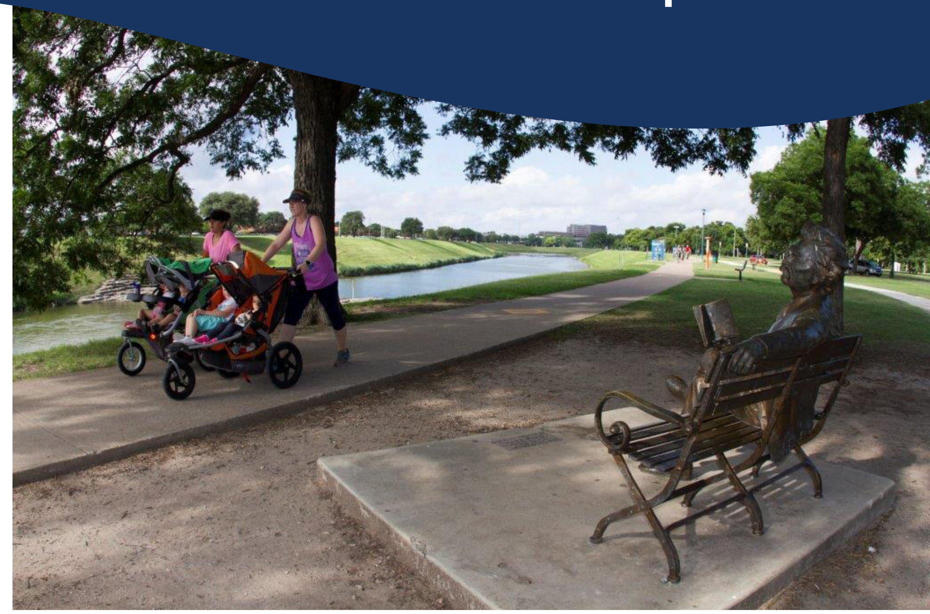
Fort Worth Active Transportation Plan

BICYCLE FACILITY SELECTION GUIDE AND DESIGN TOOLBOX

April 2019



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YMCA

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Bicycle Facility Selection Guide

Introduction

The Fort Worth Active Transportation Plan identifies a seamless citywide network of on- and off-street bicycle facilities for people of all ages and abilities. This Facility Selection Guide outlines a process to select the appropriate bicycle facility for the roadway and land use context in order to provide a comfortable bicycling experience for a large cross-section of the population.

This guide focuses on the on-street bicycle facilities part of the network. It should be used to determine the appropriate and feasible facility for that roadway to achieve a high level of bicyclist comfort.[1] Where the Master Thoroughfare Plan has designated a bicycle facility, the MTP must be followed or a waiver must be obtained.

The accompanying Active Transportation Design Toolbox provides information on the design of trails, sidepaths, bicycle facilities, and pedestrian infrastructure.

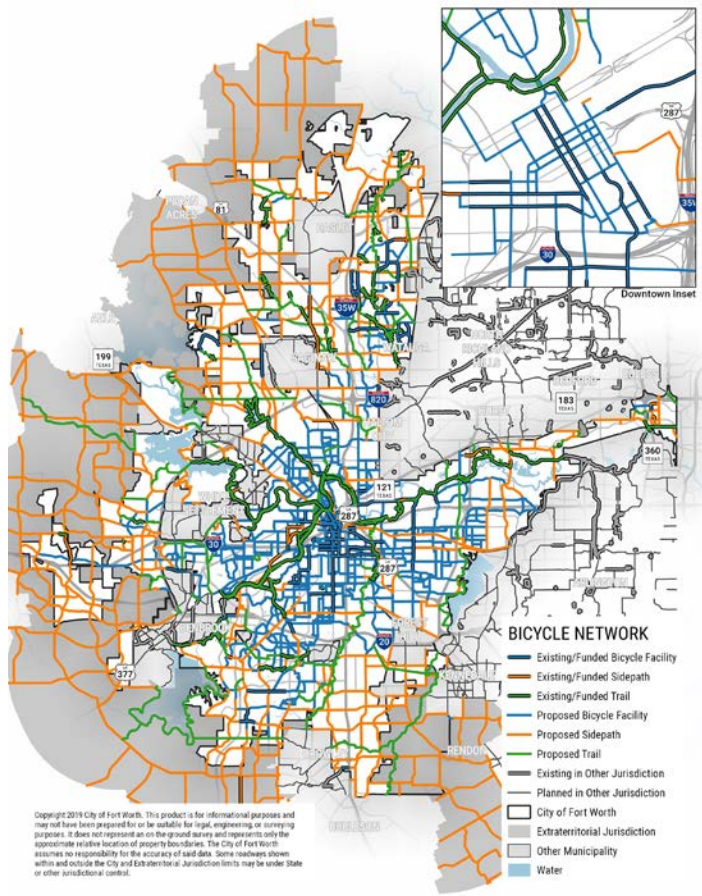


Figure 1. Fort Worth ATP Bicycle Network.

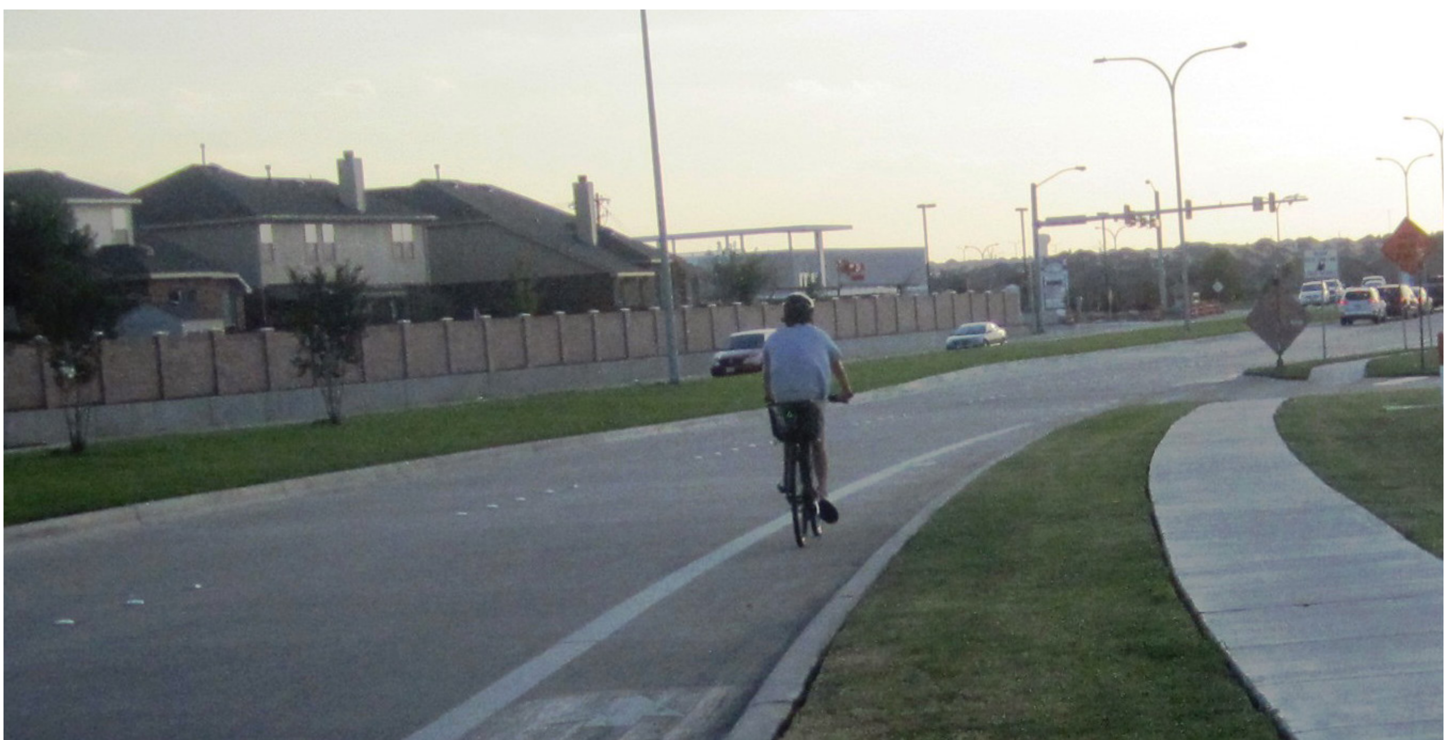


Figure 2. A conventional bike lane on Timberland Boulevard. (Photo credit: City of Fort Worth)

1 For more information on selecting a bicycle facility, see the Federal Highway Administration publication Bikeway Selection Guide, February 2019. https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18077.pdf

Bicycle User Types

Research indicates that people vary in their tolerance for sharing the road with motor vehicles while bicycling. A small number of people will bicycle under any roadway conditions. More people are comfortable on trails, sidepaths, separated bike lanes, or lower-volume and -speed residential streets (see Figure 3).

Bicyclist Level of Comfort analysis is described in Chapter 3 of the ATP. It is used to measure comfort and stress on Fort Worth's roadways. **The selected bicycle facility should achieve a level of traffic stress (LTS) rating of 1 to accommodate users of all ages and abilities.** An LTS score of 2 accommodates most adults. Fewer people will be attracted to an LTS 3 or 4 facility, except those who are more comfortable riding near or with traffic. If it is infeasible to design to an LTS 1 or 2, an alternative route could be considered in certain circumstances. In order to achieve an all ages and abilities network, **the default target bicycle user for the ATP is the "Interested But Concerned" bicyclist.**

Figure 3 shows how different facilities impact comfort for different users.

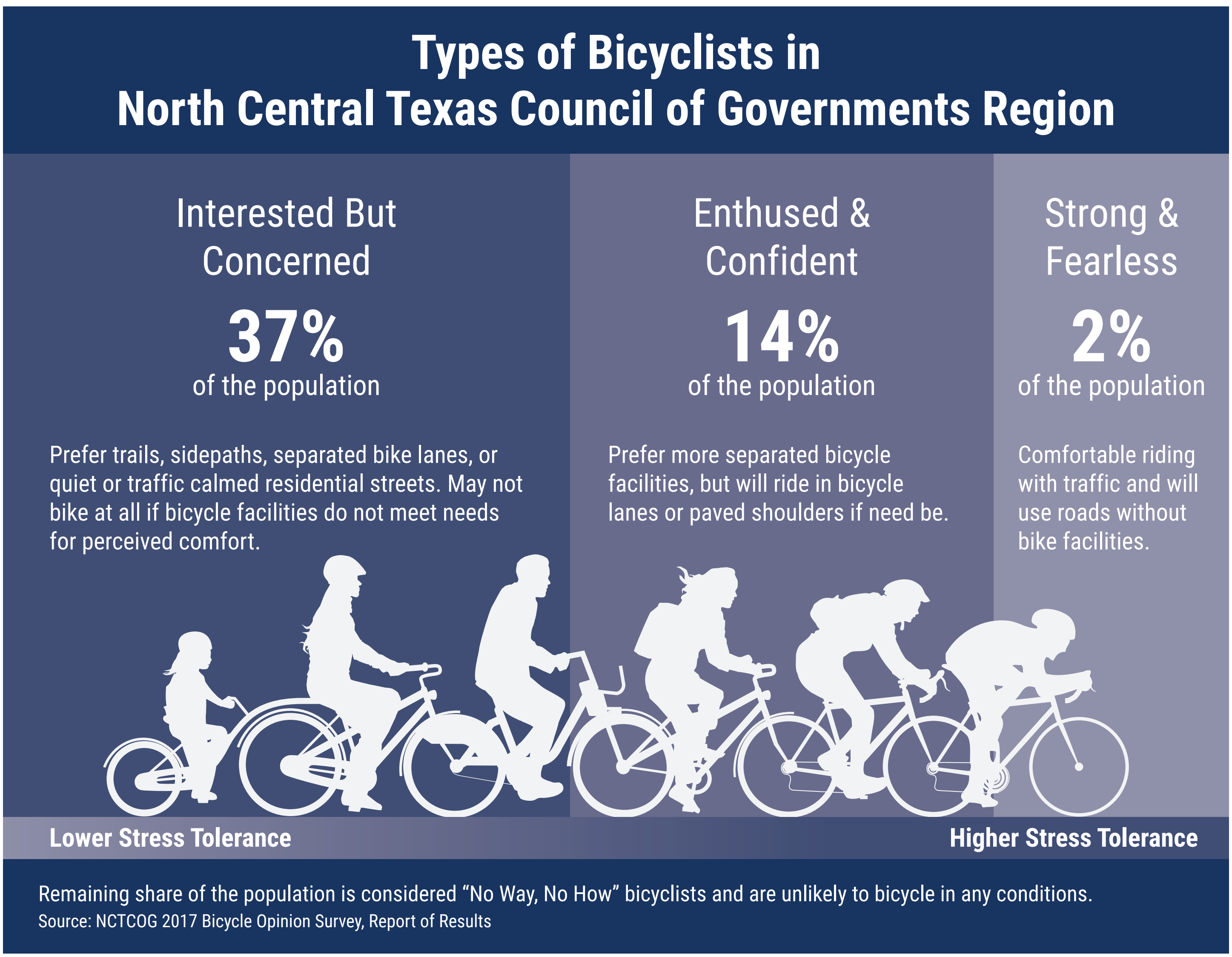


Figure 3. Types of Bicyclists in the North Central Texas Council of Governments Region, which includes Fort Worth.

Facility Types

This section describes various bicycle facilities and briefly discusses their relationship with the level of comfort experienced by people in different contexts. The facility that enables people of all ages and abilities to bike comfortably should be selected. Refer to the Traffic Engineering Manual (TEM) for information on how to design these facilities.

Trails

(Photo credit: Tarrant Regional Water District)

A path fully separated and independent from a road, shared by bicyclists, pedestrians, and others.

- Comfortable for users in most contexts.
- Higher-demand trails, such as those included in the ATP Spine network, should be wider to accommodate more users traveling at varied speeds. Pedestrians and bicyclists may be separated to increase comfort. If the trail is congested, some bicyclists may choose to ride on adjacent roads.

Sidepaths

(Photo credit: City of Fort Worth)

A path separated from – but traveling along – a road.

- Comfortable for users in most contexts.
- Intersections and driveways must be designed to maximize safety.
- Special attention should be paid to turning vehicles in the planning and design process.

Separated Bike Lanes

A bike lane that is physically separated from automobile travel lanes and sidewalks by a vertical element, such as curbs, flex-posts, or parked cars.

- Comfortable for users in most contexts.
- Intersections and driveways must be designed to maximize comfort and safety.
- Several common designs for Separated Bike Lanes are highlighted in Figure 4 below.

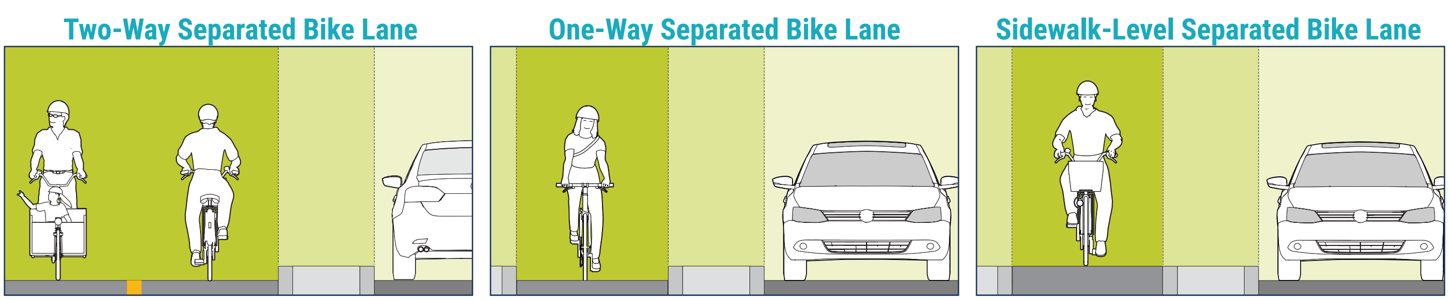


Figure 4. Common Separated Bike Lane Designs (Graphic: Toole Design)

Buffered Bike Lanes


(Photo credit: City of Fort Worth)

A bike lane with a painted buffer to provide additional lateral space between bicyclists and traffic or parked cars.

- More comfortable than conventional bike lanes.
- May provide comfort for adults where traffic speeds and volumes are medium to high.

Wayfinding

(Photo credit: City of Fort Worth)

Wayfinding is directional signs indicating the direction of and distance to points of interest.

- Wayfinding does not improve bicyclist comfort when used alone, but may be recommended on low volume and low speed streets.

Bicycle Boulevards


(Photo credit: Toole Design, Portland, OR)

Streets with low motorized traffic volumes and speeds designed to provide priority to bicyclists and intended to serve local motor vehicle traffic.

