

CHAPTER 10: ROADWAY CROSSING DESIGN

10.1 Introduction

The term crosswalk is defined in the Maryland Code:

§ 21-101. Definitions.

Crosswalk “means that part of a roadway that is: (1) Within the prolongation or connection of the lateral lines of sidewalks at any place where 2 or more roadways of any type meet or join, measured from the curbs or, in the absence of curbs, from the edges of the roadway; or (2) Distinctly indicated for pedestrian crossing by lines or other markings.”

As a result of this definition, there are two types of crosswalks: marked crosswalks and unmarked crosswalks. As defined in the Maryland MUTCD, a marked crosswalk is “any portion of a roadway at an intersection or elsewhere distinctly indicated as a pedestrian crossing by lines on the surface, which may be supplemented by contrasting pavement texture, style, or color.” Legal crossings without painted lines or other markings are known as unmarked crosswalks and drivers are required by law to stop for pedestrians in these locations just as they are at marked crosswalks (See Figure 10.1 below). Crosswalk markings are desirable in certain places because they alert motorists to locations where they should expect pedestrians and show pedestrians a preferred crossing location. The decision of where to locate crosswalk markings requires careful consideration and the use of engineering judgment. This chapter addresses where to mark crosswalks, how to design crosswalks, and engineering measures to improve the safety of crosswalks.

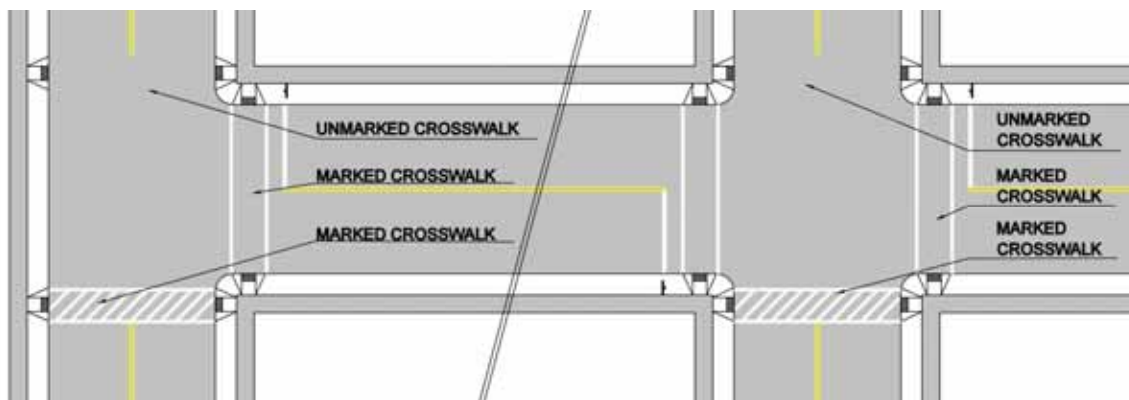


Figure 10.1 - Examples of Marked and Unmarked Crosswalks

10.2 Where to Mark Crosswalks

Below are guidelines for where to mark crosswalks at controlled and uncontrolled locations. A controlled location is one with a traffic signal or stop sign. An uncontrolled location is one without a traffic signal or stop sign. Guidance will also be presented for where engineering treatments should be used in conjunction with marked crosswalks in order to improve the safety of pedestrians crossing the roadway.

General Considerations

When marking crosswalks at controlled and uncontrolled locations, designers should consider the following general factors:

- **Bus stops:** The locations of bus stops and marked crosswalks should be coordinated. For safety reasons, it is preferred that a bus stop is located at the far side of the intersection (Zegeer et al, February 2002).
- **Adequate sight distance:** Pedestrians and motorists should be able to see each other.
- **Convenience:** Crosswalks should be located to provide the most direct connection between destinations.
- **Signage:** See Chapter 11 for information on signs at crosswalks.
- **Potential for shortening crossing distance:** Shortened crossing distances reduce the amount of time that pedestrians are exposed in the roadway. Information on road diets, curb extensions and pedestrian refuge islands is presented later in this chapter.
- **Traffic calming:** Appropriate use of traffic calming will reduce excessive vehicle speeds at crosswalks and may result in a safer environment. (Refer to the ITE/FHWA publication, *Traffic Calming: State of the Practice* for more information on traffic calming.)
- **Use of other innovative safety features:** Many other innovative safety features are described in this design guide.

Controlled Locations

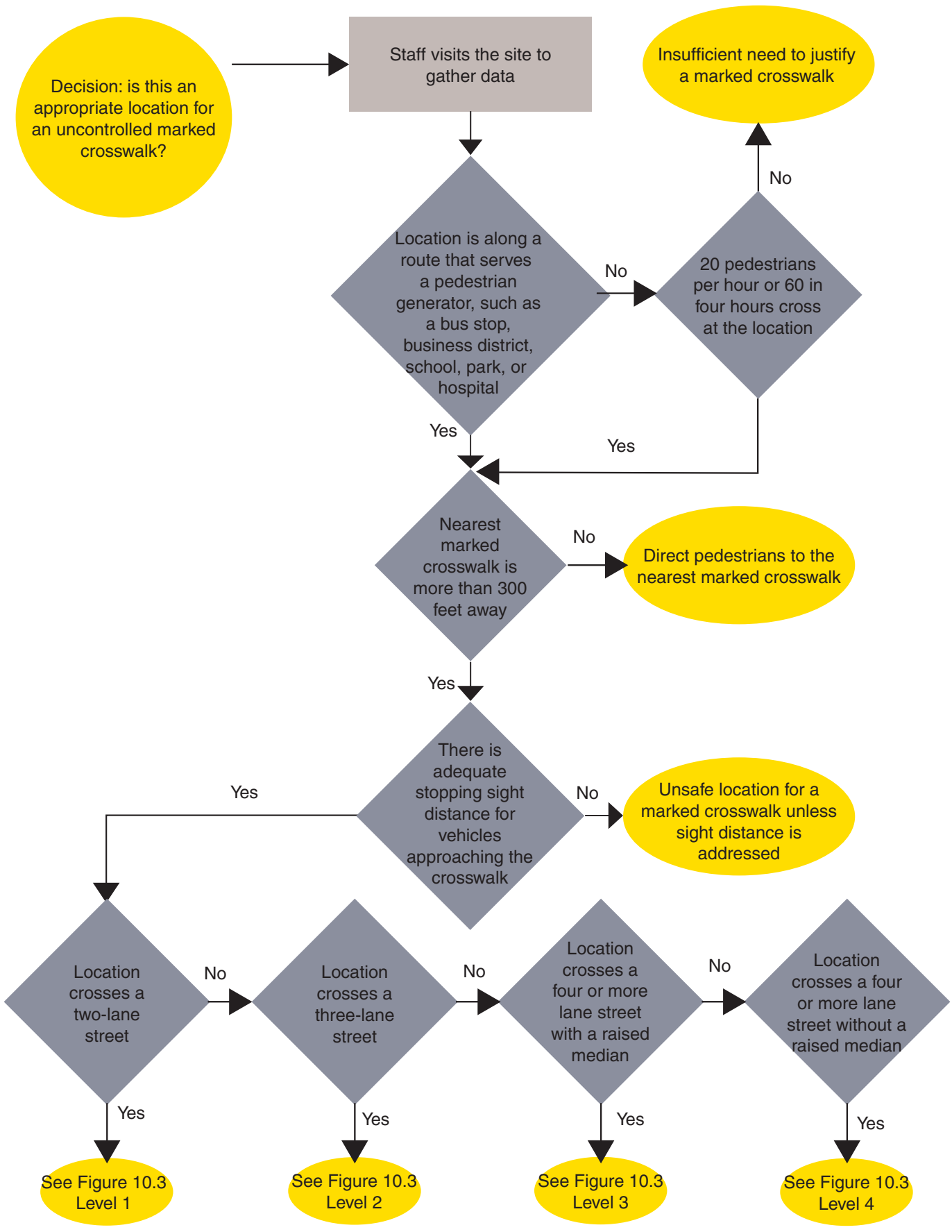
Marked crosswalks shall be provided across all street approaches to signalized intersections (on all legs of the intersection except those legs where a pedestrian crossing is determined to be unsafe). Marked crosswalks may also be considered at STOP controlled intersections where pedestrian traffic commonly occurs – particularly along routes that serve parks, schools, transit stops, and other similar areas.

