Transportation System Safety Analysis Final Report

City of Vancouver

Vancouver, Washington

November 29, 2018

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Acronyms

AASHTO	American Association of State Highway and Transportation Officials
CMF	Crash Modification Factor
FHWA	Federal Highway Administration
HSIP	Highway Safety Improvement Program
MAP-21	Moving Ahead for Progress in the 21st Century Act (federal transportation funding legislation)
NHTSA	National Highway Traffic Safety Administration
ROW	Right-Of-Way
TAC	Technical Advisory Committee
TSP	Transportation System Plan
TSSA	Transportation System Safety Analysis
VMT	Vehicle Miles Travelled
WSDOT	Washington State Department of Transportation

Definitions

AADT	The counted or estimated total traffic in one year at a location divided by 365 days/year.
Collision Diagram	A schematic representation of crashes that have occurred at a site within a given time period.
Countermeasure	A strategy to reduce the crash frequency or crash severity or both at a site. Countermeasures are also called “treatments” and can be physical engineering strategies or enforcement or policy strategies.
Crash	A set of events that result in injury or property damage due to the collision of at least one motorized vehicle and may involve collision with another motorized vehicle, a bicyclist, pedestrian or other object.
Crash Frequency	Number of crashes occurring at a particular site, facility or network in a period. Measured as numbered of crashes per year.
Crash Location	A type of position, based on roadway features and direction of travel, on which the first impact occurred. Example locations: intersection, segment, work zone, school zone, shoulder and median.
Crash Modification Factor	Multiplicative factor to compute the expected number of crashes after implementing a given countermeasure.
Crash Rate	Number of crashes per unit of exposure. For intersections this is usually the number of crashes divided by the total entering average daily traffic, for road segments this is typically the number of crashes per million vehicle miles travelled.
Crash Severity	Crash severity can be: fatality, serious injury, evident injury, possible injury, and no injury or property damage only. The crash severity is defined by the most severe injury in the crash.
Crash Type	A type of impact for a crash based on which collision unit struck another, the movement of the units, and other factors. Example crash types include: rear-end, sideswipe, head-on, turning, fixed object etc.
Diagnosis	Evaluating crash data to identify the factors contributing to the occurrence of the crash. The identification of factors that may contribute to crashes.
Distribution	The set of frequencies or probabilities assigned to various outcomes of a particular event.
Expected Crashes	An estimate of the long range average number of crashes per year for particular type of roadway or intersection.
Intersection	General area were two or more roadways or highways meet, including the roadway and roadside facilities for pedestrians and bicycle movements.
Network Screening	Process for reviewing a transportation network to identify and rank sites from most likely to least likely to benefit from a safety improvement.
Regression to the mean	The tendency for the occurrence of crashes at a particular site to fluctuation up or down over the long term and to converge to a long-term average.
Road Segment	Portion of a road that has a consistent cross-section (e.g. number of lanes, width of lanes, presence type and width of bike lanes etc.)
Safety	The number of crashes, by severity, expected to occur on the entity per unit of type. An entity may be any type of intersection, ramps or road segment, or a driver etc.
Site	Project location consisting of, but not limited to, intersections, segments ramps, interchange, ramp terminal intersections.
Site with Potential for Safety Improvement	Location identified as having the possibility of responding positively to a safety improvement.
Systemic Safety Analysis	Analyze and identify the common characteristics (e.g., number of lanes, traffic volume, location type, etc.) of a selected crash type. The most common characteristics are called common contributing factors or sometimes risk factors. Low cost countermeasures are selected to mitigate the common characteristics.

1 Introduction

1.1 Background

The Transportation System Safety Analysis (TSSA) for the City of Vancouver is a comprehensive analysis of crash trends and contributing factors on City-owned collectors and arterial roads. The analysis has been conducted to support the City's ongoing efforts to establish programs addressing transportation system safety needs. The City has never conducted a comprehensive citywide crash analysis; completing this analysis lays the groundwork for proactively considering crash frequency and severity for all users in the City's upcoming Transportation System Plan (TSP) update.

The purpose of the analysis is to evaluate citywide crash trends, identify transportation system safety priority crash types and major contributing factors associated with these priority crash types, prioritize roadway segments and intersections, identify potential solutions for the highest priority locations, develop a toolbox of countermeasures to address safety concerns, and provide ideas for integrating safety analysis into the City's upcoming TSP update. The analysis is focused on infrastructure-related issues and potential solutions. This document is a compilation of the project analyses. A separate document has also been prepared to summarize the key findings of this analysis.

1.2 Analysis Overview

The TSSA was completed in six major steps, each step slightly more detailed than the previous step:

1. Analyze citywide crashes and understand overall performance, trends, and identify priority focus crash areas (Section 2);
2. Narrow the analysis to understand the major common characteristics of crashes in the focus crash areas (Section 3);
3. Identify intersections and roadway segments with potential for safety improvement, and identify improvements at selected locations (Section 4);
4. Identify a toolbox of countermeasures (Section 5);
5. Develop project options at selected prioritized locations (Section 6), and
6. Develop options for integrating safety into the upcoming TSP update (Section 7).

A Technical Advisory Committee composed of staff from the City of Vancouver, Clark County, Southwest Washington Regional Transportation Council, and Washington State Department of Transportation participated in discussions of project milestones and recommendations from each phase of the project. Participants are identified in Appendix A.

All of the following analyses are conducted using Washington State Department of Transportation 2010-2016 crash data. Seven years of crash data were used instead of 10 years of crash data because of changes in city boundaries and changes in crash

data. To simplify data integration, the analysis was narrowed to 10-years of data. The analysis for "Citywide Crash Performance and Trends" (Section 2) is conducted on City-owned arterial, collector, and local roads and at intersections with state-owned roads. The analyses for "Common Roadway Characteristics of the Focus Areas" (Section 3) and "Prioritization of Intersections and Roadway Segments" (Section 4) are conducted on City-owned arterial and collector roads at intersections with state-owned roads, but do not include local roads. These analyses were conducted on the most recent five years of crash data (2012-2016) to focus on more travel, environment and roadway characteristics.

2 Citywide Crash Performance and Trends

The three components of the citywide crash analysis include an assessment of:

- Safety performance using the Federal Highway Administration Safety performance measures (Section 2.1)
- Crash trends categorized by crash type, mode of crash, and contributing factors (Section 2.2)
- Safety performance as compared to State of Washington Target Zero Plan priority areas (Section 2.3)

2.1 Citywide Safety Performance Using Federal Safety Performance Measures

The Federal Highway Administration, through the Moving Ahead for Progress in the 21st Century (MAP-21) transportation legislation, has instituted five transportation safety performance measures to evaluate safety conditions and inform safety improvement strategies.

1. Number of fatalities
2. Number of serious injuries
3. Number of non-motorized fatalities and non-motorized serious injuries (combined); non-motorized includes pedestrian, bicyclist, other cyclist, and person on personal conveyance
4. Rate of fatalities per 100 million Vehicle Miles Travelled (VMT)
5. Rate of serious injuries per 100 million VMT

State Departments of Transportation and Metropolitan Planning Organizations are required to establish targets for each of these performance measures. While cities are not required to adopt or establish targets for these performance measures, they do provide a useful summary of citywide crash conditions. The following analysis includes crashes on City-owned arterial, collector, local roads, and at intersections with state-owned roads, but does not include state-owned road segments.

Between 2010 and 2016, there were:

- 41 fatalities from traffic crashes; approximately six fatalities per year

- 285 serious injuries due to traffic crashes; approximately 41 serious injuries per year; and
- 110 non-motorized fatalities and serious injuries (combined); approximately 16 fatalities and serious injuries per year.

Figure 1, Figure 2, and Figure 3 show the fatalities, serious injuries and combined non-motorized fatalities and serious injuries, respectively. Each figure shows the number of people killed or seriously injured per year, plus the average number of people killed or seriously injured per five-year period. Overall, all three are remaining relatively flat; however given the relatively limited number of data points (three), this should be monitored over time.

Figure 1. Annual and Five-Year Rolling Average Fatalities per Year (2010-2016)

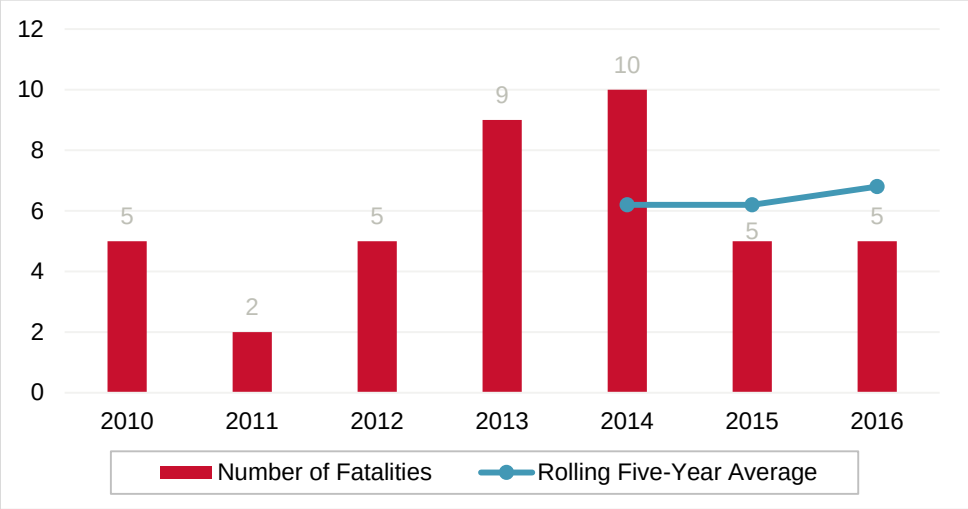


Figure 2. Annual and Five-Year Rolling Average Serious Injuries per Year (2010-2016)

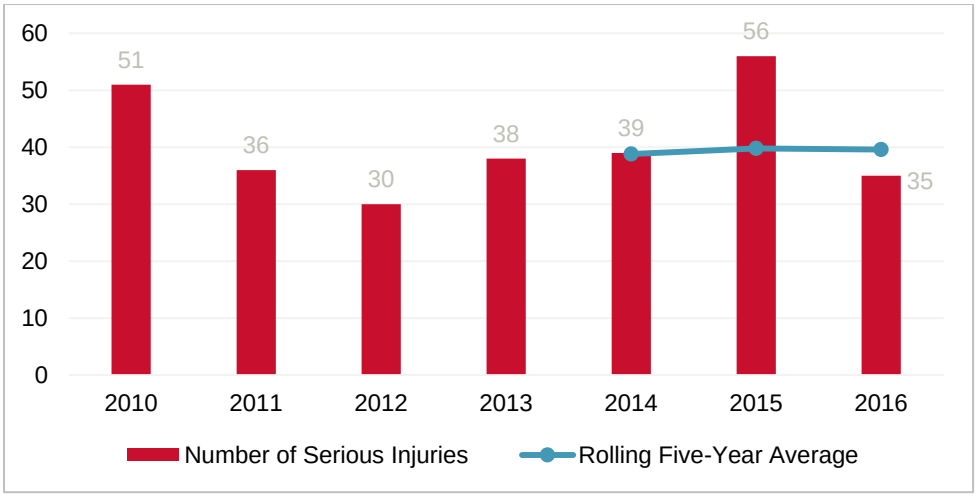
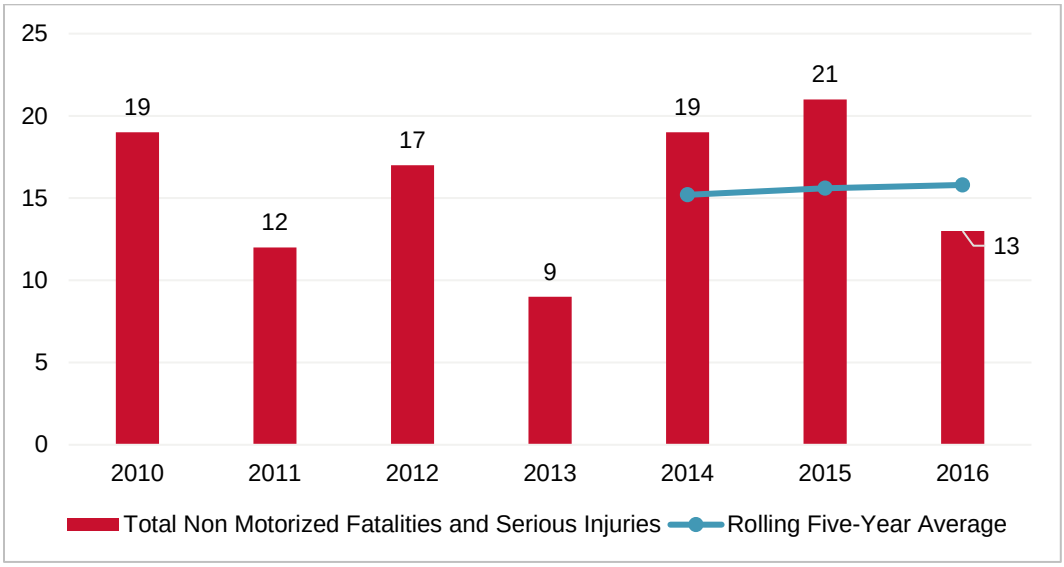


Figure 3. Annual and Five-Year Rolling Average Fatalities and Serious Injuries for Non-Motorized (Pedestrian and Bicyclist) (2010-2016)



The fourth and fifth federal safety performance measures are rate-based: number of fatalities per 100 million VMT, and number of serious injuries per 100 million VMT. Calculating VMT-based crash rates normalizes for increases or decreases in traffic volume in the city. VMT for each year was estimated as follows:

1. Southwest Washington Regional Transportation Council provided an estimate of citywide 2017 VMT using their Highway Performance Management System data. According to Regional Transportation Council, in 2017 there were 415,543,275 miles travelled on all City-owned arterial, collector and local roads (does not include state routes).
2. The 2017 VMT was deflated by one percent per year to provide a VMT estimate for each year from 2010 to 2016[1].

The resulting estimates were applied to the number of fatalities and serious injuries in the City to estimate the rate of fatalities per year and the rate of serious injuries per year (Figure 4 and Figure 5, respectively). Because the estimated change in VMT is relatively small, the rate-based trends are similar to the number-based trends and remain relatively flat. Again, the rolling five-year average should be monitored over time to measure progress in the city.

[1] Rate of traffic volume change derived from historic ADT data provided by RTC.

Figure 4. Annual and Five-Year Rolling Average Crash Rates of Fatalities per 100 Million VMT (2010-2016)

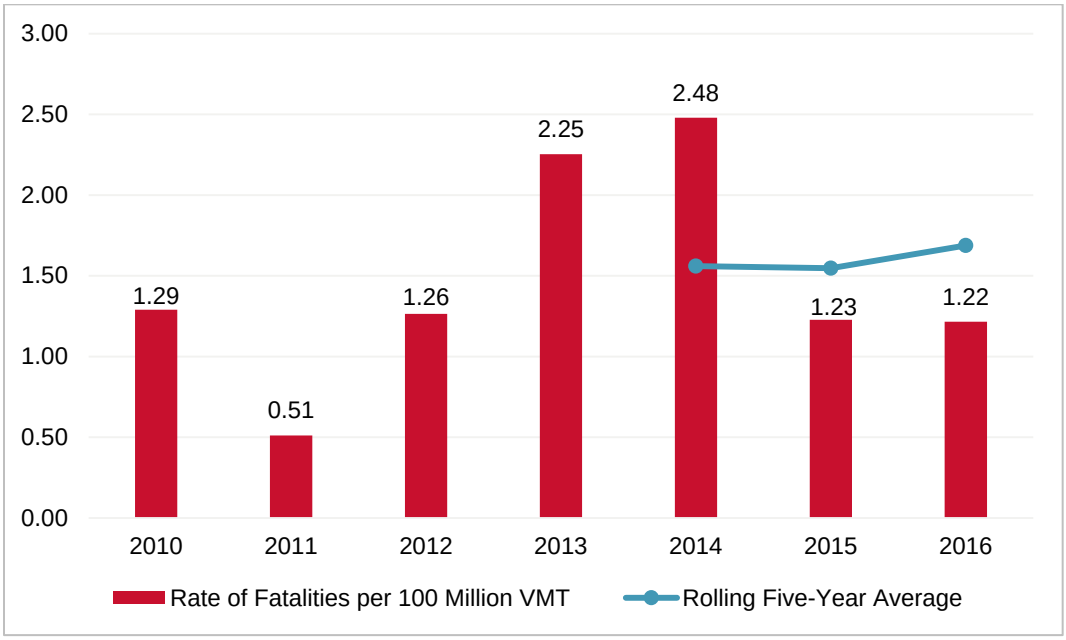
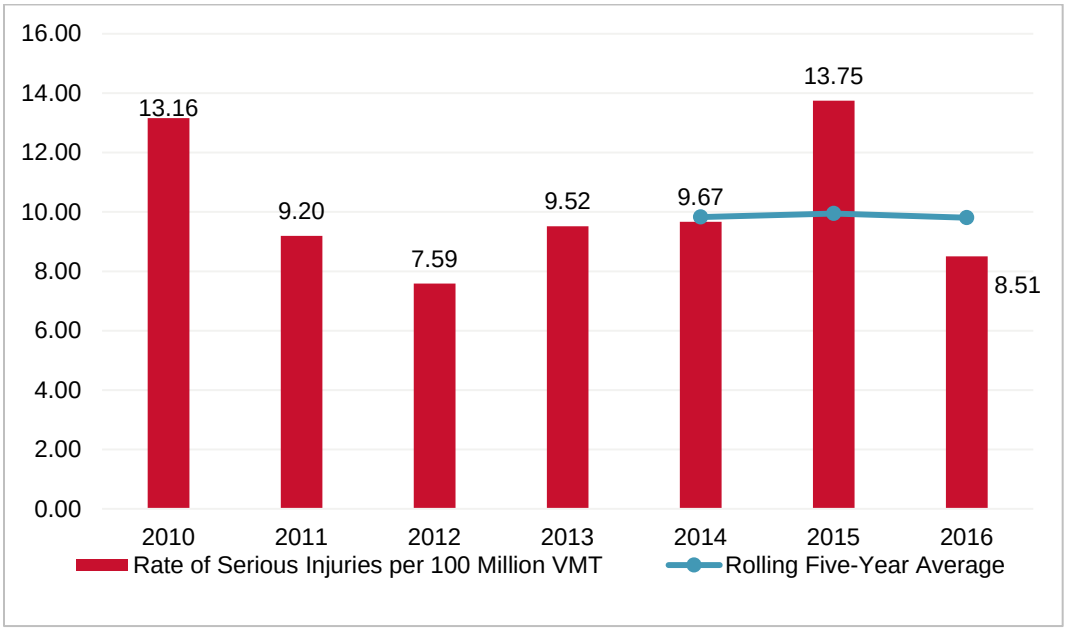


Figure 5. Annual and Five-Year Rolling Average Crash Rates of Serious Injuries per 100 Million VMT (2010-2016)



2.2 Citywide Crash Trends

This section provides an overview of major crash trends from 2010-2016 on City-owned arterial, collector, and local roads (i.e., excluding any state owned roads) in the context of:

- How many crashes occurred (Section 2.2.1)?
- Who was involved in crashes (Section 2.2.2)?
- What behaviors are involved in the crashes (Section 2.2.3)?
- Where and when did the crashes occur (Section 2.2.4)?
- How did the crashes occur (Section 2.2.5)?

2.2.1 How many crashes occurred?

From 2010 to 2016, there were 8,804 crashes, 36 fatal crashes, and 248 serious injury crashes in Vancouver (Figure 6 and Figure 7). While there was an increase in the total number of crashes (all severities) and the number of fatal and serious injury crashes in 2015, this decreased again in 2016 and the number of crashes and fatal and serious injury crashes has remained relatively stable during the study period. The majority of the crashes did not cause injuries (Figure 8). Figure 9 shows the locations of fatal and serious injury crashes in the City.