- Typically have signs, shared lane markings, and traffic calming elements, such as speed humps, traffic circles, curb extensions, and diverters.
- Comfortable for most users, depending on speed and volume of traffic. Comfortable crossings at intersections are critical.

Shared Lane Markings


(Photo credit: Toole Design)

Shared lane markings show bicyclists and drivers where bicyclists should ride in a shared roadway.

- Shared lane markings do not improve bicyclist comfort when used alone but may be recommended on low volume and low speed streets.
- Can encourage some bicyclists to ride outside of the “door zone,” the zone of a parked car’s door opening.

Selecting a Facility

The diagram below outlines the bicycle facility selection process for the Fort Worth ATP. This process is intended to cover locations where the Master Thoroughfare Plan does not specify a bicycle facility in a cross-section. If it is determined that there is insufficient space to build the desired bikeway facility on a primary route, the process may lead to implementation of both a facility on the primary route designed for confident cyclists and one on a parallel route designed for a broader range of existing and potential bicyclists. This is not a duplicate route, but rather two routes that support different users and functions, in the same way that freeways and parallel frontage roads support different trips and are not considered duplicative.

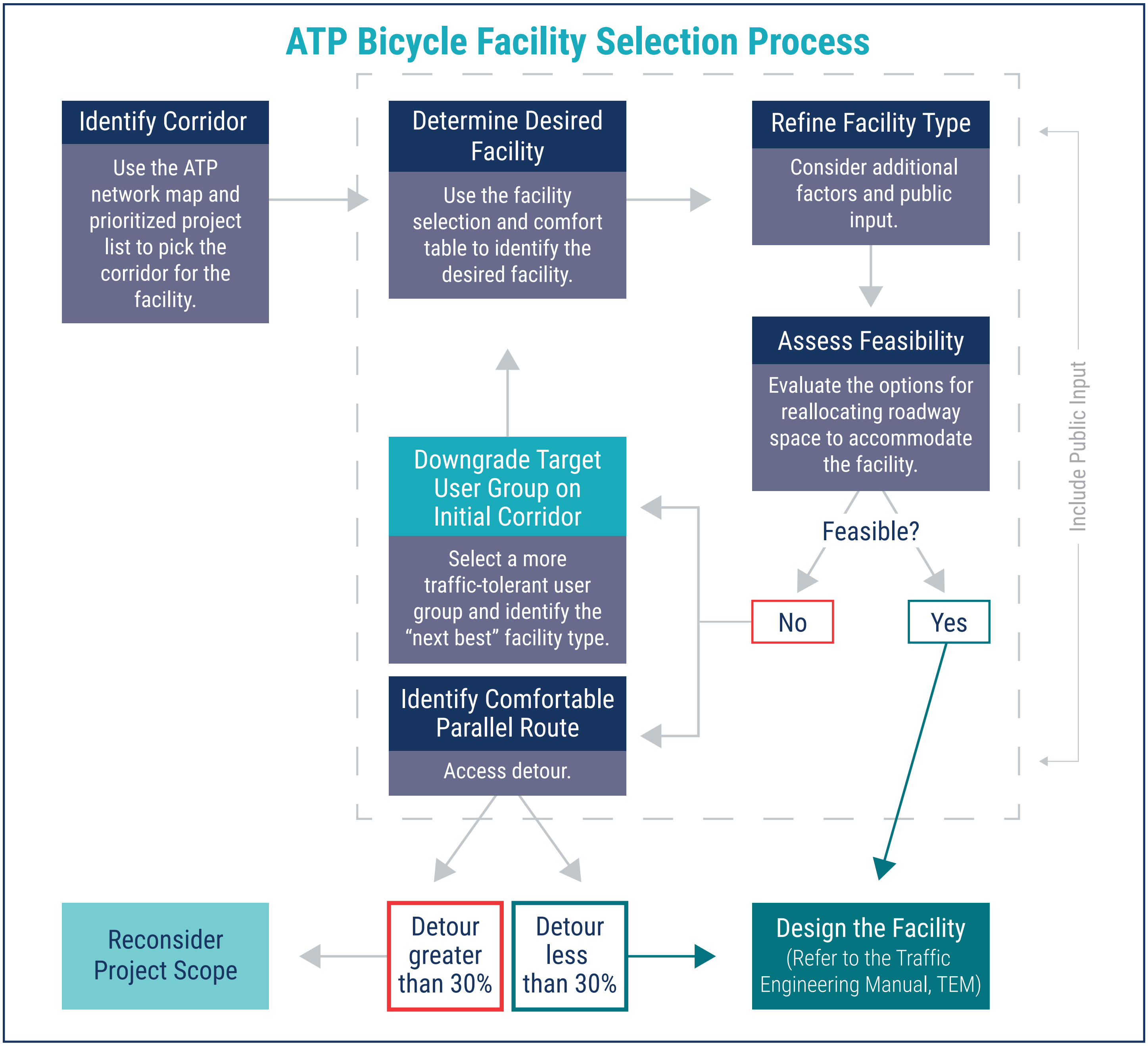


Figure 5. Bicycle Facility Selection Process

Refine Bikeway Type & Design

The facility selection table in this guide provides basic information on the expected comfort of facilities based on roadway conditions. The following factors are considered when determining the facility type and design.

Role in the ATP network – Corridors in the ATP bicycle network are classified as Spine, Rib, and Neighborhood Connectors, based on the role they play in the network. On Spine and Rib corridors, comfort and adequate physical separation (e.g., between bicycles and vehicles and between bicycles and pedestrians) should not be compromised. The most comfortable facility possible should be selected because these corridors play an important role in connecting neighborhoods.

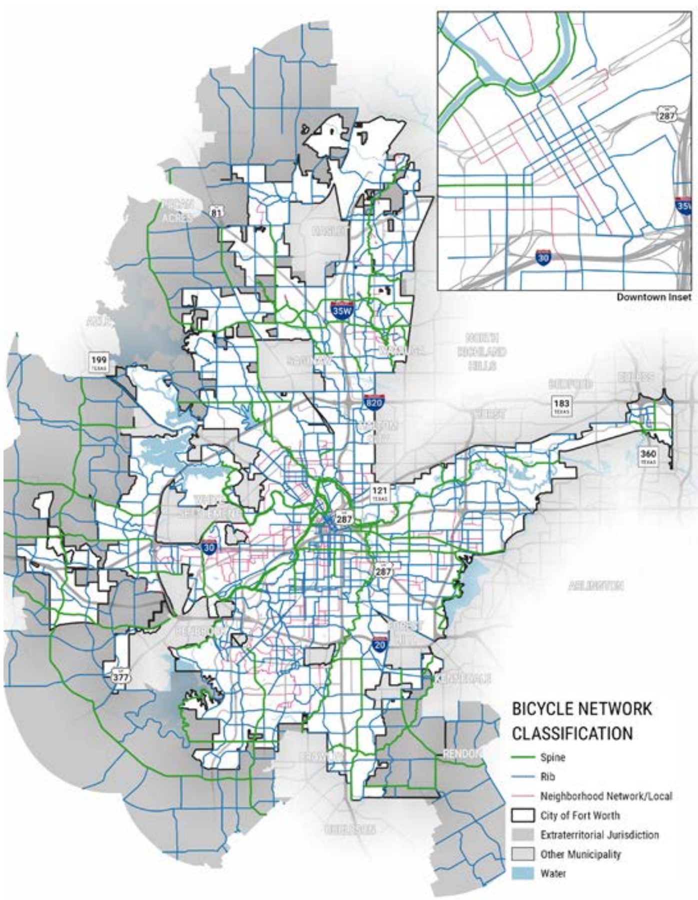


Figure 6. Map showing Spine, Rib, and Neighborhood Connectors in the Fort Worth ATP.

Unusual motor vehicle peak hour volumes – On roadways that regularly experience unusually high peak hour volumes (e.g., 12%+ of ADT), more separation can be beneficial, particularly when the peak hour also coincides with peak volumes of bicyclists.

Traffic vehicle mix – Additional separation between bicyclists and motorists should be provided on moderate to high-volume streets where heavy vehicles are more than 5 percent of traffic. Higher percentages of trucks and buses increase risks and discomfort for bicyclists due to vehicle size and weight, and the potential for motorists to not see bicyclists because of blind spots.

Parking turnover and curbside activity – Conflicts with parked or temporarily stopped motor vehicles present a risk to bicyclists. High parking turnover and curbside loading may expose bicyclists to being struck by opening vehicle doors or people walking in their travel path. Wider bike lanes or separated bike lanes can help to alleviate conflicts in locations with high parking turnover or curbside loading needs.

Driveway/intersection frequency – The frequency of driveways and intersections impacts the amount of separation needed between the street and the separated bike lane. Frequently spaced driveways may require elimination of on-street parking adjacent to bike lanes and separated bike lanes and the raising of the bike lane to provide separation from traffic. Engineering judgment should be used, given that there is generally a context-sensitive design and that there is currently no broadly applicable rule of thumb for driveway frequency.

Vulnerable populations –Areas where high concentrations of children and older adults are expected (such as near schools or senior living centers) should be considered during project planning. These groups may only feel comfortable bicycling on physically separated facilities, even where motor vehicle speeds and volumes are relatively low. Children are less visible to motorists and often lack roadway experience and sufficient cognitive or physical maturity to recognize and anticipate potential conflicts.

Evaluating Feasibility and Reallocating Space

Bicycle facilities must be designed according to the dimensions specified in the TEM, the Master Thoroughfare Plan (MTP), and the ATP Design Guidance. In new construction, the facility designated in the MTP must be constructed or a waiver will need to be obtained. In established road corridors, feasibility for a facility and design will depend on the ability to reallocate space. Strategies for accomplishing this include:

Narrowing Travel Lanes – Existing lanes may be narrowed to provide space for bicycle facilities. The AASHTO Green Book provides flexibility to use travel lanes as narrow as 10 feet in some situations depending on operating speeds, volumes, traffic mix, horizontal curvature, use of on-street parking, and street context.

Removing Travel Lanes – Roads with excess capacity may be re-configured to provide space for bicycle facilities. There are also often additional safety and operational benefits for drivers. FHWA indicates that roadways with ADT of 20,000 vehicles per day or lower may be good candidates for a lane-reconfiguration and should be evaluated for feasibility.[2]

Reorganizing Street Space – It may be possible to create or upgrade bikeways by reorganizing street space without removing travel lanes.

Making Changes to On-Street Parking – Working closely with local businesses and neighborhoods, it may be possible to modify parking to provide space for bicycle facilities, by:

- Removing parking on one side
- Converting diagonal parking to parallel parking
- Converting parallel parking to reverse-angle parking on one side

It may also be possible to accommodate more parking on side streets, or to consolidate it in newly created parking bays or in (off-street) surface lots or parking structures. Parking consolidation or reconfiguration can take many different forms. A parking utilization study can be undertaken to determine feasibility. When parking is modified, it is important to review requirements for providing accessible parking spaces for individuals with disabilities.

New Construction vs. Retrofit

New construction projects generally have fewer constraints than projects on established corridors.

Projects on existing roads and reconstruction projects generally involve right-of-way and other constraints that should be taken into consideration and may result in a modification to the preferred bikeway.

On-street separated, buffered, and conventional bike lanes are more suitable than sidepaths and sidewalk-level separated bike lanes for maintenance projects that do not involve curb modifications.

Note that a modification to an adopted MTP cross-section requires a waiver. If a modification to an existing cross-section of an established thoroughfare is considered, the MTP provides information on how to prioritize different factors and required width ranges.

Sidepath or Separated Bike Lane?

Land use context is one of the main determining factors on whether a sidepath or separated bike lane should be installed. Sidepaths and separated bike lanes are generally preferred on urban corridors identified as Spines or Ribs in the ATP network and where bicycling and pedestrian volumes are expected to be higher and where space to retrofit roadways behind the curb is often infeasible.

2 FHWA. Road Diet Informational Guide. FHWA-SA-14-028. Federal Highway Administration, U.S. Department of Transportation, Washington, DC, November 2014.

Figure 7. Guidance on separating bicyclists and pedestrians. (Photo credit: Toole Design)

Shared use paths or sidepaths are preferred in suburban areas where land use is expected to be less dense and where the roadway network has not been built out.

As volumes increase over time, the need for separation between bicyclists and pedestrians on sidepaths should be revisited. FHWA's Shared Use Path Level of Service Calculator[3] can guide decisions on when separation is needed between pedestrians and bicyclists by using volume thresholds where passing movements between bicyclists and pedestrians will limit the facility's effectiveness. To improve comfort and safety for users and to improve the efficiency of the shared use path for bicycle travel, separation of bicyclists and pedestrians should be considered when:

- Shared Use Path Level of Service is projected to be at or below level "C - Fair" during peak hours.[4]
- Pedestrians can reasonably be anticipated to be 30 percent or more of the volume during peak hours.
- Higher volumes of children, older adults, or individuals with disabilities are likely to be present.
- Where faster bicycle speed is desired to serve regionally significant bicycle travel.

Identifying Alternatives if the Preferred Facility is Infeasible

There may be instances in constrained environments where the preferred facility is not feasible and a suitable alternative must be identified. It is important to recognize and understand the implications of an alternative facility on likely ridership, safety, and comfort. The facility selection table on page 11 indicates the expected level of comfort of different users under different roadway conditions, and Figure 3 shows the expected share of the population who will likely bike based on more and less stressful conditions.

Parallel Routes

In circumstances where the preferred bikeway is not feasible, the next-best facility should be selected for the primary route and a parallel route should be evaluated to accommodate the design user. As noted above, this is not a duplicate route, given that the two routes support different user groups.

Parallel routes can often be low-volume, low-speed local streets. These can be designed to operate

3 The use of the Shared Use Path Level of Service Calculator requires the following inputs to calculate a LOS score: 1. volumes of people walking and running, adult bicyclists, child bicyclists, and in-line skating, 2. proposed or existing path width, and the presence of a center line.

4 Shared Use Path Level of Service C means that the trail has at least minimum width to meet current demand and to provide basic service to bicyclists. A modest level of additional capacity is available for bicyclists and skaters; however more pedestrians, runners, or other slow–moving users will begin to diminish LOS for bicyclists.

and function as bicycle boulevards, with daily traffic volumes under 3,000 and speeds of 25 mph or lower.

Research indicates that *for an alternative low-stress route to be viable, the increase in trip length should be less than 30 percent*. This detour is calculated by measuring the distance between the end-to-end points of the original corridor and comparing it to the distance between the end-to-end points of the alternative route. The difference between the two is divided by the original distance.

Note that for the parallel route to be a viable alternative, safe and comfortable street crossings, especially of arterials, must be provided.

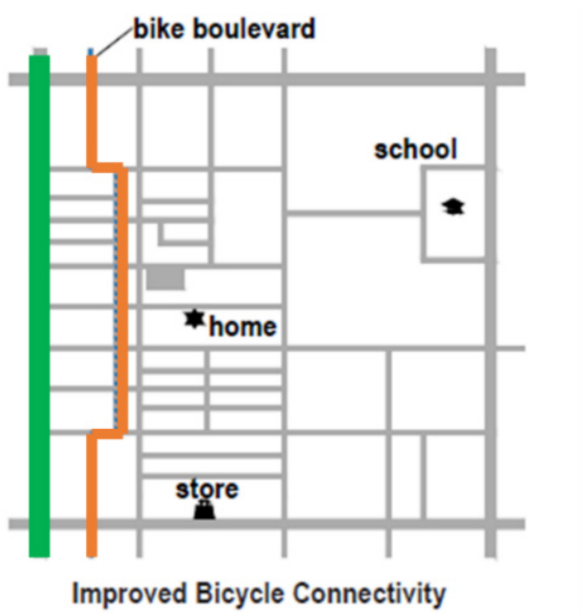


Figure 8. An example parallel route (orange) adjacent to a primary route (green). The parallel route should address major street crossings and increase the total trip distance by no more than 30 percent over the primary route.

The Next-Best Facility

After all options for reallocating space have been exhausted, a different target user for the route may need to be selected. A more traffic-tolerant user may be comfortable with "the next best" bicycle facility with lower levels of separation. If the provision of a lower-quality bikeway will not accommodate the preferred design user on the primary route (e.g. the interested but concerned bicyclist), a parallel route should be identified where possible.

Facility Selection Table

Bicyclist comfort is impacted by many factors. Several of the most important are traffic speed, the number of automobile travel lanes, and the presence of a bicycle facility. This table shows the comfort and stress associated with typical Fort Worth cross-sections and with common bicycle facility types.

