



# SAFE TRAVEL FOR EVERY PEDESTRIAN

## DECISION GUIDE AND BEST PRACTICES

### Uncontrolled Intersections and Mid-Block Crossings



**FHWA – Every Day Counts Initiative**

**South Dakota Department of Transportation**

# SAFE TRAVEL FOR EVERY PEDESTRIAN



## FHWA - EVERY DAY COUNTS INITIATIVE

### SOUTH DAKOTA DEPARTMENT OF TRANSPORTATION

#### EXECUTIVE SUMMARY

The South Dakota Department of Transportation participated in a FHWA Every Day Counts Initiative titled “Safe Travel for Every Pedestrian (STEP)”. Pedestrians account for an estimated 15 percent of all roadway fatalities, the majority of which are at uncontrolled crossing locations (such as non-intersections) or at intersections with no traffic signal or STOP sign. The STEP innovation helps transportation agencies address such crashes by promoting cost-effective countermeasures with known safety benefits.

A committee composed of people with a broad range of interests participated in the STEP initiative:

Name	Representing
Beth Davis	SD Dept. of Health
Derek Englund	SDDOT – Transportation Alternatives Program
Heath Hoftiezer	City of Sioux Falls
Patsy Horton	City of Rapid City
Sharon Johnson	FHWA
Mark Leiferman	SDDOT -Project Development
Brian Raecke	SDDOT – Road Design
Dirk Rogers	Brown County
Laurie Schultz	SDDOT- Administration
Greg Vavra	LTAP
Andrew Peterson	LTAP
Lynda Douville	Rosebud Sioux Tribe
Dustin Witt	SDDOT - Hwy Safety
Jon Suomala	SDDOT- Rapid City Region Traffic Engineer

The committee chose to target pedestrians crossing at uncontrolled locations such as mid-block crossings and intersections that do not have signals. The goal is to develop a guidance document listing best practices that can be used by city engineers and designers.

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# PEDESTRIAN CROSSINGS

## DECISION GUIDE AND BEST PRACTICES

### **INTRODUCTION:**

A pedestrian's ability to safely cross highways and streets needs to be considered by designers. Expecting pedestrians to travel significantly out of their way to cross a roadway to reach their destination is unrealistic and counterproductive to encouraging healthier transportation options.

According to the National Highway Traffic Safety Administration (NHTSA), in 2015 pedestrians accounted for approximately 15 percent of all fatalities in motor vehicle traffic crashes. The majority of these deaths occur at uncontrolled crossing locations such as mid-block or un-signalized intersections. These are among the most common locations for pedestrian fatalities generally because of inadequate pedestrian crossing facilities and insufficient or inconvenient crossing opportunities, all of which create barriers to safe, convenient, and complete pedestrian networks.

The information in this Decision Guide and Best Practices is provided as a resource to assist agencies in their effort to more safely accommodate pedestrians on their systems of roads and highways. The information in this guidance is consistent with best practices in safety planning as presented in guidance prepared by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP). This information is provided in an effort to reduce the number of severe crashes with pedestrians on their roadway systems, and it is understood that the final decision to implement any of the strategies resides with the agency. There is no expectation or requirement that agencies implement any specific safety strategies, and it is understood that actual implementation decisions will be made by agency staff based on consideration of safety, economic, social, and political issues and location-specific considerations.

Various countermeasures are discussed in this guide, and they include the following:

#### COUNTERMEASURES:

1. **Speed Limit Sign Beacon**
2. **Radar Speed Feedback Sign**
3. **Rectangular Rapid Rate Flashers Beacons (RRFB)**
4. **Choosing between RRFB and HAWKS**
5. **LED Enhanced Signs**
6. **Reduce Speed**
7. **Road Diet**
8. **Pedestrian Refuge Islands**
9. **Bump outs**
10. **Choker**
11. **Narrower Lanes**
12. **Crosswalk Visibility Enhancements**
13. **Raised Crosswalks or speed Humps**

Knowing how to determine good crossing locations and which countermeasures to use enables city engineers, highway agencies and other organizations to increase pedestrian safety. This guide is intended to assist in the decision making process of determining the best solutions for each particular location.

The type of pedestrian traffic control used, either warning or regulatory, should be related to the volume and speed of traffic, street width and number of travel lanes, existing traffic control, and number of pedestrians crossing the road. Therefore, the traffic control needed on a major road may not be needed on a residential road, and uniform standard warrants for traffic control are needed to assure the use of similar controls for similar situations. This uniform application of traffic control promotes uniform behavior on the part of the motorist and pedestrian, which in turn provides the safest practical traffic control system.

#### BENEFITS:

**Improved Safety.** Countermeasures are available that offer proven solutions for reducing pedestrian fatalities at uncontrolled crossing locations.

**Targeted Investment.** By focusing on uncontrolled locations, agencies can address a significant national pedestrian safety problem.

**Enhanced Quality of Life.** Improving crossing opportunities boosts quality of life for pedestrians of all ages and abilities.

## COUNTERMEASURES:

### 1. Speed Limit Sign Beacon



Figure 1 – School Speed Limit Sign Beacon installed near Washington High School on North Sycamore Avenue in Sioux Falls, SD

**Definition:** A Speed Limit Sign Beacon is composed of two circular yellow lens sections, each having a visible diameter of not less than six inches; or alternately, one or more circular yellow lenses, each having a visible diameter of not less than eight inches.

The yellow lens color shall be in accordance with the requirements of the Standard for Adjustable Face Vehicle Traffic Control Signal Heads, Revised 1977.

Where two lens sections are used, they may be vertically or horizontally aligned and they shall be alternately flashed.

Speed Limit Sign Beacons shall be flashed at a rate of not less than 50 nor more than 60 times per minute. The illuminated period of each flash shall be not less than one-half and not more than two-thirds of the total cycle. The lenses of a Speed Limit Beacon when used with a School Speed Limit Sign may be positioned within the face of the sign.

All flashing contacts should be equipped with a filter for suppression of radio interference.

When illuminated, the Speed Limit Sign Beacon shall be clearly visible to all drivers it faces for a distance of at least a quarter of a mile, under normal atmospheric conditions, unless otherwise physical obstructed. A typical installation of a Speed Limit Sign Beacon is shown in Figure 1.

**Intended uses:** A Speed Limit Sign Beacon is intended for use with a fixed or variable speed limit sign, to indicate that the speed limit shown is in effect.

Typical applications of Sign Beacons include the following:

- A. At obstructions in or immediately adjacent to the roadway;
- B. As supplemental emphasis to warning signs;
- C. As emphasis for midblock crosswalks;
- D. As supplemental emphasis to regulatory signs, except STOP, DO NOT ENTER, WRONG WAY, and SPEED LIMIT signs; and
- E. In conjunction with a regulatory or warning sign that includes the phrase WHEN FLASHING in its legend to indicate that the regulation is in effect or that the condition is present only at certain times.

Sign Beacons should be operated only during those periods or times when the condition or regulation exists.

Sign Beacons that are actuated by pedestrians, bicyclists, or other road users may be used as appropriate to provide additional warning to vehicles approaching a crossing or other location.

## 2. Radar Speed Feedback Sign

**Definition:** Radar speed feedback signs (RSFS) are installed to provide a real-time dynamic display of a driver's vehicular speed at a particular location where speeding has been documented to be a problem. When used in conjunction with a regulatory speed limit sign (R2-1), drivers receive immediate confirmation of their actual speed in comparison to the legal speed limit static signs. When the RSFS are activated, the display format shall not include animation, rapid flashing, or other dynamic elements as stated in Section 2L.04 Changeable Message Signs of the Manual on Uniform Traffic Control Devices (MUTCD). A typical installation of a Radar Speed Feedback Sign is shown in Figure 2 below.



Figure 2 – RSFS installed in Sioux Falls, SD



Figure 3 – Close up of typical School Zone RSFS

RSFS are typically used at locations where a speed limit transition occurs or in an area where driving the appropriate speed for the highway conditions is particularly critical, such as around school speed zones, or as drivers enter lower speed zones in municipalities. Because law enforcement agencies cannot be expected to constantly monitor speeds in a particular location, the RSFS serve to supplement regular enforcement of speed limits alerting drivers to specific driving behavior.

RSFS are allowed under, and guidance is provided for their use in, Part 2 of the MUTCD. When installed in association with school speed zones, the RSFS shall operate only when the school speed zone is in effect.

For school locations, the RSFS should operate only on days that schools are in session, for thirty minutes before and fifteen minutes after the time in which the school day begins; and fifteen minutes before and thirty minutes after the time in which the school day ends.

A Speed Limit Sign Beacon may be installed along the streets and highways in addition to the School Speed Limit Sign providing four (4) or more of the following warrants are met:

- 1) The speed limit on the street or highway in question when school is not in session is 30 miles per hour or more.
- 2) There are at least 20 pedestrians during the highest crossing hour regardless of gaps; or there are at least 10 pedestrians during the highest crossing hour and there are less than 60 adequate gaps in traffic during that period.
- 3) During the period of time that the school speed limit of 15 miles per hour is in effect, 15 percent or more of the vehicles are exceeding 25 miles per hour and adequate trial of enforcement has failed to reduce this number to less than 15 percent.
- 4) The volume of traffic is 250 vehicles per hour or greater during normal school hours on the street under consideration.
- 5) The traffic utilizing the street or highway is comprised of 10 percent or more trucks and commercial vehicles. Truck and commercial vehicles shall be defined as any vehicle with six or more wheels on the ground or which exceeds 10,000lbs GVW.
- 6) If the preceding criteria should not exist to the extent otherwise required, the Engineer at his/her discretion may determine that other conditions exist which may satisfy one warrant. Factors that should be considered include: automobile, bicycle and pedestrian volumes, vehicular speeds, crossing distances, the presence of a median or not, potential impact to corridor signal progression, proximity to signalized intersection, and vehicle queue formation.

