

When electing to use moisture barriers, documentation shall be provided to verify successful use of the proposed strategy. The designer may consider references such as FHWA NHI-05037 Geotechnical Aspects of Pavements Reference Manual Chapter 7 (Ref 33).

Additional design elements which should be considered to extend the horizontal moisture zone of influence: extension of base/stabilized subgrade beyond pavement section, use of curb and gutter or ribbon curb, and consideration of plastic sheeting (although this material may not be durable and have limited life).

6 Life Cycle Cost Analysis (LCCA)

LCCA is an engineering economic analysis that allows engineers to quantify the differential costs of alternative investment options for a given project. LCCA can be used to compare alternate pavement sections or pavement types (flexible versus rigid) on new construction and rehabilitation projects. LCCA considers all agency expenditures and user costs throughout the life of the facility, not just the initial capital construction investment, and allows for cost comparison of options with varying design lives to be compared on an equivalent basis.

The intended results of the LCCA is to lower the life cycle costs and increase the Level of Service throughout the life of the street. As a consequence, the first cost will be increased and additionally may cause some difficulty during reconstruction in developed areas. In many cases the first cost of initial construction is born by the developer and the life cycle costs of street maintenance is born by the agency (and public). The user “cost” and the impact and inconvenience for premature street repairs need to be considered. A balance must be reached between private development and public agency and public user costs, since the public perception overall regarding street conditions affects both the developer and the agency.

LCCA is required with more than one design alternative. Alternative flexible pavement designs that are equivalent sections are expected to have same life cycle costs and may fall back to first cost. However if reconstruction/rehabilitation options have different life cycle profiles, the cost will be affected. The CAPEC member agencies will provide life cycle profiles and associated costs.

Pavement options shall be compared using the FHWA’s LCCA program RealCost 2.5 (deterministic procedure) (Ref 3). FHWA references (Technical Bulletin, User’s Manual, and Primer are available on the FHWA’s LCCA Web page (<https://www.fhwa.dot.gov/infrastructure/asstmgmt/lccasoft.cfm>) or by request from the FHWA’s Office of Asset Management. The input parameters are discussed in more detail in Section 6.4. Complete details are provided in the RealCost 2.5 User’s Manual (Ref 4). RealCost 2.5 reports life cycle costs on a total project cost. User costs may also be included.

The FHWA’s LCCA program RealCost 2.5 is a simplified system that allows the user to enter up to 24 unique activities over the life cycle of 2 different alternatives. It can compare HMAC and PCC alternatives on the same cost basis. Input variables are as follows:

6.1 Project Details

These inputs are a description of the project level specifics and include:

- a. **State Route** – Enter Street or County Road name
- b. **Project Name** – Enter the proposed project common name
- c. **Region** – Enter Council District, Subdivision, or Precinct
- d. **County** – Enter County where project is located
- e. **Analyzed By** – Enter name of engineer or staff member preparing the solution

- f. **Mileposts** – Enter Beginning and Ending Mileposts as estimated base on the project stationed length.
- g. **Comments** – A text box is available to enter additional analysis details and or assumptions.

6.2 Analysis Options

These are the analysis criteria which determine the analysis guidelines by which the program calculates costs. Notes on several of the variables as specified by CAPEC are as follows:

- a. **Analysis Period (Years)** – CAPEC requires a minimum of a 40 year analysis period.
- b. **Discount Rate** – This value is determined using the estimated interest rate (%) and inflation rate (%)
- c. **User Cost Computation Method (Calculated or Specified)** – CAPEC recommends allowing the built-in models calculate the user delay costs

6.3 Summary of Inputs

Other variable definitions and details are included in the exhibits below which are from the FHWA RealCost 2.5 User's Manual.

Table 6.1 Summary of Inputs for FHWA RealCost 2.5 (Ref 4)

Option/Input	Description	FHWA Recommendation
Analysis Period	The number of years over which the alternatives will be compared.	35 to 40 years
Discount Rate	The rate by which future expenditures will be discounted to present value. This is entered as a decimal number.	Real discount rate of 3% to 5%
Beginning of Analysis Period	Sets the first year of the analysis period. RealCost expenditure diagrams draw their dates from this field and the analysis period field. This can also be referred to as the base year for the analysis.	Year the project will be undertaken
Include Agency Cost Remaining Service Life	Indicates whether the remaining service life value will include a prorated share of agency costs if the service life of an improvement extends beyond the analysis period.	Checked (Yes)
Include User Costs in Analysis	Indicates whether user costs will be included in the analysis and displayed in the results.	Checked (Yes)
User Cost Computation Method	Directs RealCost to either 1) calculate user costs ("Calculated") based upon input data in accordance to best-practice methods or 2) utilize inputted user costs ("Specified") values when calculating user life-cycle costs.	Calculated
Traffic Direction	Directs RealCost to calculate user costs for the "inbound" lanes, the "outbound" lanes, or "both" inbound and outbound lanes.	
Include User Cost Remaining Service Life	Indicates whether the remaining service life value will include a prorated share of user costs if the service life of an improvement extends beyond the end of the analysis period.	Checked (Yes)

6.4 Traffic Data

These inputs provide the required project specific details which are to be used in the calculations which estimate the user delay costs. Variable definitions and details are provided below in the exhibit below from the FHWA RealCost 2.5 User's Manual.

Table 6.2 FHWA RealCost 2.5 Traffic Data (Ref 4)

Input	Description
AADT in Both Directions	This is the annual average daily traffic in the construction or base year of the analysis. This is the total AADT for both directions.
Single Unit Trucks	The percentage of the AADT that is single unit trucks.
Combo Trucks	The percentage of the AADT that is combination trucks.
Annual Growth Rate of Traffic	The percentage by which "AADT in both directions" increases each year.
Normal Operations Speed Limit	Speed limit in normal operating conditions (the time periods between agency work zones).
Normal Number of Lanes Open	Number of roadway lanes available under normal operating conditions.
Queue Dissipation Capacity	Capacity of each lane during queue dissipation operating conditions.
Normal Free Flow Capacity	Capacity of each lane under normal operating conditions.
Free Flow Capacity Calculator	This button opens a form that calculates free flow lane capacities based upon the <i>Highway Capacity Manual, 3rd Ed.</i>
Maximum AADT in both Directions	Caps the traffic growth at this number. If traffic grows beyond this value, this value is substituted for the computed future AADT figure and future user costs are calculated based upon this maximum AADT figure. This is used to prevent growth beyond possible capacity.
Maximum Queue Length	Models the effects of self-imposed detours (traffic exiting from the work zone route yet still incurring some user costs). Queue-related user costs, which are based upon queue length, are calculated with this figure instead of the calculated queue length. However, all vehicles, even those that detour, are charged queue costs.
Rural or Urban Traffic	Allows the choice between two hourly traffic distributions. Default values for these distributions (the defaults are accessible in the software) are taken from the Texas Transportation Institute's MicroBENCOST.