Uncontrolled Locations

A recent national research project completed by the Federal Highway Administration provides specific guidance on the installation of crosswalks and other safety measures at uncontrolled locations (Zegeer et al, February 2002). As the authors of the report state:

“When considering marked crosswalks at uncontrolled locations, the question should not simply be: ‘should I provide a marked crosswalk or not?’ Instead, the question should be: ‘Is this an appropriate tool for getting pedestrians across the street?’ Regardless of whether marked crosswalks are used, there remains the fundamental obligation to get pedestrians safely across the street.”

Figures 10.2 and 10.3 offer guidance on the use of crosswalk markings at uncontrolled locations based on the FHWA study. Figure 10.2 provides a decision tree for determining whether a specific location is an appropriate candidate for an uncontrolled marked crosswalk. Based on the outcome of the decision tree, Figure 10.3 provides further guidance on the appropriate type of design treatment given the amount and speed of traffic at this location.



Sources: Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations, 2002 and City of Sacramento Public Works Department

Figure 10.2 - Uncontrolled Marked Crosswalks

Instructions: Complete the flow chart in Figure 10.2 and refer to the corresponding level below.

Level 1: 2 Lane Street

ADT	POSTED SPEED		
	30 mph or less	35 mph	40 mph or more
Up to 12,000 cars per day	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)
12,000-15000	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings	Pedestrian signal or grade separated crossing
15,000 cars or more per day	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Pedestrian signal or grade separated crossing

Level 3: 4 or more Lanes with a Raised Median

ADT	POSTED SPEED		
	30 mph or less	35 mph	40 mph or more
9,000 cars or fewer per day	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)
9,000-12,000	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Pedestrian signal or grade separated crossing
12,000-15,000	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Pedestrian signal or grade separated crossing
15,000 or more	Pedestrian signal or grade separated crossing	Pedestrian signal or grade separated crossing	Pedestrian signal or grade separated crossing

Level 2: 3 Lane Street

ADT	POSTED SPEED		
	30 mph or less	35 mph	40 mph or more
9,000 cars or fewer per day	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)
9,000-12,000	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)
12,000-15,000	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Pedestrian signal or grade separated crossing
15,000 or more	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Pedestrian signal or grade separated crossing	Pedestrian signal or grade separated crossing

Level 4: 4 or more Lanes without a Raised Median

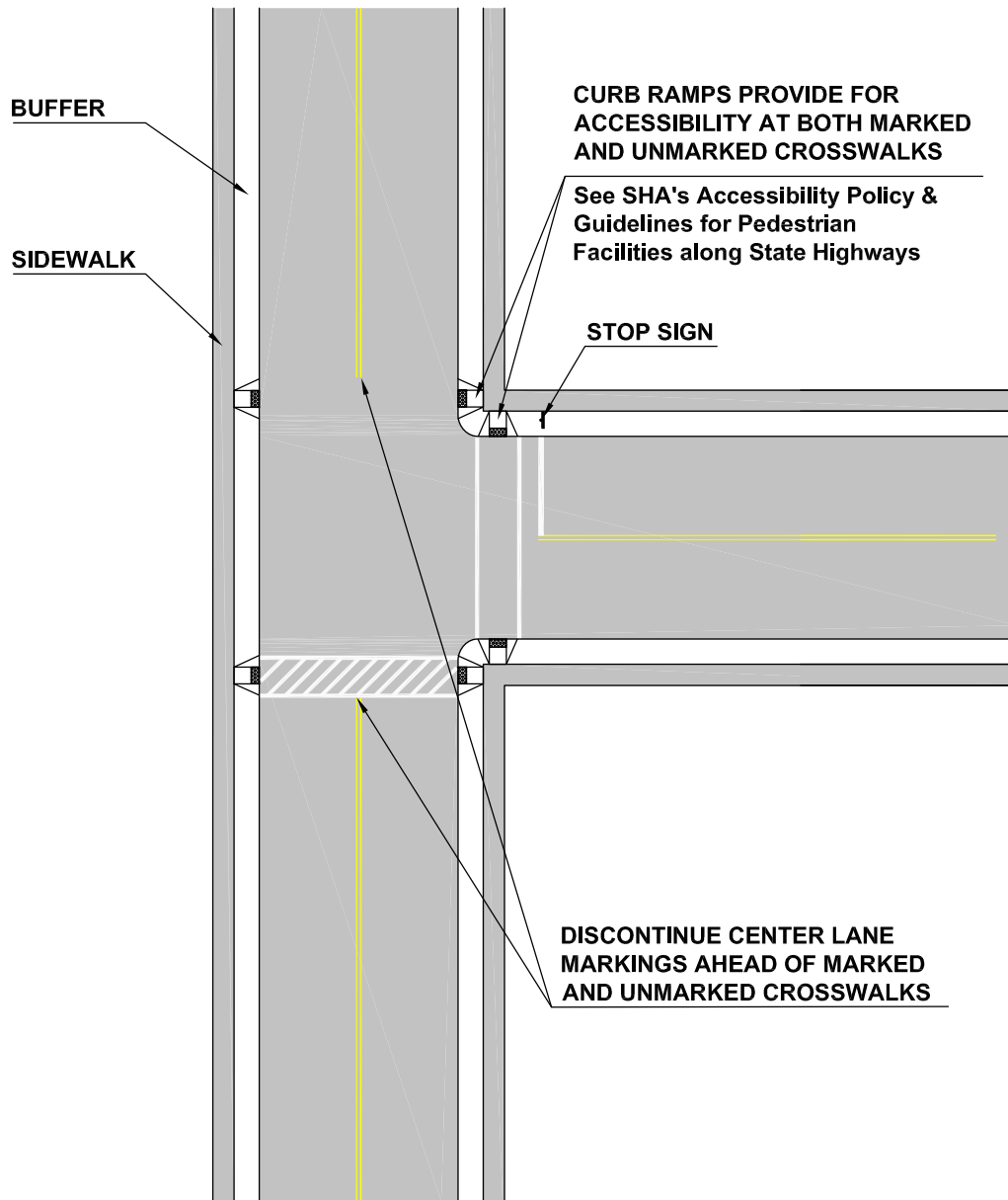
ADT	POSTED SPEED		
	30 mph or less	35 mph	40 mph or more
9,000 cars or fewer per day	Longitudinal or diagonal crosswalk markings	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Pedestrian signal or grade separated crossing
9,000-12,000	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Longitudinal or diagonal crosswalk markings plus an engineering treatment (see below)	Pedestrian signal or grade separated crossing
12,000-15,000	Pedestrian signal or grade separated crossing	Pedestrian signal or grade separated crossing	Pedestrian signal or grade separated crossing
15,000 or more	Pedestrian signal or grade separated crossing	Pedestrian signal or grade separated crossing	Pedestrian signal or grade separated crossing