The colors in the table below indicate the following:

- 1 (dark green) indicates an All Ages and Abilities condition, comfortable for most children and adults
- 2 (light green) indicates a low stress or comfortable facility for the majority of adults
- 3 (orange) indicates a condition that may be acceptable for confident bicyclists, but that will likely not be used by the majority of people
- 4 (red) indicates a generally stressful condition, except for a small number of very confident cyclists

Table 1. Level of Comfort and Stress for Typical Cross-Sections and Facility Types

Roadway Type/ Characteristics	Posted Speed	Lanes Per Direction	Presence of Parking	Traffic Volume (ADT)	Trails	Sidepaths; Separated Bike Lanes	Buffered Bike Lanes (8'+); Botts Dots	Conventional Bike Lanes (5'-6')	Signs and Shared Lane Markings (no roadways with no treatment	Bicycle Boulevards with Traffic Calming
Independent Right of Way	n/a	n/a	n/a	n/a	1	n/a	n/a	n/a	n/a	n/a
Thoroughfares										
System Link	45	3	No	All Volumes	n/a	1	4	4	4	n/a
System Link	45	2	No	All Volumes	n/a	1	3	4	4	n/a
Commercial or Neighborhood Connector	35	3	No	All Volumes	n/a	1	3	4	4	n/a
Commercial or Neighborhood Connector	35	2	No	20,001+	n/a	1	3	4	4	n/a
Commercial or Neighborhood Connector	35	2	No	8,001 - 20,000	n/a	1	3	3	4	n/a
Commercial or Neighborhood Connector	35	2	No	<8,000	n/a	1	2	3	3	n/a
Commercial or Neighborhood Connector	35	1	No	1501+	n/a	1	2	2/3*	4	n/a
Commercial or Neighborhood Connector	35	1	No	751-1500	n/a	1	2	2	3	n/a
Commercial or Neighborhood Connector	35	1	No	<750	n/a	1	2	2	2	n/a
Commerce/Mixed Use or Activity Street	35	2	Yes	>8,000	n/a	1	3	3	4	n/a
Commerce/Mixed Use or Activity Street	35	2	Yes	<8,000	n/a	1	2	3	3	n/a

Table continued on next page.

Roadway Type/ Characteristics	Posted Speed	Lanes Per Direction	Presence of Parking	Traffic Volume (ADT)	Trails	Sidepaths; Separated Bike Lanes	Buffered Bike Lanes (8'+); Botts Dots	Conventional Bike Lanes (5'-6')	Signs and Shared Lane Markings (no roadways with no treatment	Bicycle Boulevards with Traffic Calming
Commerce/Mixed Use or Activity Street	35	2	No	>8,000	n/a	1	2	3	3	n/a
Commerce/Mixed Use or Activity Street	35	2	No	<8,000	n/a	1	2	2	3	n/a
Collectors or 2-Lane Commerce/Mixed Use or Activity Streets										
Residential/Industrial/Retail Collectors and Commerce/ Mixed Use or Activity Streets	35	1	Yes	1501+	n/a	1	3	3	3	n/a
Residential/Industrial/Retail Collectors and Commerce/ Mixed Use or Activity Streets	35	1	Yes	751-1500	n/a	1	2	3	3	2
Residential/Industrial/Retail Collectors and Commerce/ Mixed Use or Activity Streets	35	1	Yes	0-750	n/a	1	2	2	3	1
Residential/Industrial/Retail Collectors and Commerce/ Mixed Use or Activity Streets	35	1	No	1501+	n/a	1	3	3	3	n/a
Residential/Industrial/Retail Collectors and Commerce/ Mixed Use or Activity Streets	35	1	No	751-1500	n/a	1	2	2	3	1
Residential/Industrial/Retail Collectors and Commerce/ Mixed Use or Activity Streets	35	1	No	0-750	n/a	1	2	2	2	1
Local Streets										
Standard Local Streets	25-30	50' ROW	Yes	3,001-6,000	n/a	n/a	n/a	1	3	n/a
Standard Local Streets	25-30	50' ROW	Yes	1501-3000	n/a	n/a	n/a	1	2	2
Standard Local Streets	25-30	50' ROW	Yes	751-1500	n/a	n/a	n/a	1	1	1
Standard Local Streets	25-30	50' ROW	Yes	0-750	n/a	n/a	n/a	1	1	1
Limited Local Streets	25-30	40' ROW	No	0-1000	n/a	n/a	n/a	1	1	1

Notes:

The comfort/stress values in this table are based on Level of Traffic Stress research and best practice. Some planning-level judgments were made where existing documentation was not available. Additional information that may impact bicycling conditions should be considered to refine the facility selection.

The table describes expected stress based on the posted speed. If actual speeds exceed the listed posted speed, stress should be expected to increase by one to two levels, depending on the magnitude of the excessive speed.

The number of lanes and presence of parking are drawn from MTP cross sections.

For Collectors, the MTP calls for 8 foot bike lanes adjacent to parking.

At speeds of 35mph and above, in-street separated bike lanes comfort depends on design and robustness of physical separation. Flexposts are likely to achieve an LTS of 2, rather than 1.

The preferred traffic volume for a bicycle boulevard is 1,000 ADT or lower. 2,000 ATD is acceptable; 3,000 ADT is the maximum; Bicycle boulevards should generally not exceed two lanes.

Shared Lane Markings are not recommended on roadways with speeds above 35 MPH.

*This cross-section is a 2 below 6,000 ADT and a 3 above 6,000 ADT.

Bicycle Comfort at Intersections Based on Intersection Control Treatment

Bicyclist comfort is impacted by many factors. Several of the most important are traffic speed, the number of automobile travel lanes, and the presence of a bicycle facility. This table provides information on the impact of these factors on the expected resulting comfort based on the presense traffic signals, stop signs, and protected intersections.

The colors in the table below indicate the following:

- 1 (dark green) indicates an All Ages and Abilities condition, comfortable for most children and adults
- 2 (light green) indicates a low stress or comfortable facility for the majority of adults
- 3 (orange) indicates a condition that may be acceptable for confident bicyclists, but that will likely not be used by the majority of people
- 4 (red) indicates a generally stressful condition, except for a small number of very confident cyclists

Table 2. Level of Comfort and Stress for Intersection Treatments

Characteristics of the roadway being crossed by the bicyclist			Presence of infrastructure/control at the intersection *being crossed* by the bicyclist								
				Protected Intersection							
Posted Speed	Lanes Per Direction to Cross	Total Lanes to Cross	Grade Separation	With Dedicated Bicycle Signal Phase	Without Dedicated Bicycle Signal Phase	Stop Control (on crossing traffic)	Traffic Signal with Dedicated Bicycle Signal Phase	Traffic Signal or HAWK (with concurrent bicycle and motorist movements)"	Rapid Rectangular Flashing Beacon (RRFB)	Stop Sign (controling the crossing traffic)	No Control (on the crossing traffic)
Two-Way Streets											
40+	3	6	1	1	2	NA	2	3	4	NA	4
40+	2	4	1	1	1	NA	2	2	3	NA	4
35	3	6	1	1	2	NA	1	3	4	NA	4
35	2	4	1	1	1	NA	1	2	2	2 (very rare)	3
35	1 or 2	3	1	1	1	1	1	1	2	2	3
35	1	2	1	1	1	1	1	1	2	1	2
25-30	1	2	NA	1	1	1	1	1	1	1	1

Table continued on next page.

Characteristics of the roadway being crossed by the bicyclist		Presence of infrastructure/control at the intersection *being crossed* by the bicyclist								
			Protected Intersection							
Posted Speed	**Lanes Per Direction (One-way) to Cross**	**Grade Separation**	**With Dedicated Bicycle Signal Phase**	**Without Dedicated Bicycle Signal Phase**	**Stop Control (on crossing traffic)**	**Traffic Signal with Dedicated Bicycle Signal Phase**	**Traffic Signal or HAWK (with concurrent bicycle and motorist movements)"**	**Rapid Rectangular Flashing Beacon (RRFB)**	**Stop Sign (controling the crossing traffic)**	**No Control (on the crossing traffic)**
One-Way Streets Crossing a one-way street requires watching for cross-traffic in one direction instead of two. Therefore stress scores are tailored for one-way streets.										
40+	3	1	1	1	NA	1	2	3	NA	3
40+	2	1	1	1	2	1	1	3	NA	3
35	3	1	1	1	NA	1	1	2	NA	2
35	2	1	1	1	1	1	1	2	2 (very rare)	2
25-30	2	NA	1	1	1	1	1	1	2 (very rare)	1

Notes:

Protected intersection stress: The stress ratings in these tables are based on the Mineta Transportation Institute Low-Stress Bicycling and Network Connectivity methodology, which does not address protected intersections. The stress estimates in the table above are based on professional planning and engineering judgement. Protected intersections are judged to reduce stress by one step compared to the default control (e.g. a protected intersection with a dedicated phase is a 1 while a dedicated phase without a protected intersection is a 2). Because the stress at protected intersections is so dependent on the control, protected intersections are broken into three columns: dedicated bicycle signal phase, without dedicated bicycle signal phase, and stop controlled.

Median Islands: Median islands reduce the number of lanes a bicyclist must cross at a time. To evaluate the intersection stress of a roadway with a median island, use the table above to look up the stress of each leg of the crossing, using one-way streets and number of lanes to cross each leg.

Complex intersections: Multiple-leg intersections create additional stress for bicyclists and require special consideration for bicyclists.

Off-set intersections: Off-set intersections, made up of two T-intersections, should be evaluated based on the stress at each of the T-intersections.

Turning movements: Turning movements and turn lanes increase bicyclist stress at intersections due to additional crossing distance and intersection complexity. Traffic signals with dedicated bicycle signal phases reduce bicyclist stress by separating movement timing between the modes. At intersections with significant turning movements and turn lanes, the stress estimate may be increased by 1 to 2 steps depending on number of turning vehicles and signal control based on the designer's professional judgement.

Additional design treatments: Additional design treatments are recommended to reduce turning vehicle speeds, communicate right of way, and provide designated space for bicyclists at intersections. These treatments should be installed when possible.

- Conflict markings
- Bike boxes
- 2-stage turn boxes
- Protected intersections
- Median Islands

Refer to Table 1 for information on stress on roadway segments with various bicycle facility types. The selection of the appropriate design treatment at intersections depends on the facility along the roadway and intersection approach.

Roundabouts: While the confident bicyclist may be comfortable traversing a roundabout in a shared lane environment, many bicyclists will not feel comfortable navigating roundabouts with vehicular traffic, especially multilane roundabouts. For shared lane conditions, if a roundabout contains one circulating lane, then stress related to sharing the lane depends on the traffic volume (4,000 or less = LTS 1; 4,001 to 6,000 = LTS 2;

>6,000 = LTS 4); if there is more than one circulating lane, the LTS is 4. Bike lanes are not to be located within the circulatory roadway of a roundabout. For comfort and safety reasons, roundabouts should be designed to facilitate bicycle travel outside of the circular roadway. The stress of the intersection crossing will be determined by the number of lanes and speed of traffic being crossing. Refer to the table above.

For more information on bicycle intersection treatments, see the intersection toolbox on Page 45.

Using the ATP Facility Selection Table and MTP Dimensional Guidance in Conjunction

Implementing bicycle facility types that align with the dark green and light green colors on the table on the previous pages will, over time, help to create an All Ages and Abilities network in Fort Worth. In doing so, Table 1 provides strategic context-sensitive guidance on facility type selection based on roadway characteristics. This information should be used in conjunction with engineering judgment and information in the MTP on bike facility dimensions, which is shown in Table 2 for established thoroughfares. These dimensions are minimums and can be exceeded. The MTP covers established thoroughfares and future roadways, while the ATP covers other roadway types including local roads and collectors. The MTP supersedes the ATP and this facility selection guide. This information is intended to inform the project-level planning and design process.

Established Thoroughfares

Table 3. Dimensions for established thoroughfares from the MTP, including preferred and minimum widths for bicycle lanes.

<table>
<tr><th></th><th colspan="36">Established Thoroughfares – Width Ranges (in feet)</th></tr>
<tr><th></th><th colspan="3">Auto Lanes</th><th colspan="3">On-Street Dedicated Bike Lanes</th><th colspan="3">On-Street Transit Lanes</th><th colspan="6">On-Street Parking</th><th colspan="6">Non-Traversable Median</th><th colspan="3">Sidewalk / Pedestrian Zone</th><th colspan="3">Sidepath</th><th colspan="3">Separated Bike Lane</th><th colspan="3">Clear + Furnishing Zone [minus 6” curb]</th><th colspan="3">Frontage Zone</th></tr>
<tr><th></th><th colspan="3"></th><th colspan="3"></th><th colspan="3"></th><th colspan="3">Parallel</th><th colspan="3">Angle</th><th colspan="3">Standard</th><th colspan="3">Wide</th><th colspan="3"></th><th colspan="3"></th><th colspan="3"></th><th colspan="3"></th><th colspan="3"></th></tr>
<tr><th></th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th><th>Min</th><th>Max</th><th>Preferred</th></tr>
<tr><td>Activity Street</td><td>10</td><td>11</td><td>11</td><td>5</td><td>6</td><td>6*</td><td colspan="3">11</td><td>7.5</td><td>8</td><td>8</td><td colspan="3">19</td><td colspan="3">NA</td><td colspan="3">NA</td><td>5</td><td>NA</td><td>6</td><td colspan="3">NA</td><td colspan="3">NA</td><td>6.5</td><td>NA</td><td>NA</td><td>7</td><td>NA</td><td>8</td></tr>
<tr><td>Commerce/ Mixed-Use Street</td><td>10</td><td>11</td><td>11</td><td>5</td><td>6</td><td>6*</td><td colspan="3">11</td><td>7.5</td><td>8</td><td>8</td><td colspan="3">19</td><td colspan="3">NA</td><td colspan="3">NA</td><td>5</td><td>NA</td><td>6</td><td colspan="3">NA</td><td colspan="3">NA</td><td>6.5</td><td>NA</td><td>NA</td><td>7</td><td>NA</td><td>8*</td></tr>
<tr><td>Neighborhood Connector</td><td colspan="3">11</td><td colspan="3">6</td><td colspan="3">11</td><td colspan="3">7*</td><td colspan="3">NA</td><td>14</td><td>16</td><td>16</td><td colspan="3">NA</td><td>5</td><td>6</td><td>6</td><td>8</td><td>12</td><td>10</td><td colspan="3">6</td><td>4.5</td><td>NA</td><td>NA</td><td>0</td><td>NA</td><td>6</td></tr>
<tr><td>Commercial Connector</td><td>11</td><td>12</td><td>*</td><td colspan="3">6</td><td>11</td><td>12</td><td>*</td><td colspan="3">NA</td><td colspan="3">NA</td><td>14</td><td>16</td><td>16</td><td colspan="3">NA</td><td>5</td><td>6</td><td>6</td><td>8</td><td>12</td><td>10</td><td colspan="3">NA</td><td>4.5</td><td>NA</td><td>NA</td><td>0</td><td>NA</td><td>6</td></tr>
<tr><td>System Link</td><td>11</td><td>12</td><td>*</td><td colspan="3">NA</td><td>11</td><td>12</td><td>*</td><td colspan="3">NA</td><td colspan="3">NA</td><td>15</td><td>16</td><td>16</td><td>26</td><td>28</td><td>28</td><td>5</td><td>6</td><td>6</td><td>8</td><td>12</td><td>10</td><td colspan="3">NA</td><td>4.5</td><td>NA</td><td>NA</td><td>0</td><td>NA</td><td>6</td></tr>
<tr><td>*Notes:</td><td colspan="3">The 12’ max width is only allowed on outside curb lanes.</td><td colspan="3">For bike lanes adjacent to parking, add a 2’ buffer for angle parking and a 3’ buffer for parallel parking.</td><td colspan="3">The 12’ max width is only allowed on outside curb lanes.</td><td colspan="3">7’ Applies to the Special Residential Section.</td><td colspan="18"></td><td colspan="3">On streets with on-street parking, 4 feet of the clear/ furnishing zone can be reduced with the implementation of curb bulb-outs/tree wells</td><td colspan="3">If a segment can be demonstrated to have lesser frontage needs, a waiver may be considered to allow a width less than the minimum.</td></tr>
</table>

Active Transportation Design Toolbox

INTRODUCTION

The purpose of this document is to provide guidance on facility design that improves the experience of walking, biking, and using trails in Fort Worth. As a part of the Fort Worth Active Transportation Plan (ATP), this toolbox is intended to supplement the Fort Worth Traffic Engineering Manual, Master Thoroughfare Plan (MTP), and other relevant plans. It is intended to introduce active transportation facilities and treatments and is not intended to provide exhaustive design guidance.

The Active Transportation Plan (ATP)

The ATP includes a trail network, a bicycle network, and a pedestrian network. Each network supports access to transit and is comprised of the following facility types:

- The trail network contains trails and sidepaths.
- The bicycle network contains trails, sidepaths, on-street facilities, traffic-calmed streets, and intersection treatments.
- The pedestrian network contains sidepaths, sidewalks, and intersections. Trails and pedestrian-friendly transit corridors are the backbones of the network that support longer-distance travel.