Figure 6. Crashes per Year, All Severities (2010-2016)

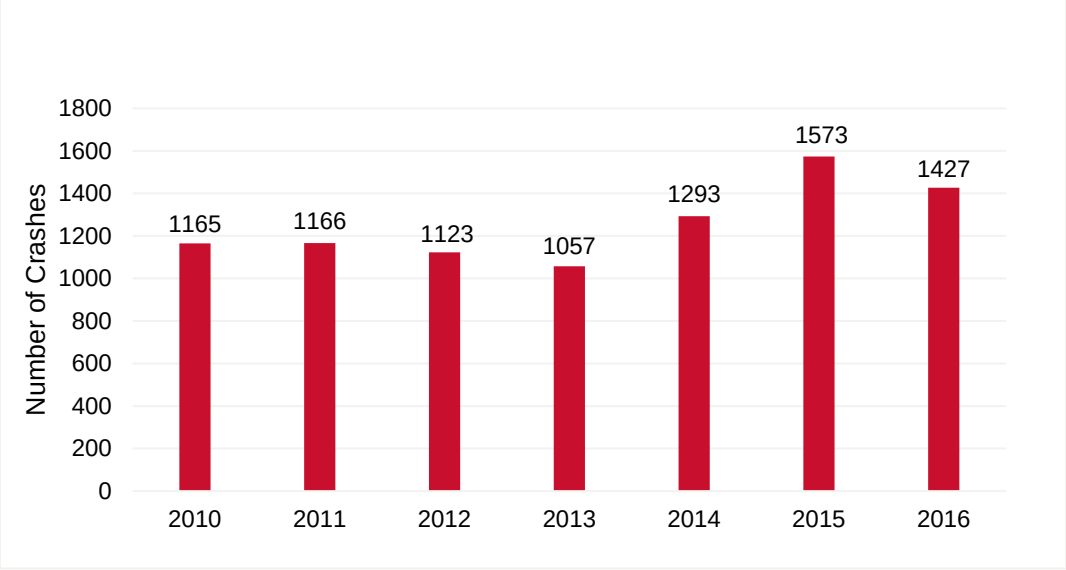


Figure 7. Crashes that Resulted in Fatal and Serious Injuries per Year (2010-2016)

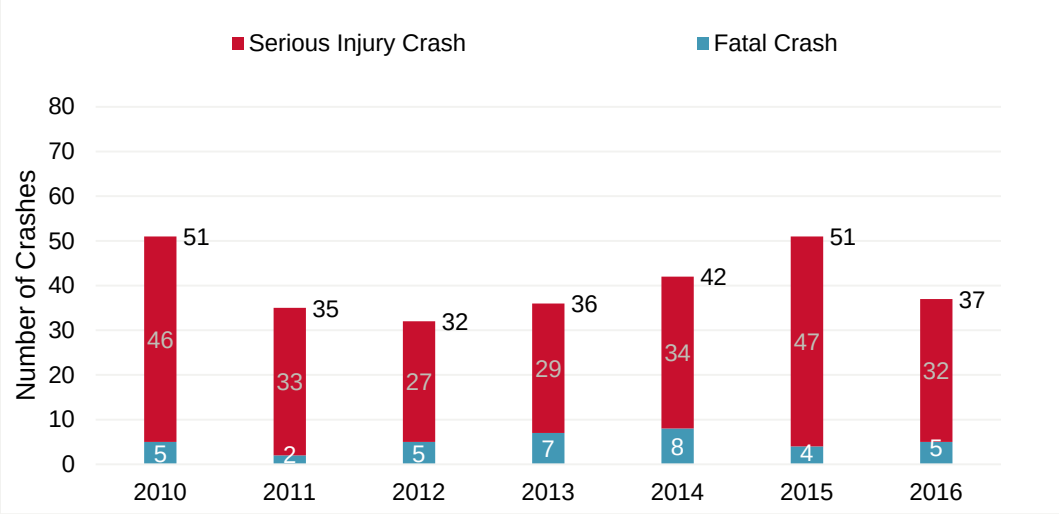


Figure 8. Distribution of Crashes by Severity (2010-2016)

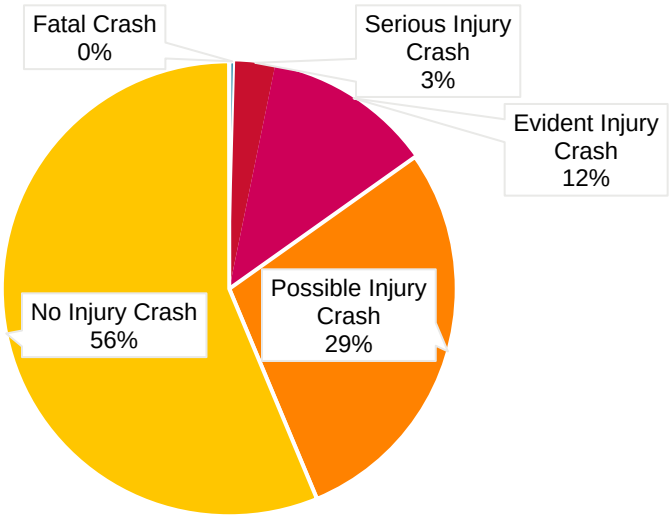
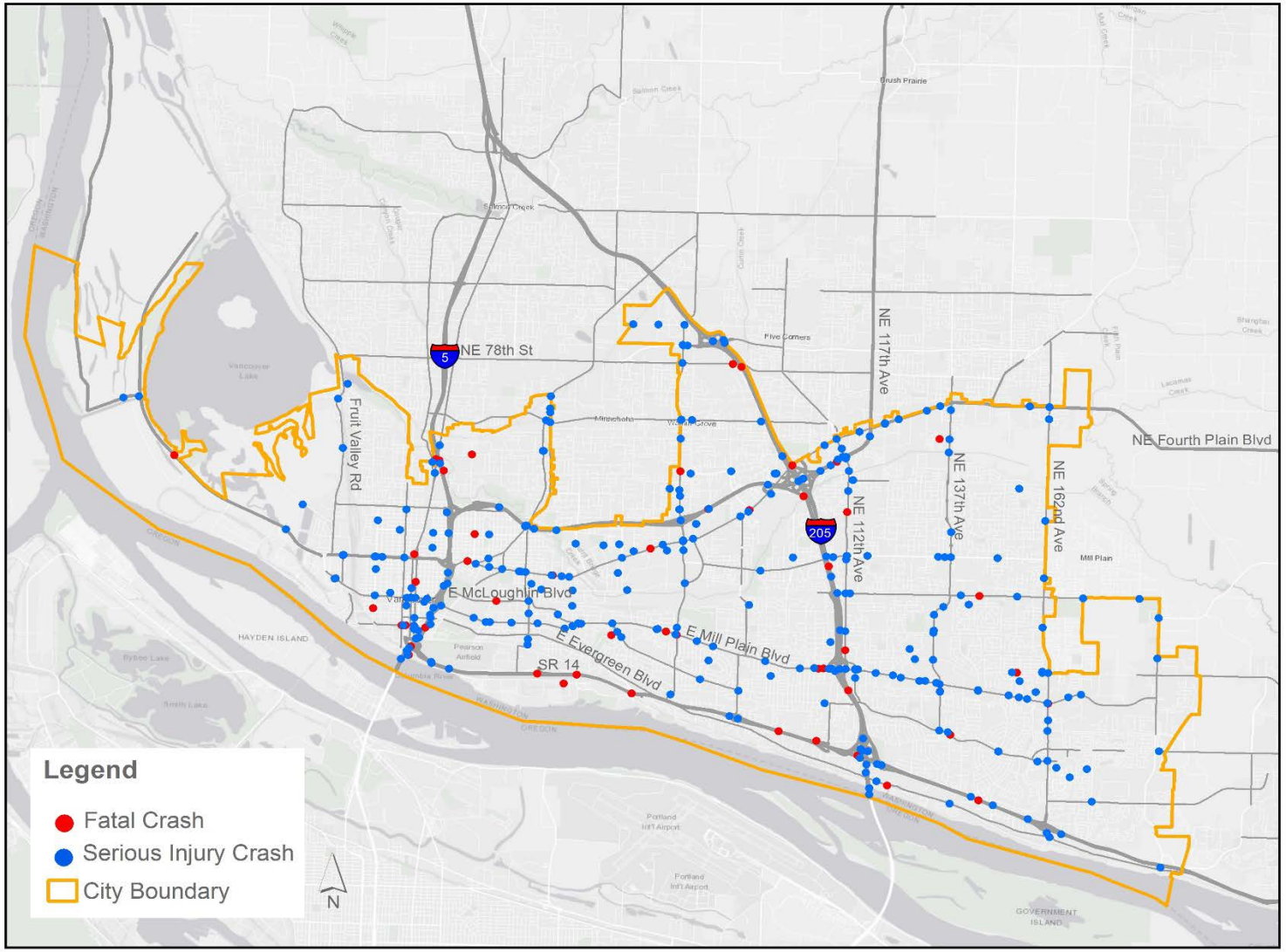


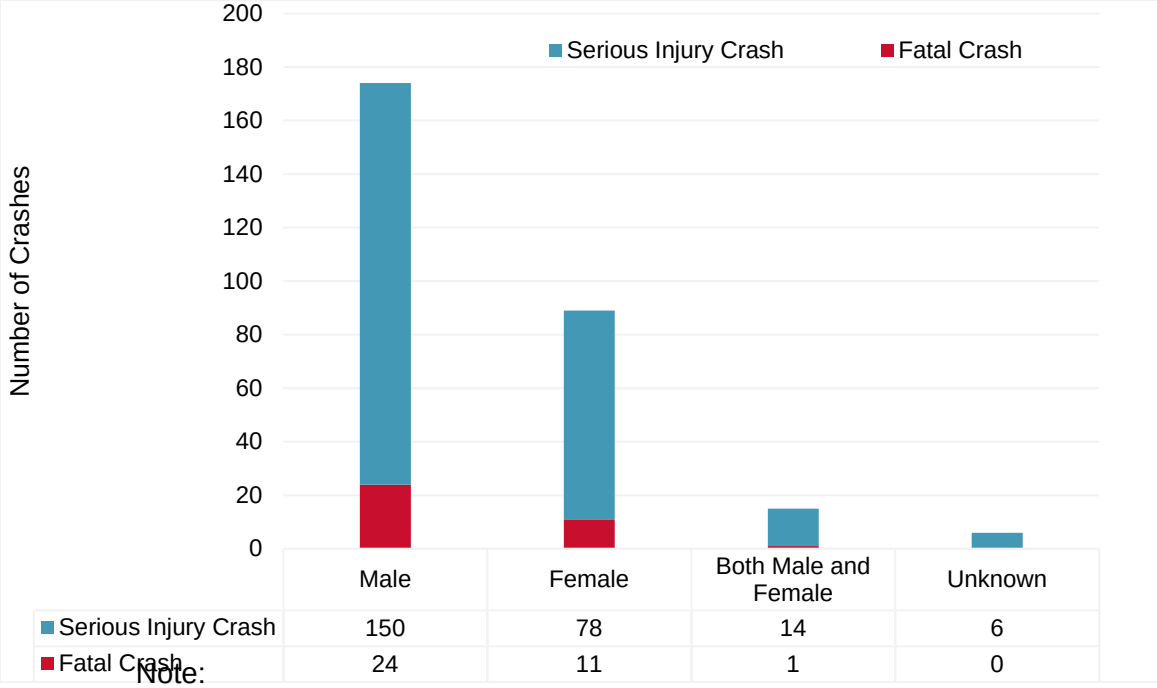
Figure 9. Serious Injury and Fatal Crash Locations (2010-2016)



2.2.2 Who was involved in crashes?

More men than women were involved in crashes. Approximately 67 percent of the fatal and serious injuries included men and 37 percent included women (Figure 10). Note the sum does not equal 100 percent as 15 fatal and serious injury crashes included both men and women. Gender associated with a crash is defined by the gender of the most seriously injured person in the crash.

Figure 10. Fatal and Serious Injury Crashes by Gender Involved (2010-2016)



Note:

There are several different groups of road users that should also be specifically considered in this analysis (see Figure 11 and Figure 12). These groups are considered separate from the majority of drivers aged 25 to 70 on the system Note that the groups are not mutually exclusive; a motorcyclist could also be a young driver, or a young driver could have struck a pedestrian. In addition, the young drivers were most frequently involved in crashes in Vancouver by a wide margin (Figure 11). Young drivers were also the largest group of people involved in fatal and serious injury crashes, followed by pedestrians, motorcycle riders, and participants not using restraints (i.e., seatbelts; Figure 12). However, in proportion to the number of crashes, there was more risk of fatal or serious injury associated with pedestrian crashes: 25 percent of all pedestrian crashes included a fatal or serious injury and three percent of young driver crashes involved a fatal or serious injury. In addition, there were 348 traffic crashes involving pedestrians, approximately 4.0 percent of the total number of crashes in the City. In contrast

2.8 percent of all crashes statewide involved pedestrians.[2] Separate urban and rural information was not available for this analysis.

Figure 11. Crashes by Involved Road User, All Severities (2010-2016)

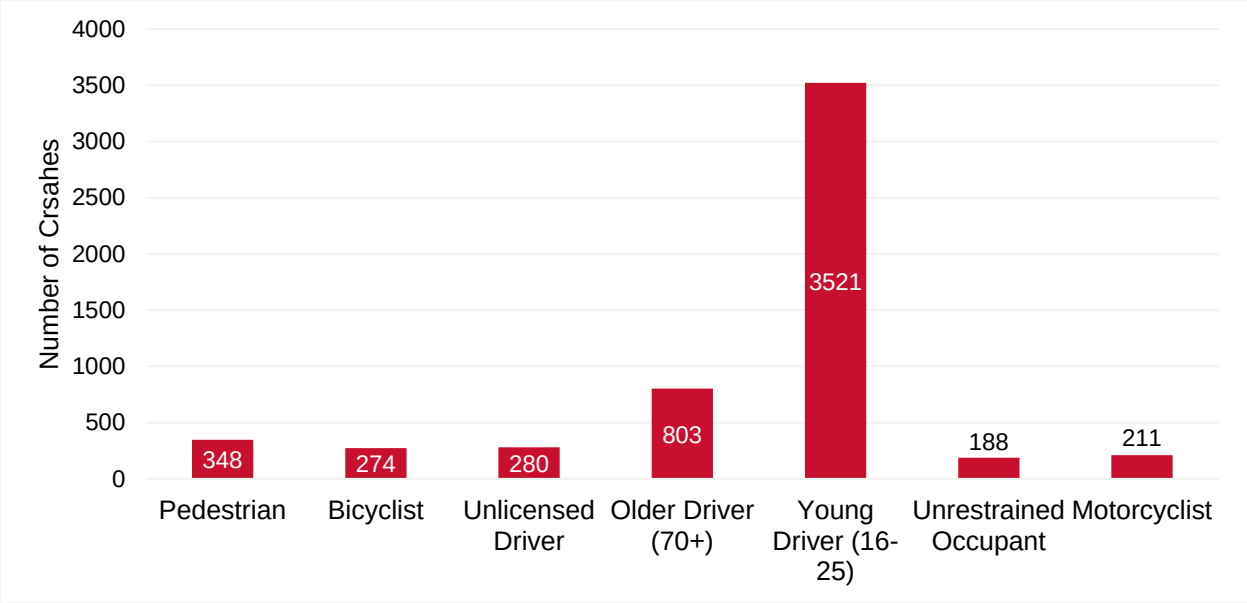
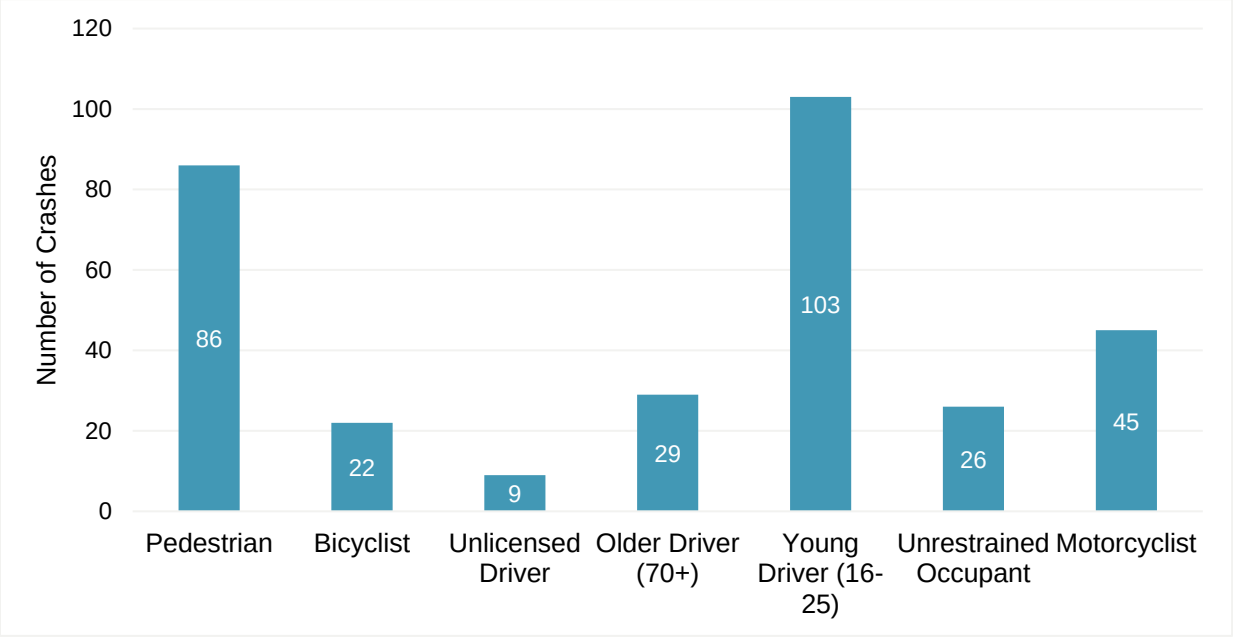


Figure 12. Crashes that Resulted in Fatal and Serious Injuries by Involved Road User (2010-2016)

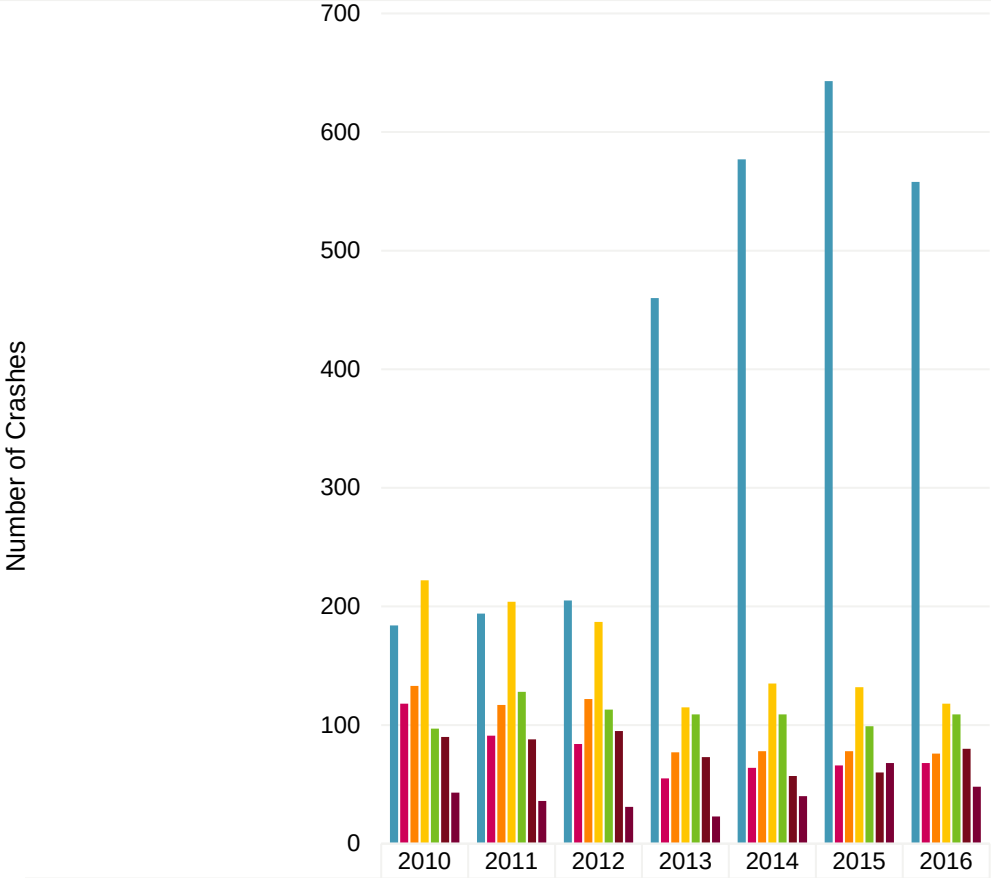


[2] *Crash Data Summary for 2012-2016 for City of Vancouver*, Local Programs Division, Washington State Department of Transportation, 2017

2.2.3 What behaviors led to crashes?

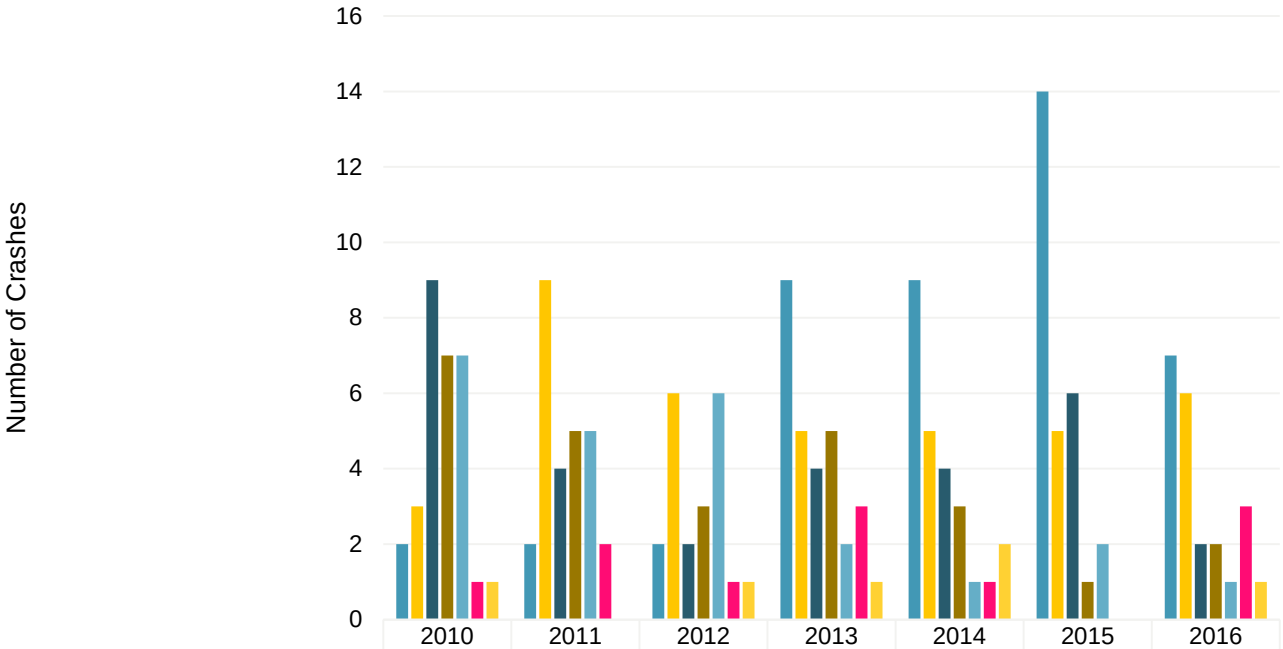
Driver distraction is the leading contributor to all crashes in Vancouver. This trend has increased since 2013 (Figure 13). The increase may be partially due to a change in crash reporting. Beginning in 2013, inattention was no longer disregarded and recorded as a distraction. The leading contributors to fatal and serious injury crashes are: driver distraction, alcohol and/or drugs, and speeding (Figure 14).