Menu of Engineering Treatments

- Road Diet
- Crossing Islands
- Curb Extensions
- Advance Stop Lines
- In-Roadway Warning Lights
- Pedestrian Signals
- Grade Separated Crossing (should not be used in conjunction with longitudinal or diagonal crosswalk markings)

Figure 10.3 - Engineering Treatments for Uncontrolled Marked Crosswalks

NOT TO SCALE



DESIGN OF CROSSWALKS AT UNCONTROLLED LEGS OF INTERSECTIONS:

- See Figures 10.2 and 10.3 for guidance on whether to mark crosswalks at uncontrolled locations
- Roadway centerlines should not continue through the intersection, as for any other intersection; The centerlines should stop before the crosswalk, whether it is marked or unmarked
- Curb ramps provide for accessibility at both marked and unmarked crosswalks at T intersections and over the major approaches of uncontrolled roadway intersections, see SHA's *Accessibility Policy & Guidelines for Pedestrian Facilities along State Highways*

Figure 10.4 - Crosswalks at Uncontrolled Legs of Intersections

The intent of Figures 10.2 and 10.3 is to provide initial guidance on whether an uncontrolled location might be a candidate for a marked crosswalk alone and/or whether additional geometric and/or traffic control improvements are needed. As a part of the review process for pedestrian crossings, an engineering study should be used to analyze such other factors, including (but not limited to), as gaps in traffic, approach speed, sight distances, illumination, the needs of special populations, and the distance to the nearest traffic signal.

The spacing of marked crosswalks in uncontrolled situations should also be considered so that they are not placed too close together. Overuse of marked crosswalks may breed driver disrespect for them, and a more conservative use of marked crosswalks is generally preferred. Thus, it is recommended that in situations where marked crosswalks alone are acceptable, a higher priority be placed on their use at uncontrolled locations having a minimum of 20 pedestrian crossings per peak hour (or 15 or more elderly and/or child pedestrians per peak hour). In all cases, good engineering judgment must be applied. (Zegeer et. al., February 2002)

Figure 10.4 shows design guidance for marked and unmarked crosswalks at uncontrolled locations.

10.3 Crosswalk Markings

When it has been determined that a marked crosswalk is an appropriate treatment for a given location, Figure 10.5 provides a summary of guidelines for the design of the marked crosswalk, including crosswalk width. Further guidance is given in the Maryland MUTCD.

Decorative Crosswalk Markings

Some residents request decorative crosswalk markings because they find them to be more aesthetically pleasing than other types of crosswalk markings. In general, high visibility crosswalk markings are strongly preferred over decorative markings because they are easier for motorists to see. In the event that decorative crosswalk markings are used in place of high visibility markings, they should be edged with 12-inch wide reflective white lines. In addition, the decorative surface must be firm, stable and slip resistant (vertical displacement shall not exceed 1.4 inch, and horizontal gaps shall not exceed 1/2 inch).



Figure 10.6 - Example of Decorative Crosswalk Markings

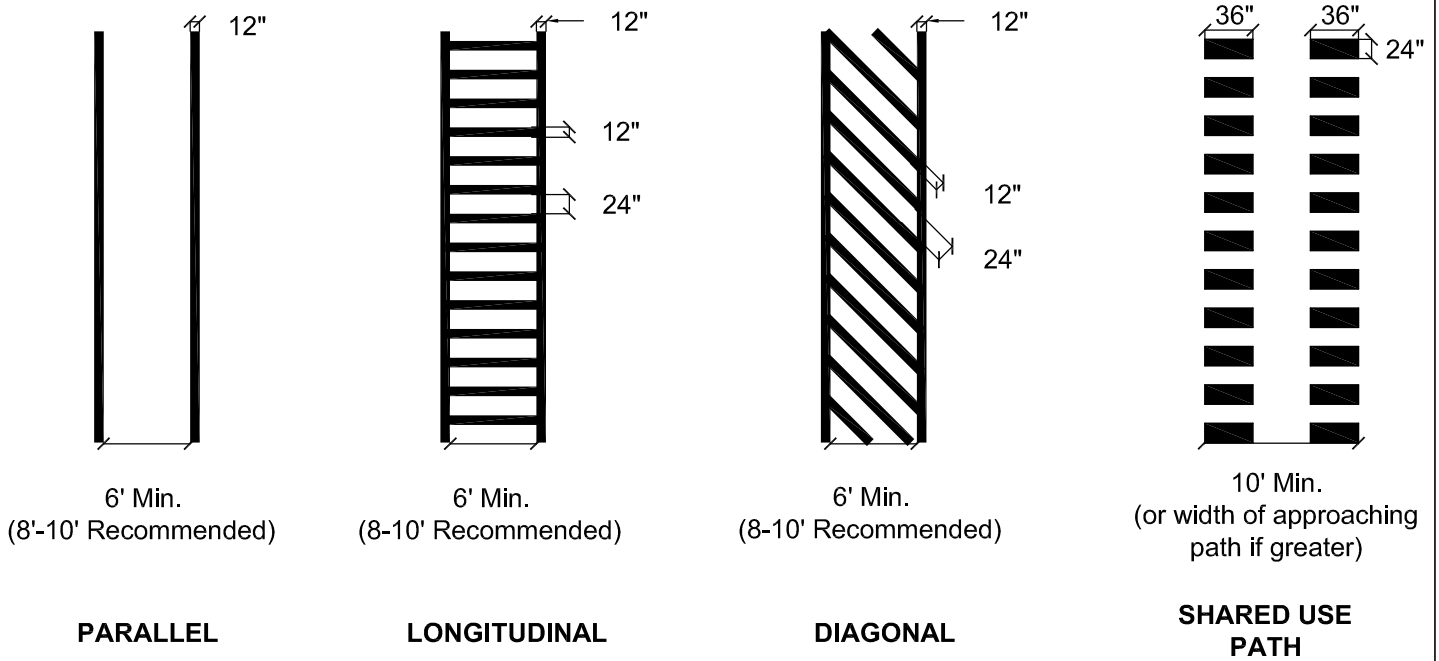
10.4 Midblock Crossings

Midblock crossings are a type of uncontrolled marked crosswalk and are subject to the standards in Section 10.2. While every attempt should be made to cross pedestrians at intersections, midblock crossings are a necessary pedestrian movement in many urban, suburban and rural locations. Since pedestrian travel speeds are much slower than other modes of transportation, pedestrians have a particularly strong desire to travel the shortest possible distance between two points. For example, when faced with the option to cross an 80-foot wide road at a midblock location versus walk 600 feet to the nearest intersection, cross at the crosswalk and walk back down the street, the majority of pedestrians cross midblock. Assuming a walking speed of 4 feet per second, the midblock crossing in this example requires 20 seconds to complete, while the alternative route requires more than 5 minutes.