6.5 Value of User Time

The cost values of user time are specified based on the type of vehicle. RealCost 2.5 can model these costs as deterministic or probabilistic values. There are three basic costs as follows:

- a. **Value of Time for Passenger Cars (\$/Hour)** – This includes all the passenger vehicle costs for fuel, oil, tire wear, antifreeze, maintenance, depreciation, and driver. These costs are used to compute user costs associated with delays in traffic due to initial and future construction delays.
- b. **Value of Time for Single Unit Trucks (\$/Hour)** - This includes all the single unit delivery truck costs for fuel, oil, tire wear, antifreeze, maintenance, depreciation, and driver. These costs are used to compute user costs associated with delays in traffic due to initial and future construction delays.
- c. **Value of Time for Combination Trucks (\$/Hour)** - This includes all the combination truck (tractor/semi-trailer and multiple trailers) costs for fuel, oil, tire wear, antifreeze, maintenance, depreciation, and driver. These costs are used to compute user costs associated with delays in traffic due to initial and future construction delays.
- d. **Traffic Hourly Distributions by Hour of the Day** – These distributions are built into the program as defaults, but can also be input by the user if specific values are known. Variable definitions and details are provided below in the exhibit below from the RealCost 2.5 User’s Manual.

Table 6.3 FHWA RealCost 2.5 Value of User Time (Ref 4)

Input	Description
AADT Rural %	The percentage of the AADT that is traveling on the roadway, in both directions, during the indicated hour under the rural traffic distribution.
Inbound Rural %	<p>The percentage of that hour’s traffic that is traveling inbound on the route under the rural traffic distribution. The formula:</p> <p style="text-align: center;">(AADT Rural %) x (Inbound Rural %)</p> <p>describes the percentage of the AADT traveling in the inbound direction for the indicated hour.</p> <p>Note: The same interpretations apply to the urban components of Figure 15.</p>
Restore Defaults	Returns all values on this form to their original, as delivered, default values. Default values for these distributions are taken from MicroBENCOST, software produced by the Texas Transportation Institute. MicroBENCOST, which is used to calculate benefits and costs of transportation improvements, includes an hourly traffic distribution that has been adopted as a default traffic distribution for RealCost.

6.6 Alternative Level Data Entry

As noted earlier two alternatives, each with up to 24 activities in the complete life cycle can be entered into RealCost 2.5. Variable definitions and details are provided below in the exhibit below from the RealCost 2.5 User's Manual.

Table 6.4 RealCost 2.5 Alternative Activities (Ref 4)

Input	Description	Notes
Alternative Description	Name of this alternative.	
Activity Description	Name of this activity.	
Agency Construction Cost	Agency costs that will be included in the life-cycle cost analysis for this activity of this alternative.	Thousands of dollars
Service Life	Service life of the activity. This field defines how many years after this activity the next activity will take place.	Years
User Costs	This field allows direct entry of user costs. The field is accessible only when the User Cost Computation Method field on the Analysis Options form is set to Specified. When this field is set to Calculated it will be presented in gray font and will not be accessible.	1) Thousands of dollars 2) Inaccessible if User Cost is set to Calculated.
Maintenance Cost	Cost of minor, scheduled maintenance that is performed between major activities. These minor activities incur no user costs. Their purpose is to allow for the inclusion of the agency costs of minor activities such as preventive maintenance. In order to remove minor routine maintenance from the analysis, set the value of this field to zero (0).	1) Thousands of dollars 2) Enter zero (0) if not being used.
Maintenance Frequency	Cyclical frequency of minor maintenance. This frequency only applies during the service life of the specific major activity that it is described for and expires as soon as the next major activity begins.	Enter zero (0) if not being used.
Work Zone Length	How long the actual work zone is. This is measured from the beginning to the end of the reduced speed area (where the work zone speed limit is in effect).	Miles

Work Zone Duration	Number of days that the work zone will be affecting traffic. For example, if the work zone is in effect 5 days a week for 3 weeks, this value would be 15.	Days
Work Zone Capacity	Vehicular capacity of one lane of the work zone for 1 hour.	Vehicles per hour per lane
Work Zone Speed Limit	Posted speed limit within the work zone.	Miles per hour
Lanes Open in Each Direction During Work Zone	Number of lanes open in the work zone area when the work zone is in effect. The number of lanes open applies to each direction.	
Work Zone Hours	Hours each day of the Work Zone Duration during which the work zone is in effect. During these hours, capacity is limited to Work Zone Capacity. Work zone timing may be modeled separately for inbound and outbound traffic. Up to three separate periods of work zone can be modeled for each day. For example, to model a work zone that is in effect from 9:00 AM to 3:00 PM and from 8:00 PM to 5:00 AM, enter these numbers: 00 05 09 15 20 24	Use a 24-hour clock

6.7 Probability Functions

The RealCost 2.5 software allows the user to estimate the life cycle cost based on seven different statistical distributions of the traffic data. The analysis can be performed using both the deterministic as well as the probabilistic model. The deterministic approach determines the value most likely to occur for each parameter based on historical evidence and/or professional judgment, while the probabilistic model uses probability functions that express a range of likely inputs and the likelihood of their occurrence. CAPEC requires the deterministic option be used instead of one of the probability functions.

6.8 FHWA RealCost 2.5 Typical Outputs (\$/SY)

The following is a summary output from RealCost 2.5 for the deterministic analysis. Probabilistic analysis outputs are similar in format and both output types include graphical information.

