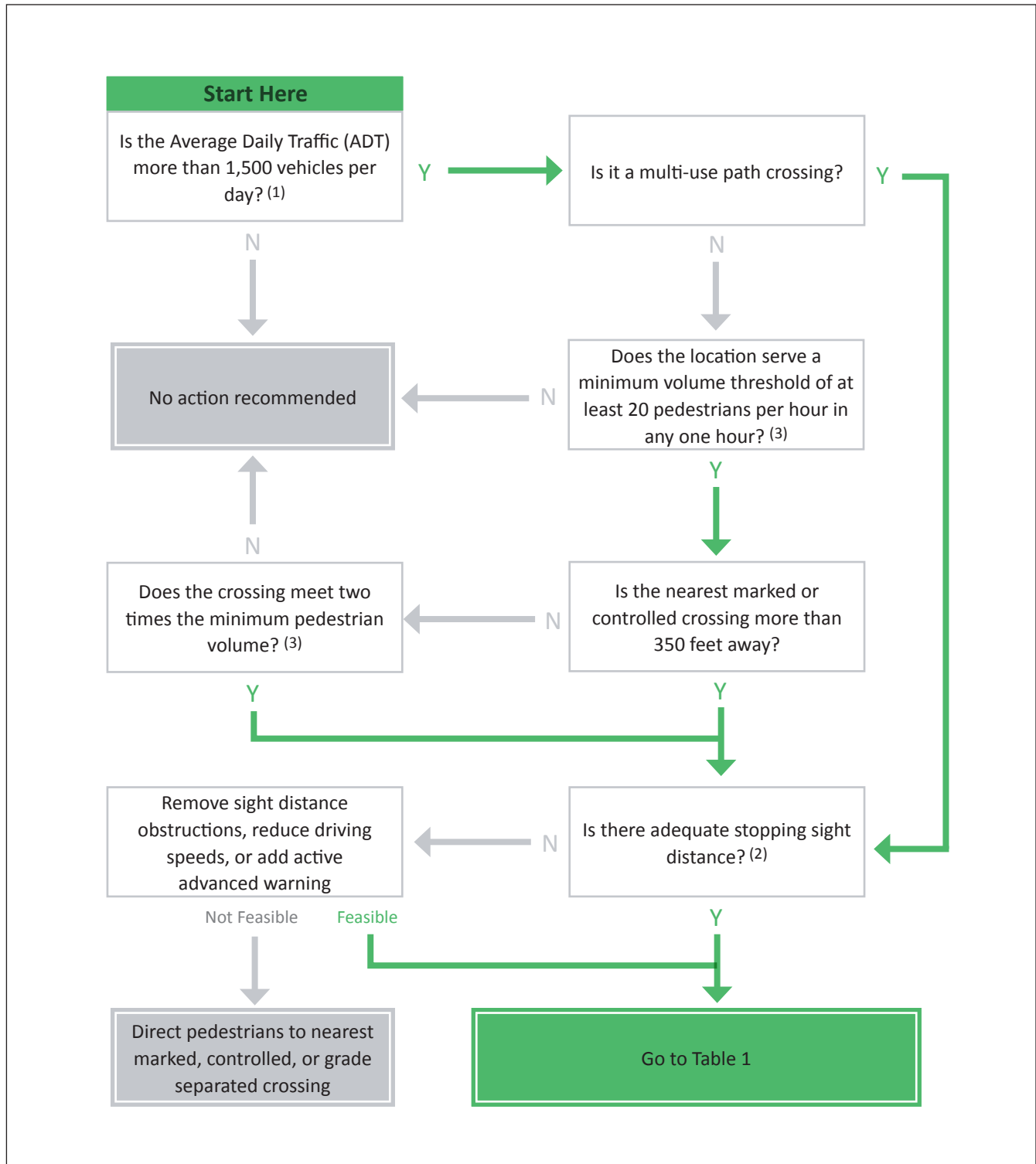


Figure 1. Pedestrian Crossing Site Evaluation Guidelines for Uncontrolled Locations



(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. Examples of regional trails in Saint Paul include Bruce Vento Regional Trail and Samuel Morgan Regional Trail.