This toolkit provides information on each of these categories of facility and the color of the headers corresponds to those in the ATP network maps:

1. Trails
2. Sidepaths
3. Bicycle Facilities
4. Pedestrian Facilities
5. Intersections
6. Transit Corridors

1. Trail Design Toolbox

For the purposes of this plan, trails are defined as pedestrian and bicycle facilities located in their own right-of-way. They may interact with streets to make neighborhood connections; however, the majority of the trail network is planned outside of the road right-of-way.

This section covers the following subjects related to designing trails:

- Network Classifications
- Trail Amenity Checklist
- Trail Design Best Practices

2. Sidepath Design Toolbox

Sidepath facilities are located along the road network; however, they are separated from vehicular traffic. The following topics are addressed in this section:

- Sidepath Definition
- Sidepaths in Fort Worth's MTP
- Design Guidance

3. Bicycle Facility Design Toolbox

On-street bicycle facilities include conventional bike lanes, buffered bike lanes, separated bike lanes, and bike boulevards.

This section includes covers:

- Facility Definitions
- When to Use Them
- Design Guidance
- Traffic Calming Treatments

TRAIL DESIGN TOOLBOX

Introduction

The Trail Design Toolbox describes the design criteria that the Fort Worth Active Transportation Plan recommends for trails that run in an independent right-of-way. This toolbox is divided into three sections:

1. Trail Network Classifications
    A. Spines
    B. Ribs
    C. Local Trails
4. Trail Amenity Accommodation Checklist
5. Trail Design Best Practices
    A. Trailheads
    B. Creating Trail Identity
    C. Lighting
    D. Signage & Wayfinding
    E. Intersections & Crossings

To guide the future development of trails in Fort Worth, a range of design standards have been developed to accommodate different conditions based on the current or anticipated level of activity and user type. Providing a range takes into account the many constraints and particularities of varying trail settings. This flexible approach to trail design aims to maintain superior standards and ensures that all users can feel comfortable using active transportation facilities all over the City of Fort Worth.

Figure 9. Trail system map sign. (Photo: City of Fort Worth)

Figure 10. Share the trail signs. (Photo credit: Kimley-Horn and Associates)

Figure 11. Map under bridge along the Clearfork Branch of Trinity Trails. (Photo credit: Kimley-Horn and Associates)

Trail Classifications

Trail classifications bring a context-sensitive approach that uses the anticipated function to inform how the trail should be designed. The trail network was designed by classifying all trails into three categories:

- Spines
- Ribs
- Local Trails

Trails classified as **Spines** act as the primary backbone for the network and largely incorporate the Regional Veloweb network. They emphasize long-distance connectivity and create major cross-town connections.

Branching off of the spine trails are the **Ribs**. The primary purpose of these trails is to connect spine trails to neighborhoods and make non-regional connections.

Local Trails are the final network level and make the last-mile connections to destinations and neighborhoods.

Figure 12. Welcome sign at River Park. (Photo credit: Kimley-Horn and Associates)


Figure 13. Decorative statue along the Clearfork Branch of Trinity Trails. (Photo credit: Kimley-Horn and Associates)

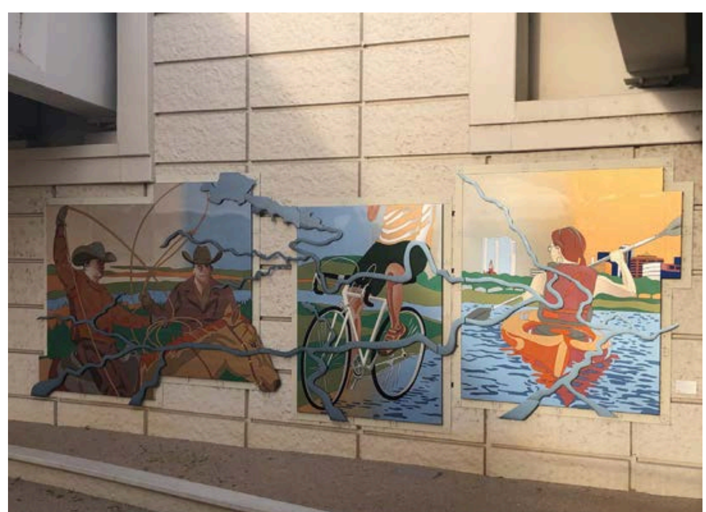
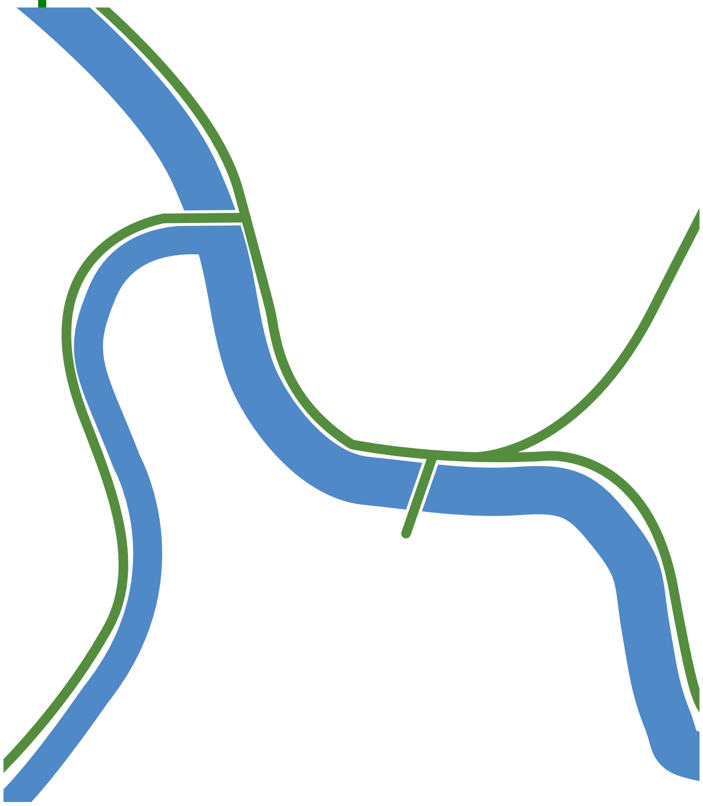


Figure 14. Wall mural along the Clearfork Branch of Trinity Trails. (Photo credit: Kimley-Horn and Associates)

Network Classifications: Spines



Description

Spine trails are the highest level of trail classification. They make regional connections and accommodate large volumes of users.

Design

The standard width of a spine should ideally be between 12 and 16 feet. The width may go down to 10 feet in constrained conditions. An operational study should be conducted to determine the appropriate width of trails based on context and projected volume of users. Since spine trails need to be able to serve large volumes of users, and potentially emergency vehicles, the recommended surface material is Portland cement concrete.

The following design elements, including shoulder width, vertical clearance, maximum cross slope, and maximum grade for spine trails, were all determined according to AASHTO design recommendations.

Design Elements

Standard Width	12’ – 16’
Minimum Width	10’
Easement Width	25’ – 35’ Depending on width of trail
Surface Material	Concrete
Shoulder Width	3’
Horizontal Clearance	2’
Vertical Clearance	10’ 12’ for emergency vehicles
Maximum Cross Slope	2%
Maximum Grade	5%
Design Speed	18 mph
Pavement Thickness	5” 6” for PARD 6” for TRWD

Dual-Track Alternative

If a trail consistently has higher volumes of users, there may be a need to separate wheeled users from pedestrians. In these cases, a spine may be designed as a dual-track path. This design dedicates 10 feet of width to bicyclists and 5 feet to pedestrians.

Centerline striping, directional arrows, and mode symbols should be used on spines where directions and modes are separated. Centerlines can be painted or represented by a change in surface.

Traffic Calming

If bicyclists regularly ride at speeds that reduce comfort or safety for other users, traffic calming techniques can be applied: speed limit signs, slow zones, center islands, and chicanes.

Network Classifications: Ribs

Description

Trails classified as ribs provide important connections, dispersing spine traffic out to their final destinations.

Design

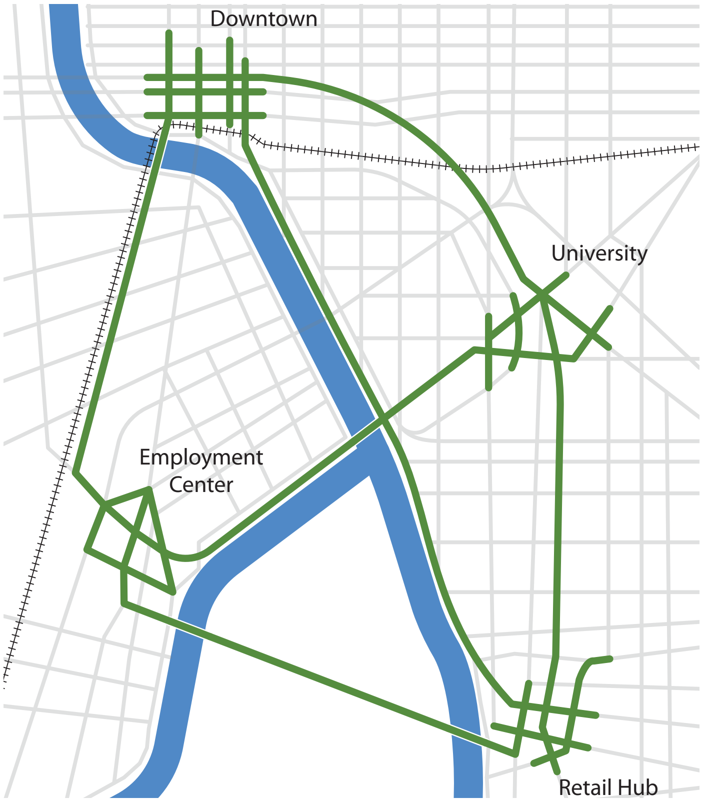
The standard width of a rib trail is 12 feet with 10 feet as a minimum. The surface material of rib trails can be either concrete or asphalt, depending on the local context.

The following design elements, including shoulder width, vertical clearance, maximum cross slope, and maximum grade for rib trails, were all determined according to AASHTO design recommendations.

Design Elements

Standard Width	10’ – 12’
Minimum Width	10’
Easement Width	25’
Surface Material	Concrete or Asphalt
Shoulder Width	2’
Vertical Clearance	10’
Maximum Cross Slope	2%
Maximum Grade	5% 8.33% for segments <200’
Design Speed	18 mph

Network Classifications: Local Trails



Description

Local trails serve as the final connection to common destinations for bicyclists. Destinations may include anything from a local neighborhood to downtown. These trails may be narrower than spine and rib trails because they tend to have lower user volumes.

Design

On local trails, the preferred width is 10 feet, and the minimum width is 8 feet. Concrete is the preferred material in most contexts, but asphalt, crushed limestone or other materials may be used at the direction of the appropriate City agency. Default to the relevant agency design standards.

The shoulder width, vertical clearance, maximum cross slope, and maximum grade for local trails were all determined according to AASHTO design recommendations.

Design Elements

Standard Width	10’
Minimum Width	8’
Easement Width	20’
Surface Material	Concrete (preferred), Asphalt, or Limestone
Shoulder Width	Optional
Vertical Clearance	10’
Maximum Cross Slope	2%
Maximum Grade	5 – 8.33% for <200’ or 8.33 – 10% for <30’
Design Speed	15 mph

Trail Amenity Checklist

Recommended Amenities

Trail amenities are essential for improving user experience and enhancing trail safety. **The following list of amenities are recommended on all trails in Fort Worth:**

- **Bicycle Parking** allows trail users to safely park their bicycles if they wish to stop along the way, particularly at parks and other destinations.
- **Maps and Wayfinding** allow users to navigate the trail system. Information kiosks with maps at trailheads and wayfinding signs can provide all the information that someone would need to use the trail system to reach key destinations. The Trinity Trails App provides information on the location of restrooms, 911 signs, trail parking, and kayak launch sites.
- **Pedestrian-Scale Lighting** improves safety by providing night-time visibility and the perception of security. Lighting allows the trail to be used throughout the evening.
- **Reference Location Markers** communicate the trail name and reference location in miles approximately every 1,000 feet. This includes 911 emergency markers.
- **Trash Receptacles and Dog Waste Pick-Up Stations** help keep the trails clean and litter free. Periodic containers at access points should be provided, and regularly trash collection service is key.
- **Fix-It Stations** provide basic tools that can be used to address common repair problems that may occur during a bike ride.

(Photo credit: Kimley-Horn and Associates)


(Photo credit: Kimley-Horn and Associates)

(Photo credit: City of Fort Worth)


Fort Worth Bike Sharing Station at a Trailhead.
(Photo credit: Kimley Horn and Associates)

(Photo credit: Kimley-Horn and Associates)

Figure 15. Trail Amenities in Fort Worth.

Optional Amenities

The following trail enhancements are provided in strategic locations and can further enhance trail users' comfort and safety.

- **Art Installations** make a trail system distinct and can reflect local culture or history.
- **Bike Share** bicycles are made available for shared use on a short-term basis for the cost of a daily or annual membership fee. Fort Worth Bike Sharing provides stations across the central city of Fort Worth.
- **Drinking Fountains** provide drinking water for people (and pets in some cases).
- **Trailhead Maps** provide trail users with information and the rules of the trail. A legible trail system map with a "you are here" marker is helpful for orientation.
- **Landscaping** should consider practical and aesthetic appeal, including trees for shade and native, low-maintenance plants.
- **Restrooms** shall be ADA accessible and are particularly appropriate at major trailheads. There are also many existing restrooms in City parks along trail routes.
- **Shade Pavilions** give trail users a respite from the sun and weather. Shade pavilions should include furniture for trail users to take a break or have a picnic.
- **Trail Furniture** encourages people of all ages to use the trail by ensuring that they have a place to rest along the way. Benches can be provided at rest areas and viewpoints, as well as periodically along longer routes.

(Photo credit: City of Fort Worth)

(Photo credit: Kimley-Horn and Associates)

(Photo credit: Tarrant Regional Water District)

(Photo credit: City of Fort Worth)

(Image: Tarrant Regional Water District)

Figure 16. Examples of optional amenities in Fort Worth.

Trail Design Best Practices

Trailheads

It is important that trails are designed to be accessed at multiple points.

Long stretches of trail with no access points can feel isolated to users. More access points and intersections also increase a sense of security because they create moments of visibility and permeability between the trail and surrounding uses. They also provide opportunities for people to exit the trail if they suddenly feel unsafe. Access points should be no more than ¼ mile to a ½ mile apart, and placement of access points should take into consideration the nearby on-street transportation network, transit stops, bike share stations, and points of interest. Access points should provide adequate signage and wayfinding, though they do not all need to be designed as trailheads.

Figure 17. Proposed Marine Creek Public Art Space (Source: Confluence: The Trinity River Strategic Master Plan)

Figure 18. Proposed University Drive Trail Bridge (Source: Confluence: The Trinity River Strategic Master Plan)

Figure 19. Coffee Shop Cart at the Clearfork trailhead. (Photo: Kimley-Horn Associates)

Figure 20. Stock Yards Entrance Sign (Photo: Kimley-Horn Associates)

Creating Trail Identity

Trails are a source of community identity and pride. These effects are magnified when communities use trails to highlight and provide access to historic and cultural resources. Many trails themselves preserve historically significant transportation corridors.

The City of Fort Worth has a rich historical background that can be incorporated into many different trail projects such as the Trinity Trails, the Bomber Spur, and the Cotton Belt Trail. Incorporating a unified vision and character into a trail's design can help transform trails from basic transportation corridors into cherished community gathering places.

