# City of San Diego's *Comprehensive Pedestrian Safety Crossing Guidelines*

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*In association with:*

SafeTREC Safe Transportation Research & Education Center

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*Transportation Research Board*

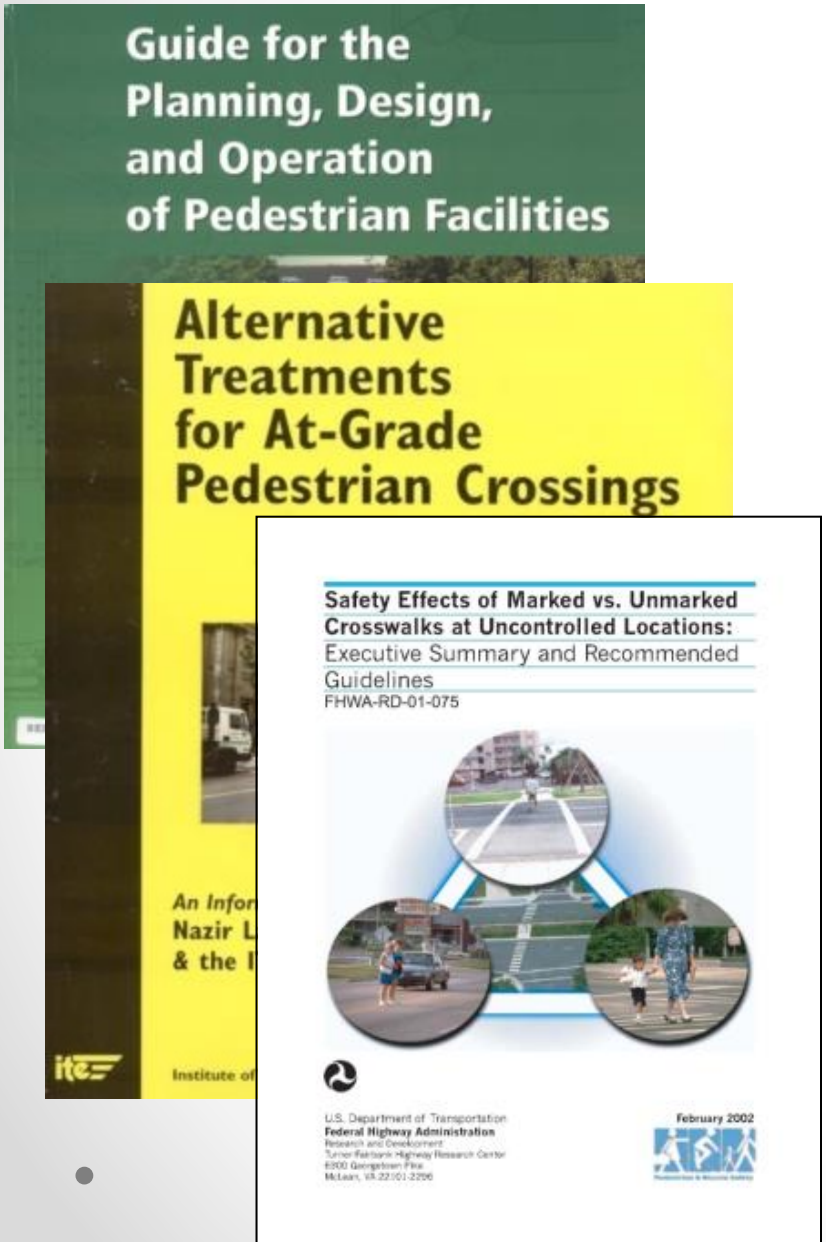
# Presentation Overview

- Purpose and Background
- Collision Trends in San Diego
- Study Sites
- Data Collection
- Analysis Results
- Crossing Policy Update


# Project Purpose

- Develop a ***Pedestrian Risk Model*** to inform City's update to their Pedestrian Crossing Policy at Uncontrolled Crossings (Council Policy 200-07)
- Policy last updated in 1990
- Herms (1970) - marked crosswalks induce incautious pedestrian behavior

# Background - More Recent Research

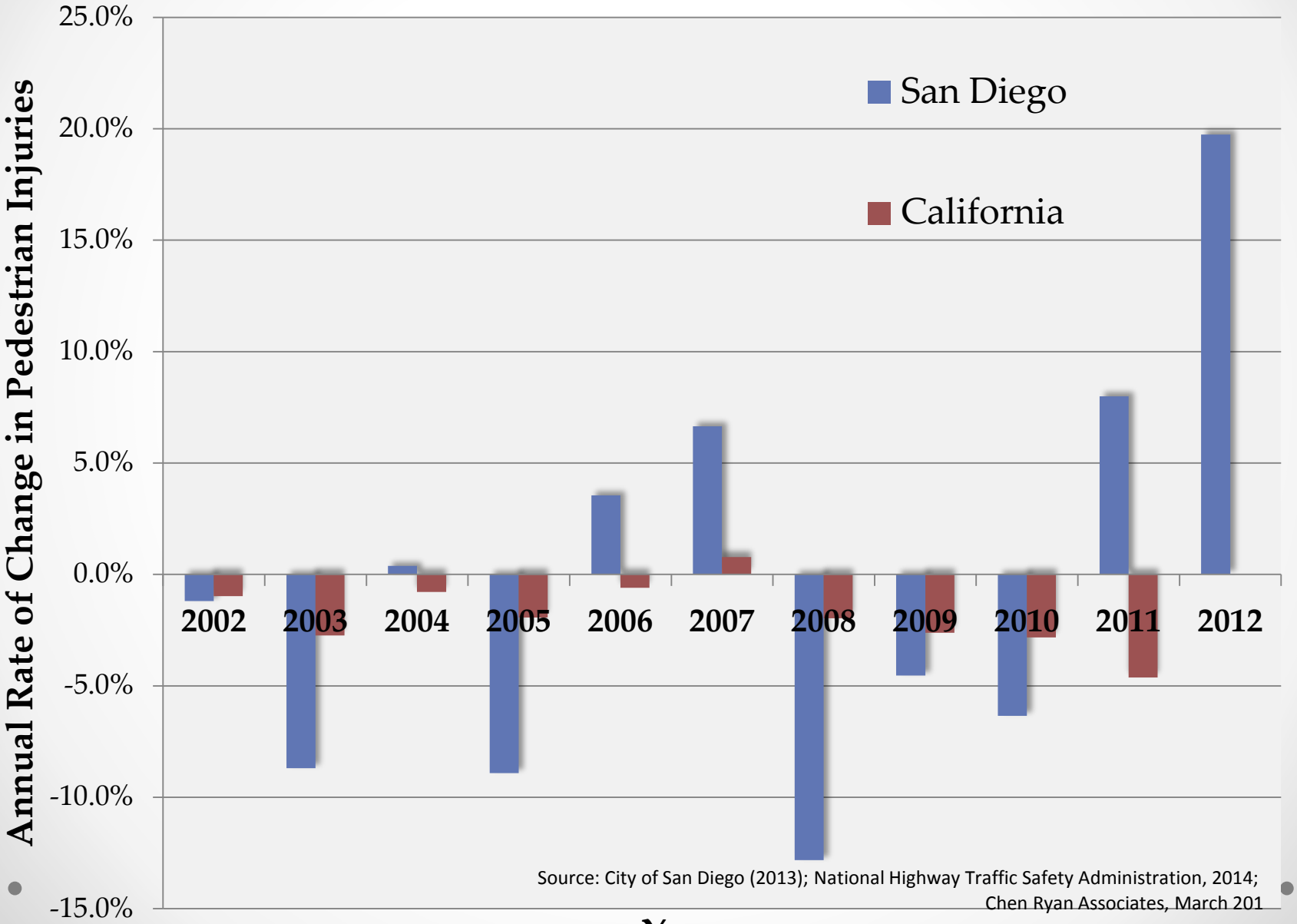



- Zegeer et al. (2005)
- Lalani et al. (2006)
- Ragland et al. (2007)

