CHAPTER 3

Facility Standards

Types of Pedestrian and Bicycle Facilities

CHAPTER 3 FACILITY STANDARDS

The Pedestrian and Bicycle Master Plan recommends a variety of facilities for Sugar Land. To ensure that the overall system is consistent as it is developed over a number of years, this section provides general standards and guidelines for each major type of facility. These include three categories of facilities:

- Pedestrian-only facilities such as sidewalks;
- Facilities that can be used by both pedestrians and bicycle riders such as shared use paths and sidepaths; and
- On-street bicycle lanes, shared lane markings that are for both bicyclists and cars, and cycle tracks that are intended for bicycles only.

The discussion of facility types, associated standards and potential costs covered in this section are general in nature. When planning for any of these facilities, more detailed design to adapt them to specific site conditions may be needed prior to actual implementation. For example, a preliminary engineering report (PER) may be needed for more complex projects, but it would not necessarily be needed for simple projects such as adding shared lane markings.

Guidance in the placement and development of standards shown in this section comes from the 2012 Guide for the Development of Bicycle Facilities published by the American Association of State Highway and Transportation Officials (AASHTO), and from the 2011 Urban Bikeway Design Guide published by the National Association of City Transportation Officials (NACTO). In the future, the City should follow any updates that have been made to these standards.

In some specific cases, variations from AASHTO could be considered to respect the character or special conditions of an area. To codify these standards, some of the City's development standards may need to be modified as a follow-up to this Plan. Revisions to the City's development standards are discussed in Chapter 6.

Figure 3-1 Types of pedestrian and bicycle facilities

Pedestrian-Only Facilities

Figure 3-2 Example of a typical sidewalk in Sugar Land

Sidewalks

Sidewalks provide walking connections from neighborhoods to area destinations such as parks, schools and businesses. Sidewalks are intended for pedestrians and generally are not appropriate facilities for bicycle use, since pedestrians and bicyclists travel at different speeds and sidewalks are often too narrow to accommodate both users. The exception to this may be around schools where off-street paths are not available and where sidewalks are the only off-street option that is available for children.

The goal for any sidewalk in Sugar Land should be to create as inviting a location as possible for walking. Sidewalks should provide a space where people want to walk and make logical connections to and from destinations. Planners and designers should ask how can we make this location be as attractive and accessible as possible for walking? Human comfort is important to the success of facilities and can be enhanced with provisions such as lighting, shade, greater separation from vehicular traffic, and attractive landscaping.

Recommended standards for sidewalks are as follows:

Placement - Sidewalks should always be placed a minimum of four feet (4') from the adjacent back of curb on suburban/neighborhood streets. Where feasible, an even greater separation approaching eight to ten feet (8' to 10') is preferred to provide an area for planting street trees which act as a protective buffer from adjacent vehicular traffic on the street. Sidewalks that abut the curb are only appropriate in urban areas such as Town Center or the historic area of the Imperial Development where adjacent vehicular speeds are lower and amenities for human comfort are provided.

Width - Along major streets in Sugar Land and along neighborhood streets that provide a direct connection to a school, neighborhood park or access point to a trail, the recommended minimum width of sidewalks is six feet (6'). Note that this is a change from current City standards which require a five foot (5') width on all public streets. The six foot (6') width allows two adults to comfortably walk side-by-side. Within residential neighborhoods where less frequent walking or lower concentrations of pedestrian activity is anticipated, five foot (5') sidewalks can be used.

Vertical clearance - A clear zone of at least ten feet (10') between the ground level of the sidewalk and any overhead branches or other obstructions is recommended.

Pavement type and thickness - Sidewalks in Sugar Land should continue to be built with concrete. The concrete should be reinforced with

steel rebar. In new installations or areas where uplifting by tree roots is possible, a thicker pavement depth of six inches (6") is recommended to increase the durability of the sidewalk. Root barriers are also recommended where new trees are planted adjacent to sidewalks.

Tree-lined corridors that shade sidewalks and streets are a valued feature of Sugar Land. When replacing sidewalks in areas with mature trees or trees in close proximity to the sidewalk, the health of those trees should be considered, and extraordinary actions may be needed. These may include acquiring additional right of way from adjacent properties, reducing the width of the sidewalk for a short distance, installing tree wells, creating small "bridges" over exposed roots, or using decomposed granite as an alternative walking surface near the trees.

Width of replacement walks - When replacing existing sidewalk segments, the new recommended sidewalk width of six feet (6') along major streets and five feet (5') for local streets should be used, except for areas without a clear stopping and starting point such as driveways or an intersection. While this may cause sections of variable sidewalk widths, it will ultimately result in a better system.

Combined Off-Street Pedestrian and Bicycle Facilities

Sidepaths

Sidepaths are pathways that are adjacent to a roadway. Unlike sidewalks, they are intended for use by both pedestrians and bicyclists and are therefore wider than traditional sidewalks.

The most suitable type of street for a sidepath typically has very few driveways or side street intersections, as illustrated by the example of a section of University Boulevard shown in Figure 3-3.

Figure 3-3 Example of a sidepath in Sugar Land

Sidepaths are preferred by many Sugar Land residents, who desire bicycle facilities that are physically separated from motor vehicle traffic. These facilities are seen as a comfortable place to ride on streets with high traffic volumes and speeds.

Sidepaths require special design considerations. Bicycle movements at intersections or driveways where motor vehicles are turning can be a concern since drivers may not anticipate bicyclists coming from either direction. Significant attention should be paid to the design of sidepath crossings of driveways, roadways or intersections. Special design features such as placing a pedestrian/rider stop sign along



the sidepath at an intersection will be required. These are discussed on page 41. Recommended standards for sidepaths include the following:

Figure 3-4 Sidepath curves and has bollard placed in middle when approaching intersections, causing bicyclists to slow down.

Figure 3-5 Trail stop sign when approaching intersection. Source: Danny McCullough - pedbikeimages.org

Figure 3-6 Painted crosswalk. Source: Dan Burden - pedbikeimages.org

Placement - Sidepaths should generally be placed a minimum of five feet (5') from the adjacent back of curb. Where feasible, a greater separation approaching eight to ten feet (8' to 10') is preferred to provide an area for planting street trees. The edge of the sidepath should be at least two feet (2') away from adjacent trees or landscaping. A minimum of two feet (2') between the sidepath and the property line is recommended.