(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	Speed Limit								
	≤30 mph			35 mph			≥40 mph		
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
2 lanes*	1 2 3 4 5 6	1 3 5 6 7	1 3 5 6 7	1 3 4 5 6	1 3 5 6 7	1 3 5 6 7	1 3 4 5 6 7	1 3 5 6 7	1 3 5 6 7
3 lanes with raised median*	1 2 3 4 5	1 3 5 7	1 3 5 7	1 3 4 5 7	1 3 5 7	1 3 5 7	1 3 4 5 7	1 3 5 7	1 3 5 7
3 lanes w/o raised median†	1 2 3 4 5 6 7	1 3 5 6 7	1 3 5 6 7	1 3 4 5 6 7	1 3 5 6 7	1 3 5 6 7	1 3 4 5 6 7	1 3 5 6 7	1 3 5 6 7
4+ lanes with raised median‡	1 3 5	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7
4+ lanes w/o raised median‡	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8

*One lane in each direction †One lane in each direction with two-way left-turn lane ‡Two or more lanes in each direction

Given the set of conditions in a cell,

- ⊕ 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 the countermeasure is a candidate treatment at a marked uncontrolled crossing location.

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 restriction on crosswalk approach, adequate nighttime lighting levels
- 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 Pedestrian Hybrid Beacon
- 8 Road Diet

This table was developed using information from: Zegeer, C. V., Stewart, J. R., Huang, H. H., Lagerwey, P. A., Feaganes, J., & Campbell, B. J. (2005), Safety effects of marked versus unmarked crosswalks at uncontrolled locations: Final report and recommended guidelines (No. FHWA-HRT-04-100); Manual on Uniform Traffic Control Devices, 2009 Edition, Chapter 4F. Pedestrian Hybrid Beacons; the Crash Modification Factors (CMF) Clearinghouse website (<http://www.cmfclearinghouse.org/>); and the Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE) website (<http://www.pedbikesafe.org/PEDSAFE/>).

CITY OF SAINT PAUL

PEDESTRIAN CROSSING SITE EVALUATION GUIDELINES FOR UNCONTROLLED CROSSINGS: BACKGROUND

May 31, 2018

This document summarizes research and best practices related to enhancing pedestrian crossings at uncontrolled intersections. These findings are the foundation for the City of Saint Paul's Draft Pedestrian Crossing Policy for Uncontrolled Intersections.

Uncontrolled Pedestrian Crossings

1. Pedestrians are among the most vulnerable of road users, accounting for approximately 16 percent of all roadway fatalities nationally, and approximately 14 percent of severe crashes in Saint Paul¹.
2. Pedestrians have the right of way at all unsignalized intersections in Minnesota, whether or not crosswalk markings are present.²

Uncontrolled crossings occur at intersections where neither a stop sign nor a traffic signal controls traffic at the street of the crossing. Enhancing these crossings with crosswalk markings and other features can serve to remind motorists of their responsibility to stop for pedestrians and reduce crossing risk for pedestrians, especially on high volume, high speed roads. When considering enhancing a pedestrian crossing at an uncontrolled location, Saint Paul staff must respond to two questions:

1. Is there sufficient justification for enhancing a crossing at a candidate location?
2. What level of enhancement is appropriate for that particular crossing location?

Evaluating Candidate Locations for Enhancing Crossings

Agencies have adopted a variety of criteria to determine whether to enhance a crossing at any given location. These criteria typically include both safety considerations (e.g. adequacy of sight distances that allow motorists to stop at the crossing) and considerations determined by community values.

¹ Blackburn, L., Zegeer, C., Brookshire, K., Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations, Report No. FHWA-SA-17-072 Federal Highway Administration, Washington, DC, September 2017; City of Saint Paul Roadway Safety Plan, January 2016

² Minnesota Statutes 169.21 Pedestrian

While choosing values criteria involves subjective judgment, applying these criteria consistently throughout the community and in accordance with publicly-adopted policies provides a foundation for equitable and cost-effective implementation. “Values-based” criteria adopted by peer agencies typically include peak hour counts of users, proximity to other crossings, or connectivity with multi-use trails.

