CITY OF CORCORAN

Council Work Session Agenda
March 9, 2023 – 5:30 pm

1. **Call to Order / Roll Call**
2. **Pedestrian Crosswalk Policy***
3. **Unscheduled Items**
4. **Adjournment**

HYBRID MEETING OPTION AVAILABLE

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Enter Meeting ID: 815 3998 5966
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***Includes Materials** - *Materials relating to these agenda items can be found in the house agenda packet book located by the Council Chambers entrance, or online at the City's website at www.corcoranmn.gov.*

Memo

Stantec

To:	City of Corcoran	From:	Steven Hegland, PE Kent Torve, City Engineer
File:	193806101	Date:	March 3, 2023
Subject:	Pedestrian Crosswalk Policy Discussion		

Discussion Background

As the City of Corcoran continues to grow, one of the many challenges will be the planning and management of interaction between our growing pedestrian facilities and our traffic network. With this growth comes many questions, concerns and requests for pedestrian improvements or pedestrian safety considerations.

To date, staff manage these requests on a case by case basis as we meet with residents and discuss their concerns. We typically review the situation and engage in discussions on what if any alternatives there are to the specific circumstance. This approach has worked to date but we anticipate these types of requests will increase so we thought it was appropriate to discuss with the City Council our management strategies going forward and consider if developing a policy for pedestrian crosswalks is appropriate or if other approaches should be considered.

Similar to other City Goals, we know staff time and City resources are at a premium. Reviewing, researching, creating and implementing these types of programs take staff time and budget so we want to have a discussion with the City Council on how they want to proceed.

Work Session Outline

Staff will provide a brief presentation at the March 9th Work Session to begin the discussion with the City Council on this topic. Below are some questions and thoughts that we think will be an important part of the conversation.

Is developing a Pedestrian Crosswalk Policy appropriate?

- Having a policy may be beneficial as it allows for a process for these requests to be addressed consistently and in alignment with the overall city vision
- Development of a policy would take staff time and resources away from other pressing matters in the community. Is now the right time?
- Is what we are doing now fine?

If we wanted to develop a policy what would that look like?

- There are several resources available for the City to consider in development of a policy
    - The MNDOT in conjunction with the Local Road Research Board provided a Policy Development Guideline which is attached.
- It could look a number of ways. The final programming really depends on how we want to make decisions and what kind of pedestrian facilities the City wants.
- Could be an interactive program that has community based approach and incorporates multiple avenues of feedback
    - Could incorporate feedback and guidance from multiple stakeholders. Evaluation committee approach.
    - May be very difficult to manage as many different stakeholders have different opinions.

- It could be a very technical approach in which everything is compared to predefined warrants.
    - This creates consistency but engineering warrants often have high thresholds and may not create facilities that the City desires.
    - The LTAP Pedestrian Crossing Guide (Attached) is a very technical based approach which would show what that might look like.
- It could be a guidance type approach that has general guidelines or flow charts like Albert Lea and Shakopee
    - Gives guidance but still requires someone to be the ultimate decision maker
    - Both the City of Albert Lea and Shakopee have this type of policy which guides potential solutions but there must be a decision maker in the end.

How do we manage resource/funds to implement the policy/program?

- There would be costs to managing/implementing an evaluation system, even if we continue to operate as we currently do.
- City could consider an escrow type approach that requestor has to fund evaluations.
- How to does the City fund the installation and ongoing maintenance and replacement of this infrastructure.

Attachments

MNDOT Local Road Research Board Policy Development Guide
LTAP Pedestrian Crossing Guide
City of Albert Lea Pedestrian Crossing Policy
City of Shakopee Pedestrian Crossing Policy

4.10 ALBERT LEA CROSSWALK POLICY

PURPOSE: Pedestrian crosswalks are an integral part of our transportation infrastructure. To be effective and promote safety, marked crosswalks must be installed after careful consideration and review. The review shall be done with adherence to accepted guidelines and good engineering practice. This policy establishes the guidelines and considerations for the installation of marked crosswalks from the date of the adoption of this policy.

POLICY STATEMENT:

The City of Albert Lea may consider the installation of marked crosswalks where there is substantial conflict between vehicular and pedestrian movements as an enhancement for pedestrian crossings of roadways under the City's jurisdiction. Crosswalk installation shall be in accordance with State Law and the guidelines contained herein.

I. AUTHORITY:

This policy is based on administrative implementation of policy and Minnesota State Statute 169. The policy is administered under the direction of the Director of Public Works and applies to roadways under the City's jurisdiction.

II. BACKGROUND:

Minnesota State Statute defines that crosswalks exist at intersections, whether marked or unmarked, and provides for pedestrian and motorist responsibilities.

MN Statute 169.011 DEFINITIONS.
Subdivision 20. Crosswalk. "Crosswalk" means (1) that portion of a roadway ordinarily included with the prolongation or connection of the lateral lines of sidewalks at intersections; (2) any portion of a roadway distinctly indicated for pedestrian crossing by lines or other markings on the surface.

MN Statute 169.21 PEDESTRIAN.
Subdivision 2. Rights in absence of signal. (a) Where traffic-control signals are not in place or in operation, the driver of a vehicle shall stop to yield the right-of-way to a pedestrian crossing the roadway within a marked crosswalk or at an intersection with no marked crosswalk. The driver must remain stopped until the pedestrian has passed the lane in which the vehicle is stopped. No pedestrian shall suddenly leave a curb or other place of safety and walk or run into the path of a vehicle which is so close that it is

impossible for the driver to yield. This provision shall not apply under the conditions as otherwise provided in this subdivision.

III. EVALUATION PROCESS

A. Engineering Study

An engineering study should be performed to determine if criteria are met for a marked crosswalk and to determine the level of marking to be used. The level of detail required for an engineering study will vary with the location under consideration. The engineering study may include:

1. Speed and traffic volume data on streets being crossed
2. Pedestrian volume, age, and level of mobility
3. Location of pedestrian origin and destination point and crossing patterns
4. Designated school walking routes
5. Existing sidewalk network and sidewalk ramps
6. Sight distances and sight obstructions
7. Street characteristics including grades, curvature, radii, pavement widths, medians, and number of vehicle and bicycle lanes
8. Location of adjacent driveways
9. On-street parking
10. Street lighting
11. Location of drainage structures
12. Distance to nearest protected (traffic signal or stop sign controlled, or grade separated) or marked crossing
13. Traffic signal progression
14. Potential for rear end crashes
15. Pedestrian accidents

B. Guidelines

General guidelines to be satisfied when considering installation of marked crosswalks, includes the following:

1. The installation of marked crosswalks should be based on engineering study.

2. Marked crosswalks should connect to established sidewalks/trails at both ends.
3. ADA accessible ramps should be included at both ends of marked crosswalk installations unless there are engineering reasons they cannot be provided.
4. Adequate street lighting should be provided for the safety of pedestrians.
5. Street parking must be restricted adjacent to marked crosswalks to allow for adequate sight lines for both the motorists and the pedestrians. The length of the parking restriction shall be based on an engineering study (judgment).
6. The provisions of the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) shall be followed.

IV. INSTALLATION CRITERIA

1. Minimum Traffic Volume

Marked crosswalks should generally not be considered for roadways with less than 1,000 vehicles per day unless as part of a school walking route

2. Pedestrian Volumes

Consideration can be given to marking a crosswalk if there is a minimum of 20 pedestrian crossings during the pedestrian peak hour. A lower pedestrian traffic volume of 15 may be used if the proposed location is part of a school walking route or adjacent to an elderly facility.

3. Traffic Gaps

Consideration can be given to marking a crosswalk if there is less than one adequate crossing gap in traffic per minute during the peak hour. A crossing gap is measured as the time (in seconds) between vehicles crossing (regardless of direction of travel) the proposed crosswalk location. An adequate gap is determined by dividing the roadway width (in feet) by a walking rate of 3.5 feet per second (may be slower for a crossing location serving elderly pedestrians) and adding 3 seconds of perception/reaction time.

4. Crosswalk Spacing

Marked crosswalks should be spaced a minimum of 300 feet from a protected or marked crossing.

5. Mid-Block Crosswalks

The use of mid-block crosswalks is generally discouraged unless an engineering study determines a specific need for this type of crosswalk. Installation of new

mid-block crosswalks shall include provisions for adequate street lighting and supplemental signage as determined appropriate by an engineering study.

6. Crosswalk Control

The control for a marked crosswalk, including signing, pavement marking, traffic signals, flashing beacons, etc. shall be determined by engineering study and should conform to the MN MUTCD.

7. Traffic Signals

Marked crosswalks should be installed at signalized intersections in accordance with the traffic signal design.

8. **Central Business District**

Marked crosswalks should be considered in the Central Business District in areas of concentrated pedestrian activity.

9. Roundabouts

Marked crosswalks should be installed at roundabouts in accordance with the roundabout engineering design.

10. Street Type and Speed

Marked crosswalks may be considered at locations that are not protected by a Stop Sign or a Traffic Signal, subject to the table on the next page.

(cont'd)

Roadway Configuration[1,5]	Vehicle ADT ≤ 9,000				Vehicle ADT > 9,000 - 12,000				Vehicle ADT > 12,000 - 15,000				Vehicle ADT > 15,000			
	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph
2 lanes (with or without a raised median)	A	A	B	D	A	A	B	D	A	A	C	D	A	B	C	D
3 lanes with raised median	A	A	C	D	A	B	C	D	A	C	C	D	B	C	C	D
3 lanes without raised median	A	B	C	D	A	B	C	D	B	B	C	D	B	C	C	D
Multilane (4 or more lanes) with raised median[2]	A	A	C	D	A	B	C	D	A	B	C	D	C	C	C	D
Multilane (4 or more lanes) without raised median[2]	A	C	C	D	B	C	C	D	C	C	C	D	C	C	C	D

Treatment Descriptions:

A. Consider marked crosswalk and signs

Guidance: Consider installing marked crosswalk with advance warning signs (W11-2); use S1-1 signs for school crossings. Consider in-roadway (R1-6) or overhead (R1-9b) signs.

B. Consider marked crosswalk with enhanced signs (R1-6 or R1-9b) and/or geometric improvements

Guidance: Consider installing treatment options from Type A treatments. Add curb extensions or median refuge islands.

C. Consider marked crosswalk with signs, geometric improvements, and pedestrian activated warning devices [4]

Guidance: Consider installing a raised median refuge island if one is not present. Consider installing marked crosswalk and appropriate crossing signs along with a pedestrian activated warning device (i.e., RRFB). Consider adding curb extensions if possible.

D. Do not install marked crosswalk. [3]

Guidance: Consider pedestrian hybrid beacon, pedestrian traffic signal, or grade separated crossing.

Specific Notes:

1. Advanced stop lines and signing (R1-5b or c) should be used whenever possible if a multiple threat crash issue is present. Overhead signing, RRFBs or other overhead treatments should be used to mitigate multiple threat crash risks.
2. Do not install a marked crosswalk where there are 3 or more through lanes per direction. Consider a pedestrian hybrid beacon, pedestrian traffic signal, or grade separated crossing.
3. Traffic calming measures should be considered to reduce speed.
4. If a median cannot be or is not currently installed go to Treatment Type D.
5. Minimum acceptable median width to provide a refuge is 6 feet.

General Notes:

1. Adding crosswalks alone will not make crossings safer, result in more vehicles stopping for pedestrians, nor will they necessarily create a false sense of security.
2. Crosswalks have not been proven to create a false sense of security - research shows that pedestrians scan the road more at marked crosswalks.
3. Whether a crosswalk is marked or not, additional crossing enhancements should be considered. See the "Additional Treatment Considerations" section.
4. See MUTCD Section 3B.18 for additional guidance on using this table.
5. Lanes are total cross section.

V. STREET LIGHTING

Street lighting should be considered at all crosswalk locations, based on engineering study and City street lighting practice.

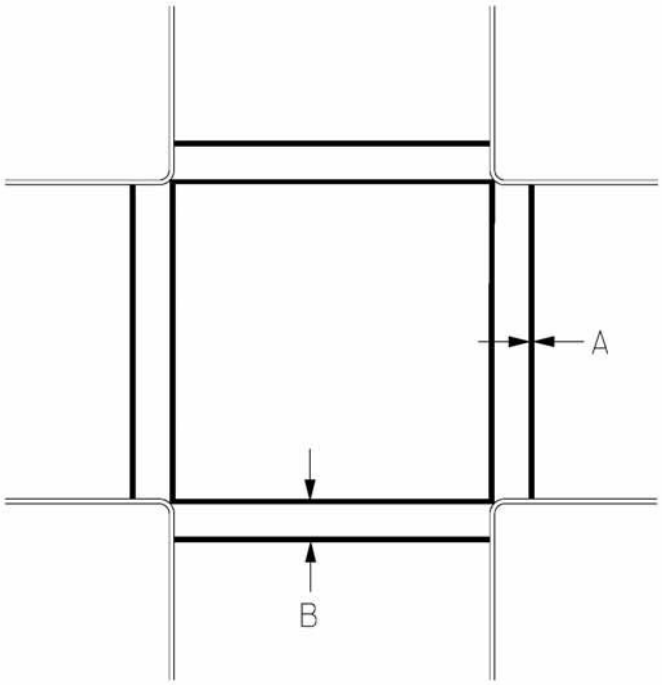
VI. TREATMENTS

1. Pavement Markings

Pavement markings shall be in accordance with the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD).

a. Standard Crosswalks

Standard crosswalks shall be a minimum of 6 feet and may be the same width as the approach walkway if the walkway is wider than 6 feet. This marking should be considered for crosswalks at Stop Sign, Traffic Signal, and Roundabout controlled intersections and intersection crosswalks of two-lane roadways.



Standard
A = 6 - 12”
B* = 6’

*Dimension B shall be 6’ min., and may be the same width as the approach walkway.

Figure 1 –Standard Crosswalk Markings.

b. Special Emphasis Crosswalks

Special emphasis crosswalk markings consist of white 3 foot wide bars with a 3 foot space at 90 degrees to the crosswalk (Figure 2). This marking should be used at mid-block crosswalks and crossings of multi-lane roadways with speed limits equal to or greater than 35 mph.

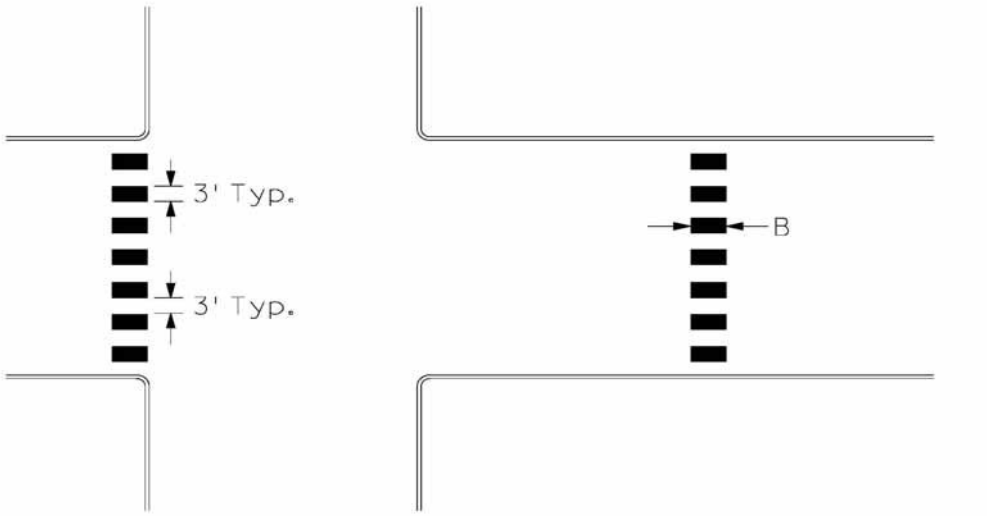


Figure 2 - Special Emphasis Crosswalk Markings

c. Decorative Crosswalks

The use of decorative materials by themselves does not designate a crosswalk. Crosswalks are legally designated at intersections and no markings are needed. At mid-block crossings, standard or special emphasis markings must be used for designation as a crosswalk.

d. Stop Lines

Stop lines should be considered on multi-lane roadways in advance of mid-block crosswalks and crosswalks at intersections not controlled by a Stop Sign.

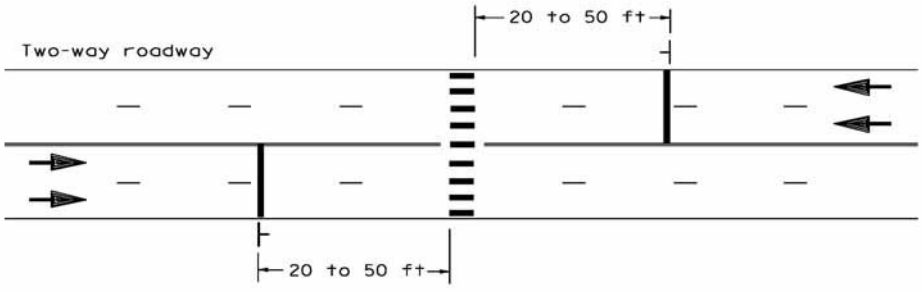


Figure 3 – Stop Line Markings

2. Traffic Signing

Traffic signing shall be in accordance with the MN MUTCD.

The W11-2 Crosswalk Sign shall be used at marked mid-block crosswalks, and other crosswalks as indicated by engineering study.

W11-2

The S1-1 School Crossing Sign should be used at marked school crosswalks.

S1-1

When a W11-2 Crosswalk Sign or a S1-1 School Crossing Sign are used, a W16-7p arrow sign shall also be used.

W16-7p

The W11-2 and S1-1 signs shall also be used as advance warning signs for crosswalks as established by the MN MUTCD

When a W11-2 or S1-1 sign is used as an advance warning sign, a W16-9p sign shall also be used.

W16-9p

The R1-X1 “Stop for Pedestrian in Crosswalk” sign should be used based on engineering study, in advance of high volume pedestrian and school crosswalks.

R1-X1

The R1-6a, 6b, or 6c sign may be used as a temporary enhancement for a new crossing where there are a high number of pedestrian crossings. The use shall be in accordance with the MN MUTCD.

R1-6b

Other signage and/or enhancements may be considered based on engineering study and updates to the MN MUTCD.

3. Traffic Signals

a. Traffic Signal

Traffic signals may be installed when warrants are met in accordance with the MN MUTCD.

b. Pedestrian Hybrid Beacon (HAWK)

Pedestrian Hybrid Beacons may be installed when warrants are met in accordance with the MN MUTCD.

c. Flashing Beacons

Flashing beacons may be used based on engineering study as an enhancement to a crossing. If used, consideration should be given to having them actuated, so that they are only operating when pedestrians are present.

d. Rectangular Rapid Flashing Beacon (RRFB)

RRFBs may be used based on engineering study as an enhancement to a crossing. When used, they shall be actuated, so that they are only operating when pedestrians are present.