Figure 13. Most Frequent Crash Causes per Year, All Severities (2010-2016)



	2010	2011	2012	2013	2014	2015	2016
Distraction/Inattention	184	194	205	460	577	643	558
Speeding	118	91	84	55	64	66	68
Follow Too Closely	133	117	122	77	78	78	76
Did Not Grant ROW to Vehicle	222	204	187	115	135	132	118
Alcohol and/or Drugs	97	128	113	109	109	99	109
Disregard Traffic Signal	90	88	95	73	57	60	80
Improper Turn	43	36	31	23	40	68	48

Figure 14. Most Frequent Crash Causes per Year, Fatal and Serious Injury Crashes (2010-2016)



	2010	2011	2012	2013	2014	2015	2016
Distraction/Inattention	2	2	2	9	9	14	7
Alcohol and/or Drugs	3	9	6	5	5	5	6
Speeding	9	4	2	4	4	6	2
Did Not Grant ROW to Vehicle	7	5	3	5	3	1	2
Fail to Yield ROW to Pedestrian	7	5	6	2	1	2	1
Disregard Traffic Signal	1	2	1	3	1	0	3
Improper Turn	1	0	1	1	2	0	1

Drivers under the influence of alcohol and/or drugs were involved in 764 total crashes (9 percent of all total crashes) and 48 fatal and serious injury crashes (17 percent of all fatal and serious injury crashes). To understand how this compares to other involved road users, Table 1 shows the number of road users involved in any crash or a fatal and severe injury crash compared to the number of *impaired* road users involved in these crashes. For example, there were 46 fatal/serious injury crashes involving a motorcycle; of these one involved a motorcyclist under the influence of alcohol and/or drugs. Note, these are not mutually exclusive; a crash could involve more than one impaired road user. The road user categories shown are the WSDOT Target Zero road user categories. Again, these are not mutually exclusive categories.

Table 1. Road Users Involved In Crashes Involving Alcohol and/or Drugs (2010-2016)

Road User Type	All Severities		Fatal and Serious Injury	
	All Crashes	Crashes Involving Road Users under the Influence of Alcohol and/or Drugs	All Crashes	Crashes Involving Road Users under the Influence of Alcohol and/or Drugs
Pedestrian	348	19 (5.5 %)	91	11 (12.1%)
Bicyclist	274	5 (1.8%)	23	0 (0%)
Unlicensed Driver	280	44 (15.7%)	10	4 (40%)
Older Driver	803	9 (1.1%)	30	0 (0%)
Young Driver	3,521	243 (6.9%)	114	11 (9.6%)
No Restraints	188	28 (14.9%)	43	4 (9.3%)
Motorcycle	211	10 (4.7%)	46	1 (2.1%)

Distracted drivers were involved in 2,821 total crashes (32 percent of all total crashes) and 45 fatal and serious injury crashes (16 percent of all fatal and serious injury crashes). Table 2 shows the number and proportion of distracted road users involved in all crashes and fatal and serious injury crashes. These use the same WSDOT Target Zero categories as in Table 1.

Table 2. Crashes Involving Distracted Road Users by Type (2010-2016)

Road User Type	All Severities		Fatal and Serious Injury	
	All Crashes	Crashes Involving Distracted Road Users	All Crashes	Crashes Involving Distracted Road Users
Pedestrian	348	44 (12.6%)	91	0 (0%)
Bicyclist	274	33 (12.0%)	23	1 (4.3%)
Unlicensed Driver	280	45 (16.1%)	10	0 (0%)
Older Driver	803	161 (20%)	30	2 (6.7%)
Young Driver	3521	696 (19.7%)	114	6 (5.2%)
No Restraints	188	34 (18.0%)	43	1 (2.3%)
Motorcycle	211	23 (10.9%)	46	1 (2.2%)

2.2.4 Where and when did the crashes occur?

The majority of all crashes (all severities and all modes), including fatal and serious injury crashes, occur at intersections and principal arterials (Figure 15, Figure 16, and Figure 17).

Figure 15. Crashes by Location Type, All Severities (2010-2016)

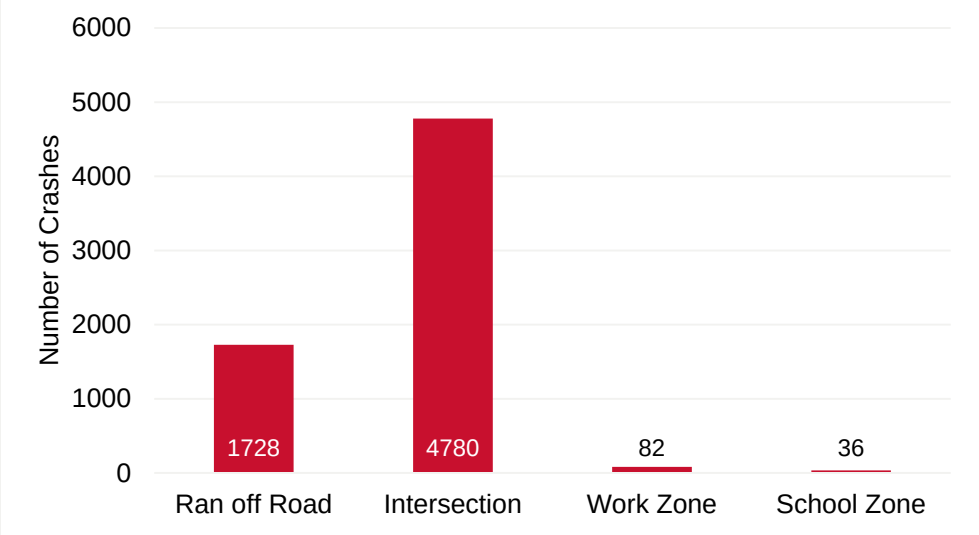


Figure 16. Number of Crashes that Resulted in Serious Injuries and Fatalities by Location Type (2010-2016)

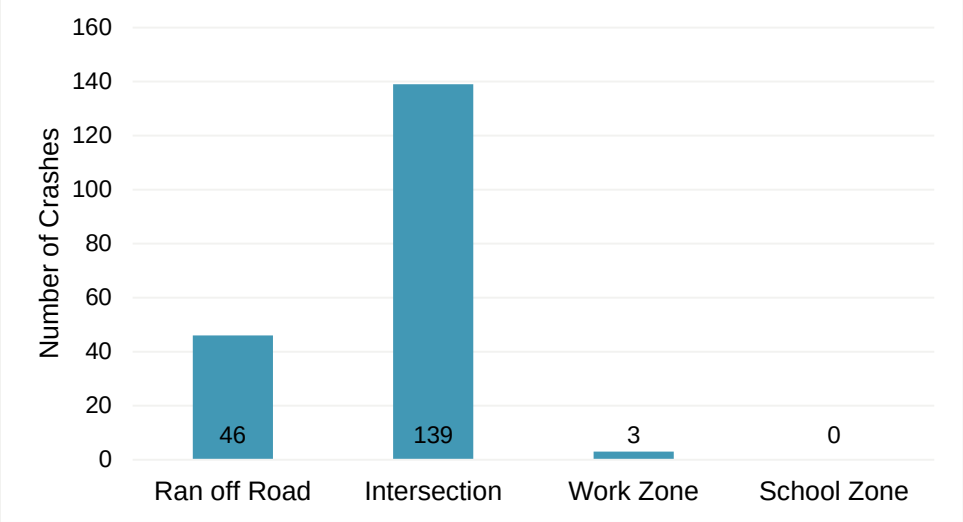
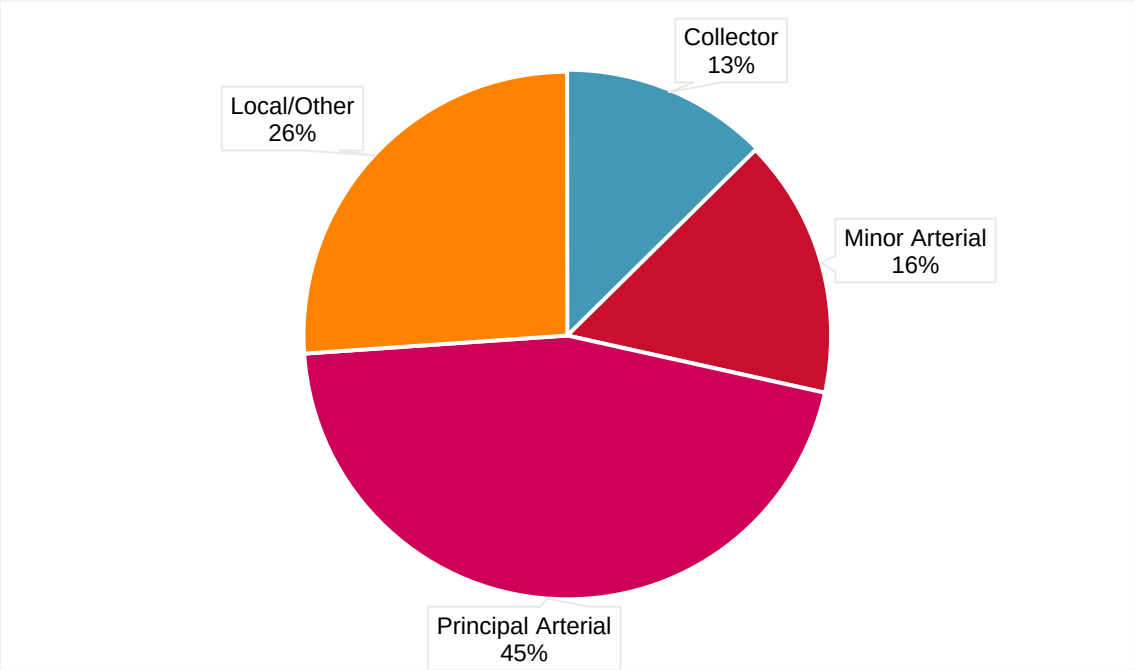


Figure 17. Distribution of Crashes by Functional Classification, All Severities (2010-2016)



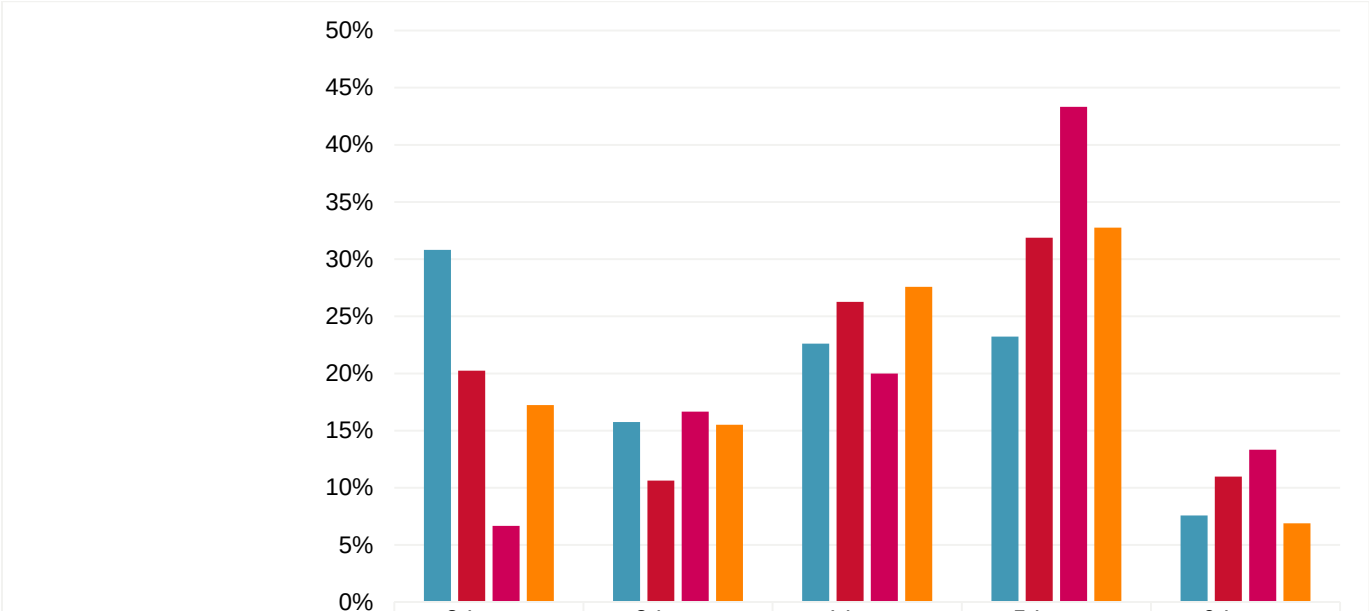
In addition, the analysis roadways were evaluated to identify where there may be more crashes occurring than expected. Figure 18, Figure 19, Figure 20 show percentage of crashes per number of lanes and functional classification as compared to the percentage of miles of each facility type. For example, Figure 18 shows that approximately 23 percent of the undivided principal arterials in Vancouver are five lane roads, 32 percent of all crashes are occurring on five-lane roads; 43 percent of all pedestrian crashes are occurring on five lane roads, and 33 percent of all bicyclist crashes are occurring on five lane lades. Therefore, as compared to the number of miles of facilities, five lane roads are over-represented for crashes.

Key findings are as follows:

1. Undivided Principal Arterials (e.g., E 4th Plain Boulevard, Figure 18)
    - Total crashes are over-represented on roads with four to six lanes.
    - Pedestrian crashes are most over-represented on five-lane principal arterials, by a factor of nearly two. Only 23 percent of undivided principal arterial centerline miles have five lanes, yet 43 percent of pedestrian crashes on undivided principal arterials occurred on five-lane roadways. Pedestrian crashes are also over-represented on roadways with three or six lanes.
    - Bicyclist crashes are over-represented on four or five-lane roads.

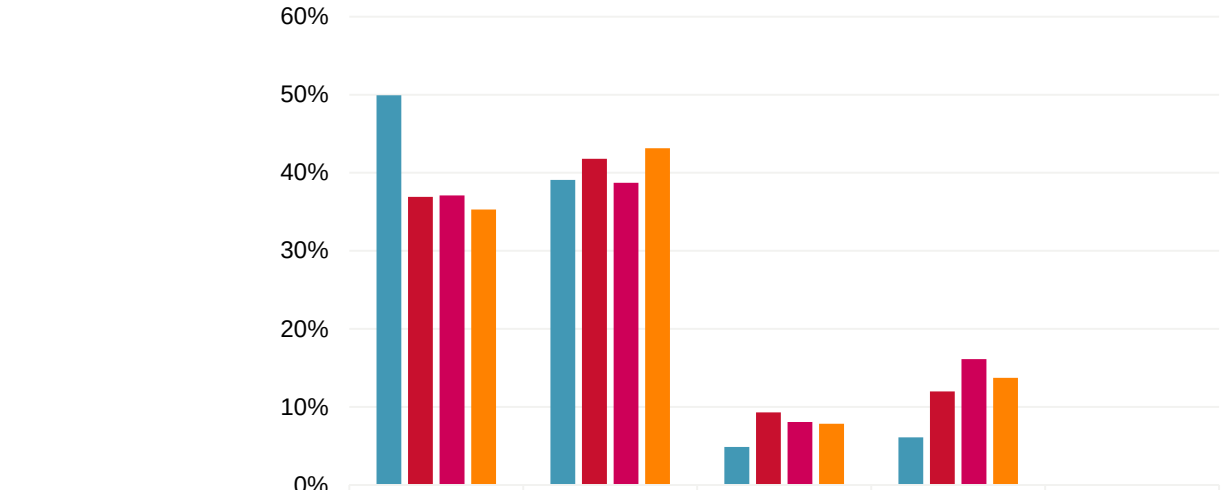
2. Undivided Minor Arterials (e.g., NE 28th Street, Figure 19)
    - Total, pedestrian, and bicyclist crashes are over-represented on minor arterials with four or five lanes.
3. Undivided Collectors (e.g., E 18th Street; Figure 20)
    - Total crashes are approximately proportional to the number of centerline miles for roads with two to six lanes.
    - Pedestrian crashes are over-represented on undivided collectors with four or six lanes.
    - Bicyclist crashes are most over-represented on undivided collectors with three lanes. As shown, 16 percent of undivided collector centerline miles have three lanes, yet 27 percent of bicyclist crashes on undivided collectors occurred on three-lane roadways. Bicyclist crashes are also over-represented on five-lane roads.

