05

TECHNICAL APPENDIX

APPENDIX A: TASK 3 COLLISION MEMO

KITTELSON & ASSOCIATES
2 E CONGRESS STREET, SUITE 705
TUCSON, AZ 85701
P 520.544.4067 F 520.544.9616

MEMORANDUM

Date:	June 12, 2019	Project #: 23710
To:	Krista Hansen City of Tucson Department of Transportation 201 N. Stone Ave Tucson, AZ 85701	
From:	Felipe Ladron de Guevara and Erin Ferguson	
Project:	City of Tucson Pedestrian Safety Action Plan	
Subject:	Pedestrian Crash Data Analysis Summary	

INTRODUCTION

Kittelson & Associates, Inc. (Kittelson) has been retained by the City of Tucson Department of Transportation (TDOT) to prepare a Pedestrian Safety Action Plan (PSAP) to reduce pedestrian crashes and increase pedestrian safety on the transportation network.

This memorandum summarizes pedestrian crash analysis including the identification of high-injury locations, social equity analysis, and the identification of pedestrian crash risk factors. These findings will be the basis of the forthcoming location prioritization and countermeasure identification stages of the PSAP. This memorandum is organized as follows:

- **Descriptive Crash Statistics:** This section describes high-level pedestrian crash trends, as identified by variables in the crash data provided by the City of Tucson and by associating available spatial data (e.g., roadway characteristics, intersection control type) with crashes.
- **Network Screening:** This section describes network screening process conducted to find high-injury locations (intersections and roadway segments) in Tucson.
- **Pedestrian Crash Risk Factors:** This section uses the on the high-injury location analysis to find roadway, land use, or behavior characteristics most associated with risk. Risk factors can be used to identify locations where crashes have not yet occurred to make proactive safety improvements.
- **Social Equity Analysis:** This section describes social equity analysis conducted to associate high-injury locations with populations that experience a relative transportation disadvantage.
- **Summary of Findings:** This section summarizes the major findings of this memorandum.
- **Next Steps:** This section outlines the next steps in the Pedestrian Safety Action Plan.

DESCRIPTIVE CRASH STATISTICS

Data and Approach

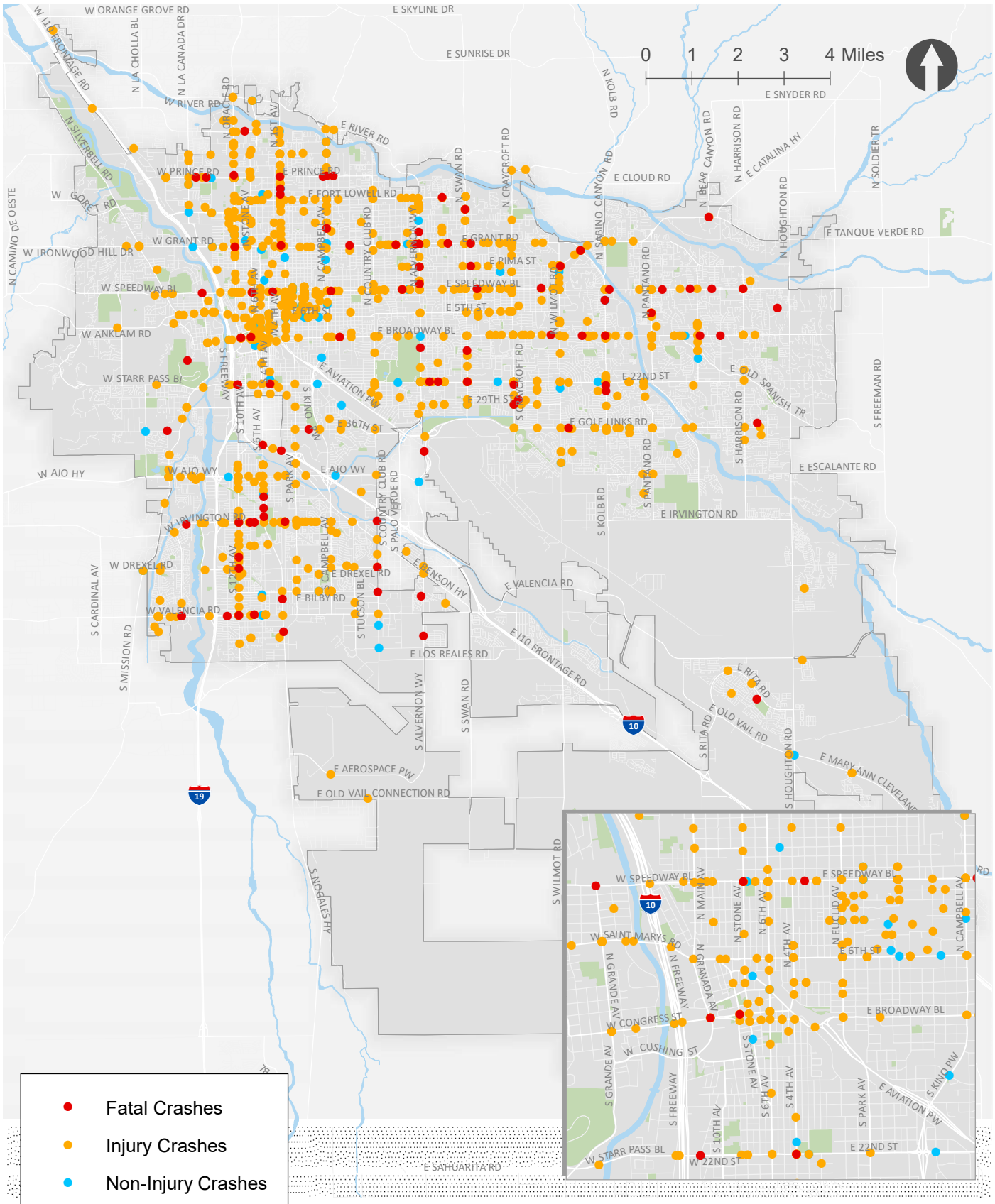
Kittelson, with assistance from the City of Tucson, created a database of the most recent (5) years of reported crashes (January 1, 2014 to December 31, 2018). The City of Tucson provided the crash data in three datasets, each at a different level of analysis: incidents (the crash level), units (the vehicle level), and occupants (the individual level). Each record for the three datasets contains a crash identification number which may be used to link crashes across the three databases to assemble a complete picture of each crash record.

Kittelson filtered the crash data to include only pedestrian-involved crashes within the City of Tucson limits. A total of 1,137 pedestrian crashes were identified based on the City's Uniform Crime Reporting (UCR) code and another 63 crashes had an occupant classified as a pedestrian. Combining these two categories brought the total number of pedestrian crashes analyzed to 1,200. Throughout this memorandum, "crashes" refers to these 1,200 reported pedestrian crashes included in the database unless otherwise noted.

Kittelson imported the crash data into a spatial database using GIS software by utilizing the provided latitude and longitude location data within the crash records. Kittelson spatially joined the crash data to the available roadway network data provided by the City of Tucson to map roadway attributes to individual crashes for analysis. Kittelson added roadway data including posted speed limits and functional classification and other spatial information like the distance to transit stops and parks the crash data for each incident record. The pedestrian crash locations by crash severity are presented in Figure 1.

Many of the findings presented in this memo are extracted from attributes and variables in the crash data, while others are taken from spatial analysis conducted based on crash location (i.e., associating roadway characteristics to crashes). Crash data inherently rely on the judgment of the reporting officer at the scene or on details obtained in a follow-up investigation. As such, these data are imperfect. For example, many factors influence crashes, but a single contributing factor is often attributed to a crash for the purposes of reporting. Thus, the descriptive statistics presented in this memorandum rely upon these data with the understanding that they may be incomplete or imperfect. In certain instances when a data attribute is incomplete or otherwise appears unreliable, we have not reported findings.

For findings based on our spatial analysis, Kittelson used the underlying roadway characteristics of the roadways based on the reported location of crashes (e.g., 20 feet east of an intersection). These analysis results are as reliable as the reported location. Kittelson opted not to use some available spatial data after checking data attributes against real-world characteristics, either because the data appeared to be unreliable or because the data were sparse.



Pedestrian Collisions
City of Tucson, AZ

Figure
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Coordinate System: NAD 1983 HARN StatePlane Arizona Central FIPS 0202 Feet Intl

Findings

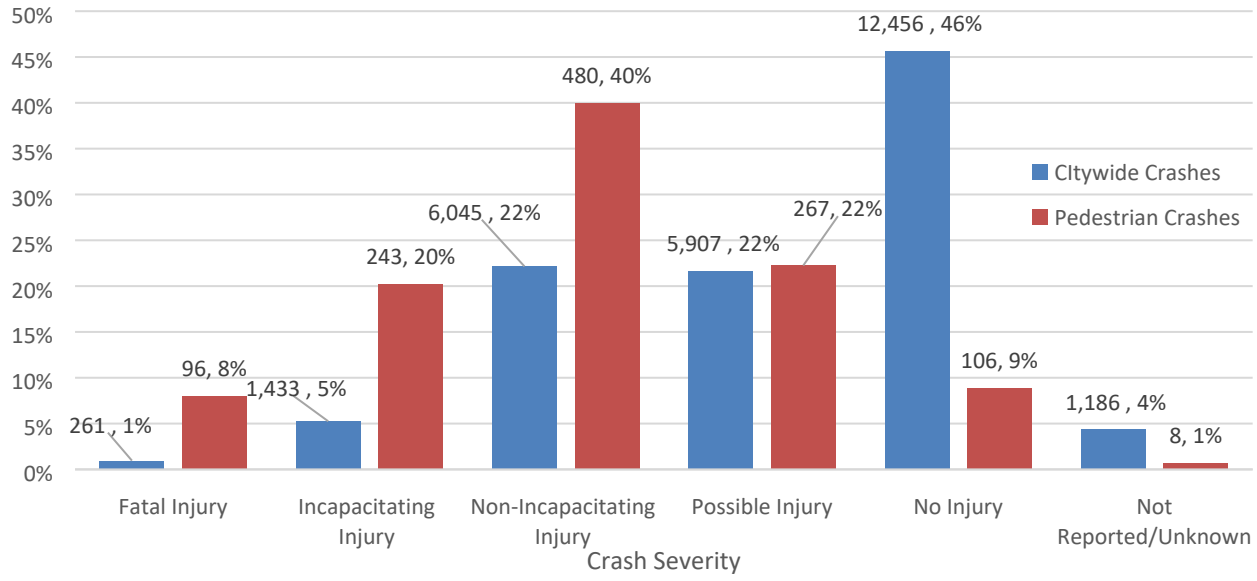
Kittelson analyzed the assembled crash and roadway data to develop citywide descriptive statistics for pedestrian crashes, including the following attributes:

- Crash severity
- Time of day
- Driver and pedestrian actions
- Crash location and roadway characteristics
- Pedestrian characteristics

Crash Severity

Exhibit 1 summarizes crashes by severity. Severity is defined by the most severe injury experienced in the crash. Exhibit 1 compares the share of injuries among pedestrian crashes compared to citywide reported crashes for all modes.

Exhibit 1: Pedestrian Crash Severity by Mode



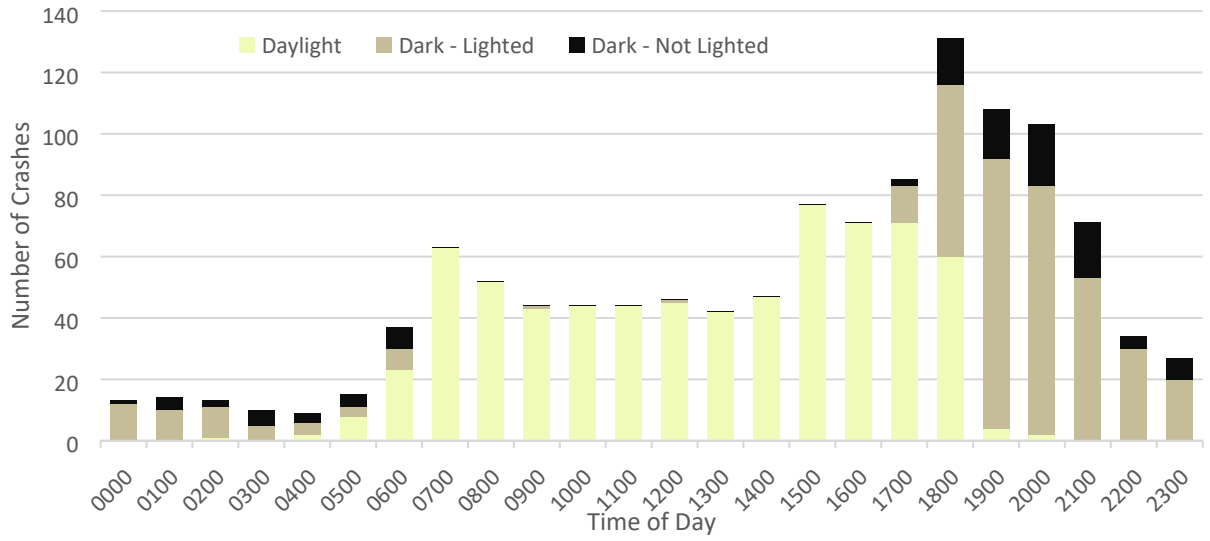
Source: City of Tucson, 2014-2018

- Overall, 90% of pedestrian crashes result in a fatality or injury with 28% resulting in a fatality or incapacitating injury.
- Pedestrian crashes are over four times more likely to result in a fatal and incapacitating injury outcome than citywide crashes for all modes (28% compared to 6%).
- The 1,200 pedestrian-related crashes involved 1,253 pedestrians, with 96 fatalities and 246 incapacitating injuries.

Time of Day

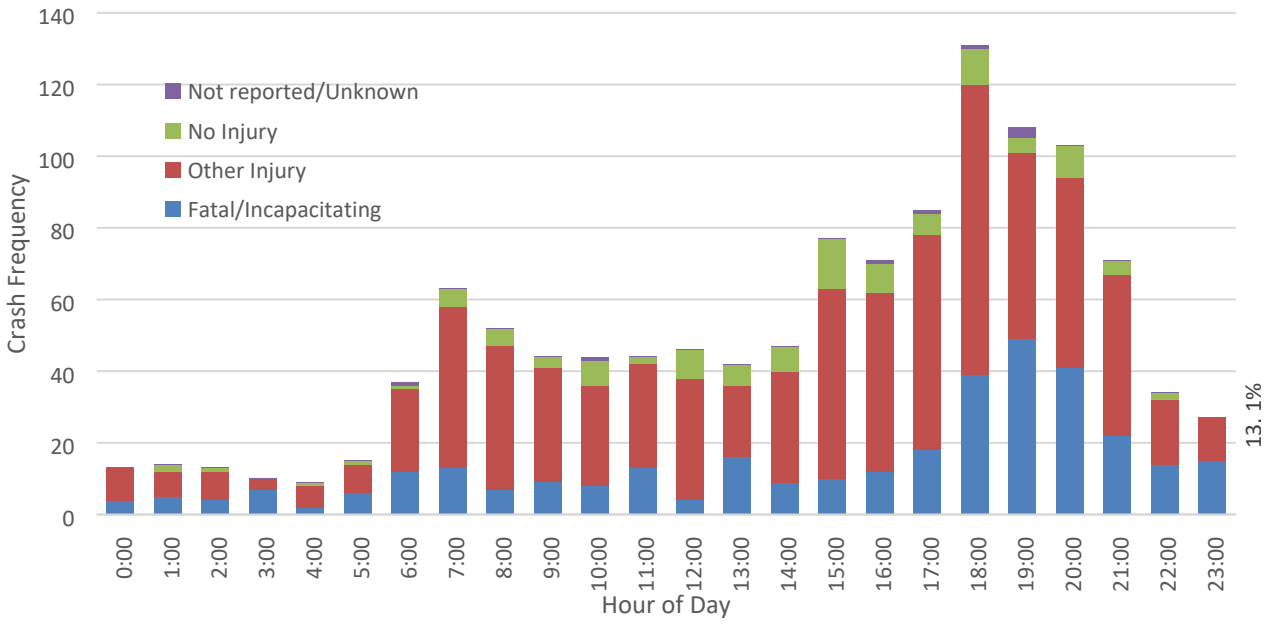
Exhibit 2 presents crashes by time of day and lighting condition. Exhibit 3 presents crashes by severity and time of day. The fatal/incapacitating crashes are displayed at the bottom of each column to facilitate for comparison of those crashes by hour.

Exhibit 2: Pedestrian Crashes by Time of Day



Source: City of Tucson, 2014-2018

Exhibit 3: Pedestrian Crashes and Severity by Time of Day



Source: City of Tucson, 2014-2018

- Over one-third of crashes (34%) occurred between 6 and 10 p.m. during primarily dark conditions.
- Over half of crashes (53%) occurred during daylight conditions.
- Eight percent (8%) of crashes occurred in dark conditions without lighting.
- Between 7:00 PM and 6:00 AM, 40% of pedestrian crashes are fatal/incapacitating—notably higher than the overall pedestrian crash share (29%):

Driver and Pedestrian Actions

Table 1 and Table 2 summarize the reported driver and pedestrian violations or behaviors for each crash, respectively. Where multiple violations or behaviors were recorded, only the first one was used as the officer at the scene deemed to be the primary violation. Where the reported violation is "no improper action," the responding officer did not cite the participant in the crash.

Table 1: Reported Driver Violations or Behaviors

Reported Violation	Number of Crashes	Percent
No Improper Action	499	39%
Failed to Yield Right-of-Way	433	34%
Speed Too Fast for Conditions	40	3%
Disregarded Traffic Signal	23	2%
Inattention / Distraction	20	2%
Made Improper Turn	14	1%
Failed to Keep in Proper Lane	12	1%
Followed Too Closely	5	<1%
Ran Stop Sign	5	<1%
Unknown	168	13%
Other	57	4%

Source: City of Tucson, 2014-2018

Table 2: Reported Pedestrian Violations or Behaviors

Reported Violation	Number of Crashes	Percent
No Improper Action	663	53%
Did Not Use Crosswalk	285	23%
Unknown	159	13%
Other	50	4%
Disregarded Traffic Signal	44	4%
Failed to Yield Right-Of-Way	41	3%
Inattention / Distraction	5	<1%

Source: City of Tucson, 2014-2018

From Tables 1 and 2, the following points can be made:

- Driver violations/behaviors were cited in at least 48% of crashes with failure to yield right of way, representing 34% of pedestrian crashes.
- Pedestrian violations/behaviors were cited in at least 34% of crashes; "Did not use crosswalk" was the leading violation type (23% of reports).

Other relevant violations included in the data:

- Two hundred sixty-five (265) crashes (22%) were hit and runs.
- Twenty-five (25) drivers (2%) and 102 pedestrians (9%) were reported to be under the influence of drugs or alcohol.

Crash Location and Roadway Characteristics

This section includes analysis of crashes by location and roadway characteristics, including:

- Pedestrian location
- Traffic control
- Speed
- Roadway Functional Classification

Pedestrian Location

Table 3 presents crashes by location relative to intersections and crosswalks. Kittelson analyzed the location as recorded in the provided crash data, so these locations represent the conclusion of the reporting officer or associated investigation.

Table 3: Pedestrian Crashes by Pedestrian Location

Pedestrian Location	Number of Crashes	Percent
Marked Crosswalk at Intersection	487	39%
In Roadway (Not in Crosswalk/Intersection)	383	31%
At Intersection but No Marked Crosswalk	138	11%
Sidewalk	71	6%
Driveway Access Crosswalk	36	3%
Unknown	31	2%
Non-Intersection Crosswalk	30	2%
Other	24	2%
Shoulder	15	1%
Roadside	12	1%
Outside of Trafficway	11	1%
Inside Building	5	<1%
School Crosswalk	4	<1%

Source: City of Tucson, 2014-2018

- Pedestrian crashes occurred primarily at intersections: 45% of crashes occurred in marked crosswalks and another 9% occurring off the roadway (Table 3).
- Pedestrians were reported as crossing outside a crosswalk in 31% of crashes.

Traffic Control

Table 4 presents intersection crashes by the type of traffic control at the intersection. Kittelson identified all crashes reported within 250 feet of an intersection as *intersection crashes*.

Table 4: Pedestrian Crashes by Traffic Control

Traffic Control	Number of Crashes	Percent
Traffic Signal	608	54%
Unsignalized	452	40%
HAWK/Pedestrian Hybrid Beacon	55	5%
Toucan	3	<1%
Red Flasher	3	<1%
Railroad Beacon	1	<1%
Pelican Beacon	1	<1%

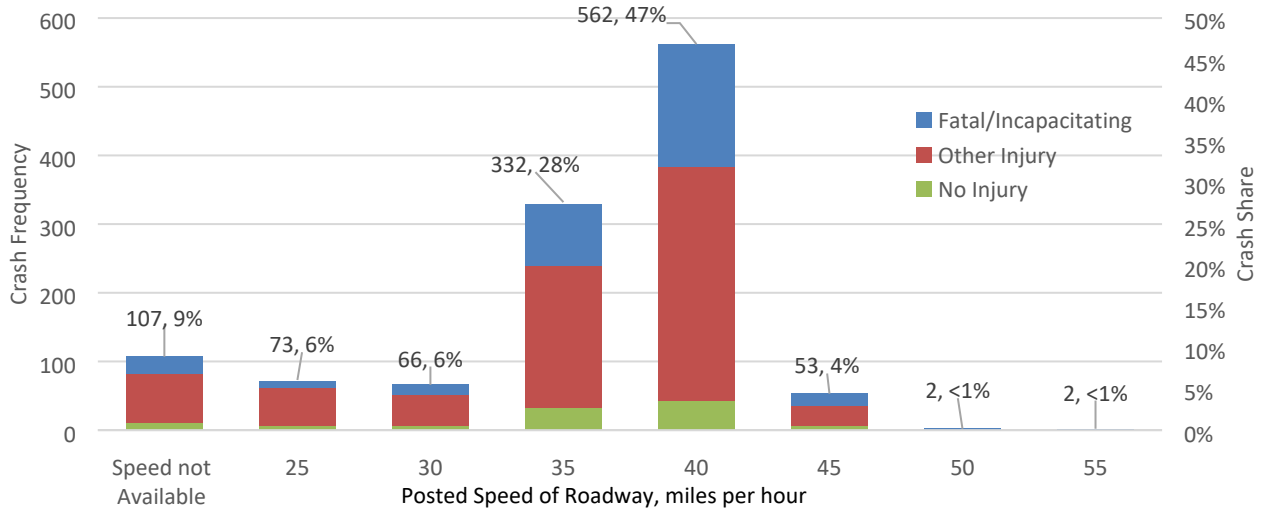
Source: City of Tucson, 2014-2018

- Just over one half of crashes (54%) occurred at signalized intersections, while HAWK/Pedestrian Hybrid Beacons and other beacons only accounted for 5% of crashes.
- Seventy percent (70%) of crashes occurred within 300 feet of a Sun Tran or Sun Link stop.