4. Roadway Features

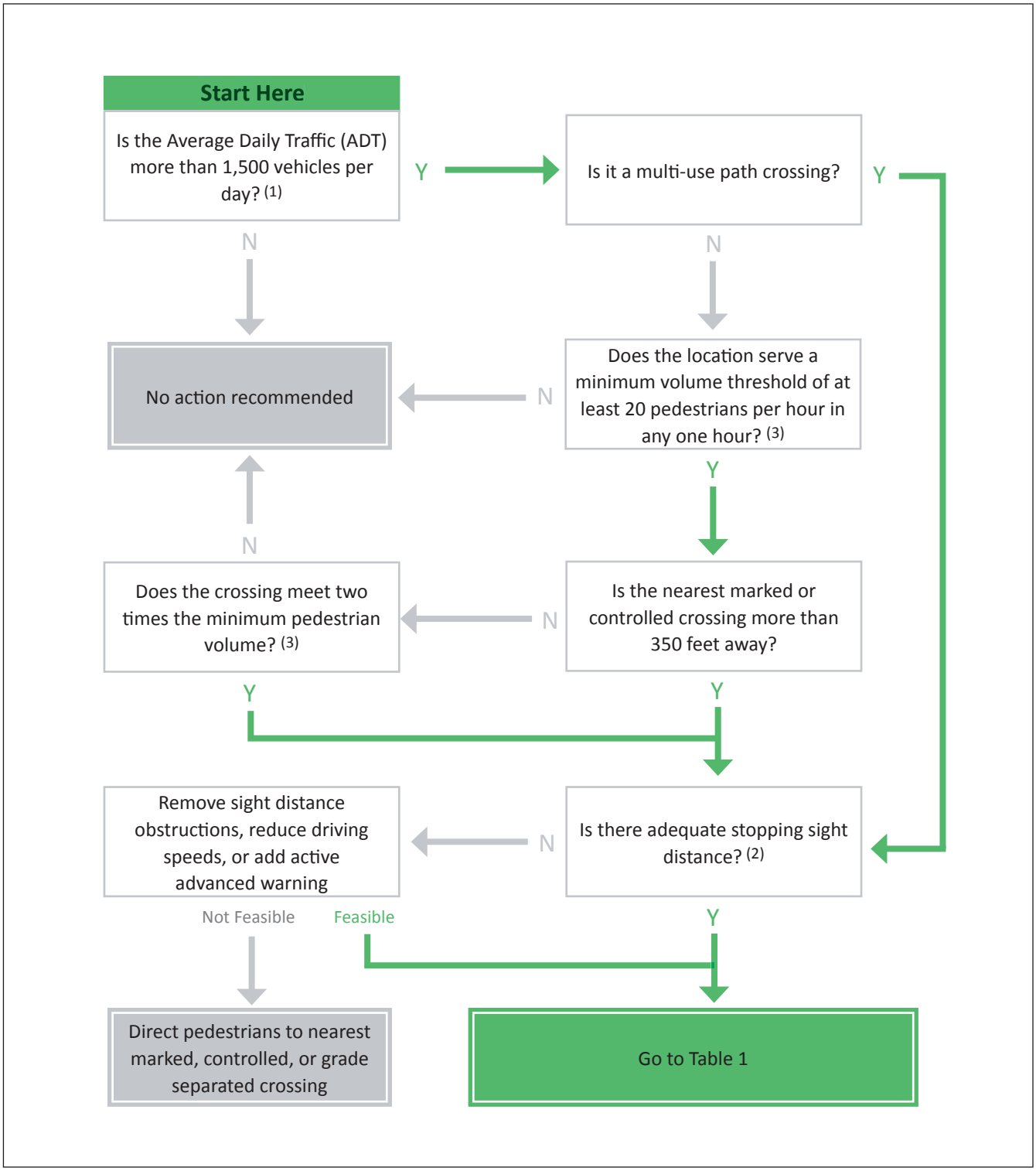
a. Curb Extensions

Curb extensions or bulb-outs may be used based on engineering study to shorten the length of the crosswalk and/or improve the sight distance of and for the pedestrian.

b. Medians

Medians may be used based on engineering study on streets with two-way traffic flow to allow for the pedestrian to cross one direction of traffic at a time and have a safe refuge in the roadway. The minimum median width for pedestrian refuge is 6 feet, but the design should be based on the pedestrian demand.

Figure 1. Pedestrian Crossing Site Evaluation Guidelines for Uncontrolled Locations



(1) Exceptions to the 1,500 vehicle minimum average daily traffic threshold may be made for school crossings or at regional trail crossings.

- A school crossing is defined as a crossing location that is patrolled OR a crossing location with 10 or more students crossing per hour.
- Regional trails are identified by the Metropolitan Council as trails that are designed as multi-use facilities to serve both recreation and transportation trips.

(2) Stopping Sight Distance is the distance needed for a driver to stop based on the speed at which they are traveling. Generally, stopping sight distance can be determined by multiplying the speed by eight. For instance, 30 miles per hour (mph) times eight equals 240 feet.

(3) School-aged pedestrians count two times towards the minimum pedestrian volume threshold.

Table 1. Application of pedestrian crash countermeasures by roadway feature.

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	● 2 4 5 6	● 5 6 7 9	○ 5 6 ● 9	● 4 5 6	● 5 6 7 9	○ 5 6 ● 9	● 4 5 6 7 9	○ 5 6 7 9	○ 5 6 ● 9
3 lanes with raised median (1 lane in each direction)	● 2 3 4 5 ● 5 ● 7 9	● ● 5 ● 7 9	○ ● 5 ● ● 9	○ 3 4 5 ● 5 7 9	○ ● 5 ● 7 9	○ ● 5 ● ● 9	○ ● 4 5 ● 5 7 9	○ ● 5 ● ● 9	○ ● 5 ● ● 9
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	● 2 3 4 5 6 7 9	● ● 5 6 7 9	○ ● 5 6 ● 9	○ 3 4 5 6 7 9	○ ● 5 6 ● 9	○ ● 5 6 ● 9	○ ● 4 5 6 7 9	○ ● 5 6 ● 9	○ ● 5 6 ● 9
4+ lanes with raised median (2 or more lanes in each direction)	● ● 5 7 8 9	● ● 5 7 8 9	○ ● 5 ● 8 9	○ ● 5 7 8 9	○ ● 5 ● 8 9	○ ● 5 ● 8 9	○ ● 5 ● 8 9	○ ● 5 ● 8 9	○ ● 5 ● 8 9
4+ lanes w/o raised median (2 or more lanes in each direction)	● ● 5 6 7 8 9	○ ● 5 ● 7 8 9	○ ● 5 ● 8 9	○ ● 5 ● 7 8 9	○ ● 5 ● 8 9	○ ● 5 ● 8 9	○ ● 5 ● 8 9	○ ● 5 ● 8 9	○ ● 5 ● 8 9

Given the set of conditions in a cell,

- # Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.
- ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1. High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
2. Raised crosswalk
3. Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4. In-Street Pedestrian Crossing sign
5. Curb extension
6. Pedestrian refuge island
7. Rectangular Rapid-Flashing Beacon (RRFB)**
8. Road Diet
9. Pedestrian Hybrid Beacon (PHB)**

*Refer to Chapter 4, 'Using Table 1 and Table 2 to Select Countermeasures,' for more information about using multiple countermeasures.

**It should be noted that the PHB and RRFB are not both installed at the same crossing location.

This table was developed using information from: Zegeer, C.V., J.R. Stewart, H.H. Huang, P.A. Lagerwey, J. Feaganes, and B.J. Campbell. (2005). Safety effects of marked versus unmarked crosswalks at uncontrolled locations: Final report and recommended guidelines. FHWA, No. FHWA-HRT-04-100, Washington, D.C.; FHWA. Manual on Uniform Traffic Control Devices, 2009 Edition. (revised 2012). Chapter 4F, Pedestrian Hybrid Beacons. FHWA, Washington, D.C.; FHWA. Crash Modification Factors (CMF) Clearinghouse. http://www.cmfclearinghouse.org/; FHWA. Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE). http://www.pedbikesafe.org/PEDSAFE/; Zegeer, C., R. Srinivasan, B. Lan, D. Carter, S. Smith, C. Sundstrom, N.J. Thirsk, J. Zegeer, C. Lyon, E. Ferguson, and R. Van Houten. (2017). NCHRP Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. Transportation Research Board, Washington, D.C.; Thomas, Thirsk, and Zegeer. (2016). NCHRP Synthesis 498: Application of Pedestrian Crossing Treatments for Streets and Highways. Transportation Research Board, Washington, D.C.; and personal interviews with selected pedestrian safety practitioners.

Source: Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations, FHWA, July 2018

Pedestrian Crossings:
Uncontrolled Locations

Minnesota Department of Transportation

Minnesota LTAP
CENTER FOR
TRANSPORTATION STUDIES
University of Minnesota

Bolton & Menk
Engineers & Surveyors

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LOCAL
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Document Information and Disclaimer

The information presented in this guidebook is provided as a resource to assist agencies in their efforts to evaluate uncontrolled pedestrian crossings and determine appropriate treatment options. The evaluation procedure provided in this guidebook takes into account accepted practice, safety, and operations.

Pedestrian crossings are an important feature of the multimodal transportation system. They enable pedestrians and bicyclists to cross conflicting traffic so they can access locations on either side of streets and highways. Pedestrian crossings can be either marked or unmarked and can be placed at intersections or mid-block locations. Uncontrolled pedestrian crossings are crossing locations that are not controlled by a stop sign, yield sign, or traffic signal.

This guidebook is a summary of the evaluation procedure presented in the *Uncontrolled Pedestrian Crossing Evaluation and Highway Capacity Manual Unsignalized Pedestrian Crossing Training Report*.

This guidebook considers best practices in pedestrian crossing evaluation by the Federal Highway Administration, the Minnesota Department of Transportation, the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board, and other research. The information is intended to offer agencies a consistent methodology for evaluating uncontrolled pedestrian crossing locations on their roadways that considers both safety and delay.

The final decision to implement the evaluation methodology or any of the crossing location treatment strategies presented in this guidebook resides with the agency. There is no expectation or requirement that agencies implement this evaluation strategy, and it is understood that actual implementation of the evaluation decisions will be made by agency staff.

It is the responsibility of agencies to determine if the procedure presented in this guide is appropriate and consistent with their needs.

- This guidebook does not set requirements or mandates.
- This guidebook contains no warrants or standards and does not supersede other publications that do.
- This guidebook is not a standard and is neither intended to be, nor does it establish, a legal standard of care for users or professionals.
- This guidebook does not supersede the information in publications such as:
    - Minnesota Manual on Uniform Traffic Control Devices
    - AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities
    - Minnesota's Best Practices for Pedestrian/Bicycle Safety
    - Best Practices Synthesis and Guidance in At-Grade Trail-Crossing Treatments
    - 2010 Highway Capacity Manual

Introduction and Background

According to 2013 Minnesota State Statutes, "where traffic-control signals are not in place or in operation, the driver of a vehicle shall stop to yield the right-of-way to a pedestrian crossing the roadway within a marked crosswalk or at an intersection with no marked crosswalk." Additionally, "Every pedestrian crossing a roadway at any point other than within a marked crosswalk or at an intersection with no marked crosswalk shall yield the right-of-way to all vehicles upon the roadway."

Although the state statute says that motorists should stop for a pedestrian within a marked crosswalk or crossing at an intersection, in practice motorists do not always stop for pedestrians and yield the right-of-way. Additionally, at locations with high traffic volumes, there may not be adequate gaps in the traffic stream to allow pedestrians to safely cross. These situations can result in crossings that are challenging to navigate and cause long delays for pedestrians, which may lead to a high risk-taking environment and decrease safety.

Pedestrian crossing treatments that either reduce the crossing distance or increase driver yield rates have been shown to reduce the potential delay experienced by a pedestrian. While state statutes support the rights of pedestrians at all intersections and marked crosswalks, it is a small comfort when a crash between a vehicle and a pedestrian occurs because a motorist failed to stop and yield the right-of-way.

Providing safe crossing situations for pedestrians relies on placing crosswalks and other pedestrian crossing treatments at appropriate locations in a way that also results in minimal pedestrian delay. The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) states that crosswalk pavement markings should not be placed indiscriminately and an engineering study should be completed when crosswalk markings are being contemplated at a crossing.

Defining where to place pedestrian crossing facilities—including markings, signs, and/or other devices—depends on many factors, including pedestrian volume, vehicular traffic volume, sight lines, and speed. This guidebook presents a methodology for the evaluation of pedestrian crossing locations that takes into account both pedestrian safety and delay.

Sources:
State of Minnesota, "2013 Minnesota Statutes 169.21 Pedestrian," 2013. Available: *https://www.revisor.mn.gov/statutes.* [Accessed January 2014].
Minnesota Department of Transportation, Minnesota Manual on Uniform Traffic Control Devices, Roseville, MN: MnDOT, January 2014.

Pedestrian Crossing Evaluation Methodology

The evaluation of a pedestrian crossing location should be thoroughly documented. This includes not only the location details, evaluation, decisions, and design process, but also any stakeholder involvement and public comments. The evaluation methodology presented is based on research on the safety of pedestrian crossings and the procedure developed in the 2010 *Highway Capacity Manual* on pedestrian delay.

The jurisdictional authority has the final decision on the control and design of pedestrian crossing facilities and features on their roadways.

The evaluation methodology guidance is shown in the flowchart on pages 6–7.

MEASURING CROSSING LENGTH

STEP 1 Field Data Review

A Data Collection Field Review Worksheet is provided at the end of this guidebook (pages 28–29). The field data review should consider and collect information about the following elements:

GEOMETRICS

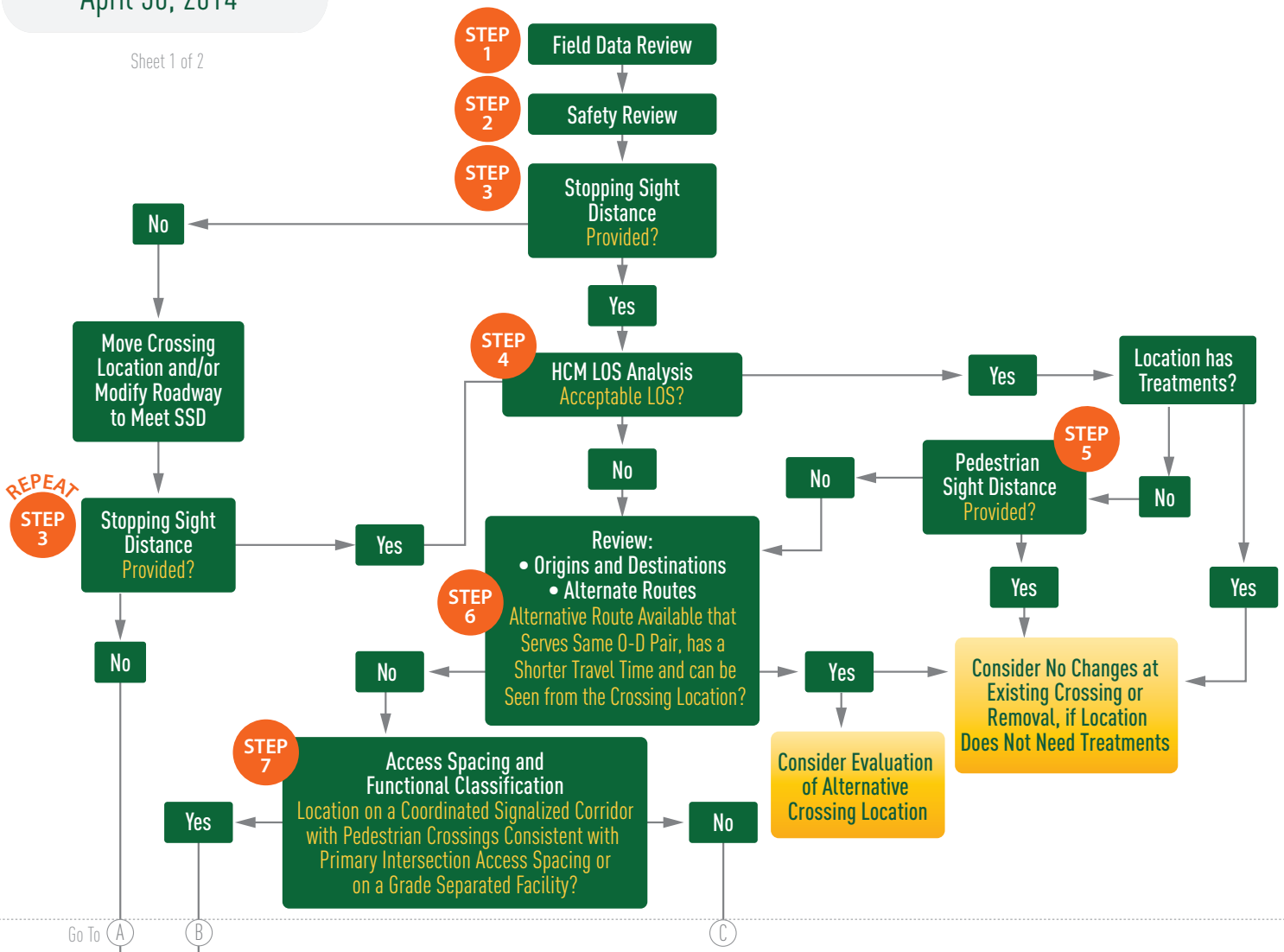
Crossing Length

- Shorter pedestrian crossing lengths are preferred by pedestrians.
- The crossing length (L) is measured from curb face to curb face and is the total length a pedestrian is exposed to conflicting traffic (as shown at right).
- If there is a median, two separate crossing lengths are measured.
- Pedestrian exposure is reduced on shorter crossings.

UNCONTROLLED PEDESTRIAN CROSSING EVALUATION FLOWCHART

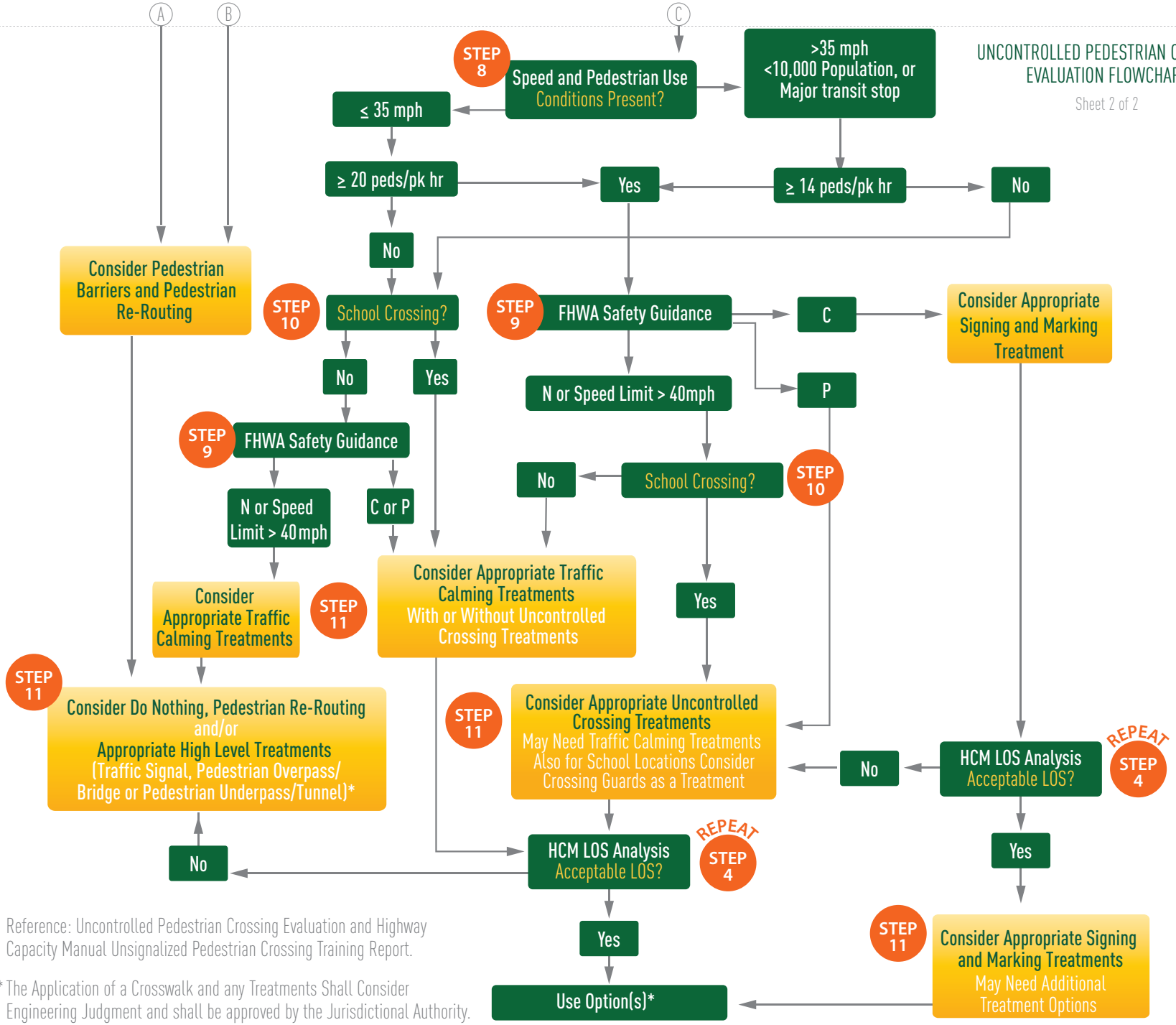
April 30, 2014

Sheet 1 of 2



UNCONTROLLED PEDESTRIAN CROSSING EVALUATION FLOWCHART

Sheet 2 of 2



Reference: Uncontrolled Pedestrian Crossing Evaluation and Highway Capacity Manual Unsignalized Pedestrian Crossing Training Report.

* The Application of a Crosswalk and any Treatments Shall Consider Engineering Judgment and shall be approved by the Jurisdictional Authority.