Figure 18. Percentage of Centerline Miles and Total, Pedestrian, and Bicycle Crashes by Number of Lanes on Undivided Principal Arterials (2012-2016)



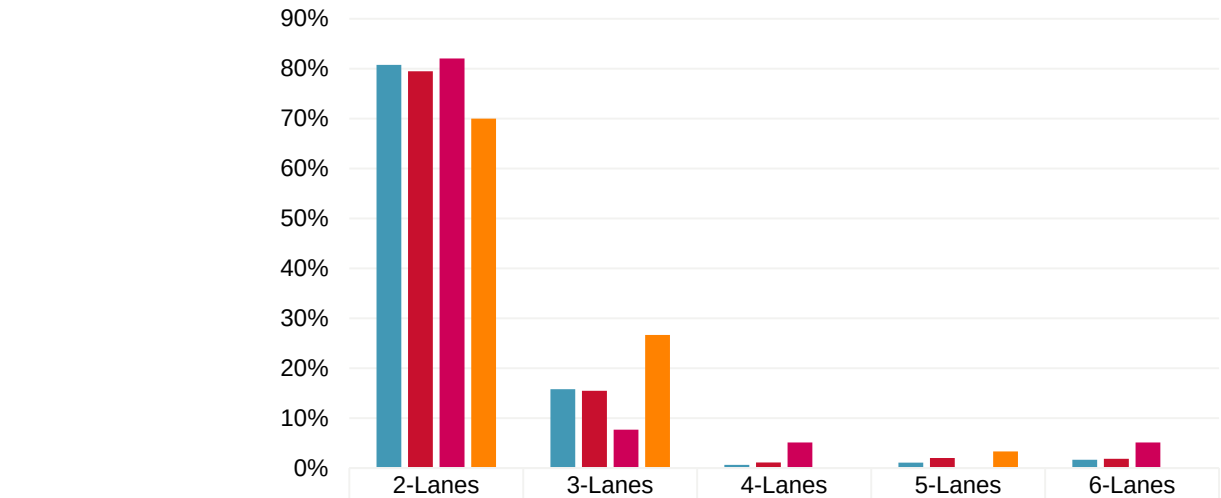
	2-Lanes	3-Lanes	4-Lanes	5-Lanes	6-Lanes
Centerline Miles Percentage	31%	16%	23%	23%	8%
Total Crash Percentage	20%	11%	26%	32%	11%
Pedestrian Crash Percentage	7%	17%	20%	43%	13%
Bicyclist Crash Percentage	17%	16%	28%	33%	7%

Figure 19. Percentage of Centerline Miles and Total, Pedestrian, and Bicycle Crashes by Number of Lanes on Undivided Minor Arterials (2012-2016)



	2-Lanes	3-Lanes	4-Lanes	5-Lanes	6-Lanes
Centerline Miles Percentage	50%	39%	5%	6%	0%
Total Crash Percentage	37%	42%	9%	12%	0%
Pedestrian Crash Percentage	37%	39%	8%	16%	0%
Bicyclist Crash Percentage	35%	43%	8%	14%	0%

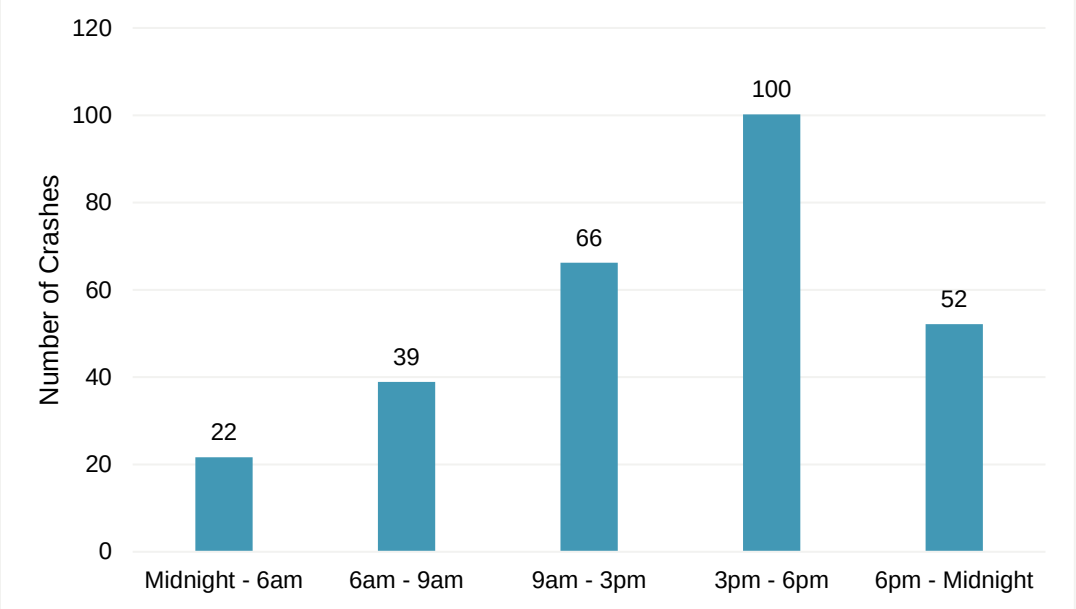
Figure 20. Percentage of Centerline Miles and Total, Pedestrian, and Bicycle Crashes by Number of Lanes on Undivided Collectors (2012-2016)



	2-Lanes	3-Lanes	4-Lanes	5-Lanes	6-Lanes
Centerline Miles Percentage	81%	16%	1%	1%	2%
Total Crash Percentage	79%	15%	1%	2%	2%
Pedestrian Crash Percentage	82%	8%	5%	0%	5%
Bicyclist Crash Percentage	70%	27%	0%	3%	0%

Consistent with urban areas, most crashes occur during the afternoon commute period when traffic volumes are highest (Figure 21).

Figure 21. Average Number of Crashes by Time of Day (2010-2016)



2.2.5 How did crashes occur?

The majority of crashes occur at intersections, and accordingly the most frequent crash types are consistent with intersection crashes: rear-end, fixed object, and angle crashes (Figure 22). Note that pedestrian crashes are not among the most frequent crash types (all severities) citywide. However, when considering fatal and serious injury crashes only, pedestrian are the most frequent. (Figure 23).

Figure 22. Crashes by Type, All Severities (2010-2016)

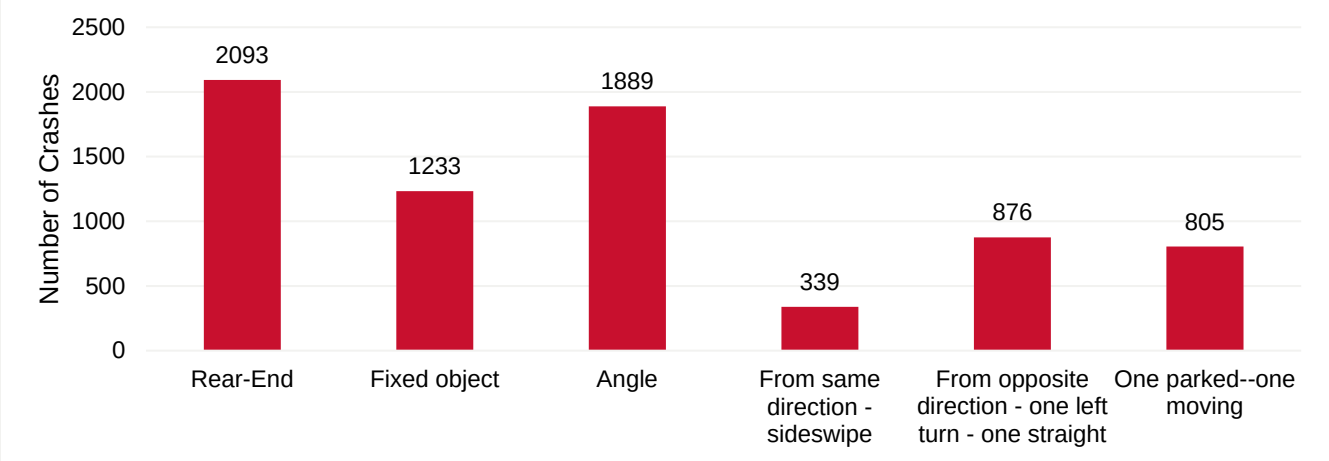
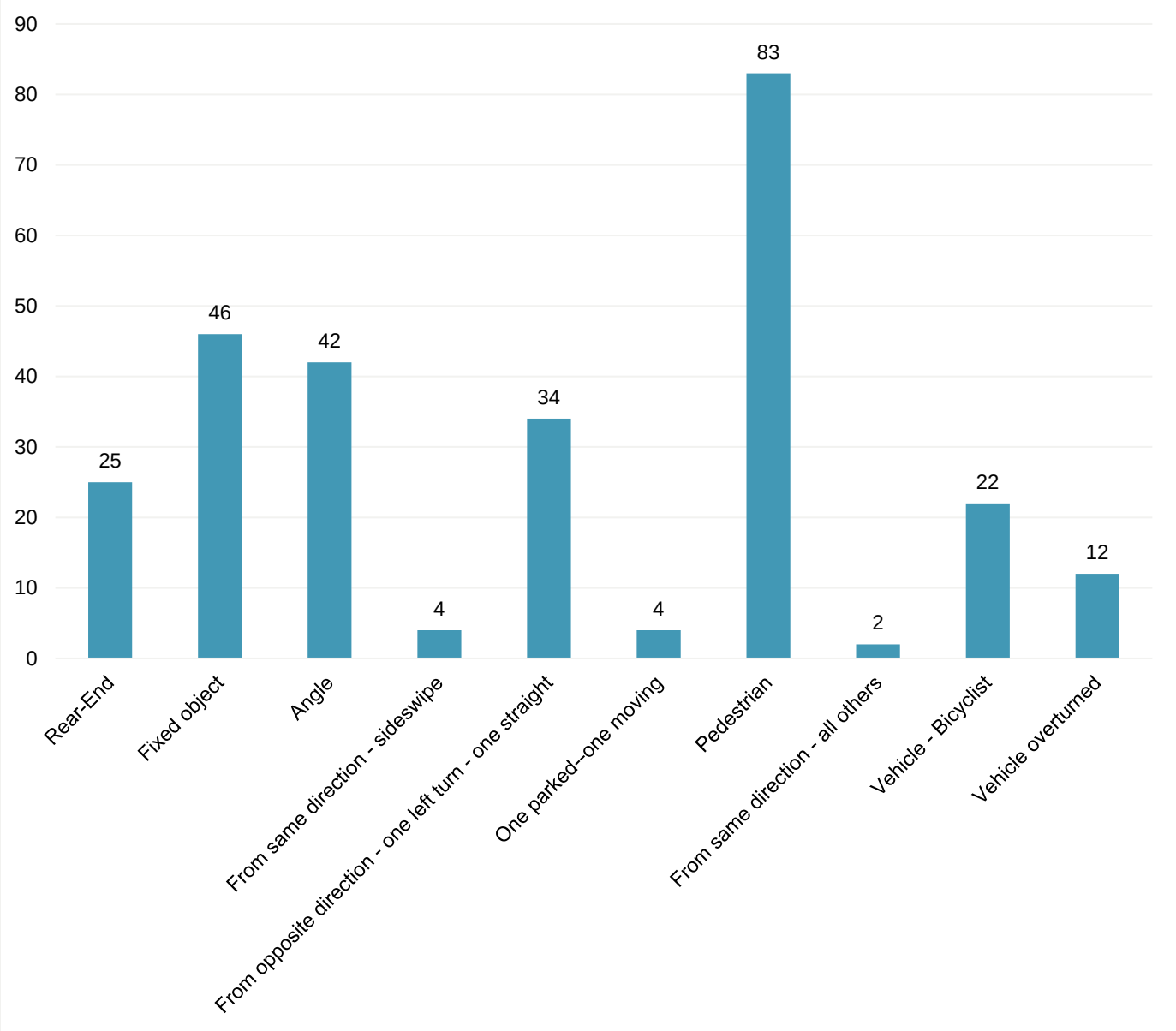


Figure 23. Fatal and Serious Injury Crashes by Type (2010-2016)



2.3 Citywide Performance Compared to Washington State Target Zero Priorities

The *Washington State Strategic Highway Safety Plan: Target Zero* identifies the statewide highest priority crash contributing factors. The priority areas are developed to understand the most common contributing factors to crashes and to subsequently develop programs, policies, or projects to include countermeasures that address these

categories of contributing factors. The state Target Zero plan identifies three priority levels for crash contributing factors[3]:

- **Priority Level One** includes crashes with factors associated with the largest number of fatalities and serious injuries in the state. Each of these factors are involved in at least 30 percent of the traffic fatalities or serious injuries between 2012 and 2014 (the most recent analysis period).
- **Priority Level Two** factors, while frequent, are not as common as priority level one factors. Level two factors are seen in at least 10 percent of traffic fatalities or serious injuries in the analysis period.
- **Priority Level Three** factors are associated with less than 10 percent of fatalities and serious injuries in the analysis period.

The following analysis includes crashes on City-owned arterial, collector, and local roads and at intersections with state-owned roads. The state method for establishing priority areas was applied to City facilities to help identify focus crash areas for the remainder of this analysis. The analysis considers behavior, infrastructure, and user types, as such potential solutions will include engineering, education and enforcement countermeasures.

As shown in Table 3, the Priority Level One crashes on Vancouver streets:

- Involve Speeding
- Involve Driver Distraction
- Intersection-Related
- Involve Pedestrians
- Involve Young Drivers

Pedestrians, bicyclist, lane departure and young driver crashes were selected as focus crash types for the remainder of the analysis because:

- **Pedestrian Involved** – There is a high risk of fatal or serious injury when a pedestrian crash occurs. The proportion of pedestrian fatalities and serious injuries in the city is higher than the statewide average, and the city's is focused on improving multimodal transportation (Section 3.1);
- **Bicyclist Involved** – Although a low number of bicycle crashes occur citywide, the proportion of fatal and serious injury crashes is higher than the statewide average. In addition, the city is focused on improving bicycle facilities city wide (Section 3.2);
- **Lane Departure** – Understanding the characteristics of crashes along a roadway segment is important to implementing roadway improvements that will help achieve the complete street policy objectives of the City and to encourage non-auto modes of transportation (Section 3.3);

[3] *Washington State Strategic Highway Safety Plan, Target Zero*, 2016, Page 10

- **Young Driver Involved** – There is a high frequency of young driver crashes in the City. In addition, although the most of the young driver crashes are relatively low severity, the small proportion of serious injury young driver crashes is higher than the statewide average (Section 3.4).

The project analysis also includes an intersection analysis to rank intersections based on crash frequency and severity. Therefore, intersections were not selected as a focus area for this analysis. Speeding as a contributing factor to crashes was analyzed for each of the selected focus areas and was not selected as a focus area itself.

Table 3. Priority Level Based on Fatalities and Serious Injuries Compared to Statewide Priorities (2010-2016)

Vancouver Priority	Statewide Priority		Fatalities	Vancouver %	Washington State %	Diff	Serious Injuries	Vancouver %	Washington State %	Diff
High Risk Behavior										
2	1	Impairment Involved	10	24.4%	56.6%	↓	51	17.9%	22.3%	↓
2	2	No Restraints	10	24.4%	22.2%	↑	26	9.1%	10.2%	↓
1	1	Speeding Involved	16	39.0%	38.0%	↑	53	18.6%	26.5%	↓
1	2	Distraction Involved	7	17.1%	29.6%	↓	88	30.9%	22.9%	↑
3	2	Unlicensed Driver Involved	1	2.4%	18.6%	↓	8	2.8%	-	
3	3	Drowsy Driver Involved	0	0.0%	2.9%	↓	6	2.1%	3.2%	↓
Crash Type										
2	1	Lane Departure	11	26.8%	56.1%	↓	49	17.2%	38.5%	↓
1	1	Intersection-Related	16	39.0%	20.7%	↑	148	51.9%	34.8%	↑
Road Users										
1	2	Pedestrians	15	36.6%	15.3%	↑	73	25.6%	14.8%	↑
1	1	Young Driver (16-25) Involved	12	29.3%	31.7%	↓	112	39.3%	33.6%	↑
2	2	Motorcyclists	5	12.2%	16.8%	↓	44	15.4%	18.1%	↓
2	2	Older Driver 70+ Involved	6	14.6%	12.1%	↑	27	9.5%	8.6%	↑
3	3	Heavy Truck Involved	3	7.3%	9.1%	↓	5	1.8%	5.2%	↓
3	3	Bicyclists	2	4.9%	2.2%	↑	20	7.0%	4.8%	↑
Other Monitored Emphasis Areas										
Wildlife			0	0.0%	0.5%	↓	0	0.0%	0.8%	↓
Work Zone			0	0.0%	0.2%	↓	3	1.1%	1.6%	↓
Vehicle-Train			1	2.4%	0.2%	↑	0	0.0%	0.1%	↓
School Bus-Involved			0	0.0%	0.0%	↓	0	0.0%	0.2%	↓

3 Common Roadway Characteristics of the Focus Areas

For each focus area, common roadway characteristics are evaluated to identify focus crash types, support prioritization of sites, and to help identify countermeasures most appropriate for the City of Vancouver countermeasure toolbox. In this analysis, a “crash tree” is developed to tabulate the number of crashes occurring in several different categories of common roadway characteristics (e.g., posted speed limit, number of lanes, divided or undivided facility, or type of intersection control). Roadway characteristics that are associated with more crashes are considered major contributing factors and flagged to be potential performance measures for ranking sites. This section documents the results of the crash tree analysis and identification of key crash types and contributing factors for each focus area: pedestrians, bicyclists, young drivers and lane departure crashes. The following analysis includes crashes on City-owned arterial and collector roads, but *does not* include local (residential) streets.

The remainder of the project analysis focusses on 2012-2016 crashes only so as to consider most recent roadway, environment, and driver trends.

3.1 Pedestrian Involved Crashes

Figure 24 is a crash tree showing the disaggregation analysis of *only* pedestrian-involved crashes. Each level is a disaggregation of the level immediately above it. For example, the sum of all pedestrian intersection crashes (112) and segment crashes (96) equals the total for all pedestrian crashes (208). Figure 25 shows the location of all pedestrian-involved crashes, and Figure 26 is a “heat map” showing where pedestrian crashes are clustered. The color ranges in Figure 26 are based on natural breaks in the lowest to highest frequency of crashes based on crash density within the area.

The crash tree analysis shows pedestrian-involved crashes occur frequently at signalized intersections with posted speeds of 35 or 40 miles per hour. Further, while 60 percent of intersections in Vancouver are signalized, 87 percent of the pedestrian intersection crashes occurred at signalized intersections – which may be due to more pedestrians on streets with signalized intersections than other streets in the city. Signalized intersections are selected as a focus facility to proactively address the potential risk and reduce the number and/or severity of crashes.

Pedestrian crashes on segments occurred on undivided roadways at a larger frequency compared to divided roadways and approximately proportionally to the percentage of undivided roadways in Vancouver — approximately 80 percent. As shown in Figure 18, Figure 19, and Figure 20, pedestrian crashes were most over represented on undivided roadways with five or six lanes.

Figure 24. Pedestrian Crash Tree (All Severities, 2012-2016)

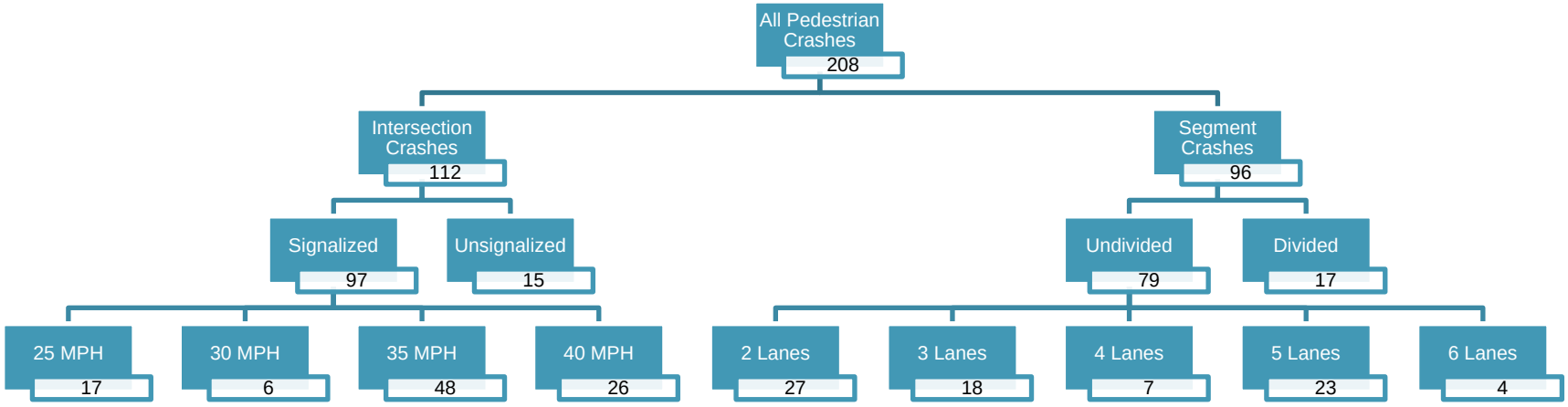


Figure 25. Pedestrian Crash Locations (All Severities, 2012-2016)