A school speed limit shall not be used at any school crossing controlled by Stop signs, Yield signs, or traffic control signals unless an engineering study indicates a special need. School Speed Limit Sign Beacons shall not be installed where a traffic signal exists within a school speed zone of 250 feet or less in length.

For added visibility, a second School Speed Limit Sign Beacon may also be located on the left side of the approaching roadway. For even more emphasis, the School Speed Limit Sign Beacon sign may be mounted overhead over the approximate center of the approach.



### 3. Rectangular Rapid Flash Beacons

**Definition:** Rectangular rapid flash beacons (RRFBs) are user-actuated amber LEDs that use an irregular flash pattern that is similar to emergency flashers on police vehicles to supplement warning signs at unsignalized intersections or mid-block crosswalks. RRFBs are a lower cost alternative to traffic control signals and have been shown to significantly increase driver yielding behavior at crosswalks when supplementing standard pedestrian and school crossing warning signs and markings. The RRFBs are typically activated by manual pedestrian pushbuttons.

An RRFB shall consist of two rapidly and alternately flashed rectangular yellow indications having LED-array based pulsing light sources, and shall be designed, located, and operated in accordance with the detailed requirements specified below.



Figure 4 Rapid Rate Flasher Beacon

In July 2008 the Federal Highway Administration gave interim approval to the use of rectangular rapid flash beacons (RRFBs) for optional use in limited circumstances. The interim approval allows for usage as a warning beacon to supplement standard signs and markings at designated pedestrian or school crossings where the crosswalk approach is not controlled by a yield sign, stop sign, traffic-control signal, or at a crosswalk at a roundabout. RRFBs may be installed on 2-lane or multi-lane roadways.

The use of RRFBs is optional. However, if an agency opts to use an RRFB, the following design and operational requirements shall apply, and shall take precedence over any conflicting provisions of the MUTCD for the approach on which RRFBs are used.

- An RRFB shall only be installed to function as a Warning Beacon (see 2009 MUTCD Section 4L.03).
- An RRFB shall only be used to supplement a Pedestrian Crossing Sign Assembly or School Crossing Sign Assembly located at or immediately adjacent to a marked crosswalk.
- An RRFB shall not be used for crosswalks across approaches controlled by YIELD signs, STOP signs, or traffic control signals. This prohibition is not applicable to a crosswalk across the approach to and/or egress from a roundabout.

In the event sight distance approaching the crosswalk at which RRFBs are used is less than deemed necessary by the engineer, an additional RRFB may be installed on that approach in advance of the crosswalk, as a Warning Beacon to supplement the Advance Pedestrian Warning sign or Advance

School Warning sign. This additional RRFB shall be supplemental to and not a replacement for RRFBs at the crosswalk itself.

For any approach on which RRFBs are used, two Pedestrian Crossing Sign Assemblies or School Crossing Sign Assemblies (each with an RRFB) shall be installed at the crosswalk, one on the right-hand side of the roadway and one on the left-hand side of the roadway. On a divided highway, the left-hand side assembly should be installed on the median, if practical, rather than on the far left side of the highway.

Each RRFB shall consist of two rectangular-shaped yellow indications, each with an LED-array based light source. Each RRFB indication shall be a minimum of approximately 5 inches wide by approximately 2 inches high.

The two RRFB indications shall be aligned horizontally, with the longer dimension horizontal and with a minimum space between the two indications of approximately 7 inches, measured from inside edge of one indication to inside edge of the other indication.

The outside edges of the RRFB indications, including any housings, shall not project beyond the outside edges of the crossing assembly signs.

As a specific exception to 2009 MUTCD Section 4L.01 guidance, the RRFB shall be located between the bottom of the crossing warning sign and the top of the supplemental downward diagonal arrow plaque (or, in the case of a supplemental advance sign, the AHEAD plaque), rather than 12 inches above or below the sign assembly.

When activated, the two yellow indications in each RRFB shall flash in a rapidly alternating “wig-wag” flashing sequence (left light on, then right light on).

As a specific exception to 2009 MUTCD Section 4L.01 requirements for the flash rate of beacons, RRFBs shall use a much faster flash rate. Each of the two yellow indications of an RRFB shall have 70 to 80 periods of flashing per minute and shall have alternating, but approximately equal, periods of flashing light emissions and dark operation. During each of its 70 to 80 flashing periods per minute, the yellow indications on the left side of the RRFB shall emit two slow pulses of light after which the yellow indications on the right side of the RRFB shall emit four rapid pulses of light followed by a long pulse.

The flash rate of each individual yellow indication, as applied over the full on-off sequence of a flashing period of the indication, shall not be between 5 and 30 flashes per second, to avoid frequencies that might cause seizures.

The light intensity of the yellow indications shall meet the minimum specifications of Society of Automotive Engineers (SAE) standard J595 (Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles) dated January 2005.

The RRFB shall be normally dark, shall initiate operation only upon pedestrian actuation, and shall cease operation at a predetermined time after the pedestrian actuation.

All RRFBs associated with a given crosswalk (including those with an advance crossing sign, if used) shall, when activated, simultaneously commence operation of their alternating rapid flashing indications and shall cease operation simultaneously.

Pedestrian pushbuttons shall be used to actuate the RRFBs, and a pedestrian instruction sign with the legend PUSH BUTTON TO TURN ON WARNING LIGHTS should be mounted adjacent to or integral with each pedestrian pushbutton.

The duration of operation of the RRFBs following each actuation should be determined by the following equation:

$$T = W/S + 7$$

Where: T = Time the RRFBs flash, in seconds

W = Width of roadway, from curb to curb, in feet

S = Assumed walking speed in feet/second (use 3.5 for students and 4.0 for normal pedestrian traffic)

7 = Pedestrian start-up time in seconds (allows time for drivers to see and react to the RRFBs and for the pedestrian to recognize that traffic has yielded appropriately before starting to cross)

RRFBs may be used to enhance a Designated School Crossing when there are a minimum of 20 pedestrians crossing during the highest crossing hour and engineering judgment determines that extra emphasis is needed to increase drivers' requirement to yield to pedestrians in the crossing.

Rectangular rapid flash beacons should not be installed at locations where the distance to the nearest traffic control signal along the major road is less than 300 feet. If elementary school children use the crossing equipped with RRFBs an adult crossing guard shall be provided to assist and instruct the students in the proper use of the beacons and selection of safe gaps in which to cross. If junior high students use the signal an adult crossing guard should be provided.

#### **4. Choosing Between a Pedestrian Traffic Signal, HAWK Beacon, or RRFBs**

Pedestrian traffic signals may be considered for application at high volume pedestrian crossings based on engineering judgment. The MUTCD contains warranting procedures for conventional pedestrian traffic signals based on automobile and vehicle traffic volumes to help determine if a pedestrian signal is appropriate. These signals are typically considered when there are over 130 pedestrians an hour crossing a roadway.

Hybrid Beacons (HAWK beacons) may also be considered and the MUTCD contains warranting guidelines that utilize automobile traffic, pedestrian traffic, automobile speeds, and pedestrian crossing distance. HAWK beacons may be installed where the crossing volume is as low as 20 pedestrians per hour, depending on the crossing distance, automobile traffic volume, and engineering judgment.



Figure 5 – Typical HAWK Installation



Figure 6 – Pedestrian crossing signal at John Harris Elementary School on E 49<sup>th</sup> Street in Sioux Falls, SD

RRFBs have been successfully used to increase motorist yielding to pedestrians at unsignalized crossings, typically where there are two travel lanes in each direction. A minimum crossing volume of 20 pedestrians per hour is typically required. However, there may be cases where the combination of high pedestrian and traffic volumes may make application of RRFBs inappropriate. Figure 7 and Figure 8 illustrate recommendations for the use of RRFBs, and LED Enhanced Signs overlain on the MUTCD Hawk beacon and Pedestrian Traffic Signal warrant guidelines. The recommendations are based on safety and operational evaluations performed over the years at high volume RRFB locations.

In many cases, either HAWK beacons, RRFBs, or LED Enhanced Signs could be considered for application, and the final decision should be based on engineering judgment. Factors that should be considered include: automobile, bicycle and pedestrian volumes, vehicular speeds, crossing distances, the presence of a median or not, potential impact to corridor signal progression, proximity to signalized intersection, and vehicle queue formation.