Some agencies have adopted flowcharts and others have lists of criteria that must be met to describe their process for considering crossing treatments at a location. A summary of agency crossing policies reviewed by Saint Paul staff is provided in Appendix A.

Criteria for evaluating candidate locations

Key literature identifying guidance for reviewing candidate crossing locations is summarized below.

- As a part of the review process for pedestrian crossings, an engineering study should be used to analyze [...] gaps in traffic, approach speed, sight distances, illumination, the needs of special populations, and the distance to the nearest traffic signal.”³ (Page 60).
- FHWA-SA-17-072 Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations recommends communities review their pedestrian network and available crash data to identify high-risk locations such that priority locations may be identified through documentation and mapping of roadway characteristics and crash risks. This methodology requires a high level of data collection and analysis.

In addition to a literature review, Saint Paul staff reviewed guidance compiled for nine peer agencies. Three criteria are common to nine peer agencies:

1. Peak number of hourly pedestrians currently using the crossing
2. Proximity of other crossings
3. Determination of adequate visibility of the crossing location

Other criteria are common to other agencies, though not used consistently by all:

4. Association with a multi-use trail
5. Determination of a school crossing
6. Minimum ADT thresholds
7. Maximum crossing distances

Each of these criteria is described in greater detail below.

Pedestrian Crossing Thresholds

A minimum of 20 pedestrians per hour is the typical threshold for consideration of the installation of a crosswalk or additional treatments.

Zegeer, et al (2005) suggest the minimum utilization of 20 pedestrian crossings per peak hour: “The spacing of marked crosswalks should also be considered so that they are not placed too close together. Overuse of marked crosswalks may breed driver disrespect for them, and a more conservative use of crosswalks generally is preferred. Thus, it is recommended that in situations

³ Zegeer, C., Stewart, J., Huang, H., Lagerwey, P., Feaganes, J., Campbell, B., *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations Final Report and Recommended Guidelines*, Report No. FHWA: HRT-04-100 Federal Highway Administration, Washington, DC, September 2005.

where marked crosswalks alone are acceptable a higher priority be placed on their use at locations having a minimum of 20 pedestrian crossings per peak hour (or 15 or more elderly and/or child pedestrians per peak hour). In all cases, good engineering judgment must be applied (Page 60).”

The City of Boulder conducted data collection and observations indicating that motorist compliance at crosswalks typically increases with higher crossing volumes. City of Boulder findings indicate that below approximately 20 pedestrians per hour, motorist compliance at crosswalks decreases.⁴

Several peer agencies, including Boulder, have chosen to modify pedestrian crossing requirements to accommodate more vulnerable users, including children and the elderly. In Boulder, young, elderly, and disabled pedestrians count two times towards volume thresholds. In other words, if ten children or elderly pedestrians are counted in a crosswalk, it is marked.

The City of Saint Paul collected counts of pedestrian activity at 91 locations in 2016, at both signalized and unsignalized intersections. Within this dataset, the median number of pedestrians crossing each intersection per peak hour is 19; half the intersections had more than 19 pedestrian crossings per hour and half had less. This suggests that 20 pedestrians per hour is a reasonable threshold in Saint Paul by which to compare pedestrian activity at different intersections.

Establishing minimum pedestrian crossing thresholds for crosswalk treatments requires staff capacity to collect data counting pedestrians at candidate locations as requests are made or in advance of street alteration projects.

Proximity of other crossings

Peer agencies typically set guidance that candidate crossing locations will not be enhanced if they are 300 feet (approximately one city block) or less from another facilitated crossing. This criteria serves to limit the total number of locations where an agency invests in enhancements. While this is primarily a values-based criteria, literature suggests that “Overuse of marked crosswalks may breed driver disrespect for them, and a more conservative use of crosswalks generally is preferred” (Zegeer, et al, 2005).

Determination of adequate visibility of the crossing location

This criteria is used by all agencies and is intended to address underlying safety issues of the crossing location that may make it inherently dangerous for pedestrians to cross. A crossing's visibility can be addressed by adding lighting, restricting parking near the crossing, or removing trees or obstructions blocking pedestrians who are waiting to cross. It can also be enhanced by lowering motorist speeds on the road, which reduces the amount of space needed to slow down for the crossing. Some visibility issues, such as curves in the road or hills that obstruct motorists' views of the crossing may not be able to be addressed and jeopardize the safety of the crossing.