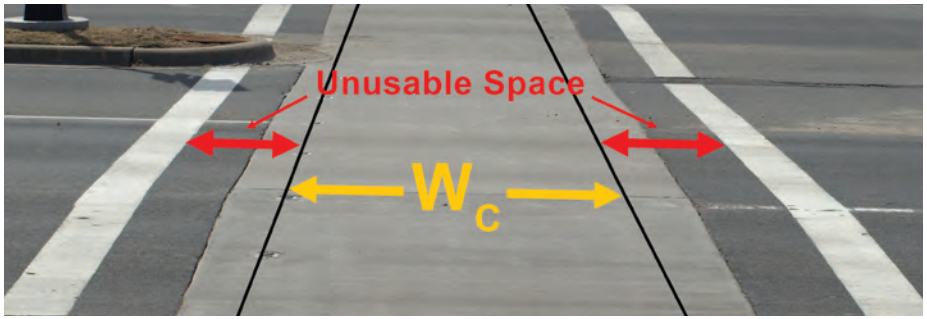
Median Width

- A median wider than 6 feet can provide a refuge space for pedestrians.
- A wider median is preferred by pedestrians.
- The median width (W) is measured from curb face to curb face (as shown below).
- A median should be sufficiently sized to handle the pedestrians using it.

MEASURING MEDIAN WIDTH

Crosswalk Width

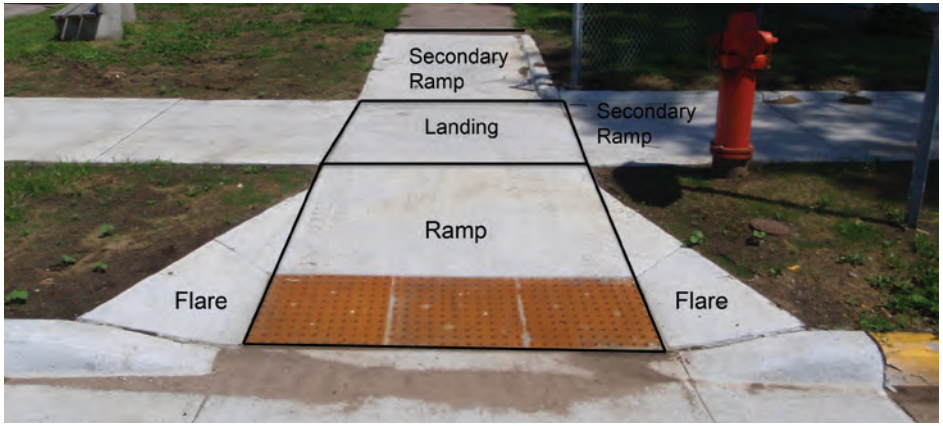
- Crosswalk width provide a defined area in which to cross.
- Effective crosswalk width is measured at the narrowest point of the crossing, be it in the ramp or the crosswalk.
- Crosswalk width (W_c) is the width measurement of at the narrowest point of the crossing (as shown at right), unless other space is usable by pedestrians (i.e., in downtown locations).



MEASURING CROSSWALK WIDTH

Curb Ramps

- Curb ramps provide equal access to all users.
- Pedestrian curb ramps are required for all pedestrian crossing locations.



CURB RAMP DIAGRAM

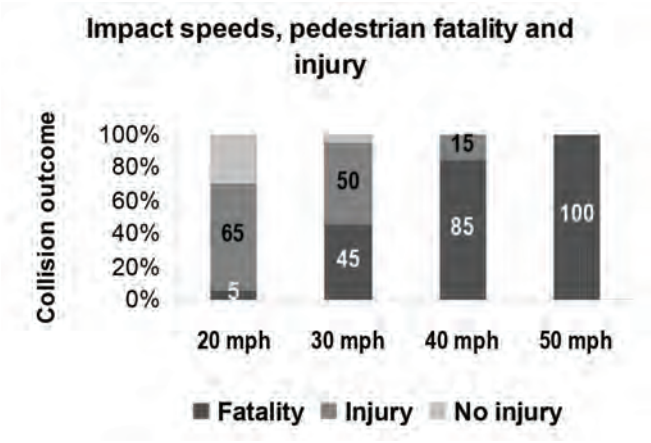
Americans with Disabilities Act (ADA) Requirements

- ADA requirements for pedestrian crossings include grades, tactile surfaces/truncated domes, ramp width, and landing areas.
- The requirements are expansive and are beyond the scope of this guidebook.
- Please see the Minnesota Department of Transportation Accessibility Design Guidance, *http:///www.dot.state.mn.us/ada/design.html,* for detailed information.

Sources:
Minnesota Department of Transportation, "Accessibility and MnDOT," [Online]. Available: *http://www.dot.state.mn.us/ada/index.html.* [Accessed November 2013].

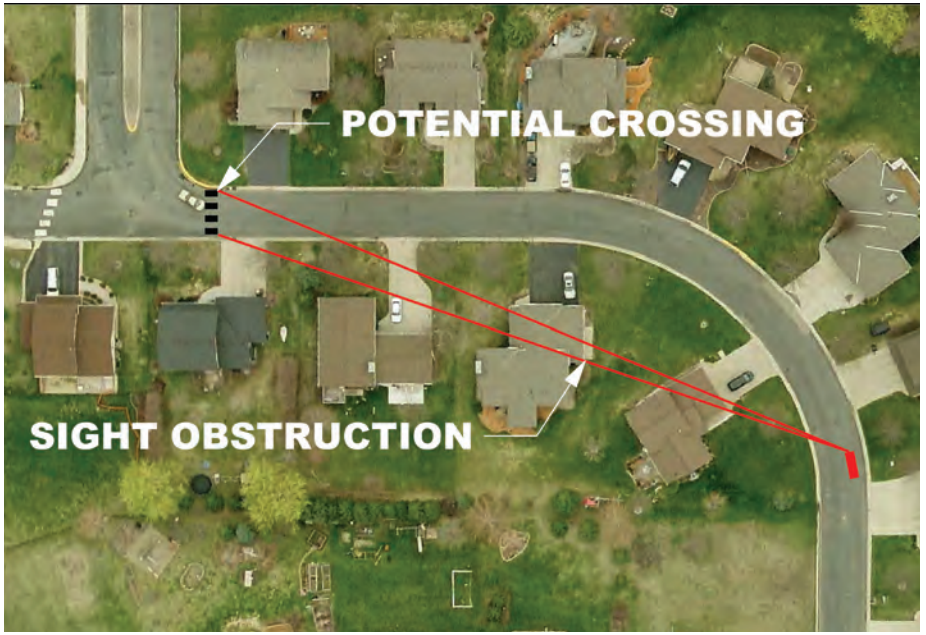
Roadway Speed

- Slower speeds are preferred by pedestrians.
- The speed of a vehicle directly impacts the sight distance needed and the braking time of a vehicle.
- The speed (S) is used to determine the stopping sight distance. The speed should be the 85th percentile speed of the roadway being crossed. In the absence of collected speed data, it is assumed that the 85th percentile speed is equal to the speed limit.
- Slower speeds have been shown to reduce the possibility of a fatal crash in pedestrian/vehicle crashes based on study results by the Washington State Department of Transportation, as shown in the chart below.



Roadway Curvature

- The vertical and horizontal curvature of a roadway can impact sight lines for both motorists and pedestrians.
- For more information on vertical and horizontal curvature, please see the American Association of State Highway and Transportation Officials: A Policy on Geometric Design of Highways and Streets (AASHTO Green Book).



SIGHT OBSTRUCTION CAUSED BY ROADWAY CURVATURE

Sources:
A. V. Moudon, L. Lin and P. Hurvitz, "Managing Pedestrian Safety I: Injury Severity," Washington State Department of Transportation, Olympia, WA, February 2007.

Stopping Sight Distance

- Stopping sight distance (SSD) is the distance covered by a vehicle during a stopping procedure. SSD should be provided at all pedestrian crossings.
- The SSD considers both brake reaction distance and braking distance.

$$SSD = 1.47St + 1.075\frac{S^2}{30\left[\left(\frac{a}{32.2}\right) \pm G\right]}$$

Where:

SSD = stopping sight distance
S = speed (mph)
t = brake reaction distance, 2.5 s
a = deceleration rate, ft/s^2, default = 11.2 ft/s^2
G = grade, rise/run, ft/ft

For more information on SSD, please see the AASHTO Green Book.

Pedestrian Sight Distance

- While Minnesota State Statute requires that motorists stop for pedestrians legally crossing, many pedestrians wait for an adequate gap in traffic before crossing.
- Pedestrian sight distance (PedSD) is a term to describe the distance covered by a motorist during the time it takes a pedestrian to recognize an adequate gap in traffic and cross the roadway.

$$PedSD = 1.47S\left(\frac{L}{S_p} + t_s\right)$$

Where:

$PedSD$ = pedestrian crossing sight distance
S = design speed (mph)
L = crossing distance (ft)
S_p = average pedestrian walking speed (ft/s), default = 3.5 ft/s
t_s = pedestrian start-up and end clearance time (s), default = 3.0 s

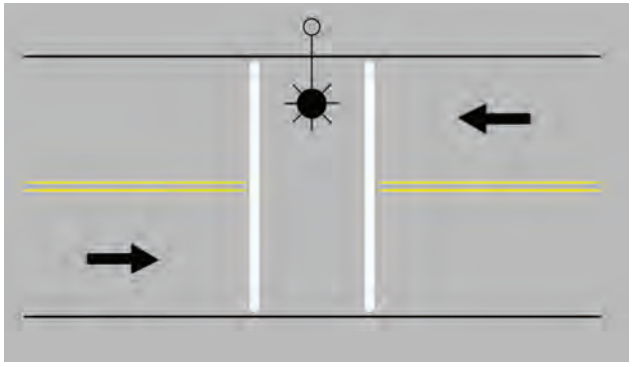
Traffic and Pedestrian Data

- The volume of vehicles on the roadway directly affects the number of gaps available for pedestrians to cross a roadway.
- The volume of pedestrians using the crossing affects how motorists view the crossing. A highly used crossing may be more recognizable to a motorist, resulting in a safer crossing.

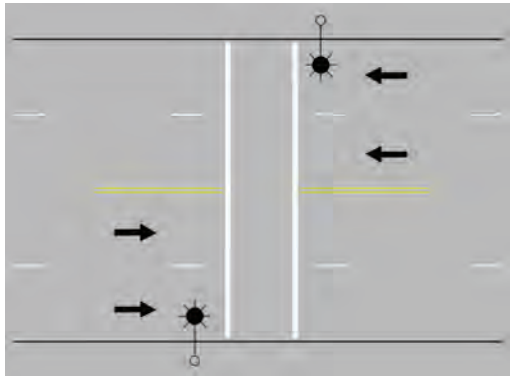
ADDITIONAL SITE CHARACTERISTICS

Lighting

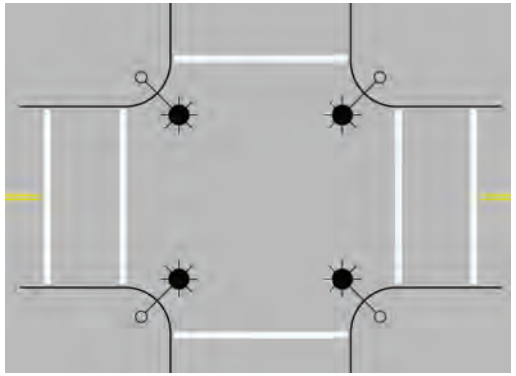
- Lighting should be provided at intersection crossings and marked crossings that are used at night.
- Intersection or pedestrian scale lighting may be appropriate to light the pedestrian crossing location.
- Continuous street lighting can provide adequate lighting of pedestrian facilities but may need to be supplemented at pedestrian crossing locations.
- Lighting should follow the recommended levels provided in the AASHTO Roadway Lighting Design Guide.
- Lighting should provide positive contrast if possible.
- Positive contrast lights the pedestrian from the front so they are more easily seen by approaching motorists.
- Examples of lighting configurations are shown in the diagrams below and at right.



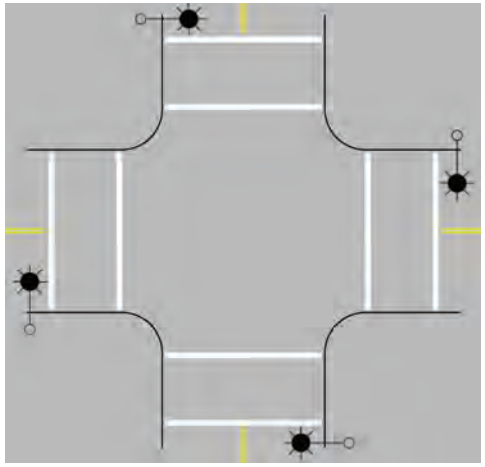
TWO LANE MID-BLOCK CROSSING LIGHTING



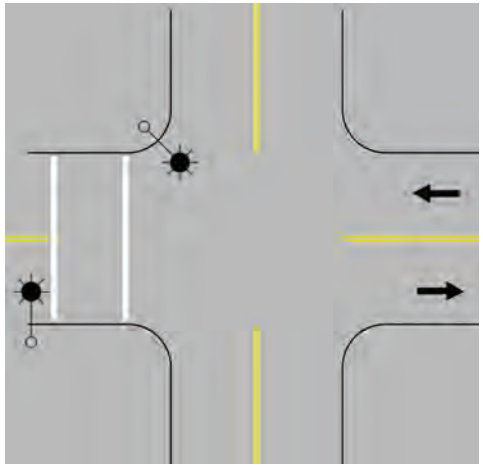
MULTI-LANE OR LONG MID-BLOCK CROSSING LIGHTING



TRADITIONAL INTERSECTION LIGHTING (ALL LEGS)



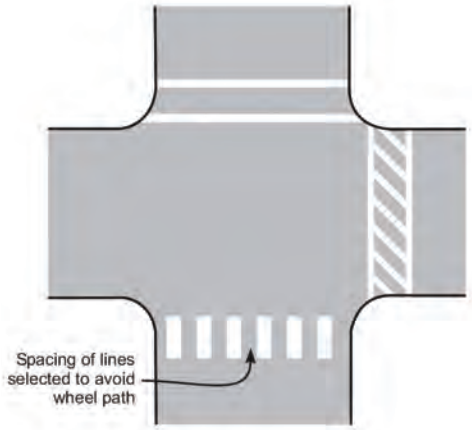
PEDESTRIAN CROSSING INTERSECTION LIGHTING (ALL LEGS)



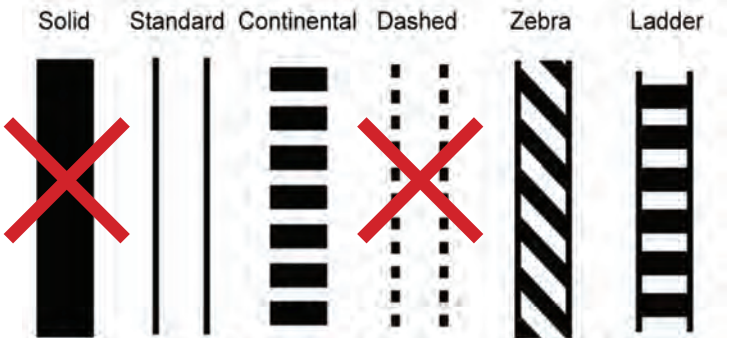
PEDESTRIAN CROSSING INTERSECTION LIGHTING (ONE LEG)

Crosswalk Pavement Markings

- Crosswalk markings shall follow the designs as stated in the MN MUTCD.
- High-visibility crosswalk markings include continental, zebra, and ladder (examples shown below and at right). Markings should be in good to excellent condition and highly visible to approaching traffic.



CROSSWALK MARKING EXAMPLES



ACCEPTABLE CROSSWALK MARKING PATTERNS

STANDARD/TRANSVERSE CROSSWALK PAVEMENT MARKINGS

CONTINENTAL CROSSWALK PAVEMENT MARKINGS

Signing

- Signing shall follow the design and placement as stated in the MN MUTCD.
- Signing options are shown in the images below.

PEDESTRIAN CROSSING WARNING SIGN PLUS IN-ROAD SIGNS

SCHOOL CROSSING WARNING SIGN

Sources:
Minnesota Department of Transportation, Minnesota Manual on Uniform Traffic Control Devices, Roseville, MN: Minnesota Department of Transportation, January 2014.
C. V. Zeeger, J. R. Stewart, H. H. Huang, P. A. Lagerwey, J. Feaganes and B. Campbell, "Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines," Federal Highway Administration, McLean, VA, September 2005.

Distance to Adjacent Pedestrian Crossing Facilities

- If there is a nearby pedestrian crossing facility that can serve the same movements with a shorter travel time—and if this nearby crossing facility can be seen from the crossing location being studied—the crossing location being studied may not be needed.
- In some cases, an existing pedestrian crossing may not serve the pedestrian movements of the area and should be moved to a more appropriate location.
- The other location may actually provide a shorter travel time when considering the time waiting to cross.
- If pedestrians are already crossing at a location, they are unlikely to choose to cross at another location unless it is shorter, regardless of safety. It is important to provide crossings at locations where pedestrians are already crossing, or consider creating physical barriers if safety can be achieved and direction to a nearby crossing is provided.

Distance to Adjacent Intersections with All-Way Stop, Signal, or Roundabout Control

- An adjacent controlled crossing location may provide a shorter travel time when considering the time waiting to cross.

Origins and Destinations

- Review pedestrian paths between nearby origins and destinations.
- Typical origins and destinations of importance include:
  - Bus stops to businesses and residences
  - High-density residential to bus stops and commercial/retail
  - Hospitals and medical centers to bus stops and parking
  - Retirement communities to bus stops and commercial retail
  - Schools/colleges/universities to housing and parking
  - Parks to residences
  - Recreational/community centers to residences and parking
  - Theatres and museums to parking
  - Trails to parks and other trails
  - Commercial/retail space to parking

STEP 2 Safety Review

The safety review includes evaluating the crash records for the crossing location. Pedestrian crashes may necessitate a more in-depth look at the issues and concerns at a crossing location.

Rear-end crashes at a location may indicate that motorists are stopping for pedestrians, but they may also indicate that there is inadequate stopping sight distance. Other types of crashes should be reviewed to determine if the conflicts are impacting the crossing safety and if they indicate other intersection concerns.

STEP 3 Stopping Sight Distance

Every pedestrian crossing location should have adequate stopping sight distance (SSD). If adequate SSD cannot be provided at a potential crossing location, the location may not be suitable for a pedestrian crossing. Adequate SSD ensures that most motorists under normal conditions will be able to stop for a pedestrian that has entered the roadway.

If adequate SSD is not provided, consider pedestrian barriers and pedestrian routing to alternate crossing locations.

STEP 4 HCM Level of Service Analysis

To determine the level of service (LOS) of the current crossing condition, follow the procedure outlined in the 2010 *Highway Capacity Manual*. The methodology follows a six-step program, as shown below.

Step 1: Identify Two-Stage Crossings

↓

Step 2: Determine Critical Headway

↓

Step 3: Estimate Probability of a Delayed Crossing

↓

Step 4: Calculate Average Delay to Wait for Adequate Gap

↓

Step 5: Estimate Delay Reduction due to Yielding Vehicles

↓

Step 6: Calculate Average Pedestrian Delay and Determine LOS

This six-step procedure to determine LOS for pedestrians at uncontrolled crossing locations is provided in the worksheets at the end of this guidebook (pages 30–34).

The input information for use in the equations is provided in the input table on the second worksheet. An explanation of measuring crosswalk length (L) and crosswalk width (W_c) can be found on page 4 of this guidebook.

LOS is generally deemed acceptable between A and D and deemed unacceptable at E or F. Local agency direction on acceptable service levels should be verified. If the LOS is acceptable and the location already has treatments such as signing and/or striping, consider making no changes at the existing crossing.

If LOS is unacceptable, skip to Step 6. If this procedure is completed after Step 11, consider applying appropriate treatment option(s) if LOS is acceptable. If LOS is deemed acceptable, consider making no changes at the crossing or possibly removing treatments if they are not needed.

Pedestrian Sight Distance

If adequate service levels are provided, pedestrian sight distance (PedSD) should be checked if the crossing is absent of any treatment options. This indicates that the crossing is unmarked and unsigned. If adequate PedSD is provided, consider no changes at the existing crossing.

Review: Origins and Destinations, Alternate Routes

The potential origins and destinations in the area should be reviewed for the most likely path to see how it lines up with the crossing being analyzed. The most important thing to remember is that pedestrians will take the shortest possible route. Understanding this is essential to understanding why a route is being used, especially when there are alternatives available that may actually be safer and provide less delay. In some cases, existing crossings may not actually be placed in locations where pedestrians are using them if the understanding of origins and destinations is incorrect.

Check to see if an alternative route can serve the same movements effectively while providing less delay. This includes the time to traverse to the alternative crossing, cross, and complete the movement to the destination. Average wait time at signals should be added into the equation if the crossing requires traversing a traffic signal.

If the primary origin-destination movements can be accomplished effectively at another crossing without much backtracking, consider making no changes at the existing crossing or adding pedestrian channelization and/or wayfinding. Also consider evaluating the alternate crossing location.