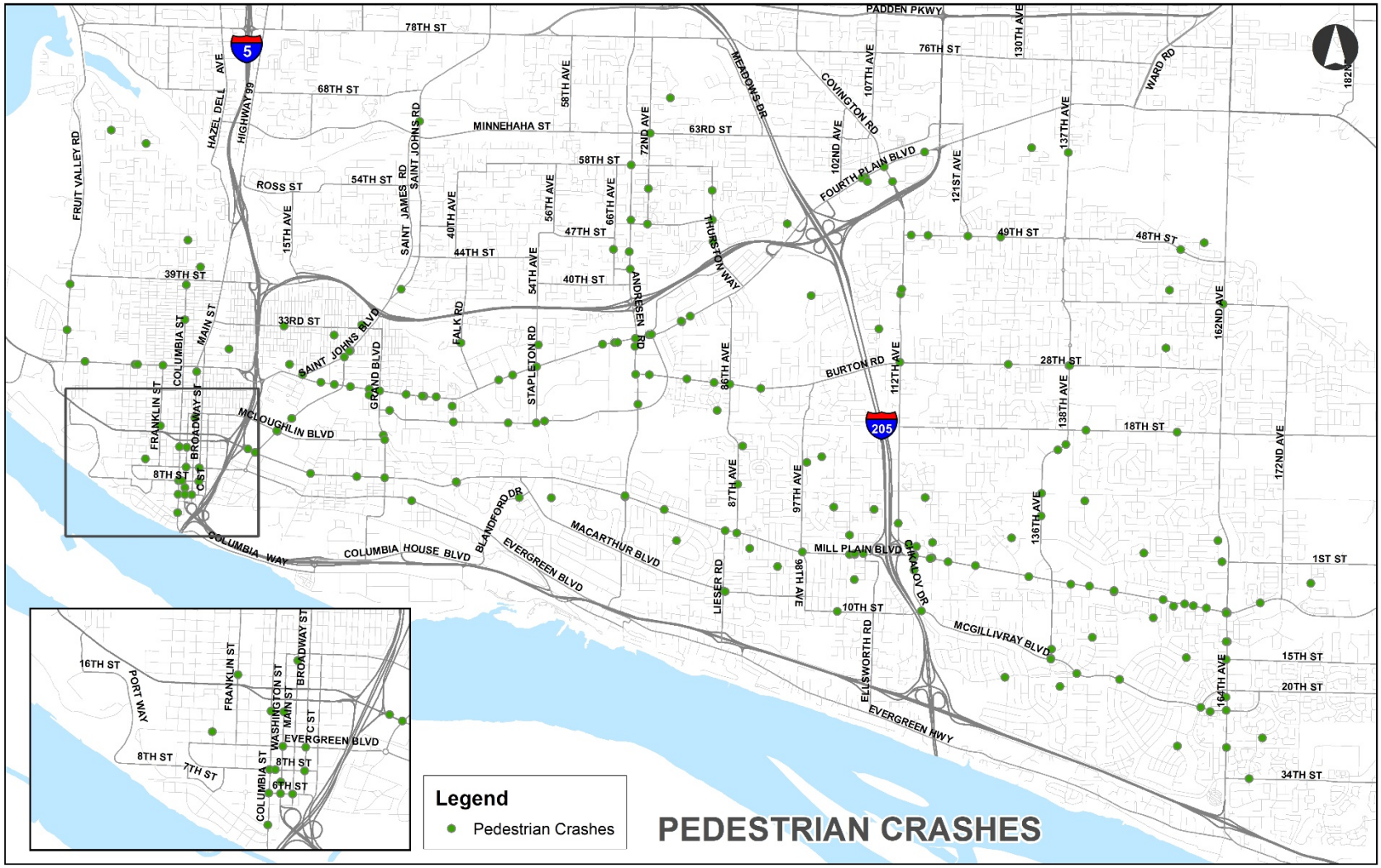
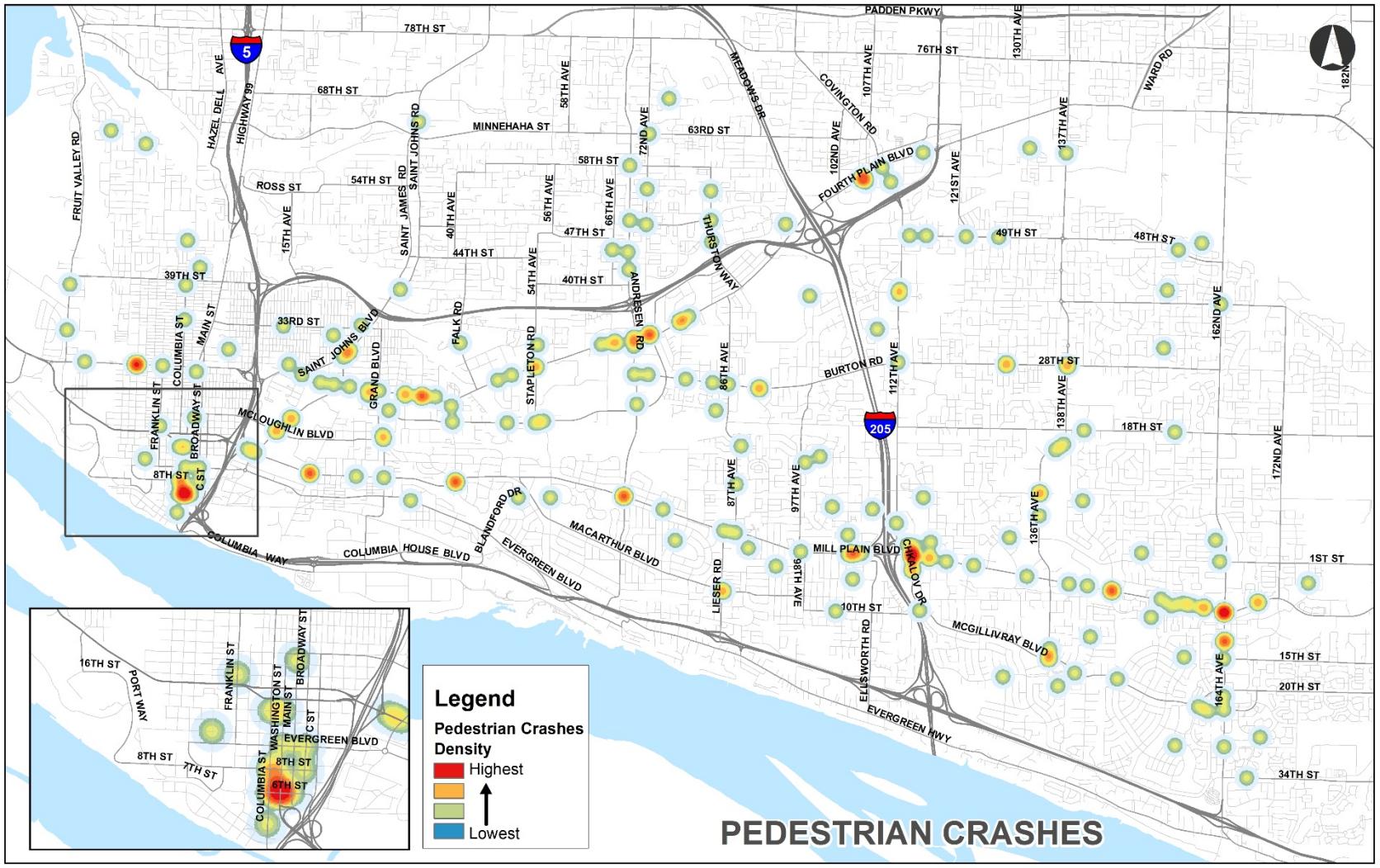


Figure 26. Pedestrian Crash Locations — Heat Map (All Severities, 2012-2016)



3.1.1 Pedestrian Focus – Signalized Intersection Crashes with Posted Speeds of 35 or 40 miles per hour

The severity of pedestrian crashes at signalized intersections with posted speeds of 35 or 40 miles per hour is shown in Figure 27. As shown there is a relatively higher distribution of fatal and serious injury crashes for pedestrian crashes as compared to the severity distribution of all crashes in Vancouver. The number of pedestrian focus (i.e., signalized intersections with posted speeds of 35 or 40 mph) intersection crashes by time of day is shown below in Figure 28; 28 of the pedestrian focus intersection crashes occurred between 6:00 p.m. and midnight, which for a large part of the year is dark, potentially reducing visibility for drivers and pedestrians.

Figure 27. Pedestrian Focus Intersection Crashes by Severity Level (2012-2016)

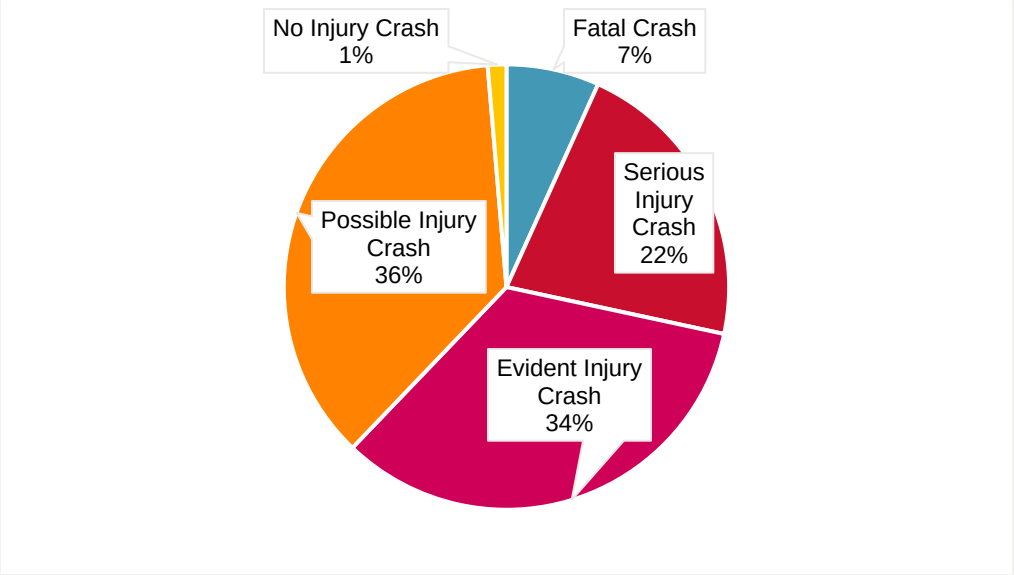
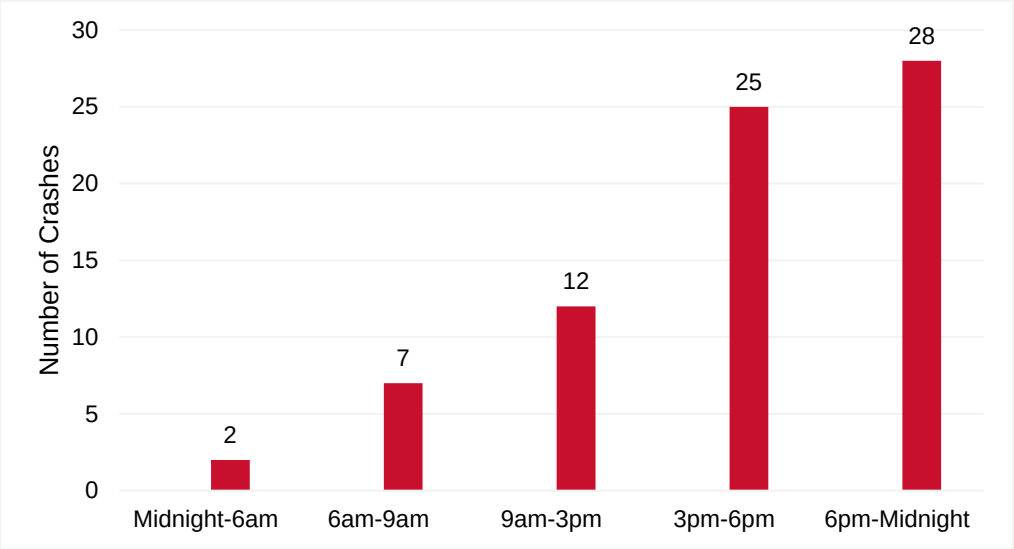
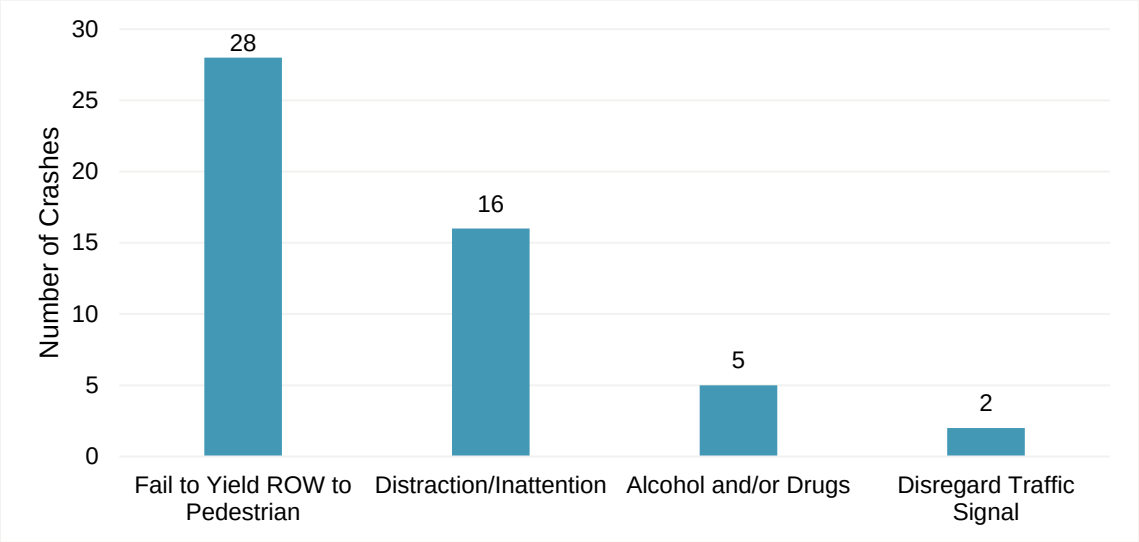


Figure 28. Pedestrian Focus Intersection Crashes by Time of Day (2012-2016)



The most common contributing factors to the pedestrian focus intersection crashes were failing to yield right-of-way (ROW) and inattention/distraction (Figure 29). Alcohol and/or drugs were involved in five of the pedestrian focus crashes. The remaining two crashes involve disregarding a traffic signal.

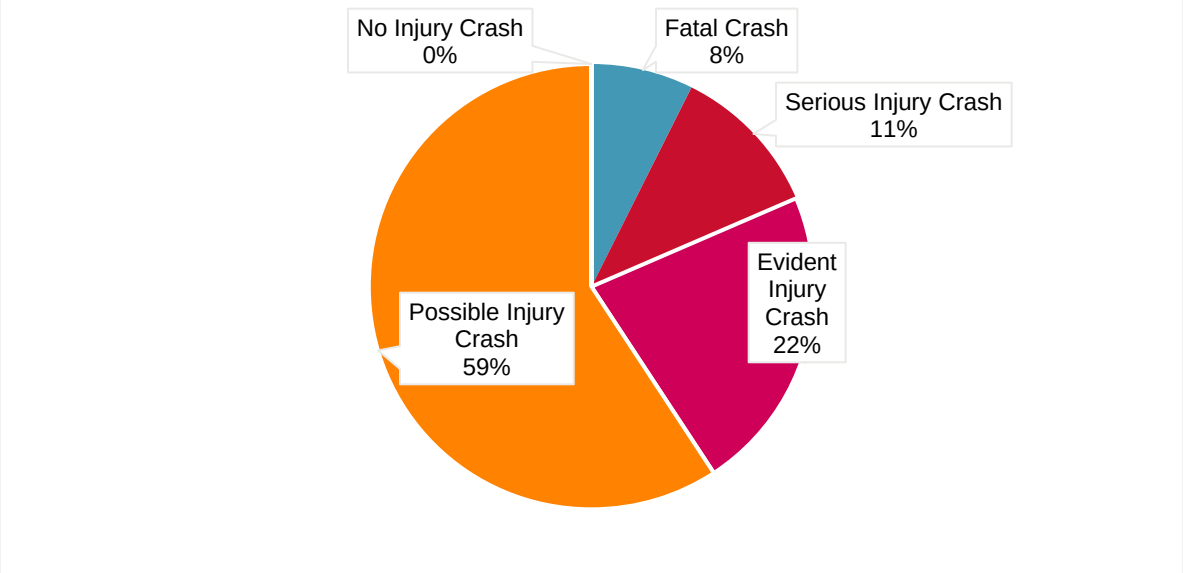
Figure 29. Pedestrian Focus Intersection Crashes by Contributing Factor (2012-2016)



3.1.2 Pedestrian Focus – Segment Crashes on Undivided Five-Lane or Six-Lane Roadways

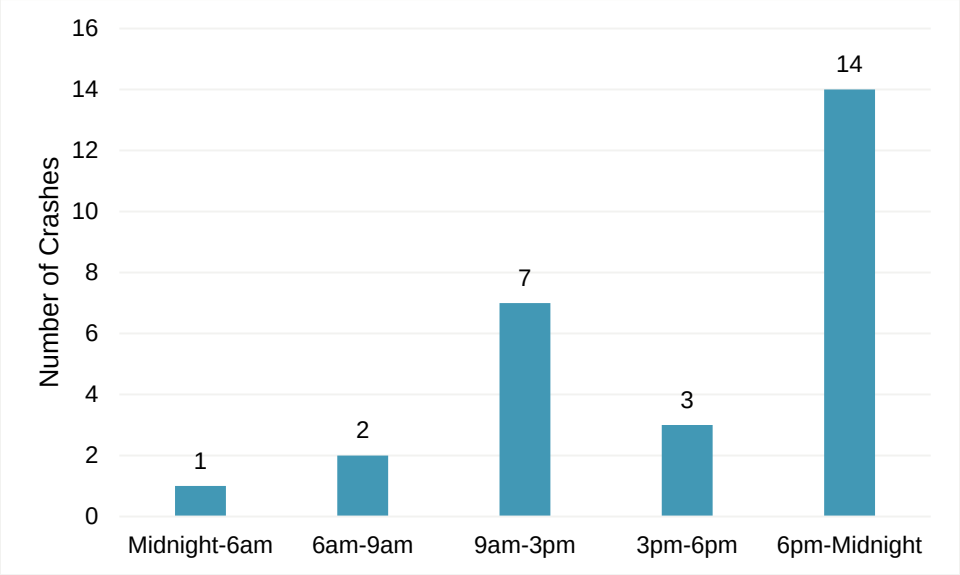
Between 2012 and 2016, there were 27 pedestrian crashes on undivided road segments with five or six lanes. The most common crash severity level was evident injury and possible injury (22 crashes). Figure 30 shows the distribution of pedestrian crash severities on segments. As shown, pedestrian crash severity is also relatively high on segments as compared to the severity distribution of all crashes in Vancouver (Figure 8).

Figure 30. Pedestrian Focus Segment Crashes by Severity Level (2012-20160



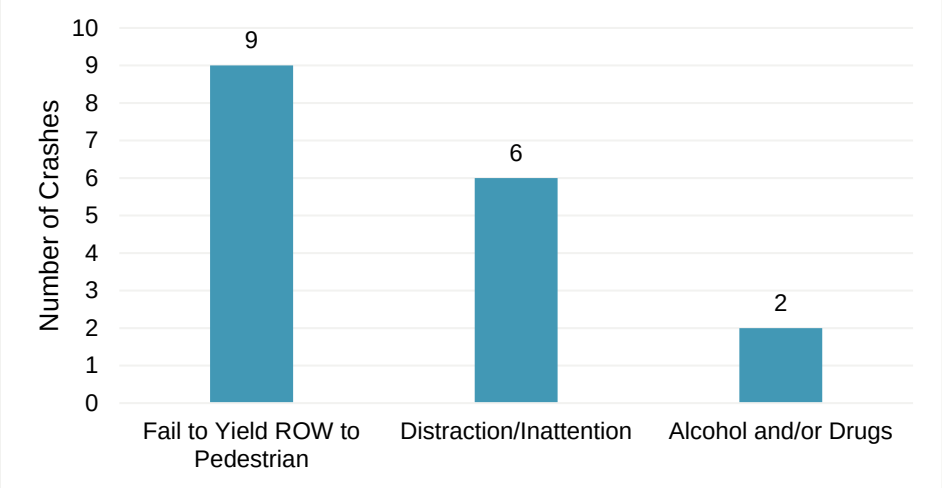
The number of pedestrian focus segment crashes by time of day is shown below in Figure 31; 14 of the pedestrian focus segment crashes occurred between 6:00 p.m. and midnight.

Figure 31. Pedestrian Focus Segment Crashes by Time of Day (2012-2016)



The factor contributing to the most crashes was failing to yield ROW to the pedestrian — nine crashes, or 33 percent, of the pedestrian focus segment crashes (Figure 32). Alcohol and/or drugs were involved in two of the pedestrian focus segment crashes.

Figure 32. Contributing Factors to Pedestrian Focus Segment Crashes (2012-2016)



3.2 Road/Lane Departure Crash Analysis

Figure 33 is a crash tree showing the breakdown of road/lane departure crashes on Vancouver City-owned roads. Figure 34 shows the location of all road/lane departure crashes on City streets and Figure 35 is a heat map showing where road/lane departure crashes are clustered on City streets. . The color ranges are based on natural breaks in the lowest to highest frequency of crashes based on crash density within the area. From 2012 to 2016 there were 837 traffic crashes involving road/lane departures, approximately 15 percent of the total number of crashes in the City. Most of the road/lane departure segment crashes occurred on undivided roadways with two lanes.