Provisions for midblock crossings should be carefully considered, because a poorly designed midblock crossing will violate driver expectance and could cause safety problems for pedestrians. In some situations, the flow of traffic created by adjacent timed traffic signals

produces highly reliable gaps, one direction at a time, that allow pedestrians to cross the roadway easily. In these locations mid-block crossings may provide a safer alternative to pedestrians that would otherwise have to cross at a busy intersection with conflicting turning movements. In other situations, there may not be enough gaps for pedestrians to cross at the midblock location unless a pedestrian-activated traffic signal is added.

Since no two midblock crossings are alike, there is no single standard design. Engineering judgment must be used, based on the design principles described throughout this design guide. In general, however, midblock crossings should be considered at locations that are already a source of a significant number of midblock crossings, or are anticipated to generate midblock crossings as a result of new development, and/or where the land use is such that a pedestrian is highly unlikely to cross the street at a nearby intersection.



TYPES OF CROSSWALK MARKINGS:

Parallel Crosswalk Markings: The standard crosswalk striping treatment for low-volume pedestrian crossing locations.

Longitudinal Crosswalk Markings: May be used to provide added visibility for a crosswalk.

Diagonal Crosswalk Markings: "Across roadways at non-intersection locations, locations that are unexpected, locations within school zones and across ramps" diagonal markings shall be used (Maryland MUTCD Section 3B.17).

Shared Use Path Markings: In locations where a shared use path intersects a roadway.

Figure 10.5 - Crosswalk Marking Types
(Sheet 1 of 3)

SUITABLE LOCATIONS:

General:

Crosswalks should be marked at all intersections where there is a substantial conflict between vehicular and pedestrian movements including.

According to the the Maryland MUTCD, crosswalks *shall* be marked at the following locations:

1. all school crossings;
2. all recreational pedestrian and/or bicycle crossings;
3. all locations having pedestrian crossing warning signs;
4. all pedestrian crossings having pedestrian signal indications;
5. all mid-block/non-intersection locations;
6. any point where pedestrian crossings would be unexpected.

Marked crosswalks should also be provided at other appropriate points of pedestrian concentration such as loading islands, midblock pedestrian crossings, or where pedestrians may not otherwise recognize the proper place to cross.

According to the Maryland MUTCD, crosswalks *should* be marked at the following locations:

1. at points toward which pedestrians are directed to cross through special signing, public information and education campaigns, etc.
2. near major generators of pedestrian activity such as, transit facilities, office parks, stadiums, shopping centers, etc.
3. at intersections that have special pedestrian refuge islands/medians.
4. across ramps and right turn slots.

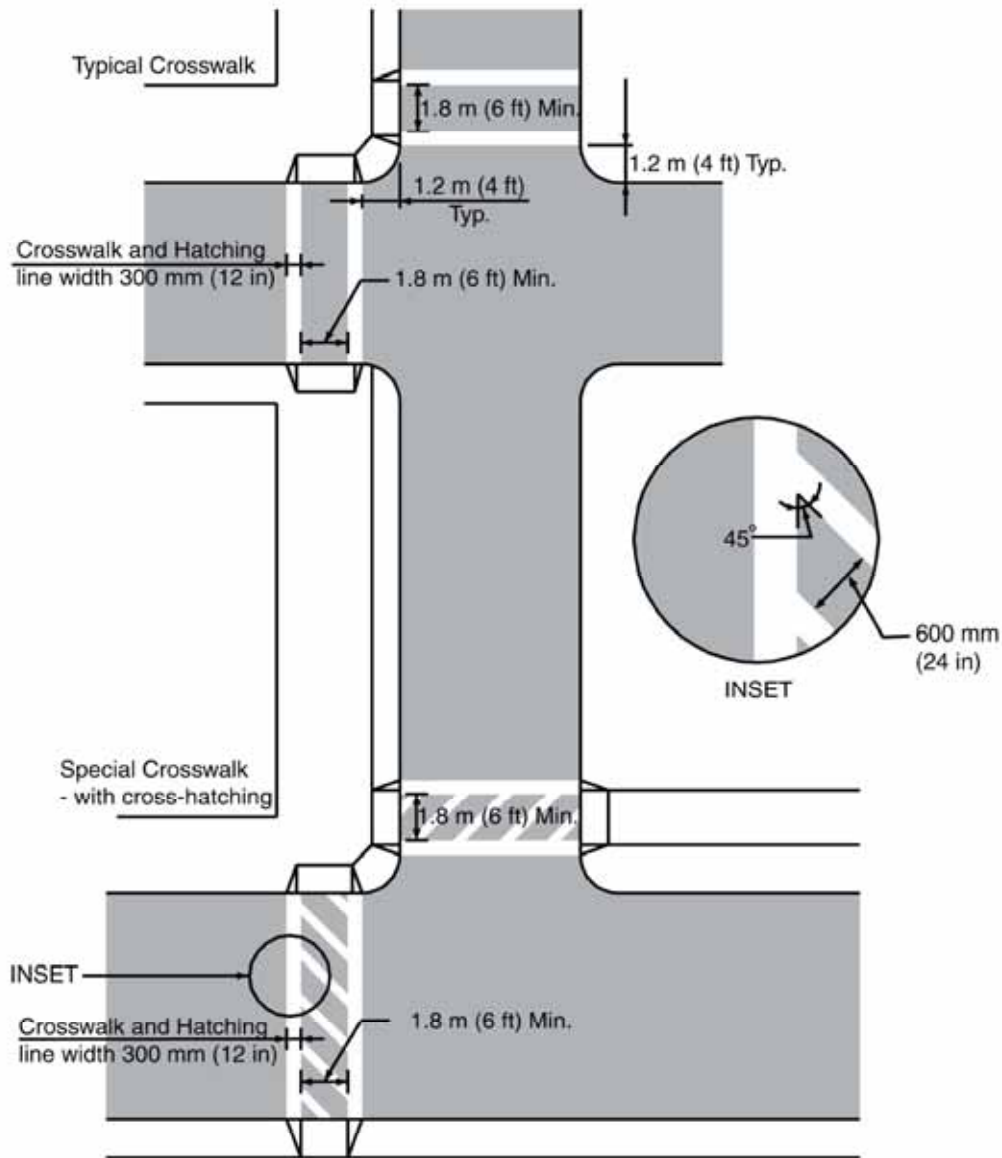
DESIGN OF CROSSWALK MARKINGS:

- Some consideration should be given to using the same type of crosswalk marking (i.e. the high visibility longitudinal or diagonal lines) on an area-wide basis, rather than only using them for certain locations.
- Crosswalk widths of 8-10' are recommended, crosswalks up to 15' may be appropriate for areas with high volumes of pedestrians;
- When diagonal or longitudinal crosswalk markings are used, the transverse crosswalk lines may be omitted;
- See Maryland MUTCD Section 3B.17 for more details on design of crosswalk markings and stop lines in relation to crosswalk markings;

NOTE:

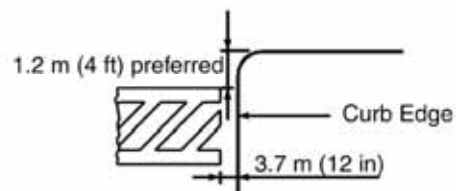
Crosswalk design should meet the *Accessibility Policy & Guidelines for Pedestrian Facilities along State Highways*.