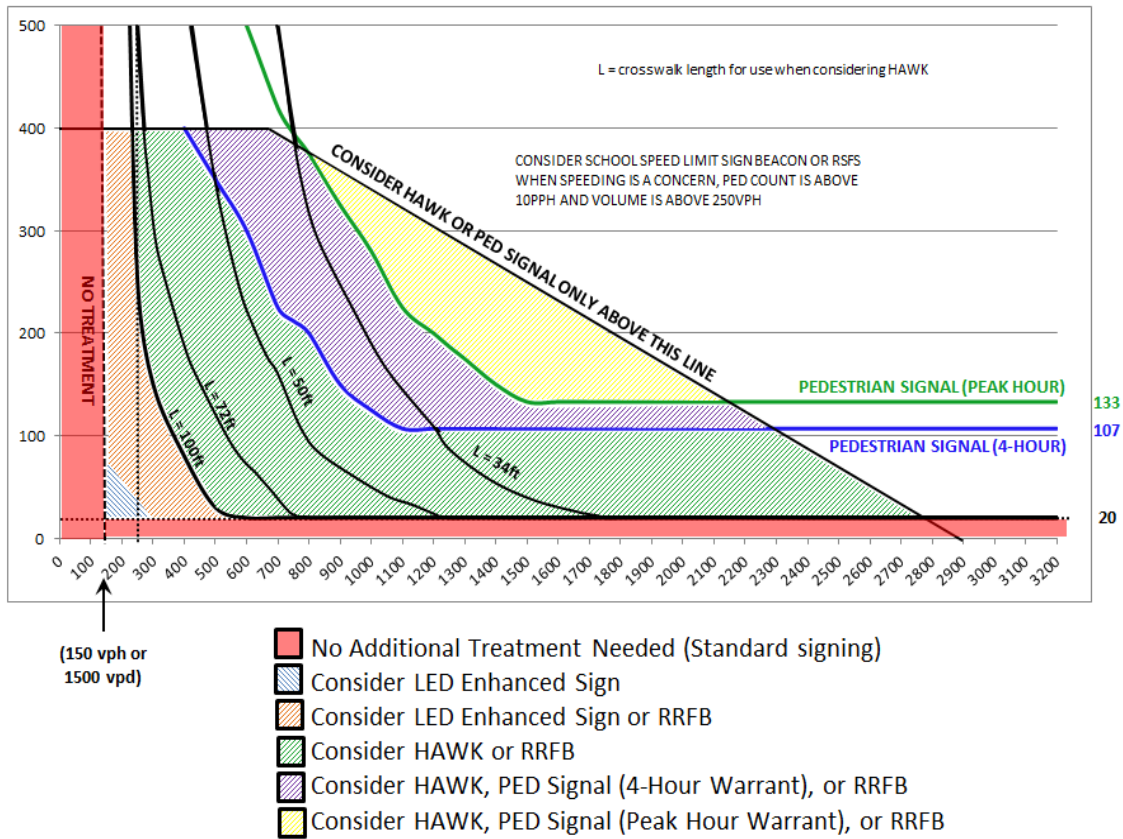


Figure 7 –Guidelines for the Installation of Pedestrian Hybrid (HAWK) Beacons, Pedestrian Signals, Rectangular Rapid Flash Beacon (RRFB), or LED Enhanced Signs on Low-Speed Roadways (35MPH or Less)

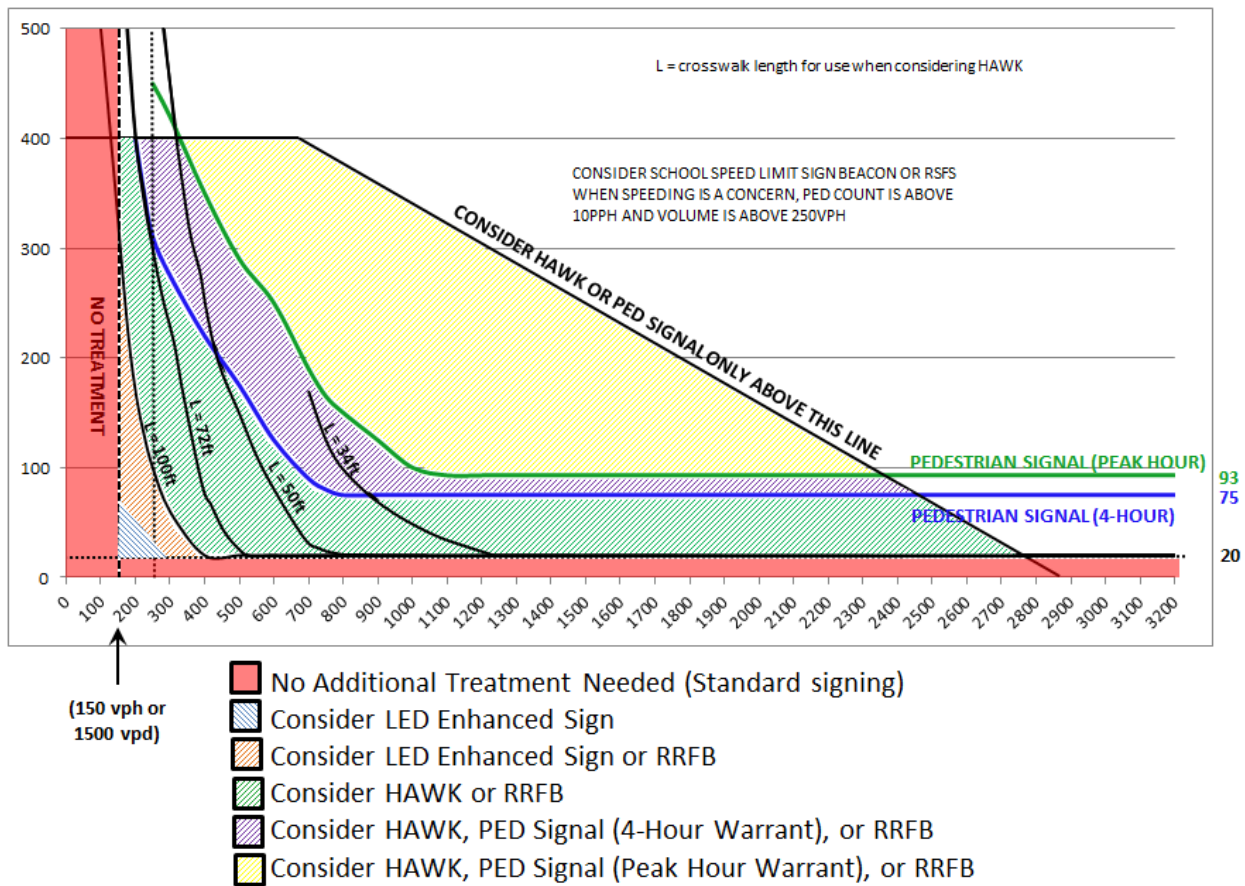


Figure 8 –Guidelines for the Installation of Pedestrian Hybrid (HAWK) Beacons, Pedestrian Signals, Rectangular Rapid Flash Beacon (RRFB), or LED Enhanced Signs on Low-Speed Roadways (Above 35MPH)

## 5. Light-Emitting Diode (LED) Enhanced Signs

### Definition:

LEDs can be embedded in standard highway warning and regulatory signs to outline either the sign itself or the words and symbols on the sign. The LEDs may be set to flash or operate in steady mode. LEDs may be illuminated 24 hours a day, or be activated by vehicles or pedestrians. Due to the low power requirements of LEDs, signs with embedded LEDs can typically be powered using stand-alone solar panel units.

LED Enhanced Signs provide another, cost effective option for improving safety at intersections by increasing driver awareness.

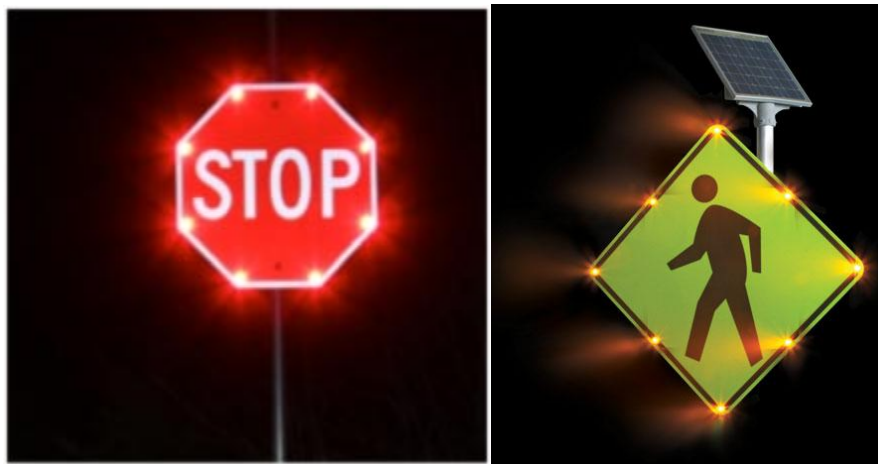


Figure 9 LED Enhanced Signs

Day or night LED enhanced signs have been shown to significantly improve driver response times in locations such as crosswalks, school zones, parks, playgrounds, shopping malls, and hospitals. Diamond-grade reflective sheeting maximizes reflective brightness providing visibility up to 200 yards away.

This treatment is applicable for regulatory and warning signs at unsignalized intersections with the intended purpose of improving the visual conspicuity of the signs. Typical locations where LED-embedded signs can be implemented include:

- Locations with sight visibility limitations (horizontal curves, dusk/dawn glare, etc.);
- Locations with documented problems of drivers failing to recognize an intersection; and
- At STOP signs – this treatment may help to increase the rate of vehicles stopping and to avoid drivers failing to detect the STOP sign.

In general, embedded LED units are used to:

- Improve driver compliance with regulatory signs through improved conspicuity; and
- Enhance visibility and recognition of regulatory and warning signs to drivers, especially under low-light or low-visibility conditions.

A study on safety effects of LEDs embedded in STOP signs, conducted by the Texas Transportation Institute in 2004, found:

- A 28.9 percent reduction in the number of vehicles not fully stopping; and
- A 52.9 percent reduction in the number of vehicles moving through the intersection without significantly slowing.

A similar study, conducted by the Virginia Transportation Research Council in 2007, found:

- A statistically significant decrease in vehicle approach speeds ranging from 1.9 to 3.4 miles per hour (mph) with an average of 2.7 mph (a 7 percent decrease) indicated that LED STOP signs positively affected driver behavior.
- Speed decreases tended to be greater during the night than during the day. *E. D. Arnold, Jr., and K. E. Lantz, Jr., "Evaluation of Best Practices in Traffic Operations and Safety: Phase 1: Flashing LED Stop Signs and Optical Speed Bars."*

Manual on Uniform Traffic Control Devices (MUTCD) Specifications

- If used, the LEDs shall be the same color as the sign legend, border, or background. If flashed, all LED units on an installation shall flash simultaneously at a rate of more than 50 and less than 60 times per minute. The uniformity of the sign shall be maintained without any decrease in visibility, legibility, or driver comprehension during either daytime or nighttime conditions. *MUTCD, Section 2A.08.*
- MUTCD, Section 2A.08 contains further information that should be consulted when installing a sign with embedded LEDs.
- Lighting elements for illuminated signs (e.g. LED-embedded signs) should be replaced on a regular maintenance schedule. *MUTCD, Section 2A.22.*

This treatment is applicable for regulatory and warning signs at unsignalized intersections with the intended purpose of improving the visual conspicuity of the signs.