- Marked crosswalks are *insufficient* at some locations

# Annual Rate of Change in Pedestrian Injures

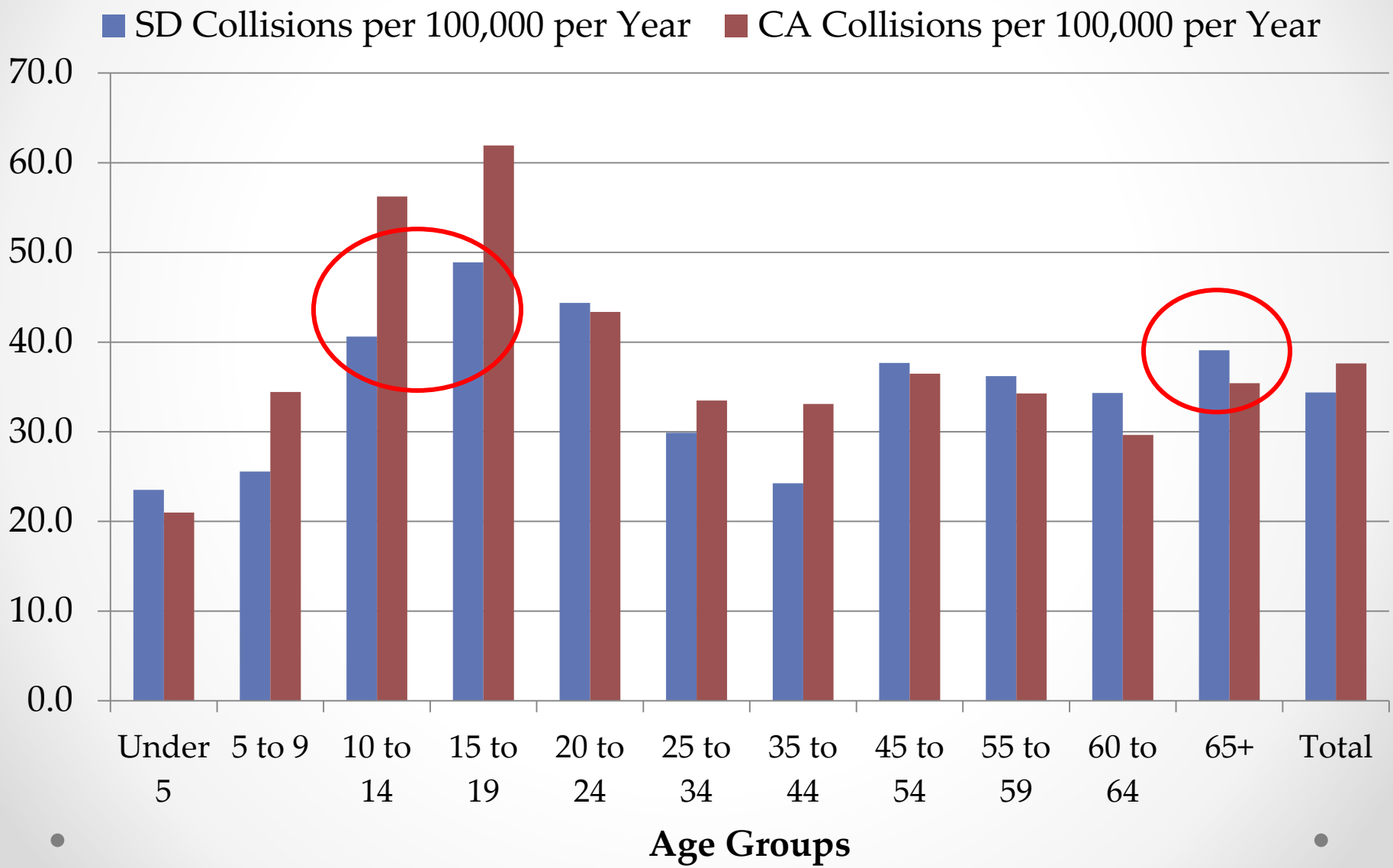
## *(City of San Diego vs State of California)*



