Determining Whether and How to Mark Crosswalks

June 2023

Prepared for:

Town of Prescott Valley, Arizona

Prepared by:

Lee Engineering, LLC
3610 N. 44th Street, Suite 100
Phoenix, AZ 85018
(602) 955-7206

1213.11

Determining Whether and How to Mark Crosswalks

Town of Prescott Valley

June 2023

PRESCOTT VALLEY

Table of Contents

Introduction

This document provides guidance and direction on crosswalk signing and marking specific to Prescott Valley.

In this document, the term "crosswalk" may refer to a crosswalk either ***with*** or ***without*** markings. The term "marked crosswalk" is used to refer to a crosswalk designated with markings and "unmarked crosswalk" to a crosswalk without markings. The term "crossing" is used to refer to a location where pedestrians cross that may or may not be a crosswalk.

In general, crossings can be categorized as follows:

- ***Grade-separated crossings*** are those where pedestrians cross on either an overpass or underpass and are not exposed to conflicts with vehicular traffic. Grade-separated crossings are not considered "crosswalks" under state law.

- ***Controlled crossings*** are those where the street crossed is controlled at the crossing by a traffic signal, pedestrian hybrid beacon (PHB), or STOP sign.

- ***Uncontrolled crossings*** are those where the street crossed is free-flowing (i.e., is not controlled by a traffic signal, PHB, or STOP sign).

LEE ENGINEERING · 3610 N. 44th St., Suite 100 · Phoenix, Arizona, 85018

Laws and Standards

Crosswalk Types and State Law

Arizona state law defines "crosswalk" as follows:

> "(a) That part of a roadway at an intersection included within the prolongations or connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or, in absence of curbs, from the edges of the traversable roadway.
>
> "(b) Any portion of a roadway at an intersection or elsewhere that is distinctly indicated for pedestrian crossing by lines or other markings on the surface."[1]

The word "sidewalk" is defined by state law as:

> "That portion of a street that is between the curb lines or the lateral lines of a roadway and the adjacent property lines and that is intended for the use of pedestrians."[2]

The state-law definition of "sidewalk" is somewhat different than the word's common usage. According to state law, a sidewalk exists even if an area is "intended" for use by pedestrians. A sidewalk does not need to be paved or otherwise improved to meet the state-law definition. Sidewalks exist along almost all roadways as long as the roadside is traversable by pedestrians.

Arizona state law considers crosswalks in two categories:

- At ***intersections*** of two public streets, either signalized or unsignalized, crosswalks exist across every leg, whether or not crosswalk markings are provided. State law confirms that pedestrians and motorists have the same rights and responsibilities at both marked and unmarked crosswalks. There is no legal requirement under state law to mark crosswalks at intersections to give pedestrians the legal right-of-way to cross. Most controlled crossings are at intersections; these are considered "crosswalks" under state law even if unmarked.

- At crossings ***away from intersections*** (such as a trail that crosses a street midblock), crosswalk markings must be provided to give pedestrians the legal right-of-way over motor vehicles. This condition usually occurs at uncontrolled crossings. If crosswalk markings are not provided at crossings away from intersections, two cases are defined in state law:
    - At locations "between adjacent intersections at which traffic control signals are in operation," pedestrians are not legally permitted to cross.[3] If pedestrian crossings are needed at a location with no unsignalized intersections between two adjacent signalized intersections, then crosswalk markings are required.
    - At any other location, pedestrians are legally permitted to cross but must yield to motor vehicles.[4] In the event of a crash at a non-intersection location without crosswalk markings, the pedestrian is likely to be considered at fault for failing to yield.

[1] Arizona Revised Statutes, §28-601.
[2] Arizona Revised Statutes, §28-601.
[3] Arizona Revised Statutes, §28-793(C).
[4] Arizona Revised Statutes, §28-793(A).