MUTCD Requirements Applicable to LED Signs:

*Section 2A.07 Retroreflectivity and Illumination*

*Support:*

*01 There are many materials currently available for retroreflection and various methods currently available for the illumination of signs and object markers. New materials and methods continue to emerge. New materials and methods can be used as long as the signs and object markers meet the standard requirements for color, both by day and by night.*



Standard:

02 Regulatory, warning, and guide signs and object markers shall be retroreflective (see Section 2A.08) or illuminated to show the same shape and similar color by both day and night, unless otherwise provided in the text discussion in this Manual for a particular sign or group of signs.

03 The requirements for sign illumination shall not be considered to be satisfied by street or highway lighting.

Option:

04 Sign elements may be illuminated by the means shown in Table 2A-1.

**Table 2A-1. Illumination of Sign Elements**

Means of Illumination	Sign Element To Be Illuminated
Light behind the sign face	<ul style="list-style-type: none"> <li>■ Symbol or word message</li> <li>■ Background</li> <li>■ Symbol, word message, and background (through a translucent material)</li> </ul>
Attached or independently mounted light source designed to direct essentially uniform illumination onto the sign face	<ul style="list-style-type: none"> <li>■ Entire sign face</li> </ul>
Light emitting diodes (LEDs)	<ul style="list-style-type: none"> <li>■ Symbol or word message</li> <li>■ Portions of the sign border</li> </ul>
Other devices, or treatments that highlight the sign shape, color, or message:  Luminous tubing Fiber optics Incandescent light bulbs Luminescent panels	<ul style="list-style-type: none"> <li>■ Symbol or word message</li> <li>■ Entire sign face</li> </ul>

05 Retroreflection of sign elements may be accomplished by the means shown in Table 2A-2.

**Table 2A-2. Retroreflection of Sign Elements**

Means of Retroreflection	Sign Element
Reflector "buttons" or similar units	Symbol Word message Border
A material that has a smooth, sealed outer surface over a microstructure that reflects light	Symbol Word message Border Background

06 Light Emitting Diode (LED) units may be used individually within the legend or symbol of a sign and in the border of a sign, except for changeable message signs, to improve the conspicuity, increase the legibility of sign legends and borders, or provide a changeable message.

Standard:

07 Except as provided in Paragraphs 11 and 12, neither individual LEDs nor groups of LEDs shall be placed within the background area of a sign.

08 If used, the LEDs shall have a maximum diameter of 1/4 inch and shall be the following colors based on the type of sign:

- A. White or red, if used with STOP or YIELD signs.
- B. White, if used with regulatory signs other than STOP or YIELD signs.
- C. White or yellow, if used with warning signs.
- D. White, if used with guide signs.
- E. White, yellow, or orange, if used with temporary traffic control signs.
- F. White or yellow, if used with school area signs.

09 If flashed, all LED units shall flash simultaneously at a rate of more than 50 and less than 60 times per minute.

10 The uniformity of the sign design shall be maintained without any decrease in visibility, legibility, or driver comprehension during either daytime or nighttime conditions.

Option:

11 For STOP and YIELD signs, LEDs may be placed within the border or within one border width within the background of the sign.

12 For STOP/SLOW paddles (see Section 6E.03) used by flaggers and the STOP paddles (see Section 7D.05) used by adult crossing guards, individual LEDs or groups of LEDs may be used.

Support:

13 Other methods of enhancing the conspicuity of standard signs are described in Section 2A.15.

14 Information regarding the use of retroreflective material on the sign support is contained in Section 2A.21.



Figure 10 – Example of LED Enhanced signs (School Crossing Sign and Stop Paddle)

## 6. Reduce Speed

Speeding is a contributing factor in almost one-third of all fatal crashes in the United States.

Vehicle speed is a significant determinant of crash severity, especially between a vehicle and a pedestrian. The operating speed along a street must reflect not on the roadway, but on the context. Reducing vehicle speeds opens up a range of design options that allows a street to resemble less a speedway and more a neighborhood street.



Figure 11 Reduce speed ahead sign

A low speed street looks and feels different than a high-speed street, whether traveling along, crossing, living or doing business on it. With lower speeds, design options increase as the need to protect all users from the unintended consequences of higher speeds lessens. While faster speeds can reduce travel time for motorists, the vulnerability of other users is increased.

Simply posting a lower speed limit is usually not effective. A variety of operational and geometric elements can be used to control speeds, such as:

- Signals synchronized to target speed
- Narrower lanes
- Roadways physically narrowed through bicycle facilities, on-street parking, raised medians/islands, curb extensions
- Traffic calming devices – speed bumps, mini-roundabouts
- Limited sight distance such as buildings on the corner
- Terminating vistas, such as at a T intersection or at a traffic circle. When drivers cannot see to the horizon, they tend to drive slower.
- Rhythms created with trees, poles, landscaping and crosswalks

As speeds increase, there is more kinetic energy, which means more energy to be dissipated for pedestrians, who have an 85% chance of being killed by a vehicle traveling at 40 mph, but only a 5% chance of being killed at 20 mph.

As speeds increase, our brains process less of what is seen in our peripheral vision. This is most problematic on wider streets with activity (parking, cycling, children present,) on the side of the roadway.

## 7. Road Diet

### Definition:

A roadway reconfiguration known as a Road Diet offers several high-value improvements at a low cost when applied to traditional four-lane undivided highways. In addition to low cost, the primary benefits of a Road Diet include enhanced safety, mobility and access for all road users and a "complete streets" environment to accommodate a variety of transportation modes.

A classic Road Diet converts an existing four-lane undivided roadway segment to a three-lane segment consisting of two through lanes and a center two-way left turn lane (TWLTL). A Road Diet improves safety by including a protected left-turn lane for mid-block left-turning motorists, reducing crossing distance for pedestrians, and reducing travel speeds that decrease crash severity. Additionally, the Road Diet provides an opportunity to allocate excess roadway width to other purposes, including bicycle lanes, on-street parking, or transit stops.

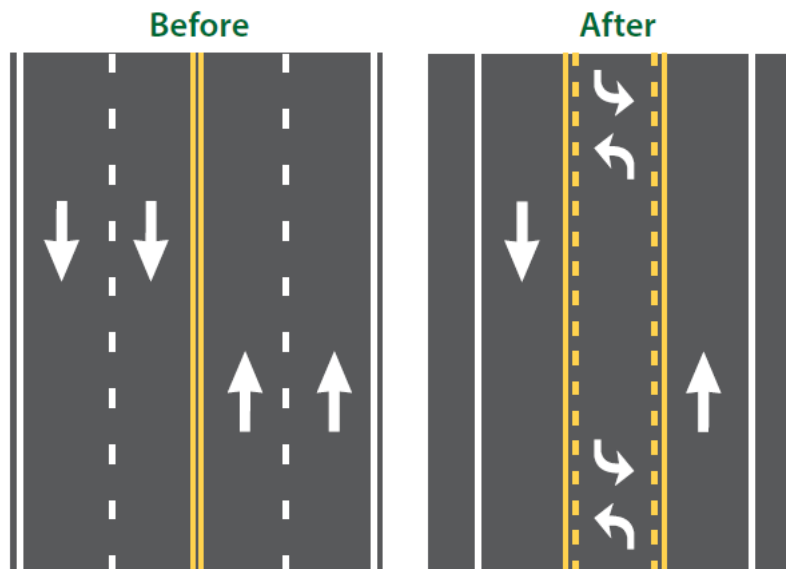


Figure 12 Typical Road Diet



**BEFORE AFTER**

Figure 13 Before and After Road Diet construction.

Benefits of Road Diet installations may include:

- An overall crash reduction of 19 to 47 percent.
- Reduction of rear-end and left-turn crashes through the use of a dedicated left-turn lane.
- Fewer lanes for pedestrians to cross and an opportunity to install pedestrian refuge islands.
- The opportunity to install bicycle lanes when the cross-section width is reallocated
- Reduced right-angle crashes as side street motorists must cross only three lanes of traffic instead of four.
- Traffic calming and reduced speed differential, which can decrease the number of crashes and reduce the severity of crashes if they occur.
- The opportunity to allocate the “leftover” roadway width for other purposes, such as on-street parking or transit stops.
- Encouraging a more community-focused, “Complete Streets” environment.
- Simplifying road scanning and gap selection for motorists (especially older and younger drivers) making left turns from or onto the mainline.

FHWA developed a [Road Diet Informational Guide](#) to help communities understand the safety and operational benefits and determine if Road Diets may be helpful in their location.

Uncontrolled and midblock pedestrian crossing locations tend to experience higher vehicle travel speeds, contributing to increased injury and fatality rates when pedestrian crashes occur. Midblock crossing locations account for more than 70 percent of pedestrian fatalities. Figure 14 shows the

percentage of pedestrian fatalities by Land Use, Location and Light Condition. This is research from Fatality Analysis Reporting System 2015. The research found a reduction in pedestrian crash risk when crossing two- and three-lane roads compared to roads with four or more lanes. With the addition of a pedestrian refuge island – a raised island placed on a street to separate crossing pedestrians from motor vehicles – the crossing becomes shorter and less complicated. Pedestrians only have to be concerned with one direction of travel at a time. Refuge islands have been found to provide important safety benefits for pedestrians. Road Diets often include either on-street parking or a bike lane, which create a buffer between pedestrians and moving vehicles. This is especially beneficial in central business districts if officials desire to improve the pedestrian experience.