Width - Because sidepaths are intended to be used by bicycle riders and pedestrians and are two-way facilities, a width of ten feet (10') is preferred. In constrained locations or along routes where a low volume of bicycle traffic and few pedestrians are anticipated, a width of eight feet (8') can be used for shorter distances but is generally not preferred. In areas where a higher amount of both pedestrians and bicyclists are anticipated, such as along Town Center Boulevard, a width of twelve feet (12') should be considered.

Vertical clearance - A vertical clear zone of ten feet (10') is preferred. In limited conditions, an absolute minimum distance of eight feet (8') may be considered for short distances, but should be clearly marked so it can be seen at night.

Curvature - Curves in the sidepath should be gentle and should follow minimums established for the design speed. Guidance for the design of horizontal and vertical curves provided in the 2012 AASHTO Guideline should be followed. These vary based on the design speed and gradient of the facility. Typically in Sugar Land, most sidepaths will be straight or have minimum curvature because of corridor width restrictions.

Corridor width - The overall corridor width should be at least eighteen to twenty feet (18' to 20') wide to allow for a minimum of five feet (5') of clearance between the street curb and the sidepath, and a minimum of two to four feet (2' to 4') between the facility and fences, walls, or landscaping along the adjacent property line.

Pavement type and thickness - The design of sidepaths is similar to that of sidewalks. The concrete should be reinforced with steel rebar and should have perpendicular jointing to control cracking. In areas where uplifting by tree roots is anticipated, a thicker pavement depth of six inches (6") or greater, root barriers and additional steel or mesh reinforcement are recommended to increase the durability of the sidepath.

Where installing a sidepath in place of an existing sidewalk - Where this plan recommends replacing an existing sidewalk with a wider sidepath, an entire segment from block to block should be constructed

at one time. It is always preferable to build an entirely new sidepath rather than adding to the width of an existing sidewalk, even if that existing sidewalk is new and in good condition. The new joint in the center of the widened sidepath can create uneven movement and become a future tripping hazard, and the overall longevity of the concrete can be compromised if not poured at the same time.

Sidepaths at Intersections and driveways - Intersections and driveways create conflict points between sidepath users and vehicles. As a separated facility, sidepaths can create a false sense of security, and pedestrians and bicyclists must be cautious when arriving at an intersection or crossing a driveway. Turning drivers may not see or expect the bicycle rider. At intersections, bicycle riders are expected to stop and check for vehicles that have the right of way (just as pedestrians do) but do not always do this. Therefore, each crossing of a roadway or driveway by a sidepath should be carefully designed and should include the current best practices for sidepaths. The design should clearly indicate that both pedestrians and bicyclists should stop at the intersection and proceed only when clear.

Treatments may include some or all of these or other techniques to alert bicycle riders of an upcoming intersection, and to alert motor vehicles that bicyclists may be traveling through the intersection or across a driveway:

- Deviation of the sidepath or other devices near an intersection to stop the rider at the intersection (see Figure 3-4);
- Signage and paint to alert the rider to stop and look (see Figure 3-5);
- Painted crossing areas, such as colored crosswalks (see Figure 3-6);
- Additional signage to alert motorists to the presence of crossing pedestrians and bicyclists (see Figure 3-7);
- Moving the vehicular stop bar location farther back from the intersection to allow for wider crossing areas (see Figure 3-8);
- Reduction or removal of landscaping or trees near intersections to increase the visibility of bicycle riders (see Figure 3-9);
- At high volume intersections, give pedestrians and bicyclists their own crossing signal cycles separate from vehicles, or at a minimum a ten second leading pedestrian interval before the vehicular lights turn green (see Figure 3-10); and
- The prohibition of right turn on red at these high volume intersections (see Figure 3-11).

Figure 3-7 Sign examples. Source: Dan Burden - pedbikeimages.org

Figure 3-8 Stop bar located farther back. Source: Dan Burden - pedbikeimages.org

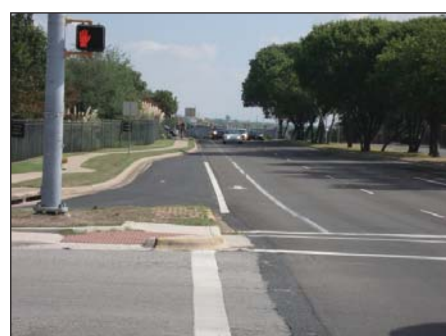

Figure 3-9 Limited landscaping at intersections

Shared Use Paths (Trails)

Commonly referred to as trails, shared use paths are intended to be used by both bicycle riders and pedestrians. They use corridors that

Figure 3-10 At busy intersections, pedestrian and bicyclists should get a crossing signal before the vehicles get a green light. Source: Dan Burden - pedbikeimages.org

Figure 3-11 Prohibited right turn sign. Source: Owen Skoler - http://kirkwood.patch.com/groups/politics-and-elections/p/no-right-on-red-to-stay-at-essex-and-kirkwood

Figure 3-12 Example of a HAWK signal

are completely separate from roads, such as drainage channels, utility corridors, or within parks.

Placement - Shared use paths should be placed a minimum of five feet (5') from adjacent obstructions. A minimum shoulder or clear area of two feet (2') is required.

Width - Because shared use paths are intended to be used by bicycle riders and pedestrians and are two way facilities, a minimum width of ten feet (10') is recommended. In constrained locations or along routes where a low volume of bicycle traffic and few pedestrians are anticipated, a width of eight feet (8') can be used for short distances, but is generally not preferred.

Vertical clearance - A clear zone of at least ten feet (10') is preferred. In limited conditions, an absolute minimum distance of eight feet (8') may be considered for short distances, but should be clearly marked so it can be seen at night.

Curvature - Curves in the shared use path should be gentle and should follow minimums established for the design speed. Guidance for the design of horizontal and vertical curves provided in the 2012 AASHTO Guideline should be followed. These vary based on the design speed and gradient of the facility. Typically, in Sugar Land most shared use paths will be straight or have minimum curvature because of corridor width restrictions.

Corridor width - The overall corridor width should be at least twenty feet (20') wide to allow for a minimum of five feet (5') of clearance between adjacent features and either side of the shared use path. The edge of the sidepath should be at least two feet (2') away from adjacent trees or landscaping.