RealCost Total Cost - Deterministic				
Total Cost	Alternative 1: HMAC OVER FLEX BASE WITH LSS		Alternative 2: PCC ALTERNATIVE	
	Agency Cost (\$1000)	User Cost (\$1000)	Agency Cost (\$1000)	User Cost (\$1000)
<i>Undiscounted Sum</i>	\$580.00	\$128.10	\$556.00	\$116.43
Present Value	\$515.61	\$122.89	\$553.89	\$116.43
EUAC	\$26.31	\$6.27	\$28.26	\$5.94
Lowest Present Value Agency Cost		Alternative 1: HMAC OVER FLEX BASE WITH LSS		
Lowest Present Value User Cost		Alternative 2: PCC ALTERNATIVE		

Figure 6.1 RealCost 2.5 Output

7 References

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Attachment B.1

USDA Soils Report Output



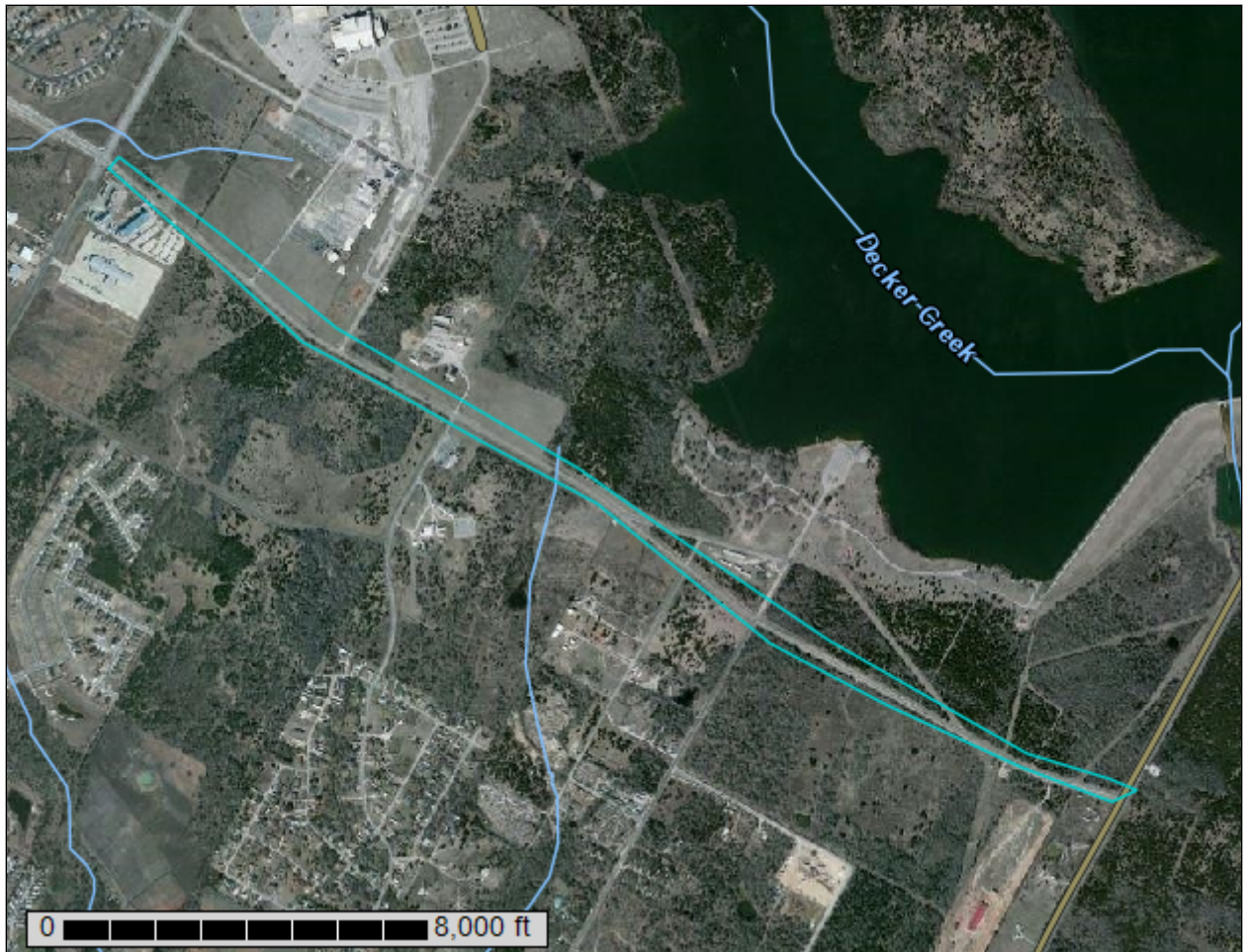
United States
Department of
Agriculture

NRCS

Natural
Resources
Conservation
Service

A product of the National
Cooperative Soil Survey,
a joint effort of the United
States Department of
Agriculture and other
Federal agencies, State
agencies including the
Agricultural Experiment
Stations, and local
participants

Custom Soil Resource Report for Travis County, Texas



Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (<http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/>) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (<http://offices.sc.egov.usda.gov/locator/app?agency=nrcs>) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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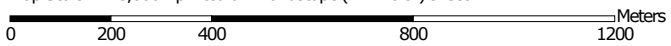
Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report Soil Map



Map Scale: 1:15,000 if printed on A landscape (11" x 8.5") sheet.




Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84




MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)




















Soils







 Soil Map Unit Polygons

 Soil Map Unit Lines


 Soil Map Unit Points

Special Point Features






-  Blowout
-  Borrow Pit
-  Clay Spot
-  Closed Depression
-  Gravel Pit
-  Gravelly Spot
-  Landfill
-  Lava Flow
-  Marsh or swamp
-  Mine or Quarry
-  Miscellaneous Water
-  Perennial Water
-  Rock Outcrop
-  Saline Spot
-  Sandy Spot
-  Severely Eroded Spot
-  Sinkhole
-  Slide or Slip
-  Sodic Spot

-  Spoil Area
-  Stony Spot
-  Very Stony Spot
-  Wet Spot
-  Other
-  Special Line Features