Figure 3B-17a. Examples of Crosswalk and Crosswalk Lines 



A crosswalk placed at an intersection is preferred to be placed no closer than 1.2 m (4 ft) from the nearest edge of the intersecting roadway.

Across roadways at non-intersection locations, locations that are unexpected, locations within school zones, and across ramps, crosswalk lines shall be 300 mm (12 in) wide. The space between the crosswalk lines shall be hatched with diagonal white lines that are 300 mm (12 in) wide.



When using lane tape material, allow for gutter drainage by starting material 300 mm (12 in) from the curb edge.

Sect. 3B.17

Source: Maryland MUTDC 2006 Edition (Interim Edition), Section 3B.17

Figure 10.5 - Crosswalk Marking Types
(Sheet 3 of 3)

10.5 Measures to Improve Crossing Safety

The remainder of this chapter will present a toolbox of options for increasing the safety of pedestrians crossing the roadway. Signs and signals will be covered separately in Chapter 11. Engineering judgment will be necessary for picking the appropriate tools for a given location.

Removing travel lanes – “road diets”



Figure 10.7 - Example Before a Road Diet
(Photo by Peter Lagerwey)



Figure 10.8 - Example After a Road Diet
(Photo by Peter Lagerwey)

Roadway width is directly correlated with pedestrian safety. Wide roadways with multiple lanes expose pedestrians to increased crash risk. Some roadways may have more travel lanes than necessary for the amount of motor vehicle traffic they carry. A “road diet” may be possible for such roads. For example, an engineering analysis may determine that it is possible to reduce the cross section of a four lane road to a two-lane road with a center turn lane. Reducing the number of lanes on a multi-lane roadway can generate a number of positive benefits for both pedestrians and motorists, including:

- reduced motor vehicle collisions
- reduced crossing distances for pedestrians at intersections
- slower vehicle speeds
- additional space for streetscape and/or bike lane improvements
- additional space to provide a landscaped median

Four-lane roads with average daily traffic volumes of less than 25,000 are potential candidates for road diet treatments. Six-lane roads with volumes of 30,000 or less may also be candidates. Projected future traffic volumes should also be taken into consideration when proposing road diet projects.

Design of Crossing Islands

Figures 10.9 and 10.10 show examples of a continuous raised median and a raised crossing island at crosswalks. In the FHWA crosswalk study, it was found that “the presence of a raised median (or raised crossing island) was associated with a significantly lower pedestrian crash rate at multi-lane sites with both marked and unmarked crosswalks (Zegeer et al, February 2002).” Figure 10.9 shows a crosswalk through a continuous raised median. Although the detail shows a midblock location, a similar design is also possible at an intersection location. Figure 10.10 shows a raised crossing island. The detail shows the

crossing island at an intersection location, but raised crossing islands are also possible at midblock locations.

Curb Extensions

Curb extensions, as shown in Figure 10.11, are another method for shortening pedestrian roadway crossing distance. Curb extensions are possible on roadways with on-street parking, at both midblock and intersection locations.

Curb extensions should not be used on roadways where parking is prohibited or is uncommon. If curb extensions are used on roadways with no or limited parking, great care shall be taken to ensure that they do not create a hazardous condition for bicyclists, i.e. they shall not force bicyclists to merge into motor vehicle lanes.



Figure 10.12 - Example of a Curb Extension
(Photo by Dan Burden)

Advance Stop Lines

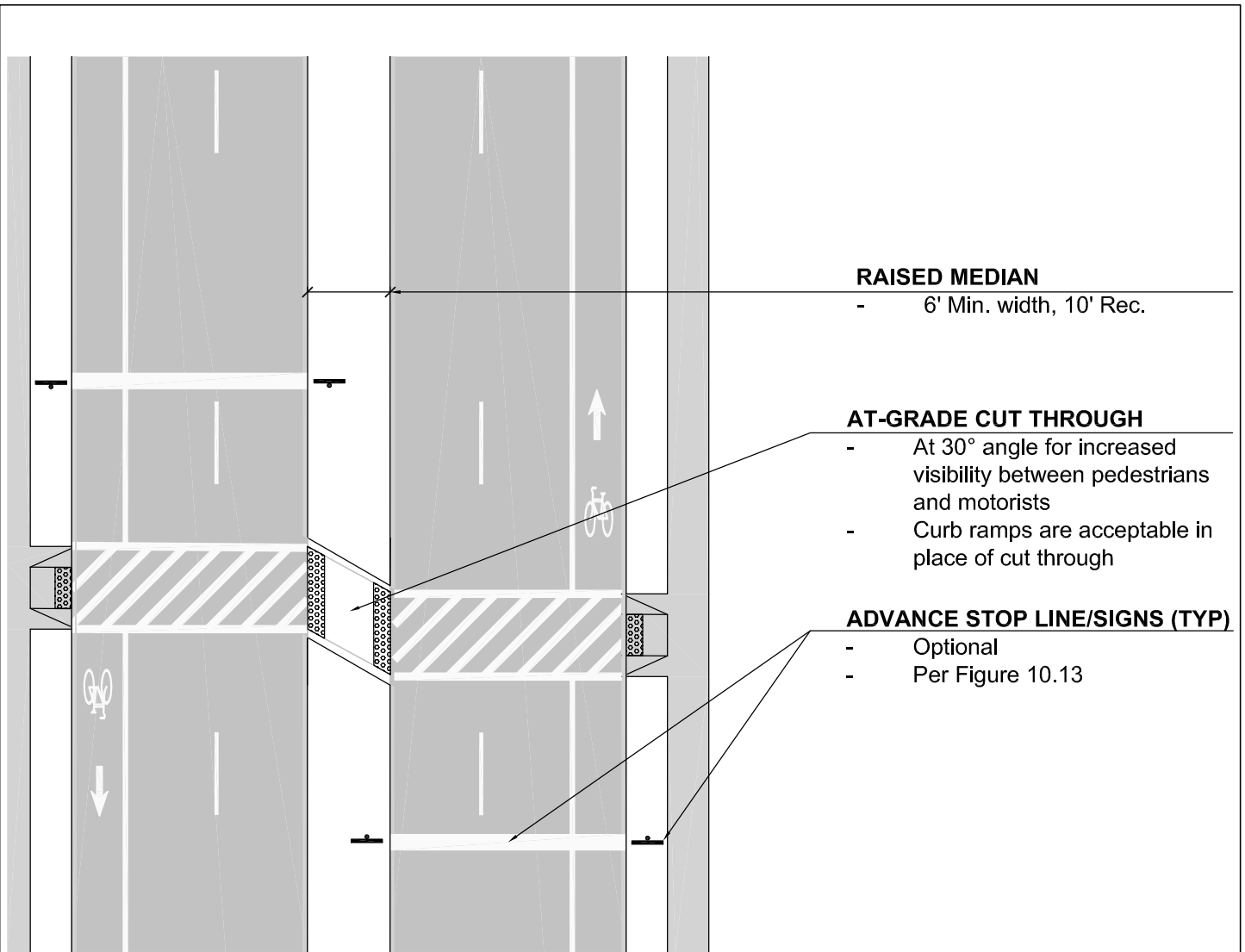
Figure 10.13 shows an application of advance stop lines, an optional treatment at uncontrolled midblock crosswalks. Research suggests that advance stop lines reduce the instance of multiple-threat crashes, in which a motorist in one lane stops for a pedestrian crossing the roadway, and the pedestrian is hit by a motorist in the adjacent lane that does not stop. (Van Houten; Van Houten and Malefant)