Speed

Exhibit 4 presents pedestrian crash severity (consolidated into fatal/incapacitating, minor injury, and no injury reported) by the posted speed limit. Kittelson associated crashes with the underlying roadway data to attribute the posted speed to each crash. For intersection crashes, the highest roadway posted speed is presented.

Exhibit 4: Pedestrian Crash Severity by Posted Speed

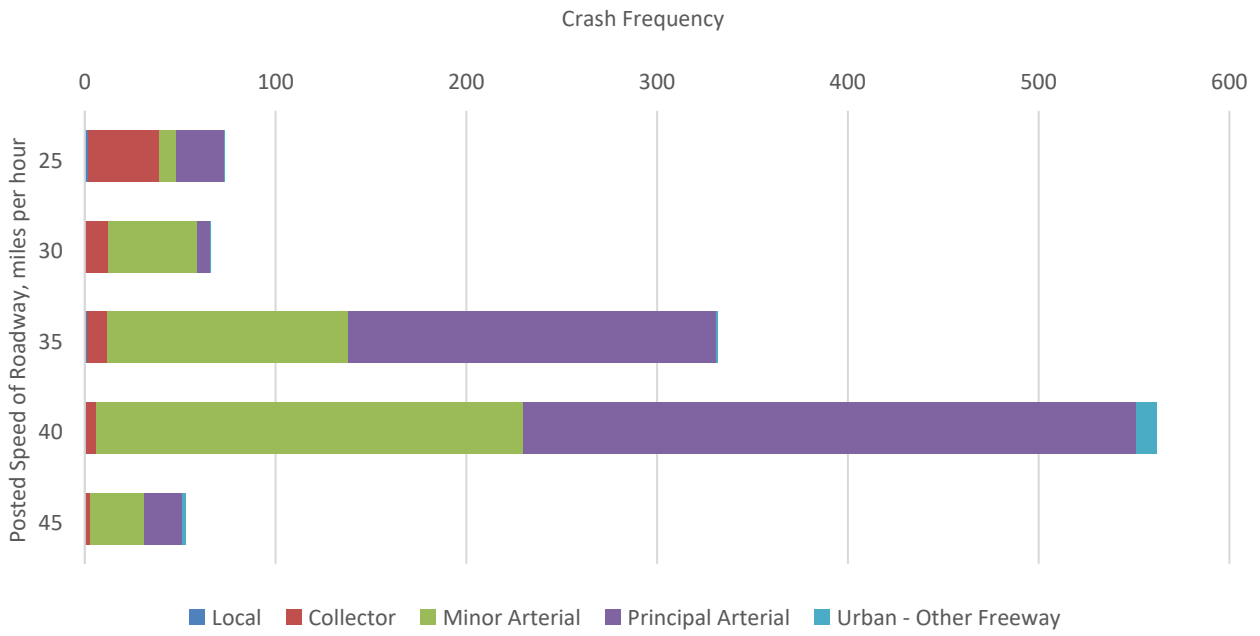


Note: Posted speed of highest-speed roadway is presented if crash occurred at an intersection.
Source: City of Tucson, 2014-2018

- The majority of crashes (75%) occur on roadways with posted speeds of 35 and 40 miles per hour.
- Between 25 and 50 miles per hour, the share of fatal/incapacitating injuries increases with posted speed. The share of fatal/incapacitating injury crashes at roadways with 25 mile-per-hour posted speed is 14%; at 45 miles per hour the share is 34%.

Because there are a variety of roadway types and functional classifications that may have the same posted speed, Kittelson also compared the crashes on roadways with a given posted speed to the corresponding functional classification of the roadways.

Exhibit 5 Pedestrian Crashes per Type of Roadway



Note: Posted speed of highest-speed roadway is presented if crash occurred at intersection
Source: City of Tucson, 2014-2018

- Among crashes occurring on or at roadways with 40 or 45 mile-per-hour posted speed, the share at arterials was 97% and 91%, respectively. For 45 mile-per-hour roadways, the remainder of crashes were along or at roadways classified as O*ther Urban Freeway*.[1]
- Among crashes occurring on 25 mile-per-hour roadways, 51% were along or on collector roadways.

Roadway Functional Classification

Kittelson used the functional classification of roadways to classify where crashes occurred. Using the spatial location of crashes, Kittelson attributed the functional classification of the associated roadway to each crash. For crashes at intersections, the higher-classification roadway is displayed. They are presented, in order, in Table 5.

[1] All but one of the crashes along or at *urban other freeway* roadways were on Golf Links Road; the remaining crash was within the influence area of the Aviation Parkway ramp.

Table 5: Pedestrian Crashes by Roadway Functional Classification

Roadway Classification	Number of Crashes	Share of Crashes	Fatal/Incapacitating Crashes	Share of Fatal/Incapacitating Crashes	Percentage of Centerline Miles in Tucson
Local	101	8%	25	7%	77%
Collector	70	6%	13	4%	12%
Minor Arterial	436	36%	130	39%	8%
Principal Arterial	567	48%	164	49%	3%
Urban Other Freeway	14	1%	5	1%	<1%

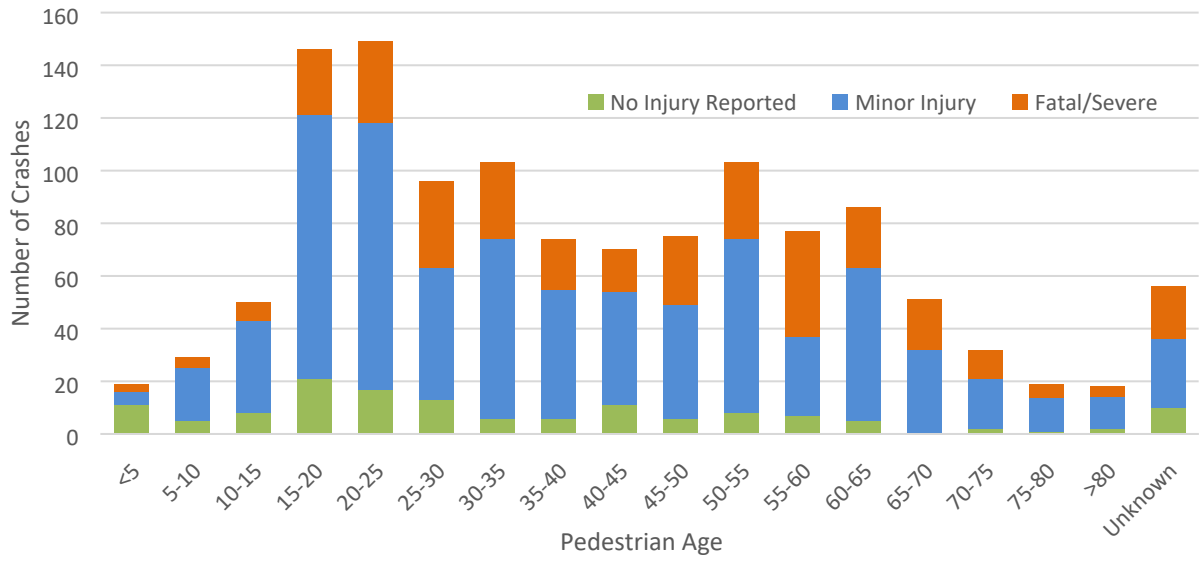
Note: Due to rounding, percentages may not sum to exactly 100%.
Source: City of Tucson, 2014-2018

- More crashes occurred on or at principal arterial roadways (48%) than on any other roadway type; this share far outweighs the relative proportion of the roadway that principal arterials constitute by centerline miles (3%).
- The share of crashes resulting in death or incapacitating injury on each roadway functional classification type (not shown) varied between 19% (13 of 70 crashes) on collector roadways to 36% on roadways classified as *urban other freeway*.
- Eighty-seven percent (88%) of fatal/incapacitating pedestrian crashes occur on or at minor or principal arterial roadways, which collectively comprise 11% of centerline miles in Tucson.

Pedestrian Characteristics

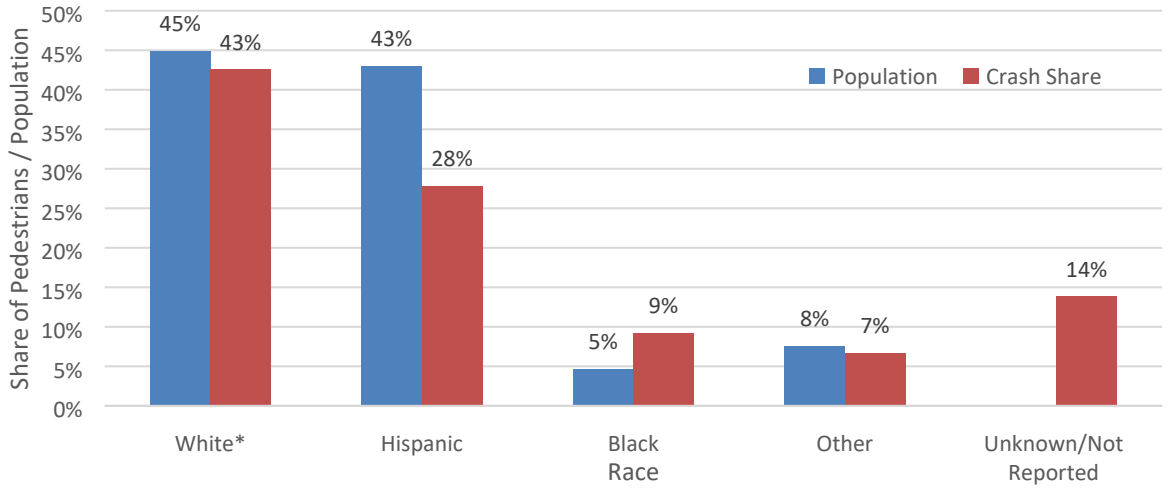
Kittelson analyzed pedestrian crashes by the characteristics of the people involved. Findings are presented in in Exhibit 6 and Exhibit 7.

Exhibit 6: Pedestrian Crashes by Pedestrian Age and Crash Severity



Source: City of Tucson, 2014-2018

Exhibit 7: Crashes by Pedestrian Race and Gender



*For population data, *White* indicates non-Hispanic White; and *Black* indicates non-Hispanic Black. Among crash data, race is reported by the given categories; with no distinction among Hispanic/non-Hispanic.
Source: City of Tucson, 2014-2018; American Community Survey Five-year data, 2017

- Pedestrians between the ages of 15 and 24 are overrepresented in crashes, accounting for 25% of crash participants, but only 19.5% of the Tucson population.[2]
- Pedestrians involved in crashes appear to be represented in rough proportion to their share of the Tucson population. Note that the crash data do not make a distinction between Hispanic and non-Hispanic White, and the discernment between racial identity is not straightforward in crash reporting.
- Kittelson also analyzed pedestrians in crashes by gender. Males account for 60% of crashes where gender was reported.

SPATIAL ANALYSIS

Data and Approach

This section describes the network screening and systemic evaluation of the Tucson roadway network. Kittelson used a buffer distance of 250 feet to define the intersection influence area; crashes within 250 feet of an intersection were associated with that location, and the remaining crashes were associated with the roadway segment on which they occurred.

[2] Source: American Community Survey Five-year data, 2017

Kittelson identified the intersections and segments with the highest severity-weighted crash frequency using the Equivalent Property Data Only (EPDO) network screening performance measure from the AASHTO *Highway Safety Manual* (HSM). We performed the EPDO screening calculation for all intersections and roadway segments within the City. The EPDO performance measure is described below.

Equivalent Property Damage Only Methodology

The EPDO performance measure assigns weight to individual crashes based on the severity of the crash. The weighting is based on the relative differences in crash costs by crash severity, giving each crash a relative score in terms of the equivalent number of PDO crashes. These weights, shown below, are based on the Oregon Safety Priority Index System (SPIS) scoring method, which assign weights of 100 to fatal and incapacitating crashes and 10 to other injury crashes.

- **Fatal and Incapacitating Injury Crashes:** 100 points
- **Non-incapacitating and possible injury crashes:** 10 points
- **Non-injury crashes:** 1 point

The weights provide an order of magnitude difference between the societal costs of fatal and severe injury crashes versus non-severe injury crashes. Note that the weighting factors intentionally weigh fatal and severe injury crashes equally. This is done to recognize that the difference between a crash resulting in a fatality or severe injury is often a function of the individual involved rather than the circumstances of the crash itself.

Intersection Analysis Methodology and Findings

Kittelson first identified intersections in the Tucson road network. During this process, intersections created by driveways were removed and minimally offset intersections were consolidated into a single nodes. Intersections where on- and off-ramps met local streets were retained.

Crashes within 250 feet of each intersection were spatially joined and summarized in ArcGIS to show the total number of crashes by severity at each intersection. Where intersections were less than 500 feet from each other, crashes were assigned to the nearest of the two intersections. Crashes occurring more than 250 feet from any intersection were separated to be used in the segment analysis discussed below. Out of the 1,200 crashes in the database, 1,124 (94%) were within 250 feet of an intersection.

Kittelson calculated the EPDO score for the intersections by multiplying each crash severity total by the associated weight and summing the results, using the following formula:

> **EPDO Score** = 100 * (# of fatal crashes + # of incapacitating injury crashes) + 10 * (# of *non-incapacitating injury* crashes # of *possible* injury weight crashes) + non-injury crashes

Kittelson annualized the EPDO score by dividing the score by the number of years (5) of crash data used in the analysis. Figure 2 presents the results of the EPDO screening.

High-Injury Intersections

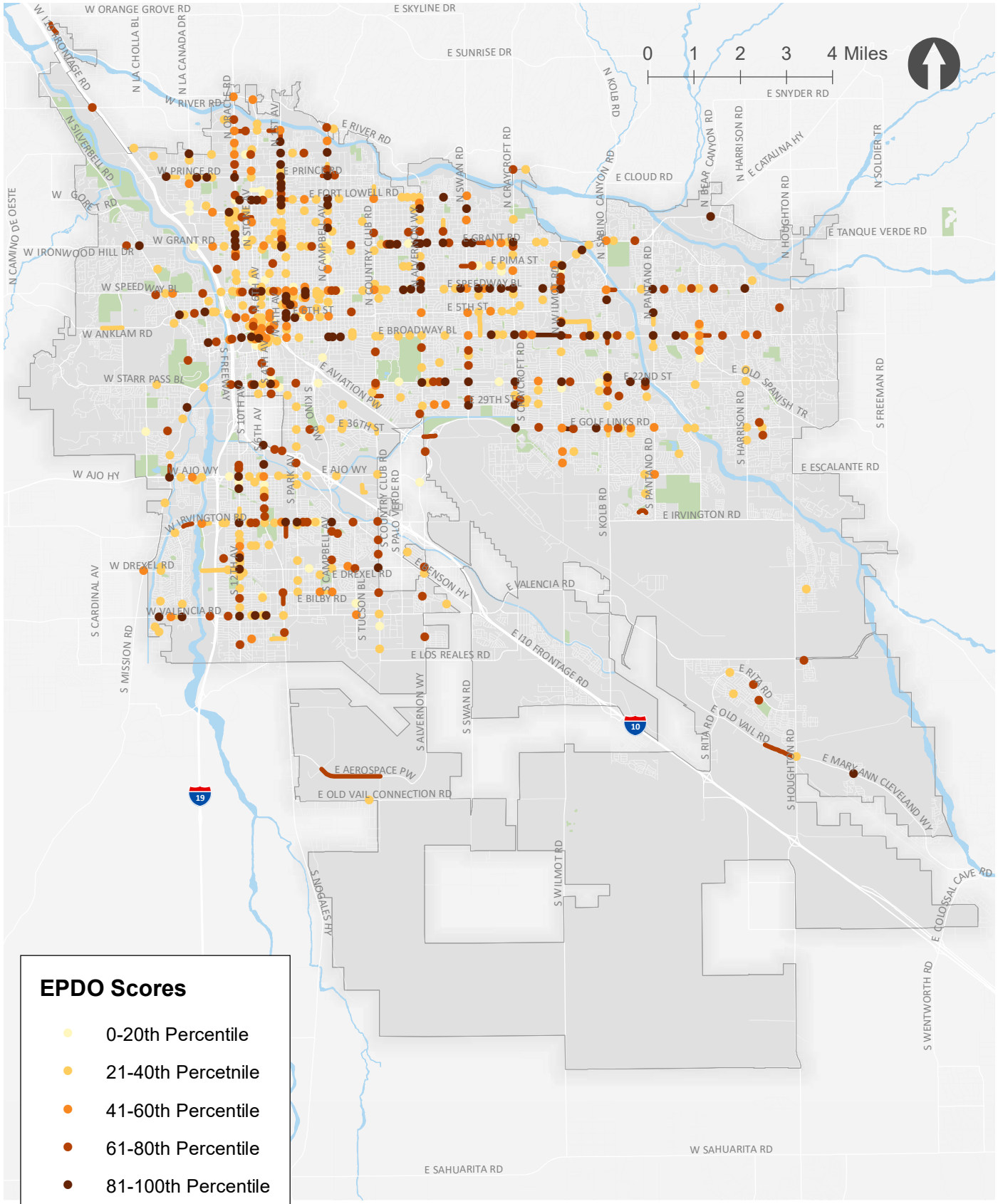
Figure 3 presents identified high-injury intersections. Among intersections EPDO scores ranged from zero (no crashes during the five-year time frame analyzed) to 134. Among 647 intersections with a crash history over the five-year period, 120 high-injury locations represent the highest 19% of EPDO scores with an EPDO score of 20.2 or higher. For context, a score of 20.2 translates to one fatal or severe injury crash plus one no-injury crash over the five-year period. Within the identified high-injury intersection locations, we subclassified "Tier 1" (higher score) and "Tier 2" (lower score) locations. Tier 1 locations are intersections with an EPDO score of 30 or greater; there are 54 such locations (8% of all intersections with crash history). "Tier 2" locations were intersections with an EPDO score greater than 20 and less than 30. A complete list of high-injury intersections is included in Appendix A.

Segment Analysis Methodology and Findings

After completing the intersection analysis, Kittelson took the remaining crashes that occurred more than 250 feet from the nearest intersection (6% of total) and completed a separate segment analysis. We analyzed street segments between intersections and spatially joined non-intersection crashes to each segment. Similar to the intersection methodology above, we summarized the crashes by severity, and multiplied the totals by the EPDO weights for roadway segments. The weighted EPDO scores of the crashes were totaled and annualized by the number of years of crash data (5) to generate an annualized EPDO score. Figure 2 presents the results of the EPDO screening.

High-Injury Segments

Figure 3 presents identified high-injury roadway segments. For roadway segments, the EPDO scores ranged from zero to 40. Three segment locations were identified as high-injury locations with scores of 20.2 or above. Because there were relatively few segment crashes compared to intersection crashes, we used the intersection high-injury and tiering thresholds to define high-injury for segment locations rather than to identify percentiles within roadway segment results. The list of high-injury roadway segments is presented in Appendix A.



EPDO Scores

- 0-20th Percentile
- 21-40th Percetnile
- 41-60th Percentile
- 61-80th Percentile
- 81-100th Percentile
- Parks
- City of Tucson

Safety Screening
City of Tucson, AZ

Figure **2**

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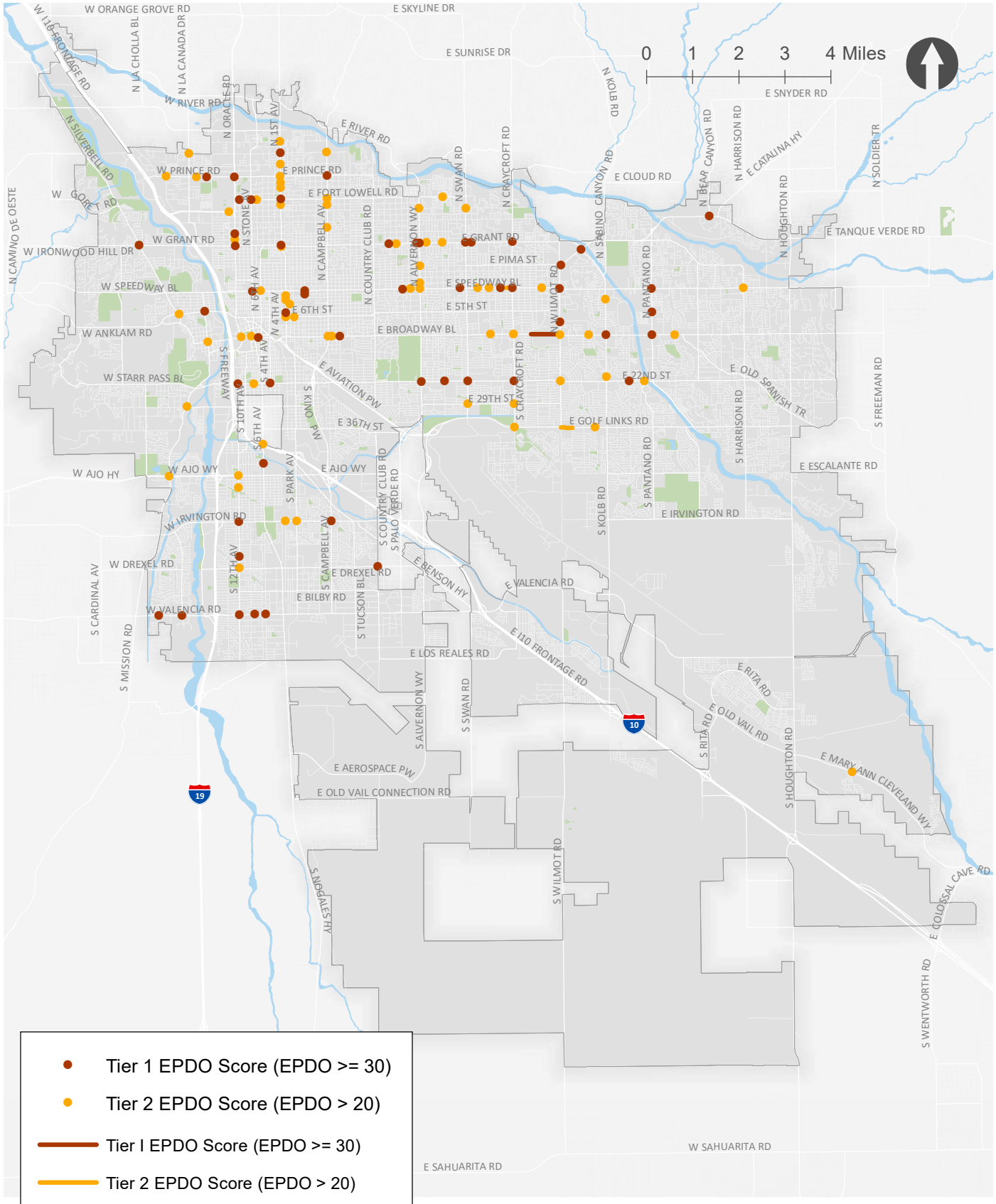

High Injury Locations
City of Tucson, AZ

Figure **3**

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PEDESTRIAN CRASH RISK FACTORS

Data and Approach

Kittelson conducted a risk-based analysis of locations identified through the intersection and roadway segment network screening. For the memorandum, risk is defined as common traffic or physical characteristics shared by the top segments and intersections. Based on this commonality, the presence of risk factors is indicative of a potentially higher risk for pedestrian crashes in Tucson. This analysis does not prove causality; its goal is to show potential connections and contributing factors.