Sources:
American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Highways and Streets, 6th Edition, Washington DC: American Association of State Highway and Transportation Officials, 2011.
C. V. Zeeger, J. R. Stewart, H. H. Huang, P. A. Lagerwey, J. Feaganes and B. Campbell, "Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines," Federal Highway Administration, McLean, VA, September 2005.
Transportation Research Board, HCM 2010 Highway Capacity Manual, Washington, DC: National Academy of Sciences, 2010.

STEP 7 Access Spacing and Functional Classification

The functional classification of the roadway and the current access control of the roadway being crossed should be considered.

Roadways that carry more than 12,000 vehicles per day and are classified as high-mobility corridors are generally not candidates for marked uncontrolled pedestrian crossings. Marked uncontrolled pedestrian crossings should only be implemented on signalized roadway corridors if the spacing between the signalized intersections does not adequately serve the pedestrian traffic in the community.

The spacing of pedestrian crossing facilities should follow the access spacing guidelines for signals and primary intersections on the corridor of interest. Primary access intersections are intersections that will remain full access over time while secondary access intersections may provide full or limited access over time.

Due to the limited access along grade-separated roadway facilities, marked and unmarked pedestrian crossings on those facilities are limited to interchanges, tunnels, and bridges. The high speed of the facilities, along with the driver expectations for conflicts, makes any at-grade crossing a safety concern.

Sources:
C. V. Zeeger, J. R. Stewart, H. H. Huang, P. A. Lagerwey, J. Feaganes and B. Campbell, "Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guide lines," Federal Highway Administration, McLean, VA, September 2005.
K. Fitzpatrick, S. Turner, M. Brewer, P. Carlson, B. Ullman, N. Trout, E. S. Park and J. Whitcare, "Improving Pedestrian Safety at Unsignalized Crossings," Transportation Research Board of the National Academies, Washington, DC, 2006.

STEP 8 Speed and Pedestrian Use

Consistent with previous research and evaluation methods, the conditions present at the crossing location should be reviewed and the need for the crossing should consider pedestrian traffic volume using the crossing. It is important that the pedestrian use data be collected at multiple times of day to get an accurate picture of the pedestrian traffic need. The highest hour pedestrian need may not coincide with the highest hour traffic volume crossing the location. In such circumstances, the level of service should be evaluated for the highest pedestrian volume hour and the highest vehicle volume hour separately.

If the crossing location is on a roadway with speeds greater than 35 miles per hour (mph), is in a community of less than 10,000 people, or provides a connection to a major transit stop, there should be a minimum of 14 pedestrians using the crossing during one hour of the day.

If the crossing location is on a roadway with a speed of 35 mph or less, there should be a minimum of 20 pedestrians using the crossing during one hour of the day.

The above pedestrian volume thresholds can be reduced by 0.33 if more than 50 percent of the pedestrian traffic using the crossing consists of the elderly or children.

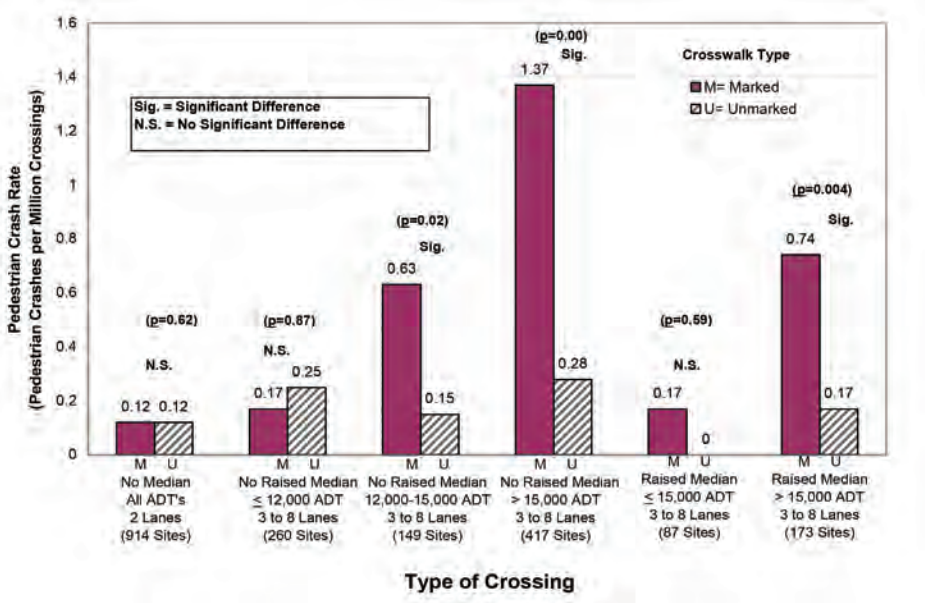
If these thresholds cannot be met, traffic calming treatments should be considered. In such cases, additional uncontrolled crossing treatments may be considered in conjunction with the traffic calming treatments. Uncontrolled crossing treatments should not be considered by themselves.

STEP 9

FHWA Safety Guidance

Federal Highway Administration (FHWA) guidance in the Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations should be determined based on the traffic volume, speed, and roadway type. The study indicates the types of treatments recommended for installing marked crosswalks at uncontrolled locations.

Research indicates that there is a statistically significant difference in the safety between a marked and unmarked crossing when traffic volume is over 15,000, or over 12,000 without a median, under most speeds, as shown in the table below.



This research provides the basis for the guidance in Table 1 on page 18. Guidelines provided in the table include intersections and midblock locations with no traffic signals or stop signs on the approach to the crossing.

Crosswalks should not be installed at locations that could present an increased safety risk to pedestrians—such as where there is poor sight distance, complex or confusing designs, a substantial volume of heavy trucks, or other dangers—without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will not make crossings safer, nor will they necessarily result in more vehicles stopping for pedestrians.

Whether or not marked crosswalks are installed, it is important to consider other pedestrian facility enhancements (e.g., raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic-calming measures, curb extensions, etc.) as needed to improve the safety of the crossing.

Guidelines outlined in the table are general recommendations; good engineering judgment should be used in individual cases when deciding where to install crosswalks.

Sources:

C. V. Zeeger, J. R. Stewart, H. H. Huang, P. A. Lagerwey, J. Feaganes and B. Campbell, "Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guide lines," Federal Highway Administration, McLean, VA, September 2005.

K. Fitzpatrick, S. Turner, M. Brewer, P. Carlson, B. Ullman, N. Trout, E. S. Park and J. Whitcare, "Improving Pedestrian Safety at Unsignalized Crossings," Transportation Research Board of the National Academies, Washington, DC, 2006.

Table 1: FHWA Safety Guidance Table

Roadway Type (Number of Travel Lanes and Median Type)	Vehicle ADT ≤ 9,000			Vehicle ADT > 9,000–12,000			Vehicle ADT > 12,000–15,000			Vehicle ADT > 15,000		
	Speed Limit*											
	≤ 48.3 km/h (30 mph)	56.4 km/h (35 mph)	64.4 km/h (40 mph)	≤ 48.3 km/h (30 mph)	56.4 km/h (35 mph)	64.4 km/h (40 mph)	≤ 48.3 km/h (30 mph)	56.4 km/h (35 mph)	64.4 km/h (40 mph)	≤ 48.3 km/h (30 mph)	56.4 km/h (35 mph)	64.4 km/h (40 mph)
Two lanes	C	C	P	C	C	P	C	C	N	C	P	N
Three lanes	C	C	P	C	P	P	P	P	N	P	N	N
Multilane (four or more lanes) with raised median**	C	C	P	C	P	N	P	P	N	N	N	N
Multilane (four or more lanes) without raised median	C	P	N	P	P	N	N	N	N	N	N	N

*Where the speed limit exceeds 64.4 km/h (40 mph), marked crosswalks alone should not be used at unsignalized locations.

**The raised median or crossing island must me at least 1.2 meters (4 feet) wide and 1.8 meters (6 feet) long to serve adequately as a refuge area for pedestrians, in accordance with MUTCD and Amerian Association of State Highway and Transportation Officials (AASHTO) guidelines.

C = Candidate sites for marked crosswalks. Marked crosswalks must be installed carefully and selectively. Before installing new marked crosswalks, an engineering study is needed to determine whether the location is suitable for a marked crosswalk. For an engineering study, a site review may be sufficient at some locations, while a more in-depth study of pedestrian volume, vehicle speed, sight distance, vehicle mix, and other factors may be needed at other sites. It is recommended that a minimum utilization of 20 pedestrian crossings per peak hour (or 15 or more elderly and/or child pedestrians) be confirmed at a location before placing a high priority on the installation of a marked crosswalk alone.

P = Possible increase in pedestrian crash risk may occur if crosswalks are added without other pedestrian facility enhancements. These locations should be closely monitored and enhanced with other pedestrian crossing improvements, if necessary, before adding a marked crosswalk.

N = Marked crosswalks alone are insufficient, since pedestrian crash risk may be increased by providing marked crosswalks alone. Consider using other treatments, such as traffic-calming treatments, traffic signals with pedestrian signals where warranted, or other substantial crossing improvements, to improve crossing safety for pedestrians.

STEP 10

School Crossings

The safety of children as they get to and from school is of special consideration and may require the implementation of a crosswalk at locations that might otherwise not be considered. A school crossing location will traditionally have significant use by children that occurs in conjunction with standard school start and dismissal times, making the crossing use noticeable to motorists. Consider appropriate uncontrolled treatment options, including crosswalk markings, signs, and crossing guards.

MARKED AND SIGNED SCHOOL CROSSING

ADULT SCHOOL CROSSING GUARD

STEP 11

Consider Appropriate Treatment Options

Appropriate treatment options should be considered for crossing locations based on the evaluation flowchart on pages 6–7. In many cases, the most appropriate option is to keep the location unmarked and unsigned, as any treatment may increase the crash potential at the location.

The treatment options have been organized into four separate categories depending on their primary function in serving pedestrian crossings. Some of the options have not been shown to noticeably affect motorist yielding and service levels, but they are provided as examples that have been implemented by some agencies.

SIGNING AND MARKING TREATMENTS

Signing and marking treatments are generally low cost and provide little to no benefit in terms of operational impacts. The most significant impact is for high-visibility markings. The treatments can be appropriate by themselves on low-volume and low-speed roadways unless accompanied by other types of treatments.

Potential signing and marking treatments are outlined in Table 2 on page 21 (treatments should be justified through an engineering study). Examples of selected treatments are also shown at right.

Sources:
"Minnesota's Best Practices for Pedestrian/Bicycle Safety," MnDOT Office of Traffic, Safety and Technology, September 2013.
"Best Practices Synthesis and Guidance in At-Grade Trail-Crossing Treatments," Minnesota Department of Transportation, St.Paul, MN, September 2013.
NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings. Transportation Research Board of the National Academies, Washington D.C., 2006.
Assessment of Driver Yield Rates Pre- and Post-RRFB Installation, Bend, Oregon. Oregon Department of Transportation, Washington D.C., 2011.
Bolton & Menk, Inc.
Transportation Research Board, HCM 2010 Highway Capacity Manual, Washington D.C.: National Academy of Sciences, 2010.
Before-and-After Study of the Effectiveness of Rectangular Rapid-Flashing Beacons Used with School Sign in Garland, Texas. Texas Transportation Institute, College Station, TX, April 2012.

CROSSING WARNING SIGN

CROSSWALK MARKINGS AND SIGN

IN-STREET CROSSING SIGN

HIGH-VISIBILITY CROSSWALK MARKINGS

Table 2: Signing and Marking Treatments

Treatment	Advantages	Disadvantages	Recommended Locations	Staged Pedestrian Yield Rate	Unstaged Pedestrian Yield Rate	Cost
Crosswalk Markings Only	• Inexpensive • Helps define a crossing location • Indicates to drivers that crossing location is present	• Very little effect at night • Speeds increase over time • Not shown to reduce crashes	• Not usually recommended alone • Low-volume and low-speed roadways • Where justified	NR	NR	$500–$2,000
Warning Signs	• Inexpensive • Helps define a crossing location • Warning to drivers that crossing location is present	• Tend to be ignored unless pedestrians use the crossing consistently • Proven to be ineffective at reducing crashes at uncontrolled intersections	• Where unexpected entries into the road by pedestrians may occur • At or before the crossing location • With or without a marked crosswalk	NR	NR	$300–$1,200
Overhead Warning Signs	• May decrease vehicle speed	• Requires overhead structure • Tend to be ignored unless pedestrians use the crossing consistently	• Multilane roadways • Midblock crossing locations • Usually coupled with other measures such as RRFBs or beacons	NR	NR	$60,000–$75,000
Colored Concrete/Brick Pavers	• Inexpensive • Warning to drivers that crossing location is present • May decrease vehicle speed	• Can be expensive • Not shown to reduce crashes	• Downtown/urban conditions • Traffic signal locations • In conjunction with pavement markings	NR	NR	$10,000–$75,000
Crosswalk Markings and Signs	• Inexpensive • Warning to drivers that crossing location is present • May decrease vehicle speed	• Make snow removal more difficult • Need consistent maintenance and replacement due to vehicle hits	• Where justified	7%	7%	$800–$3,200
In-Street Crossing Signs (25–30 mph)	• Inexpensive • Additional warning to drivers that crossing location is present	• Not shown to reduce crashes • Speeds increase over time	• Downtown/urban conditions • Supplement warning signs at high pedestrian volume locations • In conjunction with pavement markings	87%	90%	$500–$1,000
High-Visibility Crosswalk Markings	• May decrease vehicle speed	• Not shown to reduce crashes • Speeds increase over time	• Where justified • Urban conditions	61% (25mph) 17% (35mph)	91% (25mph) 20% (35mph)	$5,000–$50,000

NR = No research found on effect to yielding rate

UNCONTROLLED CROSSING TREATMENTS

Uncontrolled crossing treatments generally provide some level of increased yielding rate. They are typically applied to locations with marked crosswalks to provide additional operational and safety benefits in areas with higher volumes and speeds.

Uncontrolled crossing treatement options are outlined in Table 3 on page 23 (treatments should be justified through an engineering study) . Selected treatment examples are also shown below.

OVERHEAD FLASHING SIGNAL BEACONS

CENTER MEDIAN WITH REFUGE ISLAND

IN-ROAD WARNING LIGHTS

PEDESTAL-MOUNTED FLASHING SIGNAL BEACONS

RAPID RECTANGULAR FLASHING BEACONS

Table 3: Uncontrolled Crossing Treatments (in conjunction with markings and signs)

Treatment	Advantages	Disadvantages	Recommended Locations	Staged Pedestrian Yield Rate	Unstaged Pedestrian Yield Rate	Cost
Center Median with Refuge Island	• Decreases pedestrian crossing distance • Provides higher pedestrian visibility • Reduces vehicle speeds approaching the island • Reduces conflicts • Increases usable gaps • Reduces pedestrian exposure time	• May make snow removal more difficult • May be a hazard for motorists • Small islands not recommended on high-speed roadways (>40 mph)	• Wide, two-lane roads and multilane roads with sufficient right-of-way	34%	29%	Variable depending on length
School Crossing Guards	• Inexpensive • Provides higher pedestrian visibility • Highlights when a pedestrian crossing is being used	• May require trained staff or local law enforcement, especially on high-speed and high-volume roadways	• At school locations	NR	86%	Variable
Pedestrian Crossing Flags	• Inexpensive • Provides higher pedestrian visibility to drivers assuming the flag is held in a noticeable location	• No effect at night • Requires pedestrians to actively use a flag • Can be easily removed/stolen • Shorter crossings are preferred	• Downtown/urban locations • High pedestrian volume locations • Across low-speed (<45mph) roadways	65%	74%	<$500
Warning Sign with Edge Mounted LEDs	• Highlights a crossing both at night and during the day	• Requires pedestrian activation • Minimal to no effect on speed	• In conjunction with in-road warning lights • Downtown/urban conditions	NR	28%	$3,000–$8,000
In-Road Warning Lights	• Highlights a crossing both at night and during the day • Provides higher driver awareness when a pedestrian is present	• Snowplows can cause maintenance issues • No effect when road surface is snow covered • Requires pedestrian activation	• Downtown/urban conditions	NR	66%	$20,000–$40,000
Pedestal Mounted Pedestrian Flashing Signal Beacons	• Provides higher driver awareness when a pedestrian is present	• Requires pedestrian activation • Not advisable on multilane streets • Not shown to reduce crashes	• Low-speed school crossings • Two-lane roads • Midblock crossing locations	NR	57% (two-lane, 35mph)	$12,000–$18,000
Pedestrian Overhead Flashing Signal Beacons	• Provides higher driver awareness when a pedestrian is present	• Requires pedestrian activation	• Multilane roadways • Mid-block crossing locations • Lower speed roadways	active 47% passive 31%	active 49% passive 67%	$75,000–$150,000
Rectangular Rapid Flash Beacons (RRFBs)	• Provides higher driver awareness when a pedestrian is present • Increases yielding percentage • Increases usable gaps • Reduces probability of pedestrian risk taking • Can be seen from 360 degrees	• Requires pedestrian activation	• Supplement existing pedestrian crossing warning signs • School crossings • Midblock crossing locations • Low- and high-speed roadways	84%	81%	$12,000–$18,000

NR = No research found on effect to yielding rate

TRAFFIC CALMING TREATMENTS

Traffic calming treatments are generally applied to locations experiencing high traffic speeds. Traffic speeds should be lowered to enable any type of at-grade crossing. Traffic calming treatments can also be used to shorten crossing distances and improve pedestrian visibility. The shortened crossing distances reduce the total time of exposure to conflicting traffic, resulting in safer crossing environments. These treatments may be completed in conjunction with other uncontrolled crossing treatments.

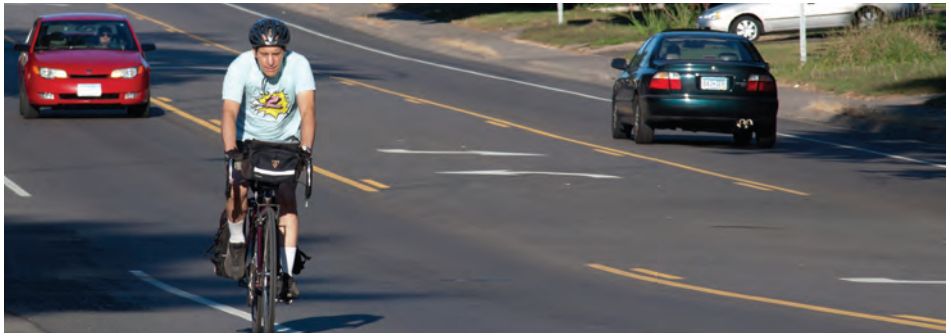
A variety of traffic calming treatments are outlined in Table 4 on page 25 (treatments should be justified with an engineering study). Examples of selected treatment options are also shown at right.

For more information on traffic calming treatment options, please see these resources (in addition to the sources listed below):

- LRRB Report MN/RC-1999-01, Effective Traffic Calming Applications and Implementation;
- TRS 0801, Traffic Calming for High Speed Rural Highways
- LRRB Report 2013-31, Implications of Modifying State Aid Standards: Urban Construction or Reconstruction to Accommodate Various Roadway Users
- http://mndot.gov/planning/completestreets

CURB BUMP-OUTS

CHANNELIZED TURN LANE WITH RAISED CROSSING



ROAD DIET/4-LANE TO 3-LANE CONVERSION

CENTER MEDIAN WITH REFUGE ISLAND

Sources:
"Minnesota's Best Practices for Pedestrian/Bicycle Safety," MnDOT Office of Traffic, Safety and Technology, September 2013.
"Best Practices Synthesis and Guidance in At-Grade Trail-Crossing Treatments," Minnesota Department of Transportation, St.Paul, MN, September 2013.
NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings. Transportation Research Board of the National Academies, Washington D.C., 2006.
Assessment of Driver Yield Rates Pre- and Post-RRFB Installation, Bend, Oregon. Oregon Department of Transportation, Washington D.C., 2011. Bolton & Menk, Inc.
Transportation Research Board, HCM 2010 Highway Capacity Manual, Washington D.C.: National Academy of Sciences, 2010.
Before-and-After Study of the Effectiveness of Rectangular Rapid-Flashing Beacons Used with School Sign in Garland, Texas. Texas Transportation Institute, College Station, TX, April 2012.