MUTCD Crosswalk Marking Provisions

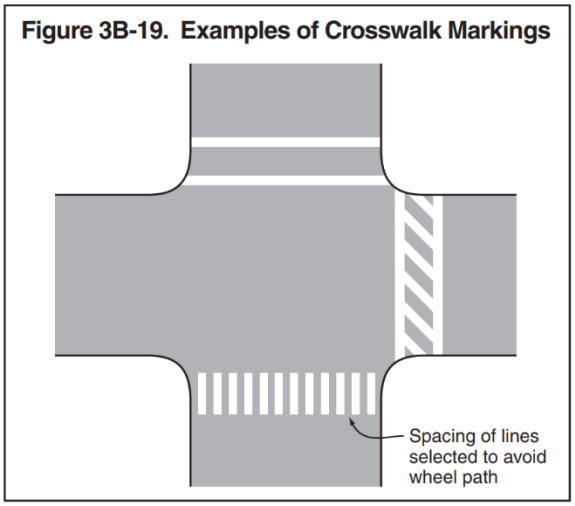
The *Manual on Uniform Traffic Control Devices* (MUTCD) distinguishes among "standard" and "high-visibility" crosswalk markings. Although these terms are not used in the MUTCD, they are used widely in the industry, and are defined as follows:

- ***Standard*** crosswalks consist of two parallel transverse solid white lines, required to be between 6 and 24 inches wide.[5]

- ***High-visibility*** crosswalks use additional markings to draw increased attention to the crosswalk. While several marking patterns are permissible, a frequent pattern involves longitudinal lines either added to or replacing the transverse lines used for standard markings. Where longitudinal lines (perpendicular bars) are used to form high-visibility crosswalks, they should be 12 to 24 inches wide separated by gaps of 12 to 60 inches. However, the gap should not exceed 2.5 times the width of the lines, and the design should avoid vehicle wheel paths if possible.[6]

MUTCD Figure 3B-19, reproduced at right, illustrates a standard crosswalk (at the top of the figure) and two methods of marking high-visibility crosswalks (at the right and bottom of the figure). Other methods of marking high-visibility crosswalks are also permitted by the MUTCD, but for consistency, one method is recommended for use in Prescott Valley, as discussed on page 13.

Figure 3B-19. Examples of Crosswalk Markings



The following provisions in the MUTCD apply to crosswalk markings:

- Crosswalks should be at least 6 feet wide.[7]
- Crosswalk markings should extend across the full width of the pavement or to the edge of the intersecting crosswalk.[8]
- Warning signs should be installed for all marked non-intersection crosswalks.[9]
- Crosswalk markings should be located so the curb ramps are entirely within the extension of the crosswalk markings.[10]

[5] MUTCD Sec. 3B.18, para. 04.
[6] MUTCD Sec. 3B.18, para. 15.
[7] MUTCD Sec. 3B.18, para. 05.
[8] MUTCD Sec. 3B.18, para. 06.
[9] MUTCD Sec. 3B.18, para. 11.
[10] MUTCD Sec. 3B.18, para. 17.

Deciding Whether to Mark Controlled Crosswalks

Controlled crosswalks may be either marked or unmarked according to engineering judgment; no engineering study is required to install markings at controlled crosswalks.

At pedestrian hybrid beacons (PHBs), crosswalks are always marked.

At signalized intersections, crossings are almost always marked where they have pedestrian accommodations such as pedestrian pushbuttons and/or pedestrian signal heads.

At stop-controlled crossings, the presence of markings varies considerably. Jurisdictions typically have hundreds or thousands of stop-controlled crossings, and it is not necessary or practical to mark most of these. Markings are typically not needed at stop-controlled intersections of local streets unless they involve unusual circumstances. It may be desirable to consider markings at stop-controlled intersections in the following situations:

- Markings are often provided for crosswalks serving a park, playground, or school along the school walking route.
- Markings are often used where multi-use paths (MUPs) cross streets.
- Markings may be used at stop-controlled crossings parallel to collector or major streets; these markings are more likely to be used in urban and suburban areas where at least occasional pedestrian traffic is expected.

Markings are often omitted at stop-controlled intersections without paved sidewalks in the direction of crossing pedestrians.

Deciding Whether to Mark Uncontrolled Crossings

Uncontrolled crossings should be marked only after review and application of these guidelines. Research has shown that on some streets, crosswalk markings alone may not improve pedestrian safety at uncontrolled crossings. These guidelines were developed in accordance with the most recent available pedestrian safety research to ensure that crosswalk markings, where used, have positive safety effects.