Channelizing Devices

Channelizing devices such as landscaping and fences can be used to encourage pedestrians to use marked crosswalks. Channelization should be in accordance with existing specifications.

Free Flow Right Turn Design for Improved Pedestrian Safety

As stated in FHWA's *Pedestrian Facilities Users Guide: Providing Safety and Mobility*, "while right-turn slip lanes are generally a negative facility from the pedestrian perspective due to the emphasis on easy and fast motor vehicle travel, they can be designed to be less problematic (Zegeer et al, March 2002)." Figure 10.14 shows details for how to design free flow right turns for improved pedestrian safety.



BENEFITS:

- Reduces the width of roadway that pedestrians must cross at one time
- Reduces pedestrian crashes at multi-lane sites
- Medians and channelization islands reduce the rate of motor vehicle crashes and have particular benefits for older drivers

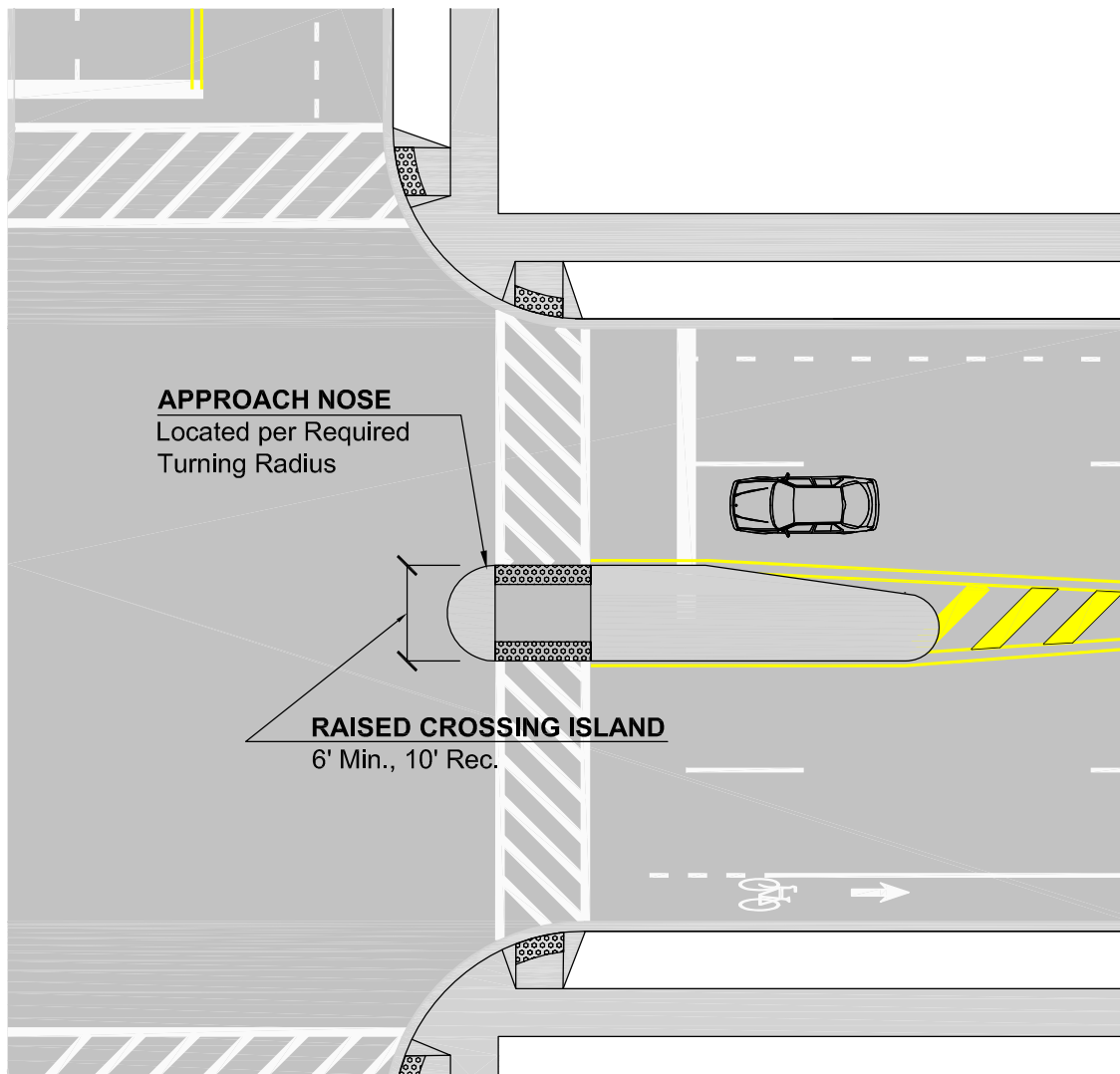
SUITABLE LOCATIONS:

- Particularly beneficial on multi-lane roadways
- Suitable at both controlled and uncontrolled locations
- Suitable at both intersection and midblock locations

DESIGN OF CROSSING ISLANDS:

- Raised medians require at-grade cut throughs or curb ramps to provide an accessible pedestrian path
- Should be aligned directly with marked crosswalks
- Raised approach noses should be included for raised medians at intersections
- Should meet the luminance contrast levels needed to improve detection by older drivers, per the recommendations in FHWA's Highway Design Handbook for Older Drivers and Pedestrians (2001)
- If median is landscaped, the vegetation must not obstruct necessary clear sight triangles
- Must meet SHA's *Accessibility Policy & Guidelines for Pedestrian Facilities along State Highways*.