Water Features

 Streams and Canals

Transportation

-  Rails
-  Interstate Highways
-  US Routes
-  Major Roads
-  Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL: <http://websoilsurvey.nrcs.usda.gov>
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Travis County, Texas
 Survey Area Data: Version 16, Sep 24, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 18, 2010—Feb 13, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Travis County, Texas (TX453)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AgC2	Altoga silty clay, 3 to 6 percent slopes, moderately eroded	0.7	1.4%
BtB	Burleson gravelly clay, 1 to 3 percent slopes	1.4	2.8%
ChC2	Chaney fine sandy loam, 2 to 5 percent slopes, moderately eroded	2.9	5.6%
FhF3	Ferris-Heiden complex, 8 to 20 percent slopes, severely eroded	2.6	5.1%
HeC2	Heiden clay, 3 to 5 percent slopes, eroded	2.8	5.5%
HeD2	Heiden clay, 5 to 8 percent slopes, eroded	13.9	27.2%
HgF2	Heiden gravelly clay, 8 to 20 percent slopes, moderately eroded	2.2	4.2%
HnB	Houston Black clay, 1 to 3 percent slopes	2.5	4.8%
HnC2	Houston Black clay, 3 to 5 percent slopes, moderately eroded	6.4	12.6%
HoD2	Houston Black gravelly clay, 2 to 8 percent slopes, moderately eroded	7.0	13.7%
WIB	Wilson clay loam, 1 to 3 percent slopes	8.6	16.9%
Totals for Area of Interest		51.0	100.0%

Soil Information for All Uses

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Chemical Properties

This folder contains a collection of tabular reports that present soil chemical properties. The reports (tables) include all selected map units and components for each map unit. Soil chemical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil chemical properties include pH, cation exchange capacity, calcium carbonate, gypsum, and electrical conductivity.

Chemical Soil Properties

This table shows estimates of some chemical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Cation-exchange capacity is the total amount of extractable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

Effective cation-exchange capacity refers to the sum of extractable cations plus aluminum expressed in terms of milliequivalents per 100 grams of soil. It is determined for soils that have pH of less than 5.5.

Custom Soil Resource Report

Soil reaction is a measure of acidity or alkalinity. It is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Calcium carbonate equivalent is the percent of carbonates, by weight, in the fraction of the soil less than 2 millimeters in size. The availability of plant nutrients is influenced by the amount of carbonates in the soil.

Gypsum is expressed as a percent, by weight, of hydrated calcium sulfates in the fraction of the soil less than 20 millimeters in size. Gypsum is partially soluble in water. Soils that have a high content of gypsum may collapse if the gypsum is removed by percolating water.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Sodium adsorption ratio (SAR) is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration. Soils that have SAR values of 13 or more may be characterized by an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

Custom Soil Resource Report

Chemical Soil Properties—Travis County, Texas								
Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	<i>In</i>	<i>meq/100g</i>	<i>meq/100g</i>	<i>pH</i>	<i>Pct</i>	<i>Pct</i>	<i>mmhos/cm</i>	
AgC2—Altoga silty clay, 3 to 6 percent slopes, moderately eroded								
Altoga, eroded	0-5	15-30	—	7.9-8.4	30-70	0	0	0
	5-24	15-30	—	7.9-8.4	40-75	0	0	0
	24-60	10-30	—	7.9-8.4	40-75	0	0	0
BtB—Burleson gravelly clay, 1 to 3 percent slopes								
Burleson	0-16	40-60	—	5.6-8.4	0-5	0	0.0-2.0	0
	16-42	40-60	—	5.6-8.4	2-8	0	0.0-4.0	0-1
	42-60	40-60	—	7.4-8.4	2-15	0	0.0-4.0	0-2
ChC2—Chaney fine sandy loam, 2 to 5 percent slopes, moderately eroded								
Chaney, eroded	0-6	5.0-10	—	5.6-7.3	0	0	0.0-2.0	0
	6-24	15-30	—	5.6-7.3	0	0	0.0-2.0	0
	24-54	15-30	—	5.6-8.4	0-2	0-2	0.0-2.0	0
	54-60	15-30	—	5.6-8.4	0-2	0-2	0.0-2.0	0

Custom Soil Resource Report

Chemical Soil Properties—Travis County, Texas								
Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	<i>In</i>	<i>meq/100g</i>	<i>meq/100g</i>	<i>pH</i>	<i>Pct</i>	<i>Pct</i>	<i>mmhos/cm</i>	
FhF3—Ferris-Heiden complex, 8 to 20 percent slopes, severely eroded								
Ferris, severely eroded	0-6	40-60	—	7.9-8.4	0-5	0	0.0-2.0	0
	6-36	40-60	—	7.9-8.4	2-30	0	0.0-2.0	0-1
	36-60	20-45	—	7.9-8.4	0-15	0-5	0.0-2.0	1-5
Heiden, severely eroded	0-6	20-45	—	7.9-8.4	0-30	0	0.0-2.0	0-2
	6-15	20-45	—	7.9-8.4	10-40	0-1	0.0-2.0	0-2
	15-50	20-45	—	7.9-8.4	20-40	0-5	0.0-2.0	2-12
	50-80	20-40	—	7.9-8.4	25-55	0-5	0.0-2.0	2-10
HeC2—Heiden clay, 3 to 5 percent slopes, eroded								
Heiden, moderately eroded	0-13	38-62	—	7.9-8.4	0-5	0	0.0-2.0	0-2
	13-22	36-60	—	7.9-8.4	2-35	0-1	0.0-2.0	0-2
	22-58	36-56	—	7.9-8.4	5-35	0-5	0.0-2.0	2-12
	58-80	24-37	—	7.9-8.4	15-40	0-5	0.0-2.0	2-12
HeD2—Heiden clay, 5 to 8 percent slopes, eroded								
Heiden, moderately eroded	0-8	38-62	—	7.9-8.4	0-5	0	0.0-2.0	0-2
	8-22	36-60	—	7.9-8.4	2-35	0-1	0.0-2.0	0-2
	22-44	36-56	—	7.9-8.4	5-35	0-5	0.0-2.0	2-12
	44-80	24-37	—	7.9-8.4	15-40	0-5	0.0-2.0	2-12