Table 4: Traffic Calming Treatments

Treatment	Advantages	Disadvantages	Recommended Locations	Staged Pedestrian Yield Rate	Unstaged Pedestrian Yield Rate	Cost
Center Median with Refuge Island	• Decreases pedestrian crossing distance • Provides higher pedestrian visibility • Reduces vehicle speeds approaching the island • Reduces conflicts • Increases usable gaps • Reduces pedestrian exposure time	• May make snow removal more difficult • May be a hazard for motorists • Small islands not recommended on high-speed roadways (>40 mph)	• Wide, two-lane roads and multilane roads with sufficient right-of-way	34%	29%	Variable depending on length
Raised Crossings	• Provides higher pedestrian visibility to vehicles • Can reduce vehicle speeds	• Make snow removal more difficult • May reduce emergency vehicle response times • Only appropriate in low-speed/urban environments	• Low-speed/urban environments	NR	NR	$5,000–$25,000
Lighting	• Can be inexpensive • Can reduce vehicle speeds	• No effect during daylight	• Targeted crossing locations not located on a street with continuous roadway lighting	NR	NR	$1,000–$40,000
Pavement Striping (Road Diet)	• Can be inexpensive • May decrease vehicle speed • May decrease illegal right-side passing • Can be an interim solution	• Does not provide a physical barrier between modes • Pedestrian crossing distance same as existing	• Four-lane undivided roadways • Locations with very long crossings	NR	NR	Variable depending on length
Curb Bump-Outs/ Extensions	• Can be inexpensive • Reduces pedestrian crossing distance • Provides higher pedestrian visibility to vehicles • Reduces speed for turning vehicles • Decreases in illegal right-side passing	• May make snow removal more difficult • Proximity of curb to through traffic may be a safety concern	• Downtown/urban locations	NR	NR	$5,000–$15,000 per crossing
Channelized Turn Lanes (Corner Islands) *(Not usually recommended as a pedestrian crossing treatment)*	• Decreases pedestrian crossing distance • Provides higher pedestrian visibility • Decrease in illegal right-side passing	• May require new pavement • Can be more challenging for visually impaired pedestrians • Right turning drivers often fail to yield to pedestrians • Can increase right-turn vehicle speeds • May make snow removal more difficult • Vehicle crashes may increase	• Intersections with wide approaches • Intersections with right turn lanes and sufficient corner right-of-way • Intersections with operational improvment needs	NR	NR	$50,000–$100,000 per intersection
NR = No research found on effect to yielding rate						

HIGH-LEVEL TREATMENTS

High-level treatments are high cost and are generally implemented on high-volume and high-speed roadways. They are much more difficult to implement unless they are justified based on traffic and pedestrian volume.

Possible high-level treatments are outlined in Table 5 on page 27, and examples of selected treatment options are shown below. For additional information on Treatment Options, please see the sources listed below.

PEDESTRIAN HYBRID BEACON


TRAFFIC SIGNAL


UNDERPASS


OVERPASS

REPEAT STEP 4

Evaluate LOS for Treatment Options

Step 4 should be repeated after deciding on a treatment option. Determine the level of service (LOS) of the crossing condition with the potential treatment options following the procedure as outlined in the 2010 *Highway Capacity Manual*. An acceptable service level should be determined by the agency.

If acceptable service levels cannot be met:

- Do nothing (consider leaving the crossing unmarked and unsigned),
- Consider pedestrian routing to another location, and/or
- Consider appropriate high-level treatments.

Sources:
"Minnesota's Best Practices for Pedestrian/Bicycle Safety," MnDOT Office of Traffic, Safety and Technology, September 2013.
"Best Practices Synthesis and Guidance in At-Grade Trail-Crossing Treatments," Minnesota Department of Transportation, St.Paul, MN, September 2013.
NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings. Transportation Research Board of the National Academies, Washington D.C., 2006.
Assessment of Driver Yield Rates Pre- and Post-RRFB Installation, Bend, Oregon. Oregon Department of Transportation, Washington D.C., 2011.
Bolton & Menk, Inc.
Transportation Research Board, HCM 2010 Highway Capacity Manual, Washington D.C.: National Academy of Sciences, 2010.
Before-and-After Study of the Effectiveness of Rectangular Rapid-Flashing Beacons Used with School Sign in Garland, Texas. Texas Transportation Institute, College Station, TX, April 2012.

Table 5: High-Level Treatments

Treatment	Advantages	Disadvantages	Recommended Locations	Staged Pedestrian Yield Rate	Unstaged Pedestrian Yield Rate	Cost
Pedestrian Hybrid Beacon	• Provides higher driver awareness when a pedestrian is present • Has been shown to decrease pedestrian crashes	• Potential increase in vehicle crashes • Can have spotty compliance rates due to a lack of driver understanding	• Justified locations • Mid-block crossing locations	97%	99%	$150,000–$300,000
Traffic Signal	• Provides higher driver awareness when a pedestrian is present • Easily understandable	• May increase crashes due to the driver expectation of a green signal indication	• High pedestrian volume crossings • Justified locations, meets signal warrants	NA	NA	$150,000–$300,000
Underpass Grade Separation	• Removes pedestrian/vehicle conflicts	• Potential of the crossing not being used • Very location specific • Very expensive • Drainage within an underpass can be problematic • Underpass would require lighting	• Location with compatible grades • High pedestrian volume crossings • High-volume roadways • High-speed roadways	NA	NA	$800,000+
Overpass Grade Separation	• Removes pedestrian/vehicle conflicts	• Potential of the crossing not being used • Very location specific • Very expensive • Snow removal on overpass may be difficult	• Location with compatible grades • High pedestrian volume crossings • High-volume roadways • High-speed roadways	NA	NA	$1,200,000+
NA = Not applicable or no research found on effect to yielding rates						

Uncontrolled Pedestrian Crossing
Data Collection Worksheet

Location: _____ Date: _____

City, State: _____ Scenario: _____

Reviewer(s): _____ Agency: _____

Project #: _____ ID #: _____

The first step in understanding the pedestrian needs at a potential crossing location is completing a review of the location and adjacent facilities.

Geometrics

Crossing Length: Measure the crossing distance from curb to curb. Crossing 1 _____ ft.

Fill in Crossing 1 distance if there is no median. If there is a median at the crossing location, fill in Crossing 1 and 2 distances. Crossing 2 _____ ft.

Median: width of median at crossing location _____ ft.

Crossing Width: effective crosswalk width _____ ft.

Raised Median Available? ☐ Yes ☐ No

ADA Compliant Median Available (minimum 4' x 4' landing)? ☐ Yes ☐ No

Curb Ramps Available? ☐ Yes ☐ No

ADA Compliant Curb Ramp Available (width, grades, truncated domes)? ☐ Yes ☐ No

Speed: Posted or 85th percentile speed _____ mph

Roadway Curvature and Sight Distances: Average walking speed _____ ft/s

Is the crossing location within a horizontal or vertical curve? ☐ Yes ☐ No

Equations to calculate the following are located on the next page

Direction 1: Stopping Sight Distance (SSD) _____ ft. provided? ☐ Yes ☐ No

Direction 2: Stopping Sight Distance (SSD) _____ ft. provided? ☐ Yes ☐ No

Direction 1: Pedestrian Sight Distance (PedSD) _____ ft. provided? ☐ Yes ☐ No

Direction 2: Pedestrian Sight Distance (PedSD) _____ ft. provided? ☐ Yes ☐ No

Traffic and Pedestrian Data

Measure traffic and pedestrian volume in 15-minute increments on the roadway to be crossed.

Attach Counts	**vehicles:**	Daily		**pedestrians:**	Daily	
AM Peak	Hourly		Pk 15-min	Hourly	Pk 15-min	
PM Peak	Hourly		Pk 15-min	Hourly	Pk 15-min	

Additional Site Characteristics

Lighting:

Is street lighting present and does it light the crosswalk location? ☐ Yes ☐ No

Crosswalk Pavement Markings: Is the pedestrian crossing currently marked? ☐ Yes ☐ No

What is the condition of the markings? ☐ Excellent ☐ Good ☐ Fair ☐ Poor

Are the markings easily defined? ☐ Yes ☐ No

Do they need replacement? ☐ Yes ☐ No

What is the crosswalk marking pattern? _____

Signing: Currently signed at crosswalk? ☐ Yes ☐ No

Currently signed in advance of crosswalk? ☐ Yes ☐ No

Distances? direction 1 _____ ft. direction 2 _____ ft.

Enhancements: What enhancements are currently at the crossing location? _____

Adjacent Facilities: Distance to nearest marked crosswalk? _____ ft.

What pedestrian control devices are present at the nearest adjacent marked crosswalk? _____

Distance to nearest all-way stop, roundabout or signalized intersection _____ ft.

Could another location serve the same pedestrian crossing movement? ☐ Yes ☐ No

Could another location serve the the movement more effectively? ☐ Yes ☐ No

Uncontrolled Pedestrian Crossing
Data Collection Worksheet

Mark the following: site distances and potential conflicts, pavement markings (crosswalk, edge lines, center lines, lane lines, stop lines, and any other markings), signing, location of lighting units, curb ramps, truncated domes, presence of any other crosswalks or crossing locations parallel to and nearby the location being studied, adjacent intersection traffic control, parking, intersection width, lane lengths, shoulder widths, sign placement, and nearby orgins and destinations .

draw or insert map of location being studied

Notes: _____

_____

_____

_____

_____

Sight Distance Calculations:

Stopping sight distance (SSD), ft = $1.47St + 1.075S^2/a$

Pedestrian sight distance (PedSD), ft = $1.47S(L / S_p + t_s)$

where: S = design speed, mph

L = length of crossing, ft

where:	defaults:
t = brake reaction time, s	2.5
a = deceleration rate, ft/s^2	11.2
S_p = average pedestrian walking speed, ft/s	3.5
t_s = pedestrian start-up and end clearance time, s	3.0

2010 Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Introduction:

The Worksheets provide a procedure for evaluating the Level of Service (LOS) at uncontrolled pedestrian crossings according to the methodology presented in Chapter 19 of the 2010 Highway Capacity Manual. Uncontrolled pedestrian crossings include: marked crossings at mid-block locations; marked crossings at intersections; and unmarked crossings at intersections, that are not controlled by a traffic control device such as signals and stop or yield signs.

Use of these Worksheets in Microsoft Excel results in an automated procedure. While this automated procedure has been checked for accuracy using multiple examples, no warranty is made by the developers as to the accuracy, completeness, or reliability of the equations and results. No responsibility is assumed for incorrect results or damages resulting from the use of these worksheets.

This process is not for use at signalized crossings and has not been verified to be accurate for unsignalized pedestrian crossings within a signalized corridor.

The equations and methodology presented through this process is contained within the 2010 Highway Capacity Manual (HCM). Any questions on the approach, assumptions, and limitations of the procedure or for verification of equations are directed to the 2010 HCM.

This material was developed by Bolton & Menk, Inc. in coordination with the Local Road Research Board (LRRB) for the use by practicioners. These Worksheets are made without charge and under no circumstances shall be sold by third parties for profit.

Submitted for Approval: May 12, 2014
Updated June 6, 2014

2010 Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Crossing Location: _____ Date: _____

City, State: _____ Scenario: _____

Reviewer(s): _____ Agency: _____

Project Number: _____ ID #: _____

The following is the base information needed to complete the analysis.
If this is a one-stage crossing, use only Crossing 1.
If this is a two-stage crossing, each stage must be evaluated separately using Crossing 1 and Crossing 2.

Crossing 1: _____

Evaluation Inputs:

L = crosswalk length (ft)
S_p = average pedestrian walking speed (ft/s)
t_s = pedestrian start-up and end clearance time (s)
V = vehicular hourly volume (veh/hr)
v_p = pedestrian flow rate (ped/s)
v = vehicular flow rate (veh/s) = V/3600
W_c = crosswalk width (ft)
N = number of through lanes crossed (Integer)

defaults:	
S_p =	3.5
t_s =	3.0
v_p =	0*
v =	V/3600
W_c =	8.0
N =	INT(L/11)

Input Table:	
L =	
S_p =	
t_s =	
V =	
v_p =	
v =	
W_c =	
N =	

*no platooning observed

Crossing 2: _____ (only used for two-stage crossings)

Evaluation Inputs:

L = crosswalk length (ft)
S_p = average pedestrian walking speed (ft/s)
t_s = pedestrian start-up and end clearance time (s)
V = vehicular hourly volume (veh/hr)
v_p = pedestrian flow rate (ped/s)
v = vehicular flow rate (veh/s) = V/3600
W_c = crosswalk width (ft)
N = number of through lanes crossed (Integer)

defaults:	
S_p =	3.5
t_s =	3.0
v_p =	0*
v =	V/3600
W_c =	8.0
N =	INT(L/11)

Input Table:	
L =	
S_p =	
t_s =	
V =	
v_p =	
v =	
W_c =	
N =	

*no platooning observed

Crossing Treatment Yield Rate

M_y = motorist yield rate (decimal)

Input Table:	
M_y =	

Entering data into the tables above will populate the evaluation tables in Microsoft Excel.

Results:

Average Delay		sec/ped
LOS		

Uncontrolled Pedestrian Crossing Level of Service Evaluation Worksheet

Crossing Location: _____ Date: _____

City, State: _____ Scenario: _____

Reviewer(s): _____ Agency: _____

Step 1: Identify Two-Stage Crossings

Is there a median available for a two-stage crossing? ☐ Yes ☐ No

If yes, does the median refuge meet ADA requirements (4' x 4' landing)? ☐ Yes ☐ No

If yes, do pedestrians treat this as a two-stage crossing location? ☐ Yes ☐ No

Step 2: Determine Critical Headway

Critical headway is the time below which a pedestrian will not attempt to begin crossing the street. Pedestrians use judgement to determine whether the available headway is sufficent for a safe crossing.

For a single pedestrian:

$$t_c = \frac{L}{S_p} + t_s$$

where: t_c = critical headway for a single pedestrian (s)

L = crosswalk length (ft)

S_p = average pedestrian walking speed (ft/s)

t_s = pedestrian start-up and end clearance time (s)

crossing 1				crossing 2			
L =		t_s =		L =		t_s =	
S_p =		t_c =		S_p =		t_c =	

S_p = 3.5 ft/s

t_s = 3 sec

If pedestrian platooning is observed, the spatial distribution of pedestrians should be computed:

1. use field observations or estimate platoon size using equation:

$$N_c = \frac{v_p e^{v_p t_c} + v e^{-v t_c}}{(v_p + v) e^{(v_p - v) t_c}}$$

where: N_c = total number of pedestrians in crossing platoon (ped)

v_p = pedestrian flow rate (ped/s)

v = vehicular flow rate across crossing (veh/s)

t_c = single pedestrian critical headway (s)

crossing 1				crossing 2			
v_p =		t_c =		v_p =		t_c =	
v =		N_c =		v =		N_c =	

2. compute spatial distribution:

$$N_p = INT\left[\frac{8.0(N_c - 1)}{W_c}\right]$$

where: N_p = spatial distributions of pedestrians (ped)

N_c = total number of pedestrians in crossing platoon (ped)

W_c = crosswalk width (ft)

8.0 = default clear width used by a single pedestrian to avoid interference with other pedestrians (ft)

clear width, if other than 8: _____ ft.

crossing 1				crossing 2			
N_c =		N_p =		N_c =		N_p =	
W_c =				W_c =			

3. compute group critical headway:

$$t_{c,G} = t_c + 2(N_p - 1)$$

where: $t_{c,G}$ = group critical headway (s)

t_c = single pedestrian critical headway (s)

N_p = spatial distributions of pedestrians (ped)

crossing 1				crossing 2			
N_p =		$t_{c,G}$ =		N_p =		$t_{c,G}$ =	
t_c =				t_c =			

Step 3: Estimate Probability of a Delayed Crossing

Probability that a pedestrian will not incur any crossing delay is equal to the likelihood that a pedestrian will encounter a gap greater than or equal to the critical headway immediately upon arrival at the intersection.

$$P_b = 1 - e^{\frac{-t_{c,G} v}{L}}$$

$$P_d = 1 - (1 - P_b)^L$$

where: P_b = probability of blocked lane

P_d = probability of delayed crossing

N = number of through lanes crossed

$t_{c,G}$ = group critical headway (s) = t_c if no platooning

v = vehicular flow rate across crossing(veh/s)

crossing 1				crossing 2			
$t_{c,G}$ =		P_b =		$t_{c,G}$ =		P_b =	
v =		P_d =		v =		P_d =	
N =				N =			

LRRB

Uncontrolled Pedestrian Crossing Level of Service Evaluation Worksheet

Step 4: Calculate Average Delay to Wait for Adequate Gap

Average delay assumes that no motor vehicles yield and the pedestrian is forced to wait for an adequate gap.

$$d_g = \frac{1}{v}\left(e^{vt_{c,G}} - vt_{c,G} - 1\right)$$

where: d_g = average pedestrian gap delay (s)
$t_{c,G}$ = group critical headway (s)
v = vehicular flow rate across crossing (veh/s)

crossing 1		crossing 2	
$t_{c,G}$ =		$t_{c,G}$ =	
v =	d_g =	v =	d_g =

Average delay for a pedestrian who is unable to cross immediately upon reaching the intersection (e.g., any pedestrian experiencing nonzero delay.)

$$d_{gd} = \frac{d_g}{P_d}$$

where: d_{gd} = average gap delay for pedestrians who incur nonzero delay
d_g = average pedestrian gap delay (s)
P_d = probability of a delayed crossing

crossing 1		crossing 2	
d_g =		d_g =	
P_d =	d_{gd} =	P_d =	d_{gd} =

Step 5: Estimate Delay Reduction due to Yielding Vehicles

(If yielding is zero, then skip step 5)

When a pedestrian arrives at a crossing and finds an inadequate gap, that pedestrian is delayed until one of two situations occurs: (a) a gap greater than the critical headway is available, or (b) motor vehicles yield and allow the pedestrian to cross. While motorists are legally required to stop for crossing pedestrians in MN at all intersections and at all marked crossings, motorist yield rates actually vary considerably.

Some crossing treatments and yield rates based on research are provided on the next page.

Average pedestrian delay

$$d_p = \sum_{i=1}^{n} h(i-0.5)\,P(Y_i) + \left(P_d - \sum_{i=1}^{n} P(Y_i)\right) d_{gd}$$

where: d_p = average pedestrian delay (s)
i = crossing event (i=1 to n)
h = average headway for each through lane = N/v
$P(Y_i)$ = probability that motorists yield to pedestrian on crossing event i
n = Int(d_{gd}/h), average number of crossing events before an adequate gap is available, >0
j = crossing event (j=0 to i-1)
$P(Y_j)$ = probability that motorists yield to pedestrian on crossing event j

crossing 1			crossing 2		
h =	n =		h =	n =	
	d_p =			d_p =	

1. One-Lane Crossing

$$P(Y_i) = P_d M_y (1 - M_y)^{i-1}$$

2. Two-Lane Crossing

$$P(Y_i) = \left[P_d - \sum_{j=0}^{i-1} P(Y_j)\right]\left[\frac{(2P_b(1-P_b)M_y) + (P_b{}^2 M_y{}^2)}{P_d}\right]$$

3. Three-Lane Crossing

$$P(Y_i) = \left[P_d - \sum_{j=0}^{i-1} P(Y_j)\right]\left[\frac{P_b{}^3 M_y{}^3 + 3P_b{}^2(1-P_b)M_y{}^2 + 3P_b(1-P_b)^2 M_y}{P_d}\right]$$

4. Four-Lane Crossing

$$P(Y_i) = \left[P_d - \sum_{j=0}^{i-1} P(Y_j)\right] \text{x} \left[\frac{P_b{}^4 M_y{}^4 + 4P_b{}^3(1-P_b)M_y{}^3 + 6P_b{}^2(1-P_b)^2 M_y{}^2 + 4P_b(1-P_b{}^3)M_y}{P_d}\right]$$

M_y = motorist yield rate (decimal) M_y =

Summary	
Average	
LOS	

Step 6: Calculate Average Pedestrian Delay & Determine LOS

LOS	Control Delay (sec/ped)	Comments
A	0-5	Usually no conflicting traffic
B	5-10	Occasionally some delay due to conflicting traffic
C	10-20	Delay noticeable to pedestrians, but not inconvienencing
D	20-30	Delay noticeable/irritating, increased chance of risk-taking
E	30-45	Delay approaches tolerance level, risk-taking likely
F	>45	Delay exceeds tolerance level, high chance of risk-taking

Uncontrolled Pedestrian Crossing Level of Service Evaluation Worksheet

Determine if there is a crossing treatment used that could provide vehicle yielding. This then provides a possible reduction in delay.