The following steps should be taken to decide whether to install markings at an uncontrolled crossing:

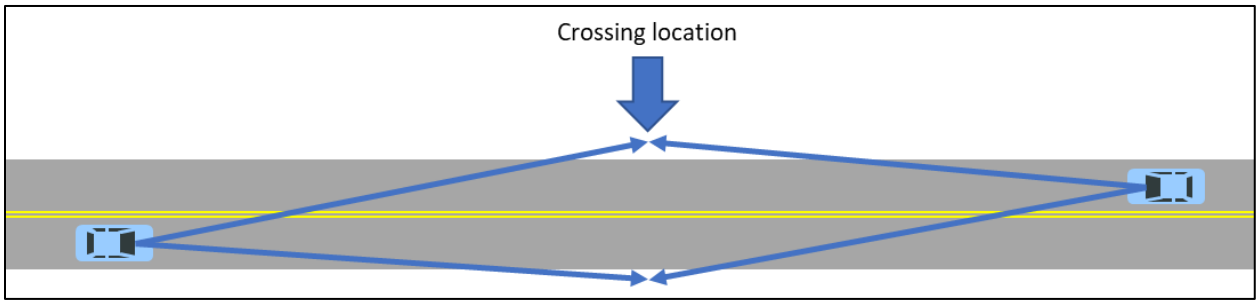
- **Step 1** involves assessing the crossing using the *Uncontrolled Crossing Flowchart* on page 8.
- If directed to proceed to Step 2 by the flowchart, **Step 2** involves evaluating the crossing using the *Uncontrolled Crossing Evaluation Worksheet*, on page 9.
- If directed to proceed to Step 3 by the flowchart or the worksheet, **Step 3** involves determining the Tier number of the crossing and associated traffic control devices according to the *Uncontrolled Crossing Tier Matrix* on page 11.

If this three-step process indicates that crosswalk markings should be considered, then markings should *only* be installed along with other traffic control devices recommended for the applicable tier number. Crosswalk markings should not be installed before (or without) the other devices recommended for that tier.

Following is additional information about two questions in the Step 1 flowchart:

- ***Does the crossing provide critical pedestrian connectivity?*** The purpose of this question is to assess whether crosswalk markings are desirable regardless of other site characteristics and pedestrian activity. For instance, crossings that are important for connectivity may be the only available crossing point, or the most logical crossing point, between a pedestrian generator (such as a park or retail center) and a residential neighborhood.

- ***Is sight distance sufficient?*** Available sight distance at the crossing should be measured in four ways, as shown in the figure below, involving all combinations of motorist travel direction and pedestrian travel direction. Sight distance is measured along the length of the roadway. The *shortest* of these four sight lines should be used for analysis purposes.



Two different sight distance criteria are relevant:

  - *Stopping Sight Distance (SSD)*: Motorists approaching a marked crosswalk must have enough time to stop after seeing a crossing pedestrian and before reaching the crosswalk. SSD must comply with the table below:

Speed Limit (mph)	***Minimum Required Stopping Sight Distance (SSD), in feet***
25 or less	155
30	200
35	250
40	305
45	360
50	425
55	495