Figure 33. Road/Lane Departure Crash Tree (All Severities, 2012-2016)

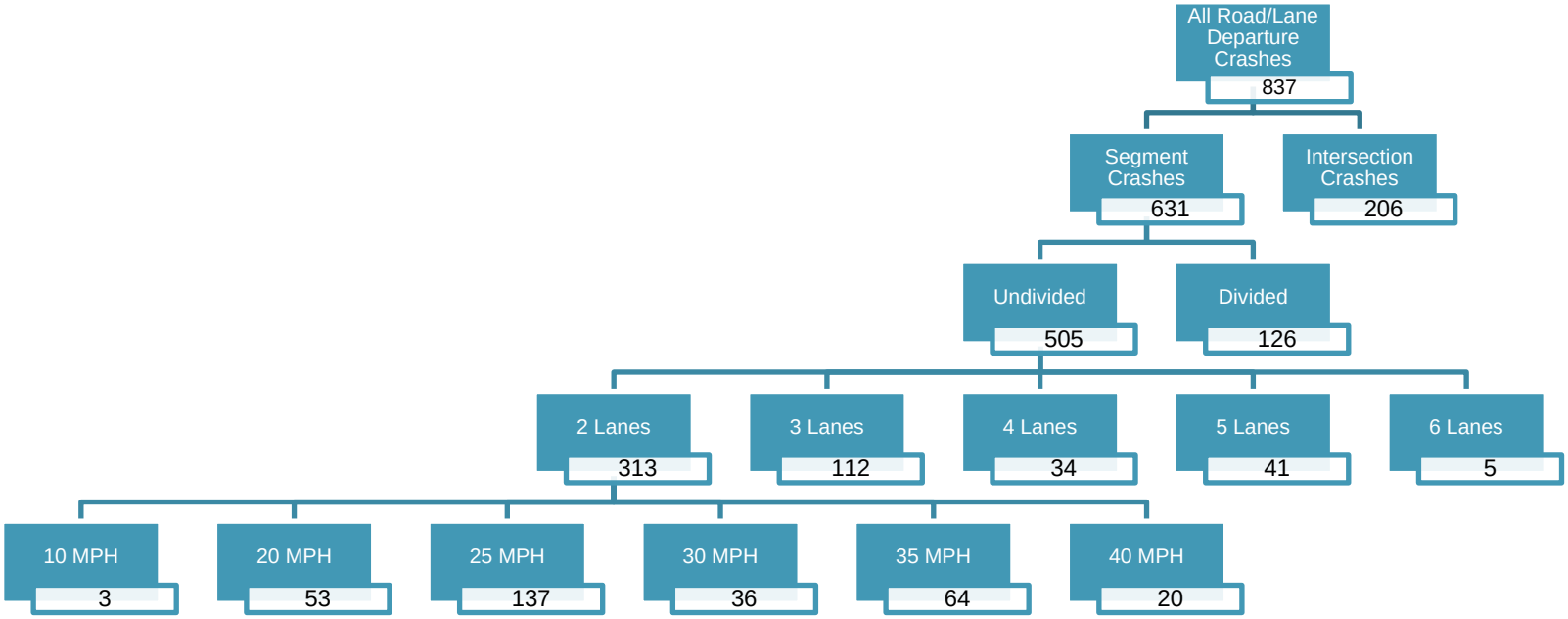


Figure 34. Road/Lane Departure Crash Locations (All Severities, 2012-2016)

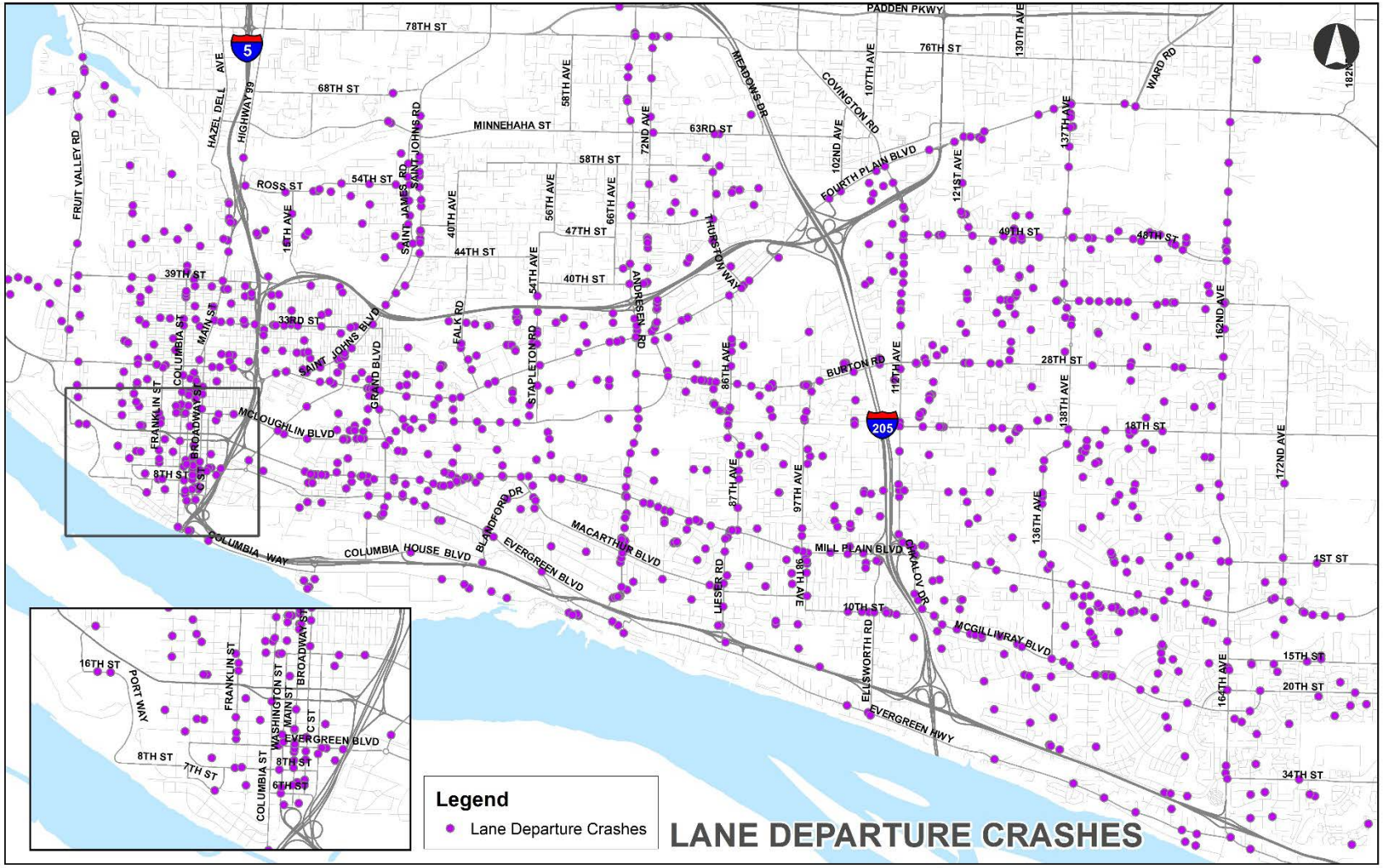
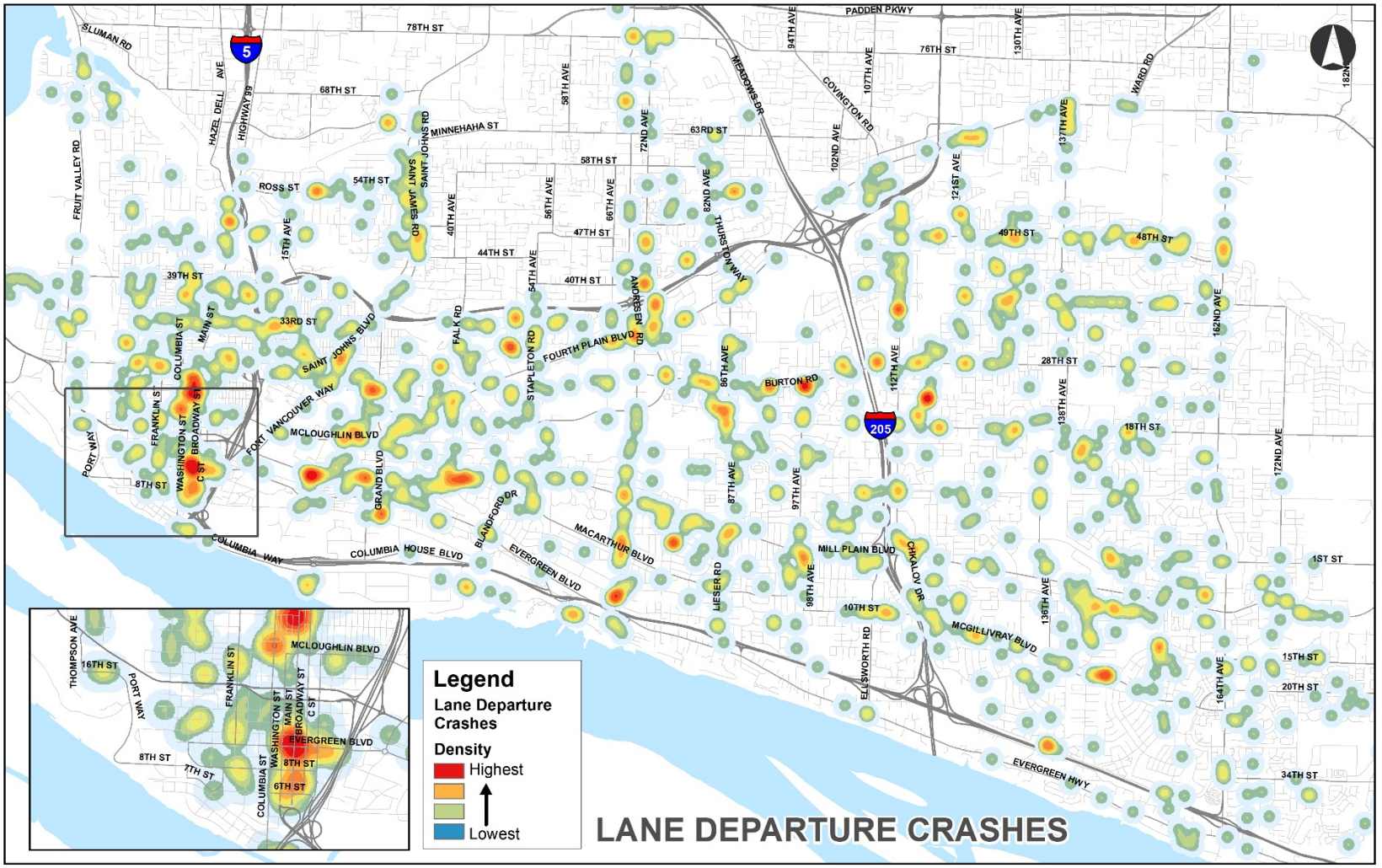


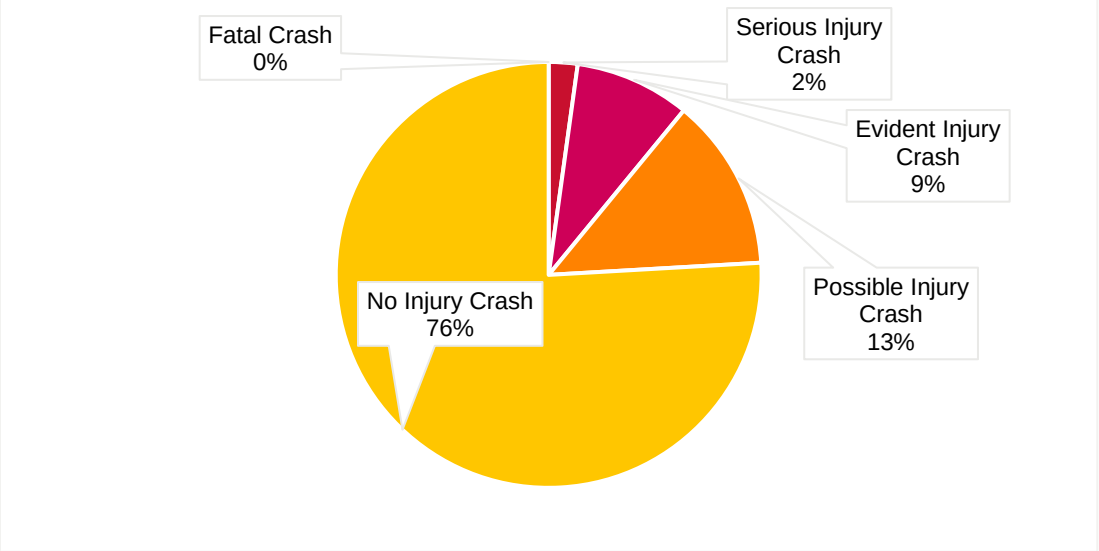
Figure 35. Road/Lane Departure Crash Locations — Heat Map (All Severities, 2012-2016)



3.2.1.1 Road/Lane Departure Focus – Segment Crashes on Two-Lane Undivided Roadways with Posted Speeds of 25 miles per hour

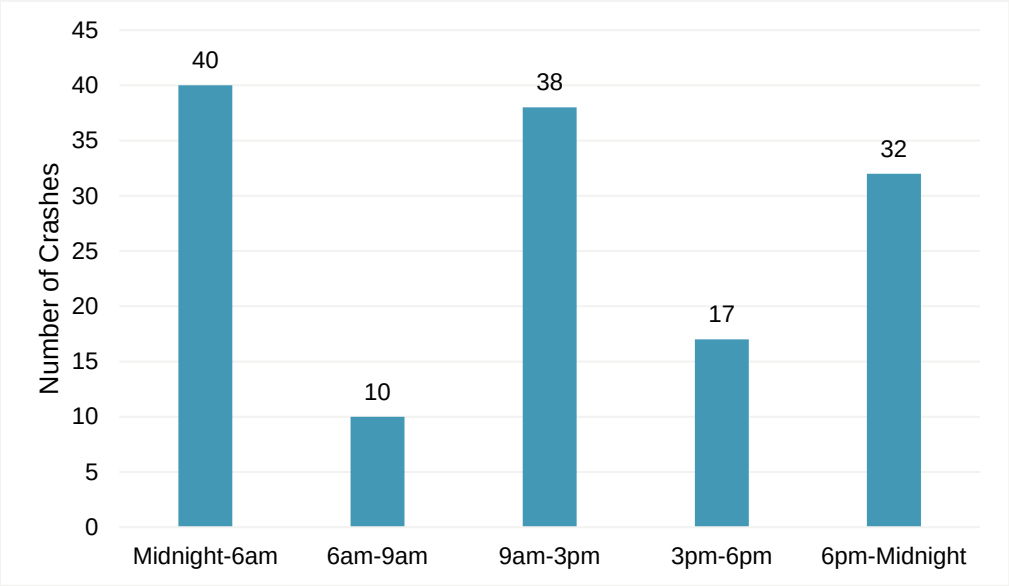
Between 2012 and 2016, crashes most frequently occurred on two-lane undivided roadways with posted speeds of 25 miles per hour (137 crashes). Given these relatively low speeds, the most common severity level was property damage only (104 crashes). There were no fatal crashes and three serious injury crashes (Figure 36).

Figure 36. Road/Lane Departure Focus Crashes by Severity Level (2012-2016)



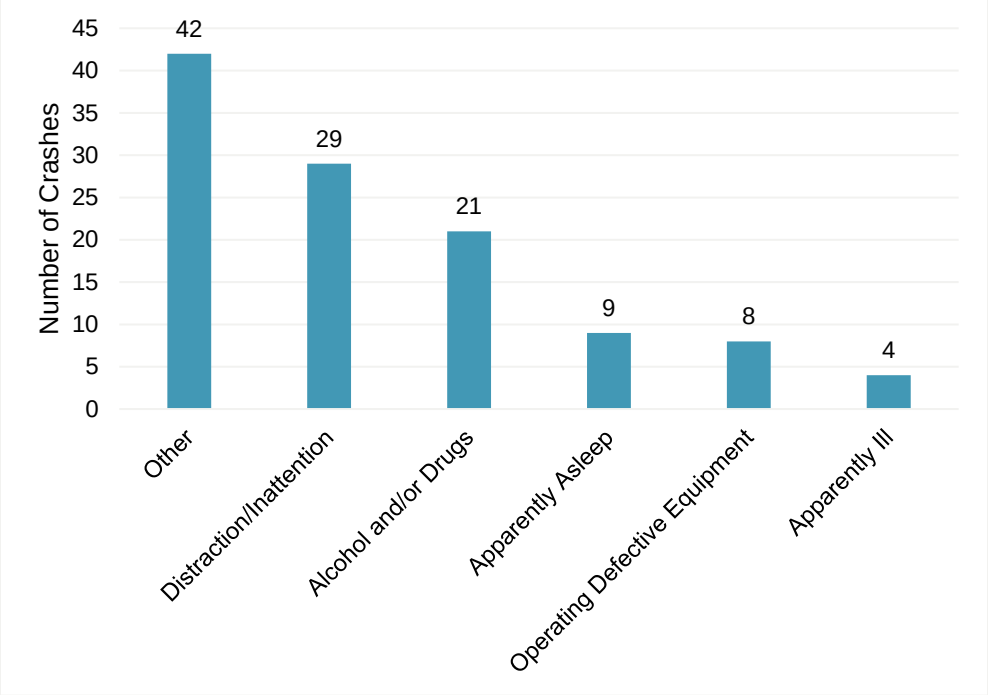
The highest number of road/lane departure focus crashes (40) occurred between midnight and 6:00 a.m. (Figure 37). This time period corresponds with lower traffic volumes, more potential to speed and/or pay less attention to driving.

Figure 37. Road/Lane Departure Focus Crashes by Time of Day (2012-2016)



The single most common contributing factor to the road/lane departure focus crashes was under the influence of alcohol or drugs (Figure 38). The next largest factor was inattention, contributing to 21 crashes, or 15 percent of road/lane departure focus crashes.

Figure 38. Road/Lane Departure Focus Crashes by Contributing Factor (2012-2016)



3.3 Bicyclist Crash Analysis

Figure 39 is a crash tree showing the breakdown of bicyclist crashes in Vancouver from 2012 to 2016. In this period there were 168 traffic crashes involving bicyclists, approximately three percent of the total number of crashes in the City. This percentage is higher than the Washington statewide average of 1.2 percent of crashes involving bicyclists in 2015.[4]

Figure 40 shows the location of all bicyclist crashes on City streets, and Figure 41 is a heat map showing where bicyclist crashes are clustered on City streets. The color ranges are based on natural breaks in the lowest to highest frequency of crashes based on crash density within the area. Refer to Figure 3 to compare similarities and differences in the locations of pedestrian and bicycle crashes.

While 87 percent of the bicyclist intersection crashes occurred at signalized intersections, only 60 percent of intersections in Vancouver are signalized; therefore, similar to pedestrians, bicyclist crashes are over-represented at signalized intersections. This may

[4] 2015 Annual Collision Summary (WSDOT, 2015)
http://www.wsdot.wa.gov/mapsdata/crash/pdf/2015_Annual_Collision_Summary.pdf

be due to higher volumes of bicyclists on streets with signalized intersections than other streets in the city.

A relatively higher number of bicyclist segment crashes occurred on undivided roadways compared to divided roadways. Similar to pedestrian crashes, bicyclist crashes on five or six lane undivided roadways were most over-represented compared to the number of centerline miles, as shown previously in Figure 18.

Figure 39. Bicyclist Crash Tree (All Severities, 2012-2016)

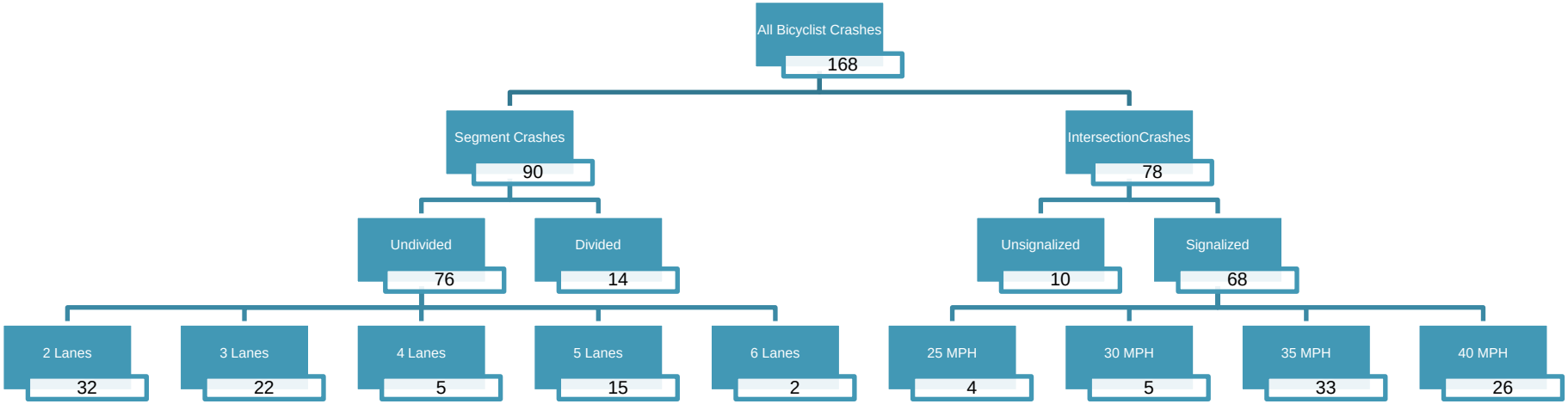


Figure 40. Bicyclist Crash Locations (All Severities, 2012-2016)