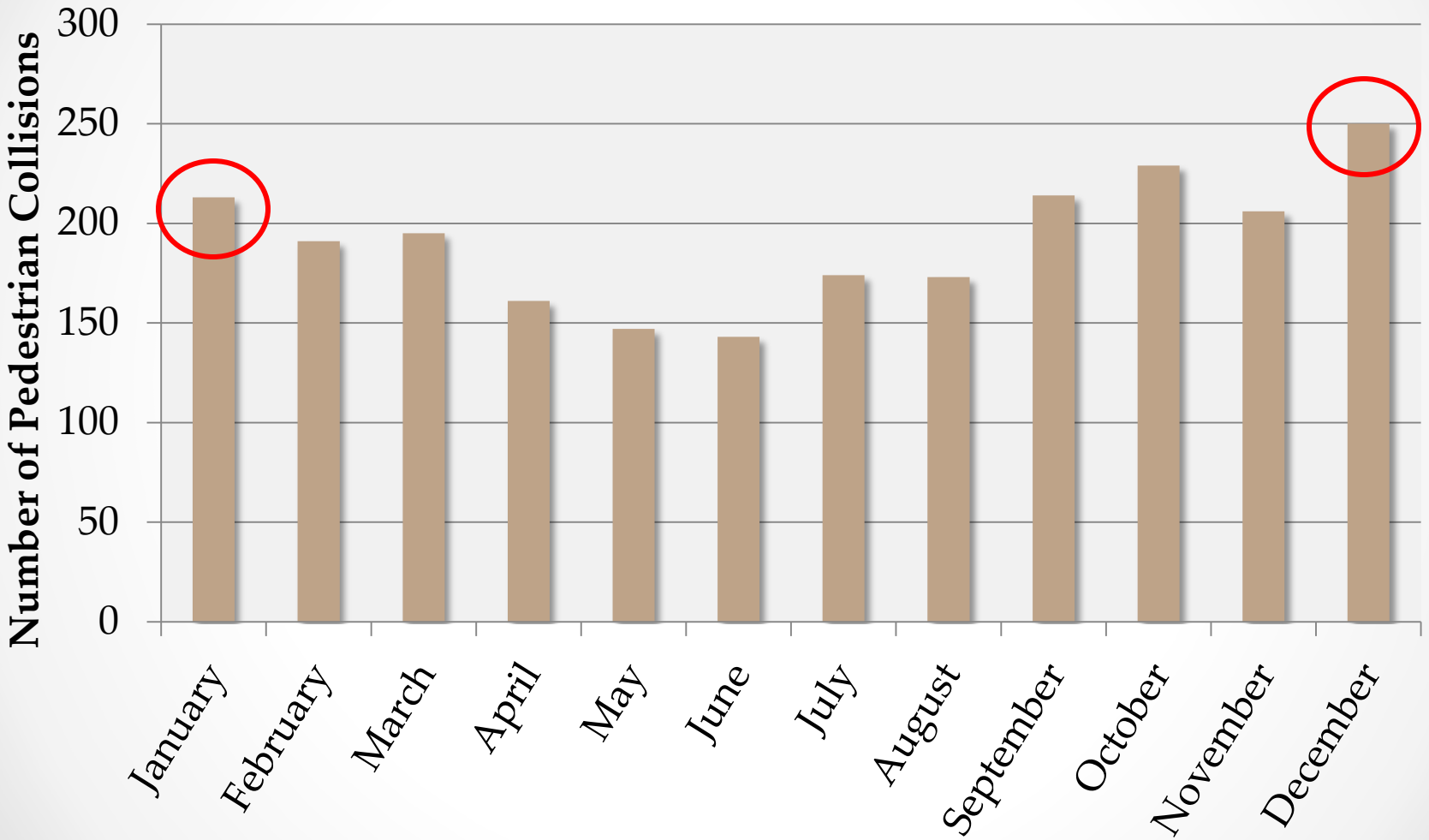

Source: City of San Diego (2013); National Highway Traffic Safety Administration, 2014;
Chen Ryan Associates, March 201

# Pedestrian Collisions per 100K Population by Age

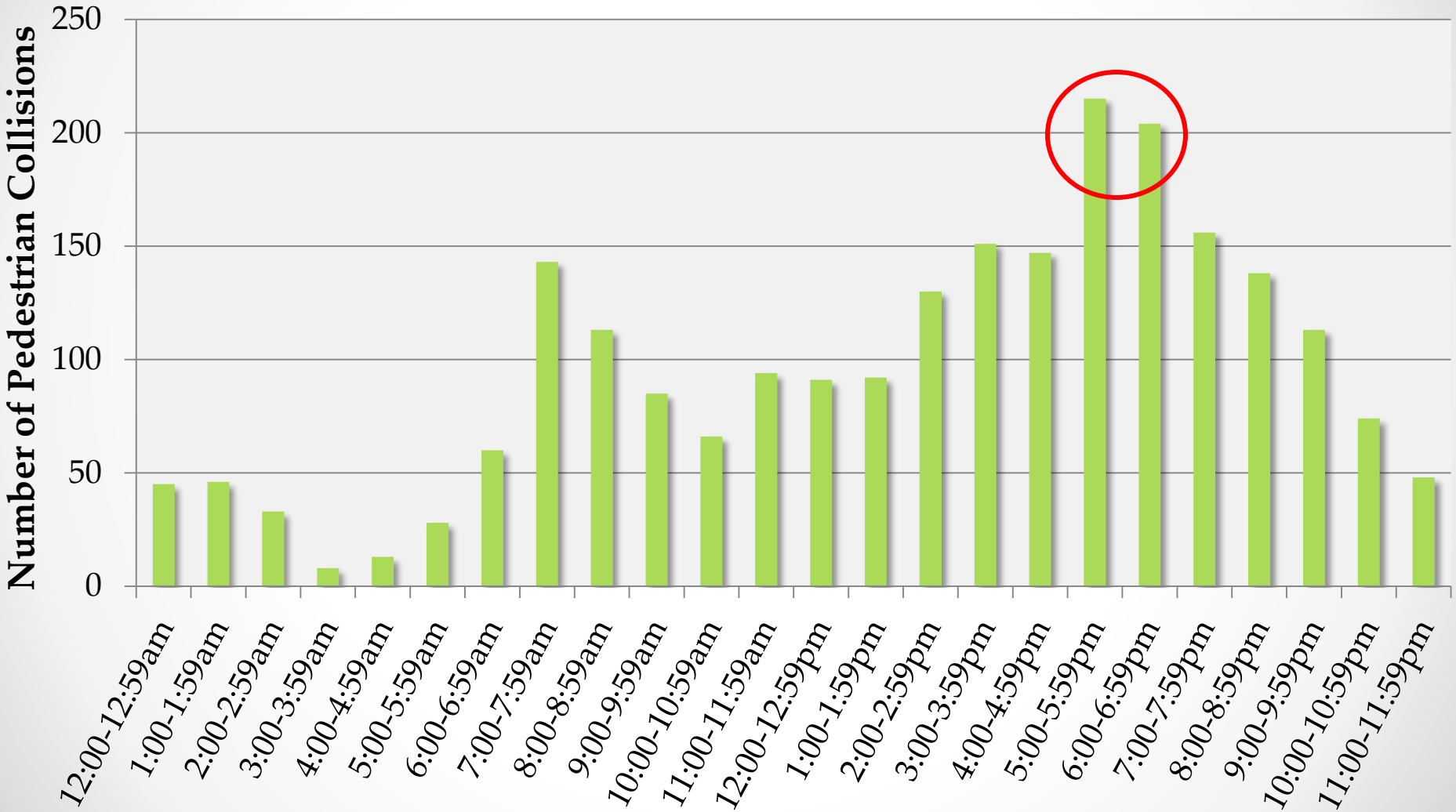
*(City of San Diego vs State of California)*