The risk factors will be used in the PSAP to assist in identifying treatments to reduce the frequency and severity of pedestrian crashes as part of projects within the city. These risk factors can also be used to identify additional locations where crashes have not yet been reported. The location of crashes is to a degree inherently random; therefore, this methodology is intended to help address potential causes of crashes rather than simply respond to crashes that have already occurred. These results can help identify opportunities to implement low-cost improvements to locations that contain risk factors to proactively treat them. These risk factors should also be considered as new development and transportation nodes are added in the city to proactively integrate treatments that address potential risks for pedestrians.

In our evaluation, we considered:

- Roadway geometry
- Number of vehicle lanes
- Posted speed
- Median presence
- Traffic signal and pedestrian signal locations
- Transit stop presence
- Roadway lighting
- Intersection type
- Presence of marked crosswalks

Kittelson reviewed the roadway characteristics among the high-injury locations to help determine potential risk factors for intersections and roadway corridors. Roadway characteristics were identified for locations using Tucson's centerline geographic shapefile. We used the available roadway data, supplemented with review of locations with Google Earth.

Findings

The high-injury locations include three arterials segments and 120 intersections. Seventy-four of the intersections are signalized and seven have HAWK beacons. The remaining 39 intersections are unsignalized.

Intersection Risk Factors

Based on our review of the intersection characteristics present across the top intersections, we identified the following characteristics as intersection risk factors:

- Locations within 200 feet of at a Sun Tran stop.
- Signalized intersections with four and six lane roadways of 35 or 40 miles per hour.

Segment Risk Factors

A review of the crashes at the three high-injury segments indicated the following risk factors for non-intersection crashes:

- Six-lane roadways
- Locations within 300 feet of a Sun Tran stop and more than 2,000 feet from a marked crosswalk

EQUITY ANALYSIS

Kittelson used 2017 five-year American Community Survey (ACS) data available at the Census block group level to evaluate the results of the safety screening with respect to social equity. To evaluate social equity we used a transportation disadvantaged population index (TDP) that scores a geographic area (in this case, Census block groups) with respect to the concentration of the population that may be at a disadvantage from a socio-economic and/or transportation mobility perspective.

Data and Approach

The TDP index incorporates a number of demographic and socioeconomic factors to identify populations with overlapping determinants of economic disadvantage. Specifically, the measure uses 2017 ACS five-year data at the block group level to identify the following attributes:

1. Communities of Color (All races other than white, non-Hispanic)
2. Low Income Population (Less than 200% of Federal Poverty line)
3. Limited English Proficiency Population (limited English-speaking households)
4. Zero-vehicle Households
5. Seniors Over Age 75
6. Youth Under Age 10
7. Persons with a Disability
8. Single-Parent Families
9. Overburdened Renters (Paying at least 40% of monthly income in rent)

To calculate the TDP index, we converted the family- or household-level variables to person-units using the average family or household size for each block group. We then summed the nine population values

and divided by the total population of the block group to generate the preliminary index value. The equation used to develop the segment transportation disadvantaged index value is shown below:

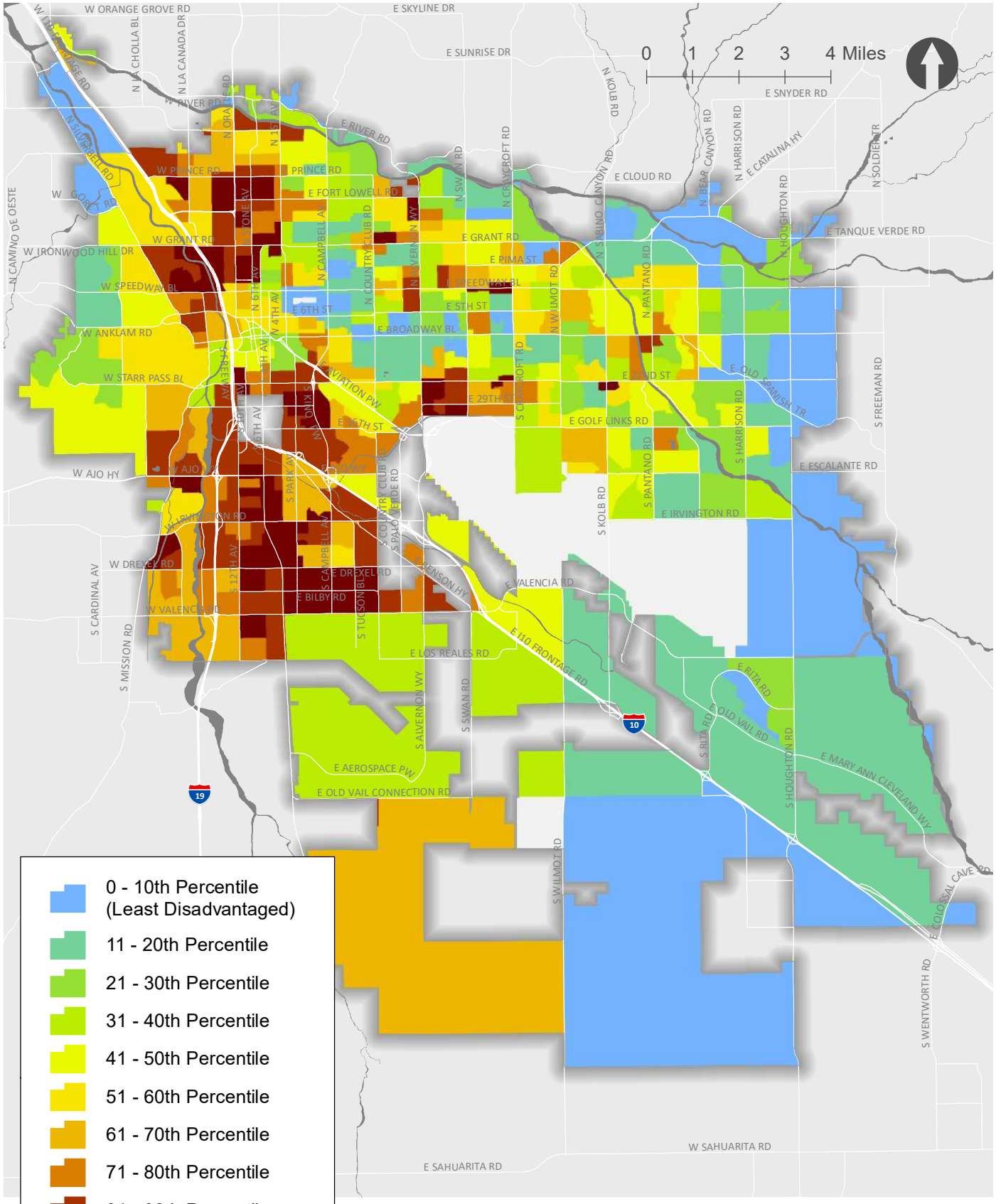
$$Equity\ \ Index = \frac{(Eld + Yth + NH + Pov + (HH(Veh + Fam + Rent + LEP) + Dis)}{Pop}$$

where:
Eld = # of residents over 75
Yth = # of residents under 10
NH = # of residents who identify as non-white or Hispanic (communities of color)
LEP = # of households identified as speak English "not well" or "not at all"
Pov = # of residents with income under 200% of poverty level
HH = Average household size within the block group
Veh = # of households with 0 vehicles
Fam = # of single-parent families
Rent = Overburdened renters
Dis = # of residents with a disability
Pop = Total population

Because an individual can meet more than one of the qualifying attributes (e.g., a person could be living in poverty and be in a single-parent household), the index intentionally counts individuals multiple times to generate an index that evaluates the relative equity disadvantage of the block group. Thus, the highest theoretical score for an index block group would be 8 if every person and household met every possible criteria.[3]

The Census block groups are displayed by their relative transportation disadvantage index value (in percentile) in Figure 4. Higher percentiles (representing greater disadvantage) are generally prevalent in the central and southern portions of the City. In the central part of the city, an important concentration of block groups representing great disadvantage areas are located between Fairview Avenue and 1st Avenue, south of Prince Road and north of Speedway Blvd. In the southern portion of the city, a large number of block groups representing great disadvantage areas are bordered by Interstate 19 to the west, Interstate 10 to the east and Valencia Road to the south.

[3] Although there are nine criteria, the *elderly* and *youth* variables are mutually exclusive. A person could meet a maximum of eight criteria.



Transportation Disadvantaged Score by Census Block Group City of Tucson, AZ

Figure **4**

Coordinate System: NAD 1983 HARN StatePlane Arizona Central FIPS 0202 Feet Intl

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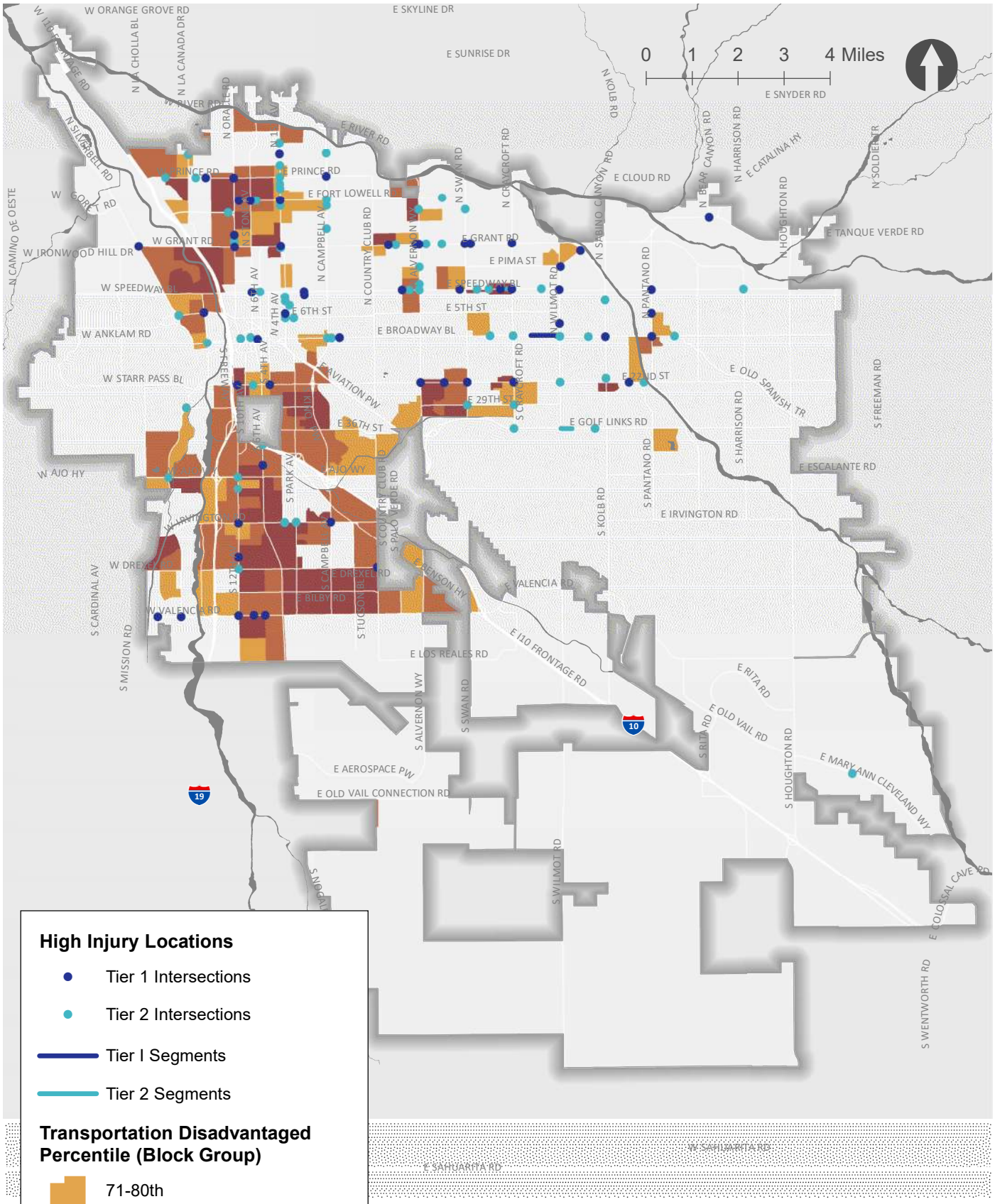
Findings

Block groups were also evaluated with respect to the presence of high-injury locations. Kittelson summed the number of high-injury intersections and segments within each block group and compared each block group's EPDO score with its TDP index score. This overlay is presented in Figure 5.

We identified high-injury and disadvantage locations based on the presence of a high relative TDP score (in the top 30% among block groups) and the presence of at least one high-injury location. Figure 6 presents these block groups, which represent high transportation-disadvantaged populations and high crash severity areas. The largest areas include:

- Neighborhoods east of Interstate 10, west of Flowing Wells and north of Prince Road;
- Areas between Fairview Avenue to the west, 1st Avenue to the east, Prince Road to the north and Grant Road to the south,
- Neighborhoods west of Interstate 10 (Santa Cruz River) between Speedway Boulevard and Grant Road;
- Areas adjacent to Interstate 19 between Interstate 10 and Valencia Road. Note that block groups include vacant and commercial areas west of Interstate 19;
- Neighborhoods on 22nd Street between Interstate 10 and 4th Avenue;
- Areas surrounding Speedway Boulevard between Alvernon Way and Craycroft Road;
- Neighborhoods west of Alvernon Way between Fort Lowell Road and Speedway.



High Injury Locations

- Tier 1 Intersections
- Tier 2 Intersections
- Tier I Segments
- Tier 2 Segments

Transportation Disadvantaged Percentile (Block Group)

- 71-80th
- 81-90th
- 90-100th (Most Disadvantaged)

Disadvantaged Block Groups and High-Injury Locations City of Tucson, AZ

Figure **5**

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Coordinate System: NAD 1983 HARN StatePlane Arizona Central FIPS 0202 Feet Intl

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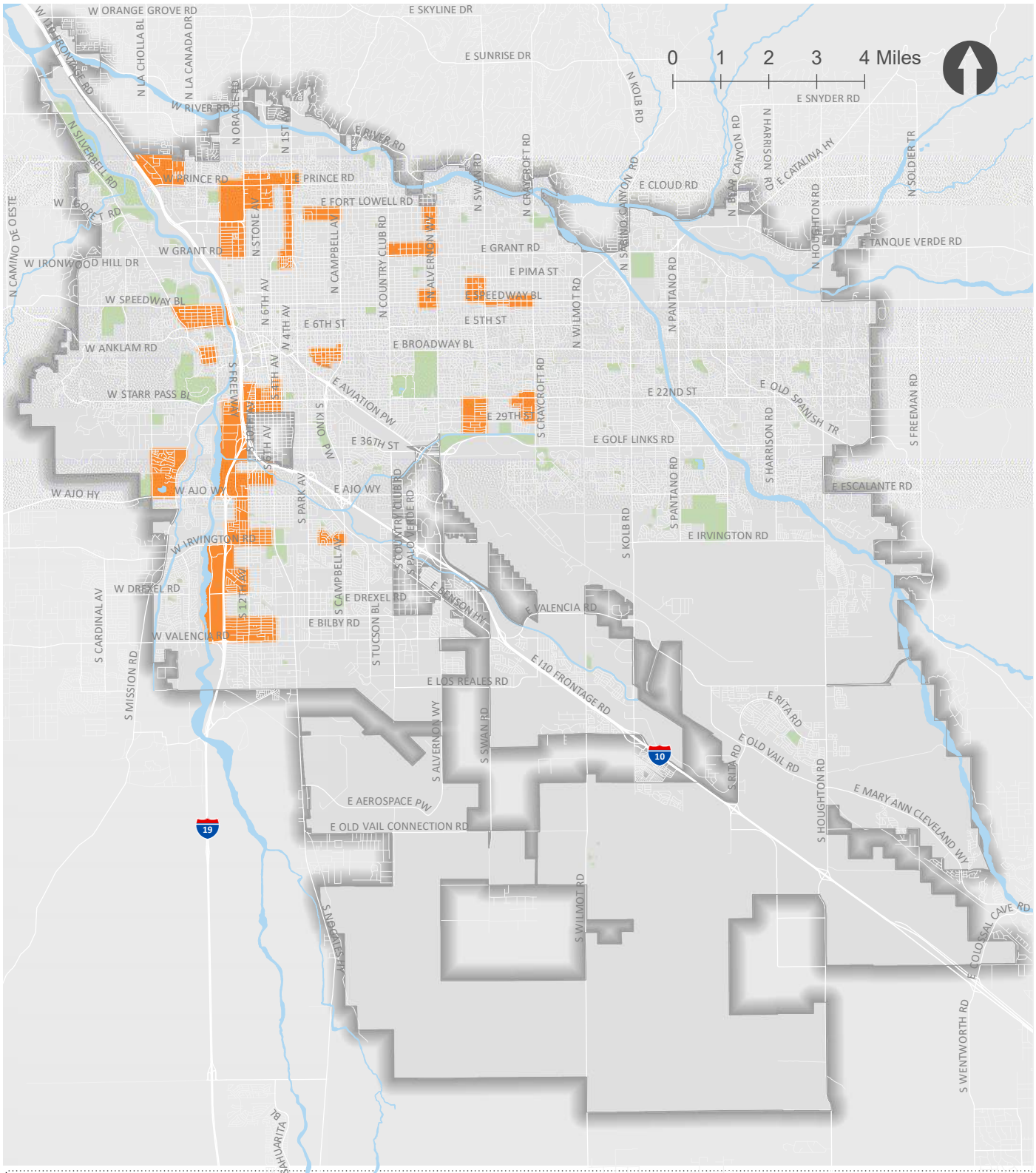

High Crash and Disadvantaged Block Groups

Parks

City of Tucson

High Crash and Disadvantaged Block Groups City of Tucson, AZ

Figure **6**

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Coordinate System: NAD 1983 HARN StatePlane Arizona Central FIPS 0202 Feet Intl

SUMMARY OF FINDINGS

This section provides an overall summary of key findings related to our descriptive and spatial analysis.

Descriptive Crash Statistics

- Pedestrian crashes are over four times more likely to result in a fatal and incapacitating injury outcome than citywide crashes for all modes (28% compared to 6%).
- Over one-third of crashes (34%) occurred between 6 and 10 p.m. during primarily dark conditions. Between 7:00 PM and 6:00 AM, 40% of pedestrian crashes are fatal/incapacitating—notably higher than the overall pedestrian crash share (29%)
- The majority of crashes occur on roadways with posted speeds of 35 and 40 miles per hour. Between 25 and 50 miles per hour, the share of fatal/incapacitating injuries increases with posted speed. The share of fatal/incapacitating injury crashes at roadways with 25 mile-per-hour posted speed is 14%; at 45 miles per hour the share is 34%.
- Twenty-five (25) drivers (2%) and 102 pedestrians (9%) were reported to be under the influence
- Pedestrian crashes occurred primarily at intersections: 45% of crashes occurred in marked crosswalks and another 9% occurring off the roadway.
- Eighty-seven percent (88%) of fatal/incapacitating pedestrian crashes occur on or at minor or principal arterial roadways, which collectively comprise 11% of centerline miles in Tucson.

Network Screening

Kittelson identified “Tier 1” and “Tier 2” high-injury intersections and segments using the annualized EPDO for intersections and segments. Among 647 intersections with crash history over the five-year period, the 120 high-injury intersection locations represent the highest 19% of EPDO scores. Three roadway segment locations were identified as high-injury locations.

The complete list of locations is presented in Appendix A.

Equity Analysis

To evaluate social equity, Kittelson compared Census block groups using a Transportation Disadvantaged Population index to identify populations that may be at a disadvantage from a socio-economic and/or transportation mobility perspective. Neighborhood areas with both high-injury crash history and transportation disadvantage are presented in Figure 6 and may be used to inform subsequent location prioritization.

Pedestrian Crash Risk Factors

Intersection risk factors:

- Locations within 200 feet of at a Sun Tran stop.
- At signalized intersections with four and six lane roadways of 35 or 40 miles per hour.

Segment risk factors:

- Six-lane roadways
- Locations within 300 feet of a Sun Tran stop and more than 2,000 feet from a marked crosswalk

NEXT STEPS

Using the risk factors, high-injury locations, and social equity findings identified in this memorandum, Kittelson will work with the City of Tucson to prioritize locations for safety improvements. The prioritization methodology and criteria have not been finalized but will be based on the location and equity findings of this memorandum.