Pavement type and thickness - Shared use paths should have a minimum pavement thickness of four inches (4") and should be reinforced with steel rebar. The exact design should conform to Sugar Land design standards and consider the soil type and usage characteristics. In areas where uplifting by tree roots is anticipated, a thicker pavement depth of six inches (6") or greater, root barriers and additional steel reinforcing are recommended to increase the durability of the shared use path. Where maintenance vehicles are anticipated to drive on the path, thicker pavement and/or deeper edge footings should be considered.

Decomposed granite may be considered in some instances, particularly within parks to provide an alternate surface type which is softer and preferred by runners. However, decomposed granite will require more frequent maintenance than concrete surfaces.

Shared use paths at intersections and driveways - Each crossing should be carefully designed for safety. Crossings at intersections are

preferred, and the City of Sugar Land typically will not allow mid-block crossings. Where mid-block crossings are considered, push button activated signals, flashing beacons or a High-Intensity Activated Crosswalk Beacon (known as a HAWK signal) should be included (see Figure 3-12). Reductions in the amount of landscaping or trees at intersections to increase the visibility of the bicycle riders may also be required. More details on intersection treatments are located in Chapter 4.

On-Street Bicycle Facilities

On-street bicycle facilities are designed for bicycles to operate like vehicles on the street. Bicyclists turn left and right in a manner similar to vehicles, and generally travel in the same direction as vehicles. On-street bicycle lanes can be implemented quickly and at a relatively low cost. While cyclists may bike on streets without any improvements, a number of treatments will increase safety and comfort of on-street biking for both cars and bicyclists. This section includes on-street treatments such as bike lanes, buffered bike lanes, cycle tracks and shared lane markings.

Bicycle Lanes

Bicycle lanes are designated by a lane stripe, pavement markings, and signage. Bicycle lane stripes are intended to promote the orderly flow of traffic by establishing specific lines of demarcation between areas reserved for bicycles and lanes to be occupied by motor vehicles. Typically, the solid stripe of the bike lane is either dropped or dashed prior to and through intersections, to allow for both bicyclist and motorist turning movements.

Figure 3-13 Examples of typical bike lane installations

Bicycle lane widths - A bicycle lane width of five feet (5') is considered a minimum, and six feet (6') wide where feasible is preferred. The lane should be measured from the center of the bicycle lane stripe to the adjacent curb facing. Where slower vehicular speeds and no gutter occurs, a width of four feet (4') can be considered, but only for highly constrained areas and where no gutter drains or other obstacles occur. In Sugar Land, a four foot (4') wide bicycle lane should rarely, if ever, be used.

The overall pavement width should continue to allow for a minimum ten foot (10') wide motor vehicle lane width along roads with slower speeds and lower volumes of traffic (typically 30 mph or lower), and eleven feet (11') wide or more motor vehicle travel lanes on roadways with higher speeds. Guidance for the design of roadway cross sections is contained in the Sugar Land 2012 Master Thoroughfare Plan.

Figure 3-14 Existing bicycle lane adjacent to on-street parking in Sugar Land (along Country Club Blvd.)

Along streets with parallel parking where a bicycle lane will be installed adjacent to on-street parking, a wider width of six to seven feet (6 to



7') should be considered to provide greater buffer area where vehicle doors may open. The preferred configuration is a seven foot (7') wide parking area and a six foot (6') wide bicycle lane.

Vertical clearance - A clear zone of at least ten feet (10') is required.

Bicycle lane striping - Bike lane striping should be four inches (4") wide. For greater visibility on shaded streets, a pavement striping width of six inches (6") should be considered. Bike lane symbol markings should be included, and spacing can vary from 100 linear feet in areas with significant driveway activity, to 250 to 400 linear feet in areas with longer distances between intersections or driveways.

Drainage inlets and utility covers - Inlet grates with slots that are designed to be used by bicycles should be included on all roads in Sugar Land in the future. Utility cover designs with grooves or stamped patterns that provide less slippery surfaces for bicycles should also be selected.

Figure 3-15 Different types of buffered bicycle lanes

Buffered Bicycle Lane

A buffered bicycle lane, sometimes called a comfort lane, is defined as a bicycle lane that is paired with a designated buffer space separating the bicycle lane from the adjacent motor vehicle lane and/or parking lane (NACTO Guide 2011). The buffer typically consists of a double line zone with diagonal striping or chevrons (see Figure 3-15).

Buffered Bicycle Lane Width - Where the buffered bicycle lane is replacing an existing travel lane, the buffer zone should be five to six feet (5' to 6') in width, and the bicycle lane area should be six to seven feet (6' to 7') in width. The remaining vehicular lane can be increased in width, but this is not preferred since it may give motorists the perception that they can drive faster. Typically, the remaining vehicular lane will be a comfortable eleven to twelve feet (11' to 12') in width without the need for any additional widening.

Along streets where the buffered bicycle lane is being added and is not replacing a travel lane, the buffer zone should be a minimum two feet (2') in width. A width of three feet (3') is the preferred width. The bicycle lane area should be a minimum of five feet (5') in width, but should not exceed seven feet (7') wide, similar to the examples shown in Figure 3-15.

Cycle Tracks

A cycle track is a bicycle lane that is physically separated from traffic with a row of parked cars, a raised curb, planters or some other physical separation. In addition, a cycle track is intended for use only by bicycles, and is separated from any adjacent sidewalks or paths intended for use by pedestrians.

Buffered bicycle lanes are similar to a cycle track, except that, in the

case of a cycle track, the painted buffer zone striping is replaced with a physical barrier. A cycle track can sometimes accommodate two-way bicycle traffic. Cycle tracks provide a completely separate place for bicycles apart from pedestrians and motor vehicles, and they can be comfortably used by riders of all skill levels.

Three general methods of implementing cycle tracks exist. One is very similar to the buffered bicycle lane discussed previously, with the exception that the buffered area is curbed to create a physical barrier between bicycles and adjacent motorized traffic. Any street in Sugar Land designated as a location for a buffered bicycle lane could ultimately be retrofitted as a cycle track in the future if deemed appropriate. However, on lower volume streets in Sugar Land such as Grants Lake and Chatham Boulevard, buffered bicycle lanes are adequate to provide a comfortable place to ride.

The second type of cycle track requires the construction of a separate bicycle-only "track" in the parkway area. This provides a location for bicycle riders as well as a separate sidewalk for pedestrians. Due to the presence of many street trees along roadways in Sugar Land, there are few locations that are wide enough for this type of cycle track in the City.