Custom Soil Resource Report

Chemical Soil Properties—Travis County, Texas								
Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	<i>In</i>	<i>meq/100g</i>	<i>meq/100g</i>	<i>pH</i>	<i>Pct</i>	<i>Pct</i>	<i>mmhos/cm</i>	
HgF2—Heiden gravelly clay, 8 to 20 percent slopes, moderately eroded								
Heiden, eroded	0-6	20-45	—	7.9-8.4	0-30	0	0.0-2.0	0-2
	6-12	20-45	—	7.9-8.4	10-40	0-1	0.0-2.0	0-2
	12-48	20-45	—	7.9-8.4	20-40	0-5	0.0-2.0	2-12
	48-80	20-40	—	7.9-8.4	25-55	0-5	0.0-2.0	2-10
HnB—Houston Black clay, 1 to 3 percent slopes								
Houston black	0-6	40-51	—	7.4-8.4	10-30	0	0.0-2.0	0
	6-70	40-51	—	7.4-8.4	15-35	0-3	0.0-2.0	0
	70-80	38-55	—	7.4-8.4	25-35	0-5	0.0-2.0	0-2
HnC2—Houston Black clay, 3 to 5 percent slopes, moderately eroded								
Houston black, moderately eroded	0-6	40-51	—	7.4-8.4	10-30	0	0.0-2.0	0
	6-70	40-51	—	7.4-8.4	15-35	0-3	0.0-2.0	0
	70-80	38-55	—	7.4-8.4	25-35	0-5	0.0-2.0	0-2
HoD2—Houston Black gravelly clay, 2 to 8 percent slopes, moderately eroded								
Houston black, eroded	0-8	30-60	—	7.4-8.4	10-30	0	0.0-2.0	0
	8-24	30-60	—	7.4-8.4	15-35	0	0.0-2.0	0
	24-80	20-45	—	7.4-8.4	30-40	0	0.0-4.0	0-2

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Chemical Soil Properties—Travis County, Texas								
Map symbol and soil name	Depth	Cation-exchange capacity	Effective cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	<i>In</i>	<i>meq/100g</i>	<i>meq/100g</i>	<i>pH</i>	<i>Pct</i>	<i>Pct</i>	<i>mmhos/cm</i>	
WIB—Wilson clay loam, 1 to 3 percent slopes								
Wilson	0-6	20-30	—	5.6-7.3	0	0	0.0-2.0	0-2
	6-42	20-30	—	5.6-7.8	1-10	0-4	0.0-4.0	2-8
	42-60	20-30	—	6.6-8.4	1-20	2-15	2.0-8.0	4-10

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007 (<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the

Custom Soil Resource Report

surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an oven-dry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and plasticity index (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

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American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

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Absence of an entry indicates that the data were not estimated. The asterisk "*" denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007 (<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>).

Engineering Properties—Travis County, Texas														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			<i>In</i>				<i>Pct</i>	<i>Pct</i>					<i>Pct</i>	
AgC2—Altoga silty clay, 3 to 6 percent slopes, moderately eroded														
Altoga, eroded	95	B	0-5	Silty clay	CH, CL	A-7-6	0- 0- 0	0- 0- 0	95-98-100	95-98-100	90-95-100	70-85-99	45-53-60	22-29-36
			5-24	Silty clay, silty clay loam	CH, CL	A-6, A-7-6	0- 0- 0	0- 0- 0	95-98-100	95-98-100	90-95-100	70-85-99	36-46-55	18-26-33
			24-60	Silty clay, silty clay loam, loam	CH, CL	A-6, A-7-6	0- 0- 0	0- 0- 0	95-98-100	95-98-100	90-95-100	58-79-99	32-44-55	15-24-33
BtB—Burleson gravelly clay, 1 to 3 percent slopes														
Burleson	90	D	0-16	Gravelly clay	CH	A-7-6	0- 0- 0	0- 3- 5	80-90-100	60-70-80	60-70-80	55-68-80	56-66-75	33-41-49
			16-42	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 1- 1	90-95-100	90-95-100	90-95-99	80-90-99	51-63-75	34-44-54
			42-60	Clay, silty clay, clay loam	CH	A-7-6	0- 0- 0	0- 1- 2	90-95-100	80-90-100	75-87-99	67-83-98	51-63-75	34-44-54

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Engineering Properties—Travis County, Texas														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			<i>In</i>				<i>Pct</i>	<i>Pct</i>					<i>Pct</i>	
ChC2—Chaney fine sandy loam, 2 to 5 percent slopes, moderately eroded														
Chaney, eroded	95	C	0-6	Fine sandy loam	CL-ML, ML, SM	A-4	0- 0- 0	0- 0- 0	95-98-100	90-95-100	80-88-95	45-55-65	16-23-30	NP-4 -7
			6-24	Clay, sandy clay	CH, CL, SC	A-6, A-7-6	0- 0- 0	0- 0- 0	90-95-100	90-95-100	90-95-100	43-64-85	39-50-60	24-33-42
			24-54	Sandy clay, clay, sandy clay loam	CH, CL, SC	A-6, A-7-6	0- 0- 0	0- 0- 0	90-95-100	90-95-100	80-90-100	45-65-85	25-40-55	11-26-40
			54-60	Channery clay, sandy clay loam, sandy clay	CH, CL, SC, SC-SM	A-2, A-4, A-6, A-7-6	0- 0- 0	0- 0- 0	90-95-100	90-95-100	80-90-100	25-55-85	25-43-60	6-23-40
FhF3—Ferris-Heiden complex, 8 to 20 percent slopes, severely eroded														
Ferris, severely eroded	60	D	0-6	Clay	CH	A-7-6	0- 0- 0	0- 0- 0	92-96-100	92-96-100	75-88-100	75-88-100	51-64-76	35-45-55
			6-36	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	92-96-100	92-96-100	75-88-100	72-86-100	51-65-78	35-46-56
			36-60	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	92-96-100	92-96-100	85-93-100	75-88-100	61-81-100	42-59-75
Heiden, severely eroded	35	D	0-6	Clay	CH	A-7-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	80-90-100	75-87-99	51-66-80	32-44-55
			6-15	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	80-90-100	75-87-99	51-66-80	32-44-55
			15-50	Clay, silty clay	CH, CL	A-7-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	75-88-100	70-80-90	49-65-80	32-44-55
			50-80	Clay	CH, CL	A-7-6	0- 0- 0	0- 0- 0	92-96-100	92-96-100	85-93-100	70-80-90	49-65-80	32-44-55