Association with a multi-use trail

Many agencies mark crossings of multi-use trails regardless of documented pedestrian volumes on the trails. These can serve to provide visual continuity for trail users, as an extra alert to motorists to the presence of vulnerable users, and as a way to reduce costs associated with collecting counts in areas where demand for walking can be assumed.

Determination of a school crossing

⁴ City of Boulder, Colorado, *Pedestrian Crossing Treatment Installation Guidelines*, November 2011

Many agencies make decisions about school crossings differently than at other locations. Young children may lack perceptual judgment and motor skills to cross busy roads safely without putting themselves in danger⁵. Agencies vary in how they define school crossings. Examples include crossings that are: noted on a Safe Routes to School Plan, patrolled by a school crossing guard, have ten or more student pedestrians per hour use the crossing, or designated school walking routes. In Saint Paul, most schools do not have completed Safe Routes to School plans or designated walking routes. Patrolled by a school crossing guard or use by student pedestrians are both measures that can be observed today in crosswalk marking decisions.

Minimum ADT thresholds

Crash risk on low volume streets is extremely low. In order to streamline decision-making, many agencies identify minimum ADT thresholds for streets where they will not enhance crossings. Common thresholds are 1,000-1,500 ADT. These volumes are consistent with maximum volumes for local streets, which are not designed to carry through-traffic or accommodate higher speeds.

Maximum crossing distances

The City of Portland has drafted interim design guidelines for Portland Bureau of Transportation capital projects for the desired frequency of marked pedestrian crossings in the City of Portland. These are intended to provide crossings proactively in areas where Portland policies incentivize pedestrian activity. In certain land use districts, Portland has identified a maximum desired spacing between marked pedestrian crossings of 530 feet. At transit stops, marked and/or enhanced crossings are desired regardless of street classification. A minimum of 20 pedestrians crossing per hour will not be required to justify new marked crossings in the above locations.

Treatment of Uncontrolled Crossings

After determining a crossing enhancement is justified, the next determination is the level of crosswalk treatment that is appropriate for the crossing location. A common suite of treatments has been used in communities throughout the U.S. and identified as countermeasures by the Federal Highway Administration based on safety research, best practices, and established national guidelines. These include:








































- Crosswalk markings and signage
- Advanced stop bars
- Centerline signs
- Rectangular Rapid Flashing Beacons
- Pedestrian Hybrid Beacons
- Refuge Islands
- Curb Extensions
- Raised Crossings

Treatments are intended to be applied in response to specific safety concerns that affect pedestrians' ability to cross the street at a specific location. The following table⁶ identifies the specific safety issues that each crosswalk treatment (countermeasure) best addresses:

⁵ <https://now.uiowa.edu/2017/04/why-children-struggle-cross-busy-streets-safely>

⁶ Blackburn, L., Zegeer, C., Brookshire, K., Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations, Report No. FHWA-SA-17-072 Federal Highway Administration, Washington, DC, September 2017.

Table 2. Safety issues addressed per countermeasure.

Pedestrian Crash Countermeasure for Uncontrolled Crossings	Safety Issue Addressed				
	Conflicts at crossing locations	Excessive vehicle speed	Inadequate conspicuity/visibility	Drivers not yielding to pedestrians in crosswalks	Insufficient separation from traffic
Crosswalk visibility enhancement					
High-visibility crosswalk markings*					
Parking restriction on crosswalk approach*					
Improved nighttime lighting*					
Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line*					
In-Street Pedestrian Crossing sign*					
Curb extension*					
Raised crosswalk					
Pedestrian refuge island					
Pedestrian Hybrid Beacon					
Road Diet					

*These countermeasures make up the STEP countermeasure "crosswalk visibility enhancements." Multiple countermeasures may be implemented at a location as part of crosswalk visibility enhancements.