# Pedestrian Collisions by Month
# 1998 - 2012

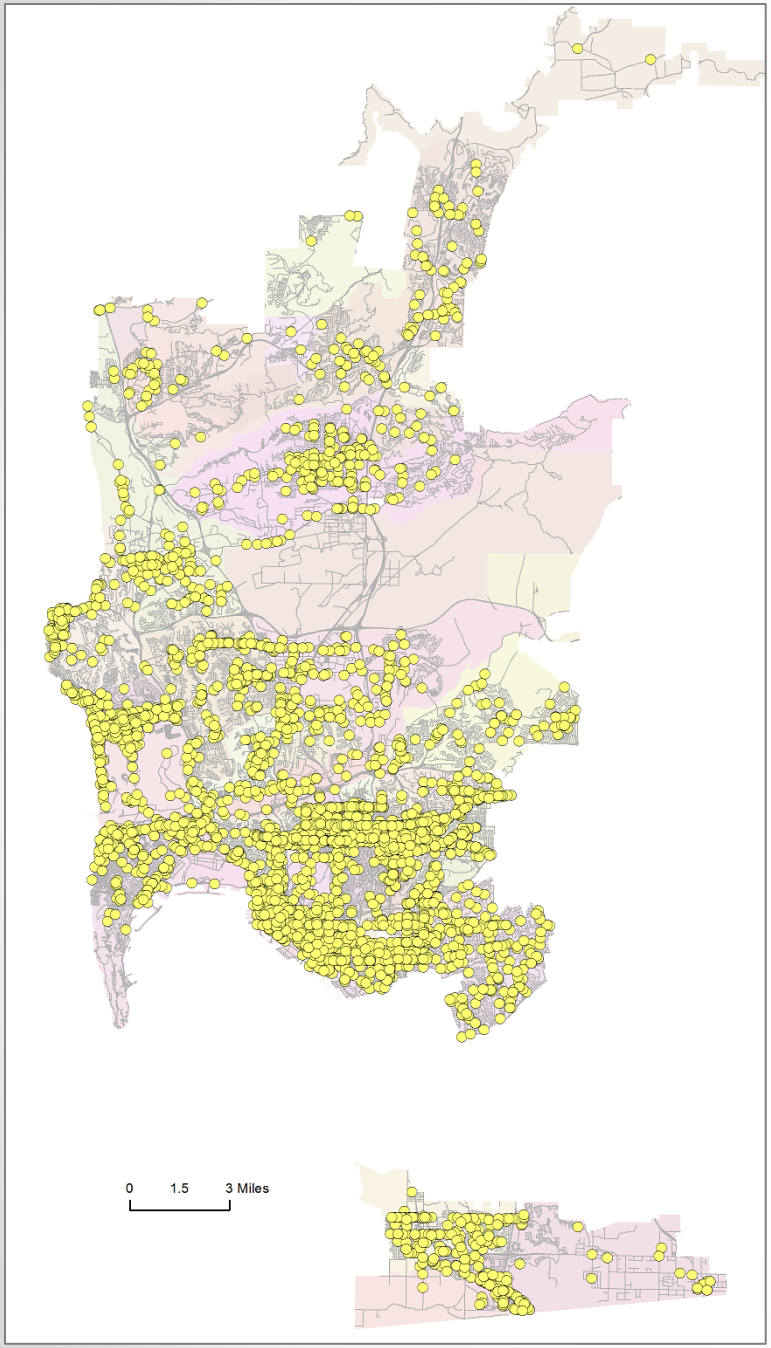


# Pedestrian Collisions by Hour of Day
# 1998 - 2012



# Pedestrian Collisions per Square Mile by Income Category 2008 - 2012

| | | City of San Diego Square Miles | % Area of City of San Diego | Pedestrian Collisions | Collisions per Square Mile |
|---|---|---|---|---|---|
| **2010 Median Household Income by Census Tract** | | | | | |
| **High** | >$78,242 | 160.0 | 48.1% | 241 | 1.5 |
| **Medium** | $54,081 to $78,242 | 86.5 | 26.1% | 722 | 8.3 |
| **Low** | <$54,081 | 85.5 | 25.8% | 1,318 | 15.4 |




# Study Area

- 1,000's of potential intersection locations
- Pedestrian-Involved Collisions 1998 to 2012
- Over 7,500 pedestrian-related collisions during this period

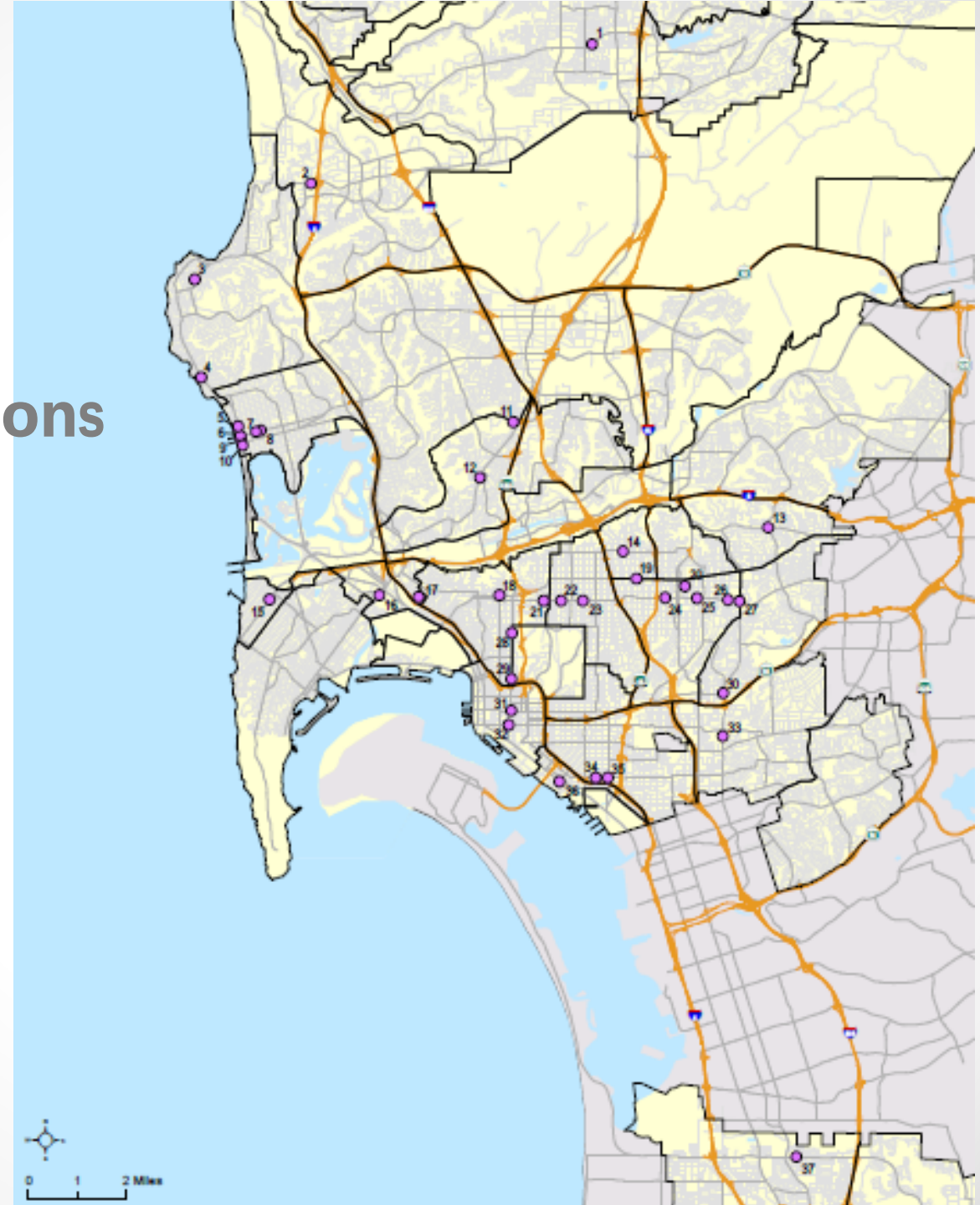
# Stratified Selection of Study Sites

- Collision Location (*intersection vs. midblock*)
- Intersection Control (*signalized vs. unsignalized*)
- Roadway Environment (roadway *width and speed*)
- Collision Cause