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Engineering Properties—Travis County, Texas														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			<i>In</i>				<i>Pct</i>	<i>Pct</i>					<i>Pct</i>	
HeC2—Heiden clay, 3 to 5 percent slopes, eroded														
Heiden, moderately eroded	85	D	0-13	Clay	CH	A-7-6	0- 0- 0	0- 0- 0	96-98-100	90-96-100	80-94-100	65-81-94	50-60-80	30-40-55
			13-22	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	96-98-100	90-96-100	80-94-100	65-81-98	50-60-80	30-40-55
			22-58	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	96-98-100	90-96-100	80-94-100	65-81-98	50-60-80	30-40-55
			58-80	Clay	CH	A-7-6	0- 0- 0	0- 0- 0	98-100-100	97-100-100	86-98-100	71-86-95	50-70-80	30-45-55
HeD2—Heiden clay, 5 to 8 percent slopes, eroded														
Heiden, moderately eroded	85	D	0-8	Clay	CH	A-7-6	0- 0- 0	0- 0- 0	96-98-100	90-96-100	80-94-100	65-81-94	50-60-80	30-40-55
			8-22	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	96-98-100	90-96-100	80-94-100	65-81-98	50-60-80	30-40-55
			22-44	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	96-98-100	90-96-100	80-94-100	65-81-98	50-60-80	30-40-55
			44-80	Clay	CH	A-7-6	0- 0- 0	0- 0- 0	98-100-100	97-100-100	86-98-100	71-86-95	50-70-80	30-45-55

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Engineering Properties—Travis County, Texas														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			<i>In</i>				<i>Pct</i>	<i>Pct</i>					<i>Pct</i>	
HgF2—Heiden gravelly clay, 8 to 20 percent slopes, moderately eroded														
Heiden, eroded	95	D	0-6	Gravelly clay	CH	A-7-6	0- 0- 0	0- 5- 10	55-68-80	55-68-80	55-68-80	50-63-75	58-74-90	34-47-60
			6-12	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	80-90-100	75-87-99	51-66-80	32-44-55
			12-48	Clay, silty clay	CH, CL	A-7-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	75-88-100	70-80-90	49-65-80	32-44-55
			48-80	Clay, silty clay	CH, CL	A-7-6	0- 0- 0	0- 0- 0	92-96-100	92-96-100	85-93-100	70-80-90	49-65-80	32-44-55
HnB—Houston Black clay, 1 to 3 percent slopes														
Houston black	80	D	0-6	Clay	CH	A-7-6	0- 0- 0	0- 0- 0	96-98-100	92-96-100	81-92-100	71-81-90	63-70-76	34-44-49
			6-70	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	98-98-100	96-96-100	85-92-100	74-81-90	58-70-76	38-44-49
			70-80	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	94-96-100	86-92-100	74-88-100	65-78-95	61-71-75	37-45-50
HnC2—Houston Black clay, 3 to 5 percent slopes, moderately eroded														
Houston black, moderately eroded	90	D	0-6	Clay	CH	A-7-6	0- 0- 0	0- 0- 0	96-98-100	92-96-100	81-92-100	71-81-90	63-70-76	38-44-49
			6-70	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	98-98-100	96-96-100	85-92-100	74-81-90	63-70-71	38-44-49
			70-80	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	94-96-100	86-92-100	74-88-100	65-78-95	61-71-75	37-45-50

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Engineering Properties—Travis County, Texas														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			<i>In</i>				<i>Pct</i>	<i>Pct</i>					<i>Pct</i>	
HoD2—Houston Black gravelly clay, 2 to 8 percent slopes, moderately eroded														
Houston black, eroded	95	D	0-8	Gravelly clay	CH	A-7-6	0- 0- 0	0- 3- 5	55-68-80	55-68-80	55-68-80	50-63-75	58-74-90	34-47-60
			8-24	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	98-99-100	98-99-100	92-96-100	88-93-97	58-78-98	37-55-72
			24-80	Clay, silty clay	CH	A-7-6	0- 0- 0	0- 0- 0	94-97-100	93-97-100	87-94-100	84-92-99	51-75-99	32-55-78
WIB—Wilson clay loam, 1 to 3 percent slopes														
Wilson	95	D	0-6	Clay loam	CL	A-6, A-7-6	0- 0- 0	0- 0- 0	95-98-100	85-93-100	80-90-100	60-78-96	38-44-49	20-25-30
			6-42	Silty clay, clay, clay loam	CH, CL	A-7-6	0- 0- 0	0- 0- 0	90-95-100	80-90-100	80-90-100	65-81-96	43-50-56	26-32-37
			42-60	Silty clay, clay, silty clay loam	CH, CL	A-6, A-7-6	0- 0- 0	0- 0- 0	95-98-100	90-95-100	85-93-100	70-83-96	38-52-65	24-36-48

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Attachment B.

Sample Output

TxDOT FPS-21

TEXAS DEPARTMENT OF TRANSPORTATION
 FLEXIBLE PAVEMENT SYSTEM

FP S21-1.3

Release:7-1-2015

PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

PROB	DIST.-14	COUNTY-227	CONT.	SECT.	JOB	HIGHWAY	DATE	PAGE
001	Austin	TRAVIS	1234	1	1	0	5/4/2017	1

COMMENTS ABOUT THIS PROBLEM

CAPEC - Urban Collector Low Traffic
 HMAC over Flexible Base
 Traffic - 700,000 ESALs
 Subgrade Modulus - 2 ksi

BASIC DESIGN CRITERIA

LENGTH OF THE ANALYSIS PERIOD (YEARS)	40.0
MINIMUM TIME TO FIRST OVERLAY (YEARS)	20.0
MINIMUM TIME BETWEEN OVERLAYS (YEARS)	8.0
DESIGN CONFIDENCE LEVEL (90.0%)	B
SERVICEABILITY INDEX OF THE INITIAL STRUCTURE	4.2
FINAL SERVICEABILITY INDEX P2	2.5
SERVICEABILITY INDEX P1 AFTER AN OVERLAY	4.0
DISTRICT TEMPERATURE CONSTANT	31.0
SUBGRADE ELASTIC MODULUS by COUNTY (ksi)	2.00
INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)	7.0

PROGRAM CONTROLS AND CONSTRAINTS

NUMBER OF SUMMARY OUTPUT PAGES DESIRED (8 DESIGNS/PAGE)	3
MAX FUNDS AVAILABLE PER SQ.YD. FOR INITIAL DESIGN (DOLLARS)	99.00
MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)	99.0
ACCUMULATED MAX DEPTH OF ALL OVERLAYS (INCHES) (EXCLUDING LEVEL-UP)	6.0

TRAFFIC DATA

ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)	4000.
ADT AT END OF TWENTY YEARS (VEHICLES/DAY)	7959.
ONE-DIRECTION 20YEAR 18 kip ESAL (millions)	0.700
AVERAGE APPROACH SPEED TO THE OVERLAY ZONE (MPH)	35.0
AVERAGE SPEED THROUGH OVERLAY ZONE (OVERLAY DIRECTION) (MPH)	35.0
AVERAGE SPEED THROUGH OVERLAY ZONE (NON-OVERLAY DIRECTION) (MPH)	35.0
PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)	5.0
PERCENT TRUCKS IN ADT	10.0