The third type involves physically widening the street to essentially provide an area for the cycle track. The presence of landscaped parkways and mature street trees in Sugar Land also limits the ability to implement this option.

One cycle track is proposed in this Plan and is located along Creekbend Drive. Future streets could be planned to accommodate cycle tracks if deemed appropriate.

Figure 3-16 Example of a cycle track in San Antonio

Figure 3-17 Sketch examples of a cycle track in an urban location. Source: Halff Associates, Inc.

Standards for Cycle Tracks in Sugar Land - One way cycle tracks should be a minimum of five feet (5') in width, with a six feet (6') wide travel lane preferred. For a two-way configuration, a minimum width of eight feet (8') is allowed, but a ten to twelve foot width (10' - 12') is preferred.

Preferred type of barrier - A raised concrete curb with a twelve to eighteen inch (12" to 18") width is the preferred barrier technique. In retrofit locations, the curb area may be doweled into the existing pavement. Street drainage needs should

be considered when installing a cycle track, with periodic gaps or slots provided for local drainage.

Pavement markings and signage - Pavement markings and signs should follow the type and frequency recommended by AASHTO for use in bicycle lanes and buffered lanes. All signs should follow the standards set by the Manual on Uniform Traffic Control Devices (MUTCD).

Figure 3-18 Example of a wide shoulder

Wide Shoulder

A shoulder is defined by AASHTO as “the portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use” (AASHTO, 1999). A shoulder can accommodate bicyclists if it is adequate in width and pavement surface, and has few driveway or other crossings. Texas code allows continuous use of the shoulder only by bicycles, emergency vehicles, and maintenance crews (Texas Transportation Code Section 545.058). Wide shoulder areas are typically used only by experienced riders. A wide shoulder bicycle facility could work on US 90A west of SH 6.

Standards - A shoulder area should be at least four feet (4’) in width along roadways with speeds under 45 miles per hour. Along roadways with speeds at or over 45 miles per hour, streets with high volumes of traffic, or streets with significant truck or bus traffic, a wider shoulder width of six to eight feet (6’ to 8’) is preferred.

Wide Curb Lane

Wide curb lanes are the right-most through traffic lanes that are greater than fourteen feet (14’) wide, measured from the inside lane strip to the adjacent curb face. These lanes are used by both bicyclists and motorized vehicle traffic; however, they typically do not have pavement markings.

Typically, only more experienced riders will use this type of facility. Wide curb lanes are generally not preferred in Sugar Land and should be considered only where no other option is available.

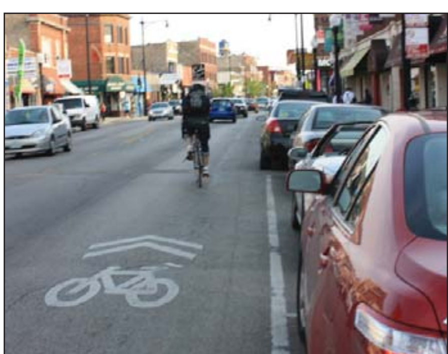

Figure 3-19 Example of a shared lane marking

Shared Lane Markings

Along streets where there is insufficient width for a bicycle lane but where bicycle travel is likely, shared lane markings can be used to provide guidance to bicyclists and motorists. For motor vehicle operators, the marking indicates that a bicycle may be present. For the bicyclist, the shared lane marking indicates where on the road the bicyclist generally should travel (AASHTO 2012).

Per AASHTO recommendations, shared lane markings should be used only on streets with lower traffic volumes and slower speeds.

Standards - Standards for the use of shared lane markings are as follows:



- If used on a street with on-street parallel parking, shared lane markings should be placed so that the center of the markings is at least twelve feet (12') from the face of the curb or from the edge of the pavement;
- If used on a street without on-street parking that has an outside travel lane that is less than fourteen feet (14') wide, the centers of the shared lane markings should be at least five feet (5') from the face of the curb or from the edge of the pavement;
- Shared lane markings shall not be used on shoulders;
- Shared lane markings typically should not be placed on roadways that have a speed limit above 35 mph; and
- Shared lane markings should be placed immediately after an intersection and spaced at intervals not greater than 250 feet thereafter (per AASHTO recommendations).

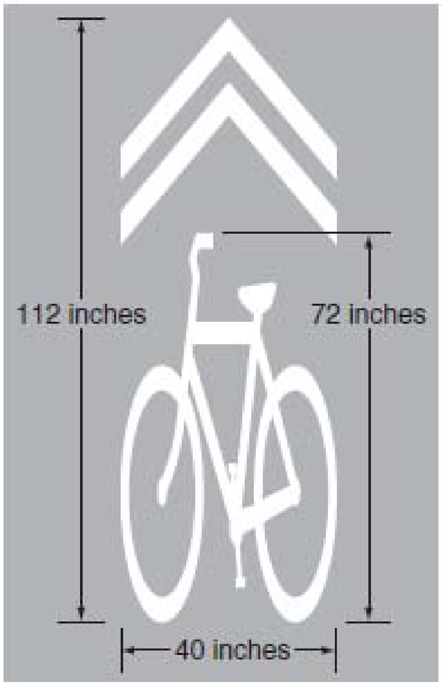

Figure 3-20 Shared lane marking symbol. Source: Manual on Uniform Traffic Control Devices, Sect. 9C.07, 2009 Edition

Other Tools for Installing and Improving Bicycle Facilities

In conjunction with installing bicycle facilities, road diets and lane diets are two techniques that can be utilized to install and/or improve bicycle facilities.

Road Diets

A road diet is a type of roadway conversion project where vehicle travel lanes are repurposed, and a portion of the roadway is converted for use as a bicycle lane. It is applied where there is excess road capacity but still preserves the level of service for cars. According to the Road Diet Handbook: Setting Trends for Livable Streets, "the resulting benefits [of a road diet] can include reduced vehicle speeds; improved mobility and access; reduced collisions and injuries; and improved livability and quality of life"[1].

Road diet applications in Sugar Land - Potential road diet conversion projects are evaluated on a case-by-case basis. Literature and case study research has established guidelines for selecting road diet conversion projects[1]. These factors include the following:

- Streets with an average daily volume at or below 10,000 trips per day were considered as potential candidates for a road diet from four to two vehicular lanes; and
- Peak hour volumes - Where high peak hour volumes are anticipated, such as around schools or at signals, the impact of the lane reduction should be considered, and other treatments in that area may be preferred.