Lighting Placement

Trail lighting is recommended at the following locations:

- Under vehicular bridges, underpasses, tunnels, or locations with limited visibility
- Along bridges used by bicycles and pedestrians
- Along routes or trail segments where frequent evening or nighttime use is anticipated
- On routes that are within ¼ mile from Trinity Metro transit stations, near schools and major employers
- Along high-use portions of Spine trails that lead to areas with frequent evening events (as determined by a lighting study)
- At trail intersections with roadways or driveways where crossing is required
- At major trail entrances/trailheads

Other Factors

Other factors to consider when planning lighting elements for a trail include:

- Limit lighting in natural and undeveloped areas to mitigate environmental disturbance, or use light fixtures designed to minimize negative impacts
- Consider timed lighting for commuting (e.g. evening and early dawn)
- Consider other needs of users related to nighttime and evening use (e.g., security measures)
- Include signage or information for trail users to notify the City if a light is out or damaged
- Artificial nighttime lighting should be turned off after curfew along riparian corridors and other less-developed areas.
- Trail lighting is not permitted on Oncor easement alignments

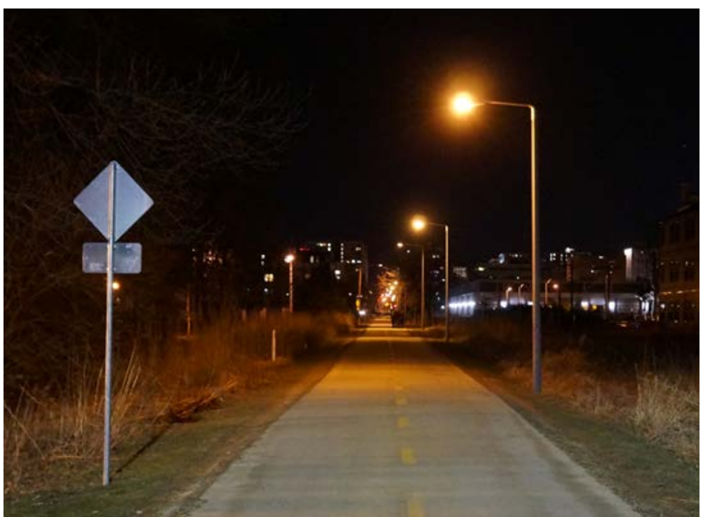


Figure 21. Sidepath Lighting in Burlington, VT.
(Photo: Toole Design)

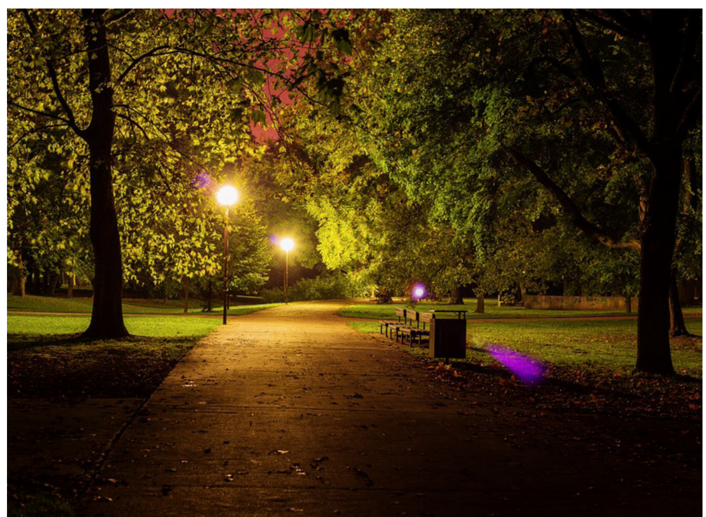


Figure 22. Pedestrian-Scale Lighting at Park
(Photo credit: ferobanjo, pixabay license)

Signage and Wayfinding

Appropriate and helpful signage is essential to making users comfortable along extensive trail systems. The elements of a well-designed signage system include:

- Uniformity and Design
- Legibility
- Placement
- Safety
- Communication
- Awareness

Figure 23. Example of Wayfinding Sign in Fort Worth.
(Photo Credit: City of Fort Worth)

Design Factors

Uniformity and Design

City staff and stakeholders should work together to create a streamlined design for wayfinding signs that allows trail users to easily identify, understand, and navigate the network.

Legibility

The shape, size, text, and icons on a sign should be legible for users of all ages and for both locals and visitors. They should also be easy to understand for English and non-English speakers, as well as visually impaired people. For important messages conveyed by text, consider including a Spanish translation.

Placement

Signs should be placed at entrances, intersections, and at forks in the trails to inform and guide trail users. Such signage aims to inform users of all directional options, nearby destinations, and attractions.

Communication

Signage should convey distance, direction, and destination. Trail etiquette signage conveys appropriate speed and “keep right, pass left” messages.

Awareness

In order for more people to use the trails, they need to know that they exist, where they are located, and how to access them. Better wayfinding and signage can attract more users.

Intersections and Crossings

It is important to properly design crossings to provide the safest situation for all users. Poorly designed or regulated crossings can lead to people disregarding traffic control measures, which reduces safety for everyone. The sign types, pavement markings, and crossing types will depend on the local conditions at each crossing.

Mid-Block Roadway Crossings

Mid-block trail crossings should be properly signed and marked. The crossing should be perpendicular to the street to minimize the crossing length. The approaching path can also have a horizontal curve in advance of the crossing to help slow down trail users as they approach. Mid-block crossings are not recommended on roadways with posted speeds of 40 MPH or greater unless a signal is installed.

Trail Bridges and Underpasses (Grade-Separated Crossings)

Bridges and underpasses are permitted when grade separation is needed for crossing a roadway or railroad, or when the natural topography cannot accommodate trail requirements such as streams or hills.

Bridges should be at least 1-2 feet wider than the trail on each side to allow users to stop without obstructing the trail and to provide a clearance for bicyclists from the adjacent railings.

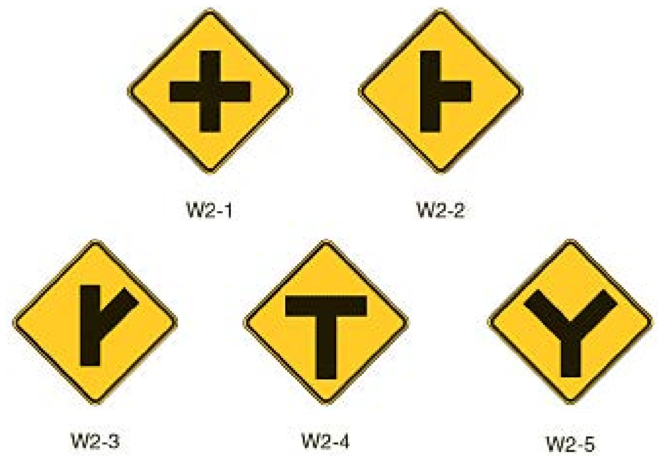


Figure 24. MUTCD signs W2-1, 2, 3, 4, 5

When designing a trail to accommodate bicycles across a high bridge, such as a bridge that goes over a body of water or major roadway, railing should be provided.AASHTO recommends a railing height of 42" – 48" depending on the site location. The railing design should also consider sight lines of pedestrians and bicyclists. Bridge approaches and span should not exceed 5% slope ADA access. Underpasses should be built to allow a vertical clearance of at least 10 feet. Refer to the 2019 Fort Worth Traffic Engineering Manual (TEM) for further guidance on bicycle facility design on bridges.

Multi-Use Trail

Users should be given adequate advance notice of intersections between two trails. Advanced warning signs, such as the MUTCD Intersection Warning signs (See Figure 23) or directional signs should be placed near the intersection. Advanced warning signs should be placed a minimum of 50 feet from the crossing and directional signs could be placed on the corners. The crossing paths should try to be aligned at a 90-degree angle when possible. The line of sight as the two trails converge should be kept clear of obstructions. Roundabout style intersections are also permitted as an alternative.

SIDEPATH DESIGN TOOLBOX

What is a Sidepath?

A sidepath is a two-way multi-use path, adjacent to the roadway, serving both pedestrians and cyclists (i.e., a trail that runs alongside a road). Sidepaths are typically separated from roadways and are 10 feet wide or greater, accommodating a variety of users. Typical users of sidepaths are bicyclists, walkers, and runners using the trail for recreation and transportation purposes.


Figure 25. Sidepath in Fort Worth. (Photo credit: City of Fort Worth)

Fort Worth MTP

In the Fort Worth Master Thoroughfare Plan (MTP), sidepaths are not used on Activity Streets and Commerce/Mixed-Use Streets, because areas with higher volumes of pedestrians and bicyclists have greater potential for conflicts between modes. For the other street types (Neighborhood Connectors, Commercial Connectors, and System Links), sidepaths are used in locations that are not considered major bicycle commuter routes.

Design Guidance

The following table summarizes the specific design elements of a sidepath. See the following sections for detailed information on these elements.

Design Elements

Elevation	Typically sidewalk-level (or street-level on curbless streets)
Width	8’ - 12’ 10’ preferred (Required for MTP sidepaths)
Surface Material	Concrete
Curb Type	Vertical
Signage and Pavement Marking	Recommended at crossings to alert drivers to a conflict zone and two-way bicyclist movement

Elevation

MTP sidepaths are required to be located behind the curb on the level of the sidewalk.

Benefits of a sidewalk-level sidepath:

- Allows separation from motor vehicles in locations where the street buffer width is constrained
- Maximizes the usable width
- May reduce maintenance needs by prohibiting debris build up from roadway run-off

Width

According to the Fort Worth MTP, sidepath widths should be are between 8 and 12 feet on established thoroughfares. If a path is designed to be two-way or is on a high-volume road, then the width must be at least 10 feet. The minimum of 8 feet should only be used in constrained conditions, where 10 feet cannot be achieved. A waiver of MTP requirements may be required.

Shy Distance

Proximity to vertical obstructions and objects along the route can affect the operation of a sidepath. In particular, bicyclists shy away from vertical obstructions and other users to avoid handlebar strikes. The effective rideable surface of the sidepath is lessened when vertical objects are immediately adjacent to the sidepath. To maintain comfort and safety of users, a shy distance of between 6” (minimum) and 24” (preferred) should be provided between the edge of the sidepath and adjacent benches, sign posts, or other objects.

Curb Type

The appropriate curb type for sidepaths is a vertical curb. Vertical curbs are designed to prohibit encroachment by motor vehicles.

Common Challenges

When designing a comfortable experience for sidepath users, it is important to address the following common challenges:

- Debris and objects in the right-of-way
- Frequent grade changes
- Signs and poles
- Pedestrians exiting parked cars
- Sight lines
- Intersections and driveway crossings

More details on how to address these challenges can be found in the AASHTO Guide for the Development of Bicycle Facilities or TEM.

BICYCLE FACILITY DESIGN TOOLBOX

There are several types of on-street bikeways classified in the Active Transportation Plan: conventional bike lanes, buffered bike lanes, separated bike lanes, and bicycle boulevards. This section describes each of these on-street facility types, as well as elements to consider when designing them. See the Fort Worth Bicycle Facility Selection Guide for information on when to select various bikeways to achieve comfortable conditions. Note that the MTP supersedes the ATP and the facility selection guidance.

Conventional Bike Lanes

Conventional bike lanes are dedicated, striped lanes for bicycle use only.

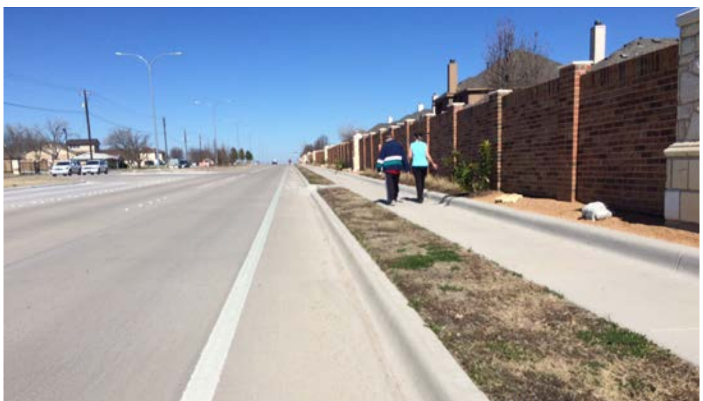


Figure 26. Conventional Bike Lane (Photo credit: City of Fort Worth)

When to Use Them

Conventional bike lanes only provide comfortable conditions on roadways with fewer lanes, lower traffic volumes, and vehicle speeds. They achieve moderate comfort, suitable for typical adult riders. For example, they may be appropriate facilities on many two-lane Residential/Industrial/Retail Collectors and Commerce/Mixed Use streets without parking.

Design Elements

Width Criteria

- The preferred width is 6 feet. The MTP allows a minimum width of 5 feet on Commerce/Mixed-Use Streets due to lower automobile speeds.

System Links in the MTP do not use conventional bike lanes in their cross sections.

Buffered Bike Lanes

Buffered bike lanes provide additional striped space between bicyclists and vehicle travel or parking lanes.

Figure 27. Buffered bike lane (Photo credit: City of Fort Worth)

When to Use Them

Use buffered bike lanes:

1. To provide separation between parked cars and the bike lane on Activity Streets and Commerce/Mixed-Use Streets.
2. To provide space between bicyclists and moving automobiles on streets such as Commercial Connectors.

Design Elements

- Adjacent to parallel parking, use a 3-foot buffer next to a 5-foot bike lane (total width of 8 feet), to keep the “door zone” clear.
- Adjacent to diagonal parking, use a 2-foot buffer next to a 5-foot bike lane (total width of 7 feet).
- Next to the curb, use a 5-foot bike lane and 3-foot buffer (total of 8 feet).

Separated Bike Lanes

A separated bike lane includes a vertical element between bicyclists and moving vehicles.

Figure 28. Example of a sidewalk-level Separated Bike Lane in Indianapolis, IN. (Photo credit: Toole Design)

When to Use Them

Separated bike lanes generally provide high levels of comfort for a range of bicyclists and are a critical component of an all ages and abilities network.

Separated bike lanes are required on some Neighborhood Connectors and may be appropriate on Commerce/Mixed Use or Activity Streets. See the Fort Worth Bicycle Facility Selection Guide starting on page 43 for information on when to use separated bike lanes.

Design Considerations

Placement of Separated Bike Lanes

The MTP calls for sidewalk-level separated bike lanes behind the curb. On-street separated bike lanes are permitted by the MTP, though specific cross-sections are not provided. Information on selecting one-way or two-way configurations and forms of separation is provided below.

Widths

On established thoroughfares, the MTP calls for 6’ one-way separated bike lanes on Neighborhood Connectors. As expected volumes of riders increase, the width may increase to accommodate a range of bicyclist speeds.

The preferred total width for a two-way separated bike lane is 11 feet (10 feet minimum) at bicyclist volumes of less than 150/hour, with preferred widths increasing as expected volumes increase.

Transit Stops

Separated bike lanes can be integrated with a variety of transit stop designs. They are compatible with mid-block, near-side and far-side transit stop locations. Where feasible, separated bike lanes should be routed between the transit stop and the curb to eliminate conflicts between buses and bicyclists. Known as a “floating transit stop,” this design repurposes street buffer space into a dedicated passenger platform between the motor vehicle lane and the bike lane. More information is provided in the Transit Corridors section of this Toolbox.

Bridge Design

Bridge crossings are significant investments and therefore typically occur infrequently. However, bridges provide critical access linkages in a community; and when they are designed, it is important that they accommodate bicyclists. A bridge without bicycling access can result in a lengthy detour that discourages the trip, or requires the use of unsafe facilities.

Separated bike lanes on bridges should include a buffer between the leading edge of a bridge railing and the edge of the approaching bicycle facility. Refer to the 2019 Fort Worth Traffic Engineering Manual (TEM) for further guidance on bicycle facility design on bridges.

Figure 29. Sidewalk-level Separated Bike Lane (Photo credit: Toole Design)

High-Volume Driveways

Driveways with low volumes of motor vehicle traffic have fewer potential conflicts and their crossings can be marked with a standard separated bike lane crossing. Driveways with higher volumes of vehicles should incorporate design treatments that increase visibility and awareness for motorists and bicyclists.

Loading Zones

Designated loading zones may accommodate passenger loading (e.g., pick-up and drop-off at schools, hotels, hospitals, taxi stands, etc.), commercial loading (e.g., goods or parcel deliveries), or both. Commercial loading zones are not required to be accessible. Passenger loading zones need to be accessible to individuals with disabilities. If necessary, the bike lane may be narrowed (to 4 feet) at accessible loading zones to accommodate the pedestrian access route. Figure 29 shows an example of an accessible loading zone next to a street-level separated bike lane.

Trash Collection

Where separated bike lanes are introduced, the general public, public works staff and contractors should be trained to place trash bins in the street buffer zone to avoid obstructing the bike lane. Sidewalk buffers may be used to store bins where street buffers are too narrow.