TEXAS DEPARTMENT OF TRANSPORTATION

FP S21-1.3

FLEXIBLE PAVEMENT SYSTEM

Release:7-1-2015

PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

PROB	DIST.-14	COUNTY-227	CONT.	SECT.	JOB	HIGHWAY	DATE	PAGE
001	Austin	TRAVIS	1234	1	1	0	5/4/2017	2

INPUT DATA CONTINUED

CONSTRUCTION AND MAINTENANCE DATA

MINIMUM OVERLAY THICKNESS (INCHES)	2.0
OVERLAY CONSTRUCTION TIME (HOURS/DAY)	12.0
ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)	1.98
ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)	200.0
WIDTH OF EACH LANE (FEET)	12.0
FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE-MILE)	125.00
ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST (DOLLARS/LANE-MILE)	50.00

DETOUR DESIGN FOR OVERLAYS

TRAFFIC MODEL USED DURING OVERLAYING	2
TOTAL NUMBER OF LANES OF THE FACILITY	2
NUMBER OF OPEN LANES IN RESTRICTED ZONE (OVERLAY DIRECTION)	0
NUMBER OF OPEN LANES IN RESTRICTED ZONE (NON-OVERLAY DIRECTION)	1
DISTANCE TRAFFIC IS SLOWED (OVERLAY DIRECTION) (MILES)	0.60
DISTANCE TRAFFIC IS SLOWED (NON-OVERLAY DIRECTION) (MILES)	0.00
DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)	0.00

PAVING MATERIALS INFORMATION

LAYER CODE	MATERIALS NAME	COST PER CY	E MODULUS	POISSON RATIO	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.
1	A ASPH CONC PVMT	115.00	500000.	0.35	3.50	4.00	30.00
2	B FLEXIBLE BASE	37.00	50000.	0.35	14.00	14.00	75.00
3	C STABILIZED SUBGR	15.00	6000.	0.30	12.00	12.00	90.00
4	D SUBGRADE (200)	2.00	2000.	0.40	200.00	200.00	90.00

TEXAS DEPARTMENT OF TRANSPORTATION
 FLEXIBLE PAVEMENT SYSTEM

FP S21-1.3

Release:7-1-2015

PAVEMENT DESIGN TYPE # 5 -- ACP + FLEX BASE + STAB SBGR OVER SUBGRADE

PROB	DIST.-14	COUNTY-227	CONT.	SECT.	JOB	HIGHWAY	DATE	PAGE
001	Austin	TRAVIS	1234	1	1	0	5/4/2017	3

C. LEVEL B SUMMARY OF THE BEST DESIGN STRATEGIES
 IN ORDER OF INCREASING TOTAL COST
 1

MATERIAL ARRANGEMENT	ABC
INIT. CONST. COST	30.57
OVERLAY CONST. COST	0.00
USER COST	0.00
ROUTINE MAINT. COST	1.41
SALVAGE VALUE	-1.25
TOTAL COST	30.73

NUMBER OF LAYERS 3

LAYER DEPTH (INCHES)	
D (1)	3.50
D (2)	14.00
D (3)	12.00

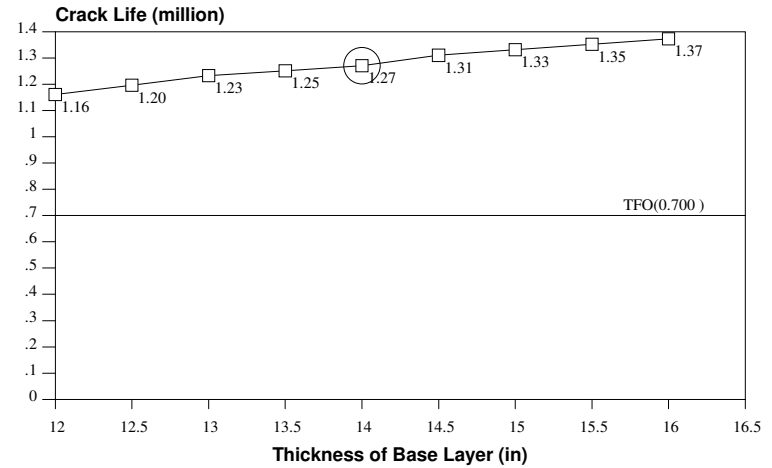
NO.OF PERF.PERIODS 1

PERF. TIME (YEARS)	
T (1)	40.

OVERLAY POLICY (INCH)
 (INCLUDING LEVEL-UP)

THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS 2

	Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
AC	3.50	500.00	0.35	ASPH CONC PVMT
Base	14.00	50.00	0.35	FLEXIBLE BASE
Subbase	12.00	6.00	0.30	STABILIZED SUBGR
Subgrade	200.00	2.00	0.40	SUBGRADE(200)



Fatigue Crack Model:

$$N_f = f_1 (\epsilon_t)^{f_2} (E_t)^{f_3}$$

$$f_1 = 7.96E-02$$

$$f_2 = 3.291$$

Rutting Model:

$$f_3 = .854$$

$$N_d = f_4 (\epsilon_v)^{f_5}$$

$$f_4 = 1.37E-09$$

$$f_5 = 4.477$$

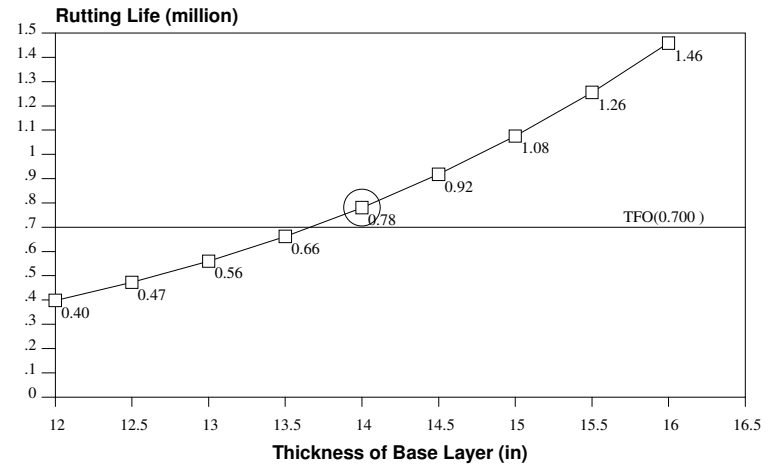
TFO(Traffic to 1st Overlay): 0.70 (million)

Crack Life: 1.27 (million) $\epsilon_t = 215.00 (\mu\epsilon)$

Rut Life: 0.78 (million) $\epsilon_v = -506.00 (\mu\epsilon)$

Traffic to 1st Overlay is calculated by analysis period: 40years and 18 kips:70millions.