Appendix A: High-Injury Locations

Table A-1: High-Injury Locations

Intersection Name	EPDO	Tier
E Grant Road / N Alvernon Way	134.2	1
E Grant Road / N Swan Road	90	1
E Speedway Boulevard / N Richey Boulevard	82	1
E Broadway Boulevard / N Kolb Road	82	1
E Fort Lowell Road / N 1st Avenue	76.2	1
E Prince Road / N Campbell Avenue	70.6	1
W Grant Road / N Oracle Road	66	1
E Speedway Boulevard / N Beverly Avenue	66	1
E 22nd Street / S Columbus Boulevard	64	1
E Tanque Verde Road / E Pima Street	64	1
E Valencia Road / S 6th Avenue	62	1
W Ironwood Hill Drive / N Silverbell Road	62	1
E Grant Road / N Haskell Drive	60	1
E Grant Road / N 1st Avenue	54	1
E 22nd Street / S 4th Avenue	50	1
E Speedway Boulevard / N Wilmot Road	48.4	1
E Speedway Boulevard / N Pantano Road	48	1
E Speedway Boulevard / N Craycroft Road	48	1
W Prince Road / N Oracle Road	46.2	1
E Irvington Road / S Campbell Avenue	46	1
E 22nd Street / S Swan Road	46	1
E 5th Street / N Pantano Road	46	1
E Carondelet Drive / N Wilmot Road	46	1
E Speedway Boulevard / N Stone Avenue	46	1
W Saint Mary's Road / N Grande Avenue	44.2	1
W Irvington Road / S 12th Avenue	44	1
E 22nd Street / S Prudence Road	44	1
E Tanque Verde Road / E Grant Road	44	1
W Fort Lowell Road / N Balboa Avenue	44	1
E Speedway Boulevard / N Venice Avenue	42	1
E Broadway Boulevard / N Plumer Avenue	42	1
E Fort Lowell Road / N Stone Avenue	42	1

Intersection Name	EPDO	Tier
E 5th Street / N Euclid Avenue	42	1
W Jacinto Street / N Oracle Road	40.4	1
E Grant Road / N Mountain View Avenue	40	1
E Drexel Road / S Country Club Road	40	1
E Tanque Verde Road / N Bear Canyon Road	40	1
W 22nd Street / S Osborne Avenue	40	1
E Grant Road / N Rita Avenue	40	1
W Prince Road / N Columbia Avenue	40	1
W Valencia Road / S Fiesta Avenue	40	1
E 1st Street / N Mountain Avenue	40	1
W Valencia Road / S Midvale Park Road	40	1
W Canada Street / S 12th Avenue	40	1
E Broadway Boulevard / S Scott Avenue	40	1
E Speedway Boulevard / N Mountain Avenue	38.2	1
E Broadway Boulevard / N Pantano Road	36	1
E 22nd Street / S Craycroft Road	34	1
W Veterans Boulevard / S 6th Avenue	34	1
E Grant Road / N Craycroft Road	30.2	1
E 22nd Street / S Alvernon Way	30.2	1
W Valencia Road / S 12th Avenue	30.2	1
E Roger Road / N 1st Avenue	30	1
W Valencia Road / S Headley Road	30	1
E Broadway Boulevard / N Craycroft Road	28.2	2
E 22nd Street / S Wilmot Road	28	2
E Broadway Boulevard / N Jessica Avenue	28	2
E Grant Road / N Palo Verde Avenue	28	2
E Speedway Boulevard / N Alvernon Way	26	2
W Prince Road / N Romero Road	26	2
E Broadway Boulevard / N Wilmot Road	26	2
E Fort Lowell Road / N Swan Road	26	2
W Congress Street / N Granada Avenue	26	2
E Speedway Boulevard / N 6th Avenue	26	2
E Irvington Road / S 1st Avenue	26	2

Intersection Name	EPDO	Tier
W Ajo Way / S Mission Road	24.2	2
W Ajo Way / S 12th Avenue	24.2	2
E Pima Street / N Alvernon Way	24.2	2
E 6th Street / N Euclid Avenue	24.2	2
W Drexel Road / S 12th Avenue	24	2
E 1st Street / N Euclid Avenue	24	2
E 6th Street / N Park Avenue	24	2
E Broadway Boulevard / N Sarnoff Drive	24	2
W Silverlake Road / S Mission Road	24	2
E Grant Road / N Columbus Boulevard	24	2
E Broadway Boulevard / N Rosemont Boulevard	24	2
W Congress Street / N Church Avenue	24	2
E Speedway Boulevard / N Dodge Boulevard	24	2
E 29th Street / S Craycroft Road	22.4	2
E Roger Road / N Campbell Avenue	22.2	2
W Congress Street / N Grande Avenue	22.2	2
E Speedway Boulevard / N Rosemont Boulevard	22.2	2
W District Street / S 12th Avenue	22.2	2
E Golf Links Road / S Langley Avenue	22.2	2
W Miracle Mile / N 14th Avenue	22	2
E Golf Links Road / S Craycroft Road	22	2
E 2nd Street / N Euclid Avenue	22	2
E Irvington Road / S Park Avenue	22	2
E Delano Street / N 1st Avenue	22	2
E University Boulevard / N Tyndall Avenue	22	2
W Saint Mary's Road / N Silverbell Road	22	2
E Blacklidge Drive / N Alvernon Way	22	2
E Prince Road / N 1st Avenue	22	2
E Hedrick Drive / N Campbell Avenue	22	2
E Pastime Road / N 1st Avenue	22	2
E Speedway Boulevard / N Arcadia Avenue	22	2
E Mitchell Street / N Campbell Avenue	22	2
W Alturas Street / N Oracle Road	22	2

Intersection Name	EPDO	Tier
E Fort Lowell Road / N Campbell Avenue	22	2
E Bellevue Street / N Alvernon Way	22	2
W Roger Road / N Flowing Wells Road	22	2
W 22nd Street / S 8th Avenue	22	2
E Fort Lowell Road / N Estrella Avenue	22	2
E Speedway Boulevard / N Sonoita Avenue	22	2
E Broadway Boulevard / N Norris Avenue	22	2
E Limberlost Drive / N 1st Avenue	22	2
E Broadway Boulevard / N Campbell Avenue	22	2
E Fort Lowell Road / N Columbus Boulevard	22	2
E Speedway Boulevard / N Harrison Road	22	2
E Mary Ann Cleveland Way / S Atterbury Wash Way	22	2
W Prince Road / N Crescent Manor Road	22	2
E North Street / N 1st Avenue	22	2
E Benson Hy / S 6th Avenue	22	2
E 21st Street / S Kolb Road	22	2
E Mohave Road / N 1st Avenue	20.2	2
E Rosewood Street / N Kolb Road	20.2	2
E Grant Road / N Sycamore Boulevard	20.2	2
E 29th Street / S Swan Road	20.2	2
E Graybill Drive / N 1st Avenue	20.2	2
E 22nd Street / S Pantano Road	20.2	2
Roadway Segment	**EPDO**	**Tier**
E Broadway Boulevard, between Craycroft and Wilmot	40.0	1
E Golf Links Road, between Wilmot and Kolb	22.0	2
E Speedway Boulevard, between Craycroft and Woodland	22.0	2

APPENDIX B: TASK 4 PRIORITIZATION MEMO

MEMORANDUM #3

Date:	August 26, 2019	Project #: 23710
To:	Krista Hansen City of Tucson Department of Transportation 201 N. Stone Ave Tucson, AZ 85701	
From:	Felipe Ladron de Guevara, Erin Ferguson, Mike Alston	
Project:	City of Tucson Pedestrian Safety Action Plan	
Subject:	Technical Memorandum #3: Location Prioritization	

1. INTRODUCTION

Kittelson & Associates, Inc. (Kittelson) has been retained by the City of Tucson Department of Transportation (TDOT) to prepare a Pedestrian Safety Action Plan (PSAP) to reduce pedestrian crashes and increase pedestrian safety on public streets across the City.

The purpose of this memorandum is to document the location prioritization methods and results identified in previous project tasks with pedestrian crash history. We present three prioritization methods to select top locations and to demonstrate sensitivity of results based on different emphasis areas (e.g., emphasis on documented crash history versus presence of systemic risk factors). The three methods give different results for top locations.

Information is organized as follows:

2. **Background:** This section provides a brief background of the crash analysis finished prior to prioritizing locations for pedestrian safety improvements.
3. **Crash Severity:** This section presents a list of the top locations with crash history ranked by crash severity scores, based on five years of pedestrian crash data.
4. **Risk Factors:** This section presents a list of the top locations with crash history, ranked by the presence of risk factors. Risk factors are roadway, land use, or behavioral characteristics associated with increased crash and injury risk for road users.
5. **Social Equity:** This section presents a list of the top locations with crash history, ranked by an index prioritizing the locations based on social equity thereby prioritizing areas with a greater share of individuals who are more likely to be dependent on walking and transit as their primary modes of transportation (i.e., transportation disadvantaged populations).

6. **Weighted Prioritization Options:** We identified three methods for ranking locations, each providing a different combination of weighting to crash severity, risk factors and social equity.
   6.1. **Equal Weights Ranking:** This approach weighs the three factor inputs --crash severity, presence of risk factors, and social equity—equally to present a list of top locations.
   6.2. **Severity-Weighted Ranking:** This approach places a greater weight or importance on locations with higher historical crash severity relative to the other two factor inputs (presence of risk factors and social equity) to present a list of top locations.
   6.3. **Severity and Equity-Weighted Ranking:** This approach prioritizes crash severity and social equity higher relative to the presence of risk factors to present a list of top locations.
7. **Summary of Findings:** This section summarizes the findings of this memorandum.
8. **Next Steps:** This section outlines the next steps in the Pedestrian Safety Action Plan.

2. BACKGROUND

The previous task of this project and associated crash analysis memo (see Appendix A) produced the following results, which were used as inputs for prioritizing locations:

1. **High-injury locations (roadways and segments):** We screened the City's road network to find the top severity-weighted crash locations, using an equivalent property damage only (EPDO) severity weighting method. Among 647 intersections with crash history over the 2014-2018 period, we identified 120 high-injury intersections. We also identified three high-injury roadway segments.
2. **Risk Factors:** We combined descriptive and spatial analysis to identify risk factors. Risk factors are roadway, land use, transit ridership or behavioral characteristics associated with increased crash and injury risk. These may be used as part of a systemic safety approach to identify locations where crashes have not yet occurred to make proactive safety improvements.
3. **Social Equity analysis:** We associated high-injury locations with socio-economic and demographic factors to identify locations with a high relative transportation disadvantage in addition to crash frequency. This measure is based on a *transportation disadvantaged population* (TDP) index. The TDP measures the level of relative transportation disadvantage faced by the population within the Census block group containing each intersection or segment.

These three factors – **EPDO score**, **presence of risk factors**, and **TDP score** – form the basis of prioritization. For this memo, we have identified the top 120 intersections and three segments as ranked by EPDO score for prioritization.

3. CRASH SEVERITY RANKING

We used the EPDO performance measure to weight crash history at each location by reported severity. The resulting scores at each location convey the relative societal cost of the crash history based on severity. Prioritizing by crash history can help the City direct improvements to locations where the most severe outcomes *have occurred*. The EPDO scores may form the basis for an economic evaluation (e.g., benefit-to-cost ratio) and are commonly used for grant funding competitiveness.

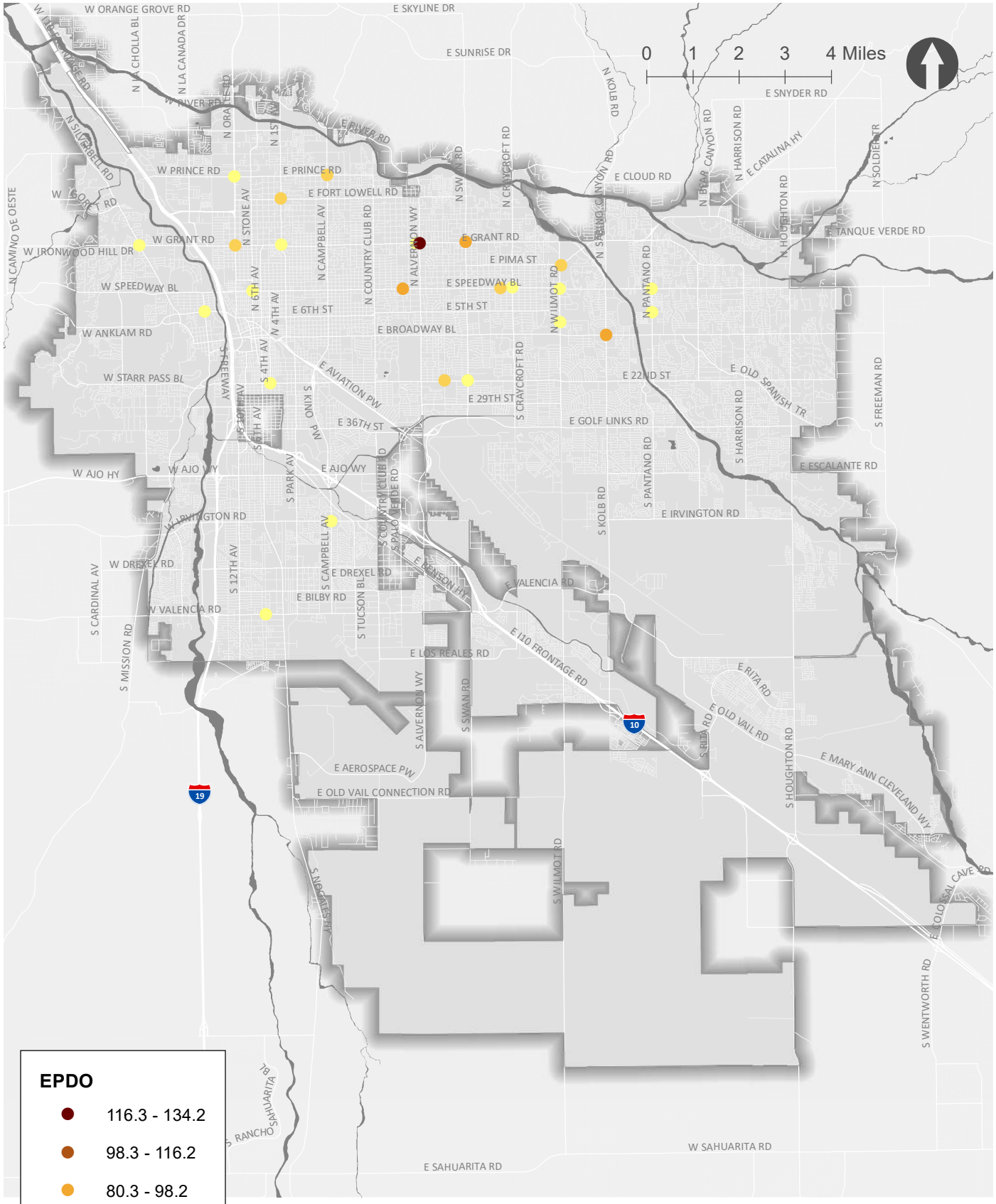
3.1 Equivalent Property Damage Only (EPDO) Methodology

The EPDO performance measure assigns weight to individual crashes based on the severity of the crash. The weighting is based on the relative differences in crash costs by crash severity, giving each crash a relative score in terms of the equivalent number of PDO crashes.

1. **Fatal and Incapacitating Injury Crashes:** 100 points
2. **Non-incapacitating and possible injury crashes:** 10 points
3. **Non-injury crashes:** 1 point

Among 647 intersections with a crash history over the five-year period, 120 high-injury locations represent the highest 19% of EPDO scores with an EPDO score of 20.2 or higher. Three segments had an EPDO score of 20.2 or higher. Thus, most of the priority locations were intersections.

The ranking of the top 25 locations as ranked by highest crash severity score is presented in Figure 1.



EPDO

- 116.3 - 134.2
- 98.3 - 116.2
- 80.3 - 98.2
- 62.3 - 80.2
- 44.2 - 62.2

Top 25 Locations Ranked by EPDO City of Tucson, AZ

Figure **1**

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Coordinate System: NAD 1983 HARN StatePlane Arizona Central FIPS 0202 Feet Intl

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4. RISK FACTOR RANKING

Kittelson conducted a risk-based analysis of locations identified through the intersection and roadway segment network screening. *Risk* is defined for this purpose as common traffic or physical characteristics shared by the top segments and intersections. Based on this commonality, the presence of risk factors is indicative of a potentially higher risk for pedestrian crashes in Tucson. Identifying risk factors does not prove causality; its goal is to show potential connections and contributing factors.

4.1 Risk Factor Methodology

The Task 3 memorandum (Appendix A) identified risk factors based on descriptive and spatial analysis. We have further refined the risk factors to those described below.

Intersection Risk Factors

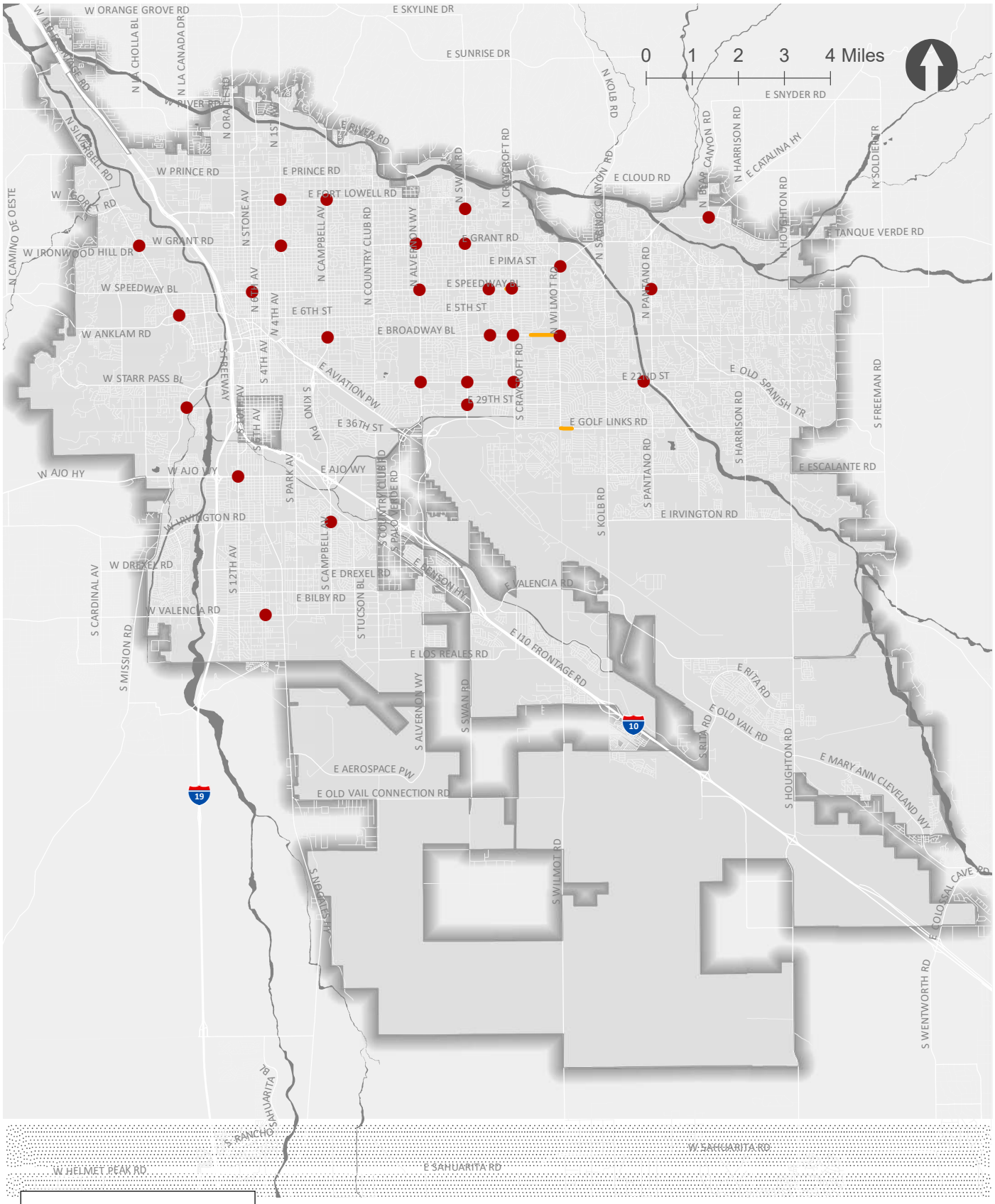
- 200 feet from a Sun Tran stop in the top one-third of ridership[1]
- A street with six or more lanes at the intersection
- A speed limit of 35 or 40 miles per hour along either approaching roadway
- A signalized intersection
- No pedestrian refuge for a pedestrian crossing of six or more lanes

Segment Risk Factors

- Six-lane roadways
- Locations within 300 feet of a Sun Tran stop in the top one-third of ridership[1]
- Segments with locations greater than 2,000 feet from a marked crosswalk

In order to calculate a risk factor score for each location, we inventoried the proportion of these risk factors present for a total score between 0 and 1. The top 30 locations as ranked by highest risk factor score (28 intersections, 2 segments) is shown in Figure 2.

[1] Ridership was calculated by summing average weekday on and off counts, based on data provided by Sun Tran on August 3, 2019.



Top Intersections

Top Segments

Top 30 Locations by Presence of Risk Factors City of Tucson, AZ

Figure **2**

Coordinate System: NAD 1983 HARN StatePlane Arizona Central FIPS 0202 Feet Intl

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5. SOCIAL EQUITY RANKING

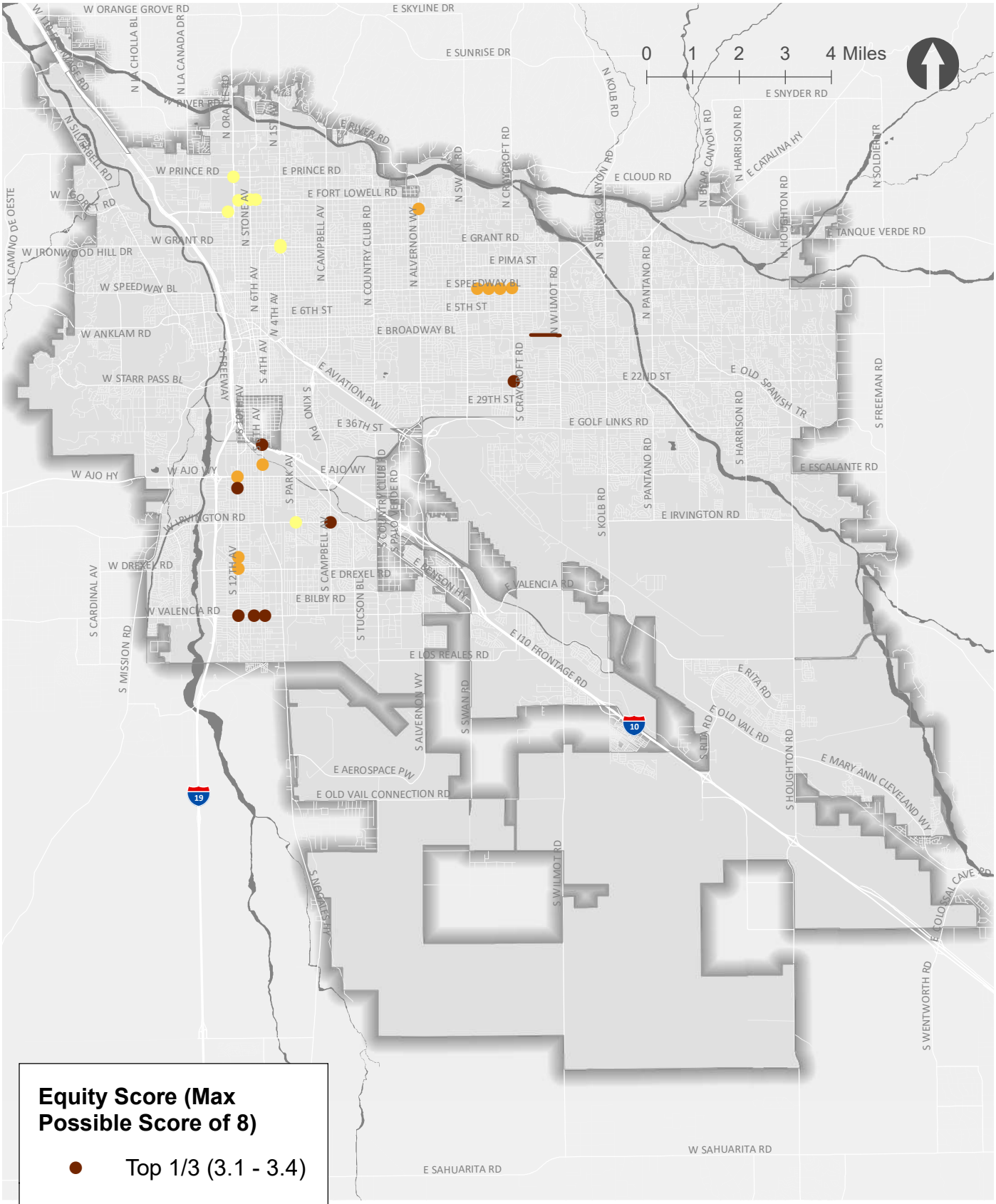
In the context of transportation, a social equity ranking identifies geographic areas with a high percentage of residents who experience challenges achieving basic access to services, goods, employment, and/or education. For example, some demographic characteristics that would cause an area to appear higher (i.e., more disadvantaged) with respect to social equity include a higher-than-average percentage of low-income people, people with a disability, and zero-vehicle households.