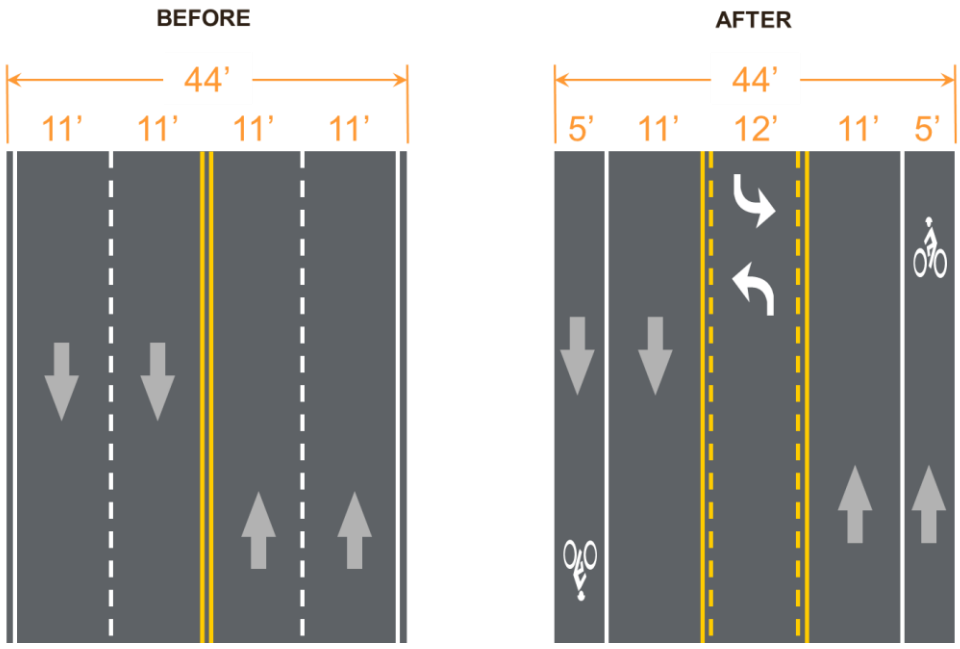
- *Crossing Sight Distance (CSD)*: Pedestrians should be able to see a sufficient distance along the road to identify an appropriate gap in traffic before beginning to cross the street. CSD should comply with the table below. In the table, the crossing length should be measured between faces of curb, edge lines, or edges of pavement on opposite sides of the crossing; however, the crossing length can be limited to the median if the median is raised and at least 6 feet wide for speed limits 35 mph and below, or at least 8 feet wide for speed limits 40 mph and above.

Speed Limit (mph)	***Minimum Crossing Sight Distance (CSD), in feet***			
	Crossing Length (feet)			
	20	***30***	***40***	***50***
25 or less	305	410	515	620
30	365	490	615	745
35	425	570	720	865
40	485	655	820	990
45	545	735	925	1115
50	605	815	1025	1235
55	665	900	1130	1360

At marked crosswalks, it is essential that the sight distance available to a motorist exceeds the minimum SSD. Motorists must have sufficient time to stop upon seeing a pedestrian. If SSD is not sufficient, the crosswalk should not be marked. It is also ideal if the sight distance available to a pedestrian exceeds the minimum CSD.

Following is additional information about road diets, which are mentioned in the Step 3 matrix.

A ***road diet*** is an informal way to refer to a reconfiguration of the lanes of a roadway, usually to eliminate one or more lanes, to provide space for other uses of the pavement. Other uses might include on-street parking, two-way left-turn lanes, bicycle lanes, paved sidewalk, and/or raised landscaped medians. A typical road diet involves converting a four-lane undivided roadway to a three-lane road with one lane and a bike lane in each direction separated by a left-turn lane, as shown below. There are many other possible configurations of road diets.