1 Jennifer Rosales, *Road Diet Handbook: Setting Trends for Livable Cities* (Parsons Brinckerhoff, 2009).



The typical application of a road diet in Sugar Land occurs where a four-lane median-divided boulevard is converted to one twelve-foot wide vehicle lane in each direction plus a buffered bike lane in each direction. Figure 3-21 illustrates the application of a road diet.

Figure 3-21 Road diet illustration before and after

Lane Diets

Lane diets occur through the narrowing of existing lanes to provide sufficient pavement width to install bicycle lanes. Lane diets do not reduce the number of vehicle lanes and do not have an impact on vehicle level of service. Vehicle lanes should generally not be reduced to a width less than ten feet (10’).

Design Tools for Pedestrian and Bicycle Friendly Neighborhood Streets

Many neighborhood streets can be great places to walk or ride a bike, and small improvements can help make these streets even more pedestrian and bike friendly. Most neighborhood streets in Sugar Land have low traffic volumes and speeds at or under 30 miles per hour. As such, many should be excellent places to walk or ride under existing conditions. However, because many of these streets have very little traffic, few parked cars and relatively few intersections, the actual speeds driven on some of these streets can exceed the 30 miles per hour limit. Even cars travelling at 30 miles per hour can be daunting for less experienced bicycle riders traveling on the same street.

While this Plan did not identify specific locations where these techniques are needed, the City should consider their use if specific problem areas become apparent. The following categories of improvements can be implemented in both new and existing neighborhoods in Sugar Land to make their streets better places for walking and biking. These improvements include:

Figure 3-22 Lane diet illustration before and after

Traffic Calming - When it is not possible to install a bicycle lane, traffic calming may improve the bicycling environment. Traffic calming devices reduce motorized vehicle speeds, improve the environment and livability of a street, and provide real and perceived safety improvements for pedestrians and bicyclists using a roadway.

A variety of traffic calming devices that are used by many Texas cities include: speed cushions, traffic circles, chicanes, semi-diverters, and curb extensions. Figure 3-23 illustrates these and other traffic calming devices identified by the Federal Highway Administration (FHWA). One or more of these treatments might be considered on neighborhood collector streets with high traffic speeds.

Slow Streets - The “Slow Streets” movement in the United States started in the 1980s, and much like traffic calming and bicycle boulevards, aims to slow motorized traffic to 20 miles per hour or less to create pedestrian and bicycle-friendly neighborhood streets. Street narrowing, curb




extensions, and other techniques are used to manage and slow traffic.

Since these impact vehicular speed and access in a neighborhood, techniques to slow or "calm" neighborhood traffic should always be developed in close consultation with area residents. Existing City of Sugar Land traffic calming policies should be followed when implementing these traffic calming and speed reduction techniques. The aesthetic qualities of each treatment should also be considered.

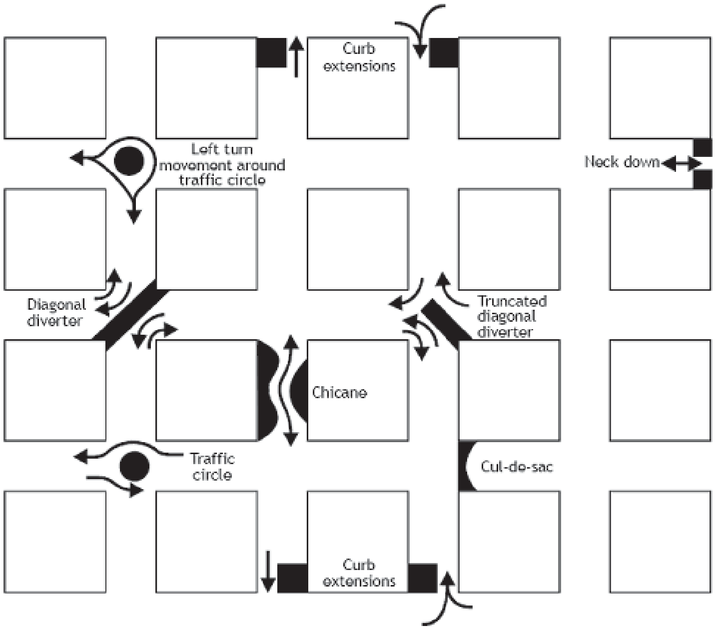

Figure 3-23 An FHWA illustration of traffic calming devices. Source: FHWA, 2006, p. 325

Intersection and Roadway Crossings

Intersections, driveways, and roadway crossings are locations with the highest potential for interaction between motorized vehicles, bicycle riders and pedestrians. Enhancing crossing locations is particularly important for bicycle riders on sidepaths or shared use trails. Riders favor continued momentum, and since stopping requires additional effort to get moving again, they may be tempted to disobey traffic signals and signs.

Each crossing location requires its own specific design to take into account unique conditions of the area, including characteristics of both the motorized vehicles and the bicyclists and pedestrians travelling in the area. Note that improvement requirements at each intersection should be developed as each facility is designed and implemented. The following techniques represent some of the "tools" that can be used to improve these crossings.

Highly visible crosswalk markings - Ladder style crosswalks (see Figure 3-25) have been shown to be more visible to approaching vehicles than standard two striped lines.

Median refuge - On wider streets that take longer to cross on foot, a refuge provides a protected mid-crossing location. These are installed as part of curbed medians (see Figure 3-26).

Raised crosswalks - Typically used at mid-block crossing locations, raised crosswalks can enhance the visibility of pedestrians crossing a street and also help slow vehicle speeds when approaching the crossing (see Figure 3-27).

Pedestrian crosswalk signals - At intersections, timed pedestrian crosswalk signals help guide pedestrians crossing the street (see Figure 3-28).