5.1 Transportation Disadvantaged Population Index (TDP) Methodology

We assigned each intersection and corridor the social equity score of the surrounding Census block group.[2] This approach presents the City with an equity-focused ranking that prioritizes intersections based on neighborhoods that stand to benefit most from pedestrian safety improvements. A higher score represents a more disadvantaged population from a transportation perspective. Scores ranged from 0.63 to 3.37 out of a maximum possible score of 8.

The ranking of the top 26 locations (with two locations tied for 25th) ranked by highest social equity score is shown in Figure 3.

[2] If a site lies in multiple block groups, we assigned it the highest score among those block groups.



Top 26 Locations Ranked by Equity Score City of Tucson, AZ

Figure **3**

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Coordinate System: NAD 1983 HARN StatePlane Arizona Central FIPS 0202 Feet Intl

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6. WEIGHTED PRIORITIZATION OPTIONS

This section presents three possible prioritization weightings that incorporate crash severity, risk factors, and social equity. In order to combine the three separate scores, we first normalized them to a common range of 0 to 1. Each of the three scores was normalized, or scaled, by dividing the value by the maximum score of the set (e.g., each EPDO score was divided by the highest score of 134.2). Finally, each weighted score was multiplied by ten to create a score with a theoretical minimum of zero and maximum of 10.

Table 1 presents the three proposed prioritization methods, which are detailed in the subsequent sections. The total score is calculated by multiplying each scaled score by weights given.

Table 1. Prioritization Methods

	Inputs		
Prioritization Method	**EPDO Score**	**Presence of Risk Factors Score**	**TDP Index Score**
Equal Weights	33%	33%	33%
Severity-Weighted	50%	25%	25%
Severity and Equity-Weighted	40%	20%	40%

6.1 Equal Weights Ranking

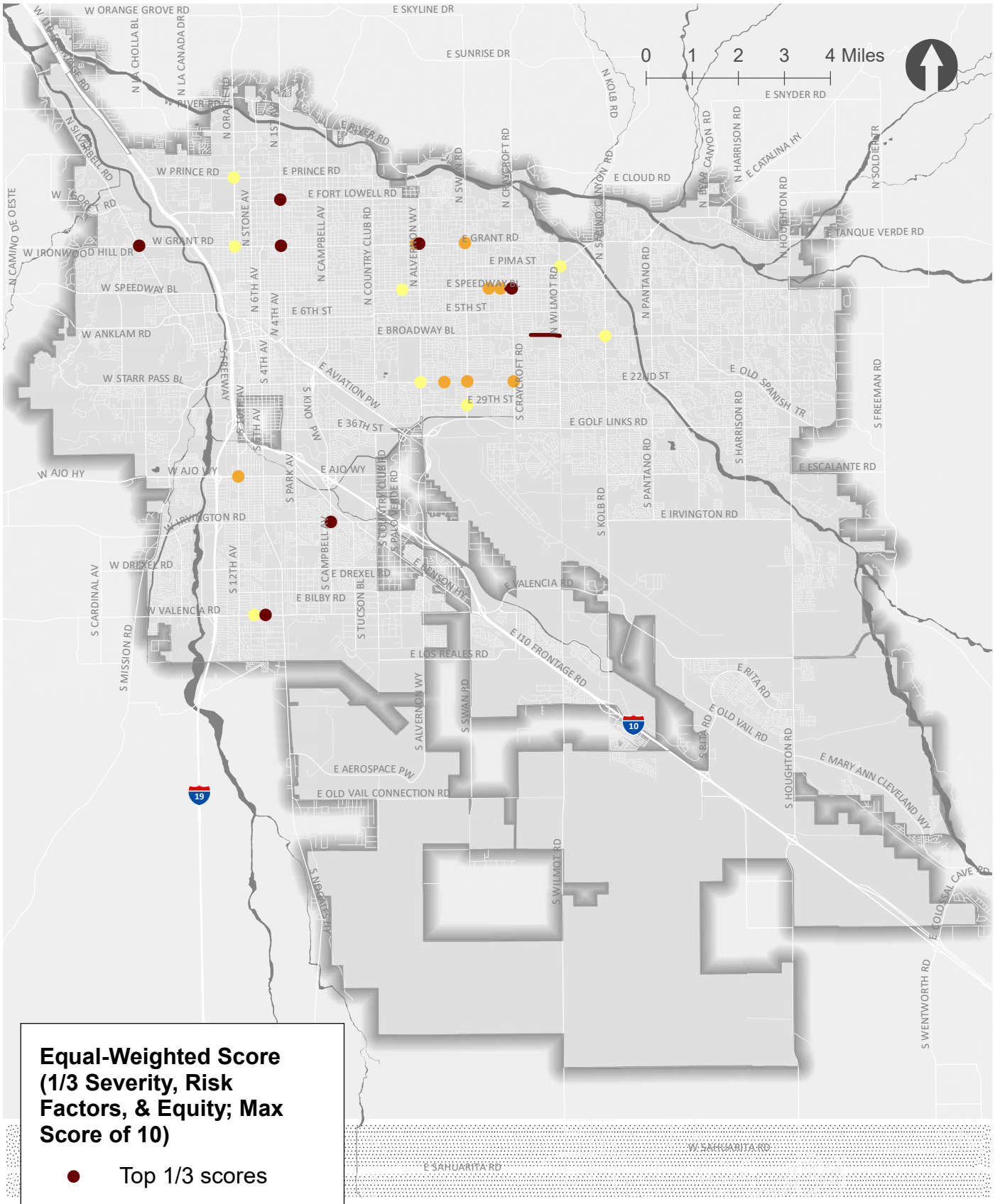
This equal-weighted ranking considers crash severity, risk factors, and social equity equally (1/3 each) to create a baseline prioritization method. This method of prioritization provides a straightforward methodology that equally weighs crash history to prioritize where crashes have occurred, presence of risk factors to apply a systemic approach, and equity to prioritize. The ranking of the top 25 locations is shown in Figure 4.

6.2 Severity-Weighted Ranking

This severity-weighted ranking prioritizes where crashes *have occurred* by emphasizing crash severity over risk factors and social equity (50% crash severity, 25% risk factors, and 25% social equity). The top locations as identified by this method would serve the City in considering competitive grant applications that rely on economic evaluations for proposed projects while still incorporating the other factors. The ranking of the top 25 locations is shown in Figure 5.

6.3 Severity- and Equity-Weighted Ranking

This severity- and equity-weighted ranking prioritizes crash severity and social equity over risk factors (40% crash severity, 40% social equity, and 20% risk factors). This ranking may be appropriate if the City wishes to pursue a policy of investing specifically in economically and transportation disadvantaged communities. The ranking of the top 25 locations is shown in Figure 6.



Equal-Weighted Score (1/3 Severity, Risk Factors, & Equity; Max Score of 10)

- Top 1/3 scores
- Middle 1/3 scores
- Lower 1/3 scores

Top 25 Locations Equal-Weighted Ranking City of Tucson, AZ

Figure **4**

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Coordinate System: NAD 1983 HARN StatePlane Arizona Central FIPS 0202 Feet Intl

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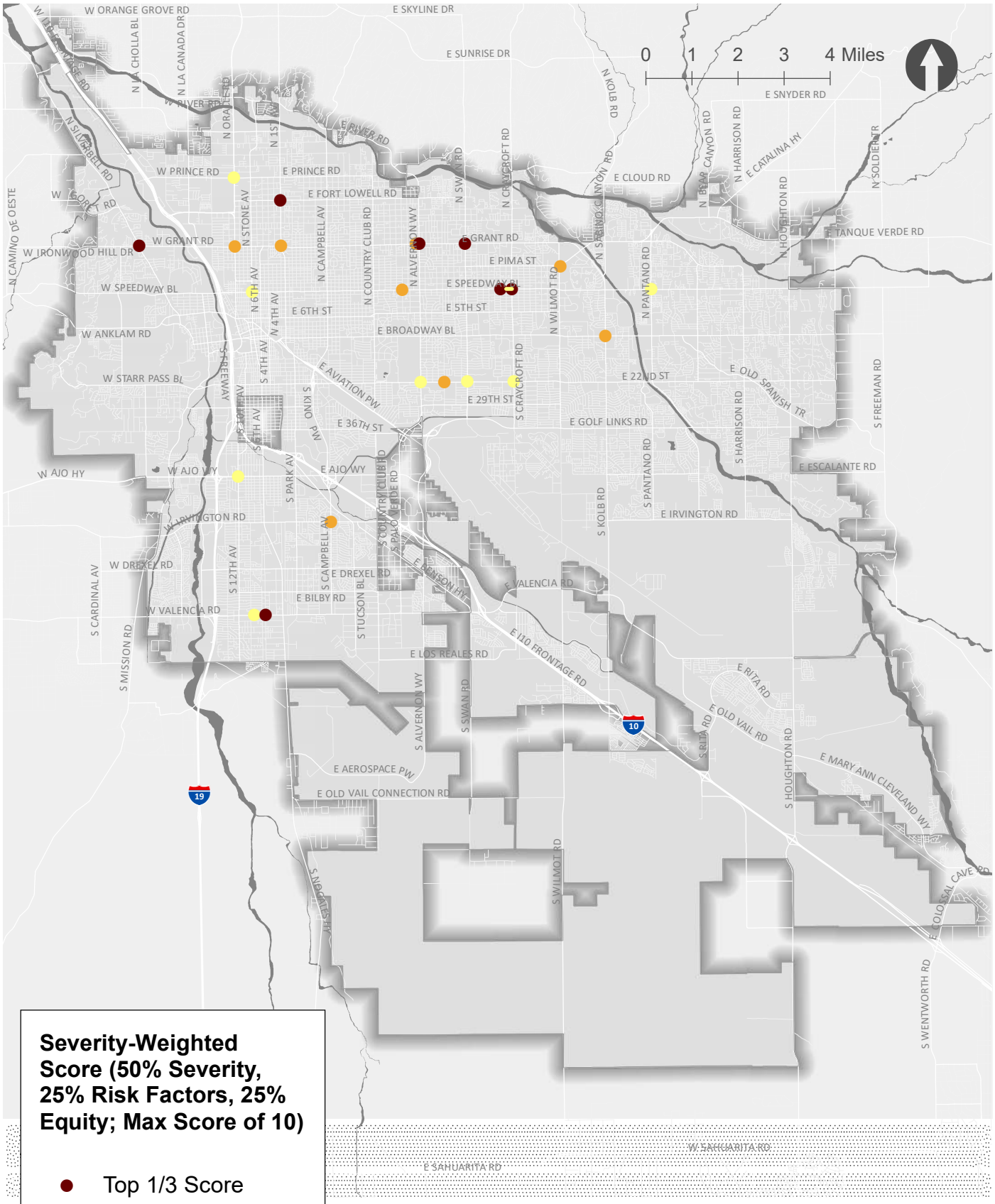

Severity-Weighted Score (50% Severity, 25% Risk Factors, 25% Equity; Max Score of 10)

- Top 1/3 Score
- Middle 1/3 Score
- Lower 1/3 Score

Top 25 Locations Severity-Weighted Ranking City of Tucson, AZ

Figure **5**

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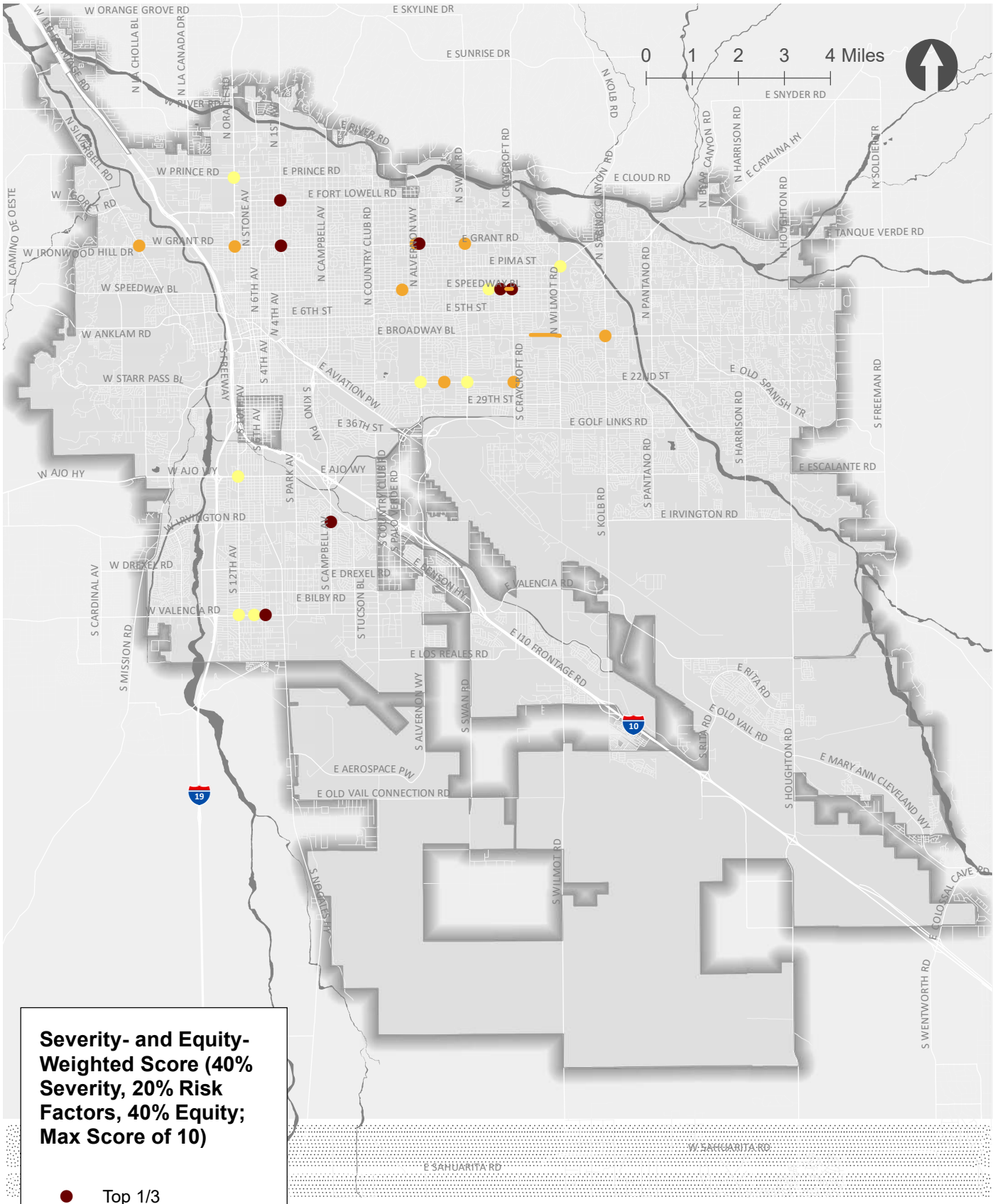

Severity- and Equity-Weighted Score (40% Severity, 20% Risk Factors, 40% Equity; Max Score of 10)

- Top 1/3
- Middle 1/3
- Lower 1/3

Top 25 Locations
Severity- and Equity-Weighted Ranking
City of Tucson, AZ

Figure **6**

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Coordinate System: NAD 1983 HARN StatePlane Arizona Central FIPS 0202 Feet Intl

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7. SUMMARY OF FINDINGS

Based on feedback provided by City of Tucson Department of Transportation, the project Technical Advisory Committee, and the City of Tucson Pedestrian Advisory Committee; the preferred prioritization method is the Equal Weights Ranking. The top 25 locations were visually presented in Figure 4 and are again provided in Table 2.

Table 2. Potential Priority Locations

Location	Normalized Equal Weights Score (Maximum of 10)
E Grant Road / N Alvernon Way	7.761
E Speedway Boulevard / N Craycroft Road	7.524
E Valencia Road / S 6th Avenue	7.354
East Broadway, between Craycroft and Wilmot	7.325
E Irvington Road / S Campbell Avenue	6.965
E Fort Lowell Road / N 1st Avenue	6.930
E Speedway Boulevard, between Craycroft and Woodland	6.878
E Grant Road / N 1st Avenue	6.874
W Ironwood Hill Drive / N Silverbell Road	6.770
E Speedway Boulevard / N Beverly Avenue	6.638
E Grant Road / N Swan Road	6.631
E 22nd Street / S Craycroft Road	6.623
E Grant Road / N Haskell Drive	6.585
E 22nd Street / S Swan Road	6.309
E 22nd Street / S Columbus Boulevard	6.283
W Ajo Way / S 12th Avenue	6.247
E Speedway Boulevard / N Rosemont Boulevard	6.216
E Broadway Boulevard / N Kolb Road	6.176
W Grant Road / N Oracle Road	6.160
W Valencia Road / S Fiesta Avenue	6.141
E 22nd Street / S Alvernon Way	6.111
E Tanque Verde Road / E Pima Street	6.096
W Prince Road / N Oracle Road	6.056
E 29th Street / S Swan Road	5.974
E Speedway Boulevard / N Alvernon Way	5.929

*Note: **bolded locations** are roadway segments, and all others are intersections.

8. NEXT STEPS

Using the results of this memo, Kittelson will work with the City to select and prioritize engineering countermeasures that will be effective at reducing pedestrian crashes and crash-risk and that will be supported for implementation by City departments and stakeholders.

Appendix A: Task 3 Memorandum – Pedestrian Crash Data Analysis Summary

Table A-1: High-Injury Locations

Intersection Name	EPDO	Tier
E Grant Road / N Alvernon Way	134.2	1
E Grant Road / N Swan Road	90	1
E Speedway Boulevard / N Richey Boulevard	82	1
E Broadway Boulevard / N Kolb Road	82	1
E Fort Lowell Road / N 1st Avenue	76.2	1
E Prince Road / N Campbell Avenue	70.6	1
W Grant Road / N Oracle Road	66	1
E Speedway Boulevard / N Beverly Avenue	66	1
E 22nd Street / S Columbus Boulevard	64	1
E Tanque Verde Road / E Pima Street	64	1
E Valencia Road / S 6th Avenue	62	1
W Ironwood Hill Drive / N Silverbell Road	62	1
E Grant Road / N Haskell Drive	60	1
E Grant Road / N 1st Avenue	54	1
E 22nd Street / S 4th Avenue	50	1
E Speedway Boulevard / N Wilmot Road	48.4	1
E Speedway Boulevard / N Pantano Road	48	1
E Speedway Boulevard / N Craycroft Road	48	1
W Prince Road / N Oracle Road	46.2	1
E Irvington Road / S Campbell Avenue	46	1
E 22nd Street / S Swan Road	46	1
E 5th Street / N Pantano Road	46	1
E Carondelet Drive / N Wilmot Road	46	1
E Speedway Boulevard / N Stone Avenue	46	1
W Saint Mary's Road / N Grande Avenue	44.2	1
W Irvington Road / S 12th Avenue	44	1
E 22nd Street / S Prudence Road	44	1
E Tanque Verde Road / E Grant Road	44	1
W Fort Lowell Road / N Balboa Avenue	44	1
E Speedway Boulevard / N Venice Avenue	42	1
E Broadway Boulevard / N Plumer Avenue	42	1
E Fort Lowell Road / N Stone Avenue	42	1

Intersection Name	EPDO	Tier
E 5th Street / N Euclid Avenue	42	1
W Jacinto Street / N Oracle Road	40.4	1
E Grant Road / N Mountain View Avenue	40	1
E Drexel Road / S Country Club Road	40	1
E Tanque Verde Road / N Bear Canyon Road	40	1
W 22nd Street / S Osborne Avenue	40	1
E Grant Road / N Rita Avenue	40	1
W Prince Road / N Columbia Avenue	40	1
W Valencia Road / S Fiesta Avenue	40	1
E 1st Street / N Mountain Avenue	40	1
W Valencia Road / S Midvale Park Road	40	1
W Canada Street / S 12th Avenue	40	1
E Broadway Boulevard / S Scott Avenue	40	1
E Speedway Boulevard / N Mountain Avenue	38.2	1
E Broadway Boulevard / N Pantano Road	36	1
E 22nd Street / S Craycroft Road	34	1
W Veterans Boulevard / S 6th Avenue	34	1
E Grant Road / N Craycroft Road	30.2	1
E 22nd Street / S Alvernon Way	30.2	1
W Valencia Road / S 12th Avenue	30.2	1
E Roger Road / N 1st Avenue	30	1
W Valencia Road / S Headley Road	30	1
E Broadway Boulevard / N Craycroft Road	28.2	2
E 22nd Street / S Wilmot Road	28	2
E Broadway Boulevard / N Jessica Avenue	28	2
E Grant Road / N Palo Verde Avenue	28	2
E Speedway Boulevard / N Alvernon Way	26	2
W Prince Road / N Romero Road	26	2
E Broadway Boulevard / N Wilmot Road	26	2
E Fort Lowell Road / N Swan Road	26	2
W Congress Street / N Granada Avenue	26	2
E Speedway Boulevard / N 6th Avenue	26	2
E Irvington Road / S 1st Avenue	26	2

Intersection Name	EPDO	Tier
W Ajo Way / S Mission Road	24.2	2
W Ajo Way / S 12th Avenue	24.2	2
E Pima Street / N Alvernon Way	24.2	2
E 6th Street / N Euclid Avenue	24.2	2
W Drexel Road / S 12th Avenue	24	2
E 1st Street / N Euclid Avenue	24	2
E 6th Street / N Park Avenue	24	2
E Broadway Boulevard / N Sarnoff Drive	24	2
W Silverlake Road / S Mission Road	24	2
E Grant Road / N Columbus Boulevard	24	2
E Broadway Boulevard / N Rosemont Boulevard	24	2
W Congress Street / N Church Avenue	24	2
E Speedway Boulevard / N Dodge Boulevard	24	2
E 29th Street / S Craycroft Road	22.4	2
E Roger Road / N Campbell Avenue	22.2	2
W Congress Street / N Grande Avenue	22.2	2
E Speedway Boulevard / N Rosemont Boulevard	22.2	2
W District Street / S 12th Avenue	22.2	2
E Golf Links Road / S Langley Avenue	22.2	2
W Miracle Mile / N 14th Avenue	22	2
E Golf Links Road / S Craycroft Road	22	2
E 2nd Street / N Euclid Avenue	22	2
E Irvington Road / S Park Avenue	22	2
E Delano Street / N 1st Avenue	22	2
E University Boulevard / N Tyndall Avenue	22	2
W Saint Mary's Road / N Silverbell Road	22	2
E Blacklidge Drive / N Alvernon Way	22	2
E Prince Road / N 1st Avenue	22	2
E Hedrick Drive / N Campbell Avenue	22	2
E Pastime Road / N 1st Avenue	22	2
E Speedway Boulevard / N Arcadia Avenue	22	2
E Mitchell Street / N Campbell Avenue	22	2
W Alturas Street / N Oracle Road	22	2