Also the start ADT:4000.0 and ending ADT:7959.0



Mechanistic Check Conclusion:

The design is OK !

FPS 21 Mechanistic Design Check Output (FPS21-1.3Release:7-1-2015)			
Highway	0	Problem	001
C-S-J	1234 - 1 - 1	Date	5/4/2017
District	Austin	County	TRAVIS
Design Type:Asphalt concrete + Flexible Base + Stabilized Subgrade over Subgrade			

	Thickness (inches)	Modulus (ksi)	Poisson's Ratio	Material Name
ASPH CONC PVMT	3.50	500.00	0.35	ASPH CONC PVMT
FLEXIBLE BASE	14.00	50.00	0.35	FLEXIBLE BASE
STABILIZED SUBGR	12.00	6.00	0.30	STABILIZED SUBGR
SUBGRADE(200)	200.00	2.00	0.40	SUBGRADE(200)
Bed Rock	200.00	200.00	0.15	Bed Rock

INPUT PARAMETERS:

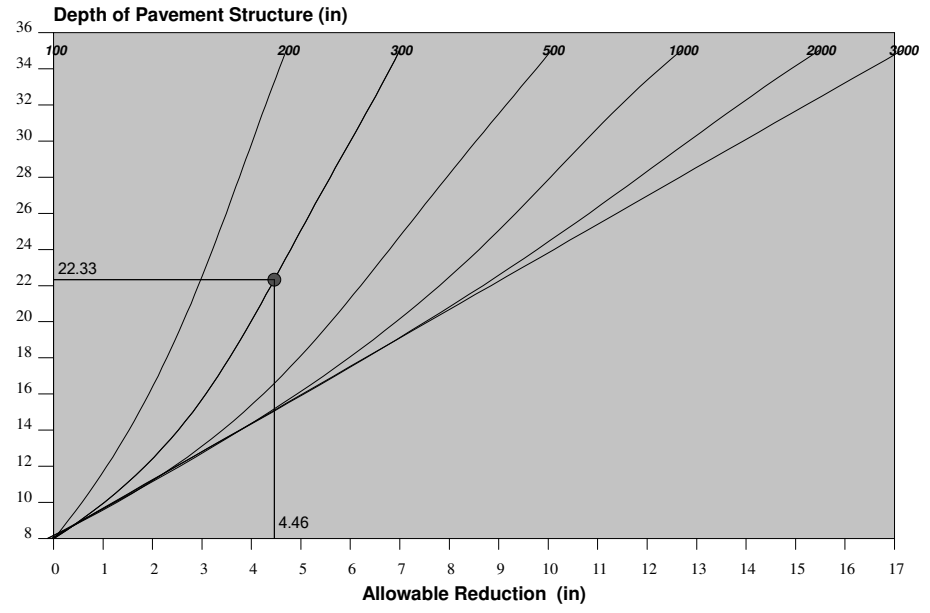
The Heaviest Wheel Loads Daily (ATHWLD)	10000.0 (lb)
Percentage of TandemAxles	40.0 (%)
Modified Cohesionmeter Value	300.0
Design Wheel Load	10000.0 (lb)
Subgrade Texas Triaxial Class Number (TTC)	5.80
TTC is based on Texas County Soil Database for (TRAVIS)	
For soils type : clay of high plasticity, fat clay(CH)	

RESULT:

Triaxial Thickness Required	22.3 (in)
The FPS Design Thickness	29.5 (in)
Allowable Thickness Reduction	4.5 (in)
Modified Triaxial Thickness	17.9 (in)

TRIAXIAL CHECK CONCLUSION:

The Design OK !



Thickness Reduction Chart for Stabilized Layers

FPS 21 Triaxial Design Check Output (FPS21-1.3Release:7-1-2015)			
Highway	0	Problem	001
C-S-J	1234 - 1 - 1	Date	5/4/2017
District	Austin	County	TRAVIS
Design Type:Asphalt concrete + Flexible Base + Stabilized Subgrade over Subgrade			

Attachment B.

Sample Output

PaymentDesigner.org



DESIGN SUMMARY REPORT FOR
COMPOSITE JOINTED-PLAIN CONCRETE PAVEMENT (JPCP)

DATE CREATED:
Thu Jan 28 2021 14:47:51 GMT-0600 (CST)

Project Description

Project Name: Urban Collector Owner: Zip Code:
 Designer's Name: Route:
 Project Description: Low Traffic;
 2,000 psi Poor Subgrade

Design Summary

Recommended Design Thickness:	Doweled 6.25 in	Undoweled 6.25 in	Maximum Joint Spacing:	Doweled 11 ft	Undoweled 11 ft
Calculated Minimum Thickness:	6.08 in	6.08 in			

Pavement Structure

SUBBASE
 Calculated Composite K-Value of Substructure: 233 psi/in

Layer Type	Resilient Modulus		Layer Thickness	
JOINTED PLAIN CONCRETE SURFACE				
Hot-Mix or Warm-Mix Asphalt Base	500,000	psi	4	in
Lime Stabilized Subgrade	20,000	psi	12	in
SUBGRADE				

CONCRETE			SUBGRADE	
28-Day Flex Strength: 620 psi	Edge Support: Yes		Known MRSG Value: 2,000 psi	
Modulus of Elasticity: 4000000 psi	Macrofibers in Concrete: 0			

Project Level

TRAFFIC		GLOBAL	
Spectrum Type: Collector		Reliability: 90 %	
Design Life: 30 years		% Slabs Cracked at End of Design Life: 10 %	
USER DEFINED TRAFFIC			
Trucks Per Day: 230		Avg Trucks/Day in Design Lane Over the Design Life: 198	
Traffic Growth Rate %: 3.5 % per year		Total Trucks in Design Lane Over the Design Life: 2,168,346	
Directional Distribution: 50 %			
Design Lane Distribution: 100 %			

Design Method

The PCA design methodology from StreetPave, was used to produce these results.