Forms of Separation

As shown in Figure 30, there are many different physical barriers that can be used to separate the bike lane from traffic, including:

- Plastic delineator posts
- Bollards
- Concrete barriers
- Concrete median/curb
- On-street parking
- Planter boxes

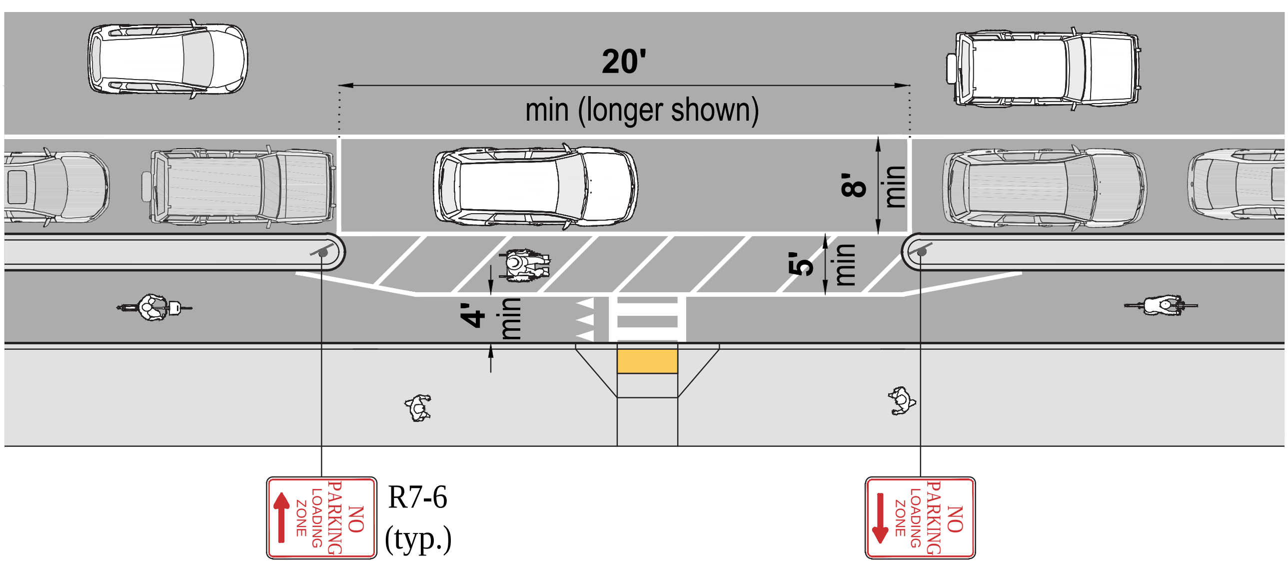


Figure 30. Loading Zone along Bike Lane (Graphic: Toole Design)

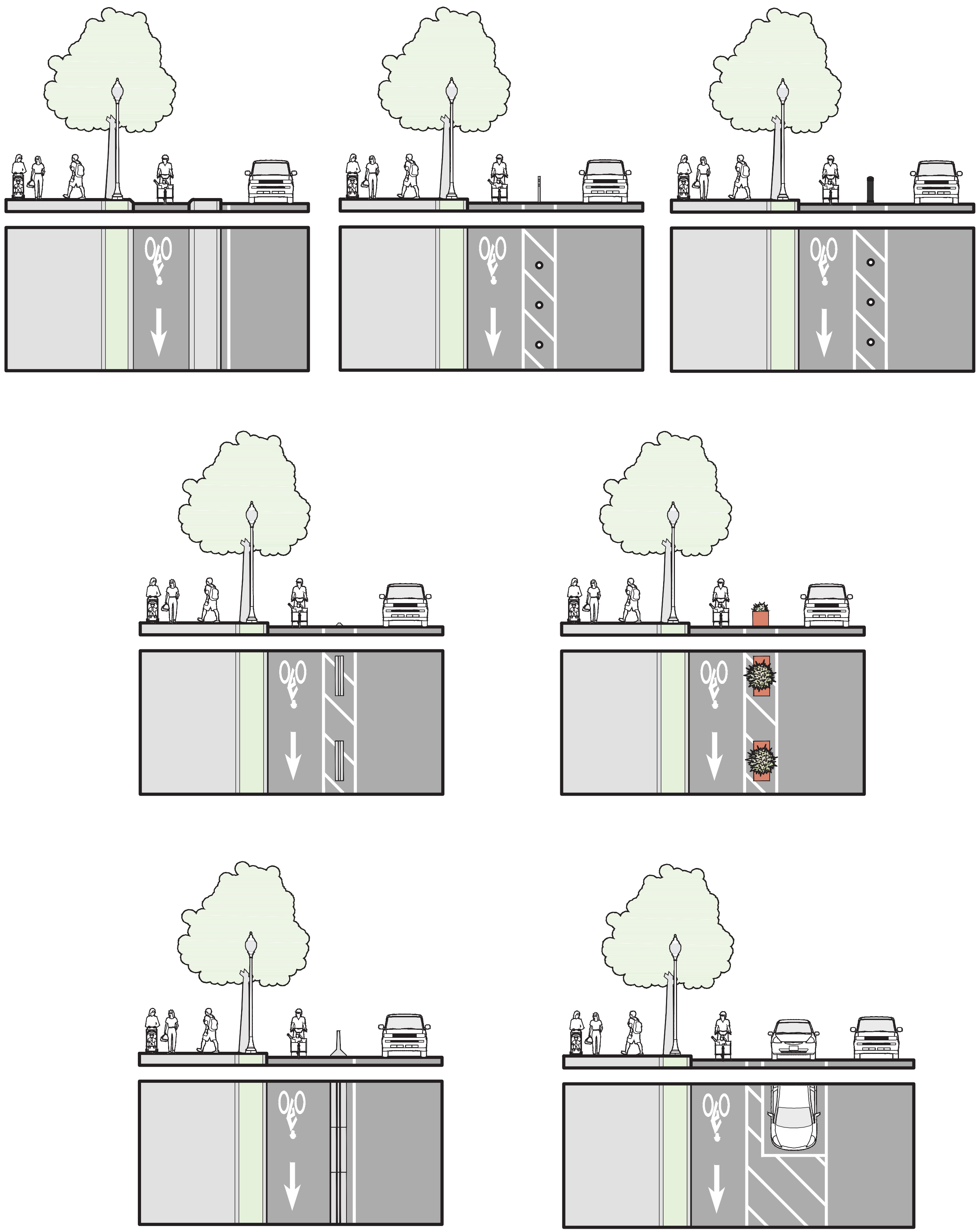


Figure 31. Vertical Elements Providing Separation Between Bicyclists and Moving Vehicles (Graphic: Toole Design)

One-way or Two-way Design

Separated bike lanes may be designed for one-way or two-way bicycle traffic and can be used on both one- or two-way streets. Figure 31 and Figure 32 describe the key considerations to determine the appropriate design.

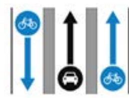
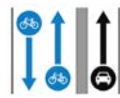
Corridor-level Planning Considerations	One-way SBL	Counterflow SBL	One-way SBL Plus Counterflow SBL	Two-way SBL
				
Access to Destinations	Limited access to other side of street		Full access to both sides of street	Limited access to other side of street
Network Connectivity	Does not address demand for counterflow bicycling, may result in wrong way riding	Requires bicyclists traveling in the direction of traffic to share the lane (may result in wrong way riding in the SBL); counterflow progression through signals may be less efficient	Accommodates two-way bicycle travel, but counterflow progression through signals may be less efficient	
Crash Risk	Lower because pedestrians and turning drivers expect concurrent bicycle traffic	Higher because pedestrians and turning drivers may not expect counterflow bicycle traffic		
Intersection Operations	May use existing signal phases; bike phase may be required depending on volumes	Typically requires additional signal equipment; bike phase may be required depending on volumes		

Figure 32. Considerations for Separated Bike Lane Configurations on a One-Way Street (Source: Toole Design)

Corridor-level Planning Considerations	One-way SBL Pair	Two-way SBL	Median Two-way SBL
			
Access to Destinations	Full access to both sides of street	Limited access to other side of street	Limited access to both sides of street
Network Connectivity	Accommodates two-way bicycle travel		
Crash Risk	Lower because pedestrians and turning drivers expect concurrent bicycle traffic	Higher because pedestrians and turning drivers may not expect counterflow bicycle traffic	Higher because pedestrians and turning drivers may not expect counterflow bicycle traffic, but median location may improve visibility and create opportunities to separate conflicts
Intersection Operations	May use existing signal phases; bike phase may be required depending on volumes	Typically requires additional signal equipment; bike phase may be required depending on volumes	

Figure 33. Considerations for Separated Bike Lane Configurations on a Two-Way Street (Source: Toole Design)

Bicycle Boulevards

Bicycle boulevards incorporate traffic calming treatments with the primary goal of prioritizing bicycle through-travel while maintaining relatively low motor vehicle speeds and volumes. These treatments are typically applied on streets in residential neighborhoods.

Bicycle Boulevards are different from signed bike routes in that they include engineering treatments that manage speed and traffic volumes. Bicycle Boulevards must also include safety enhancements for bicyclists at intersections, particularly at major crossings.

WHEN TO USE THEM

Bicycle Boulevards are appropriate on local, neighborhood streets, and are often an appropriate alternative to a high-speed parallel bike lane.

OPERATING CHARACTERISTICS

To be considered a bicycle boulevard, traffic volumes and speeds must be low. Table 1 shows target speeds and volumes.

Table 4. Bicycle Boulevard Speed and Volume Thresholds

	Hourly Traffic Volume	Daily Traffic Volume	Speed
Preferred	50 vehicles/hr	1,000 ADT	15 mph
Acceptable	75 vehicles/hr	2,000 ADT	20 mph
Maximum	100 vehicles/hr	3,000 ADT	25 mph

DESIGN ELEMENTS

Route Identification

Bicycle boulevard routes may be marked by:

- Wayfinding
- Shared Lane Markings, and
- BICYCLES MAY USE FULL LANE signs

Traffic Calming/Speed Management Strategies

Slowing vehicle speeds and managing volumes along a bicycle boulevard can improve the comfort and safety of bicyclists using the corridor. Treatments vary depending on context, but often include traffic diverters, traffic circles, chicanes, pavement markings, and signage. The next section of this Toolbox provides more guidance on Traffic Calming techniques that are appropriate on Bicycle Boulevards.

Figure 34. Bicycle Boulevard in San Louis Obisbo.
(Photo Credit: Toole Design)

Traffic Calming

Traffic calming measures are generally most appropriate in neighborhood or mixed-use settings where there is a high demand for bicycle and pedestrian activity. By reducing motor vehicle speeds, traffic calming measures have the potential to significantly reduce bicycle and pedestrian related crashes.

Traffic calming measures are most effective when they are deployed at regular intervals ranging from 200-400 feet between treatments. It is not necessary to provide the same traffic calming treatments throughout a corridor. Treatments should be chosen to meet each location's traffic or speed management objectives.

Some examples of traffic calming measures are:

- Bulb-Outs/Neckdowns
- Skinny Streets/ Narrow (Yield) Streets
- Chicanes
- Neighborhood Traffic Circles and Mini Roundabouts
- Roundabouts

Bulb-Outs/Neckdowns/Curb Extensions

Bulb-outs (also known as curb extensions) are extensions of the sidewalk/landscape zone that physically narrow streets at intersections and mid-block crossings. They provide shorter pedestrian crossing distances and improve the visibility of pedestrians as they wait to cross the street. Streets with on-street parking lanes are particularly appropriate for bulb-outs. Neckdowns are similar treatments that narrow the travelway in order to slow vehicle traffic, either through curb extensions or center islands. Neckdowns can occur anywhere along a street (including non-crossing locations).

Figure 35. Narrow or Yield Street in California. (Photo credit: Toole Design)

Narrow/Yield Streets

These streets are narrow residential roads that require motor vehicles to pull to the side into a parking lane or driveway to allow approaching vehicles to pass. Yield streets require low motor vehicle speeds and are most effective where on-street parking utilization does not exceed 40-60 percent of the street. On-street parking should be prohibited within 20 to 50 feet of the right-hand side of intersections to accommodate turning movements and increase visibility.

The City of Fort Worth's standard width for local streets is 28 ft. The width of "yield streets" should be less than 28 ft wide with parking on both sides, or 20 ft wide with parking on one side.

Figure 36. This island in Maryland narrows the travel lanes and creates a curve in the road, both of which cause vehicles to slow down (Photo credit: Toole Design)

Chicanes

A chicane is a series of two or more staggered curb extensions on alternating sides of the roadway. They are usually landscaped with ground cover, bushes, and trees. Navigating through the curve created by the chicane encourages drivers to slow down.

Figure 37. A roundabout in Olympia, WA, that accommodates pedestrians and cyclists. (Photo credit: Toole Design)

Roundabouts

When installed at appropriate locations, roundabouts can reduce delay and increase capacity through an intersection compared to a traditional all-way-stop design. Well-designed roundabouts can also reduce travel speeds and the number of conflicts points. While the confident bicyclist may be comfortable traversing a roundabout in a shared lane environment, many bicyclists will not feel comfortable navigating roundabouts with vehicular traffic, especially multilane roundabouts. Bike lanes may not be located within the circulatory roadway of a roundabout. For comfort and safety reasons, roundabouts should be designed to facilitate bicycle travel outside of the roadway.

Figure 38. Bicyclists and a bus navigate through a neighborhood traffic circle in Portland, OR. (Photo credit: Toole Design)

Neighborhood Traffic Circles and Mini Roundabouts

Neighborhood traffic circles are raised islands constructed at intersections or neighborhood streets, often replacing a two-way or all-way stop-controlled design. They are typically landscaped with ground cover, bushes, and trees. Traffic circles require drivers to slow to a speed that allows them to comfortably maneuver around them. Mini roundabouts are also installed at minor intersection crossings (i.e., usually intersections of two local streets), but typically feature yield control on all approaches.

PEDESTRIAN DESIGN TOOLBOX

Sidewalks are critical to pedestrian safety, comfort, and accessibility. They connect neighborhoods, activity streets, commercial/mixed use streets, and other community destinations.

In addition to providing space for pedestrians and transit stop facilities, the space between property lines and curbs also accommodates street trees and other plantings, stormwater infrastructure, street lights, and bicycle racks. This section defines those zones and provides considerations for better activating the streetscape to enhance the users' experience.

See the ATP for information on how factors such as transparency, enclosure, human scale design, complexity, and imageability impact the pedestrian experience and how they are measured in Fort Worth.

Subdivision Elements

When a new development is approved, it is important to consider what trails or facilities are located nearby. The ATP recommends a revision to Section 31-102 "Streets and Block Arrangement" of the Subdivision Ordinance that would require access from all neighborhoods to the proposed Active Transportation Plan network and the provision of trail network connections to community destinations.

Subdivisions should provide connectivity for pedestrians and bicyclists to adjacent ATP facilities and between adjacent neighborhoods. This is accomplished through a connected street network and, in some cases, cul-de-sac easements and internal circulation plans.

The location and orientation of buildings are also important considerations. Every effort should be made to ensure that new bicycle and pedestrian facilities lead to the front of existing and future buildings.

Master Thoroughfare Plan Street Types

Within Fort Worth's MTP, there are five different street types:

- Activity Street
- Commerce/Mixed-Use Street
- Neighborhood Connector
- Commercial Connector
- System Link

There are also two types of non-thoroughfare streets:

- Collectors
- Arterials

The MTP contains minimum dimensions for sidewalks/pedestrian zones, bicycle facilities, buffer space, and flex space for each street type. Refer to the MTP for the minimum dimensions of these street elements.

Functional Zones

As shown in Figure 37, pedestrian design divides the sidewalk width into three different zones:

- The Frontage Zone – the area that immediately abuts buildings along the street. Its elements include architectural features, awnings, signage, outdoor displays, and seating.
- The Sidewalk/Pedestrian Zone – the walking zone. This area should be kept clear of obstacles to allow more volumes of users.
- The Landscape / Furnishing Zone – the area between the curb and the Pedestrian Zone. This zone's elements include lights, trees, bicycle racks, parking meters, or any other elements that need to remain close to the curb. For the purposes of dimensions, the MTP refers to this as the "Clear Zone plus Furnishing Zone."

Sidewalk/Pedestrian Zone

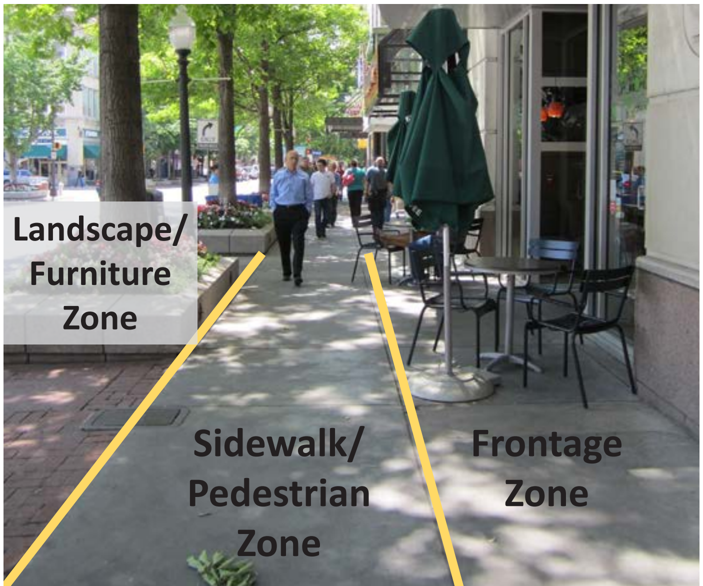


Figure 39. Various zones of the pedestrian realm. (Photo credit: City of Fort Worth)

Sidewalk Widths

Dimensions for sidewalks come from the MTP. Sidewalk width requirements vary by street type. In most cases, sidewalks should be between 5 and 6 feet.

A sidepath with a 10-foot minimum width may function as the pedestrian/sidewalk zone in locations that are not considered major bicycle commuter routes.

Refer to the MTP for specific guidance on sidewalk widths within the five different street typologies.

Accessibility Requirements

Americans with Disabilities Act (ADA) regulations apply to the accessibility requirements for sidewalks. The proposed PROWAG guidelines cover facilities within public rights-of-way.