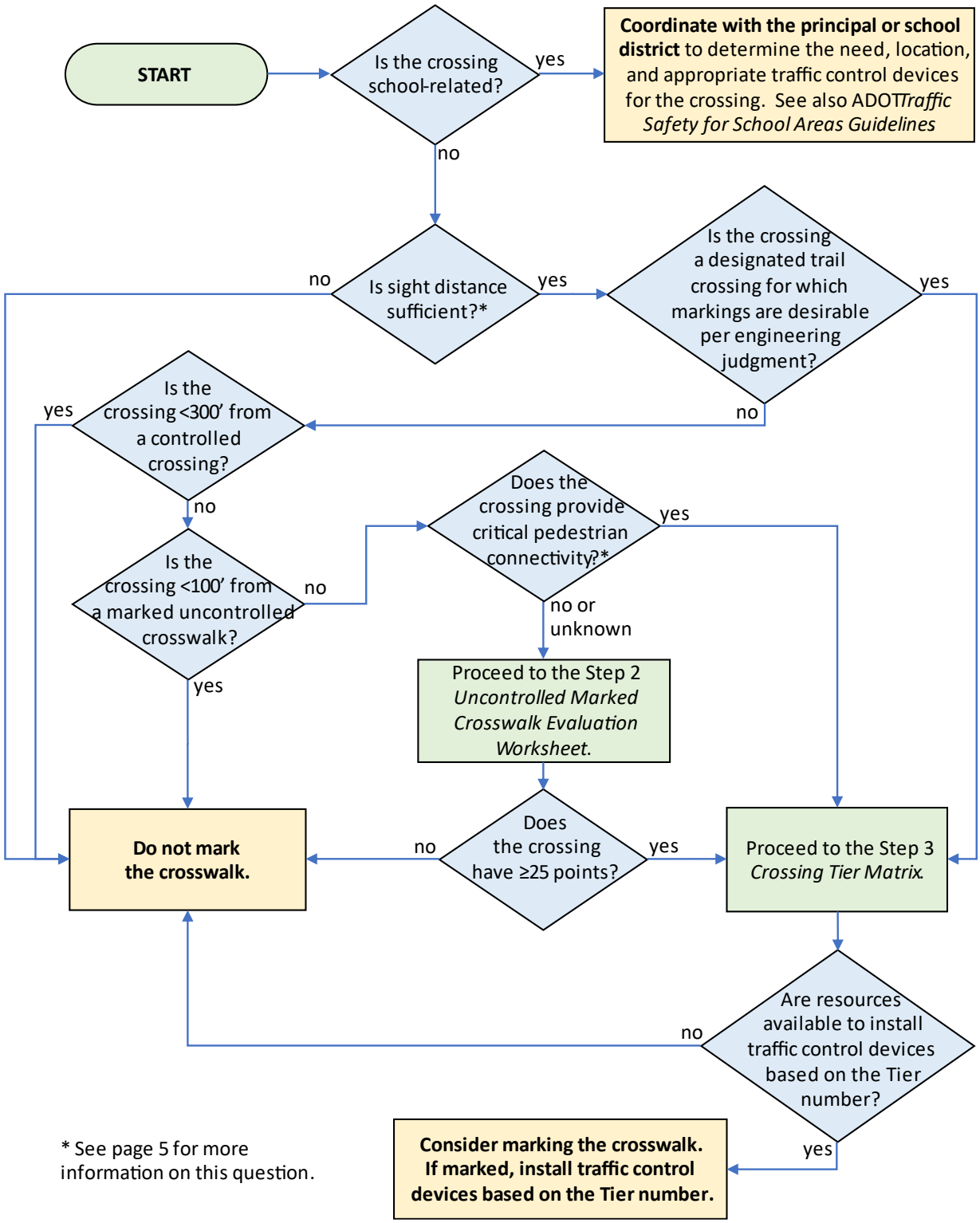
Among the many benefits of road diets is a considerable increase in pedestrian crossing comfort and safety. A four-lane undivided road is difficult to cross because a pedestrian must find gaps in all four travel lanes simultaneously, looking in both directions. A three-lane road is much easier to cross because a pedestrian must only find a gap in one lane at a time, waiting in the left-turn lane or median if necessary before completing their crossing.

Road diets typically reduce the capacity of a roadway to carry traffic. As such, traffic engineering analysis is necessary to determine the feasibility of a road diet on a case-by-case basis. However, as a rule of thumb, the road diet illustrated above is typically feasible when the amount of traffic using the roadway is below about 20,000 vehicles per day.[11]

If a road diet is feasible and planned to be implemented, the crossing should be reevaluated, starting from Step 1, to determine whether and how it should be marked after the road diet is in place.

[11] *Road Diet Informational Guide* (FHWA-SA-14-028), Federal Highway Administration, November 2014, p. 17.

Step 1: Uncontrolled Crossing Flowchart



* See page 5 for more information on this question.

Step 2: Uncontrolled Marked Crosswalk Evaluation Worksheet

Note: This worksheet should only be used if directed by the Step1 flowchart on Page 7.