Intersection Name	EPDO	Tier
E Fort Lowell Road / N Campbell Avenue	22	2
E Bellevue Street / N Alvernon Way	22	2
W Roger Road / N Flowing Wells Road	22	2
W 22nd Street / S 8th Avenue	22	2
E Fort Lowell Road / N Estrella Avenue	22	2
E Speedway Boulevard / N Sonoita Avenue	22	2
E Broadway Boulevard / N Norris Avenue	22	2
E Limberlost Drive / N 1st Avenue	22	2
E Broadway Boulevard / N Campbell Avenue	22	2
E Fort Lowell Road / N Columbus Boulevard	22	2
E Speedway Boulevard / N Harrison Road	22	2
E Mary Ann Cleveland Way / S Atterbury Wash Way	22	2
W Prince Road / N Crescent Manor Road	22	2
E North Street / N 1st Avenue	22	2
E Benson Hy / S 6th Avenue	22	2
E 21st Street / S Kolb Road	22	2
E Mohave Road / N 1st Avenue	20.2	2
E Rosewood Street / N Kolb Road	20.2	2
E Grant Road / N Sycamore Boulevard	20.2	2
E 29th Street / S Swan Road	20.2	2
E Graybill Drive / N 1st Avenue	20.2	2
E 22nd Street / S Pantano Road	20.2	2
Roadway Segment	**EPDO**	**Tier**
E Broadway Boulevard, between Craycroft and Wilmot	40.0	1
E Golf Links Road, between Wilmot and Kolb	22.0	2
E Speedway Boulevard, between Craycroft and Woodland	22.0	2

APPENDIX C: TASK 5 PROJECT CUT SHEETS

Broadway Blvd between Craycroft Rd and Wilmot Rd
Corridor Summary

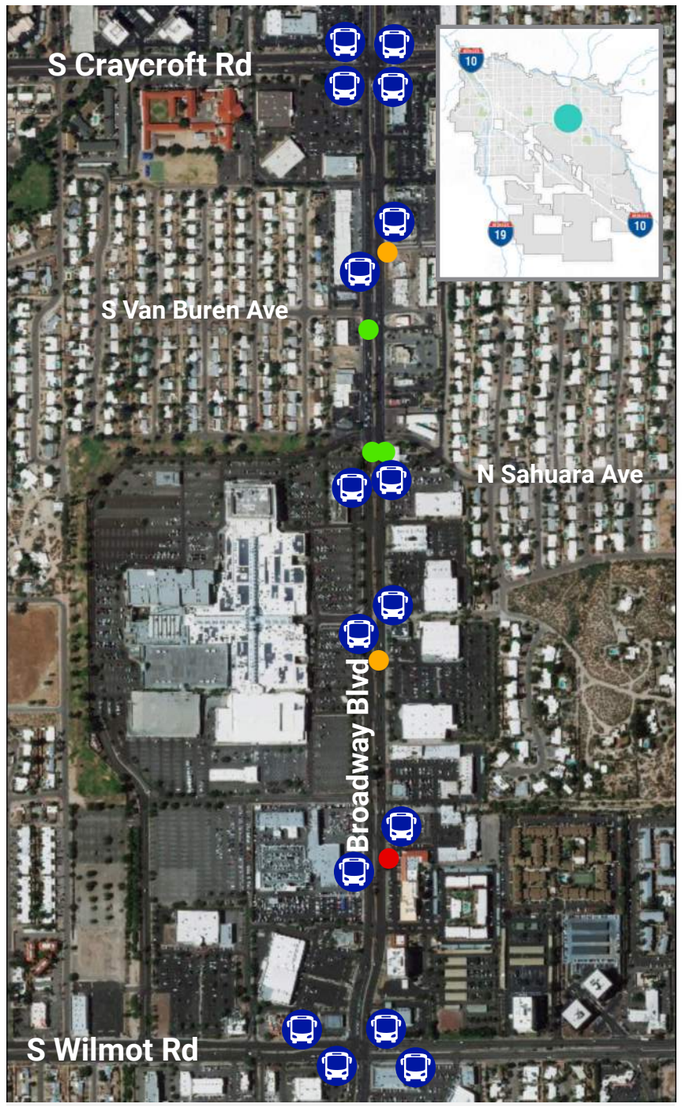
Tucson Pedestrian Safety Action Plan

Pedestrian Crashes (2014-2018)

Date	Time of Day	Injury Level	Location	Direction of vehicle travel	Violation
Saturday 5/16/2015	Dark-unknown lighting	Non-incapacitating	In crosswalk	Westbound	None Cited
Thursday 12/3/2015	Daylight	Incapacitating	Not in crosswalk	Westbound	Pedestrian – did not use crosswalk
Friday 12/18/2015	Dark-lighted	Incapacitating	Not in crosswalk	Westbound	Pedestrian – did not use crosswalk
Saturday 2/20/2016	Daylight	Fatal	In sidewalk	Westbound right turn- from a driveway	Driver- failed to yield right-of-way
Thursday 6/23/2016	Daylight	Possible injury	In crosswalk	Westbound	None cited
Wednesday 9/26/2018	Dark- lighted	Possible injury	Not in crosswalk	Eastbound	Pedestrian – failed to yield right-of-way

Site Characteristics

- Approximately 1-mile segment with three through vehicle lanes in each direction of travel and turn lane additions at intersections
- Medians present throughout corridor with 11 median breaks for vehicle access
- Shoulder-running bus and bicycle lanes in both directions
- Speed limit: 40 mph in both directions
- Marked pedestrian crossings include a PELICAN at mall entrance that provides two-stage protected crossings and a signalized intersection at Park Place Drive with a marked crosswalk on the east side. In addition, marked crosswalks are provided at the Craycroft Road and Wilmot Road intersections.
- There is a 2,200 feet segment without marked crossing opportunities.
- Commercial/retail activity uses on both sides of the corridor with three side streets intersecting and 51 driveways providing access. Continuous sidewalks are provided on both sides of Broadway.
- Sun Tran Route 8 travels along the corridor with six stops in each direction. Four of the bus stops are located within 150 feet of a marked pedestrian crossing.



Observations

- The distance between marked pedestrian crossings ranges from 950 feet to 2,400 feet.
- Two bus stops in each direction of travel are not located near marked crossings – up to 700 feet away. There is an opportunity to provide marked pedestrian crossings with bus stops.
- Given the 120-foot roadway width, pedestrians crossing at 3.5 feet per second are exposed for up to 35 seconds to on-coming traffic while crossing at any location.
- Continuous lighting is provided along the corridor but may not sufficiently illuminate existing marked crosswalks.
- Large vegetation was observed in two small areas approximately 1,500 feet and 800 feet from Wilmot Road, in the vicinity of two bus stops.
- The land use character of the corridor creates high pedestrian crossing potential. Based on the cross-section and posted speed of 40 mph, the City can consider additional signalized pedestrian crossings.

Suggested Countermeasures

Near-Term Recommendations

a. Maintain vegetation in medians such that sight distance between motorists and pedestrians is sufficient in accordance with Tucson CIty Ordinances ($5,000)
b. MB-7: Restripe crossings and install High Visibility Crosswalks at intersections and signalized pedestrian crossings ($2,500 per location)

Long-Term Recommendations

c. MB-2: Install PELICAN/HAWK crossings at Leonora Avenue ($100,000 per location)

Other Considerations

d. Bus stop relocation or consolidation – closer to marked pedestrian crossings
e. TWSC-6 Enhance lighting to provide increased illumination for pedestrian visibility
f. Speed management including narrowing lanes from 12 feet to 10-11 feet and speed feedback signs
g. Reconfigure Park Place Drive/Broadway Blvd intersection to eliminate northbound channelized right turn lane. This would minimize pedestrian exposure and distance of bus stop to marked crosswalk.
h. Consider lowering the speed limit in concert with any roadway changes

E Speedway Blvd and N Craycroft Rd
Intersection Summary

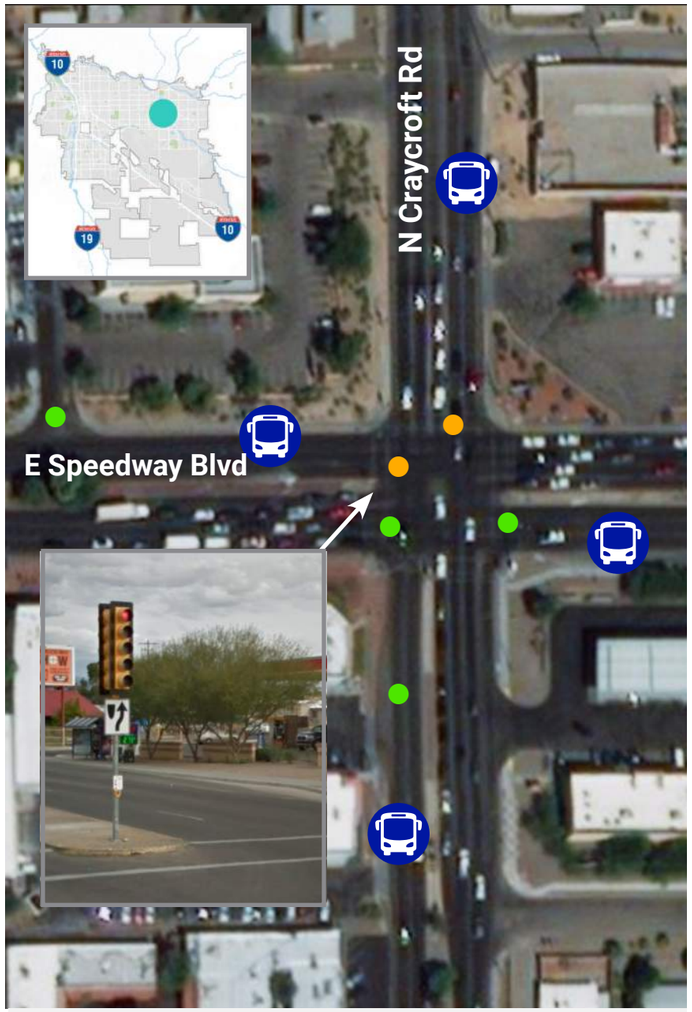
Tucson Pedestrian Safety Action Plan

Pedestrian Crashes (2014-2018)

Date	Time of Day	Injury Level	Distance from Int.	Direction of vehicle travel	Violation
Sunday 10/15/2017	Daylight	Possible injury	Approx. 120 feet south, on sidewalk	Eastbound right turn – from a driveway	None cited
Saturday 12/2/2017	Dawn	Non-incapacitating	In east leg crosswalk	Southbound left turn	Driver – failed to yield right-of-way
Sunday 12/10/2017	Dusk	Incapacitating	In west leg crosswalk	Southbound right turn	Driver – made improper turn
Monday 1/22/2018	Daylight	Non-incapacitating	In west leg crosswalk	Eastbound	Pedestrian – disregarded traffic signal
Monday 2/19/2018	Dawn	Incapacitating	In north leg crosswalk	Eastbound left turn	Driver – failed to yield right-of-way
Saturday 11/24/2018	Daylight	Possible injury	Approx. 170 feet west, on sidewalk	South – in a driveway	None cited

Site Characteristics

- Signalized intersection with five vehicle travel lanes on north Craycroft Road leg, six vehicle travel lanes on south Craycroft Road leg, and seven vehicle travel lanes on both Speedway Boulevard legs.
- Speed limits: 40 mph on Craycroft Road and 35 mph on Speedway Boulevard.
- Medians are provided on the south, east and west legs; non-ADA accessible pedestrian push buttons in all medians.
- Marked crossings present on all four legs.
- Commercial development with driveway access on all corners.
- Sun Tran routes 4 (along Speedway Boulevard) and 34 (along Craycroft Road) travel through intersection.



Sun Tran Stop

Fatal

Incapacitating Injury

Other Injury/ No Injury

N 0 60 120 180 Feet

Observations

- Bus stops on Speedway Blvd are located 80 to 150 feet from marked crossings. On Craycroft Road, bus stops are 120 to 210 feet from marked crossings. Transit riders at this intersection may choose to cross away from marked crosswalks.
- Intersection crossing distances are approximately 80 to 100 feet, with no median refuges for two-stage crossings. Long crossings increase exposure for pedestrians.
- Intersection corner radius could be reduced to slow turning movements.
- Lighting is present on all approaches; one luminaire is provided on the crosswalks on north and south legs of the intersection.
- All corners include single curb ramps with no tactile detectable warning strips.
- Pedestrian push buttons on several poles are more than 10 feet away from access ramps.

Suggested Countermeasures

Near-Term Recommendations

a. S-7 Leading Pedestrian Interval at approaches with high pedestrian or right-turn activity ($1,000)

b. S-8 Implement Left-turn Flashing Yellow Arrow and operate protected left-turn movements when pedestrian in crosswalk ($10,000)

c. MB-7 Restripe crossings and install High Visibility Crosswalks ($2,500)

d. S-2 Restrict right-turns on red ($500 - $5,000)[1]

Long-Term Recommendations

e. TWSC-2 Reconstruct existing medians to include accessible pedestrian refuges and reconfigure north leg to provide median refuge ($2,500 per location)[2,3]

f. Provide ADA-compliant pedestrian ramps ($5,000 per ramp)

g. TWSC-6 Install additional luminaries on north and south legs ($10,000 per luminaire)

h. Replace eastbound and westbound signal poles and mast arms and install additional signal heads ($30,000 per approach)

Other Considerations

i. Relocate bus stop on south leg and reconstruct right-turn driveway

j. Consider lowering speed limit in concert with any roadway changes

k. TWSC-6 Enhance lighting to provide increased illumination for pedestrian visibility

[1] The order of magnitude cost covers at the low end the purchase of a "No Right Turn on Red" sign and installation, while the high end costs represent the purchase and installation of a dynamic "No Right Turn on Red" sign.
[2] Cost assumes new crossing island, not converting existing median.
[3] Median on north leg may need to be widened.

KITTELSON & ASSOCIATES

E Irvington Rd and S Campbell Ave
Intersection Summary

Tucson Pedestrian Safety Action Plan

Pedestrian Crashes (2014-2018)

Date	Time of Day	Injury Level	Distance from Int.	Direction of Vehicle Travel	Violation
Thursday 9/3/2015	Daylight	Non-capacitating Injury	Approx.. 50 feet, east of Int.	Westbound	Pedestrian- did not use crosswalk
Friday 3/11/2016	Dusk	Possible Injury	In south leg crosswalk	Eastbound right turn	Driver - failed to yield right-of-way
Saturday 12/31/2016	Dark-lighted	Possible Injury	Approx. 50 feet west of Int.	Westbound	Pedestrian- did not use crosswalk
Wednesday 4/19/2017	Dark-lighted	Incapacitating Injury	Approx. 50 feet south of Int.	Eastbound right turn	Driver - speed to fast for conditions

Site Characteristics

- Signalized intersection with six vehicle travel lanes on each leg including right-turn lanes on all approaches.
- Speed Limits: 40 mph on Campbell Avenue and 35 mph on Irvington Road
- No pedestrian refuge median refuges.
- Crosswalks present on all four legs.
- Bicycle lanes provided on all approaches.
- Residential development on northwest corner; commercial development on northeast, southeast, and southwest corners.
- Sun Tran Routes 2 and 26 travel through intersection.

Observations

- Bus stops are located 150 to 200 feet from crosswalks at the intersection. Transit riders may not use crosswalks.
- The number of signal heads on each approach is not compliant with current guidance in the Arizona supplement to the MUTCD. There are opportunities to enhance signal conspicuity by adding signal heads.
- Intersection crossing distances are approximately 100 feet, with no intermediate refuge or opportunity for two-stage crossings. Long crossings increase exposure for pedestrians.
- Exclusive right turn lanes provided at the intersection could increase pedestrian exposure and risk.
- Lighting is present on all crosswalks.

Suggested Countermeasures

Near-Term Recommendations

a. S-7 Leading Pedestrian Interval at approaches with high pedestrian or right-turn activity ($1,000)
b. S-8 Implement Left-turn Flashing Yellow Arrow and operate protected left-turn movements when pedestrian in crosswalk ($10,000)
c. MB-7 Restripe crossings and install High Visibility Crosswalks ($2,500)
d. S-2 Restrict right-turns on red ($500 - $5,000)[1]

Long-Term Recommendations

e. Replace signal poles and mast arms and install additional signal heads ($30,000 per approach)
f. TWSC-2 Reconstruct intersection to add refuge medians and narrowed vehicle travel lanes

Other Considerations

g. Relocate bus stops on south and east legs closer to intersection and reconstruct right-turn driveway.
h. Enhance lighting to provide increased illumination for pedestrian visibility
i. Consider lowering speed limit in concert with any roadway changes

[1] The order of magnitude cost covers at the low end the purchase of a "No Right Turn on Red" sign and installation, while the high end costs represent the purchase and installation of a dynamic "No Right Turn on Red" sign.

W Ajo Way and S 12th Ave
Intersection Summary

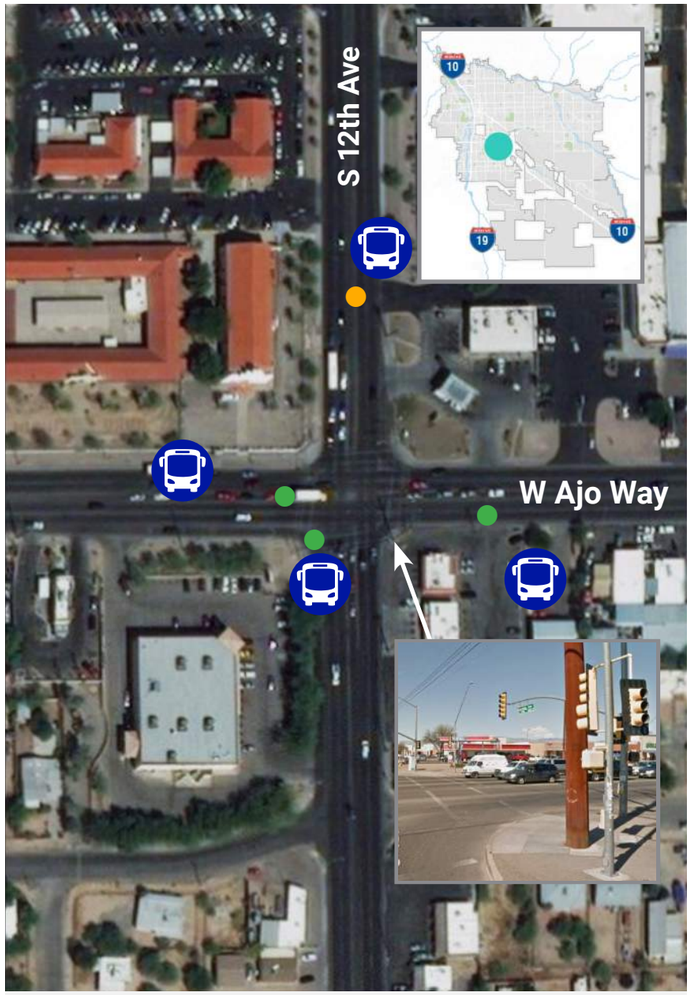
Tucson Pedestrian Safety Action Plan

Pedestrian Crashes (2014-2018)

Date	Time of Day	Injury Level	Distance from Int.	Direction of vehicle travel	Citation
Saturday 5/30/2015	Dark-lighted	Incapacitating	Unreported distance north; not in crosswalk	Northbound through	Pedestrian – did not use crosswalk
Sunday 3/12/2017	Daylight	No injury	In south leg crosswalk	Eastbound right turn	Driver - Failure to yield, fleeing scene
Friday 4/27/2018	Dark-lighted	Non-incapacitating injury	75 feet east on W Ajo Way Eastbound	Eastbound through	Pedestrian – did not use crosswalk
Thursday 12/27/2018	Dark-lighted	Possible injury	In west leg crosswalk	Northbound left	Driver - Failure to yield

Site Characteristics

- Signalized intersection with six vehicle travel lanes on north, west, south legs; five vehicle lanes on east leg.
- Speed Limits: 35 mph on all approaches.
- No medians for pedestrian refuge.
- Crosswalks present on all four legs.
- Bicycle lanes provided on all approaches.
- Commercial development with driveway access on three quadrants; elementary/middle school on northwest quadrant.
- Sun Tran Routes 12 (along 12th Avenue) and 50 (along Ajo Way) travel through intersection.



Observations

- Bus stop on north leg is 250 feet from intersection crosswalk. Transit riders may not use crosswalks.
- Lighting is present on all crossings but may not sufficiently illuminate existing marked crosswalks.
- Intersection crossing distances are all greater than 70 feet in length, with no intermediate refuge or opportunity for two-stage crossings.
- Right-turn lane on Ajo Way Eastbound increases pedestrian exposure and risk.
- Pedestrian curb ramps do not have detectable warning strips and pedestrian push buttons might be located over 10 feet from ramps.
- The north and south legs have a receiving lane which presents the potential for reallocation of curb space to shorten pedestrian crossing distance and reduce exposure.
- Utility pole located on the southeast corner, in the vicinity of the curb ramp, may limit pedestrian visibility. (See insert photo).

Suggested Countermeasures

Near-Term Recommendations

a. S-7 Leading Pedestrian Interval at approaches with high pedestrian or right-turn activity ($1,000)
b. S-8 Implement Left-turn Flashing Yellow Arrow and operate protected left-turn movements when pedestrian in crosswalk ($10,000)
c. MB-7 Restripe crossings and install High Visibility Crosswalks ($2,500)
d. S-2 Restrict right-turns on red ($500 - $5,000)[1]

Long-Term Recommendations

e. Provide push buttons within 10 feet of curb ramp ($10,000 per approach)
f. Reconstruct curbs to eliminate extra receiving lanes on north and south legs ($50,000)

Other Considerations

g. Relocate bus stops on north and south legs closer to intersection
h. Close driveway on Ajo Way – southeast corner
i. TWSC-2 Reconstruct intersection to add refuge medians and narrowed vehicle travel lanes
j. Enhance lighting to provide increased illumination for pedestrian visibility
k. Consider lowering speed limit in concert with any roadway changes

[1] *The order of magnitude cost covers at the low end the purchase of a "No Right Turn on Red" sign and installation, while the high end costs represent the purchase and installation of a dynamic "No Right Turn on Red" sign.*

W Ironwood Hill Dr and N Silverbell Rd
Intersection Summary

Tucson Pedestrian Safety Action Plan

Pedestrian Crashes (2014-2018)

Date	Time of Day	Injury Level	Distance from Int.	Direction of vehicle travel	Violation
Thursday 12/4/2014	Daylight	Incapacitating	50 feet east, not in crosswalk	Eastbound	Pedestrian – did not use crosswalk
Friday 12/9/2016	Daylight	Incapacitating	In east leg crosswalk	Northbound right turn	Driver – failed to yield right-of-way
Tuesday 6/20/2017	Daylight	Non-incapacitating	In west leg crosswalk	Southbound right turn	Driver – failed to yield right-of-way
Wednesday 2/7/2018	Dark-lighted	Incapacitating	220 feet east, not in crosswalk	Eastbound	Pedestrian – walked on wrong side of road

Site Characteristics

- Signalized intersection with seven vehicle travel lanes on west, south, and east legs; six vehicle lanes on north leg.
- Speed Limits: 40 mph on both roads.
- Medians on all approaches without pedestrian push buttons and detectable warning strips.
- Marked crossings present on all four legs.
- Bicycle lanes provided on all approaches.
- Commercial development with driveway access on all four quadrants; an apartment complex is located in the vicinity of the intersection (southwest quadrant).
- Sun Tran Route 9 (along Ironwood Drive) and 21 (along Silverbell) travel through intersection.
- Widening project was completed in early 2017 as part of an RTA project.