Grade-separated crossings must meet accessibility requirements, which may include elevators, ramps, landings, and handrails.

Pedestrian access routes (sidewalks) must meet accessibility criteria at driveway crossings. Refer to the 2019 TEM for more information.

Curb Ramps

Curb ramps provide access between the sidewalk and the street for people who use mobility aids such as wheelchairs and motorized scooters. Curb ramps are required by law for newly constructed or altered streets, roads, and sidewalks. Alteration activities include reconstruction, rehabilitation, resurfacing, and widening.

Curb ramps are required at all pedestrian crossings, including mid-block crossings and intersections. The 2019 TEM provides more information on curb ramp design.


Figure 40. Curb ramp. (Photo credit: Toole Design)

Street Spacing

Long distances between crossings reduce perceived pedestrian safety and comfort, due to increased walking distances and a higher likelihood of jay walking. Block length is dictated by the Subdivision Ordinance and street spacing is dictated by the City of Fort Worth Access Management Policy.

Figure 41. The sidewalk zone should be free of obstructions, such as signs, utilities, and landscaping. (Photos: City of Fort Worth)

Landscape and Furniture Zone

The Landscape/Furniture Zone provides a buffer between pedestrians and motor vehicle traffic.

Buffer Width

In the MTP, the widths of the buffer between the pedestrian zone and the roadway range from 2.5 feet on some Activity Streets to 6.5 feet on some Commerce/ Mixed-Use Streets. Refer to the MTP and the 2019 TEM for more information on flex space, buffer location, and buffer design.

Amenities

In addition to providing a buffer from moving motor vehicles, the Landscape/Furniture Zone provides space for the following amenities.

Street Furniture

Public seating and furniture enhances the usability and enjoyment of the street and can be provided in a number of different ways. Seating may be fixed, or it may be mobile and adaptable. Seating can be made of any number of materials, however durability and maintenance are key considerations.

Seating should be located where it is most attractive and useful, such as under shade and near lighting.

Pedestrian-Scale Lighting

Street lighting includes roadway and pedestrian lighting in the public right-of-way.

Lighting should be designed not only for vehicular traffic on the roadways, but also for pedestrians on sidewalks and sidepaths. Refer to the 2019 TEM for guidance on lighting design and placement as it relates to bicycle and pedestrian facility design.

Landscaping

Green street elements include trees, shrubs, grasses, vegetated stormwater facilities, and other landscape plantings. Green elements play an important role in making streets comfortable, memorable, and sustainable.

In particular, street trees improve walkability by providing shade and filtered light. Street trees can define street boundaries; provide shade and tranquility; act as a vertical wall that helps motorists gauge their speed; reduce air pollution; intercept rainfall and absorb stormwater runoff; and more.

The type of tree selected will depend on the constraints and conditions of the available space, including tree well width, distance to intersections and vertical elements, and the presence of overhead wires. In dense urban areas or those with limited sidewalk width, ADA-compliant tree grates are required.

Refer to the City’s Guidelines for Landscaping in Parkways for more details.

Parking as a Buffer

Although not located in one of the three pedestrian zones, it is worth noting that on-street parking can have a positive effect on walking conditions. Studies have shown that drivers tend to travel at slower speeds in the presence of on-street motor vehicle parking. A row of parallel-parked cars creates a buffer between pedestrians and moving vehicles. Parking is not allowed on thoroughfares classified as Connectors or System Links.

INTERSECTION TOOLBOX

Trail Crossings and Intersections

Trail Crossings are covered in the Trails section of this Toolbox.

Bicycle Treatments at Intersections

Good intersection design should:

- Minimize exposure to vehicle conflicts,
- Reduce speeds at conflict points,
- Communicate right of way priority,
- Provide sufficient sight lines, and
- Accommodate persons with disabilities.

The following guidance should be applied when designing intersection treatments for bicyclists:

- Provide a direct, continuous facility to the intersection,
- Provide a clear route for bicyclists through the intersection,
- Reduce and manage conflicts with turning vehicles,
- Provide signal design and timing to accommodate bicyclists, and
- Provide access to off-street destinations.

Selective removal of parking spaces may be needed to provide adequate visibility and to establish sufficient bicycle lane width at approaches to intersections.

Pavement Markings

Markings in conflict areas can be used at intersections to improve visibility, alert roadway users of expected behaviors, and reduce conflicts with turning vehicles.

The types of markings used in conflict areas shown in Figure 40 are (from left to right):

- Dotted line extensions
- Chevron markings
- Bike lane markings
- Colored conflict area
- Colored dashes
- Elephant's feet

The type of pavement marking should be chosen by the local context of the roadway. The City of Fort Worth typically uses dashed green lines for conflict areas.

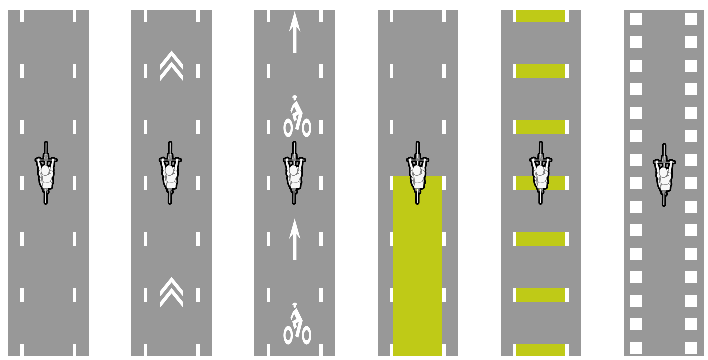


Figure 42. Pavement marking types for conflict areas (Graphic: Toole Design)

Mixing Zones

A mixing zone requires turning motorists to merge across a buffered or separated bicycle lane at a defined location in advance of an intersection. Unlike a standard bicycle lane, where a motorist can merge across at any point, a mixing zone design limits bicyclists' exposure to motor vehicles by defining a limited merge area.

Mixing zones are generally appropriate as an interim solution or in situations where right-of-way constraints make it infeasible to provide a protected intersection.

Figure 43. A bicyclist having crossed a mixing zone in Fort Worth. (Photo credit: City of Fort Worth)

A clearly defined, slow speed merging area should be established to increase the predictability and safety of all users. Motor vehicle speeds can be controlled by:

- Minimizing the length of the merge area,
- Locating the merge point as close as practical to the intersection,
- Minimizing the length of the storage portion of the turn lane,
- Providing vertical separation (e.g., flex posts) after the merge area, and
- Using pavement markings to highlight the conflict zone (see above).

Protected Intersections

A protected intersection is a specific intersection treatment that limits the intersection's conflict zone by separating motor vehicles, pedestrians, and bicyclists. It is an important tool for intersections involving separated bike lanes.

Elements of Protected Intersections

As outlined in Figure 42, protected intersections have the following elements:

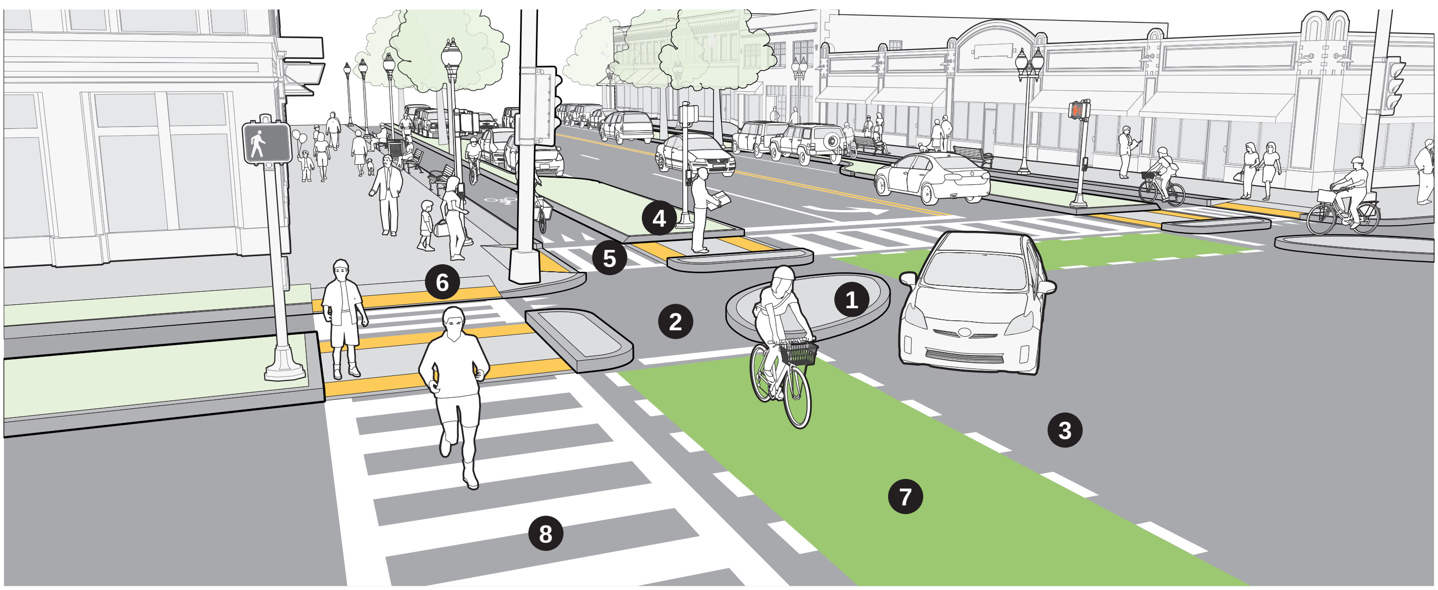
- Corner island
- Forward bicycle queuing area
- Motorist yield zone
- Pedestrian crossing island
- Pedestrian crossing of separated bike lane
- Bicycle crossing of motor vehicle lanes

When to Use Them

Protected intersections are the preferred intersection treatment when two separated bike lanes intersect one another and when conventional bike lanes transition to separated bike lanes.

Protected intersections may also be appropriate:

- At any intersection on a street with a bike lane (even if the intersecting streets have no bike facility)
- Locations where the number of bikes is at least half the number of motor vehicles
- Near schools, parks, and places where children and older adults are expected



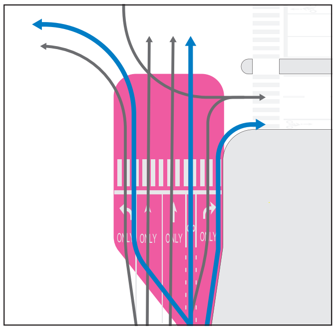
1. corner island
2. forward bicycle queuing area
3. motorist yield zone
4. pedestrian crossing island
5. pedestrian crossing of the separated bike lane
6. pedestrian curb ramp
7. bicycle crossing of travel lanes
8. pedestrian crossing of travel lanes

Figure 44. Elements of Protected Intersections (Graphic: Toole Design)

Bicyclist Exposure at Intersections

The diagrams on this page provide a comparison of the levels of exposure associated with various types of intersection designs.

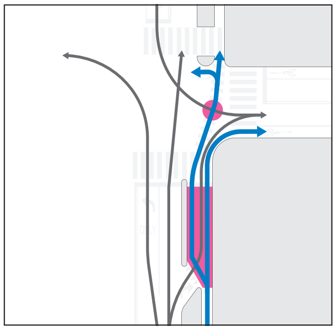
Exposure Level:
High



CONVENTIONAL BIKE LANES AND SHARED LANES

Bike lanes and shared lanes require bicyclists to share and negotiate space with motor vehicles as they move through intersections. Motorists have a large advantage in this negotiation as they are driving a vehicle with significantly more mass and are usually operating at a higher speed than bicyclists. This creates a stressful environment for bicyclists, particularly as the speed differential between bicyclists and motorists increases. For these reasons, it is preferable to provide separation through the intersection.

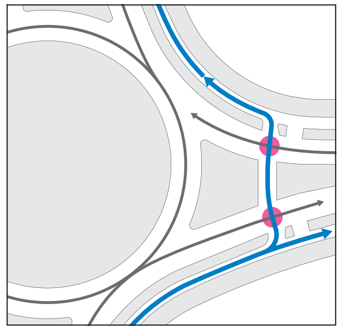
Exposure Level:
High to Medium



SEPARATED BIKE LANES WITH MIXING ZONES

One strategy that has been used in the U.S. at constrained intersections on streets with separated bike lanes is to reintroduce the bicyclist into motor vehicle travel lanes (and turn lanes) at intersections, removing the separation between the two modes of travel. This design is less preferable to providing a protected intersection for the same reasons as discussed under conventional bike lanes and shared lanes. Where provided, mixing zones should be designed to reduce motor vehicle speeds and minimize the area of exposure for bicyclists.

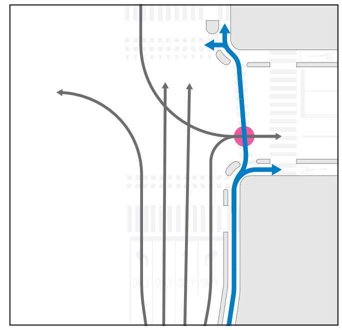
Exposure Level:
Medium to Low



SEPARATED BIKE LANES THROUGH ROUNDABOUTS

Separated bike lanes can be continued through roundabouts, with crossings that are similar to, and typically adjacent to, pedestrian crosswalks. Motorists approach the bicycle crossings at a perpendicular angle, maximizing visibility of approaching bicyclists. Bicyclists must travel a more circuitous route if turning left and must cross four separate motor vehicle path approaches. Yielding rates are higher at single-lane roundabouts.1

Exposure Level:
Low



PROTECTED INTERSECTIONS

A protected intersection maintains the physical separation through the intersection, thereby eliminating the merging and weaving movements inherent in conventional bike lane and shared lane designs. This reduces the conflicts to a single location where turning traffic crosses the bike lane.

Bicycle
Motor Vehicle
Conflict Area

Figure 45. Comparison of Bicyclist Exposure at Intersections (Source: MassDOT Separated Bike Lane Planning & Design Guide).

Pedestrian Crossing Treatments

Pedestrians legally have the right to cross at all intersections, unless otherwise prohibited. Marked pedestrian crossings can be provided at intersections or mid-block locations. Key considerations when identifying locations for pedestrians crossing treatments include:

- Locate mid-block crossings based on pedestrian movement, building entrances, attractions, etc.,
- Include overhead signage and lights,
- Provide curb extensions where there is on-street parking to maintain pedestrian visibility,
- Provide raised crossings where traffic calming is necessary (typically used on local streets),
- Align with entrances to buildings, parks, walkways, etc.,
- Use to delineate the preferred pedestrian route, and
- If u-turns are included, consider a marked pedestrian crossings to minimize conflicts with turning traffic.

Curb Extensions

Curb extensions are wider sections of sidewalk which narrow the roadway width at intersection corners or at mid-block locations. Details are provided in the Traffic Calming section of this Toolbox.

Midblock Crossings

Midblock crossings are used in locations with significant pedestrian movement or long distances between intersections. Bulb-outs and median islands allow protection to pedestrians waiting to cross the street.

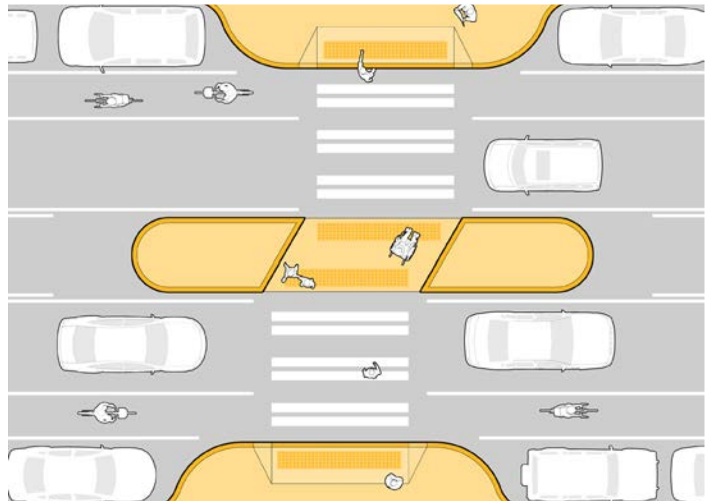


Figure 46. The curb extensions and median island allow protection to pedestrians waiting to cross the street (Graphic: Toole Design)

Crossing Islands

Crossing islands are raised islands that provide a pedestrian refuge and allow multi-stage crossings of wide streets. They can be located mid-block or at intersections and along the centerline of a street, as roundabout splitter islands, or as “pork chop” islands where right-turn slip lanes are present.