# Stratified Selection of Study Sites

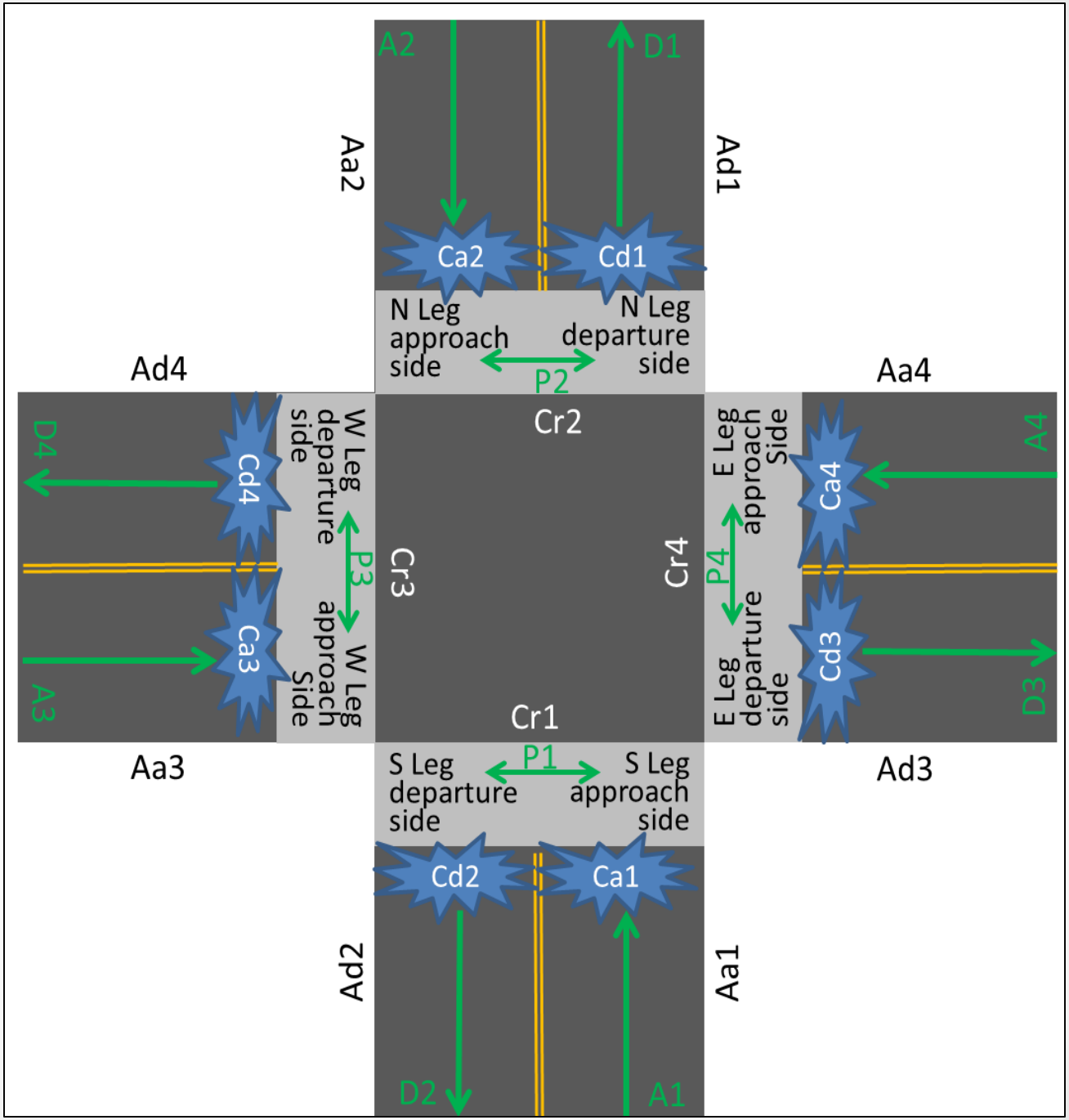
| | Signalized | | | | Unsignalized | | | | Mid-Block | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Collisions | 2,455 (39%) | | | | 1,283 (20%) | | | | 2,623 (41%) | | | |
| Speed | 35mph and > | 35mph and > | <35mph | <35mph | 35mph and > | 35mph and > | <35mph | <35mph | 35mph and > | 35mph and > | <35mph | <35mph |
| Width | 4-Ln and > | <4-Ln | 4-Ln and > | <4-Ln | 4-Ln and > | <4-Ln | 4-Ln and > | <4-Ln | 4-Ln and > | <4-Ln | 4-Ln and > | <4-Ln |
| **Collisions** | 1,546 | 212 | 340 | 357 | 343 | 120 | 116 | 704 | 851 | 241 | 194 | 1,337 |

# Final Study Area Intersections



# Data Collection

- Only 37 study sites
- 296 cases achieved by using intersection approach/departure for each crossing at 37 study sites.


A2
D1
Aa2
Ad1
Ca2
Cd1
N Leg approach side
N Leg departure side
P2
Ad4
Aa4
Cr2
D4
Cd4
W Leg departure side
E Leg approach Side
A4
Ca4
P3
Cr3
Cr4
P4
A3
Ca3
W Leg approach Side
E Leg departure side
Cd3
D3
Cr1
Aa3
P1
Ad3
S Leg departure side
S Leg approach side
Cd2
Ca1
Ad2
Aa1
D2
A1