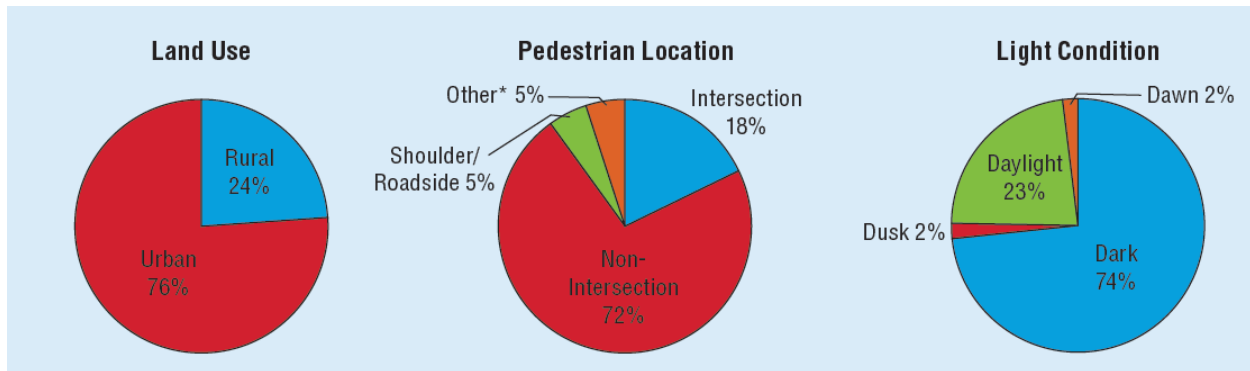


Figure 14 Percentage of Pedestrian Fatalities by Land Use, Location and Light Condition

The ADT provides a good first approximation on whether or not to consider a Road Diet conversion. If the ADT is near the upper limits of the study volumes, practitioners should conduct further analysis to determine its operational feasibility. This would include looking at peak hour volumes by direction and considering other factors such as signal spacing, turning volumes at intersections, and other access points. Each practitioner should use engineering judgment to decide how much analysis is necessary and take examples from this report as a guide.

- A 2011 Kentucky study showed Road Diets could work up to an ADT of 23,000 vehicles per day (vpd).
- In 2006, Gates, et al. suggested a maximum ADT of between 15,000 and 17,500 vpd.
- Knapp, Giese, and Lee have documented Road Diets with ADTs ranging from 8,500 to 24,000 vpd. The FHWA advises that roadways with ADT of 20,000 vpd or less may be good candidates for a Road Diet and should be evaluated for feasibility. Road Diet projects have been completed on roadways with relatively high traffic volumes in urban areas or near larger cities with satisfactory results.

The peak hour volume in the peak direction will be the measure of volume driving the analysis and can determine whether the Road Diet can be feasibly implemented. This is the traffic volume that would be used in calculating LOS analysis for intersections or the arterial corridor.

Peak-hour volumes along urban roadways typically represent 8 to 12 percent of the ADT along a roadway. The Iowa guidelines suggest, from an operational point of view, the following volume-based

Road Diet feasibility conclusions (assuming a 50/50 directional split and 10 percent of the ADT during the peak hour):

- Probably feasible at or below 750 vehicles per hour per direction (vphpd) during the peak hour.
- Consider cautiously between 750 – 875 vphpd during the peak hour.
- Feasibility less likely above 875 vphpd during the peak hour and expect reduced arterial LOS during the peak period.

Road Diet Feature	Primary/Intended Impacts	Secondary/Unintended Impacts	
		Positive	Negative
<b>Bike Lanes</b>	<ul style="list-style-type: none"> <li>• Increased mobility and safety for cyclists, and higher bicycle volumes</li> <li>• Increased comfort level for bicyclists due to separation from vehicles</li> </ul>	<ul style="list-style-type: none"> <li>• Increased property values</li> </ul>	<ul style="list-style-type: none"> <li>• Could reduce parking, depending on design</li> </ul>
<b>Fewer travel Lanes</b>	<ul style="list-style-type: none"> <li>• Reallocate space for other uses</li> </ul>	<ul style="list-style-type: none"> <li>• Pedestrian crossings are easier, less complex</li> <li>• Can make finding a gap easier for cross-traffic</li> <li>• Allows for wider travel lanes</li> </ul>	<ul style="list-style-type: none"> <li>• Mail trucks and transit vehicles can block traffic when stopped</li> <li>• May reduce capacity</li> <li>• If travel lanes are widened, can encourage increased speeds</li> </ul>
<b>Two-Way Left Turn Lane</b>	<ul style="list-style-type: none"> <li>• Provide dedicated left turn lane</li> </ul>	<ul style="list-style-type: none"> <li>• Makes efficient use of limited roadway area</li> </ul>	<ul style="list-style-type: none"> <li>• Could be difficult for drivers to access left turn lane if demand for left turns is too high</li> </ul>
<b>Pedestrian refuge island</b>	<ul style="list-style-type: none"> <li>• Increased mobility and safety for pedestrians</li> </ul>	<ul style="list-style-type: none"> <li>• Makes pedestrian crossings safer and easier</li> <li>• Prevents illegal use of the TWLTL to pass slower traffic or access an upstream turn lane</li> </ul>	<ul style="list-style-type: none"> <li>• May create issues with snow removal</li> <li>• Can effectively increase congestion by preventing illegal maneuvers</li> </ul>
<b>Buffers (grass, concrete, median, plastic delineators)</b>	<ul style="list-style-type: none"> <li>• Provide barriers and space between travel modes</li> </ul>	<ul style="list-style-type: none"> <li>• Increase comfort level for bicyclists by increasing separation from vehicles</li> <li>• Barrier can prevent users entering a lane reserved for another mode</li> </ul>	<ul style="list-style-type: none"> <li>• Grass and delineator buffers will need ongoing maintenance</li> </ul>

**Table 1 Road Diet Positives and Negatives**

As more communities desire "complete streets" and more livable spaces, they look to agencies to find opportunities to better integrate pedestrian and bicycle facilities and transit options along their corridors. When a Road Diet is planned in conjunction with reconstruction or simple overlay projects, the safety and operational benefits are achieved essentially for the cost of restriping. A Road Diet is a low-cost solution that addresses safety concerns and benefits all road users — a win-win for quality of life.

## 8. Pedestrian Refuge Islands

### Definitions:

A *median* is an area between opposing lanes of traffic, excluding turn lanes. Medians in urban and suburban areas can either be open (pavement markings only) or they can be channelized (raised medians or islands) to separate various road users.



Figure 15 Median Refuge Island

*Pedestrian crossing islands* (or refuge areas)—also known as center islands, refuge islands, pedestrian islands, or median slow points—are raised islands placed on a street at intersections or midblock locations to separate crossing pedestrians from motor vehicles.

There are several types of medians and pedestrian crossing islands, and if designed and applied appropriately, they improve the safety benefits to both pedestrians and vehicles in the following ways:

- May reduce pedestrian crashes by 46 percent and motor vehicle crashes by up to 39 percent.
- Decrease delays (by greater than 30 percent) for motorists.
- Allow pedestrians a safe place to stop at the mid-point of the roadway before crossing the remaining distance.
- Enhance the visibility of pedestrian crossings, particularly at unsignalized crossing points.
- Can reduce the speed of vehicles approaching pedestrian crossings.
- Can be used for access management for vehicles (allowing only right-in/right-out turning movements).
- Provide space for supplemental signage on multi-lane roadways.

Midblock locations account for more than 70 percent of pedestrian fatalities. This is where vehicle travel speeds are higher, contributing to the larger injury and fatality rate seen at these locations. More than 85 percent of pedestrians die when hit by vehicles traveling at 40 mph or faster while 5 percent die when hit at 20 mph or less. Installing such raised channelization on approaches to multi-lane intersections has been shown to be especially effective. Medians are a particularly important pedestrian safety countermeasure in areas where pedestrians access a transit stop or other clear origins/destinations across from each other. Providing raised medians or pedestrian refuge areas at



marked crosswalks has demonstrated a 46 percent reduction in pedestrian crashes. At unmarked crosswalk locations, medians have demonstrated a 39 percent reduction in pedestrian crashes.

## **Guidance**

Raised medians (or refuge areas) should be considered in curbed sections of multi-lane roadways in urban and suburban areas, particularly in areas where there are mixtures of significant pedestrian and vehicle traffic and intermediate or high travel speeds. Medians/refuge islands should be at least 4 feet wide (preferably 8 feet wide to accommodate pedestrian comfort and safety) and of adequate length to allow the anticipated number of pedestrians to stand and wait for gaps in traffic before crossing the second half of the street.

## **9. Bump Outs**

### **Definition:**

A curb extension or bump out is a horizontal extension of the sidewalk into the street resulting in a narrower roadway section. This device may be used at either corner or midblock. A curb extension at an intersection is called a corner extension or bulbout.

When combined with on-street parking, a corner extension can create a protected parking bay.

The effect of a corner extension on vehicle speeds is limited because of the absence of either a pronounced vertical or horizontal deflection. Its primary purpose is to "pedestrianize" an intersection. A corner extension (with a reduced corner radius) slows automobile turning speeds, shortens pedestrian crossing distance, and increases pedestrian.

When a corner extension is part of a downtown redevelopment project, it can go hand-in-hand with on-street parking bays and crosswalks (in "safe cross" designs).

A corner extension can be combined with a vertical speed control device (e.g., a raised crosswalk) to achieve a greater reduction in vehicle speed.

The design of a corner extension needs to pay close attention to the existing drainage system because the gutter alignment will be altered. A corner extension could necessitate a major utility relocation particularly if additional drainage inlets are required.

A corner extension is typically constructed to a width of between 6 and 8 feet. It should be offset from the through traffic lane by 1.5 feet.