Sun Tran Stop
Fatal
Incapacitating Injury
Other Injury/ No Injury

N 0 80 160 240 Feet

Observations

- Bus stops are located between 125 and 250 feet from crosswalks. Transit riders may not use intersection crosswalks.
- Intersection crossing distances are all greater than 100 feet in length, with median refuges that do not have pedestrian push buttons.
- Left and right-turn lanes are provided on all approaches. Right turns and permissive left turns increase pedestrian exposure and risk.
- Skewed approaches and bus pull outs allow for higher speed right turns and conflicts with crossing pedestrians.

Suggested Countermeasures

Near-Term Recommendations

a. S-7 Leading Pedestrian Interval at approaches with high pedestrian or right-turn activity ($1,000)
b. S-8 Implement Left-turn Flashing Yellow Arrow and operate protected left-turn movements when pedestrian in crosswalk ($10,000)
c. MB-7 Restripe crossings and install High Visibility Crosswalks ($2,500)
d. S-2 Restrict right-turns on red ($500 - $5,000)[1]

Long-Term Recommendations

e. TWSC-2 Convert all medians to ADA-compliant pedestrian refuges with push buttons. ($5,000 per approach)

Other Considerations

f. Reconstruct curbs to eliminate extra receiving lanes and relocate bus stops closer to crosswalks
g. Speed management including speed feedback signs on Grant Road
h. Consider lowering speed limit in concert with any roadway changes

[1] *The order of magnitude cost covers at the low end the purchase of a "No Right Turn on Red" sign and installation, while the high end costs represent the purchase and installation of a dynamic "No Right Turn on Red" sign.*

APPENDIX D: PEDESTRIAN SAFETY TOOLBOX

TREATMENT TOOLBOX

The pedestrian safety treatments are organized into the following three program areas:

- Signalized Intersections;
- Marked Uncontrolled Crosswalks at Two-Way Stop-Controlled Locations; and
- Marked Uncontrolled Crosswalks at Midblock Locations.

To apply this toolbox to corridors:

- Consider if the corridor is over built from a vehicular capacity perspective? Could a roadway reconfiguration ("road diet") be implemented?
  - Road diets reduce the number of vehicle lanes a pedestrian has to cross and also reduces *vehicle speeds.*
  - *Reducing pedestrian* exposure to vehicles and slowing vehicle speeds help lower the risk of pedestrian crashes.
- Identify intersections along the corridor that are higher risk (based on their physical characteristics and crash history) for pedestrian crashes.
  - Depending on the control at these intersections, see the treatments within the signalized intersection toolbox or treatments within the marked uncontrolled crosswalks at two-way stop-controlled locations for potential improvements.
  - If there are a number of signalized intersections along the corridor, consider signal timing changes to coordinate the signals to encourage slower vehicle speeds (e.g., coordinate signals to encourage vehicle speeds of 30 mph).
- Identify midblock crossing locations – either existing marked uncontrolled midblock crossing locations or midblock locations that due to surrounding land uses are an attractive location for pedestrians to attempt to cross (e.g., midblock transit stops, commercial uses, schools, parks).
  - See the treatments within the marked uncontrolled crosswalks at midblock locations section of the toolbox.

Table 1 summarizes the treatments provided in the toolbox by program area. Treatments marked with this symbol: ★ are treatments that may help with managing or slowing vehicle speeds. The toolbox provides more detail on each treatment type including planning level cost ranges or order of magnitude cost values, benefits and constraints, typical applications, and design considerations. Cost ranges were developed based on similar projects in Pima County. References containing additional guidance are provided for each treatment. The guidance in this toolbox should be used alongside the City of Tucson's Pedestrian Safety Action Plan guidance as well as other City's initiatives to identify the most appropriate treatment(s) at a particular location.

Table 1. Toolbox Contents

	Page #	Treatment	Image
Signalized Intersections	S-1	Add Exclusive Pedestrian Phasing	
	S-2	Restrict Right Turn on Red	
	S-3	Protected Right Turn Phase	
	S-4	Modify Signal Timing ★	
	S-5	Convert Permissive Phase to Protected or Protected/Permissive Phasing	
	S-6	Install Pedestrian Countdown Timers	
	S-7	Implement Leading Pedestrian Interval (LPI)	
	S-8	Implement Flashing Yellow Arrow	

Uncontrolled Marked Crosswalks at Two -Way Stop-Controlled Intersections	TWSC-1	Install Raised Intersection or Raised Pedestrian Crossing ★	
	TWSC-2	Install Raised Median to serve as a Pedestrian Refuge Island ★	
	TWSC-3	Install In-Street "Yield for Pedestrians" Signs ★	
	TWSC-4	Stripe Advance Yield Lines	
	TWSC-5	Restrict Parking at Intersection Approaches	
	TWSC-6	Provide Pedestrian Lighting	
	TWSC-7	Reduce Corner Radii ★	

Uncontrolled Marked Crosswalks at Midblock Locations	MB-1	Install PELICAN Traffic Signal ★	
	MB-2	Install HAWK Crossing ★	
	MB-3	Install Rectangular Rapid Flashing Beacon ★	
	MB-4	Install a Crossing Island (i.e., Pedestrian Refuge Island) ★	
	MB-5	Install Curb Extension ★	
	MB-6	Install a Raised Pedestrian Crossing ★	
	MB-7	Install a High Visibility Crosswalk Pavement Markings	
	MB-8	Implement a Road Diet (i.e., reduce the number of vehicle lanes) ★	

ADD EXCLUSIVE PEDESTRIAN PHASING

Magnitude Cost: $5,000 – $30,000 (per intersection installation)[1]

Exclusive pedestrian phasing, sometimes referred to as a "pedestrian scramble," stops all vehicular movement and allows pedestrians to cross in any direction (including diagonally).

Benefits

- Nearly eliminates all pedestrian-vehicle conflicts
- Allows pedestrians to cross in any direction

Constraints

- Increases vehicle and/or pedestrian delay due to added phasing and increased cycle lengths
- Increased cycle lengths may encourage pedestrians crossing against the signal
- Additional educational and/or enforcement efforts may be required for consistent compliance.

Typical Applications

- Intersections with patterns of conflicts and/or collisions between crossing pedestrians and turning vehicles combined with high pedestrian crossing volumes.
- Central business district and other high pedestrian volume activity centers.

Design Considerations

- Speech walk messages used at intersections with exclusive pedestrian phasing shall be patterned after the model: "Walk sign is on for all crossings."
- Locate the push button such that it is easily accessible by pedestrians, wheelchair users, and bicyclists.
- Treatment may result in longer cycle lengths at intersections with long diagonal crossing distances; this may increase total delay for pedestrians and motorists at the intersection.
- Impacts to transit operations should be considered.
- Use additional pedestrian signal heads for diagonal crossing

Additional Guidance

- *Manual on Uniform Traffic Control Devices*

[1] The low end of the estimated cost range covers signal timing and reprogramming for the additional pedestrian phase while the high end of the estimated cost includes a new controller for the signal, additional pedestrian signal heads, and construction at the intersection.

RESTRICT RIGHT TURN ON RED

Magnitude Cost: $500-$5,000 (per approach)[2]

Mounted signs eliminate the right of motorists to make a right turn at a red light. Can be used full-time or under restricted time intervals.

Benefits

- Reduces conflicts and collisions between motorists and pedestrians

Constraints

- Reduces time motorists have to make a right turn
- Potential vehicle queuing
- Potential vehicle/transit delay
- Compliance may be limited without dynamic blink out signs

Typical Applications

- Signalized intersections where right-turning movements interfere with crossing pedestrians and pedestrian crossing volumes are high. See below for restriction considerations.

Design Considerations

- Restrictions could be considered where:
  - There is inadequate sight distance for pedestrians and vehicles to see each other – inadequate sight distance means insufficient stopping sight distance for motorists and/or pedestrians do not have sufficient line of sight to judge a safe gap to cross based on prevailing vehicle speeds;
  - Geometric or operational characteristics may result in unexpected conflicts;
  - There is an exclusive pedestrian phase or an exclusive bicycle phase;
  - Heavy pedestrian volumes;
  - School or railroad crossings; and
  - Traffic signal with three or more phases.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*

[2] The order of magnitude cost covers at the low end the purchase of a "No Right Turn on Red" sign and installation, while the high end costs represents the purchase and installation of a dynamic "No Right Turn on Red" sign.

PROTECTED RIGHT TURN PHASE

Magnitude Cost: $3,000 – $5,000[3]

Protected right turn phases may be used where vehicle and pedestrian volumes are high to separate the two conflicting movements.

Portland, OR

Benefits

- Reduces conflicts and collisions between right-turning motorists and pedestrians.

Constraints

- Increases pedestrian wait time at crossings
- Requires right-turn only lane.

Typical Applications

- Signalized intersections where high right-turning vehicle movements and high volumes of crossing pedestrians.
- Locations with a documented history of right-turning vehicle and pedestrian conflicts or collisions.

Design Considerations

- Protected right turn phases could be considered where:
  - There is inadequate sight distance for pedestrians and vehicles to see each other - inadequate sight distance means insufficient stopping sight distance for motorists and/or pedestrians do not have sufficient line of sight to judge a safe gap to cross based on prevailing vehicle speeds;
  - Geometric or operational characteristics may result in unexpected conflicts;
  - There are an unacceptable number of pedestrian conflicts with right-turn movements;
  - Heavy pedestrian volumes; and
  - Heavy right-turning vehicle volumes.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*

[3] The cost range covers retiming and reprogramming the signal and one or two additional signal heads.

MODIFY SIGNAL TIMING

Magnitude Cost: $1,000 – $3,500 (per intersection)[4]

Adjusting existing signal timings to better accommodate pedestrians. This could include reducing the amount of vehicular green time to decrease pedestrian wait time at signals.

OC&E Trail, *Klamath Falls, OR*

Benefits

- Provides additional crossing times and reducing wait times.
- Can be used to manage vehicle speeds along a corridor.

Constraints

- Improving conditions for one mode is often done at the expense of others (e.g. increased delay).

Typical Applications

- Signalized intersections where pedestrian cross times are inadequate for pedestrian volumes.
- Locations with a documented crash history of pedestrians frequently crossing against the signal.
- Along a corridor signal timing could be modified to help manage vehicle speeds – e.g., establishing progression for a vehicle speed of 13 mph.

Design Considerations

- Allow pedestrians sufficient time to cross the street, including seniors, children, and people with disabilities.
- A walking speed of 3.5 feet per second should be used to calculate the minimum pedestrian clearance interval (flashing red hand plus yellow and any all-red phases).
- Where pedestrians walk slower than 3.5 feet per second, or pedestrians who use wheelchairs routinely use the crosswalk, consider a walking speed of less than 3.5 feet per second.
- Provide a walk interval at least 7 seconds long to allow time for a pedestrian to leave the curb or shoulder before the clearance time begins.

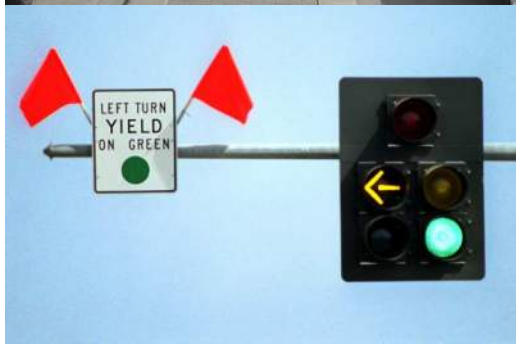
Additional Guidance

- *Manual on Uniform Traffic Control Devices*
- NACTO *Urban Street Design Guide*

[4] The cost range covers retiming and reprogramming a single intersection at the low end to more complex situations such as adjusting coordinated signals at the high end.

CONVERT PERMISSIVE PHASE TO PROTECTED OR PROTECTED/PERMISSIVE PHASING

Magnitude Cost: $5,000 - $10,000[5]



Adjust signal phasing to allow left-turning vehicles a protected or protected/permissive left-turn phase instead of a permissive phase.

Benefits

- Reduce left-turning conflicts with pedestrians and vehicles
- Improve vehicle turning-related safety for pedestrians and improve safety for left-turning motorists.
- Improve left-turning operations

Constraints

- Less green time for through and right turn movements
- Less green time for pedestrian crossings

Typical Applications

- Signalized intersections where left-turning vehicle-pedestrian crashes are frequent.
- Signalized intersections where left-turning vehicles and pedestrians have frequent conflicts.

Design Considerations

- Consider protected or protected/permissive phasing at intersections with a history of left-turning collisions, where pedestrian-vehicle turning conflicts are high, and intersections with large skews.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*
- *NCHRP Report 617: Accident Modification Factors for Traffic Engineering and ITS Improvements*
- FHWA *Toolbox of Countermeasures and Their Potential Effectiveness for Pedestrian Crashes*
- NACTO *Urban Street Design Guide*

[5] The cost range covers retiming and reprogramming the signal and one or two additional signal heads.

INSTALL PEDESTRIAN COUNTDOWN TIMERS

Magnitude Cost: $3,000 - $6,000 (per device)[6]

Static Walk/Don't Walk pedestrian signals with countdown signal informing pedestrians of the time remaining to cross the street.

Orlando, FL

Benefits

- Fewer pedestrians cross the street late in the countdown as compared to signal heads with only the Flashing Don't Walk light

Constraints

- Typically a network-wide or subarea wide treatment to create consistency for road-users, but is expensive to implement throughout an area

Typical Applications

- Signalized intersections
- Particularly useful to pedestrians for longer distance crossings so pedestrians know how much time remains before signal changes
- May be useful where crash or conflict patterns indicate pedestrians cross frequently against the signal

Design Considerations

- Countdown pedestrian signals are particularly suitable for crosswalks where the pedestrian change interval is more than 7 seconds to inform pedestrians of the number of seconds remaining in interval.
- Where they are installed, push buttons to activate the pedestrian signal should be easily accessible by pedestrians, wheelchair users, and bicyclists for each crossing.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*
- NACTO *Urban Street Design Guide*

[6] The cost range covers the device cost and additional installation.

IMPLEMENT LEADING PEDESTRIAN INTERVAL (LPI)

Magnitude Cost: $1,000 - $2,000[7]


Orlando, FL


Sacramento, CA

A leading pedestrian interval gives pedestrians a 2-5 second head start before the concurrent vehicle phase turns green to allow pedestrians to enter and occupy the crosswalk before turning vehicles get there.

Benefits

- Pedestrians are more visible in the crosswalk before vehicles start moving.
- Helps reduce conflicts with pedestrians and turning vehicles.
- Relatively low cost to implement

Constraints

- Reduces green time for vehicle movements.
- May add to delays at intersections operating near capacity.

Typical Applications

- Intersections where frequent turning vehicle movements make pedestrian crossing movements uncomfortable.
- Intersections with a documented history of turning movement-related vehicle-pedestrian crashes.

Design Considerations

- The leading pedestrian interval should give a minimum head start of 3-7 seconds depending on crossing distance.
- May be combined with a curb extension to improve visibility at high-conflict intersections.
- Should be implemented with no turn on red at high pedestrian volume intersections.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*
- ITE *Traffic Engineering Handbook*
- ITE/FHWA *Traffic Calming: State of the Practice*
- NACTO *Urban Street Design Guide*

[7] The cost range covers reprogramming of a single crossing to reprogramming an entire intersection.

IMPLEMENT LAGGING FLASHING YELLOW ARROW (FYA)

Magnitude Cost: $10,000[8]

A flashing yellow arrow with a leading pedestrian interval gives pedestrians a 2-5 second period when vehicles may turn if no conflicts are present but must yield to crossing pedestrians.


Portland, OR

Benefits

- Intended to communicate to motorists that caution should be used in making maneuver and motorists must yield to oncoming vehicles and crossing pedestrians
- Relatively low cost to implement

Constraints

- Reduces green time for vehicle movements.
- May add to delays at intersections operating near capacity.
- Does not provide a protected head start for pedestrians unless it occurs on lagging left turns

Typical Applications

- Intersections where frequent turning vehicle movements make pedestrian crossing movements uncomfortable.
- Intersections with a documented history of turning movement-related vehicle-pedestrian crashes.

Design Considerations

- The FYA leading pedestrian interval should give a minimum head start of 3-7 seconds depending on crossing distance.
- May be combined with a curb extension to improve visibility of and for pedestrians.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*
- *Improved Pedestrian Safety at Signalized Intersections Operating the Flashing Yellow Arrow*

[8] The cost range covers the upgrade and replacement of the signal head and labor, per approach.

INSTALL RAISED INTERSECTION/PEDESTRIAN CROSSING

Magnitude Cost: $10,000 – $50,000 (per crossing/intersection)[9]

A pedestrian crossing or intersection area raised vertically to give motorists and pedestrians a better view of the crossing area. It is essentially a speed table marked and signed for pedestrian crossing.

Benefits

- Increases visibility of pedestrians by motorists
- Slows motorists' travel speeds

Constraints

- Can be difficult to navigate for large trucks and buses.
- May present drainage challenges
- Emergency response times may be increased

Typical Applications

- Two-lane roadways where pedestrian volumes are high (greater than 50 pedestrians per hour) and vehicle speed control is needed.
- Locations where low-volume streets intersect with high-volume streets or where a street changes its street type or functions.
- Locations where conflict and/or crash patterns reflect vehicle-pedestrian crashes due to unsafe speeds and failure to yield to pedestrians.

Design Considerations

- Locate raised intersection/crossings where vehicles have adequate stopping sight distance to see and slow. Consider nighttime visibility.
- Challenging locations for raised crosswalks include designated transit routes or at locations with steep grades or sharp curves.
- Raised crosswalks should be long enough to allow a passenger vehicle's front and rear wheels to be on top of the table at the same time. Average wheelbase for passenger vehicles is about 9 feet.[10]
- Consider drainage patterns resulting from installation and consider impacts on emergency response times.

Additional Guidance

- ITE/FHWA *Traffic Calming: State of the Practice*
- *Manual on Uniform Traffic Control Devices*
- NACTO *Urban Street Design Guide*

[9] The low end of the cost range represents the cost of implementing the treatment as part of a larger project while the high-end of the range represents the costs of the design and installation as a standalone project.
[10] http://www.nhtsa.gov/cars/rules/CAFE/NewPassengerCarFleet.htm

INSTALL RAISED MEDIAN/REFUGE ISLANDS

Magnitude Cost: $20,000 – $30,000 (per island)[11]

Provides a raised refuge area in the median for pedestrians to stop while crossing the street. Can also help narrow roadway cross-section to slow vehicle speeds.

Benefits

- Creates possibility of two-stage crossings for pedestrians
- Can be used as a gateway to high pedestrian activity
- Can be used to help slow vehicle speeds

Constraints

- Must have at least 6 feet of space to accommodate wheelchairs; not all streets will have adequate space
- Physical barrier in the street

Typical Applications

- Intersections where:
  - Pedestrians volumes are greater than 20 pedestrians per hour;
  - Vehicle ADT volumes are greater than 12,000; and,
  - Sufficient width to provide a refuge (minimum of 6 feet).
- Locations with a high frequency of pedestrian crashes.
- Locations with long blocks and vehicle speeds are higher than desired or posted.
- Multilane roadways with pedestrian crossing needs

Design Considerations

- Raised median/refuge island should be located in places where pedestrians commonly cross (e.g., transit stops, schools, etc.)
- Can be located at intersection crossings as well as midblock crossings

Additional Guidance

- *Manual on Uniform Traffic Control Devices*

[11] The low end of the cost range covers implementation while the high end includes design costs.

INSTALL IN-STREET "YIELD FOR PEDESTRIANS" SIGNS ★

Magnitude Cost: $800 (per crossing)[12]

Signs placed in the middle of opposing travel lanes to increase driver awareness of pedestrians and the legal responsibility to yield right-of-way to pedestrians in the crosswalk.

Benefits

- Increases the number of motorists that yield to pedestrians in the crosswalk
- Reinforces the right of pedestrians in the travel-way

Constraints

- If used too often, motorists may ignore the signs
- Less effective on higher volume streets
- May require more maintenance than roadside signs.

Typical Applications

- Undivided two-lane road locations near schools and other pedestrian generators.
- In-street "Yield for Pedestrians" signs are commonly used in areas with lower vehicle volumes, low speeds (less than 35 mph), and poor yielding rates by motorists.
- Crash or conflict patterns resulting in vehicle-pedestrian crashes related to failure to yield by vehicles or unsafe speeds.

Design Considerations

- Per the *MUTCD* (Section 2B.12), the in-street sign(s) should be placed in the roadway at the crosswalk location on the center line, lane line, or on a median island.
- Consider vehicle clearance widths for roadway design vehicles to avoid signs being hit.
- Use in-streets signs strategically, overuse will lead to lower compliance.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*

[12] Cost range includes the cost of the sign and installation.

STRIPE ADVANCE STOP AND YIELD LINES

Magnitude Cost: $3,000 (per crossing)[13]

Advance stop and yield lines reduce vehicle encroachment into the crosswalk, improve drivers' view of pedestrians, and reduce multiple threat situations for pedestrians.

R1-5

Benefits

- Increase pedestrian-motorist visibility at the crosswalk.
- Reduce multiple threat situations for pedestrians

Constraints

- May interfere with vehicle operations and contribute to queuing at congested locations.
- Potential sign clutter

Typical Applications

- At multilane locations where marked crosswalks are present and vehicular ADT is greater than 12,000 per day.
- At intersections where pedestrian volumes are greater than 20 per day and vehicular ADT is greater than 8,000 per day.
- At locations where vehicle encroachment into the crosswalk is common.
- In advance of Rectangular Rapid Flashing Beacons and Pedestrian Hybrid Beacons

Design Considerations

- Yield lines should be placed 4 to 50 feet in advance of controlled marked crosswalks based; distance is based on vehicle speeds, street width, on-street parking, nearby land uses, and demand for queuing space.
- Yield lines should be placed a minimum of 4 feet in advance of uncontrolled marked crosswalk locations.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*

[13] Cost includes striping, signs, and labor.

RESTRICT PARKING AT INTERSECTION APPROACHES

Magnitude Cost: $600 (per approach)[14]

Red parking zones on the approaches to an intersection or crosswalk allow for improved sight distance between pedestrians waiting to cross or entering the crosswalk and approaching motorists.

Benefits

- Increase pedestrian-motorist visibility at the crosswalk.

Constraints

- Reduces available parking supply in area of restriction.

Typical Applications

- Locations where sight distance is currently limited and could be improved by removing parked vehicles.
- Locations with a history of frequent collisions or other documented safety concerns.