Motorist Yield Rate = M_y

Crossing Treatment	Staged Pedestrian Yield Rate	Unstaged Pedestrian Yield Rate
Crosswalk Markings and Signs Only [1]	7%	7%
Median Refuge Islands [1]	34%	29%
Pedestal Mounted Flashing Beacon (2-Lane, 35 mph) [3]	N/A	57%
Overhead Flashing Beacon (push-button activation) [1]	47%	49%
Overhead Flashing Beacon (passive activation) [1]	31%	67%
Pedestrian Crossing Flags [1]	65%	74%
School Crossing Guards [5]	N/A	86%
In-street Crossing Signs (25-30 mph) [1]	87%	90%
Warning Sign with Edge Mounted LEDs [6]	N/A	28%
In-road warning lights [1]	N/A	66%
High-visibility Signs and Markings (35 mph) [1]	17%	20%
High-visibility Signs and Markings (25 mph) [1]	61%	91%
Rectangular Rapid-Flash Beacon (RRFB) [2][4]	84%	81%
School Crossing Guards with RRFB [5]	N/A	91%
Pedestrian Hybrid Beacon (HAWK) [1]	97%	99%
	N/A: No Research Found on Effect to Yielding Rate	

Sources: (1) Fitzpatrick, K., S.M. Turner, M. Brewer, P.J. Carlson, B. Ullman, N.D. Trout, E.S. Park, J. Whitacre, N. Lalani, and D. Lord. NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings. Transportation Research Board of the National Academies, Washington D.C., 2006.

(2) Lewis, R., J.R. Ross, D.S. Serpico : Assessment of Driver Yield Rates Pre- and Post-RRFB Installation, Bend, Oregon. Oregon Department of Transportation, Washington D.C., 2011.

(3) Bolton & Menk Field Data Collection

(4) Transportation Research Board, HCM 2010 Highway Capacity Manual, Washington D.C.: National Academy of Sciences, 2010.

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DEPARTMENT OF TRANSPORTATION

Pedestrian Crosswalk Policy Development Guidelines

Kate Miner, Principal Investigator
Stonebrooke Engineering

May 2020

Research Project
Final Report 2020RIC01

LRRB
LOCAL ROAD RESEARCH BOARD

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This study was driven by the need to improve consistency in the methods and approach that local agencies use to address crosswalks. This study focuses on the question of how a crosswalk should be enhanced with additional countermeasures, if any, once the decision is made to mark it. During the research portion of this project, it was found that the primary information agencies use that provides guidance for decisions on how to mark crosswalks comes from the Federal Highway Administration. A quick reference guide was developed from FHWA's *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations*, July 2018, that will help agencies determine when to use different countermeasures based on roadway type, vehicle volumes, and posted speed limits. In addition, fact sheets for twelve countermeasures identified in the document were developed to explain what the benefit of each one is, when it is best applied, and how to provide high-level planning cost for each one.

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PEDESTRIAN CROSSWALK POLICY DEVELOPMENT GUIDELINES

FINAL REPORT

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EXECUTIVE SUMMARY

This study was driven by the need to improve consistency in the methods and approach that local agencies use to address crosswalks. This study focuses on the question of how a crosswalk should be enhanced with additional countermeasures, if any, once the decision is made to mark it. During the research portion of this project, it was found that the primary information agencies use that provides guidance for decisions on how to mark crosswalks comes from the Federal Highway Administration. A quick reference guide was developed from FHWA's *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations*, July 2018, that will help agencies determine when to use different countermeasures based on roadway type, vehicle volumes, and posted speed limits. In addition, fact sheets for twelve countermeasures identified in the document were developed to explain what the benefit of each one is, when it is best applied, and how to provide high-level planning cost for each one.

CHAPTER 1: INTRODUCTION

The development of the *Pedestrian Crosswalk Policy Development Guidelines* was identified and supported by local agencies in Minnesota because of the need to improve consistency of the methods and approach that local agencies use to address crosswalks. It is believed that improving the consistency of the approach from one community to the next will improve pedestrian safety.

The approach to providing guidelines consisted of three key parts:

- Reviewing the literature documenting the results of previously published research
- Surveying local agencies in Minnesota on their practices and policies for crosswalks
- Development of Quick Reference Fact Sheets on different crosswalk treatments

While working through this project, the Technical Advisory Panel (TAP) determined that the question on when to mark a crosswalk was an agency decision and that providing standard policy language would not be useful. Instead this document provides several existing agency policies in the Appendix that other agencies can use if they choose. An assortment of policies is provided in the Appendix and includes policies from both large and small cities and both rural and urban counties across Minnesota.

During our research, we found that the primary information agencies use that provides guidance for decisions on how to mark crosswalks comes from the Federal Highway Administration (FHWA). Because this information is very useful, the TAP determined that this study should take the guidance from FHWA and apply it in a more meaningful way for local agencies in Minnesota. This document outlines the literature research completed and the local agency survey results.

The documents provided in the Appendix primarily focus on the question of how a crosswalk should be enhanced with additional countermeasures, if any, once the decision is made to mark it. There are several tools available, but it can be somewhat unclear as to when each tool should be used. To provide consistency, the TAP determined that the guidance provided in FHWA's *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations*, July 2018, provided the guidance that Minnesota should follow. The scope of this project was then changed to provide a user-friendly way for agencies to use this information without having to read the full report. A quick reference guide was developed from the FHWA report that helps agencies determine when to use different countermeasures based on roadway type, vehicle volumes, and posted speed limits. In addition, fact sheets for twelve different countermeasures identified in the document were developed to explain what the benefit of each one is,

determine when it is best applied, and a provide a high-level planning cost for each one. The twelve countermeasures identified are:

- High-visibility crosswalk markings
- Parking restrictions on crosswalk approach
- Adequate nighttime lighting levels
- Crossing warning signs
- Raised crosswalks
- Advanced Stop Here for Pedestrian sign and stop line
- In-street pedestrian crossing sign
- Curb extension
- Pedestrian refuge island
- Rectangular Rapid Flashing Beacon (RRFB)
- Road diet
- Pedestrian Hybrid Beacon (PHB)

Before going any further, it is important that anyone reading this document understands what Minnesota law says about uncontrolled crosswalks and pedestrians. Minnesota 2019 State Statute 169.21 addresses pedestrians and crosswalks. See Section 2.1.1 for details.

CHAPTER 2: LITERATURE SEARCH

Nationally there were 7,140 pedestrian and bicycle fatalities in 2018, which was a 3.6-percent increase from the 6,881 pedestrian and bicycle fatalities in 2017. In 2018, nationally, 19.5 percent of all traffic fatalities were pedestrians or bicyclists. Minnesota pedestrian fatalities in the same year comprised 11.8 percent of all fatalities in the state, slightly better than the national percentage (1). Because of the increase in pedestrian crashes over the years and the demand for pedestrian facilities have increased, crosswalks and treatments have been studied and policies/practices have been implemented by multiple agencies with a focus on determining when an uncontrolled crosswalk should be treated and how.

2.1 LITERATURE REVIEW

The Federal Highway Administration (FHWA) and several agencies across the United States have conducted studies and adopted practices and policies to address uncontrolled crosswalks. Most of these policies are based on Average Annual Daily Traffic (AADT) and/or pedestrian volumes at an intersection.

2.1.1 2019 Minnesota State Statute 169.011 Definitions and 169.21 Pedestrian and

2.1.1.1 169.011 Definitions

Subd. 20.Crosswalk.
"Crosswalk" means (1) that portion of a roadway ordinarily included with the prolongation or connection of the lateral lines of sidewalks at intersections; (2) any portion of a roadway distinctly indicated for pedestrian crossing by lines or other markings on the surface.

Subd. 53.Pedestrian.
"Pedestrian" means any person afoot or in a wheelchair.

Subd. 68.Roadway.

"Roadway" means that portion of a highway improved, designed, or ordinarily used for vehicular travel, exclusive of the sidewalk or shoulder. During periods when the commissioner allows the use of dynamic shoulder lanes as defined in subdivision 25, roadway includes that shoulder. In the event a highway includes two or more separate roadways, the term "roadway" as used herein shall refer to any such roadway separately but not to all such roadways collectively.

2.1.1.2 169.21 Pedestrian

- Subdivision 1 - Obey traffic-control signals. Pedestrians shall be subject to traffic-control signals at intersections as heretofore declared in this chapter, but at all other places pedestrians shall be accorded the privileges and shall be subject to the restrictions stated in this section and section 169.22.

- Subdivision 2 – Rights in absence of a signal.

(a) Where traffic-control signals are not in place or in operation, the driver of a vehicle shall stop to yield the right-of-way to a pedestrian crossing the roadway within a marked crosswalk or at an intersection with no marked crosswalk. The driver must remain stopped until the pedestrian has passed the lane in which the vehicle is stopped. No pedestrian shall suddenly leave a curb or other place of safety and walk or run into the path of a vehicle which is so close that it is impossible for the driver to yield. This provision shall not apply under the conditions as otherwise provided in this subdivision.

(b) When any vehicle is stopped at a marked crosswalk or at an intersection with no marked crosswalk to permit a pedestrian to cross the roadway, the driver of any other vehicle approaching from the rear shall not overtake and pass the stopped vehicle.

(c) It is unlawful for any person to drive a motor vehicle through a column of school children crossing a street or highway or past a member of a school safety patrol or adult crossing guard, while the member of the school safety patrol or adult crossing guard is directing the movement of children across a street or highway and while the school safety patrol member or adult crossing guard is holding an official signal in the stop position. A peace officer may arrest the driver of a motor vehicle if the peace officer has probable cause to believe that the driver has operated the vehicle in violation of this paragraph within the past four hours.

(d) A person who violates this subdivision is guilty of a misdemeanor. A person who violates this subdivision a second or subsequent time within one year of a previous conviction under this subdivision is guilty of a gross misdemeanor.

- Subdivision 3 – Crossing between intersections.

(a) Every pedestrian crossing a roadway at any point other than within a marked crosswalk or at an intersection with no marked crosswalk shall yield the right-of-way to all vehicles upon the roadway.

(b) Any pedestrian crossing a roadway at a point where a pedestrian tunnel or overhead pedestrian crossing has been provided shall yield the right-of-way to all vehicles upon the roadway.

(c) Between adjacent intersections at which traffic-control signals are in operation pedestrians shall not cross at any place except in a marked crosswalk.

(d) Notwithstanding the other provisions of this section every driver of a vehicle shall

(1) exercise due care to avoid colliding with any bicycle or pedestrian upon any roadway and

(2) give an audible signal when necessary and exercise proper precaution upon observing any child or any obviously confused or incapacitated person upon a roadway.

2.1.2 Matthiesen, Wickert & Lehrer, S.C. (2)

This document published in April 2019 outlines pedestrian and crosswalk laws in all 50 states. The document states that in Minnesota, the law currently requires a vehicle to stop when a pedestrian is in a marked crosswalk or at an intersection with no marked crosswalk—controlled or uncontrolled. Drivers in Minnesota must currently stop for crossing pedestrians at marked crosswalks and at all intersections without crosswalks or stop lights. Although pedestrians must not enter a crosswalk if a vehicle is

approaching and it is impossible for the driver to stop, there is no defined distance that a pedestrian must abide by before entering the crosswalk. In addition, when a vehicle is stopped in Minnesota at an intersection for pedestrians to cross the roadway, it is illegal for another driver approaching from the rear to pass the stopped vehicle.

2.1.3 Crosswalk Policy – City of El Cerrito, CA (3)

In April 2016 the City of El Cerrito published a Crosswalk Policy as part of the city's Transportation Plan. The policy describes the function of crosswalks and their legal context in the California Vehicle Code. The purpose the policy is to enable the City to respond to crosswalk requests in a manner that improves pedestrian accessibility and maintains public safety.

The policy considers markings to be used to communicate the shortest path and best sight distance for pedestrians to cross, also to assure them of their legal right to cross at a midblock crossing. The policy provides a flow chart that uses pedestrian volumes, sight distance and location as criteria to help determine when a crosswalk should be marked. It then uses a combination of vehicle speeds and pedestrian delay level of service to determine which treatments will be considered.

2.1.4 Minnesota's Best Practices for Pedestrian/Bicycle Safety (4)

In September 2013, Minnesota Department of Transportation (MnDOT) published this document to provide a resource to assist agencies in their effort to more safely accommodate pedestrians and bicyclists on their roads and highways. The document discusses proven, tried and experimental strategies available and provides a description and definition to each in addition to the safety characteristics.

2.1.5 City of Albert Lea, MN Crosswalk Policy (5)

This policy, published as part of the City's policy and procedures manual, establishes the guidelines and considerations for the installation of marked crosswalks. The policy requires an engineering study to determine if the criteria is met for a marked crosswalk. The criteria include minimum vehicle volumes, minimum peak hour pedestrian volumes, inadequate gaps, and distance from other crossings.

Once the decision is made to mark a crosswalk, the policy identifies a chart based on AADT, vehicle speeds, and roadway configuration to determine the proper treatment needed.

2.1.6 City of Mankato, MN Crosswalk Marking Policy (6)

Adopted by the City Council in May 2011, this policy outlines a process that can be taken for a citizen to request a marked crosswalk. If a location is to be marked, it requires 20 or more pedestrians within a 2-hour period, in addition to sufficient stopping sight distance. Crosswalks are not allowed on arterial roadways or on street with a speed limit greater than 30 mph unless the intersection is signalized. The policy also provides a list of locations where conditions may warrant a crosswalk (school routes, parks, trails, etc..). The policy states that in all cases, the City Council will make the final decision.

2.1.7 City of Blaine, MN Crosswalk Policy (7)

In November 2014, the Blaine City Council adopted a policy very similar to the City of Mankato's policy from 2011. If a location is to be marked it must have over 5 pedestrian per hour during a 10-hour period. Crosswalks are not allowed on arterial roadways or on street with a speed limit greater than 30 mph unless the intersection is signalized. The policy also provides a list of locations where conditions may warrant a crosswalk (school routes, parks, trails, etc..). The Blaine policy has a process for a citizen to make a request for a crosswalk and states that in all cases, the City Council will make the final decision to mark a crosswalk.

2.1.8 Hennepin County Pedestrian Plan (8)

The Hennepin County Board of Commissioners adopted the Pedestrian Plan in September 2013. The plan was adopted for the purpose of guiding the implementation of improved opportunities for walking within Hennepin County, while remaining consistent with adopted policies and improving health outcomes. The plan does not address crosswalk guidelines but discussed a need to develop guidelines for Leading Pedestrian Intervals (LPI), Rectangular Rapid Flashing Beacons (RRFB), and High-Intensity Activated Crosswalk Beacons (HAWK) across County Roads.

2.1.9 Minnesota Manual of Uniform Traffic Control Devices (MN MUTCD) (9)

Section 3B.18 of the 2018 MN MUTCD states that an engineering study is needed to determine if crosswalks should be marked. The criteria for the study is defined, while the actual study requirements or procedure is not. Some of the criteria listed are number of lanes, the presence of medians, distance to adjacent signals, pedestrian volumes and delays, AADT, posted speed limits, geometry, and lighting. The document states that a new crosswalk shouldn't be installed alone without other measures designed to reduce traffic speeds, shorten crossing distances, and/or provide active warning of pedestrian presence if speeds exceed 40mph and either:

1. 4 or more lanes with no refuge and 12,000 ADT or higher, or
2. 4 or more lanes with raised refuge and greater than 15,000 ADT.

The MN MUTCD does not provide much in the way of guidance for what these other countermeasures should be.

2.1.10 City of Boulder, CO Pedestrian Crossing Treatment Installation Guidelines (10)

In November 2011 the City of Boulder published *The Pedestrian Crossing Treatment Installation Guidelines* which are intended to provide a consistent procedure for considering the installation of crossing treatments where needed on a case-by-case basis.

The guidelines prescribe pedestrian crossing criteria and procedures for evaluating the need for crossing treatments, including a “flowchart” approach and specific pedestrian crossing treatments that may be applicable for a particular set of pedestrian volumes, pedestrian types, vehicular volumes, vehicular speeds, and roadway geometry.

2.1.11 Best Practices for Traffic Control at Regional Trail Crossings (11)

In 2009, several Minnesota metro road and trail managing agencies came together to provide clarification on Minnesota State statutes regarding crossing locations, and to provide a general set of principles and options to consider when evaluating traffic control configurations at trail crossings. A chart was given to provide consistency along regional trails for crossing treatments based on roadway type, vehicle ADT and vehicle speeds.

CHAPTER 3: LOCAL AGENCY SURVEY

A survey of Minnesota cities and counties was completed through the use of Survey Monkey, an online survey development software. The survey was used to inform local agencies about the project and to solicit information regarding their agencies practices and policies for crosswalks. In addition, the survey examined local agencies practices and policies for removing existing marked crosswalks.

The survey was distributed to members of two organizations: The Minnesota County Engineers Association (MCEA) and the City Engineers Association of Minnesota (CEAM). The survey questions are provided in Appendix A; a summary of each questions is provided in Appendix B.

One-hundred and one (101) agencies completed the survey, all but two currently have marked crosswalks on its system. Of the 101 respondents there was a good mix of agency types with 45 being County agencies and 56 being City agencies. Key findings from all the local agencies responding to the survey are summarized below in two categories:

- Administration Policy and Practice
- Field Policy and Practice

3.1 ADMINISTRATION POLICY AND PRACTICE SURVEY RESULTS

Below is the summary when asked if an agency had a policy that addresses how, when and where pedestrian crosswalks are marked:

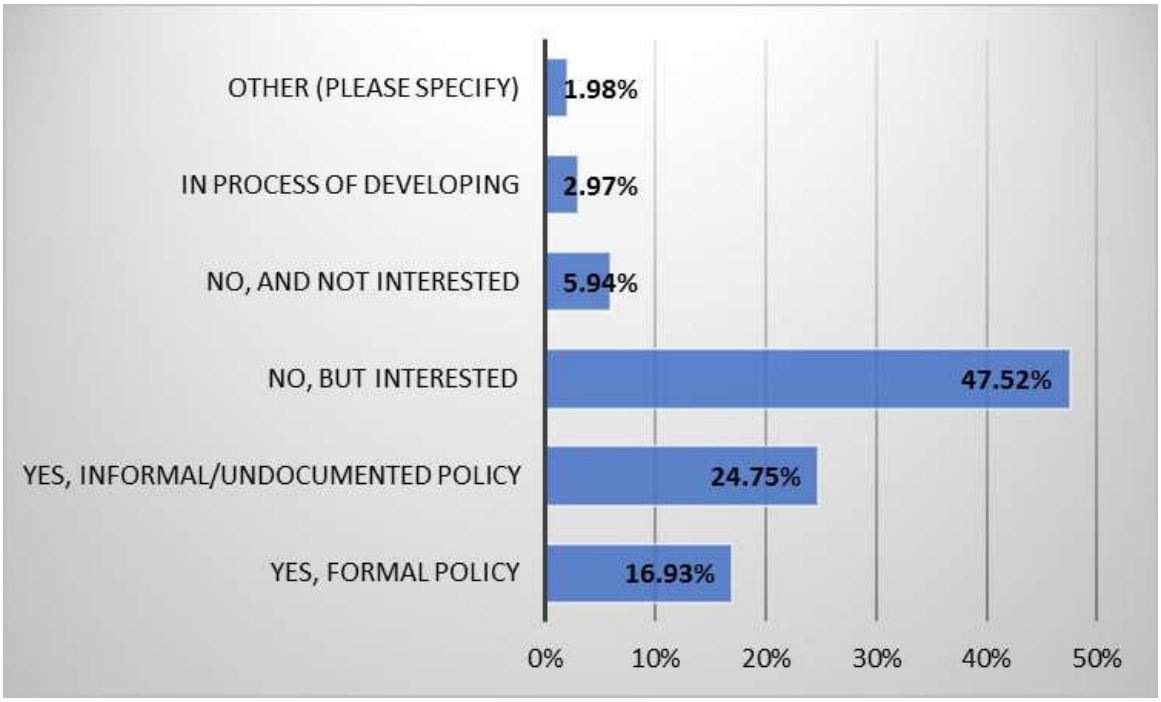

Figure 3-1 Type of Crosswalk Policy Respondents Currently Have

Overall, just under half of the respondents have either a formal or informal policy and 47% were interested in developing one. Of the agencies that have a policy, 4 of them have been updated in the past year while 13 of them are older than 5 years. Of the existing policies, 23 of them have buy-in from policy makers within the agency.

When asked if an agency currently has a policy that addresses how, when and where crosswalk treatments are discontinued, only 9 agencies stated they did address that with a policy, while 48 agencies at some point had made a decision to discontinue the use of a crosswalk treatment.

When asked what the biggest challenges an agency has with pedestrian crossings the top answer was overwhelmingly handling requests from the public. Cost and maintenance were the second and third most common challenge.

When asked what would be most helpful in developing and implementing a pedestrian crosswalk policy the biggest answer was sample policies and guidelines for best practices.