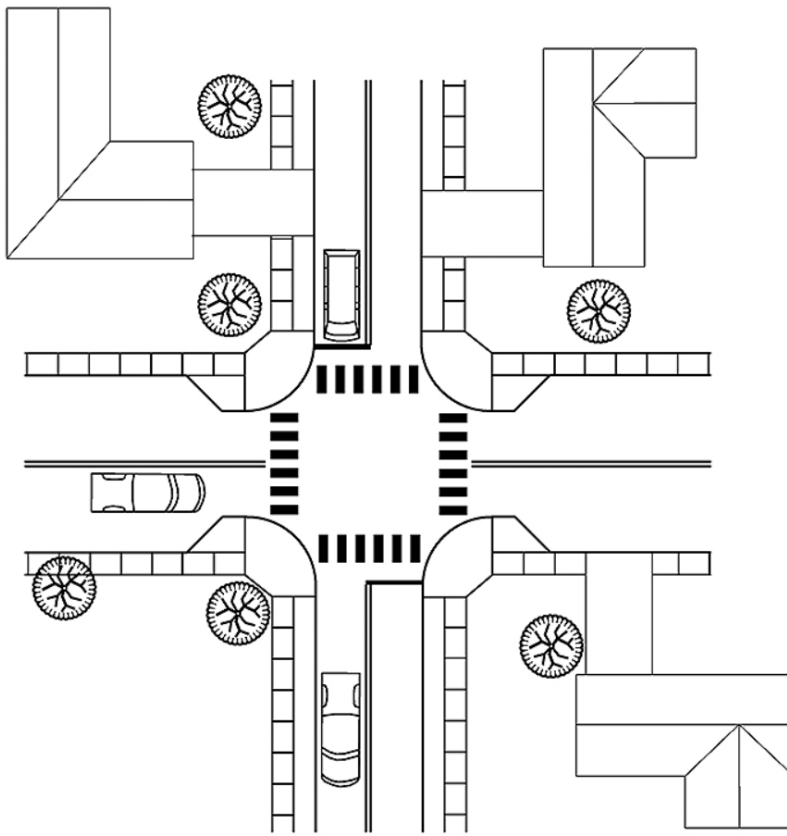


Figure 16 Bump Out

**Guidance:**

<b>Appropriate Application – Corner Extension /Bulbout</b>	
<b>Type of Street</b>	<ul style="list-style-type: none"> <li>• Appropriate for all street classifications – arterial, collector, or local street</li> <li>• Can be appropriate in both an urban and suburban setting</li> </ul>
<b>Intersection or Roadway Segment</b>	<ul style="list-style-type: none"> <li>• Applicable only at an intersection; if placed midblock, considered a choker</li> <li>• Can be applied on any or all of the approach legs of an intersection with any number of legs</li> </ul>
<b>Roadway Cross-Section</b>	<ul style="list-style-type: none"> <li>• Can be used on both one-way and two-way streets</li> <li>• Can be installed only on a roadway with an urban cross-section (i.e. curb and gutter)</li> <li>• Can be applied both with and without a bicycle facility</li> <li>• Can be applied on a roadway with, and can protect, on-street parking</li> </ul>
<b>Speed Limit</b>	<ul style="list-style-type: none"> <li>• Can be appropriate for any speed limit, provided an adequate shy distance is provided between the travel lane and the corner extension curb</li> <li>• Consider a maximum of 40 mph</li> </ul>
<b>Vehicle Traffic Volume</b>	<ul style="list-style-type: none"> <li>• Can be appropriate at all levels of traffic volume</li> </ul>
<b>Emergency Route</b>	<ul style="list-style-type: none"> <li>• Can be appropriate along a primary emergency vehicle route or street that provides access to a hospital or emergency medical services</li> </ul>
<b>Transit or Bus Route</b>	<ul style="list-style-type: none"> <li>• May not be appropriate where a bus turns along a transit or school route if an adequate turning radius cannot be provided; the stop bar on the opposite travel lane on the receiving leg of the intersection may need to be moved back in order to accommodate frequent transit vehicles making a turning movement.</li> <li>• An extended length corner extension could enable a bus stop landing area for both front and back transit bus doors, thereby eliminating the need for a bus to pull out of traffic.</li> <li>• A corner extension bus stop eliminates the need to remove on-street parking that would enable a transit vehicle to maneuver to and from the traditional curb.</li> </ul>
<b>Access Route</b>	<ul style="list-style-type: none"> <li>• Typically not appropriate along a primary access route to a commercial or industrial site if an adequate turning radius cannot be provided, the number of large turning vehicles and the total traffic volume on the receiving street are both factors when a corner extension is considered</li> </ul>
<b>Grade</b>	<ul style="list-style-type: none"> <li>• Can be installed on a crest vertical curve only if there is adequate stopping sight distance or if appropriate warning signs are provided</li> <li>• Maximum grade should comply with local standards and criteria</li> </ul>

**Table 2 Bump Out Guidance**

<b>Effects and Issues – Corner Extension /Bulbout</b>	
<b>Vehicle Speed</b>	<ul style="list-style-type: none"> <li>• Can slow traffic by funneling through narrower street opening than is provided in upstream cross section; speeds likely to decrease slightly; amount of speed reduction depends on volume and distribution of traffic</li> <li>• Speeds are reduced on intersection approach and through intersection area</li> <li>• Shorter curb radius can slow turning vehicles, if large right-turning volume, could increase delay and lower speeds</li> </ul>
<b>Vehicle Volume</b>	<ul style="list-style-type: none"> <li>• Has little effect on traffic volumes; access and turns are maintained and traffic speeds are not changed dramatically</li> </ul>
<b>Pedestrian Safety and Mobility</b>	<ul style="list-style-type: none"> <li>• Shortens intersection crossing distance for a pedestrian; shorter distance reduces the potential for pedestrian-vehicle conflict and likely improves pedestrian safety</li> <li>• Provides additional queuing space for pedestrians at corner</li> <li>• Because corner extension is elevated above the vehicle travel lanes, improves line-of-sight for pedestrian at the corner and makes that pedestrian more visible to oncoming motorist; also enables pedestrian to stand at edge of parked vehicles further increasing visibility</li> </ul>
<b>Bicyclist Safety and Mobility</b>	<ul style="list-style-type: none"> <li>• Should not extend into a bicycle lane</li> </ul>
<b>Motorist Safety and Mobility</b>	<ul style="list-style-type: none"> <li>• Likely to have minimal effect on motorist mobility and safety</li> <li>• Presence of physical feature reduces possibility of illegal parking close to intersection</li> </ul>
<b>Emergency Vehicle Safety and Mobility</b>	<ul style="list-style-type: none"> <li>• Retains sufficient width to allow for continued easy flow of emergency vehicles</li> <li>• Shortened curb radius may require emergency vehicle turning at intersection to swing across centerline</li> </ul>
<b>Large Vehicle Safety and Mobility</b>	<ul style="list-style-type: none"> <li>• Retains sufficient width to allow for continued easy flow of large vehicles like combination trucks</li> <li>• Shortened curb radius may require large vehicle turning at intersection to swing across centerline</li> </ul>
<b>Accessibility of Adjacent Property</b>	<ul style="list-style-type: none"> <li>• May require removal of some on-street parking immediately adjacent to the intersection</li> </ul>
<b>Environment</b>	<ul style="list-style-type: none"> <li>• Can be used as a landscaping opportunity; many cities use bio-swale curb extension to capture stormwater; if the corner extension includes a pedestrian crossing, the landscaping should be designed to not obstruct pedestrian visibility</li> </ul>
<b>Design Issues</b>	<ul style="list-style-type: none"> <li>• Relocation of curbing and pedestrian queuing area may require relocation of drainage features such as catch basins, concrete channels, valley gutters, inlets, and trench drains.</li> <li>• May require relocation of utilities</li> </ul>

**Table 3 Bump Out Effects and Issues**

## 10. Choker

### Definition

A curb extension located midblock is called a choker. Other terms for choker include pinch point, midblock narrowing, midblock yield point, constriction, or edge island. If the choker is marked with a crosswalk, it is sometimes called a safe cross.

A choker is the narrowing of a roadway through the use of curb extensions or roadside islands. It can be created by a pair of curb extensions at a midblock location that narrows the street by widening the sidewalk or planting strip at that location. A choker can also be created through the use of roadside islands. This narrowing is intended to discourage motorist speeding and to reduce vehicle speeds in general.



Figure 17 Choker or Pinch Point

Within a choker on a two-way, two lane roadway, vehicles are able to pass each other without conflict. But the narrower cross-section lowers the margin of error for motorists who, as a result, tend to moderate their speed. In some applications, a double-lane choker is combined with a median island as a means to reduce the possibility of opposing vehicle conflicts.

A one-lane choker forces two-way traffic to take turns going through the pinch point. If the roadway is narrowed to a single lane, the lane can be either parallel to the initial roadway alignment or angled to the alignment. The former is called a parallel choker, the latter an angled choker, twisted choker, or angle point.

A choker can be located at any spacing desired for traffic calming. A choker is often combined with on-street parking to create a protected parking bay.

Landscaping on a choker can make the traffic calming feature attractive and can make it more visible to the motorist.

A choker may be a good location to place a midblock crosswalk (either level with the roadway or as a raised crosswalk) because it shortens the distance a pedestrian walks on the travelway.