1. Pedestrian Generators. Add 2 points for each pedestrian generator within 300 feet of the crossing, to a maximum of 6 points. Pedestrian generators include parks, grocery stores, convenience stores, apartment complexes, community centers, bus stops, etc.	**Points: _____**

2. Crash History. Add 6 points for each pedestrian or bicyclist crash within 300 feet of the crossing in the past 60 months.	**Points: _____**
Add 5 additional points for any crashes counted above that resulted in fatal or serious injury.	**Points: _____**

3. Speed Limit		
25 mph or below	0 points	
30 mph	2 points	
35 mph	4 points	
40 mph or above	6 points	**Points: _____**

4. Daily Traffic Volume		
3,000 vehicles per day (vpd) or less	0 points	
3,001 to 9,000 vpd	2 points	
9,001 to 15,000 vpd	4 points	
15,001 vpd or more	6 points	**Points: _____**

5. Proximity to Nearest Controlled or Grade-Separated Crossing		
300 to 500 feet	3 points	
500 to 750 feet	5 points	
751 to 1000 feet	7 points	
1001 feet or more	9 points	**Points: _____**

6. Number of Through Lanes Crossed		
2 lanes or fewer	0 points	
3 lanes	3 points	
4 lanes	5 points	
5 lanes	7 points	
6 lanes or more	10 points	**Points: _____**

Subtotal	**Points: _____**

- If the subtotal is 25 points or greater, the crossing is considered eligible for a marked crosswalk. Designers should refer to Step 3, the *Uncontrolled Crossing Tier Matrix*, to determine appropriate traffic control devices.
- If the subtotal is less than 10 points, the crossing is not considered eligible for a marked crosswalk.
- If the subtotal is between 10 and 24 points, a pedestrian count should be conducted to determine additional points, as follows:

7. Peak-hour pedestrian and bicyclist crossing volume within 300 feet of the crossing.[12]		
Fewer than 6 crossings	0 points	
6 to 14 crossings	5 points	
15 to 29 crossings	10 points	
30 or more crossings	15 points	**Points: _____**

Crossing counts should be collected during peak pedestrian and bicyclist crossing times for a minimum of two hours. Peak pedestrian and bicyclist crossing hours may not coincide with peak motor vehicle traffic hours. If the peak crossing hours are unknown, it is desirable to conduct a 12-hour count of crossing activity to determine the peak times. The peak crossing hours for some locations (such as parks or athletic fields) may occur on the weekend.

Total	**Points: _____**

- If the total is 25 points or greater, the crossing is considered eligible for a marked crosswalk. Designers should refer to Step 3, the *Uncontrolled Crossing Tier Matrix*, to determine appropriate traffic control devices.
- If the total is less than 25 points, the crossing is not eligible for a marked crosswalk (except if otherwise indicated on the Step 1 flowchart).

[12] Each elderly, disabled, or child pedestrian may be considered to count for two crossings.

Step 3: Uncontrolled Crossing Tier Matrix

Note: This matrix should only be used if directed by the Step 1 Flowchart or the Step 2 Worksheet.

This matrix only applies to uncontrolled pedestrian crossings.

Step 3A: Determine the Tier Number

Street Functional Classification	Number of Through Lanes Crossed	Type of Median	Vehicle ADT < 9,000			Vehicle ADT 9,000 to < 12,000			Vehicle ADT 12,000 to < 15,000			Vehicle ADT ≥ 15,000		
			Speed limit (mph)											
			≤ 30	35	≥ 40	≤ 30	35	≥ 40	≤ 30	35	≥ 40	≤ 30	35	≥ 40
Local	1 or 2	Any	**6**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Collector or Arterial	1 or 2	No median or raised median	**5**	**5**	**4**	**5**	**4**	**4**	**5**	**4**	**3**	**4**	**4**	**3**
	1 or 2	TWLTL or left-turn lane	**5**	**5**	**4**	**5**	**4**	**3**	**4**	**4**	**2**	**4**	**4**	**2**
	3 or 4	Raised	**5**	**4**	**3**	**4**	**3**	**2**	**4**	**3**	**2**	**4**	**2**	**1**
	3 or 4	Not raised or no median	**3**	**2**	**1**	**3**	**2**	**1**	**3**	**2**	**1**	**2**	**1**	**1**
	≥ 5	Any	**3**	**2**	**1**	**2**	**2**	**1**	**2**	**1**	**1**	**1**	**1**	**1**

Notes:

ADT = Average Daily Traffic.