Figure 10.9 - Continuous Raised Median



BENEFITS:

- Reduces the width of roadway that pedestrians must cross at one time
- Reduces pedestrian crashes at multi-lane sites
- Medians and channelization islands reduce the rate of motor vehicle crashes and have particular benefits for older drivers

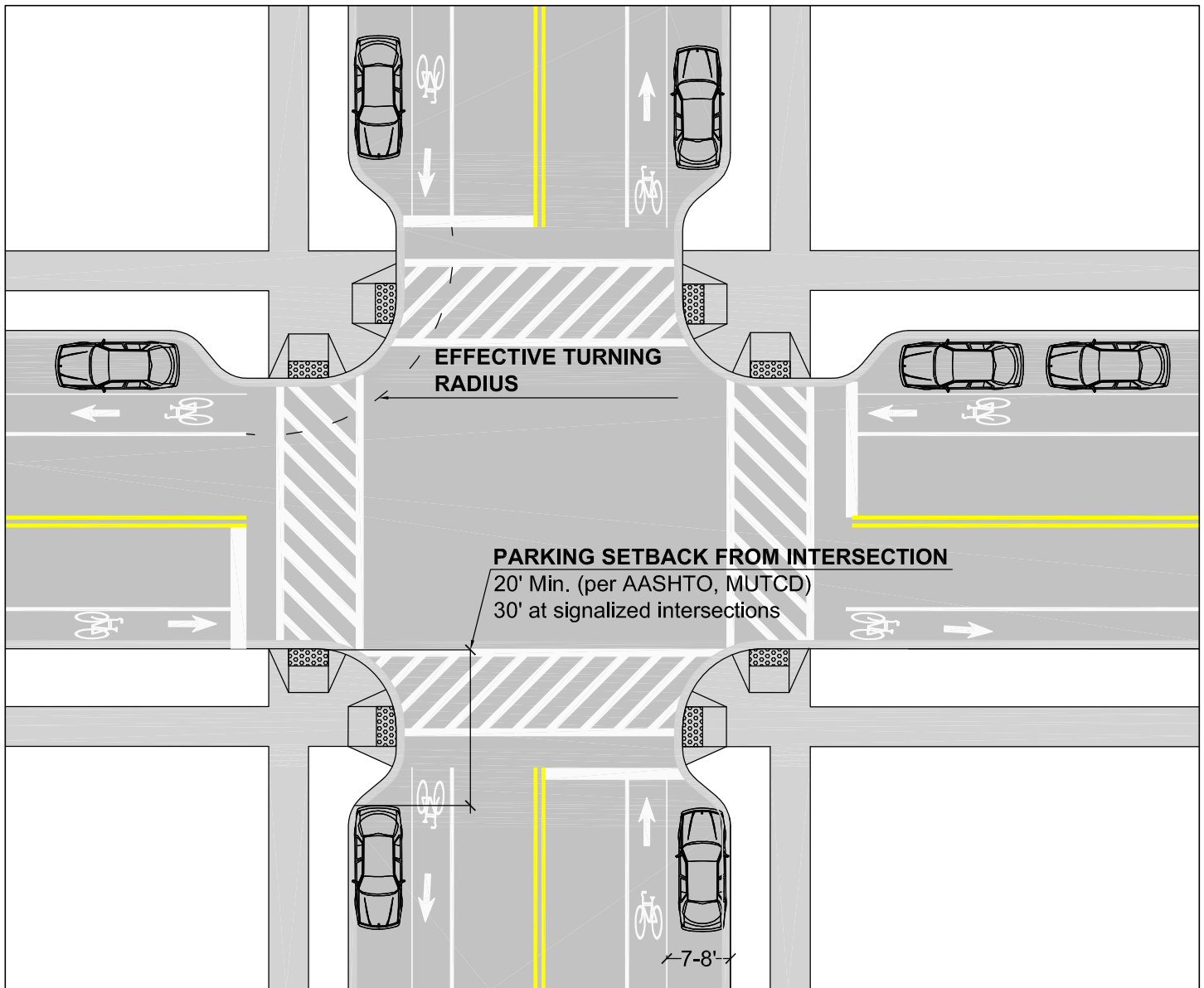
SUITABLE LOCATIONS:

- Particularly beneficial on multi-lane roadways
- Suitable at both controlled and uncontrolled locations
- Suitable at both intersection and midblock locations

DESIGN OF CROSSING ISLANDS:

- Raised medians require at-grade cut throughs or curb ramps to provide an accessible pedestrian path
- Should be aligned directly with marked crosswalks
- Raised approach noses should be included at intersection crossing islands
- Should meet the luminance contrast levels needed to improve detection by older drivers, per the recommendations in FHWA's Highway Design Handbook for Older Drivers and Pedestrians (2001)
- If median is landscaped, the vegetation must not obstruct necessary clear sight triangles
- Must meet SHA's *Accessibility Policy & Guidelines for Pedestrian Facilities along State Highways*.

Figure 10.10 - Raised Crossing Island



BENEFITS:

- Enhanced visibility between pedestrians and drivers
- Greater space for pedestrians waiting to cross the intersection
- Less exposure for pedestrians due to shorter crossing distance
- Prevent cars from parking too close to the crosswalk area

SUITABLE LOCATIONS:

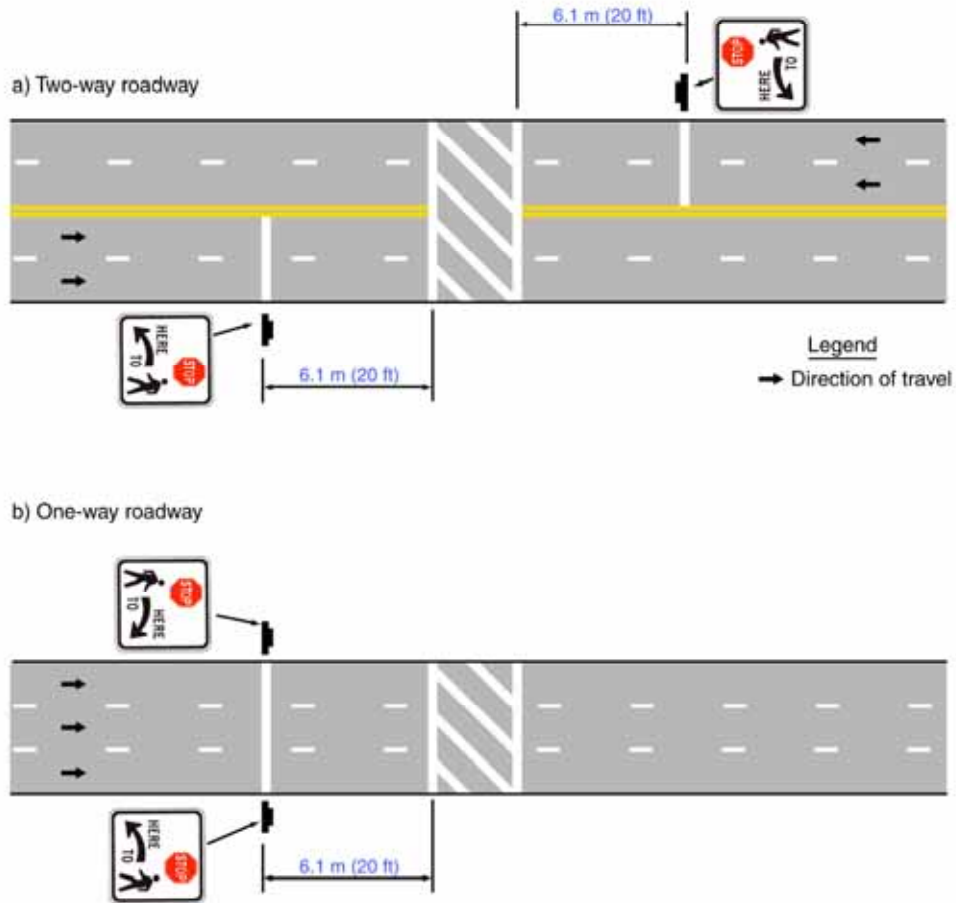
- Intersection locations on streets with on-street parking (arterial streets, residential collectors, and local streets)
- Midblock locations on streets with on-street parking