3.2 FIELD POLICY AND PRACTICES

The summary for what style crosswalk markings an agency uses is below:

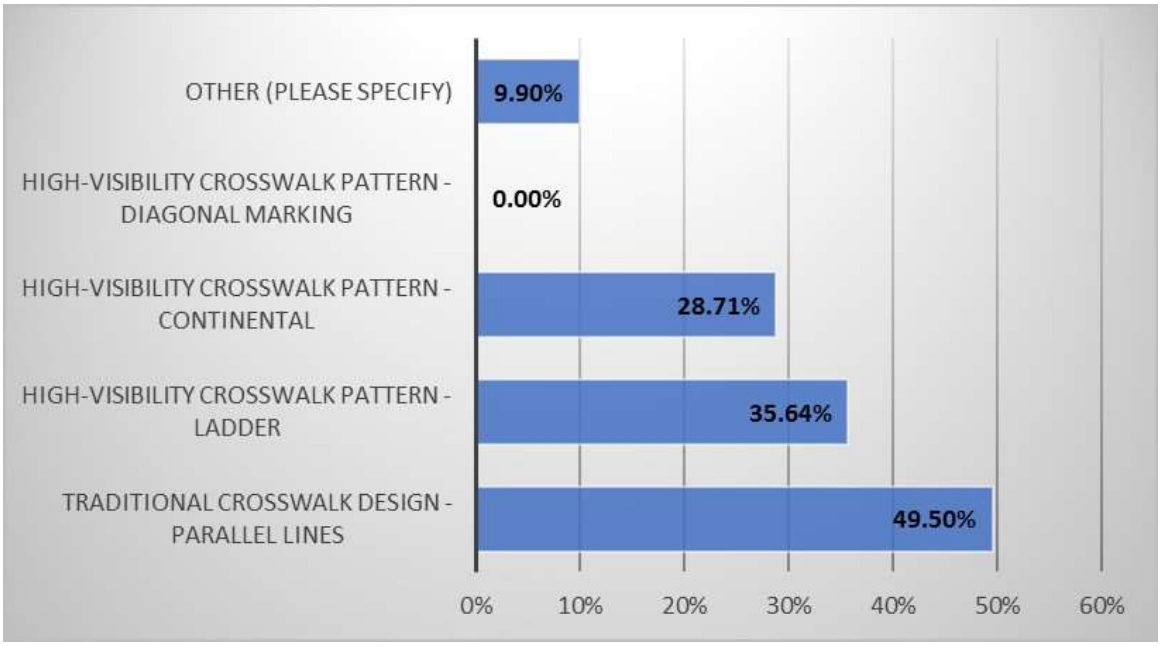

Figure 3-2 Style of Crosswalks Used by Agencies

About half of the responding agencies are using traditional crosswalk design and the other half are using a high-visibility pattern (either ladder, continental or Seattle-style).

Agencies were asked if they currently marked a crosswalk at a channelized right-turn location, 40% of the respondents said they did.

When an agency discontinues a crosswalk, they were asked how the marking is removed. The next graphic provides a summary of the results of agencies who have removed responded as well as agencies who haven't but have a method they would likely use.

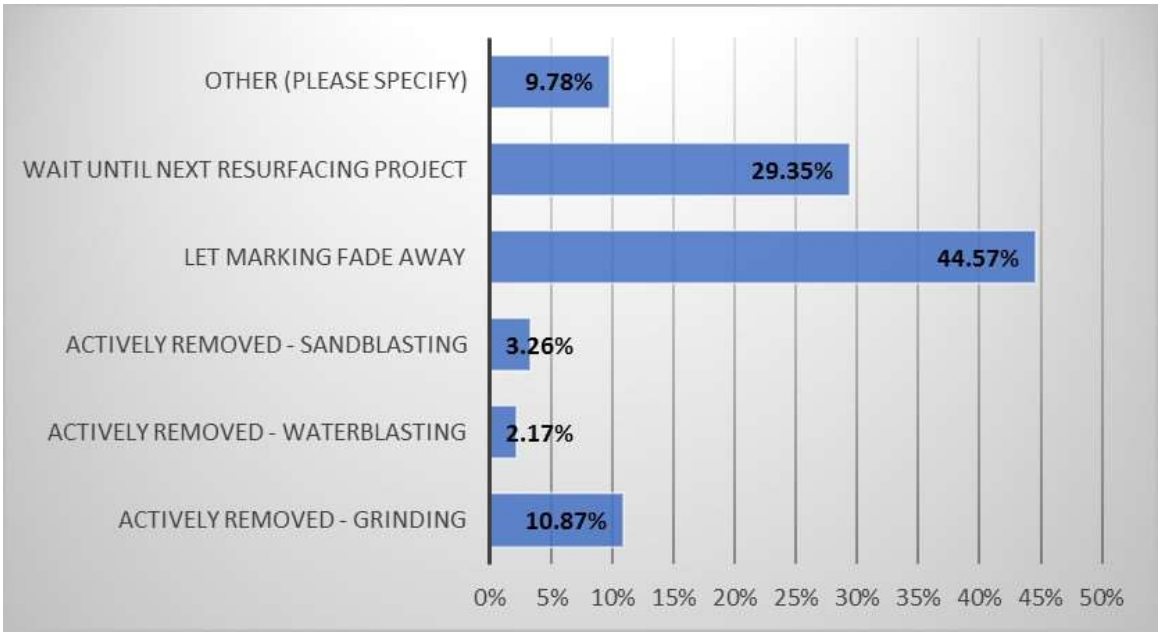

Figure 3-3 Methods Used by Agencies When Discontinuing a Crosswalk

Most of the agencies would make the change through attrition methods (fading or resurfacing project) rather than actively removing it with a physical method.

When the local agencies were asked about crosswalk treatments they have used, results show that most of the treatments identified have been used across the state.

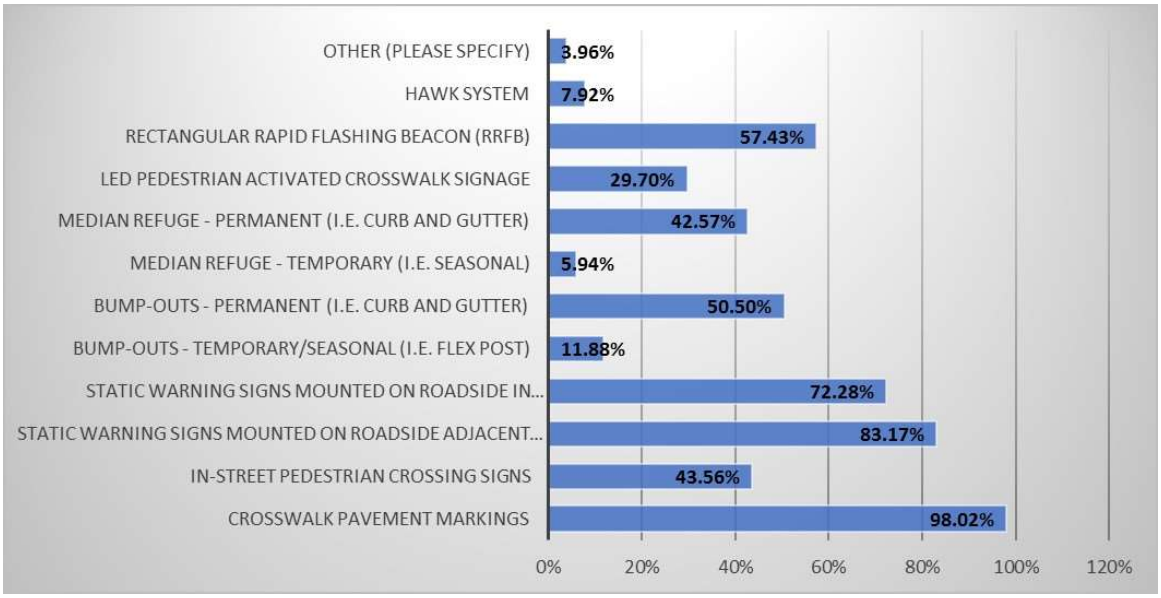

Figure 3-4 Treatments Respondents Have Used on Their Roadways

The information gathered in this survey is expected to inform local agencies of practices other agencies in the state of Minnesota are using. These survey responses were used to help develop the remainder of this project:

- Sample crosswalk policies for the decision to mark a crosswalk.
- Guidelines to follow on what treatment should be used once it is determined to mark a crosswalk.

CHAPTER 4: QUICK-REFERENCE GUIDE

Once the decision has been made to mark a crosswalk, most agencies who answered the survey are using the guidance provided by FHWA in *"Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations"* to determine how a crosswalk should be marked. A quick-reference guide was created in order to provide a quicker way for agencies to use this information without reading the full report. The quick-reference guide can be found in the Appendices and includes two parts:

- Countermeasures determined by roadway features
- Countermeasure Fact Sheets

4.1 COUNTERMEASURES BY ROADWAY FEATURE

The first part of the quick-reference guide includes charts that helps determine which of the twelve countermeasures mentioned in Chapter 1 is appropriate for a roadway. The criteria that is used for this determination is:

- Number of lanes in each direction
  - 2 lanes
  - 3 lanes with raised median
  - 3 lanes without raised median
  - 4+ lanes with raised median
  - 4+ lanes without raised median
- Average Annual Daily Traffic (AADT)
  - Less than 9,000
  - 9,000-15,000
  - Greater than 15,000
- Speed
  - Less than or equal to 30 mph
  - 35 mph
  - Greater than or equal to 40 mph

Each page is broken down into charts for number of lanes and AADT, with all speeds included in each chart. These charts guide a user to which countermeasure should always be considered, also considered, and used only in conjunction with other countermeasures. If a treatment falls under the "always consider" category, this indicates that a marked crosswalk at a location with the associated roadway features should always be considered a candidate for use but is not mandated or required. If a treatment falls under the "also consider" category, this indicates that a marked crosswalk at a location with the associated roadway features should always be considered, but it is not mandated or required, based upon engineering judgment. If a treatment falls under the "use only in conjunction with other countermeasures" category, this indicates that a marked crosswalk with the associated roadway features should only use these countermeasures with other identified countermeasures.

Not all of the countermeasures listed in the charts should necessarily be installed at a crossing. Agencies should also review safety issues, surrounding land development context, pedestrian travel patterns, countermeasure effectiveness, and costs when considering what countermeasure(s) are best suited for the crossing.

The second part of the quick reference guide will help make the determination on the most appropriate countermeasure to use.

4.2 COUNTERMEASURE FACT SHEETS

The countermeasure fact sheets include a sheet for each of the twelve countermeasures identified in the study. The fact sheets describe considerations for implementation of each countermeasure including:

- Benefits
- Best locations for use
- Design considerations
- Planning level costs

The fact sheets are meant to be used as a quick reference guide. Agencies should further review the MN MUTCD, AASHTO Pedestrian Guide, and/or agency policies and practices to identify and select countermeasures for implementation.

CHAPTER 5: CONCLUSIONS

Pedestrian crosswalks are a topic of interest across the spectrum of city and county agencies in Minnesota because appropriate use of marked crosswalks is a key part of implementing the statewide initiative of Toward Zero Deaths.

During the research portion of this project, it was determined that the scope would change slightly because the TAP members did not feel that policy language should be developed. They felt the policy decision to mark a crosswalk was an agency decision and this project should only provide existing sample policies for local agencies. Thus, this project's focus would be on answering the question of how to mark a crosswalk once the decision was made to mark it.

A review of eleven published guideline documents and sample policies indicates that the majority of communities with existing policies and practices, both documented and undocumented, have been using the guidance provided by the FHWA in its *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations.* This document was then redeveloped into a user-friendly, quick-reference guide for local agencies in Minnesota in addition to the development of countermeasure sheets to describe the twelve different countermeasures.

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APPENDIX A
UNCONTROLLED PEDESTRIAN CROSSWALK QUICK REFERENCE GUIDE

Uncontrolled Pedestrian Crosswalk

Quick Reference Guide

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Produced for the Minnesota Local Road Research Board
May 2020
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Introduction

A consistent approach and methods for treating uncontrolled crosswalks in Minnesota will improve pedestrian safety throughout the state. This quick reference guide helps local agencies select appropriate crosswalk treatments based on roadway type, vehicle volumes and posted speed limits.

The following twelve countermeasures are identified, along with their benefits and design, cost, and location considerations:

- Advance Stop Here for Pedestrians sign and stop line
- Crosswalk lighting
- Crosswalk pavement marking
- Crosswalk warning signs
- Curb extension
- In-street pedestrian crossing sign
- Parking restrictions on crosswalk approach
- Pedestrian hybrid beacon
- Pedestrian refuge island
- Raised crosswalks
- Rectangular Rapid-Flashing Beacon
- 4- to 3- lane conversion

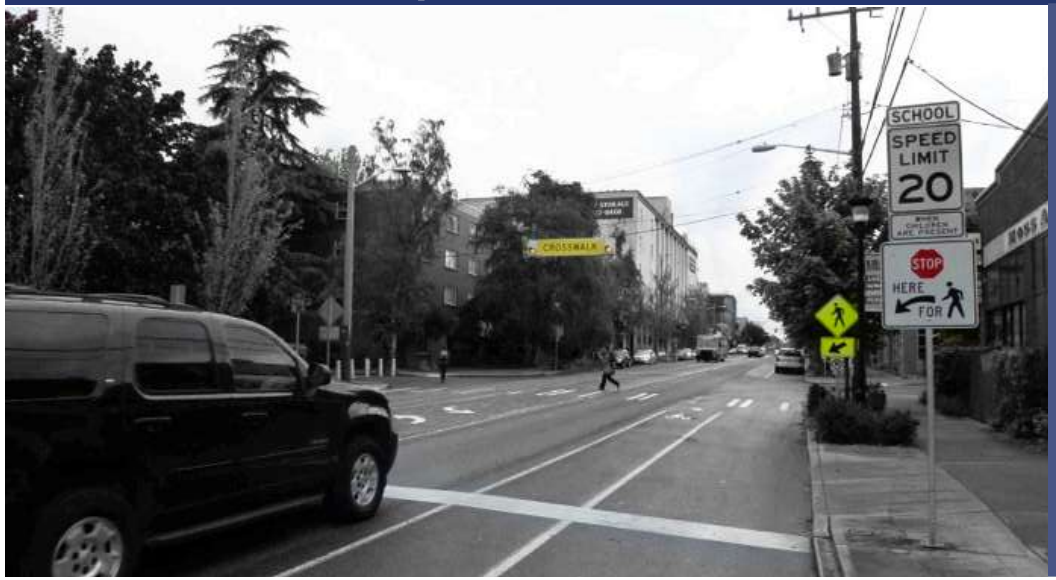
Examples are provided for various roadway segments based on the following criteria:

- Number of lanes in each direction
  - Two lanes
  - Three lanes with raised median
  - Three lanes without raised median
  - Four or more lanes with raised median
  - Four or more lanes without raised median
- Average annual daily traffic (AADT)
  - Less than 9,000
  - 9,000 to 15,000
  - Greater than 15,000
- Speed
  - Less than or equal to 30 mph
  - 35 mph
  - Greater than or equal to 40 mph

Each example lists the countermeasures that should always be considered, those that should also be considered and those that should be used only in conjunction with other countermeasures. *Note:* Treatments in the "always consider" and "also consider" categories are not mandated or required. Agencies should also review safety issues, surrounding land development, pedestrian travel patterns, countermeasure effectiveness and costs when considering appropriate countermeasures for the crossing.

This guide was developed based on guidance from the Federal Highway Administration (FHWA) and the *Pedestrian Crosswalk Policy Development Guidelines* (Report 2020RIC01), a Local Road Research Board study that aims to improve pedestrian safety at uncontrolled crosswalks. The report is available along with this quick reference guide at **lrrb.org**

Advance Stop Here for Pedestrians Sign and Stop Line



Benefits:

25% reduction in pedestrian crashes

- Reduces risk of multiple threat crash
- Reduces vehicle encroachment into crosswalk

Source: www.pedbikesafe.com / Toole Design Group

Best Locations:

- 3 or more lanes
- Speeds greater than 35 mph
- Inadequate visibility of pedestrians

Planning Level Cost (2019):

- $1,500 per location

Source: FHWA

Design Considerations:

- See also MnMUTCD Section 2B.11 and 3B.16
- Accessibility: ADA-compliant ramps

Parking Restrictions on Crosswalk Approach

Source: www.pedbikesafe.com / Peter Lagerwey

Benefit:

- Improves sightlines of pedestrians and motorists

Best Location:

- Inadequate visibility of pedestrians

Planning Level Cost (2019):

- Less than $1,000 per location

Source: FHWA

Design Considerations:

- Parking resolution may be needed from local agency
- State law prohibits parking within 20 feet of a crosswalk
- Agencies are encouraged to develop a policy on curb color use if coloring is desired

Crosswalk Lighting

Source: www.pedbikeimages.com / Brandon Whyte

Benefit:

59% reduction in pedestrian injury crashes

Best Location:

- Nighttime visibility of pedestrians is a concern

Planning Level Cost (2019):

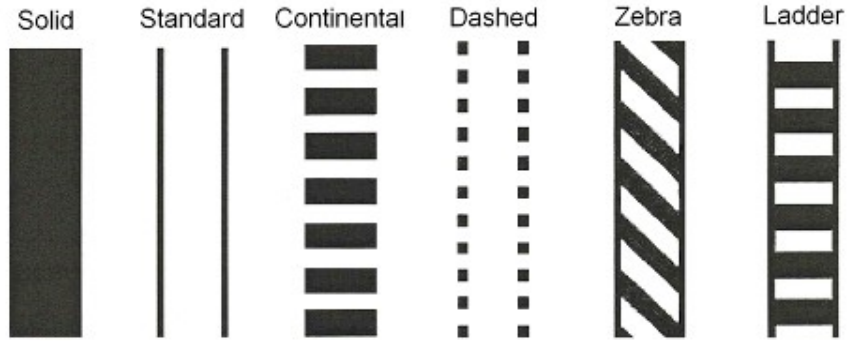
- $10,000 to 42,000 per crosswalk

Source: FHWA

Design Considerations:

- Place lights before the crossing to avoid creating a silhouette
- Use uniform lighting levels within crosswalk area

Crosswalk Pavement Marking



Benefit:

- Indicates preferred pedestrian crossing location

Best Locations:

- Convenient for pedestrian access
- Low-volume roadways
- Low-speed roadways

Planning Level Cost (2019):

- $600 to $5,700, Average $2,500

Source: FHWA

Design Considerations:

- High-visibility crosswalks preferred over parallel line crosswalks
- Accessibility: ADA-compliant ramps
- Pavement marking materials

Crosswalk Warning Signs

Source: www.pedbikeimages.com / Dan Burden

Benefit:

- Provides helpful information to motorists and pedestrians who are unfamiliar with the area

Best Location:

- Pedestrian crossing not expected by motorists

Planning Level Cost (2019):

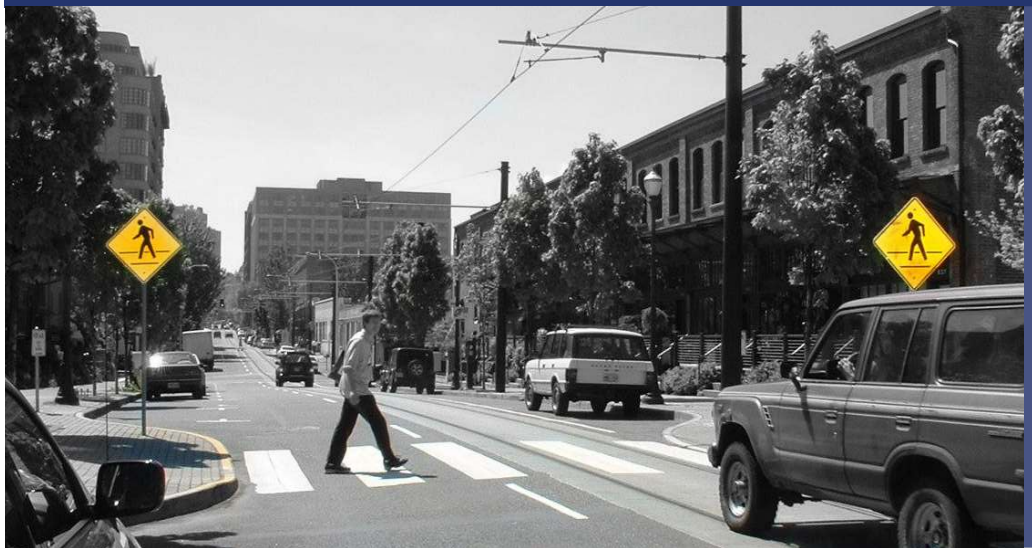
- Less than $1,000 per crossing

Source: FHWA

Design Considerations:

- Design must comply with MnMUTCD
- Signs must provide adequate retroreflectivity
- Crosswalk warning signs must fit with the location of other signs

Curb Extension



Source: www.pedbikeimages.com / Andy Hamilton

Benefits:

- Reduces pedestrian crossing distance
- Increases visibility of pedestrians to motorists
- Slows vehicle speeds at turns, increasing safety for all modes
- Can be used with unmarked crosswalk