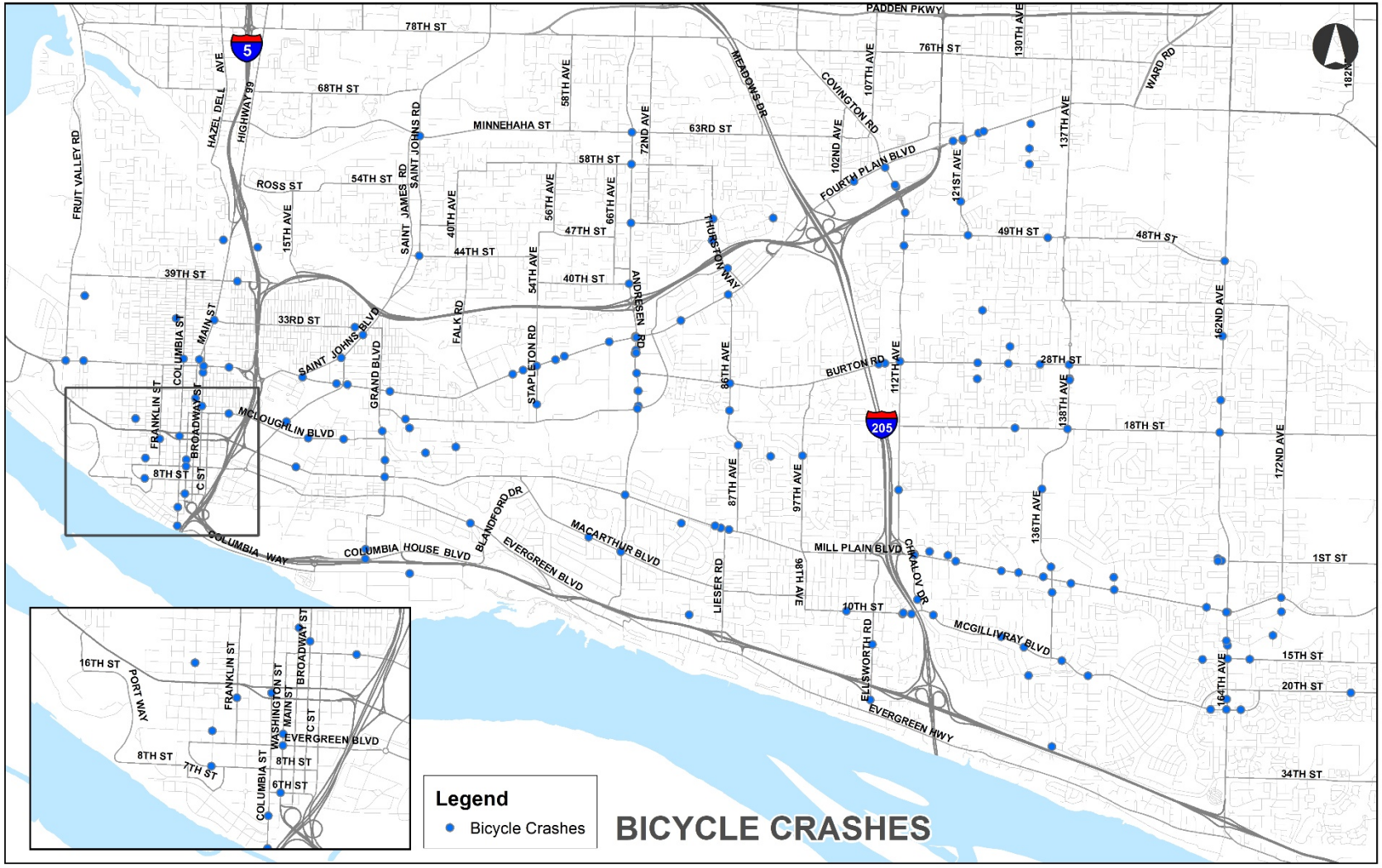
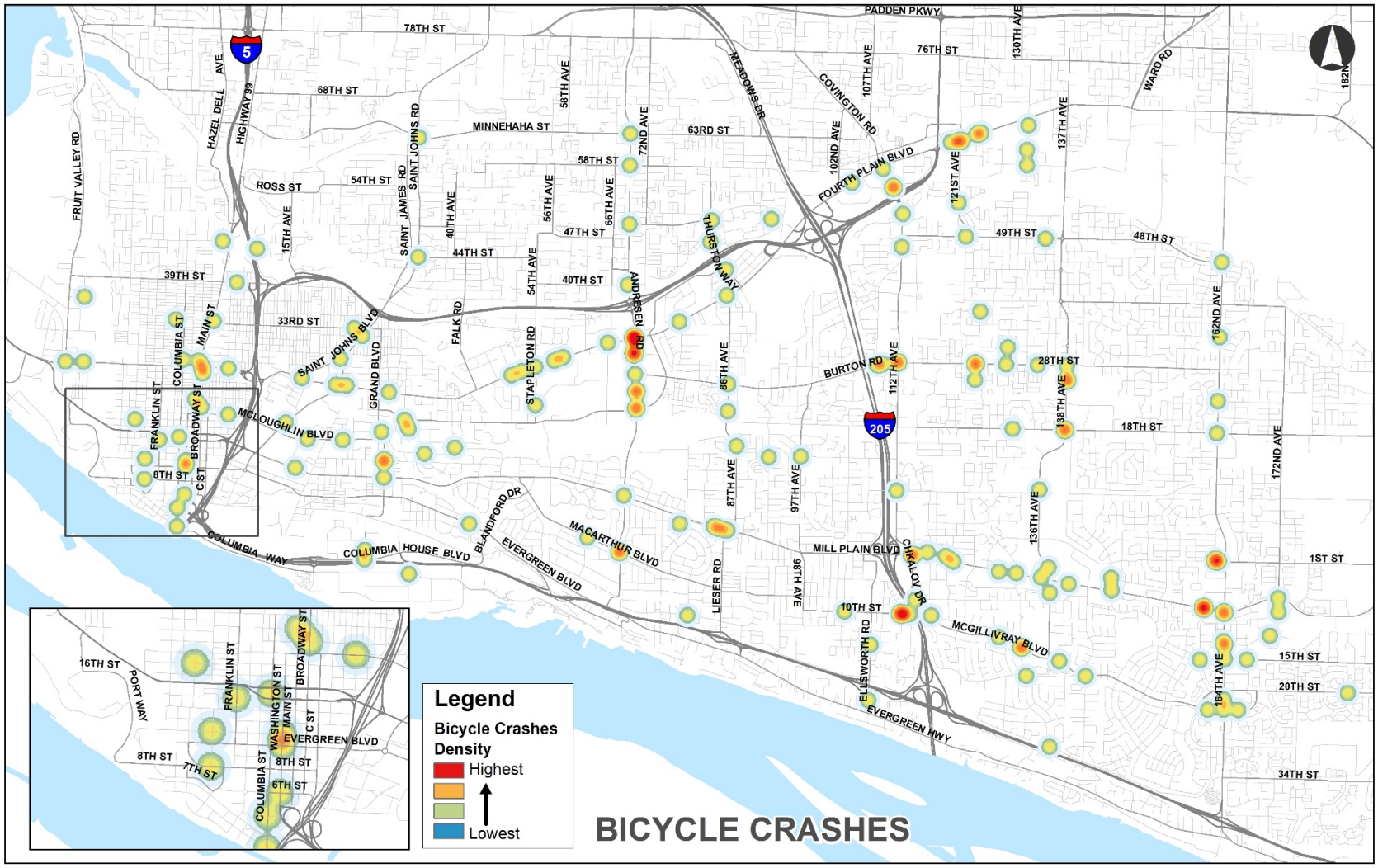


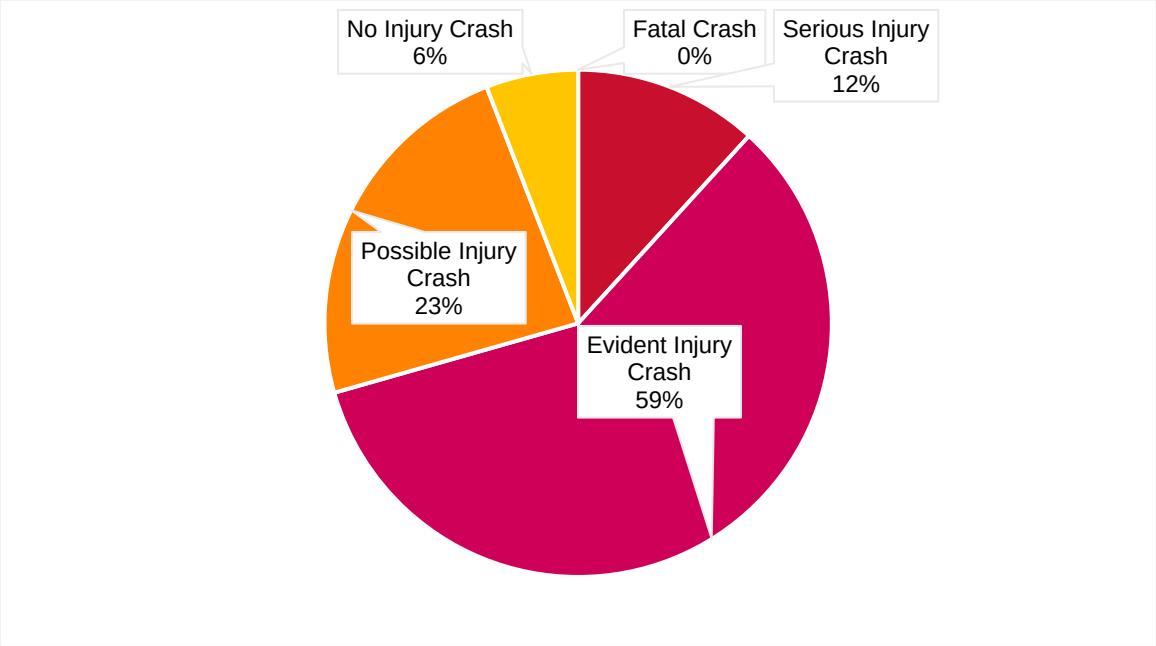
Figure 41. Bicyclist Crash Locations — Heat Map (All Severities, 2012-2016)



3.3.1 Bicyclist Focus– Segment Crashes on Undivided Five-Lane or Six-Lane Roads

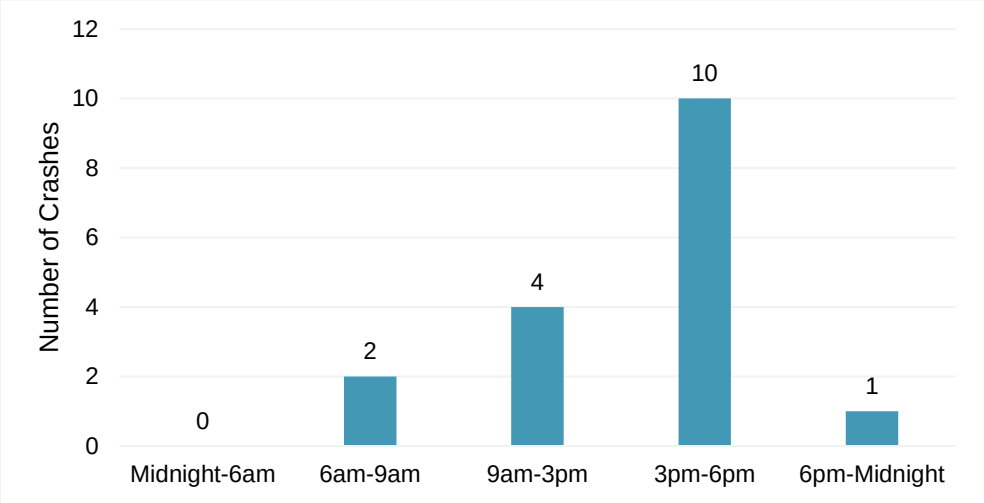
Between 2012 and 2016 there were 17 bicyclist crashes on undivided five-lane or six-lane segments. The majority of the crashes led to evident or possible injuries. There were no fatal crashes and two serious injury crashes (Figure 42).

Figure 42. Bicyclist Focus Segment Crashes by Severity Level (2012-2016)



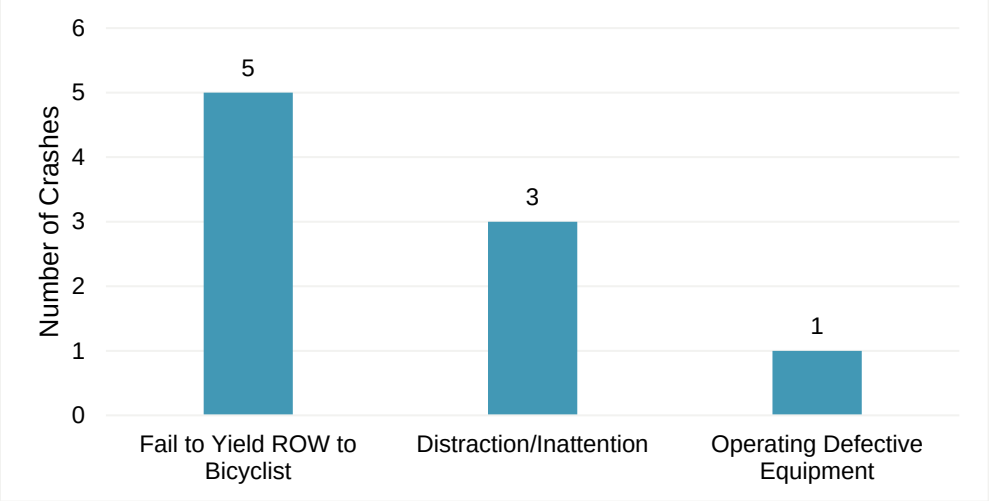
By time of day, most bicyclist focus segment crashes occurred during the afternoon peak period, 3:00 p.m. to 6:00 p.m., likely because there are more vehicles and more bicyclists during this period (Figure 43).

Figure 43. Bicyclist Focus Segment Crashes by Time of Day (2012-2016)



The factor contributing to the most crashes was failing to yield ROW to bicyclists (five crashes, or 29 percent of the bicyclist focus segment crashes — Figure 44). Alcohol or drugs were not involved in any of the bicyclist focus segment crashes.

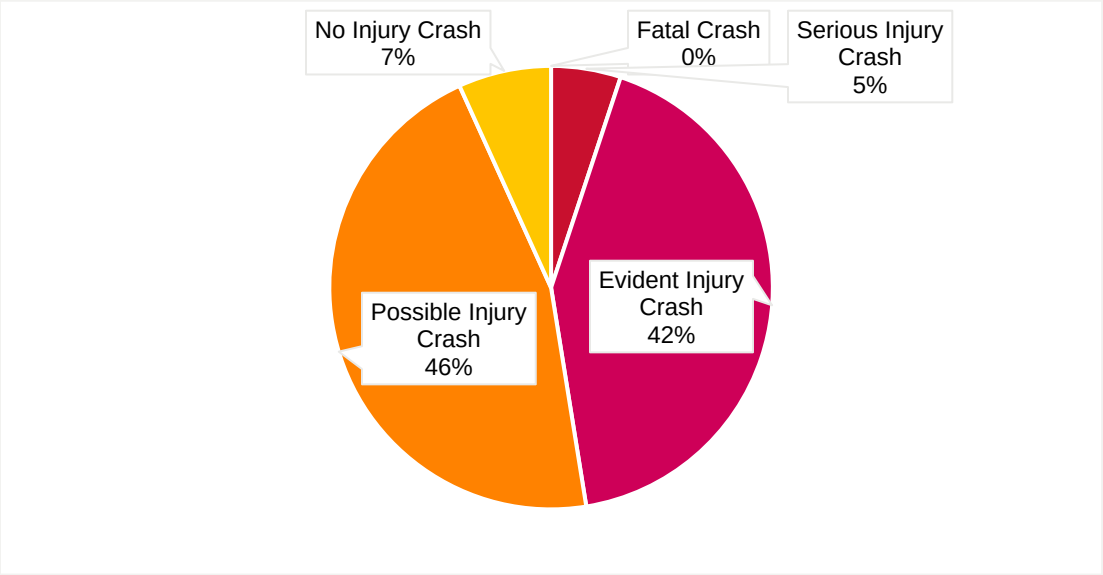
Figure 44. Bicyclist Focus Segment Crashes by Contributing Factor (2012-2016)



3.3.2 Bicyclist Focus– Signalized Intersection Crashes with Posted Speeds of 35 or 40 miles per hour

The severity of the bicyclist-involved crashes is relatively low at signalized intersections. The majority of these crashes led to evident or possible injuries. There were no fatal crashes and three serious injury crashes (Figure 45).

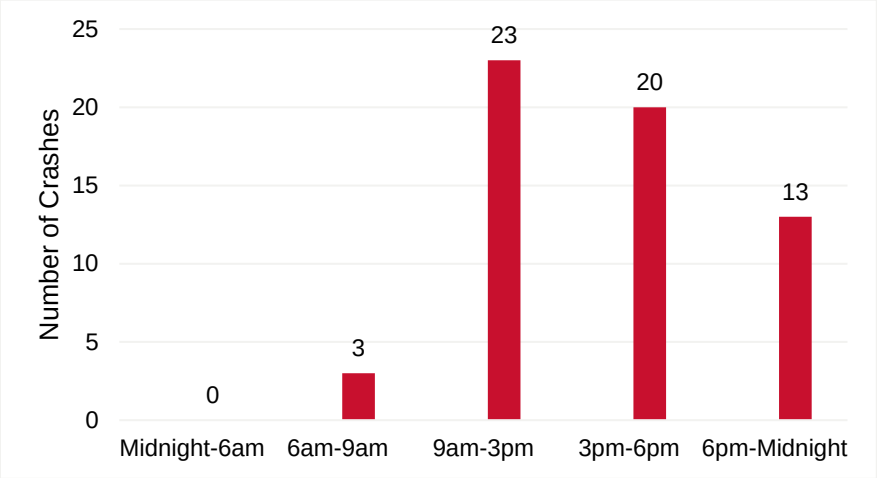
Figure 45. Bicyclist Focus Intersection Crashes by Severity Level (2012-2016)



The number of bicyclist focus intersection crashes by time of day is shown in Figure 46; 23 of the bicyclist focus intersection crashes occurred between 9:00 a.m. and 3:00 p.m.

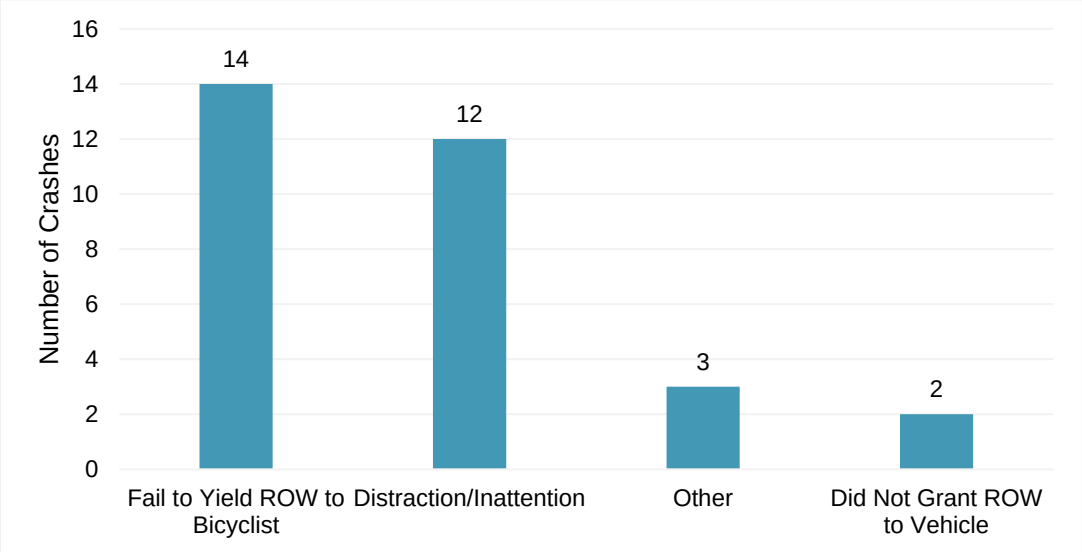
which differs from pedestrian-involved crashes which occurred most frequently between 6:00 p.m. and midnight.

Figure 46. Bicyclist Focus Intersection Crashes by Time of Day (2012-2016)



The factor contributing to the most crashes was failing to yield ROW to bicyclists, in 14 crashes, or 24 percent of the bicyclist focus segment crashes. Of the crashes from vehicles that failed to yield ROW, 12 vehicles were making a right turn. Alcohol or drugs were not involved in any of the bicyclist focus intersection crashes. The number of bicyclist focus intersection crashes by contributing factor is shown in Figure 47.

Figure 47. Bicyclist Focus Intersection Crashes by Contributing Factor (2012-2016)



3.4 Young Driver Crash Analysis

Figure 48 is a crash tree showing the breakdown of young driver crashes on Vancouver city streets. As shown, from 2012 to 2016 there were 2,282 traffic crashes involving young drivers, approximately 41 percent of the total number of crashes in the city.

Figure 49 shows the location of all young driver crashes on City streets, and Figure 50 is a heat map showing where young driver crashes are clustered on City streets. The color ranges are based on natural breaks in the lowest to highest frequency of crashes based on crash density within the area. While 86 percent of the young driver intersection crashes occurred at signalized intersections, only 60 percent of intersections in Vancouver are signalized; therefore, signalized intersections are higher risk for young drivers and pedestrians and bicyclists too. Young driver crashes on segments occurred on undivided roadways proportionally to the percentage of undivided roadways in Vancouver — approximately 80 percent. Given the relatively low frequency of crashes, divided roads were not evaluated in this analysis.