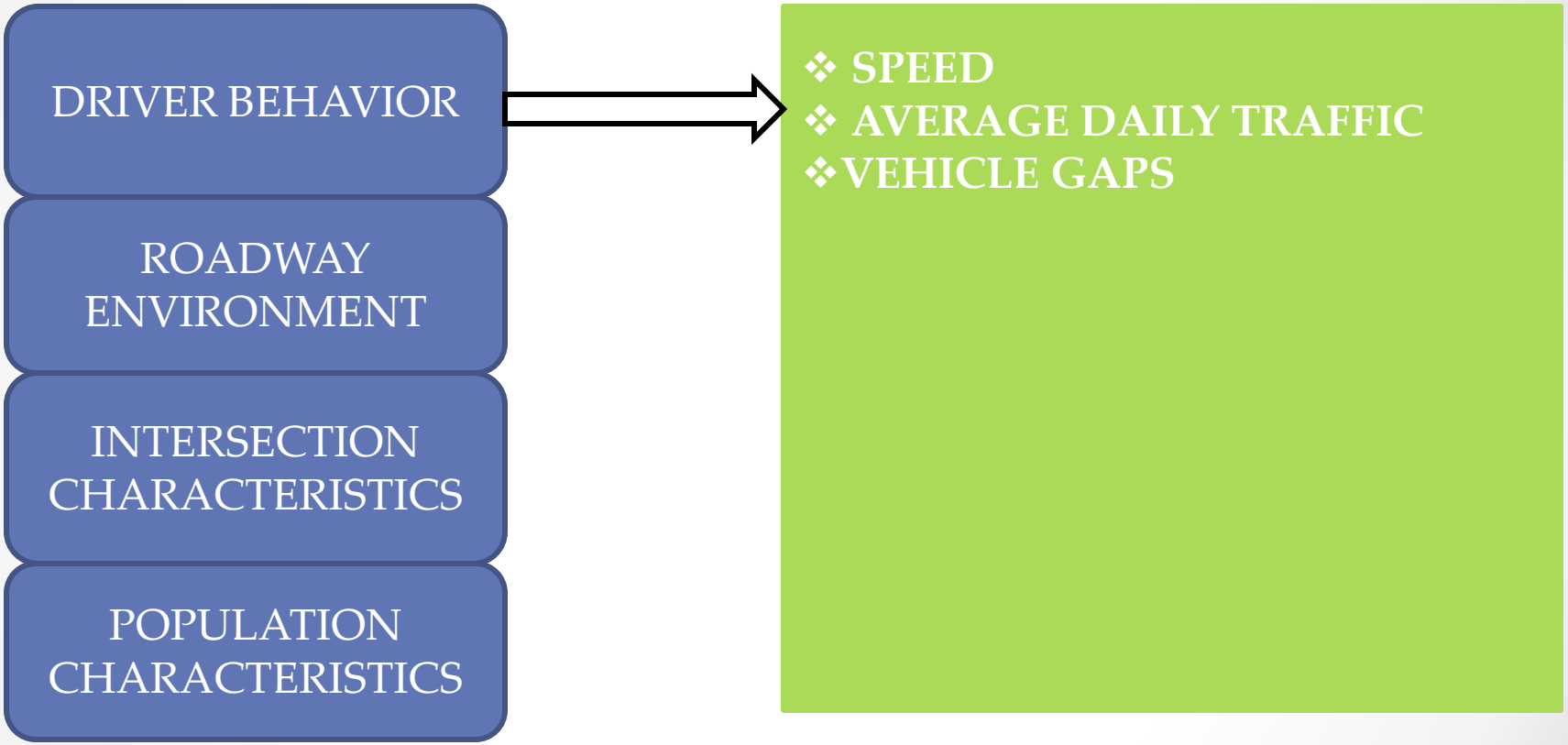
# TABLE 1: INTERPRETATION OF ALPHA-NUMERIC CODES IN FIGURE 2

| Study Unit | Behavioral | | | Roadway Environment | |
|---|---|---|---|---|---|
| | Vehicle Volumes | Pedestrian Volumes | Collision Locations | Approach Attributes | Crosswalk Attributes |
| South Leg Approach-side Crosswalk | A1 | P1 | Ca1 | Aa1 | Cr1 |
| North Leg Approach-side Crosswalk | A2 | P2 | Ca2 | Aa2 | Cr2 |
| West Leg Approach-side Crosswalk | A3 | P3 | Ca3 | Aa3 | Cr3 |
| East Leg Approach-side Crosswalk | A4 | P4 | Ca4 | Aa4 | Cr4 |
| South Leg Departing-side Crosswalk | D2 | P1 | Cd2 | Ad2 | Cr1 |
| North Leg Departing-side Crosswalk | D1 | P2 | Cd1 | Ad1 | Cr2 |
| West Leg Departing-side Crosswalk | D4 | P3 | Cd4 | Ad4 | Cr3 |
| East Leg Departing-side Crosswalk | D3 | P4 | Cd3 | Ad3 | Cr4 |

# Data Collection

- **Dependent Variable**
  - Collisions (1998-2012) / Annual Estimated Pedestrian Volumes
- **Four Categories of Independent Variables**
  - Driver Behavior
  - Roadway Environment
  - Intersection Environment
  - Population Characteristics