Design Considerations

- Each location should be evaluated to determine whether parking removal is appropriate.
- A minimum 10 foot red zone should be painted on all crosswalk approach legs.
- Longer red zones should be used at locations with a greater need for improved visibility due to unique sight distances, higher vehicle speeds, road geometry, or other conditions.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*

[14] Order of magnitude cost includes parking restriction sign, paint, and labor.

INSTALL PEDESTRIAN LIGHTING

Magnitude Cost: $10,000 (per light)[15]

Pedestrian lighting may increase nighttime street visibility for pedestrians where existing illumination does not readily address crossing locations.


Denmark, Credit: Dan Burden

Benefits

- Increases visibility of pedestrians waiting to cross and in the crossing.

Constraints

- Potential to restrict and/or clutter sidewalk environment near the crosswalk.

Typical Applications

- Crossings or areas with high levels of nighttime pedestrian activity (e.g., greater than 20 pedestrians per hour).
- Locations with a high frequency of nighttime pedestrian crashes.
- Could also be considered for crossings with lower pedestrian volume activity if crossing conflict is severe or unexpected (e.g., pedestrian crossing location across a higher speed roadway).

Design Considerations

- Illumination could be used to contribute to the identity of a district or neighborhood and serve as a unifying element in the streetscape.
- Lighting should be scaled to the street and land use contexts to avoid light pollution/trespass and ensure a comfortable illumination quality for users.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*

[15] Cost includes materials and labor per light.

REDUCE CORNER RADII

Magnitude Cost: $15,000 - $60,000 (per corner)[16]

Reduces right-turning vehicle speeds at an intersection by forcing sharper turns. Reduced corner radii also shorten crossing distances for pedestrians.

Benefits

- Reduces right-turning vehicle speeds at the intersection.
- Reduces pedestrian exposure by reducing crossing distance.

Constraints

- Potential drainage changes needed in some retrofits.
- Less effective at reducing speeds before and after turns.

Typical Applications

- Intersections with average right-turn speeds above 15 miles per hour and where pedestrian volumes are greater than 20 pedestrians per hour.
- Intersections with a documented crash history of right-turning vehicle and pedestrian conflicts.

Design Considerations

- Corner curb radii should accommodate the roadway type's design vehicle turning movements.
- A smaller curb radius expands the pedestrian area and allows for better pedestrian ramp/crosswalk alignment.
- Minimize effective turning radius where possible.
- Consider existing drainage infrastructure needs for modifications.

Additional Guidance

- *Manual for Uniform Traffic Control Devices*
- NACTO *Urban Street Design Guide*

[16] Cost range depends on site conditions such as the need to relocate drainage or utilities as well as the need for surveying and/or design.

INSTALL PELICAN TRAFFIC SIGNAL

Magnitude Cost: $200,000 (per installation)

Provides pedestrians with a signal-controlled crossing at a mid-block location or at a previously stop-controlled intersection where pedestrian volumes warrant full signalization. The signal remains green for the mainline traffic movement until actuated by a push button to call a red signal for traffic.


Tucson, AZ


Tucson, AZ

Benefits

- Has nearly 100 percent rate of motorist yielding behavior at crossing locations.
- Same appearance as standard traffic signal, so motorist understanding is high.
- Can be configured such that pedestrians are facing traffic before crossing.

Constraints

- Must be activated by pedestrians.
- More costly than other crossing treatments.

Typical Applications

- Locations meeting traffic signal warrants for pedestrians as defined in the *MUTCD* (Part 4).
- Locations where there are conflict or crash patterns between vehicle-pedestrians.
- Typical applications include:
  - Locations with four or more lanes and vehicle volumes greater than 15,000 per day
  - Locations with pedestrian volumes greater than 20 per hour and speed limits greater than 35 mph
  - At locations where multi-use paths intersect with roadways.

Design Considerations

- The push button to activate the pedestrian signal should be easily accessible by pedestrians, wheelchair users, and bicyclists (if applicable).

Additional Guidance

- *Manual on Traffic Control Devices*
- NACTO *Urban Street Design Guide*
- *NCHRP Report 562 Improving Pedestrian Safety at Unsignalized Crossings*

INSTALL HAWK CROSSING

Magnitude Cost: $150,000 (per installation)[17]

Boise, ID

A pedestrian hybrid beacon (HAWK) is a pedestrian activated display that is unlit when not in use. It begins with a yellow light alerting drivers to slow, and then displays a solid red light requiring drivers to remain stopped while pedestrians cross the street. Finally, the beacon shifts to flashing red lights to indicate motorists may proceed after pedestrians have completed their crossing.

Benefits

- Higher rates of motorists yielding than crosswalks without PHB.
- Reduces pedestrian-involved crashes.
- Less delay to motor vehicle drivers than a signal.

Constraints

- Must be activated by pedestrians.
- More costly than other crossing treatments.
- Initially, may be unfamiliar to motorists.

Typical Applications

- Conditions consistent with MUTCD guidance.
- Typical locations include:
  - Locations with four or more lanes and vehicle volumes greater than 15,000 per day
  - Locations with pedestrian volumes greater than 20 per hour and speed limits greater than 35 mph
  - At locations where multi-use paths intersect with roadways.

Design Considerations

- The push button to activate the pedestrian hybrid beacon should be easily accessible by all users.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*
- NACTO *Urban Street Design Guide*
- *NCHRP Report 562 Improving Pedestrian Safety at Unsignalized Crossings*

[17] Cost includes design, materials, and installation.

INSTALL RECTANGULAR RAPID FLASHING BEACON (RRFB)

Magnitude Cost: $30,000 (per installation)


Portland, OR


Beaverton, OR

These crossing treatments include signs that have a pedestrian-activated "strobe-light" flashing pattern to attract motorists' attention and provide awareness of pedestrians and/or bicyclists that are intending to cross the roadway.

Benefits

- Provides a visible warning to motorists at eye level.
- Increases motorists yielding behavior at crossing locations over round yellow flashing beacons (80 to 100 percent compliance).
- Allows motorists to proceed after yielding to pedestrians.

Constraints

- Flashing beacons must be activated by pedestrians.
- Motorists may not understand the flashing lights of the RRFB, so compliance may be lower than with a traffic signal.

Typical Applications

- Midblock crossings with pedestrian volumes of 20 or more pedestrians per hour and documented midblock crossing pedestrian collisions.
- Locations with:
  - Three or more lanes and posted speeds of 30 mph or higher without a raised median.
  - Three or more lanes and posted speeds of 40 mph with or without a raised median
- Locations where multi-use paths intersect with roadways (bicyclists must dismount).

Design Considerations

- The push button should be easily accessible by pedestrians, wheelchair users, and bicyclists (if applicable).
- Consider adding a push button in the median island for crossings of multi-lane facilities.
- Automated pedestrian detection may also be installed; it would increase cost of installation.
- Consider separate indication for pedestrian that warning lights are activated.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*
- NCHRP *Report 562 Improving Pedestrian Safety at Unsignalized Crossings*

INSTALL CROSSING ISLAND (PEDESTRIAN REFUGE)

Magnitude Cost: $15,000 – $25,000 (per crossing island)[18]


Portland, OR


Portland, OR

Provides a raised refuge area in between opposing travel streams for pedestrians to stop while crossing the street. They can be used at intersections or mid-block crossings.

Benefits

- Reduces pedestrian exposure at marked and unmarked crosswalks.
- Requires shorter gaps in traffic to cross the street by allowing pedestrians to cross in two phases.
- Can help reduce vehicle speeds.

Constraints

- Streets with constrained right-of-way may not have sufficient width to allow for a crossing island.
- May not be feasible where a left turn lane is necessary.

Typical Applications

- Four or more lane roadways without a raised median where:
  - Posted speeds are 30 mph or less and vehicular ADT is between 9,000 and 12,000 per day.
  - Posted speeds are 35 mph and vehicular ADT is 9,000 per day or less.
- Often used in areas with high levels of vulnerable pedestrian users, such as near schools or senior centers/housing, or a demonstrated pedestrian crash history.

Design Considerations

- Must have at least 6 feet of clear width to accommodate people using wheelchairs.
- At crossing locations where bicyclists are anticipated, a width of 10 feet or greater is desirable to accommodate bicycles with trailers or groups of bicyclists.
- Can be applied in conjunction with other treatments.

Additional Guidance

- *Manual for Uniform Traffic Control Devices*
- NACTO *Urban Streets Design Guide*
- *NCHRP Report 562 Improving Pedestrian Safety at Unsignalized Crossings*

[18] Cost range varies from installation alone at the low end to design and installation at the high end.

INSTALL CURB EXTENSIONS

Magnitude Cost: $15,000 - $60,000 (per extension)[19]

An extension of the curb or the sidewalk into the street, usually at an intersection, that narrows the vehicle path, inhibits fast turns, and shortens the crossing distance for pedestrians.


Boston, MA


Bend, OR

Benefits

- Shortens crossing distances for pedestrians.
- Reduces motorist turning speeds.
- Increases visibility between motorists and pedestrians.
- Enables permanent parking
- Enables tree and landscape planting and water runoff treatment.

Constraints

- More easily implemented on streets with on-street parking.
- Physical barrier can be exposed to traffic.
- Greater cost and time to install than standard crosswalks.
- Can present turning radius problems to large vehicles.
- Can present difficulty with drainage.

Typical Applications

- Mid-block or intersection pedestrian crossings on streets with unrestricted on-street parking.
- Crossing locations with pedestrian collision history.
- Streets with on-street parking where:
  - pedestrian volumes ≥ 20 pedestrians per hour;
  - ADT ≥ 1,500 vehicles per day; and,
  - average right-turn speeds ≥ 15 mph.

Design Considerations

- Include a passage for bicycles to prevent conflicts with vehicles.
- Provide accessible curb ramps and detectible warnings.
- Include landscaping on the curb extension to differentiate the pedestrian travel path.

Additional Guidance

- *Manual for Uniform Traffic Control Devices*
- ITE/FHWA *Traffic Calming: State of the Practice*
- FHWA *Designing Sidewalks and Trails for Access Part II*

[19] Cost range depends on site conditions such as the need to relocate drainage or utilities as well as the need for surveying and/or design.

INSTALL RAISED PEDESTRIAN CROSSING

Magnitude Cost: $10,000 – $50,000 (per crossing)[20]


Atlanta, GA

Orlando, FL


Sanford, FL

Raised pedestrian crossings bring the level of the roadway even with the sidewalk, providing a level pedestrian path and requiring vehicles to slow. Raised crossings can be used at midblock crosswalks or intersections.

Benefits

- Increases visibility for pedestrians and motorists
- Slows motorists.

Constraints

- Can be difficult to navigate for large trucks, snow plows, and low ground clearance vehicles.

Typical Applications

- Raised crosswalks are typically provided at midblock crossings on two-lane roads where pedestrian volumes ≥ 50 pedestrians per hour and speed control is needed and there is a document history of pedestrian crossing-related collisions.
- Raised crosswalks may be provided at intersections where low-volume streets intersect with high-volume streets or where a roadway context changes (e.g. commercial to residential).

Design Considerations

- Raised crosswalks should be even with the sidewalk in height and at least as wide as the crossing or intersection.
- Provide detectable warnings for pedestrians where they cross from the sidewalk into the crossing area.
- Consider drainage needs and provide appropriate treatments.
- Use colored asphalt as opposed to brick or decorative surface materials to make the crossing smoother for those with mobility impairments.
- Raised crosswalks should not be used on transit routes or where there are steep grades or curves.

Additional Guidance

- *Manual for Uniform Traffic Control Devices*
- FHWA Designing Sidewalks and Trails for Access *Part II of II: Best Practices Design Guide*
- NACTO *Urban Street Design Guide*

[20] The cost range varies from inclusion as part of a larger project to the design and installation as a standalone project.

INSTALL HIGH VISIBILITY CROSSWALK

Magnitude Cost: $2,500 (per crossing)[21]

Mount Rainier, MD

High visibility crosswalks consist of reflective roadway markings and accompanying signage at intersections and priority pedestrian crossing locations.

Benefits

- Communicates potential for pedestrian crossings to motorists.
- Designates a preferred crossing location for pedestrians.
- Increases motorists' awareness of crossing pedestrians.

Constraints

- Can be more effective with other types of traffic control (signals, stop signs)[22].
- Motorist compliance is lower than other midblock treatments.

Typical Applications

- Locations near schools, parks, hospitals, senior centers, or other pedestrian generators.
- Peak hour pedestrian volumes are higher than 40 per hour and vehicle ADT is greater than 1,500 per day.
- Location is 300 feet or more from another crossing with documented history of pedestrian crossing collisions.

Design Considerations

- Striping can vary (continental, triple four, ladder, zebra, etc.)
- Minimum width is 6 feet, but wider crossings are preferred in areas with high number of pedestrians.
- Striped crosswalks alone should not be used where:
  - the speed limit exceeds 40 mph
  - the ADT is 12,000 or greater and there are four or more lanes without a raised median or crossing island
  - the ADT is 15,000 or greater and there are four or more lanes with a raised median or crossing island
- Ensure sufficient sight distance for vehicles and pedestrians.
- In school zones, yellow striping should be used.
- Appropriate lighting conditions should be considered.

Additional Guidance

- *Manual on Uniform Traffic Control Devices*
- *NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings*

[21] Cost based on design, paint, and installation.
[22] Fitzpatrick, K. et al, *NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings* (2006).

IMPLEMENT A ROAD DIET OR ROAD RECONFIGURATION

Magnitude Cost: $30,000 - $150,000 (per mile)[23]


Orlando, FL

In a road diet project, a street's roadway space is reconfigured or restriped to reduce the number of vehicle lanes to prioritize speeds consistent with a pedestrian- and bicycle-oriented environment.

Benefits

- Decreases vehicle speeds
- Increases driver awareness of bicyclists and pedestrians
- Reallocates space for pedestrians and bicyclists
- Improves comfort level for pedestrians and bicyclists.

Constraints

- Can be more effective with other types of traffic control (signals, stop signs).
- At uncontrolled locations (midblock), motorist compliance is not as high as with other treatments.

Typical Applications

- Four or five lane undivided roadways with vehicular ADT of 20,000 or less, or peak hour directional volumes of 875 or less.
- Locations with a documented history of left-turning or speed-related collisions or conflicts with pedestrians.

Design Considerations

- Lane reconfiguration/road diet projects should have a traffic analysis conducted prior to implementation.
- The reconfiguration of the roadway space should be context sensitive, taking into account the operations, user needs, and land use context of the roadway.

Additional Guidance

[23] Cost range covers the range from design and restriping only to more complicated projects involving planning, outreach, and more complex design.

Marked Uncontrolled Crosswalks at Midblock Locations

Oakland, CA

- *Manual on Uniform Traffic Control Devices*
- *NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings*
- NACTO *Urban Street Design Guide*

APPENDIX E: STRATEGIES TO PROMOTE EQUITABLE COMMUNITY ENGAGEMENT

Strategies to Promote Equitable Community Engagement

in City Decision-Making Processes

Developed by the Arizona Prevention Research Center

University of Arizona Mel and Enid Zuckerman College of Public Health

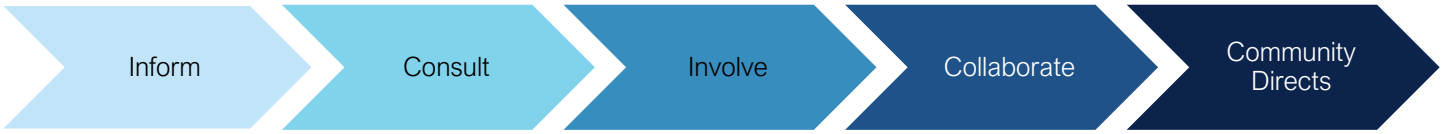
MEL & ENID ZUCKERMAN COLLEGE OF PUBLIC HEALTH
Arizona Prevention Research Center

PAPRN+ PHYSICAL ACTIVITY POLICY • RESEARCH • NETWORK • PLUS

The spectrum of community engagement

This toolkit is modeled after the International Association of Public Participation's Public Participation Spectrum, developed to assist agencies with "establishing and communicating clear expectations regarding the intent of public participation projects."

Definitions and key takeaways from each level can be found below, and a more detailed description of each level of the spectrum is found in the following pages.



Inform: Providing the community with balanced, factual and culturally appropriate information to assist them in understanding the problems, alternatives, and/or solutions

- Informing is a critical first step in educating the community to foster interest and promote further participation. Providing information in accessible formats, particularly in Spanish, communicates a commitment to equity.
- Examples: informational events, candidate forums, presentations, media campaigns, publicly available reports

Consult: Obtaining community feedback on analysis, alternatives, and/or decisions

- Consultation methods are essential when attempting to engage as many people as possible. Non-traditional and creative methods of consultation can be a critical way to build participation of marginalized communities.
- Examples: pop-up engagements, workshops, neighborhood association presentations, engagement in community settings (bus stops, parks, streets, community organizations)

Involve: Working directly with communities throughout the process to ensure that community issues and concerns are consistently understood and considered

- A critical element of involvement is the necessity to ensure it is mutually beneficial for the city and community members, including providing opportunities for skills development and coalition-building.
- Examples: task forces, community ambassadors, community mapping, digital storytelling, walking assessments

Collaborate: Partnering with communities in each aspect of the decision, including the initial development of alternatives and the preferred solution

- When seeking more extensive and long-term participation from community members, particularly community members from marginalized communities, compensation in some form is an essential element to include.
- Examples: coordinating councils, participatory planning, budgeting and project prioritization

Community Directs: Place final decision-making in the hands of the public or community

- While cities can actively support the success of grass-roots coalitions and their leadership in formal city processes, initiatives and solutions that are community directed must be just that, and originate within the community itself.
- Examples: citizen's panels and juries, participatory budgeting, ballot initiatives

Inform

Inform | Consult | Involve | Collaborate | Community Directs

Providing the community with balanced, factual and culturally appropriate information to assist them in understanding the problems, alternatives, and/or solutions

Key Considerations

- Critical for building community understanding of issues to foster interest and promote further participation.
- Providing information in accessible formats, including multiple languages and mediums, and in spaces that community members naturally access and congregate, communicates a commitment to equity.
- Ease of access to city documents at all stages of a process is critical for building community trust and interest.

Examples

- Community forums
- Public service announcements
    - Value-based messaging
- Media events
- Social media engagement
    - Events, informational posts, calls to action
- Public talks
- Informational presentations
- City progress reports
- Publicly-available documents & policies

Living Streets Alliance World Day of Remembrance for Road Traffic Victims 2017

Consult

Inform | **Consult** | Involve | Collaborate | Community Directs

Obtaining community feedback on analysis, alternatives, and/or decisions

Key Considerations

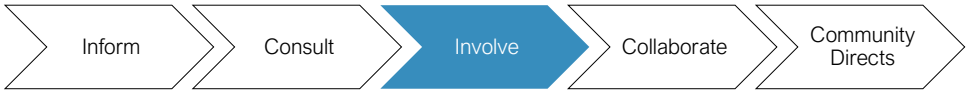
- Consultation should expand beyond traditional city engagement strategies, such as designated speaking time at official meetings and open houses, to include efforts to engage residents in community settings and using creative facilitation strategies that better foster broad participation
- While broad participation is an important goal, particular effort and attention should be given to engaging communities traditionally excluded from city engagement to ensure better representation.

Examples

- Pop-up engagements
- City presence in community settings (bus stops, parks, streets, community organizations)
    - Community walkshops
    - SpeakOuts
    - Community capacity inventories
- Community demonstrations
    - Tactical Urbanism/Lighter Quicker Cheaper Techniques
- Dialogue workshops
- Public deliberation
- Focus groups
- Surveys
    - Visual preference surveys
    - E-engagement
- Asset usage mapping
- Scenario planning

Living Streets Alliance pop-up engagement at the Community Food Bank of Southern Arizona

Involve



Working directly with communities throughout the process to ensure that community issues and concerns are consistently understood and considered

Key Considerations

- A critical element of involvement is the necessity to ensure it is mutually beneficial for the city and community members, including providing opportunities for skills development and coalition-building, rather than simply extracting information from communities.
- Specific efforts to involve youth in city planning and engagement efforts should also be considered.

Examples

- Eliciting community voice
  - Digital storytelling
  - PhotoVoice
  - Photo visioning
  - Walking assessments
- Community visioning
- Task forces & advisory committees
- Digital storytelling
- Community mapping
- Community conferences/summits
- Facilitation techniques
- Youth involvement
- Community design charrettes
- Health Impact Assessments

Creative Narrations Complete Streets digital storytelling training

Collaborate

Inform | Consult | Involve | **Collaborate** | Community Directs

Partnering with communities in each aspect of the decision, including the initial development of alternatives and the preferred solution

Key Considerations

- True collaboration requires intentionally engaging community members from the beginning of the process, with an established set of shared expectations between city and community.
- Compensation, scheduling, amenities, and facilitation styles should be approached in a way that reduces barriers to participation for people traditionally unable to attend traditional meetings.
- Utilize tools to assess power dynamics in meetings to understand additional invisible barriers to participation.

Examples

- Formalized agreements with coalitions/community organizations
- Community ambassadors
- Participatory decision-making
- Project Prioritization Processes
- Community capacity building
- Participatory action research
- Assess power dynamics in meetings
- Advocacy training

Tucson coalition's agreement gives locals more say in 4th Avenue apartment plan

Community Directs

Place final decision-making in the hands of the public or community

Key Considerations

- In order to be community-directed, engagement must be driven by the interests and leadership of the community and grow out of initiatives and coalitions started within the community.
- Other efforts to ensure the community is directing decision-making should include influence over city finances, given that how money is spent is one of the most significant measures of a city's priorities and vales.

Examples

- Support of local leadership and coalition-driven initiatives
- Ballot initiatives
    - Pro-voter policies
- Citizen's Juries
- Citizens Panels
- Participatory budgeting

Flowers and Bullets Collective

Key Resources

Below are great resources to guide effective and creative uses of community engagement in city practice that informed the creation of this toolkit.

A Blueprint for Changemakers Achieving Health Equity Through Law & Policy

A Guidebook to Community Engagement: Involving Urban & Low-Income Populations in an Environmental Planning Process

Building Healthy, Equitable Communities

By the People, For the People: Participatory Budgeting from the Bottom Up in North America

Center for Community Progress Resources

Creative Placemaking and Community Safety: Synthesizing Cross-Cutting Themes (Urban Institute)

Community Visioning Process: A Tool for Successful Planning

Cultural Indicators and Power

Data for the People – Community Research Tools

From Start to Finish: Health in All Policies - How to permanently improve government

Futurewise Community Engagement Toolkit

Health in All Policies - Collaborating across sectors to improve health

Improving Government to Improve Health

Improving Local Government

Inclusive Community Engagement & Equitable Participation to Improve 4 Core Functions of Local Government

Making Public Participation Legal

MAPC's Community Engagement Guide

National League of Cities – Local Practices in Public Engagement

Participation Tools for Better Community Planning

Participatory Budgeting Project

Reframing Public Participation: Strategies for the 21st Century (Innes & Booher)

The Principles of Equitable and Inclusive Civic Engagement

The Health and Housing Starter Kit