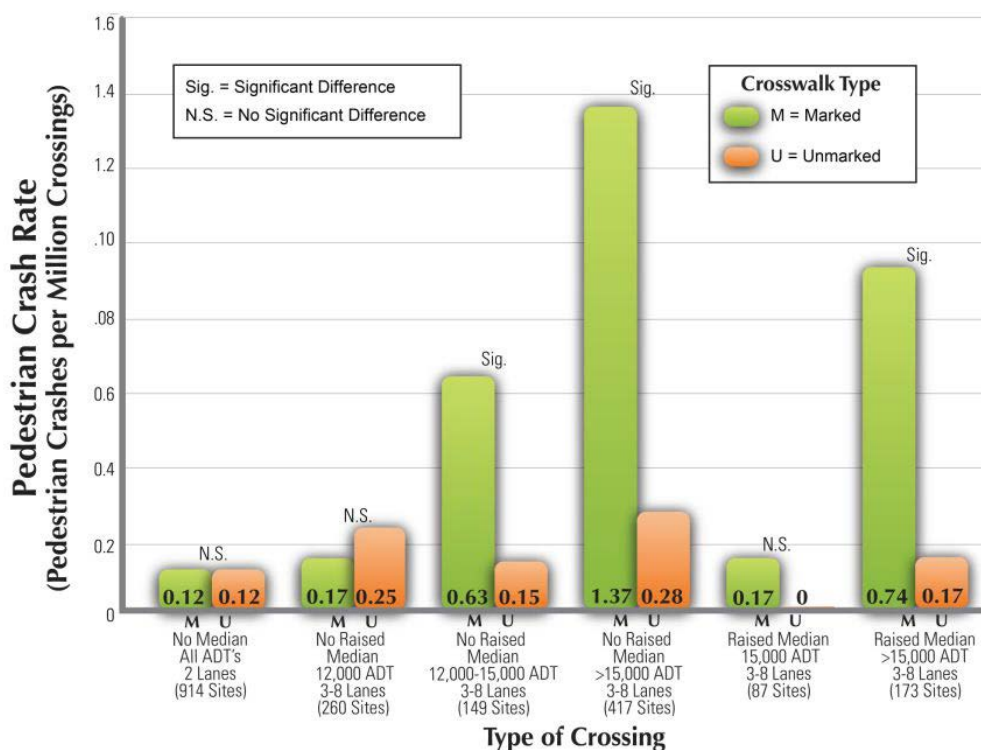
Crosswalk Markings

In 2005, Zegeer et al conducted a comprehensive study of 1,000 marked crosswalk and 1,000 unmarked crosswalks in communities around the United States⁷. The study compared pedestrian-vehicle crash rates at these locations with traffic volume, crossing distances, number of lanes, speed limit and other variable to assess the relationship between crosswalk markings and crashes. This is the most comprehensive study to date of the relationship between any type of crosswalk enhancement and crashes. Key findings from this research include:

⁷ Zegeer, C., Stewart, J., Huang, H., Lagerwey, P., Feaganes, J., Campbell, B., *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations Final Report and Recommended Guidelines*, Report No. FHWA: HRT-04-100 Federal Highway Administration, Washington, DC, September 2005.

1. The addition of marked crosswalks alone has not been found to have a positive or negative effect on pedestrian crash rates on two-lane roads and multilane roads with Average Annual Daily Traffic (AADT) below 12,000.
2. The addition of marked crosswalks alone may present an increased crash risk on multilane roads with AADT above 12,000.
3. On many roadways, particularly multilane and high-speed crossing locations, more substantial improvements are needed for safer pedestrian crossings, such as signals, raised medians, speed-reducing measures, and other best practices.

The chart below illustrates the relationship between crashes and marked crosswalks. On two-lane roads, there were 0.12 pedestrian crashes per million pedestrian crossings. The risk of a pedestrian crash on these roads is very low to begin with; adding a marked crosswalk does not significantly impact crash rates. On multi-lane roads, pedestrian crashes per million pedestrian crossings were significantly higher at marked crosswalks than at unmarked crosswalks. The researchers conclude that this indicates that greater enhancements are needed in these locations to reduce crashes.