DESIGN AND PLACEMENT OF CURB EXTENSIONS:

- Curb extensions should not extend into travel lanes.
- Typical curb extensions extend 6 feet from the curb (the approximate width of a parked car).
- The turning needs of larger vehicles should be considered in curb extension design, in locations where higher volumes of truck traffic are expected. Use the effective turning radius.
- Each curb bulb may extend into either one or two legs of the intersection, depending on the configuration of parking.

Figure 10.11 - Curb Extensions

Figure 3B-15. Examples of Stop Lines at Unsignalized Midblock Crosswalks SMA



Source: *Maryland MUTDC 2006 Edition (Interim Edition)*, Section 3B.16

BENEFITS:

- Increased visibility between far-lane motorists and pedestrians
- Reduced incidence of multiple-threat collisions

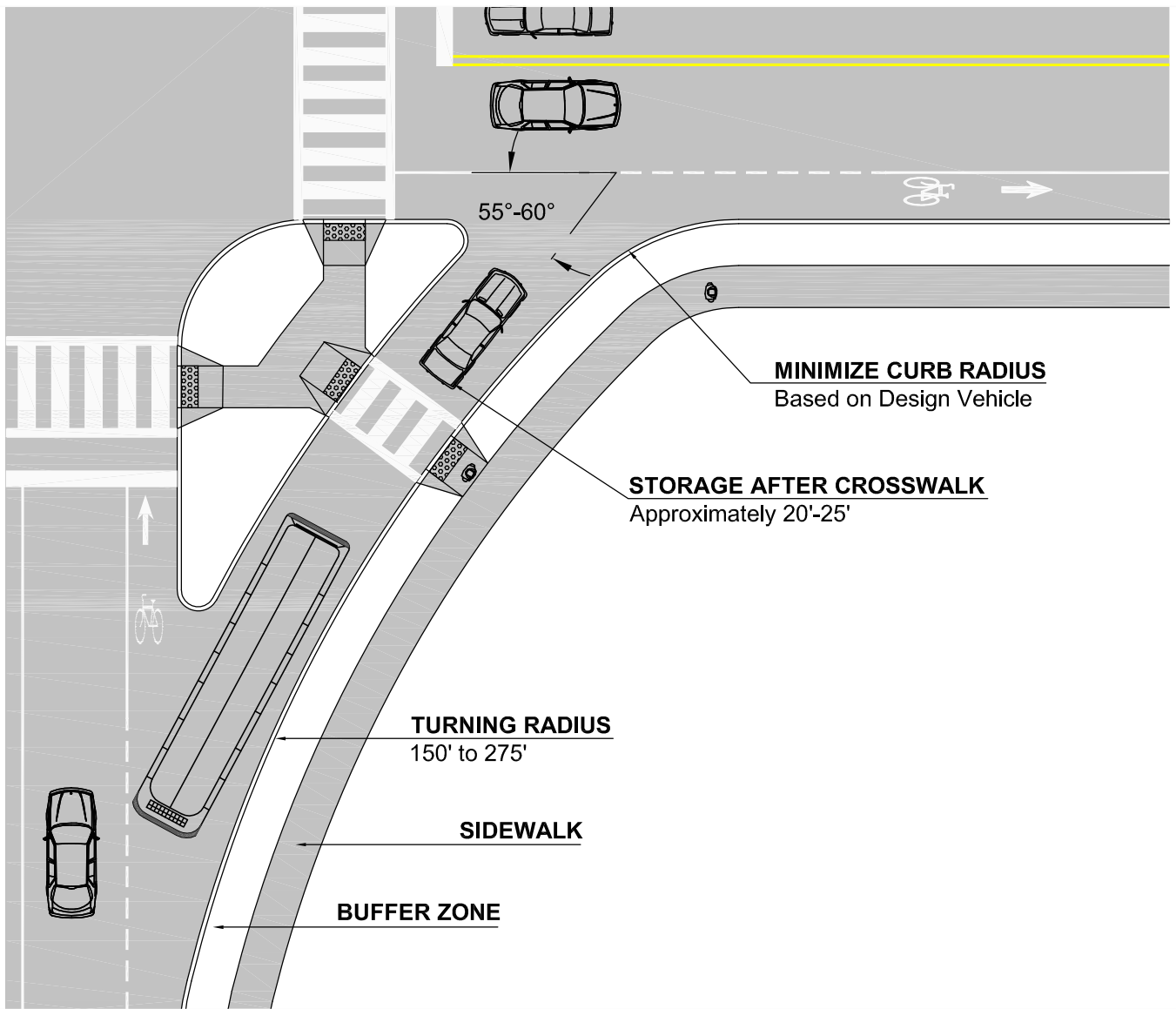
SUITABLE LOCATIONS:

- Midblock uncontrolled marked crosswalks on multi-lane roads

DESIGN OF ADVANCED STOP LINES AT UNCONTROLLED MIDBLOCK CROSSWALKS:

- Per the Maryland MUTCD
- Parking should be prohibited in the area between the stop line and the crosswalk
- Stop line should be placed adjacent to the Stop Here to Pedestrians Sign (R1-6b)
- Other engineering treatments may be needed, see Figures 10.2 and 10.3

Figure 10.13 - Advance Stop Line at Uncontrolled Midblock Crosswalk



BENEFITS:

- Approach angles between 55-60 degrees discourage high speed turns, thus reducing speeds in the ramp area
- Increase sight distances
- Reduce pedestrian crossing distances

SUITABLE LOCATIONS:

- Intersections requiring very large turning radii, or with heavy volumes of right-turning traffic

NOTES:

It may be determined that the slip turn should feed into an acceleration/speed change lane. This is usually based on multiple factors including traffic volume, speed and roadway classification. These movements are often detrimental to pedestrians because they are typically designed for higher turning speeds. Therefore, the level of pedestrian activity and adjacent land use should also be factored when determining the use of acceleration/speed change lanes at slip turns. If deemed appropriate, a similar design to that shown above can be used to slow turning vehicles at the pedestrian crossing, however this may require additional acceleration lane length on the receiving roadway.

Figure 10.14 - Free Flow Right Turn Design For Improved Pedestrian Safety