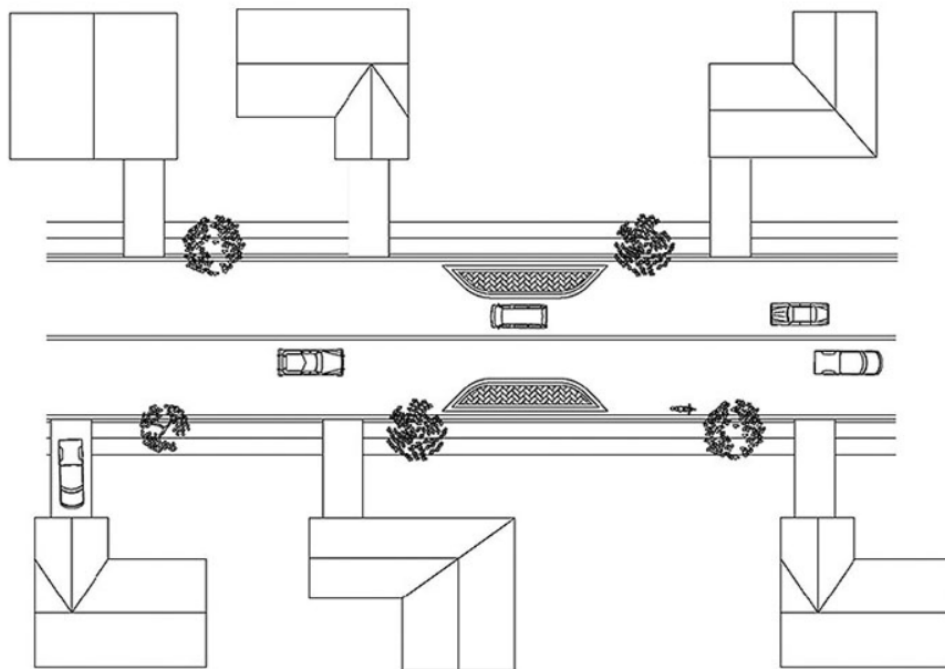


Figure 18 Choker

## 11. Narrower Lanes

Lane width influences operations, safety, quality of service, and the security felt by road users. Widths of 10 to 12 feet are typically used in practice. Driving lanes that are less than the normal 12' design leads to lower traffic speeds. Auxiliary lanes (i.e., turn lanes) at intersections are often the same width as through lanes, and seldom less than 10 feet. The width of the lane provided as part of a lane width conversion typically ranges from 10 to 16 feet. The width for a bus lane along these roadways is usually 11 to 15 feet.

Lower travel speeds may reduce potential crash severities for all users. Narrower lanes lead to lower drivers speeds.

Narrower lanes means there is less travel distance for pedestrians, and they can therefore travel out of harms way quicker. Narrower lanes may not be the best alternative when there are a large number of trucks or commercial usage of the street.

The number and frequency of slow-moving and frequently stopping vehicles using a roadway corridor is a factor to consider when evaluating this application. Some examples of these types of vehicles include agricultural equipment, buses, curbside mail delivery, and trash pick-up. These types of vehicles have a greater impact on the operation of a three-lane roadway than a four-lane undivided roadway. The primary reason for this increased impact is the inability of other vehicles to legally pass frequently stopping or slow-moving vehicles. When determining the feasibility of a Road Diet conversion, practitioners should take into account the number and duration of vehicle stops along the corridor (particularly during peak hours), as well as the enforcement levels needed to deter illegal passing. One potential mitigation measure to minimize the impact of frequently stopping vehicles is to provide pullout areas at specific locations along the corridor.

## 12. Crosswalk Visibility Enhancements

### Definition

Pedestrian visibility distance is the distance at which a driver can see a pedestrian well enough to be able to respond appropriately to the pedestrian's presence. The greater the visibility distance, the more time a driver will have to react to the pedestrian before a conflict occurs.

Contrast is the difference between the visual appearance of an object of interest and the visual background against which that object is observed, and the contrast is the basis of an object's visibility. There are two aspects of contrast – color contrast and luminance contrast. Color contrast is based on the difference in color between the object of interest and its background.

A typical street light consists of a luminaire (the lighting fixture), an arm that extends the luminaire out towards the roadway and connects to the vertical pole, and in most cases a 30- or 40-foot pole. The least expensive installation would attach the arm to a wooden utility pole. A more expensive and more attractive option would use a metal pole. Still more expensive options could involve decorative luminaires and poles.

This strategy involves the installation of street lights at intersections and crosswalks. In practice, the design of the street lights can vary from low-level, pedestrian-scale decorative lighting to a typical highway intersection style that consists of a luminaire mounted on an arm on top of a 30- to 40-foot vertical pole. Street lights can also be located at individual intersections or crosswalks or can be continuous along roadway corridors.



Figure 19 Enhanced Visibilities

Street lights can contribute to safety by providing an advance warning to drivers that they are approaching a point of potential conflict with crossing pedestrians and bicyclists. Driver recognition of pedestrians and bicyclists is also improved because street lights illuminate them when it is dark.

Most crosswalks are co-located with intersections. Because of various constraints, the present research was limited to evaluating the lighting levels that allow detection of pedestrians at midblock crosswalks. Although no specific research has been performed that addresses the higher background luminance typically found at intersections and the greater cognitive demands on drivers as they approach an



intersection, a level of 30 vertical lux is considered a conservative estimate of the lighting level required for adequate visibility.

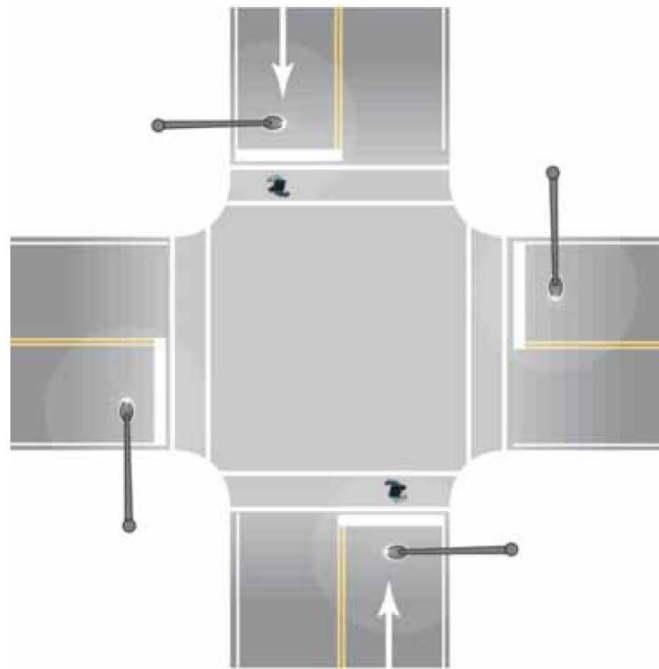


Figure 20 Intersection lighting layout for crosswalks

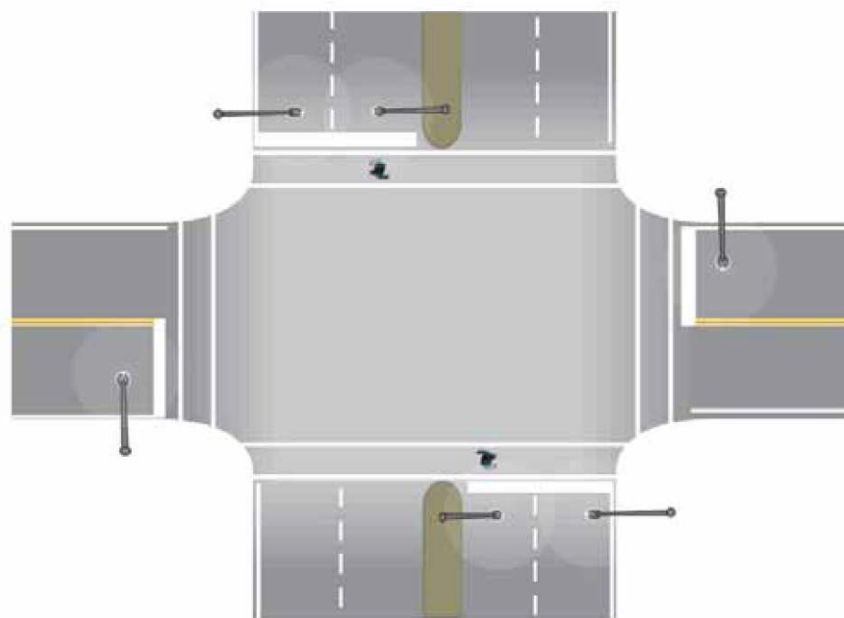


Figure 21 Wide roadway intersection lighting layout for crosswalks

The use of street lights at rural intersections has been studied extensively and is considered to be a PROVEN effective strategy for reducing a variety of crash types across a range of crash severities, including the following: nighttime crashes; head-on crashes; road departure crashes; vehicle-pedestrian and vehicle-bicycle crashes; and fatal and serious injury crashes. Research suggests that the

crash reduction is the result of the advance warning that is provided to the drivers on the major road; the lighting warns drivers that they are approaching a decision point where they need to pay closer attention because of potential conflicts associated with turning maneuvers.