Selecting Crosswalk Treatments

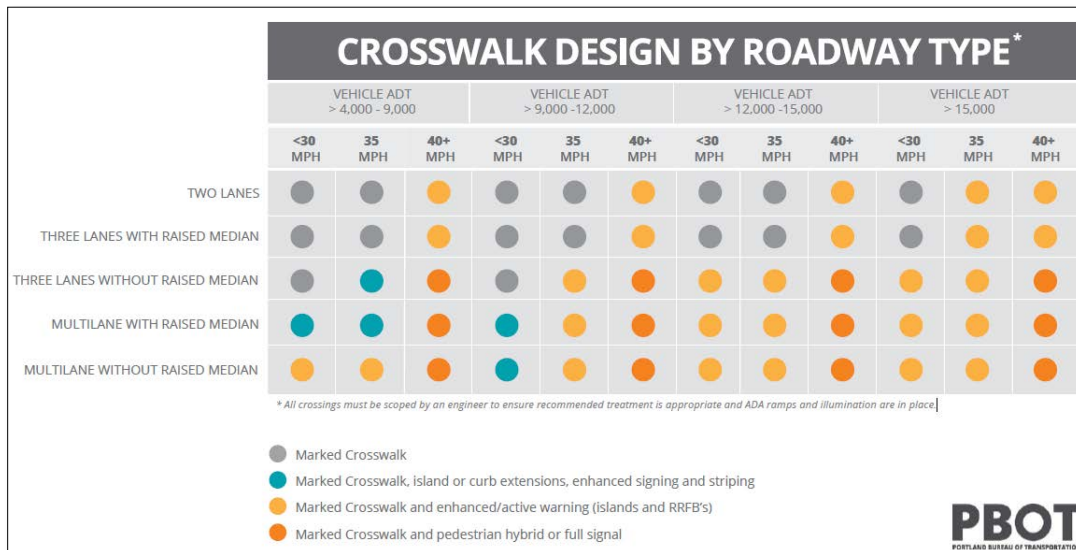
Guidance based on nation-wide research clearly attests that crosswalk markings must be paired with additional treatments in order to effectively improve safety on high volume, high speed roads. Choosing a set of crosswalk treatments for a crossing location requires agencies to select tools that adequately address the safety needs at a location in the most cost-effective way possible.

On lower volume roads, cost-effectiveness plays a role in selecting a crosswalk treatment. Because these roads have very low rates of pedestrian crashes, communities generally set guidelines to minimize levels of treatment for these roads in order to save resources for conditions with higher crash risk.

On higher volume roads, selecting a set of treatments that can meaningfully improve safety for pedestrians is critical. On these streets, doing too little may be less safe than doing nothing. The chart above illustrates that crashes per million pedestrian crossings is significantly higher at marked crosswalks than at unmarked crosswalks on similar roads. Thus, guidance is needed to determine what treatments have the most safety benefit while balancing the cost of these treatments.

Policies Reviewed

Several agencies have adopted crossing policies that include a table which identifies specific treatments based upon roadway characteristics and safety research indicating the effectiveness of treatments under certain conditions. The tables identifying treatments include similar treatments but present them with varied degrees of requirement. Some tables include language suggesting that the treatments “be considered” as well as noting conditions under which “do not install marked crosswalk” is the direction provided (MNDOT Technical Memorandum No. 15-01-T-01). Others such as Boulder are slightly more definitive stating, “install” or “do not install” treatments. The Portland Bureau of Transportation simply lists treatments without sentences or qualifiers and also states, “All crossings must be scoped by an engineer to ensure recommended treatment is appropriate and ADA ramps and illumination are in place.”



FHWA Publication Number: FHWA-SA-17-072

The 2017 FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations lists proven countermeasures to enhance crosswalk safety. The guide draws on research reports evaluating crosswalk treatments, best practices and adopted policies among state and local agencies, and discussions with key experts. The guide recommends specific pedestrian crash countermeasures by roadway feature.

Note: in a discussion with the guide’s authors in May 2018, Saint Paul staff learned that an upcoming revision will clarify the importance of implementing treatments in combination. In addition, guidelines for use of RRFBs will be added to the table. This revision is anticipated in June 2018.