Figure 3-24 Examples of traffic calming techniques (traffic circle above and chicane below)



Figure 3-25 Ladder crosswalk markings

Figure 3-26 Median refuge. Source: Dan Burden - pedbikeimages.org

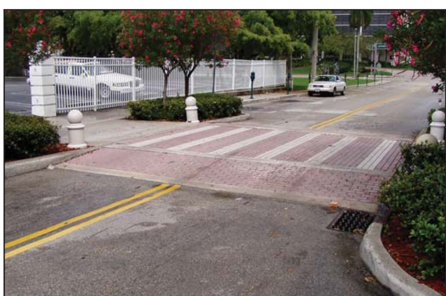

Figure 3-27 Raised crosswalk. Source: Dan Burden - pedbikeimages.org

Figure 3-28 Pedestrian crosswalk signal (HAWK signal)

Painted or paver crosswalks - In areas with higher numbers of turning vehicles, further enhancement of the crossing area through the use of paint or highly visible pavers may be considered (see Figure 3-29). In particular, this can be effective where sidepaths cross driveways into private businesses.

Access management - Reducing the number of driveways or access points may help reduce the number of conflict points along on-street and off-street facilities.

Prohibit right turn on red - At intersections with a higher frequency of pedestrian crossings and where traffic volumes permit, a right turn on red may be prohibited to provide additional safety for pedestrians.

Sidepath or trail "deviators" to slow sidepath or shared use path users at intersections - The path deviates to focus the pedestrian's line of sight on approaching traffic, and to reduce the bicyclist's speed (see Figure 3-30).

Pedestrian crossing warning signs - Additional warning signs that follow the Manual on Uniform Traffic Control Devices (MUTCD) may be appropriate to further alert motorists to the presence of pedestrians or bicyclists (see Figure 3-31).

Curb extensions - At intersections, an outward extension of the pedestrian area may be installed to reduce the crossing distance to the opposite curb. These extensions also help reduce the speeds of motorized vehicles travelling through the intersection (see Figure 3-32).

Reducing turning radii at intersections - Smaller turning radii at intersections can reduce the speed of vehicles turning right at intersections, increasing reaction times and creating safer crossings for pedestrians (see Figure 3-33).

Enhanced visibility by relocating landscaping or signs - Especially in sidepath conditions, landscaping, signs and in some cases trees may be relocated or adjusted to increase visibility.

Enhanced painted symbols at intersection crossings - Additional dashed bicycle lane striping and bicycle symbols may be used across intersections to guide bicycles and to further alert motorists as to the direction of bicycle traffic (see Figure 3-34).

Transition from on-street to off-street facility - In some instances, an on-street bicycle lane may need to transition to an off-street sidepath or shared use path. Figure 3-35 illustrates the use of a curb ramp to smooth that transition.

Green Lanes - Green painted bicycle lanes can be used to mark bicycle lanes or mark the extension of a bicycle lane through intersections and other traffic conflict areas (see Figure 3-36).

Figure 3-29 Paver crosswalk

Figure 3-30 Diverters causing bicyclists to slow down.

Figure 3-31 Pedestrian crossing warning sign. Source: Dan Burden - pedbikeimages.org

Figure 3-32 Curb extension

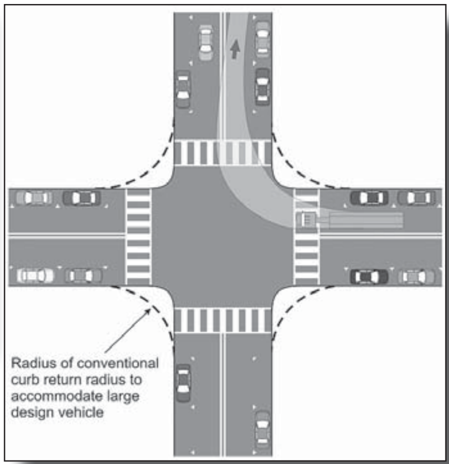

Figure 3-33 Reducing curb radii to reduce pedestrian crossing distance Source: Institute of Transportation Engineers and Kimley-Horn & Associates, Inc. http://www.ite.org/css/online/DWUT10.html

Figure 3-34 Bike lane pavement markings that continue through a T-intersection

Figure 3-35 Example of a transition from an on-street bicycle lane to an off-street sidepath

Figure 3-36 Example of a green bike lane being used at a conflict area where the bike lane crosses the right turn lane



It is important to note that new technology and best practices related to bicycle and pedestrian facility design are evolving at a rapid pace. The City should continue to monitor the best practices and incorporate where appropriate in the future.

Grade Separated Bicycle and Pedestrian Crossings

Convenience is essential in designing and locating overpasses and underpasses. Pedestrians and bicyclists will seldom use a poorly located crossing. Grade separated facilities for bicyclists and pedestrians should be considered under the following conditions:

- Where channels that may convey periodic floodwaters that can create a hazardous condition occur; or
- Where grade separation could create a route that avoids having to cross roads or railroads with high levels of vehicular or rail traffic.

Recommended standards for both are as follows.

Figure 3-37 Examples of pedestrian bridges

Bridges

Pedestrian bridges are needed to cross barriers such as drainage channels in various locations. Pre-fabricated bridges can span distances ranging from 100 feet to over 250 feet. Enhancements, such as decorative railings or upscale pedestrian lighting, should be included to fit the context of the area around the bridge.

From a user's perspective, bridges should preferably be the width of the pathway, plus an additional two feet (2') of clearance area on each side. At a minimum, bridge widths should be twelve feet (12') wide for an eight foot (8') sidepath.

Any bridge that is specifically designated for bicycle traffic must have appropriate railings for bicyclists. Texas has adopted the AASHTO Bridge Design Specifications requirement that bridge railings designated for bicycle traffic should be a minimum of fifty-four inches (54") high with the same restrictions on openings as for pedestrian railings. Pedestrian railing openings between horizontal or vertical members must be small enough that a 4-inch sphere cannot pass through them in the lower twenty-seven inches (27"). For the portion of pedestrian railing that is higher than twenty-seven inches (27"), openings may be spaced such that an 8-inch sphere cannot pass through them. Decking material should be firm and stable. Bridge approaches and span should not exceed 5% slope for ADA access.

Pedestrian bridges should be designed to accommodate the weight of maintenance vehicles. The bottom span should be above the 100-year floodplain, and the bridge should not constrict the floodway.

Footings should be located on the outside of the stream channel at the top of the stream bank. All bridges and footings in the stream corridor will need to be designed by a registered geotechnical or structural engineer. Cost, design and environmental compatibility will dictate which structure type is best for the shared use path corridor.