TWLTL = Two-way left-turn lane.

A TWLTL does not constitute a raised median.

To provide sufficient pedestrian refuge, a raised median must be at least the following width:

- For speed limits 35 mph or less: 6 feet (8 feet for bicycle/trail crossings)
- For speed limits 40 mph or more: 10 feet

Speed limit thresholds used in this table are based on industry research.

Note: This matrix should only be used if directed by the Step 1 Flowchart or the Step 2 Worksheet.

This matrix only applies to uncontrolled pedestrian crossings.

Step 3B: Determine the Devices to Use Based on the Tier Number

Tier	Crosswalk markings*	W11-2 and W16-7P warning signs at crossing**	W11-2 and W16-9P advance warning signs**	Yield lines and YIELD HERE TO PEDESTRIANS signs	PED XING or SCHOOL pavement word markings	Raised median or crossing island	Rectangular Rapid-Flash Beacon (RRFB)	PHB or traffic signal with stop lines and STOP HERE FOR PEDESTRIANS signs
Tier 1	Ladder	No	Optional	No	Optional	Optional	No	Yes
Tier 2	Ladder	Only if RRFB is used	Yes for RRFB, optional for PHB	Only if RRFB is used	Optional	Recommended if RRFB is used***	Optional in lieu of PHB	Yes
Tier 3	Ladder	Yes	Yes	On multilane approaches	Optional	Recommended if practicable***	Yes	No
Tier 4	Ladder	Yes	Yes	On multilane approaches	No	No	No	No
Tier 5	Ladder	Yes	No	No	No	No	No	No
Tier 6	Standard (2 parallel lines)	Yes if midblock, Optional otherwise	No	No	No	No	No	No

* Ladder markings should not be used for equestrian crossings.

** For 15-mph school crossings, use S1-1 signs instead of W11-2 signs. For crossings of trails with shared bicycle and pedestrian traffic, use W11-15 signs instead of W11-2.

*** Consider a raised median **before** evaluating other devices. In some cases, it may be possible to retrofit a raised median on the roadway without affecting needed left-turn access. If a raised median is feasible, re-evaluate the crossing according to its tier number with a raised median.

Notes:

· **Streetlights** should be provided for marked crosswalks on collector or arterial streets where nighttime crossings are prevalent. If the street is wider than 40 feet, streetlights should be installed on both sides of the crosswalk (if possible).

· For multilane approaches, the lane lines on the approach to a marked crosswalk should be **converted to solid lines** for 200 feet (5 skip stripes) for posted speeds of 35 mph or less, and for 280 feet (7 skip stripes) for posted speeds of 40 mph or greater.

· A **road diet** to reduce the number of through lanes should be considered for streets with 2 or more approach lanes where excess vehicular capacity exists. (See page 7.)

· For streets with raised medians, **supplemental left-side warning signs** in the median should be considered.

· Crosswalks should not be newly marked without the supplementary traffic control devices and lighting identified for the appropriate tier.

· Additional devices byond those in the Step 3B table may be used based on engineering judgment.

Recommended Crosswalk Design Features

This section is applicable ***only*** to crosswalks where markings have been determined to be desirable using the earlier methodology.

For both controlled and uncontrolled crosswalks, the following design features are recommended:

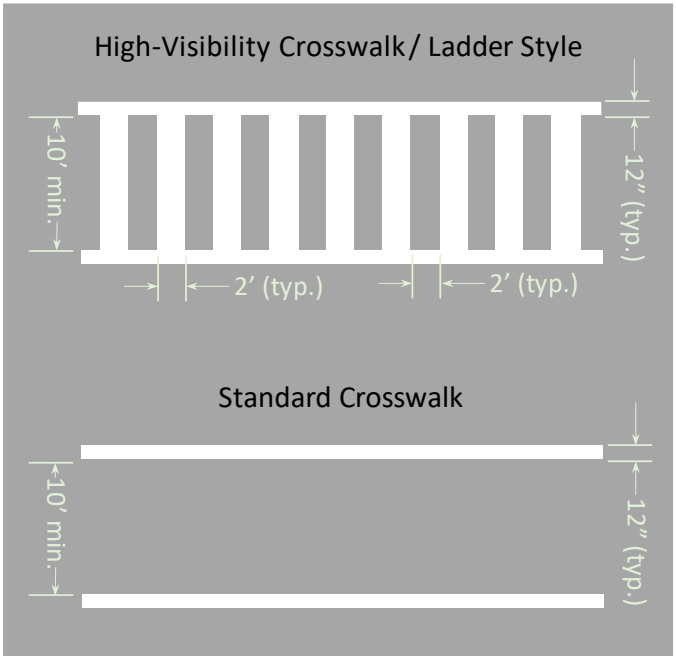
- The recommended minimum crosswalk width is 10 feet, but if the pedestrian facility approaching the crosswalk is wider than 10 feet, the crosswalk should match the width of the sidewalk, path or trail. Wider crosswalks may also be used in other locations with high pedestrian crossing volumes.
- Where standard crosswalks are used, the width of the transverse line markings should be 12 inches.
- Where high-visibility crosswalks are used:
    - 12-inch-wide transverse lines should be used on either side of the crosswalk.
    - Longitudinal lines (bars) 24 inches wide should be used between the transverse lines and parallel to the major path of approaching vehicular traffic.
    - The gaps between longitudinal lines should be 24 inches wide. Where possible, gaps should be aligned with vehicle wheel paths.

The Arizona Supplement to the MUTCD requires yellow markings for uncontrolled crosswalks associated with school crossings that use portable 15-mph speed limit signs.

All other crossings are required to use white markings. White markings are also required for *controlled* crossings associated with schools, even those where crossing guards are used.

Recommended configurations of high-visibility and standard crosswalks are shown below.

Note: Marked crosswalks also must comply with the Americans with Disabilities Act (ADA), which requires features such as curb ramps and detectable warning surfaces (DWS) at each end of the crossing. Features required by ADA are not included in these guidelines, but designers should consult other resources for required ADA provisions.



Removal of Crosswalk Markings

Crosswalk markings may be removed if they no longer serve a purpose due to a change in the traffic or pedestrian conditions.

Uncontrolled marked crosswalks should be reevaluated in conjunction with street resurfacing projects that will obliterate the crosswalk markings.

In the absence of a street resurfacing project, the following factors might be sufficient to justify reevaluating the presence of markings at uncontrolled crosswalks:

- Changes in land use
- Changes in a school's walking or attendance boundary
- Closing of a school or other pedestrian generator that prompted the installation of the crosswalk markings
- Multiple resident requests for removal or relocation of the marked crosswalk
- Observed inappropriate pedestrian or driver behavior
- Adverse pedestrian or bicyclist crash history
- Changes (increases or decreases) in traffic volumes or speeds
- Changes in roadway lane configuration, or addition or removal of a median refuge
- Road widening or narrowing

The removal or relocation of school-related marked crosswalks shall be coordinated with the principal, headmaster, or school district.

Crosswalk Marking Maintenance

Once a crosswalk is marked, its location should be recorded in an inventory for future monitoring and maintenance. Crosswalk markings should be maintained to ensure that the markings remain in serviceable condition, sufficiently visible both day and night. Crosswalk markings (as with other pavement markings) normally need to be refreshed between pavement rehabilitation cycles. The frequency of maintenance is related to the amount of traffic wear and the type of marking material (paint versus thermoplastic or other longer-lasting material).

Sign Images

The following sign images are provided for reference. The sign codes correspond to those in the Step 3B table. Warning signs at uncontrolled crossings are permitted to use fluorescent yellow-green background color, which is recommended due to their higher conspicuity. School warning signs are required to use fluorescent yellow-green backgrounds, but other warning signs may use conventional yellow or fluorescent yellow-green backgrounds. Both colors are shown below where applicable.

W11-2

W16-7P

W16-9P

W11-15

S1-1