Because it is the most comprehensive and current guidance available on selection of crosswalk treatments, City of Saint Paul staff recommend adopting this guidance rather than creating a table

unique to Saint Paul. Any updates made to the table by FHWA could be incorporated as Saint Paul policy by reference.

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

Roadway Configuration	Speed Limit								
	≤30 mph			35 mph			≥40 mph		
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
2 lanes*	1 2 3 4 5 6	1 3 5 6 7	1 3 5 6 7	1 3 4 5 6	1 3 5 6 7	1 3 5 6 7	1 3 4 5 6 7	1 3 5 6 7	1 3 5 6 7
3 lanes with raised median*	1 2 3 4 5	1 3 5 7	1 3 5 7	1 3 4 5 7	1 3 5 7	1 3 5 7	1 3 4 5 7	1 3 5 7	1 3 5 7
3 lanes w/o raised median†	1 2 3 4 5 6 7	1 3 5 6 7	1 3 5 6 7	1 3 4 5 6 7	1 3 5 6 7	1 3 5 6 7	1 3 4 5 6 7	1 3 5 6 7	1 3 5 6 7
4+ lanes with raised median‡	1 3 5	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7	1 3 5 7
4+ lanes w/o raised median‡	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8	1 3 5 6 7 8

*One lane in each direction †One lane in each direction with two-way left-turn lane ‡Two or more lanes in each direction

Given the set of conditions in a cell,

- Ⓝ 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 the countermeasure is a candidate treatment at a marked uncontrolled crossing location.

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 restriction on crosswalk approach, adequate nighttime lighting levels
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This table was developed using information from: Zegeer, C. V., Stewart, J. R., Huang, H. H., Lagerwey, P. A., Feaganes, J., & Campbell, B. J. (2005). Safety effects of marked versus unmarked crosswalks at uncontrolled locations: Final report and recommended guidelines (No. FHWA-HRT-04-100); Manual on Uniform Traffic Control Devices, 2009 Edition, Chapter 4F. Pedestrian Hybrid Beacons; the Crash Modification Factors (CMF) Clearinghouse website (<http://www.cmfclearinghouse.org/>); and the Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE) website (<http://www.pedbikesafe.org/PEDSAFE/>).

The guide also includes specific Crash Modification Factors (CMF) or Crash Reduction Factors (CRF) based on study data in available literature. The CMF or CRF are measures of the safety effectiveness of a particular treatment or design element based on the results of studies which compile crash and/or safety data.

Table 3. CRFs and CMFs by countermeasure.

Countermeasure	CRF	CMF	Basis	Reference
Crosswalk visibility enhancement ¹	—	—	—	—
Advance STOP/YIELD signs and markings	25%	0.75	Pedestrian crashes ²	Zegeer, et. al. 2017
Add overhead lighting	23%	0.77	Total injury crashes	Harkey, et. al. 2008
High-visibility marking ³	48%	0.52	Pedestrian crashes	Chen, et. al., 2012
High-visibility markings (school zone) ³	37%	0.63	Pedestrian crashes	Feldman, et. al. 2010
Parking restriction on crosswalk approach	30%	0.70	Pedestrian crashes	Gan, et. al., 2005
In-street Pedestrian Crossing sign	UNK	UNK	N/A	N/A
Curb extension	UNK	UNK	N/A	N/A
Raised crosswalk (speed tables)	45%	0.55	Pedestrian crashes	Elvik, et. al., 2004
	30%	0.70	Vehicle crashes	
Pedestrian refuge island	32%	0.68	Pedestrian crashes	Zegeer, et. al., 2017
PHB	55%	0.45	Pedestrian crashes	Zegeer, et. al., 2017
Road Diet – Urban area	19%	0.81	Total crashes	Pawlovich, et. al., 2006
Road Diet – Suburban area	47%	0.53	Total crashes	Persaud, et. al., 2010

¹This category of countermeasure includes treatments which may improve the visibility between the motorist and the crossing pedestrian.

²Refers to pedestrian street crossing crashes, and does not include pedestrians walking along the road crashes or “unusual” crash types.

³The effects of high-visibility pavement markings (e.g., ladder, continental crosswalk markings) in the “after” period is compared to pedestrian crashes with parallel line markings in the “before” period.