Figure 3-38 Example of a pedestrian underpass

Underpasses

Underpasses can provide a more direct route by going under instead of around a busy street or railroad. From the standpoint of a user, underpasses should be well lit, attractive and project a sense of security. The exit should be visible from the entrance area. A minimum height clearance of ten feet (10') is recommended. If enclosed, the underpass width should be at least fourteen feet (14') in width, and in some cases wider if the underpass exceeds one-hundred feet (100') in length. If enclosed, gravity or pump systems to remove storm drainage should be provided.

In the future, all new or reconstructed vehicular bridges over key sidepath or shared use path corridors should be considered as possible candidates for an underpass. In some cases, this may mean elevating the roadway elevation higher than otherwise necessary, but the added convenience to pedestrians and bicyclists may increase the use of the pathway corridor.

Attractive examples of underpasses can be found in the Telfair development as shown in Figure 3-38.

Railroad Crossings

A major Union Pacific rail line parallels US 90A in the northern area of the City. Rail traffic along this corridor travels at a high speed, and a second track may be added in the near future.

Figure 3-39 Pedestrian railroad crossing - FM 1640 at FM 762 in Richmond, TX. Image source: City of Sugar Land

In researching this Plan, Union Pacific Railroad staff provided the guidance on Union Pacific Railroad preferences for design of a pedestrian and bicycle rail crossing. Union Pacific Railroad staff indicated that when a pedestrian facility crosses over railroad tracks, the facility should be located outside of the railroad gate arms that block vehicles in the roadway, since the gate arms are counter-weighted and can easily be manually raised by pedestrians if they passed under the gate. Pedestrian and bicycle enhancements at railroad crossings include the following:

Cross at a perpendicular angle to the tracks - To reduce the potential for narrow bicycle or stroller wheels getting caught in the tracks, sidepaths and sidewalks crossing the tracks should do so at a 90 degree angle.

Figure 3-40 Examples of pedestrian warning signals at railroad crossings. Image source: Federal Railroad Administration

Figure 3-41 Examples of fencing at railroad crossings. Image source: Federal Railroad Administration

Concrete planking - Concrete planking that meets the rail line owner's specifications should be installed. Union Pacific Railroad staff preferred that the planking for the road and the pedestrian facility be continuous, which allows for better drainage and prevents debris buildup that would occur in a "gap" between roadway and pedestrian planking.

Separate pedestrian crossing arms or gates - Consideration could be given to installing separate pedestrian barrier gates or arms. Triggered to close when a train is approaching, these may be appropriate because of the double track condition. However, Union Pacific Railroad staff indicated that a separate gate at sidewalks or sidepaths is generally unnecessary since pedestrians and bicyclists can go around the gates fairly easily.

Pedestrian level signals - Visual signals such as flashers specifically designed to alert pedestrians should be considered, as shown in Figure 3-40. These enhance safety for users who are hearing is impaired, such as the deaf, or individuals who are listening to headphones. Warning signs should be installed that direct pedestrians and other sidepath users to look both ways before crossing the tracks.

Fencing to divert and contain pedestrians and bicyclists crossing the tracks - Fencing can be used to direct pedestrians to the correct crossing location, especially if separate pedestrian-sized gates or arms are used (see Figure 3-41). The fencing can make it more difficult for impatient pedestrians to ignore the pedestrian arms and try to go around the arms.

Grade separated crossing - In key crossing areas such as at Ulrich at US 90A, the number of pedestrians and bicyclists crossing the roadway may ultimately warrant the installation of a grade separated crossing. Refer to the general criteria for grade separated crossings discussed on page 52.

A combination of these treatments as well as others designed for a specific location may be considered. Each individual crossing should be separately designed to take into account the unique constraints of the area.



Facility Type Costs

Facility costs are shown in Table 3.1 and were derived using the following assumptions:

Cost projections are calculated on a per linear foot basis, and include a contingency amount of 15%, since all facilities in this Plan are at a pre-design stage. Costs also include an additional allowance for:

- Surveying;
- Design; and
- Construction administration associated with the design of each facility.

No allowance for right of way acquisition is included in these typical costs, since most (but not all) recommendations utilize public or quasi-publicly owned corridors. Costs shown are in 2013 dollars and do not include an escalation factor since precise construction dates have not been established. When a timeframe for development is established, escalation factors should be added and should be based on actual construction costs at the time and recent inflation trends.

Bridge costs are factored into the average cost of shared use paths (trails) and sidepaths where appropriate. An allowance for some amenities such as benches and trail signage is included. Extraordinary features, such as trail lighting or extensive landscaping are not included but can be added on a case by case basis where appropriate.

These costs are the basis for facility segment and barrier crossing enhancement cost projections shown in Chapters 4 and 6. These costs are order of magnitude estimates and should be treated as a starting point for establishing budgets. Detailed preliminary engineering reports (PERs) are needed to address the unique conditions and associated needs of each recommendation in this report, and the costs shown in this report will vary based on the more detailed assessments.

Table 3.1 Pedestrian and Bicycle Facility Cost Ranges

Facility Type	One Side or Both Sides of Street	Description	Potential Additional Requirements	Unit of Measurement	Typical Cost Range (1)
Sidewalk	One side of Street	6' wide reinforced concrete (4" to 5" thickness)	May require root barriers where near trees. May require intersection or crosswalk treatments	Linear foot of pathway only	$40
Shared Use Path	N/A	10' wide reinforced concrete (4" to 5" thickness)	May require root barriers where near trees. May require intersection or crosswalk treatments	Linear foot of pathway only	$140
Sidepath	One side only	10' wide reinforced concrete (4" to 5" thickness)	May require root barriers where near trees. May require intersection or crosswalk treatments	Linear foot of pathway only	$125
Bicycle Lane	both sides of street	Lane striping, pavement markings, signs	May require additional traffic signs and special treatments at intersections	Linear foot of roadway	$10
Buffered Bicycle Lane	both sides of street	Buffer zone striping, pavement markings, signs	May require additional traffic signs and special treatments at intersections	Linear foot of roadway	$14
Cycle track	one side of street only	Two way facility, includes barrier curbing, center lane stripe, pavement markings and signs	May require additional traffic signs and special treatments at intersections	Linear foot	$20 to $40
Shared Lane Marking	both sides of street	Shared lane pavement marking, signs	May require additional traffic signs and special treatments at intersections which are not included	Linear foot of roadway	$4
Pedestrian Bridge (does not apply to custom bridge installations)	N/A	12' to 14' wide steel truss manufactured bridge with associated structural footings	Lengths exceeding 150' feet may require additional structural supports	Linear foot of bridge	$1750 to $2000