# Driver Behavior



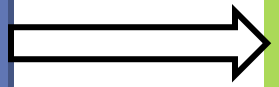
# Roadway Environment

DRIVER BEHAVIOR

ROADWAY ENVIRONMENT

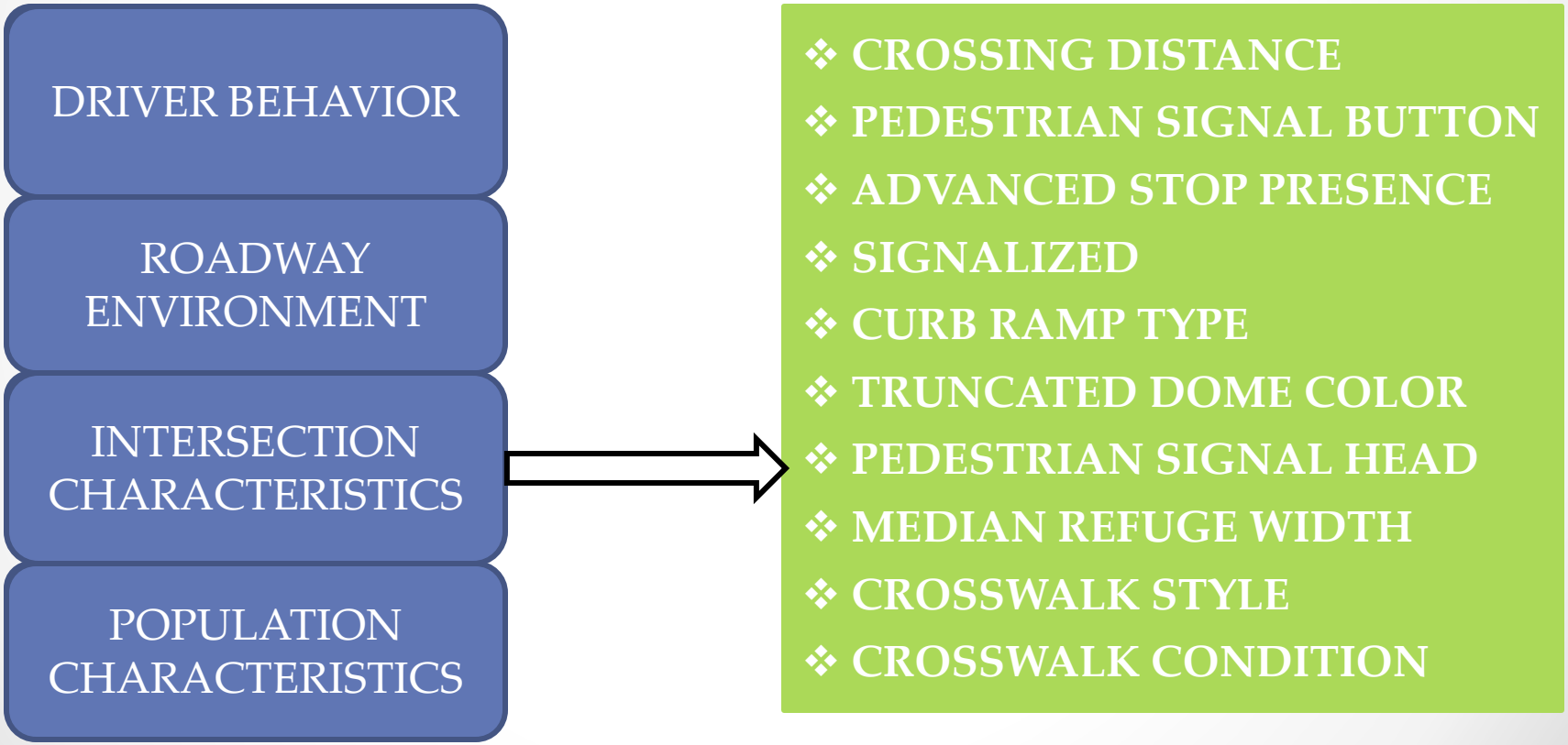
INTERSECTION CHARACTERISTICS

POPULATION CHARACTERISTICS

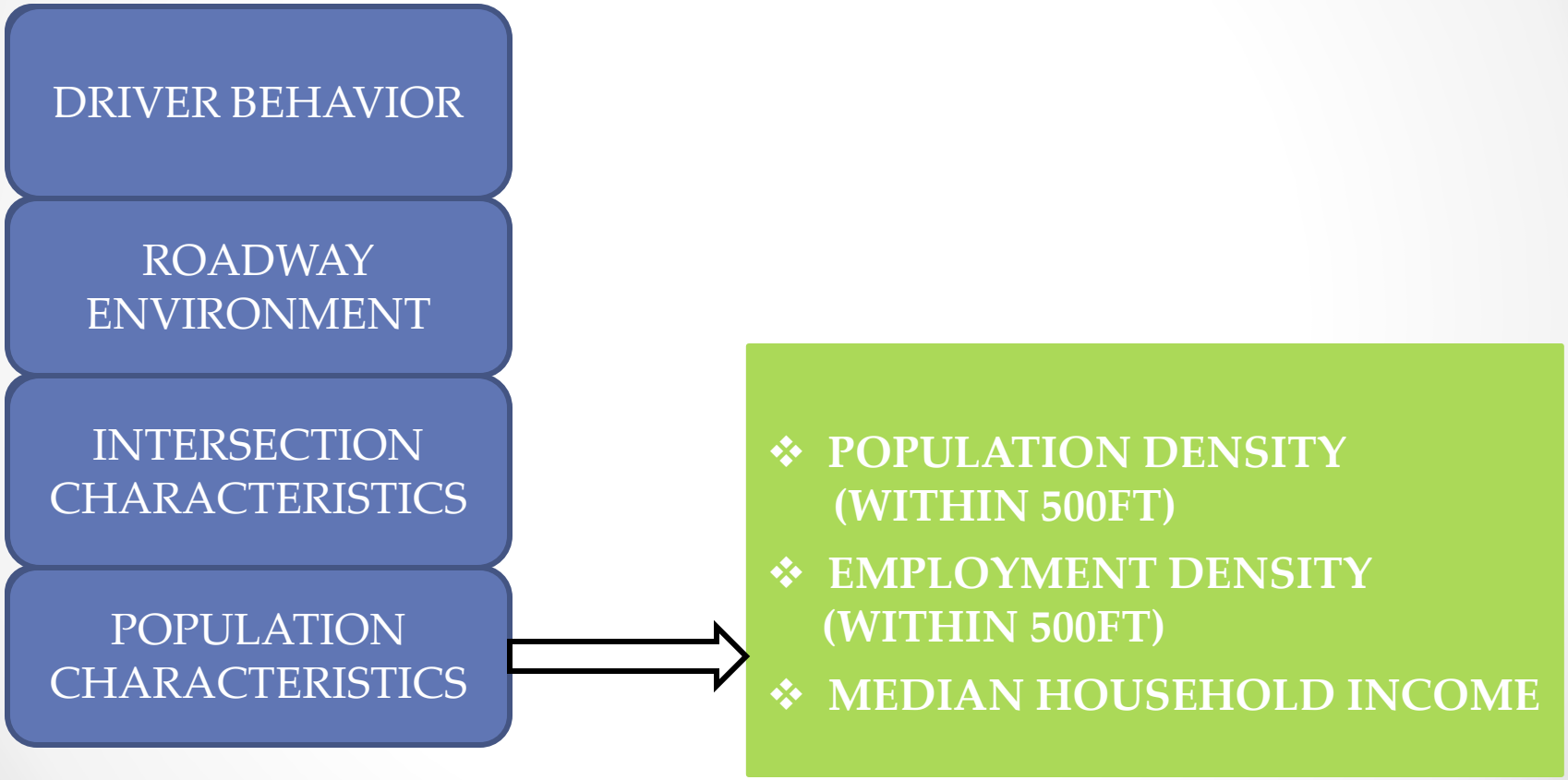


- PARKING LANE WIDTH
- SIDEWALK WIDTH
- OBSTRUCTION PRESENCE
- LANDSCAPE BUFFER WIDTH
- BIKE PARKING PRESENCE
- BIKE LANE WIDTH
- NUMBER OF LANES
- POSTED SPEED LIMIT
- INFORMAL CROSSING
- BUS STOP PRESENCE
- BIKEWAY TYPE/COLOR
- PEDESTRIAN SIGNAGE
- VEHICLE GAP

# Intersection Characteristics



# Population Characteristics



# PEDESTRIAN RISK MODEL

$$y_i = e^{(\beta_0+\beta_1 x_{i1}+\beta_2 x_{i2}+\beta_3 x_{i3}+\cdots)} \quad (1)$$

Where,

$y_i$ = collision rate at a half crosswalk 'i'. The collision rate is calculated by dividing half crosswalk collision frequency by pedestrian annual volume at the crosswalk;

$x_{ij}$ = quantitative measure of each characteristic j associated with half crosswalk 'i'; and

$\beta_j$ = coefficient corresponding to $x_{ij}$ to be determined by negative binomial regression.

# PEDESTRIAN RISK MODEL

$$y_i = EXP(-19.43 + 0.57x_{i1} + 0.86x_{i2} + 1.40x_{i3} + 1.05x_{i4} - 0.0025x_{i5} + 0.74x_{i6} + 2.31x_{i7} - 1.28x_{i8} - 1.31x_{i9} - 0.0018x_{i10} + 0.08x_{i11}) \quad (2)$$

Where,

$y_i$= collision rate at a half crosswalk i. The collision rate is calculated by dividing the half crosswalk collision frequency by the annual pedestrian volume at the crosswalk.

$x_{i1}$= Ln of ADT associated with half crosswalk i,
$x_{i2}$= the color of half crosswalk i, white,
$x_{i3}$= the color of half crosswalk i, yellow,
$x_{i4}$= the condition of half crosswalk i, medium,
$x_{i5}$= employment within 500 feet of the study intersection,
$x_{i6}$= informal crossing associated with half crosswalk i, demonstrated informal crossing,
$x_{i7}$= informal crossing associated with half crosswalk i, not passable,
$x_{i8}$= pedestrian related signage presence on the approach associated with half crosswalk i, present,
$x_{i9}$= pedestrian signal head presence at half crosswalk i, present,
$x_{i10}$= population within 500 feet of the study intersection,
$x_{i11}$= posted speed for the approach associated with half crosswalk i.