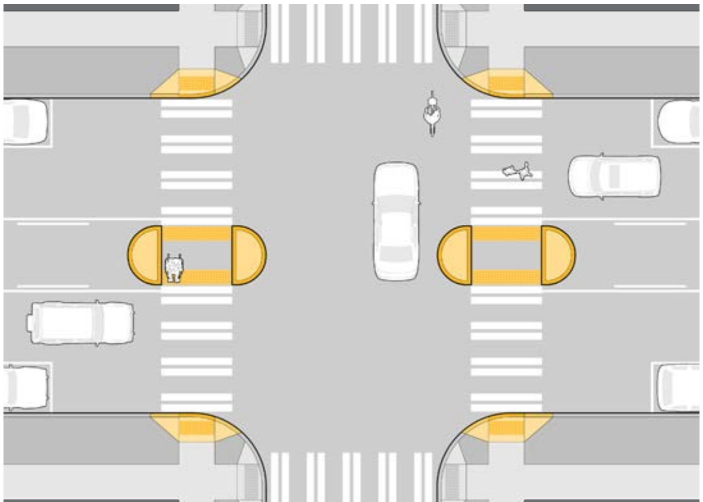


Figure 47. Crossing islands on wide streets allow refuge areas for pedestrians to wait for safe times to cross the street (Graphic: Toole Design)

Raised Crosswalks

Raised crosswalks elevate the pedestrian and encourage vehicles to slow down at the crossing. Raised crosswalks can also help eliminate ponding at curb ramps, which is especially beneficial for people with mobility and vision impairments. Raised crosswalks are often used with curb extensions to further improve pedestrian crossing safety.

Raised intersections are created by raising the roadway to the same level as the sidewalk through the entire intersection.

When to Use Them

- Raised crosswalks and intersections should be considered in school zones and locations where pedestrian visibility and motorist yielding have been identified as concerns.
- Consider using them at unsignalized mid-block locations, where drivers are less likely to expect or yield to pedestrians.
- Design speeds and emergency-vehicle needs must be considered when designing approach ramps.

Design Guidelines

- Raised crosswalks should be the same height as adjacent curbs, generally 6 inches high.
- Raised crosswalks should be 24 feet wide, including two 7-foot ramps and a 10-foot flat top.
- On-street parking should be restricted for 20 feet in advance of the crosswalk.
- Pavers or textured surfaces should not be used.

Signalization

Leading Pedestrian Interval

The leading pedestrian interval is used to allow pedestrians to enter the intersection prior to vehicular traffic. Between 3 to 7 seconds of additional walk time is added to the start of the pedestrian phase, while the vehicular traffic remains in the red phase. With this additional time, pedestrians are able to travel far enough to establish their position in the crosswalk before turning traffic is released.

Countdown Timers

Pedestrian signals are used to manage pedestrian crossings, typically in conjunctions with motor vehicles and bicycles. These signals should be used where pedestrians might be present. Pedestrian signal heads display three intervals of the pedestrian phase:

- The Walk Interval – signified by the WALK indication, alerts pedestrians to begin crossing the street
- The Pedestrian Change Interval – signified by the flashing DON'T WALK indication and numerical display of seconds remaining to cross the street, alerts pedestrians approaching the crosswalk that they should not begin crossing the street
- The Don't Walk Interval – alerts the pedestrians that they should not cross the street

Audible Signals

All countdown signals for pedestrians should include audible instructions for the hearing or sight impaired.

Right Turn on Red Restrictions

Minimizing conflicts between motor vehicle and pedestrian movements is one of the primary challenges for traffic signal design. Motorists making a right turn on red are typically focused on looking for traffic on their left and, as a consequence, may be unaware of pedestrians crossing on their right side. Restricting right turns on red is a low-cost technique to improve safety and comfort for pedestrians during the crossing phase. A traffic study may be needed to determine the appropriate use of this treatment.

This method is accomplished by adding a "NO TURN ON RED" sign, or using more effective measures like adding a red ball in the center of the sign or providing a red turn arrow in addition to the sign.

Figure 48. Example of a pedestrian countdown signal (Photo: Toole Design)

PEDESTRIAN- AND BICYCLE-FRIENDLY TRANSIT CORRIDORS TOOLBOX

Transit corridors are the backbone of the pedestrian network. Most transit trips are not door-to-door, so each one begins and ends with another mode of transportation, usually walking or bicycling. As such, transit corridors should be designed for both pedestrians and bicyclists to safely and comfortably access the bus.

Transit corridors include elements that are the responsibility of Trinity Metro, such as bus stops, shelters, and benches and transit-supportive elements that are the purview of the City of Fort Worth such as street lighting, crosswalks, and curb ramps. This section briefly describes best practices on these elements.

For more information on transit corridors, see the ATP (which identifies transit routes in the pedestrian network), the most recent transit plan, and the MTP.

Trinity Metro Support Elements

Bus Stops

Bus stops are where public transportation vehicles stop to allow passengers to board or alight the transit vehicle. Bus stops are typically located adjacent to the sidewalk and identified by signage featuring the transit operator's logo.

Figure 49. Bus stop landing pad (Photo credit: Trinity Metro)

Benches

Well-designed street furniture makes bus stops more comfortable and convenient to use. Benches provide places to rest, catch up with neighbors, or have lunch.

Figure 50. Two benches accommodate seating for up to eight people at an MBTA bu stop in Brookline, MA. (Photo: MBTA)

Bus Shelters

Where space permits, bus stops should have shelters that provide protection from the elements, seating and pedestrian scale lighting to ensure waiting users are visible at night. Shelters at bus stops can:

- Help to increase the visibility of a stop;
- Be used to incorporate various forms of rider information;
- Protect passengers from the sun, wind, rain and snow;
- Provide protected seating; and Provide additional lighting.

Passenger Information

Providing information at bus stops in traditional and technical formats is an important aspect of rider convenience and comfort. Traditional methods include providing printed schedules with maps, trip times or route frequencies. Wayfinding maps to specific local destinations are beneficial for integrating bus stops into the surrounding neighborhood and providing an immediate means for new riders to find their way.

Technological advances provide for the incorporation of more real-time information at stops, and may include:

- Electronic countdown signs showing "next-bus" arrival information (This is a greater capital and operational investment since it requires power and a data connection)
- Unique QR codes on bus stop sign posts for riders to scan for real time information

Although many riders may choose to use smart phones and tablets to access maps, schedules, and real-time arrival information, providing static maps, schedules, and real time information at stops is an important component of providing an equitable service that is easy to use for all riders.

Figure 51. Bus shelter in Fort Worth. (Photo credit: Trinity Metro)

Figure 52. Passenger information at a bus stop. (Photo credit: City of Fort Worth)

Figure 53. Example real time bus information in Chapel Hill. (Photo: Trinity Metro Master Plan)

Figure 54. Bus stop sign should be clearly visible to pedestrians (Photo credit: City of Fort Worth)

Signage

All bus stops should be anchored with at least one bus stop sign at the front of the stop that is visible to both riders and bus operators. Bus stop signs should:

- Identify the stop
- Provide passenger service information
- Function as marketing for Trinity Metro
- Delineate parking limits
- Reinforce the bus stop zone for an accessible stop
- Be retroreflective to increase visibility in the dark.

Figure 55. Bus shelter in Rhode Island. (Photo credit: RIPTA)

City of Fort Worth Supportive Elements

Lighting

Passengers feel more comfortable, safe and secure at bus stops when they are well lit. Lighting helps bus operators and other drivers see waiting passengers. Bus stops can be adequately lit by surrounding overhead street lighting, back lit signs or as part of a bus shelter structure, or they may require additional lighting.

Design Considerations

Lighting levels should be consistent along the street. Lighting should be managed to reduce energy consumption and light pollution.

Pedestrian-scale lighting (lower than 20 feet) should be used alone or in combination with roadway-scale lighting in high-activity areas to encourage nighttime use and as a traffic-calming device. In low-activity areas, roadway-scale lighting may be sufficient.

Lighting should be oriented toward travelers both in the roadway and on the sidewalk. Adequate lighting at intersections and crossings is essential. Critical locations such as ramps, crosswalks, transit stops, and seating areas that are used at night must be visible and lit.

Crossings at Bus Stops

Crossings should be provided close to bus stops when possible. The preferred placement for a crosswalk is behind the bus stop. Placing the crosswalk behind the bus stop avoids two potential crash scenarios:

- Multiple threat (pedestrians crossing in front of the bus are hidden from or can't see approaching traffic);
- Passengers hit by bus as it pulls forwards.

Locating bus stops on the far-side of intersections can help ensures pedestrians cross behind bus.

More information on pedestrian crossing treatments can be found in the Pedestrian Design Toolbox section above.

Figure 56. Marked crosswalk behind the bus stop in Madison, WI. (Photo: City of Madison)

Trees and Landscaping

Landscaping helps enhance the level of passenger comfort at a stop and improve the attractiveness of transit service. Trees at bus stops can help shade in the summer, allow sunlight in the winter, and mitigate the urban heat island effect.

Measures to ensure landscaping does not impact the visibility or accessibility of stops include:

- Trimming tree branches and shrubs so that they do not pose an obstacle to bus boarding and alighting or impede visibility. Tree branches should not extend lower than 80 inches above the path of travel;
- Maintaining shrubs and vegetation along all sidewalks used to access bus stops to allow full utilization of the paved sidewalk width and to enhance pedestrian safety;
- Maintaining a grass-free 5- foot by 8-foot landing area;
- Planting trees outside of the clear zone area;
- Using curb extensions to maintain horizontal tree lines and also meet ADA requirements for sidewalk conditions; and
- Replacing older tree grates located in the path of the travel that are not ADA compliant.

Bike Racks and Lockers

Bicycle parking should comply with section 6.204 of the Zoning Ordinance.

The installation of bicycle parking at bus stops expands rider connections to and from origins/destinations, especially for first-mile last-mile connections, and can incentivize transit users to ride their bicycle to access transit. Furthermore, they provide a bicycle parking option for riders if the bicycle rack on the bus is already at capacity.

Bicycle parking at typical stops should include a bike rack, although bike lockers or bicycle cages may be considered at higher ridership stops. Providing sufficient designated bicycle parking prevents bicycles from being locked to other streetscape objects such as poles and fences, which helps improve the attractiveness of the surrounding environment.

Design Considerations

Bike racks should be placed outside of the path of travel in the bus stop and positioned so that, no matter how a bicycle is locked to it, it will not obstruct the path of travel.

Bike racks should provide two points of contact for the bicycle to lean against and allow easy locking of the frame and at least one but preferably both wheels.

A typical bicycle parking space is 2’ by 6’, and racks should be placed 3’ apart to allow users to easily maneuver and lock and unlock their bike.

Refer to the City of Fort Worth Zoning Ordinance section 6.204 for guidance on the placement of bike racks.

Figure 57. Bike share at Fort Worth Central Station. (Photo credit: Fort Worth Bike Share)

Bike Share Stations

Bike share and transit are complementary modes and bike share can help expand a city’s overall transportation options.

Design Considerations

Bike share stations/hubs are modular and their capacity can be expanded or decreased over time in response to demand and other needs.

Stations/hubs should generally be placed in safe, convenient, and visible locations and can include installations in-street, on sidewalks, in parks and other public lands through an encroachment agreement, or on private property through the use of an agreement with the property owner.

As transit stops are likely to have heavier than average pedestrian volumes, bike share stations need to be placed in ways that do not impede pedestrian access to bus or transit stops.

Bike share stations/hubs should be placed on a hard, level, paved surface, in addition to meeting the solar exposure and cellular signal needs specific to the type of equipment (smart bike vs smart dock). In cases where stations/hubs do not meet solar or connectivity requirements, hard wiring may be necessary.

Bike share stations/hubs should be placed in line with other street furniture wherever possible.

Bicycle Accommodations

Buses often cross bicycle facilities to reach bus stops, and it is critical to address the relationship between bicycle facilities and bus stops.

Bike Lanes Adjacent to a Bus Stop

For bus stops in parking lanes that are adjacent to a traditional on-street bike lane, it is customary to dash the outer edge of the bus stop and the bike lane striping where the bus crosses over and/or might encroach on the bike lane.

When a bus stop is located within a curbside on-street bike lane, AASHTO's Guide for the Development of Bicycle Facilities allows for the bike lane markings to be continuous or dashed. Since the stopped bus will block the bike lane, dashing the bike lane marking is recommended to increase awareness of the change in use of the bicycle facility. Pavement markings in the bike lane that indicate conflict zones may be appropriate (see the Intersections chapter for details).

Figure 58. Dashed bike lane marking from the RIPTA Bus Stop Design Guide (Credit: RIPTA)

Floating Bus Islands

Floating bus islands integrate a curbside bike lane with a pedestrian crosswalk to a bus stop on a designated island (See Figure 56).

Bus islands are best used on streets with moderate to high bus frequency, and high bus ridership, pedestrian and bicycle volumes. Although there is the potential for conflicts between bicyclists and pedestrians trying to access the bus, bicyclists must yield to pedestrians. Signing and striping at the bike lane emphasizes this.

The design not only separates the passenger space from other pedestrian activity on the sidewalk, but also separates bicyclists from vehicular traffic, eliminating conflicts. Bike lanes can be flush with the sidewalk grade or at roadway grade, or lower than the sidewalk and curb extension grades, but connected via a crosswalk and curb ramps.

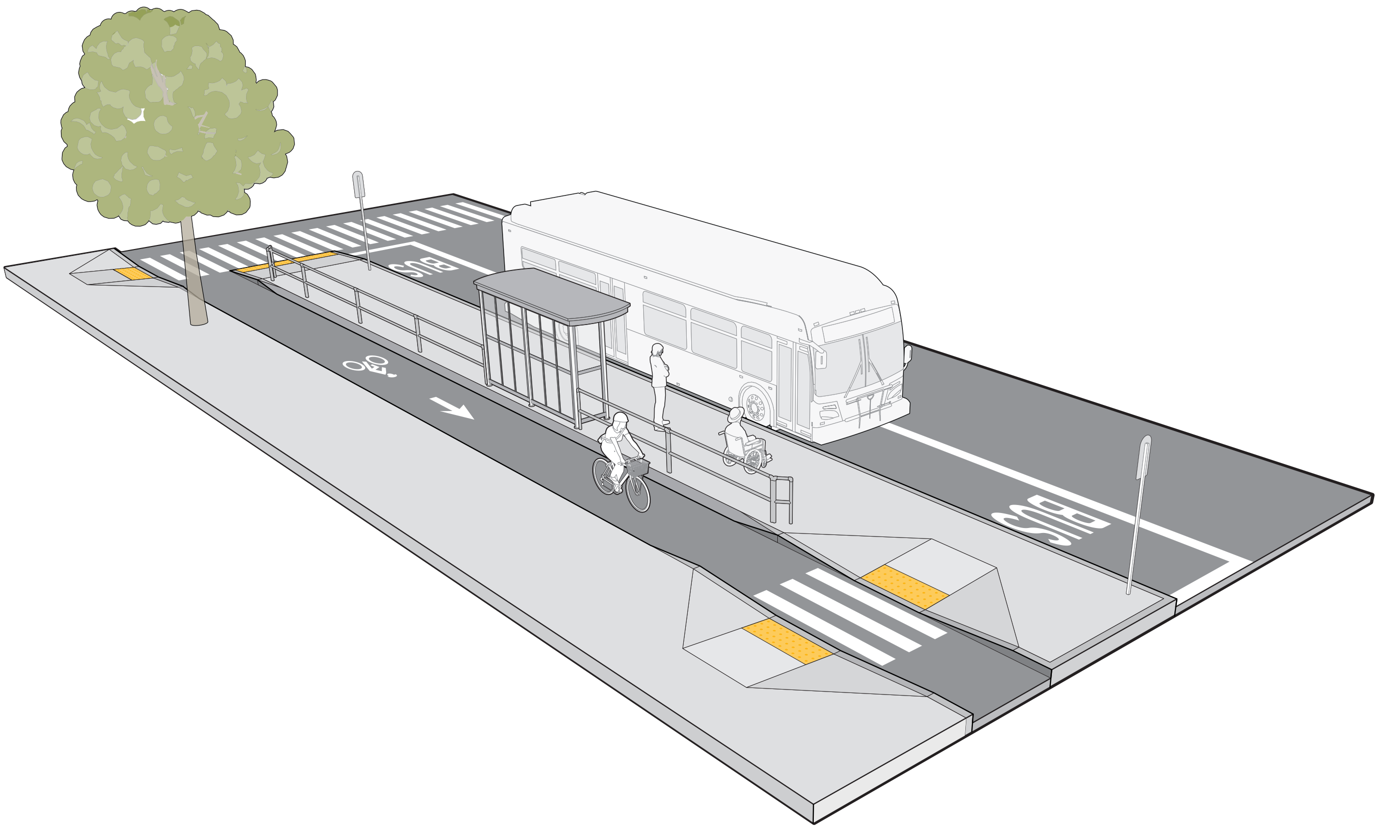


Figure 59. The ideal transit stop solution is to locate the bicycle lane between the sidewalk and the transit platform (Graphic: Toole Design)

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Fort Worth Active Transportation Plan

BICYCLE FACILITY SELECTION GUIDE AND DESIGN TOOLBOX

April 2019

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