(1) Costs shown are in 2013 dollars, are prior to design or detailed corridor assessments, and require more detailed evaluations to fit costs to specific conditions and requirements of each proposed segment



Maintenance Requirements

Maintenance of pedestrian and bicycle facilities is as important as building them. Utilizing materials to reduce regular maintenance, giving attention to regular sweeping of the facilities, and ensuring that the surface is smooth are all elements that make the facilities attractive and usable. The benefits of a good maintenance program are far-reaching, including:

- A high standard of maintenance is an effective advertisement for promoting the use of pathways or bicycle lanes;
- Good maintenance can be an effective deterrent to vandalism, litter, and encroachments;
- Good maintenance is necessary to preserve positive public relations between the adjacent land owners and the City;
- Good maintenance can make enforcement of regulations on the pathway more efficient. Local clubs and interest groups will take pride in "their" path and will be more apt to assist in protection of the facility; and
- A proactive maintenance policy will help improve safety along the pathway or bicycle lane.

Ongoing maintenance likely includes some, if not all, of the following activities:

On-Street Bicycle Lanes

Sweeping to clear debris - Bicycles are more sensitive to irregularities and road debris than cars due to their smaller and lighter weight tires. Roadway features that cause minor discomfort to motorists, such as potholes and improper drain grates, can cause serious problems for bicyclists. Debris such as loose gravel or overgrown vegetation may seem minor to a vehicle, but can be serious hazards to bicyclists. Furthermore, debris is more likely to build in bike lane areas due to the absence of vehicles in that area. In the implementation of bicycle facilities, consider the need to maintain bicycle facilities and give attention to regularly sweeping of the bike lane and gutter area (as needed). Sweeping of bicycle lanes should be integrated into the traditional street sweeping schedule.

Re-striping - Painted lanes and lane symbols in Sugar Land typically have a five year life cycle, and should be re-striped at or near to that interval. When restriping is implemented, old striping must be removed before new striping is painted. The projected cost of re-striping as estimated by the City of Sugar Land is shown in Tables 3.2 and 3.3.

Pavement condition - Ensure that riding surfaces are relatively smooth and integrate the repaving of bicycle facilities with the regular schedule of repaving travel lanes.

Table 3.2 Repaint Bike Lane Estimate (Typ)			
Size	Unit Cost	Spacing (ft)	Cost per Mile
Eliminate 4”	$0.25	N/A	$1,320.00
Eliminate Bike Symbol	$20.00	400	$264.00
Eliminate Arrow Symbol	$15.00	400	$198.00
4” lane line	$0.50	N/A	$2,640.00
Bike Symbol	$200.00	400	$2,640.00
Arrow Symbol	$100.00	400	$1,320.00
Total			**$9,000 - $10,000**

Notes:
1) Estimate is based on 4” lines adjacent to vehicle travel
2) Based on current Multipolymer Striping contract prices
3) Life for most pavement markings is estimated at 5 years; depending on volumes of roadway it may be longer or shorter
4) no parking assumed

Table 3.3 Repaint Buffered Bike Lane Estimate (Typ)			
Size	Unit Cost	Spacing (ft)	Cost per Mile
Eliminate 8”	$0.50	N/A	$2,640.00
Eliminate 4”	$0.25	N/A	$1,320.00
Eliminate 4” Hatch	$0.25	10	$373.35
Eliminate Bike Symbol	$20.00	400	$264.00
Eliminate Arrow Symbol	$15.00	400	$198.00
8” Lane Line	$1.00	N/A	$5,280.00
4” Lane Line	$0.50	N/A	$2,640.00
4” Hatch	$0.50	10	$746.70
Bike Symbol	$200.00	400	$2,640.00
Arrow Symbol	$100.00	400	$1,320.00
Total			**$17,500 - $20,000 per mile**

Notes:
1) 24” wide buffer area using 4” stripes at 45 degree
2) Hatch are at 10’ spacings
3) 8” line adjacent to traffic and 4” line adjacent to bike lane
4) no parking assumed




Sign replacement - Sign conditions should be evaluated periodically, and signs should be replaced as needed.

Sidewalk, Sidepath and Shared Use Path Maintenance

Maintenance - Maintenance activities typically include replacement of small sections of pavement, landscape maintenance, facility upkeep, sign replacement, mowing, litter removal, and painting. A successful maintenance program requires continuity and often involves a high level of citizen participation. Routine maintenance on a year-round basis will not only improve safety, but will also prolong the life of the facility.

Vegetation - Plantings should be placed far enough apart to maintain good visibility and avoid creating an enclosed feeling. This will also give pathway users good, clear views of their surroundings. Under-story vegetation within most pathway rights-of-way should not be allowed to grow higher than thirty-six inches (36”) for visibility purposes, except in cases where the under-story vegetation is natural, desirable, and part of the habitat required for wildlife. Tree species selection and placement should minimize vegetative litter on the trail and root uplifting of pavement. Vertical clearance along the trail should be periodically checked, and any overhanging branches should be pruned to a minimum vertical clearance of eight feet (8’) above sidewalks and sidepaths and ten feet (10’) above trails.

Mowing - The shoulder zone adjacent to a pathway should be frequently mowed to allow for people to step off the facility if needed when passing another user.

Surfacing - Where concrete is the recommended surface material, cracks, ruts, and water damage will need to be repaired periodically. Where drainage problems exist along the pathway, ditches and drainage structures will need to be kept clear of debris to prevent washouts along the pathway and maintain positive drainage flow. Checks for erosion along the pathway should be made during the wet season, and immediately after any storm that brings flooding to the local area. The use of pathways with natural soft surfaces may need to be minimized and/or prohibited during wet conditions.

Removal of debris - The pathway surface should be kept free of debris, especially broken glass and other sharp objects, loose gravel, leaves, and stray branches. Path surfaces should be swept periodically. Soft shoulders should be well maintained to maximize their usability.

Litter Removal - Litter receptacles should be placed at access points such as trailheads. Neighborhood volunteers, friends groups, and community service groups should be considered in addition to maintenance staff.

Sign inspection and replacement - Signage should be replaced along paths and sidewalks on an as-needed basis.



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