# Statistically Significant Variables Associated with INCREASES to Pedestrian Risk:

- **Average Daily Traffic**
- **Posted Speed Limit**
- **Crosswalk in medium condition**
- **Marked crosswalks in white**
- **Marked crosswalks in yellow**
- **Demonstrated informal crossings**

# Statistically Significant Variables Associated with DECREASES to Pedestrian Risk:

- **Presence of Pedestrian Warning Signage**
- **Presence of Pedestrian Signal Heads**
- **Population Levels**
- **Employment Levels**

# TABLE 2: INDEPENDENT VARIABLES AND STATISTICAL ANALYSIS FINDINGS

| Variable Category | Driver Behavior | Roadway Environment | Intersection Characteristics | Population Characteristics |
|---|---|---|---|---|
| Independent Variable Analyzed | Average Daily Traffic (ADT) | Parking Lane Width | Crossing Distance | Population within 500 foot Buffer |
| | 85% Traffic Speed (MPH) | Sidewalk Width | Median Refuge Width | Employment within 500 foot Buffer |
| | Vehicle Gap | Buffer Width | # of Signalized Locations | Median Household Income within 500 foot Buffer |
| | | # of Bike Parking | # of Crosswalks and Type (poor condition was significant) | |
| | | Bike Lane Width | # of Curb Ramps and Type | |
| | | Posted Speed | Truncated Dome Color | |
| | | # of Approach Sides | Crosswalk Color (white & yellow were significant) | |
| | | Demonstrated Informal Crossing Location | Pedestrian Signal Head (# of locations) | |
| | | # of Obstructions Present | Pedestrian Signal Button (# of locations) | |
| | | Bus Stop Presence | Advanced Stop Presence (# of locations) | |
| | | Bikeway Type | Crosswalk Condition (# of locations) | |
| | | Bikeway Color | | |
| | | # of Pedestrian Signs | | |
| | | # of Travel Lanes | | |
| | | Approach Median Access Restriction (not passable) | | |

Statistically Significant Positive Association with Pedestrian Risk

Statistically Significant Negative Association with Pedestrian Risk

# **Council Policy 200-07**
## Marked Crosswalk Warrants at Uncontrolled Locations

**"In order to qualify for a marked crosswalk, a location must (a) meet all of the following *Basic Warrants* AND (b) score 16 points or more under the following *Point Warrant* system."**

**Current policy extremely restrictive and prohibitive of marking pedestrian crossings at uncontrolled intersections**

# Updated Crossing Policy for Uncontrolled Intersections – *Basic Warrants*

**Previous Basic Warrants**

- Pedestrian Volume Warrant **(> 10 peds)**
- Approach Speed Warrant **(<45 mph)**
- Visibility Warrant **(>200 feet)**
- Illumination Warrant **(adequate)**

**New Basic Warrants Policy**

- Pedestrian Volume Warrant, **including Latent Demand**
- Approach Speed Warrant **(<35 mph)**
- Visibility Warrant **(>250 feet)**
- Nearest Controlled Crossing **(>200 feet)**
- Accessibility Warrant **(curb ramps)**

# Updated Crossing Policy for Uncontrolled Intersections – *Point Warrants*

- **Previous Policy**
  - Pedestrian Volume Warrant
  - General Condition Warrant
  - Gap Time Warrant
- **New Policy**
  - Similar warrant types but point distribution modified
  - 16 of 38 total points under new policy
  - 16 of 34 under previous policy

# Pedestrian Volume Point Warrants

**Previous Policy**

| Number of Pedestrians (Peak Hour) | Points |
|---|---|
| 0-10 | 0 |
| 11-30 | 2 |
| 31-60 | 4 |
| 61-90 | 6 |
| 91-100 | 8 |
| 100+ | 10 |
| Maximum | 10 |

**New Policy**

| Number of Pedestrians (Peak Hour) | Points |
|---|---|
| 10-25 | 4 |
| 26-50 | 8 |
| 51+ | 10 |
| Maximum | 10 |

**New Latent Demand Policy**

| | Condition | Points |
|---|---|---|
| (a) | It is in a commercial area. | 2 |
| (b) | The nearest controlled crossing is greater than 600 from it. | 2 |
| (c) | A pedestrian or shared use path is interrupted by a restricted crossing. | 3 |
| (d) | A pedestrian attracting land use is directly adjacent to it (schools, senior centers, transit stations, etc.) | 3 |
| | Maximum | 10 |

# General Conditions Point Warrants

| | | |
|---|---|---|
| 1. | Will clarify and define pedestrian routes across complex intersections. | Deleted |
| 2. | Will channelize pedestrians into a significantly shorter path. | Deleted |
| 3. | Will position pedestrians to be seen better by motorists. | Remains |
| 4. | Will position pedestrian to expose him/her to fewer vehicles | Deleted |
| 5. | Will legalize mid-block crossing where justified, between adjacent signalized intersections. | Remains |
| 6. | Is located within a PCOZ-zoned area. | Modified |
| 7. | Other factors. | Remains |
| 8. | Nearest controlled crossing is greater than 600-feet proposed crosswalk. | New |
| 9. | Bus stop is located on approach side of proposed crosswalk. | New |

# If Warrants are Met, Additional Treatments Must be Applied Based on ADT and Crossing Distance

## TABLE 3: CROSSING TREATMENT THRESHOLDS

| Crossing Distance[2] | Roadway ADT (vehicles per day) | | | | |
|---|---|---|---|---|---|
| | < 1,500 | 1,501 – 5,000 | 5,001 – 12,000 | 12,001 – 15,000 | > 15,000 |
| < 40’ | A | B | B | C | C / D[1] |
| 40’ to 52’ | A | B | C | C / D[1] | D |
| > 52’ | A | B / C[1] | C / D[1] | D | D |

1. For streets with more than one lane at an approach or posted speed limit 30 mph or greater.
2. Crossing distance can be measured to a pedestrian refuge island if one is present.

# TABLE 4: CROSSING TREATMENT OPTIONS

| *Traffic Control Requirements: Install a marked crosswalk and one or more of the following treatments.* | |
|---|---|
| **A** | **The following is required:**<br>• (W11-2) Pedestrian Warning Signage with the corresponding (W16-7P) arrow plaque |
| **B** | **At least one of the following is required:**<br>• (R1-6) State Law – Yield to Pedestrian sign if median is present<br>• Rectangular Rapid Flashing Beacons (RRFBs)<br>• Raised crosswalk or other traffic calming treatments if the City of San Diego's Traffic Calming Guidelines are met |
| **C** | **At least two of the following are required:**<br>• Radar Speed Feedback Signs<br>• Striping changes such as narrower lanes, painted medians, road diets, or other speed reducing treatments.<br>• RRFBs<br>• Staggered crosswalks and pedestrian refuge island<br>• Horizontal deflection traffic calming treatments[1] if the City of San Diego's Traffic Calming Guidelines are met |
| **D** | **A Traffic Signal is required if the CA MUTCD warrants are met and it is recommended by a traffic engineering study. Otherwise at least one of the following is required:**<br>• Pedestrian Hybrid Beacon if the CA MUTCD warrants are met<br>• Horizontal deflection traffic calming treatment[1] with RRFBs if the City of San Diego's Traffic Calming Guidelines are met |

1. Horizontal deflection treatments include, but are not limited to: roundabouts, pedestrian refuge islands, and pedestrian bulb-outs.

# Thank You

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