Best Locations:

- Inadequate visibility of pedestrians
- Vehicle speeds causing problems
- On-street parking or shoulders exist

Planning Level Cost (2019):

- Range $2,000 - $20,000, Average $13,000

Source: FHWA

Design Considerations:

- Must not block bicycle lanes
- Must facilitate drainage
- Must not extend into travel lanes
- Must meet turning movement needs of larger vehicles
- Accessibility: ADA-compliant ramps

In-Street Pedestrian Crossing Sign

Source: www.pedbikeimages.com / Peter Speer

Benefits:

- Reminds road users of right of way laws
- May reduce vehicle speeds, especially if used in a gating fashion

Best Locations:

- 3 lanes or fewer
- Speeds less than 30 mph
- Drivers not yielding to pedestrians in the crosswalk
- Vehicle speeds causing problems

Planning Level Cost (2019):

- Less than $1,000 per location

Source: FHWA

Design Considerations:

- Must maintain and promptly replace damaged signs
- Become less effective over time as drivers become used to signs
- See also MnMUTCD Section 2B.12
- Must comply with AASHTO breakaway requirements if placed within roadway
- Accessibility: Signs must not be placed in middle of crosswalk

Pedestrian Hybrid Beacon (PHB)

Source: www.pedbikeimages.com / Mike Cynecki

Benefits:

55% reduction in pedestrian crashes

- Improves motorist yielding for pedestrians by 90%

Best Locations:

- AADT greater than 9,000
- 3 or more lanes
- Speeds greater than 40 mph
- Traffic signal warrants not being met
- Midblock crossings (most common); also successful at intersections
- Drivers not yielding to pedestrians in the crosswalk
- Inadequate visibility of pedestrians
- Traffic volumes not providing adequate safe gaps for pedestrians to enter the crosswalk

Design Considerations:

- Proximity of closest signalized intersection
- Cost compared to a signal
- Power source or solar power required
- Impact on traffic during operation
- Accessibility: ADA compliant ramps, push buttons and audible component

Planning Level Cost (2019):

- Range $21,000 - $128,000, Average $57,700

Source: FHWA

Pedestrian Refuge Island

Source: www.pedbikeimages.com / TooleDesign

Benefits:

32% reduction in pedestrian crashes

- Reduces pedestrian delay
- Reduces/eliminates multiple threat risk
- Reduces crossing distance
- May influence driver behavior by visually narrowing roadway
- Can be used with unmarked crosswalk

Best Locations:

- Multiple-lane roadways
- High-volume roadways
- High-speed roadways
- Inadequate visibility of pedestrians
- Vehicle speeds causing problems

Planning Level Cost (2019):

- $2,140 - $41,170, Average $13,520

Source: FHWA

Design Considerations:

- Island width: minimum of 4 feet
- Preferred island width: 8 feet
- Must facilitate drainage
- Accessibility: ADA-compliant ramps

Raised Crosswalk

Source: www.pedbikeimages.com / Penn. Dept. of Transportation

Benefit:

45% reduction in pedestrian crashes

Best Locations:

- Local and collector streets
- 2- or 3- lane roadways
- Speeds of 30 mph or less
- AADT less than 9,000
- Regional trail crossing
- Drivers not yielding to pedestrians in the crosswalk
- Vehicle speeds causing problems
- Inadequate visibility of pedestrians

Design Considerations:

- Avoid truck routes, bus transit routes, emergency routes and arterial streets
- Ensure appropriate width (typically10 feet to allow front and rear wheels of a passenger vehicle to be on the table at the same time)
- Consider snowplowing needs
- Must facilitate drainage
- Accessibility: ADA-compliant ramps

Planning Level Cost (2019):

- $7,110 - $30,880 (Average $8,170)

Source: FHWA

Rectangular Rapid-Flashing Beacon (RRFB)

Source: www.pedbikeimages.com / TooleDesign

Benefit:

47% reduction in pedestrian crashes

- Motorist yielding rates as high as 98%

Best Locations:

- Multilane roadways
- Two-lane, one-way streets
- Posted speeds less than 40 mph
- Drivers not yielding to pedestrians in the crosswalk
- Inadequate visibility of pedestrians

Planning Level Cost (2019):

- $4,500 to $52,000, Average $22,250

Source: FHWA

Design Considerations:

- Power source or solar power required
- FHWA interim approval for use; Minnesota has submitted a request for statewide approval
- Accessibility: ADA-compliant ramps, push buttons and audible components

4-to-3 Lane Conversion

Benefits:

47%* reduction in all crash types

*FHWA sites a range of 19 to 47%

- Provides opportunity for shoulder and/or bike lane
- Reduces crossing distance
- Reduces risk of multiple threat crash

Best Locations:

- Roads that have 4 or more lanes without a raised median
- AADT less than 20,000 (most successful; but can also be successful where AADT is greater than 20,000)
- Inadequate visibility of pedestrians

Planning Level Cost (2019):

- $25,000 - $40,000/mile

Source: FHWA

Design Considerations:

- Current and future vehicle operations
- Roadside stops (mail, trash, transit, etc.)
- Corridorwide considerations

2 Lanes
AADT: < 9,000
(1 lane in each direction)

	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs	• Parking restrictions on crosswalk approach • Crosswalk lighting • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon
Also Consider (Candidate Treatment)	• Raised crosswalk • Pedestrian refuge island • In-street pedestrian crossing sign • Curb extension	• Curb extension • Pedestrian refuge island • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon	• Curb extension • Pedestrian refuge island
Use Only in Conjunction With Other Countermeasures			• Crosswalk pavement marking • Crosswalk warning signs

2 Lanes
AADT: 9,000-15,000
(1 lane in each direction)

	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs	• Parking restrictions on crosswalk approach • Crosswalk lighting • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon
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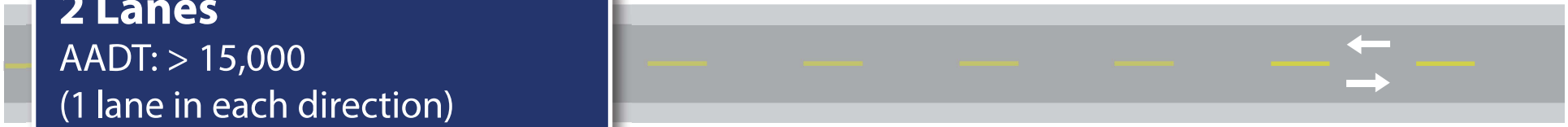
Use Only in Conjunction With Other Countermeasures			• Crosswalk pavement marking • Crosswalk warning signs

2 Lanes
AADT: > 15,000
(1 lane in each direction)



	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs	• Parking restrictions on crosswalk approach • Crosswalk lighting	• Parking restrictions on crosswalk approach • Crosswalk lighting • Pedestrian hybrid beacon
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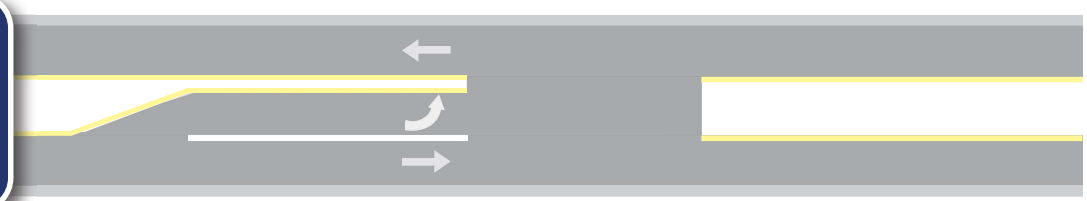
Use Only in Conjunction With Other Countermeasures		• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs

3 Lanes With Raised Median

AADT: < 9,000
(1 lane in each direction)



	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs • Advance Stop Here for Pedestrians sign and stop line	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon
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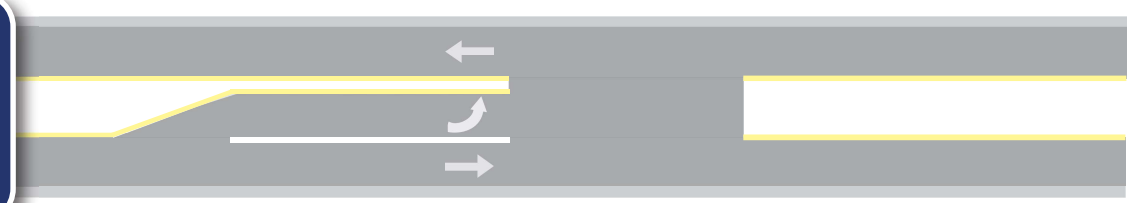
Use Only in Conjunction With Other Countermeasures			• Crosswalk pavement marking • Crosswalk warning signs

3 Lanes With Raised Median

AADT: 9,000-15,000
(1 lane in each direction)



	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon
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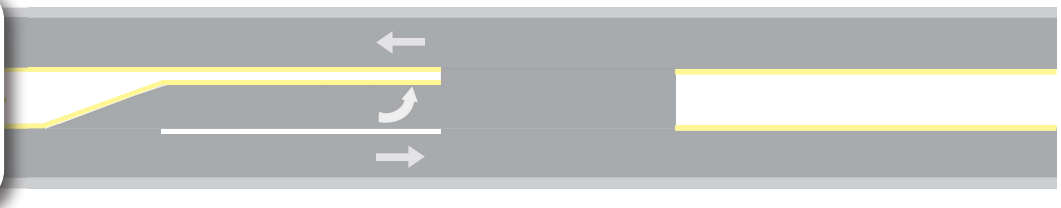
Use Only in Conjunction With Other Countermeasures	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs

3 Lanes With Raised Median

AADT: >15,000
(1 lane in each direction)



	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting	• Parking restrictions on crosswalk approach • Crosswalk lighting	• Parking restrictions on crosswalk approach • Crosswalk lighting
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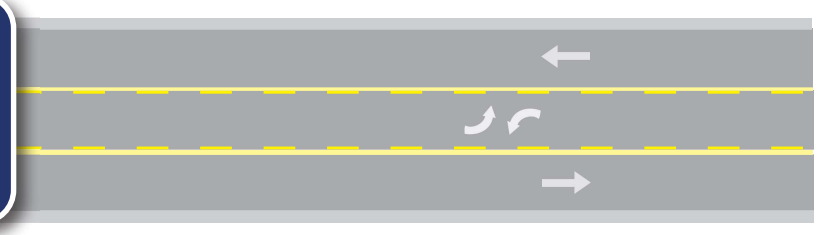
3 Lanes Without Raised Median

AADT: < 9,000

(1 lane in each direction with a two-way left-turn lane)

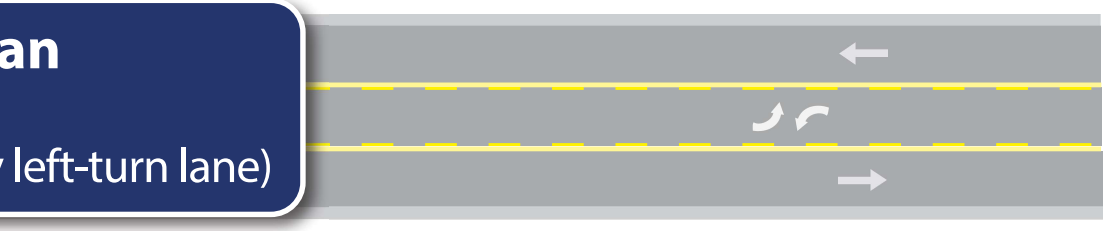


	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs • Advance Stop Here for Pedestrians sign and stop line	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian hybrid beacon
Also Consider (Candidate Treatment)	• Raised crosswalk • Advance Stop Here for Pedestrians sign and stop line • In-street pedestrian crossing sign • Curb extension • Pedestrian refuge island • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon	• Curb extension • Pedestrian refuge island • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon	• Curb extension • Pedestrian refuge island
Use Only in Conjunction With Other Countermeasures			• Crosswalk pavement marking • Crosswalk warning signs

3 Lanes Without Raised Median

AADT: 9,000-15,000

(1 lane in each direction with a two-way left-turn lane)



	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian hybrid beacon
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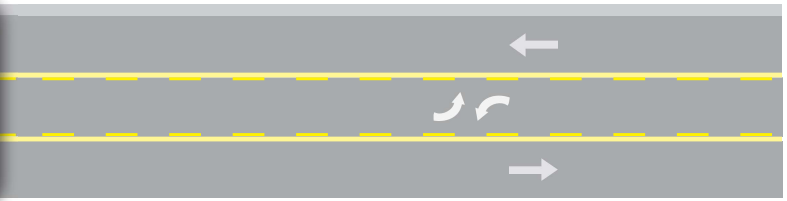
Use Only in Conjunction With Other Countermeasures	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs

3 Lanes Without Raised Median

AADT: >15,000

(1 lane in each direction with a two-way left-turn lane)

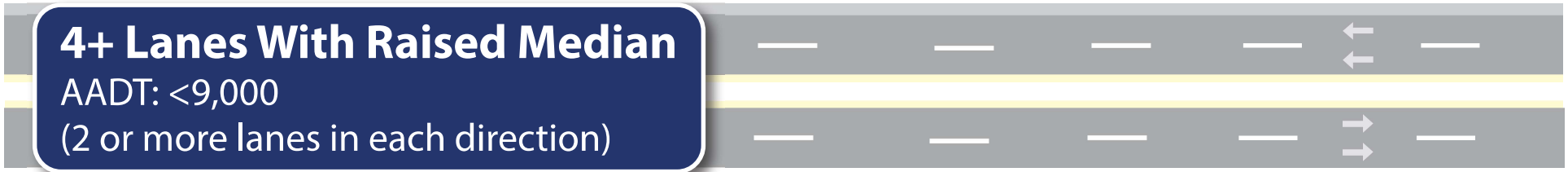


	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian hybrid beacon	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian hybrid beacon
Also Consider (Candidate Treatment)	• In-street pedestrian crossing sign • Curb extension • Pedestrian refuge island • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon	• Curb extension • Pedestrian refuge island	• Curb extension • Pedestrian refuge island
Use Only in Conjunction With Other Countermeasures	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs

4+ Lanes With Raised Median

AADT: <9,000

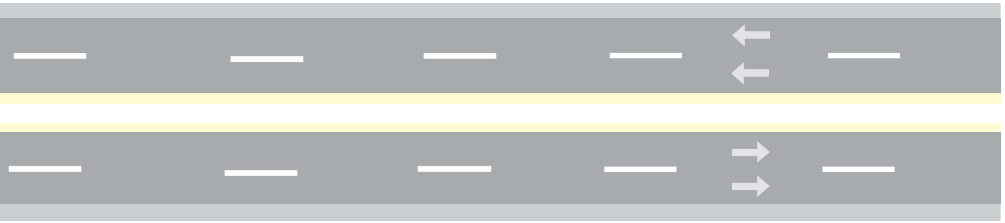
(2 or more lanes in each direction)



	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs • Advance Stop Here for Pedestrians sign and stop line	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs • Advance Stop Here for Pedestrians sign and stop line	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian hybrid beacon
Also Consider (Candidate Treatment)	• Curb extension • Rectangular Rapid-Flashing Beacon • 4-to-3 Lane Conversion • Pedestrian hybrid beacon	• Curb extension • Rectangular Rapid-Flashing Beacon • 4-to-3 Lane Conversion • Pedestrian hybrid beacon	• Curb extension • 4-to-3 Lane Conversion
Use Only in Conjunction With Other Countermeasures			• Crosswalk pavement marking • Crosswalk warning signs

4+ Lanes With Raised Median

AADT: 9,000-15,000
(2 or more lanes in each direction)



	≤30 mph	35 mph	≥40 mph
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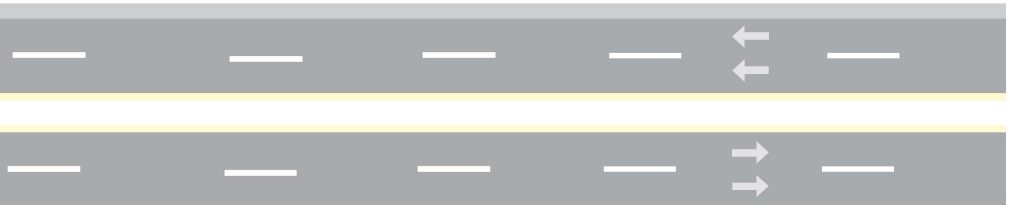
Also Consider (Candidate Treatment)	• Curb extension • Rectangular Rapid-Flashing Beacon • 4-to-3 Lane Conversion • Pedestrian hybrid beacon	• Curb extension • 4-to-3 Lane Conversion	• Curb extension • 4-to-3 Lane Conversion
Use Only in Conjunction With Other Countermeasures	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs

4+ Lanes With Raised Median

AADT: >15,000
(2 or more lanes in each direction)

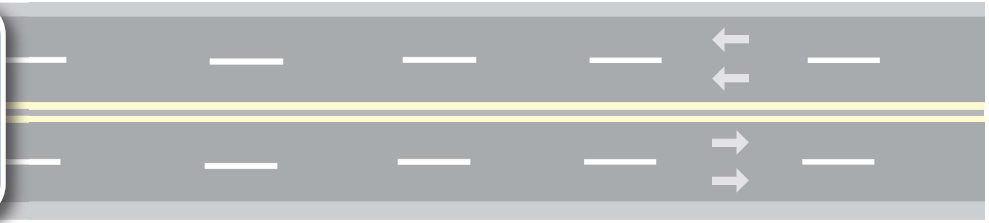


	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian hybrid beacon	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian hybrid beacon
Also Consider (Candidate Treatment)	• Curb extension • 4-to-3 Lane Conversion	• Curb extension • 4-to-3 Lane Conversion	• Curb extension • 4-to-3 Lane Conversion
Use Only in Conjunction With Other Countermeasures	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs

4+ Lanes Without Raised Median

AADT: <9,000

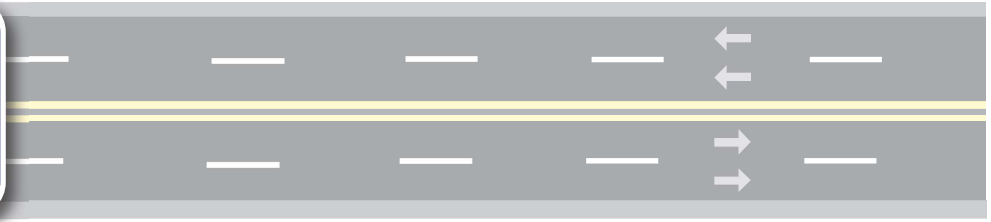
(2 or more lanes in each direction)



	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Crosswalk pavement marking • Crosswalk warning signs • Advance Stop Here for Pedestrians sign and stop line	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian refuge island	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian refuge island • Pedestrian hybrid beacon
Also Consider (Candidate Treatment)	• Curb extension • Pedestrian refuge island • Rectangular Rapid-Flashing Beacon • 4-to-3 Lane Conversion • Pedestrian hybrid beacon	• Curb extension • Rectangular Rapid-Flashing Beacon • 4-to-3 Lane Conversion • Pedestrian hybrid beacon	• Curb extension • 4-to-3 Lane Conversion
Use Only in Conjunction With Other Countermeasures		• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs

4+ Lanes Without Raised Median

AADT: 9,000-15,000
(2 or more lanes in each direction)



	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian refuge island	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Rectangular Rapid-Flashing Beacon • Pedestrian refuge island • Pedestrian hybrid beacon	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian refuge island • Pedestrian hybrid beacon
Also Consider (Candidate Treatment)	• Curb extension • Rectangular Rapid-Flashing Beacon • 4-to-3 Lane Conversion • Pedestrian hybrid beacon	• Curb extension • 4-to-3 Lane Conversion	• Curb extension • 4-to-3 Lane Conversion
Use Only in Conjunction With Other Countermeasures	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs

4+ Lanes Without Raised Median

AADT: >15,000

(2 or more lanes in each direction)

	≤30 mph	35 mph	≥40 mph
Always Consider (Candidate Treatment)	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian refuge island • Rectangular Rapid-Flashing Beacon • Pedestrian hybrid beacon	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian refuge island • Pedestrian hybrid beacon	• Parking restrictions on crosswalk approach • Crosswalk lighting • Advance Stop Here for Pedestrians sign and stop line • Pedestrian refuge island • Pedestrian hybrid beacon
Also Consider (Candidate Treatment)	• Curb extension • 4-to-3 Lane Conversion	• Curb extension • 4-to-3 Lane Conversion	• Curb extension • 4-to-3 Lane Conversion
Use Only in Conjunction With Other Countermeasures	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs	• Crosswalk pavement marking • Crosswalk warning signs

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