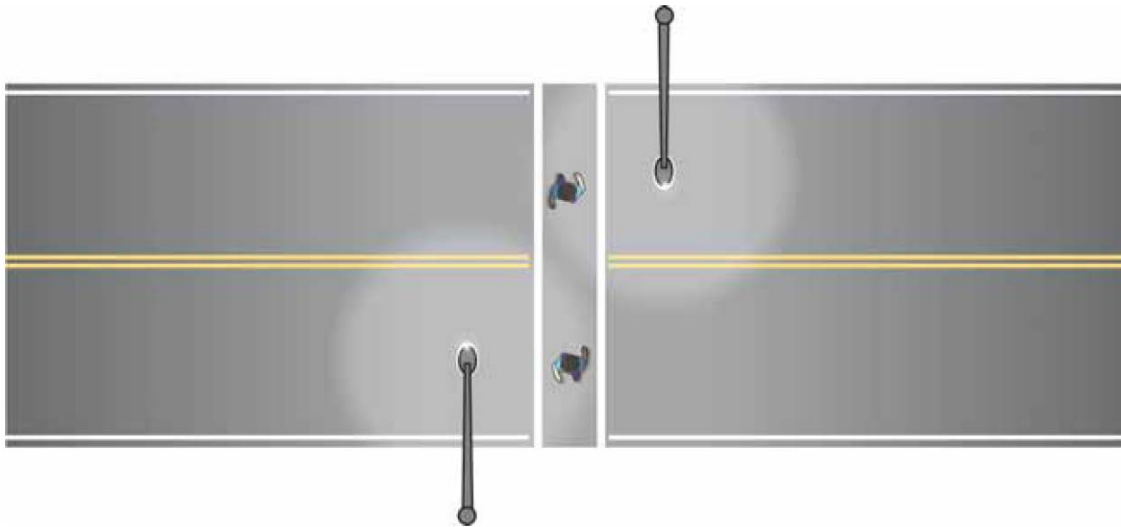


Figure 22 Midblock crosswalk lighting layout

However, there has been no research into the effectiveness of street lights relative to reducing pedestrian crashes at urban intersections or along urban roadways.

#### **TYPICAL CHARACTERISTICS OF CANDIDATE LOCATIONS**

Isolated intersections with crosswalks that are not along continuously lit roadways and mid-block crosswalks are prime candidates for installation of street lights. In both cases, the street lights would draw attention to what might be an unexpected situation for motorists—pedestrians and bicyclists crossing the road in the dark.

A vertical illuminance level of 20 lx measured at 1.5 m (5 ft.) from the road surface allowed drivers to detect pedestrians in midblock crosswalks at adequate distances under rural conditions.

A higher level of vertical illuminance may be required for crosswalks when:

- There is a possibility of continuous glare from opposing vehicles.
- The crosswalk is located in an area with high ambient light levels.
- The crosswalk is located at a lighted intersection.

The luminaire selected will influence the best mounting location and height of the luminaire with respect to the crosswalk. Metal halide or other white light sources may provide better facial recognition and comfort for pedestrians.

Along high-speed and high-volume arterials, the installation of street lights may require the use of breakaway poles and bases in order to reduce the severity of vehicle crashes involving the street lights.

New research summarized in [FHWA's Informational Report on Lighting Design for Midblock Crosswalks](#) provides some additional information on the placement of crosswalk lighting to maximize the visibility of pedestrians.

### **13. Raised Crosswalks**

#### **Definition:**

A raised crosswalk is a variation of a flat-topped speed table. A raised crosswalk is marked and signed as a pedestrian crossing. The 10-foot flat top on a typical speed table conforms to a desired crosswalk width.

A speed hump is an elongated mound in the roadway pavement surface extending across the travel way at a right angle to the traffic flow. A speed hump is typically 3 inches in height (with applications as high as 4 inches) and 12 feet in length along the vehicle travel path axis (note: a *speed hump* that is 20 feet in length and flat in the middle is considered a *speed table*.)

There are two distinct raised crosswalk designs. Both use a modified version of the common 22-foot speed table:

- The most common type is constructed flush against the roadside curb.
- The other type is constructed on an open section (requiring a curb ramp on the raised crosswalk) or separate from the curb (requiring a curb ramp on both the curb and the raised crosswalk).

A raised crosswalk improves pedestrian safety by causing motorist speed to decrease at the crossing.



Figure 23 Raised pedestrian crosswalk or speed hump

A raised crosswalk is typically between 3 and 6 inches above street level. It is common for a raised crosswalk to be level with the street curb. This height increases the visibility of a pedestrian in a crosswalk to a motorist. It also improves the line of sight for a pedestrian toward an oncoming vehicle.

A raised crosswalk can be placed midblock or at an intersection.

ITE has developed a recommended practice entitled [Guidelines for the Design and Application of Speed Humps](#). Further guidance and clarification can be found in that publication.

At typical travel speeds along a residential street or in a small commercial business district, a speed hump produces sufficient discomfort to a motorist driving above the speed hump design speed to discourage speeding. It encourages the motorist to travel at a slow speed both upstream and downstream of as well as over the speed hump.

What's the difference between a speed hump and a speed bump? A speed hump is typically 12 feet in length (in the direction of travel), between 3 and 4 inches in height, and is intended for use on a public roadway. A speed bump is much shorter, between 1 and 2 feet in length (in the direction of travel). A speed bump can be as much as 6 inches in height. A speed bump is typically found in a parking lot or commercial driveway, but not on a public roadway.

Speed humps should be designed to the following criteria:

- Slopes should not exceed 1:10 or be less steep than 1:25
- Side slopes on tapers should be no greater than 1:6
- The vertical lip should be no more than a quarter inch high
- Spaced no more than a maximum of 500 feet apart to achieve an 85<sup>th</sup> percentile speed of 25-35 mph.

Locate vertical speed control elements where there is sufficient visibility and available lighting.

<b>Appropriate Application – Speed Hump</b>	
<b>Type of Street</b>	<ul style="list-style-type: none"> <li>• Appropriate for a residential local street or any street where the primary function is to provide access to abutting residential property</li> <li>• Appropriate for a street that provides access to a school, park, or community center</li> <li>• Also appropriate for neighborhood or residential collectors</li> </ul>
<b>Intersection or Roadway Segment</b>	<ul style="list-style-type: none"> <li>• Placed at a midblock location, and not near an intersection; at least 150 feet from an unsignalized intersection and 250 feet from a signalized intersection</li> <li>• Should not be placed on a sharp curve; minimum horizontal curve radius of 300 feet</li> </ul>
<b>Roadway Cross Section</b>	<ul style="list-style-type: none"> <li>• Can be used on a single-lane one-way street or two-lane two-way street; should stretch across only one travel lane in each direction</li> <li>• Typically installed on a roadway with an urban cross-section</li> <li>• Typically placed one foot from a curb for drainage or six inches from the edge of a non-curved roadway</li> <li>• A speed hump can be applied on a cross-section both with and without sidewalks or bicycle facilities</li> </ul>
<b>Speed Limit</b>	<ul style="list-style-type: none"> <li>• Appropriate if posted speed limit is 30 mph or less</li> <li>• Generally not appropriate when the pre-implementation 85<sup>th</sup> percentile speed is 45 mph or more</li> </ul>
<b>Vehicle Traffic Volume</b>	<ul style="list-style-type: none"> <li>• Appropriate if daily traffic volume is relatively low</li> <li>• No more than 5% trucks</li> </ul>
<b>Emergency route</b>	<ul style="list-style-type: none"> <li>• Generally not appropriate for a primary emergency vehicle route or a street that provides access to a hospital or emergency medical services; speed cushion and speed table are similar vertical measures that could be appropriate</li> <li>• An emergency vehicle can cross a properly designed speed hump, but at a slow speed</li> </ul>
<b>Transit Route</b>	<ul style="list-style-type: none"> <li>• Generally not appropriate for a bus route</li> </ul>
<b>Access route</b>	<ul style="list-style-type: none"> <li>• Not appropriate along the primary access to a commercial or industrial site</li> </ul>
<b>Grade</b>	<ul style="list-style-type: none"> <li>• Can be installed on, or beyond, a crest vertical curve only if there is adequate stopping sight distance or warning signs are provided</li> </ul>

**Table 4 Speed Hump application**

<b>Effects and issues – Speed Hump</b>	
<b>Vehicle Speed</b>	<ul style="list-style-type: none"> <li>• Single speed hump reduces speeds to the range of 15 to 20 mph when crossing the hump; speed reduction effects decline at the rate of approximately 0.5 to 1 mph every 100 feet beyond the 200 foot approach and exit of a speed hump; in order to retain slower vehicle speeds over longer distance; series of speed humps are needed</li> <li>• Proper placement of initial speed hump in a series is significant; within 200' or less of a small radius curve or stop sign</li> </ul>
<b>Vehicle Volume</b>	<ul style="list-style-type: none"> <li>• As single installation, there is little traffic diversion from the street; as part of a series; typical volume reductions of 20 percent observed</li> </ul>
<b>Pedestrian Safety and Mobility</b>	<ul style="list-style-type: none"> <li>• Not a preferred location for a crosswalk</li> </ul>
<b>Bicyclist Safety and Mobility</b>	<ul style="list-style-type: none"> <li>• Bicyclist safety should not be affected; some jurisdictions use a maximum street grade of 5% on a street with a speed hump if designated as a bicycle route</li> <li>• Bicyclist can negotiate speed hump with little delay or discomfort; it is also possible for a bicyclist to bypass a speed hump by passing through the gap between the hump and the curb and gutter</li> </ul>
<b>Motorist Safety and Mobility</b>	<ul style="list-style-type: none"> <li>• Speed effects of a single or series of speed humps are greater than for any other traffic calming measure with the exception of route diversions that eliminate a particular traffic movement</li> <li>• Produces sufficient discomfort to a motorist driving above the speed hump design speed to discourage speeding</li> </ul>
<b>Emergency Vehicle Safety and Mobility</b>	<ul style="list-style-type: none"> <li>• Typical delay for a fire truck in in the 3 to 5 second range; for an ambulance with a patient, delay can be as much as 10 seconds</li> </ul>
<b>Design Issues</b>	<ul style="list-style-type: none"> <li>• May require relocation of drainage features such as catch basins, concrete channels, valley gutters, inlets, and trench drains.</li> </ul>

**Table 5 Speed Hump issues**

Placement factors include vertical and horizontal alignment of the street, proximity to the nearest intersection, location of driveways and on-street parking, presence or absence of street lighting, location of designated pedestrian crossings, drainage, and utility access points (drains, valves, etc.)

Their installation should not require relocation of above- and below-ground utilities.

May not be appropriate on a roadway where drainage gutter or flow of water is in the center of the roadway; drainage and hydraulic impacts need careful evaluation

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