Figure 48. Young Driver Crash Tree (All Severities, 2012-2016)

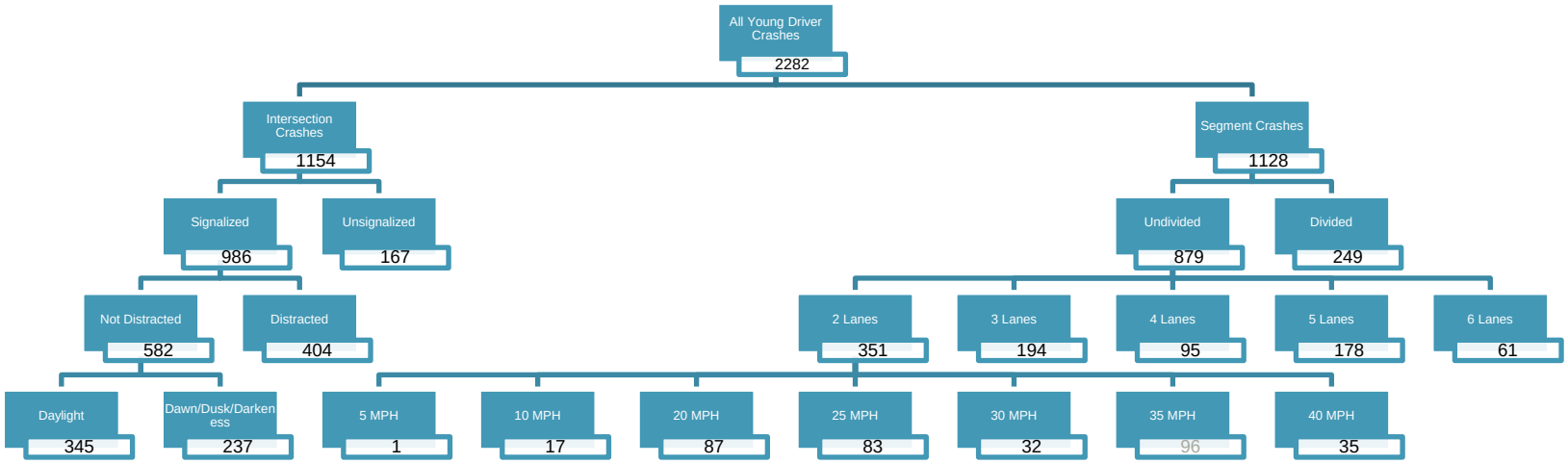


Figure 49. Young Driver Crash Locations (All Severities, 2012-2016)

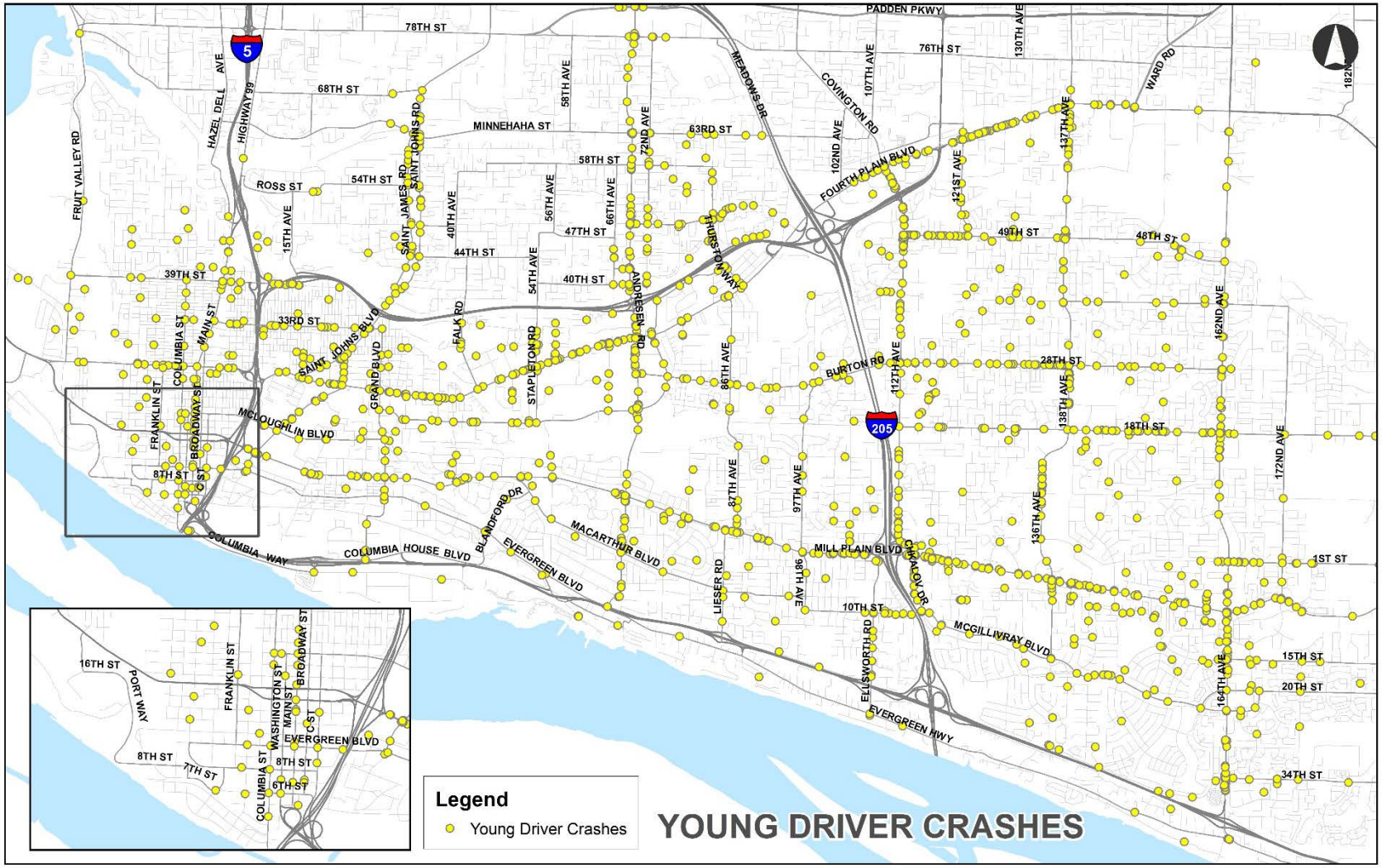
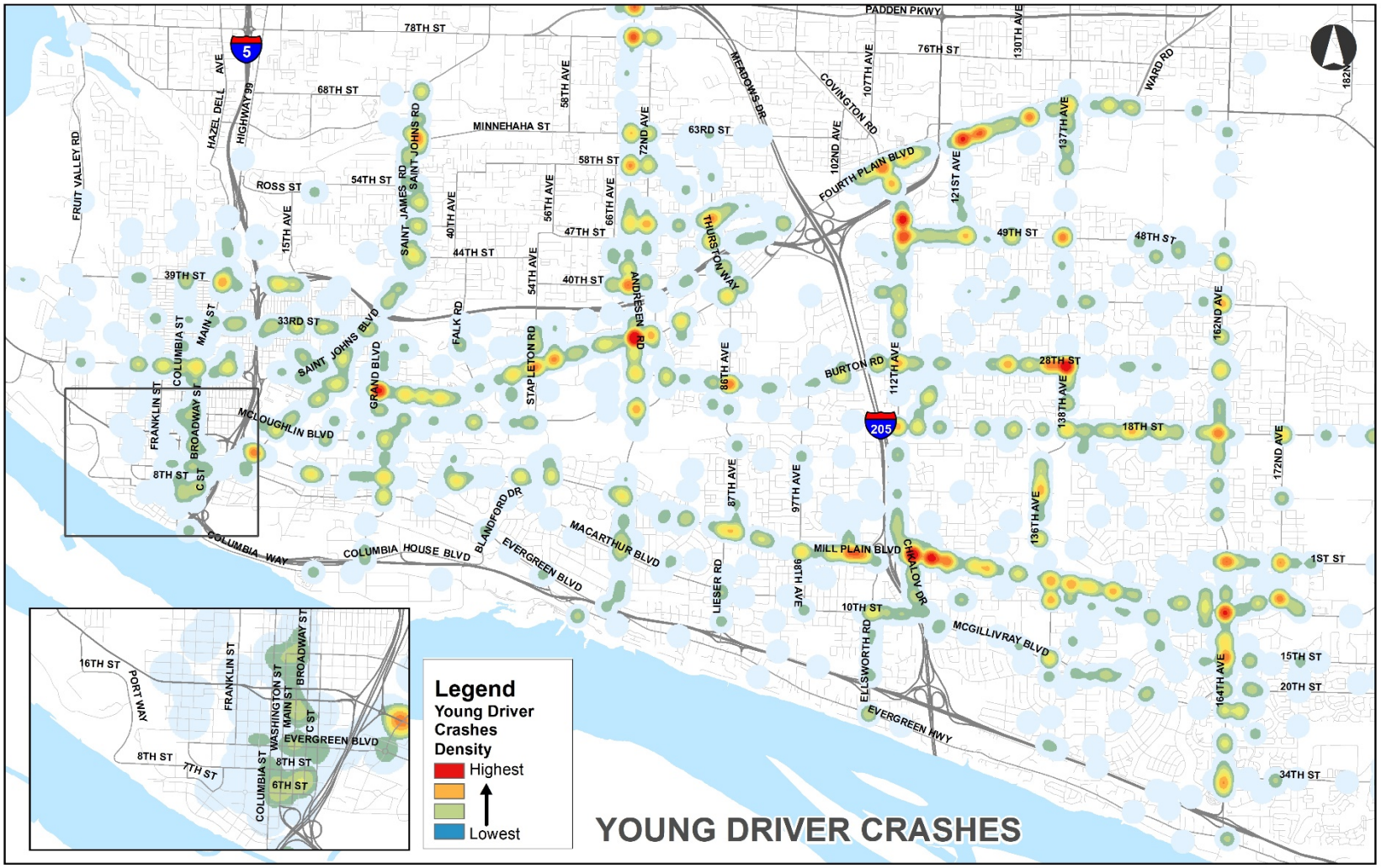


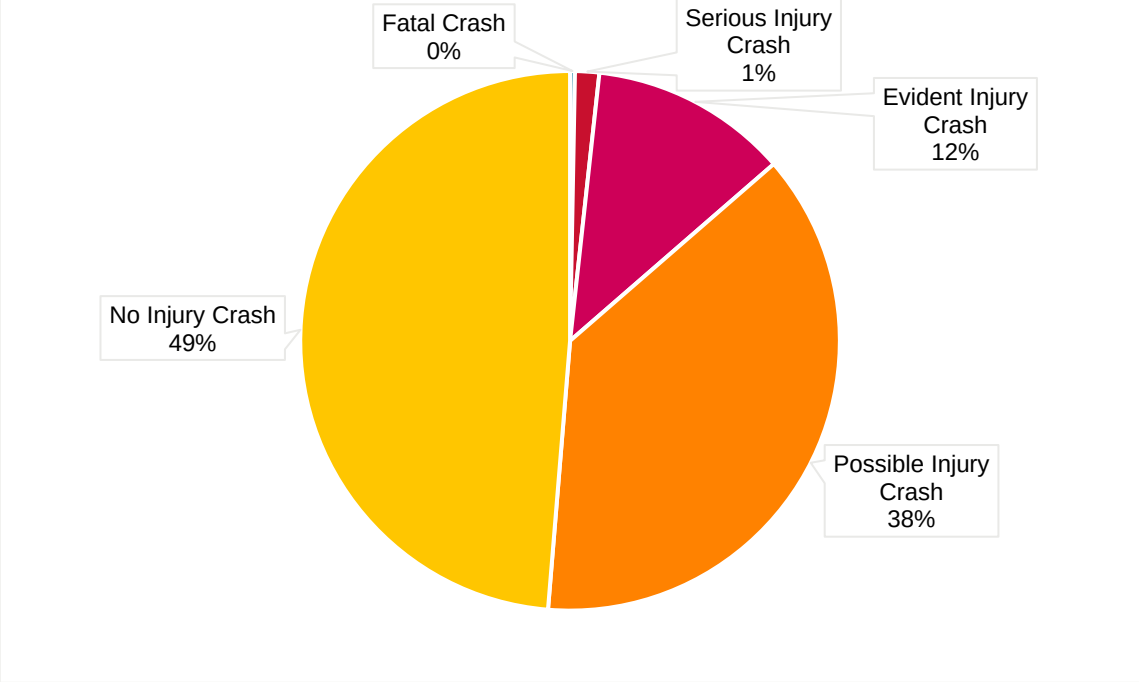
Figure 50. Young Driver Crash Locations — Heat Map (All Severities, 2012-2016)



3.4.1 Young Driver Focus – Signalized Intersection Crashes during Daylight without a Distraction Contributing to the Crash

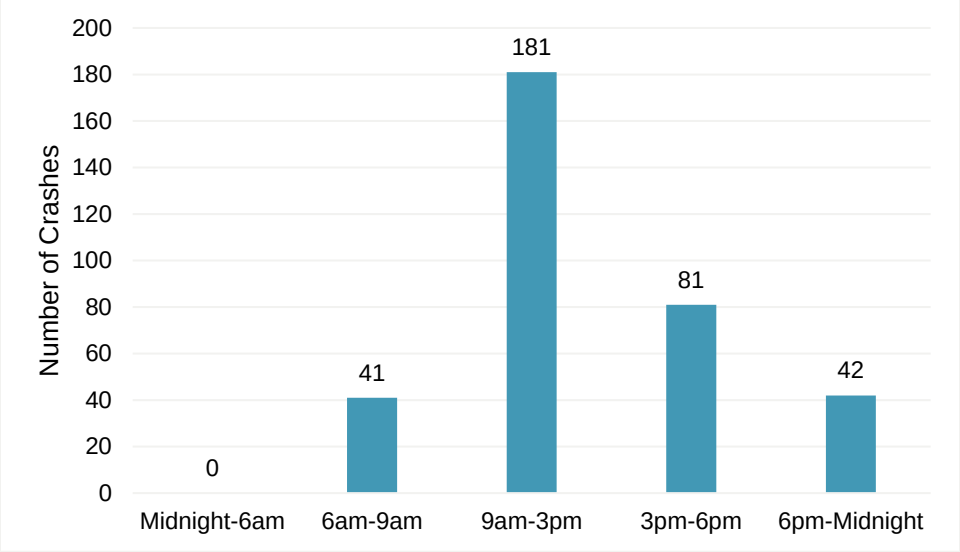
Between 2012 and 2016 there were 345 young driver crashes at signalized intersections during daylight without a distraction contributing to the crash. The most common severity level was no injury (168 crashes). There was one fatal crash and five serious injury crashes (Figure 51).

Figure 51. Young Driver Focus Intersection Crashes by Severity Level (2012-2016)



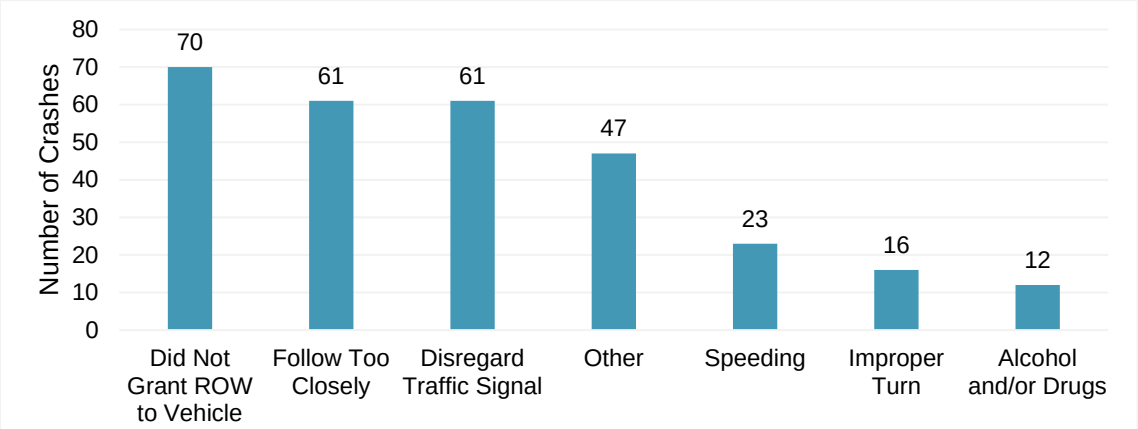
The number of young driver focus intersection crashes by time of day is shown below in Figure 52; 181 of the young driver focus intersection crashes occurred between 9:00 a.m. and 3:00 p.m.

Figure 52. Young Driver Focus Intersection Crashes by Time of Day, (2012-2016)



As shown in Figure 53, the most common contributing factors to the young driver focus intersection crashes were not granting ROW to vehicles, following too closely, disregarding a traffic signal, “Other”, and speeding. These factors are consistent with young driver inexperience and high-risk behavior. Not granting ROW is a contributing factor in 20 percent of the young driver focus intersection crashes, of these 60 percent were turning left. Alcohol and/or drugs were involved in 12 of the young driver focus intersection crashes.

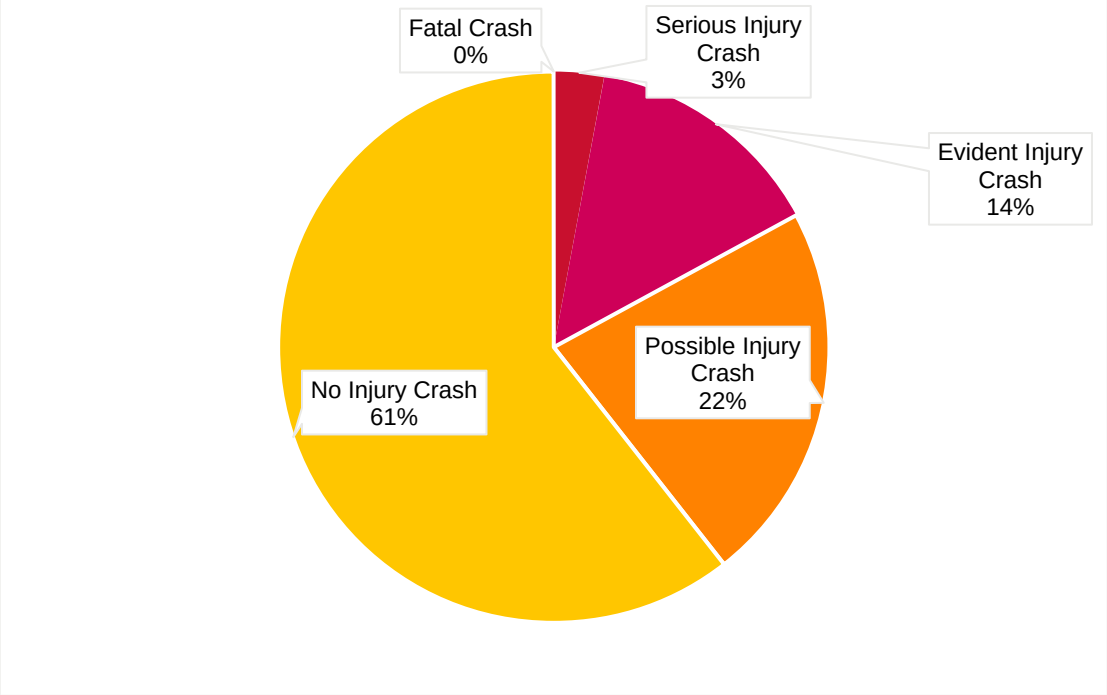
Figure 53. Young Driver Focus Intersection Crashes by Contributing Factor, (2012-2016)



3.4.2 Young Driver Focus – Segment Crashes on Undivided Two-Lane Roads with Posted Speeds of 20 or 25 miles per hour

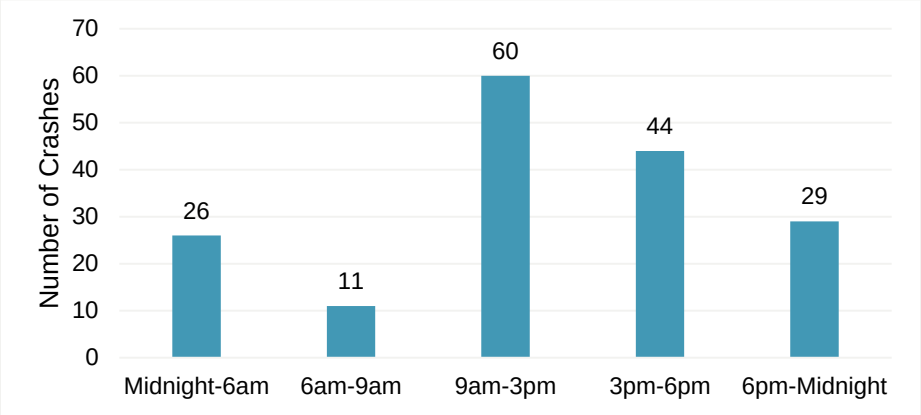
Between 2012 and 2016 there were 170 young driver crashes on undivided two-lane roads with posted speeds of 20 or 25 miles per hour. Property Damage Only crashes (i.e., no injury) were the most frequent; there were no fatal crashes and five serious injury crashes (Figure 54).

Figure 54. Young Driver Focus Segment Crashes by Severity Level (2012-2016)



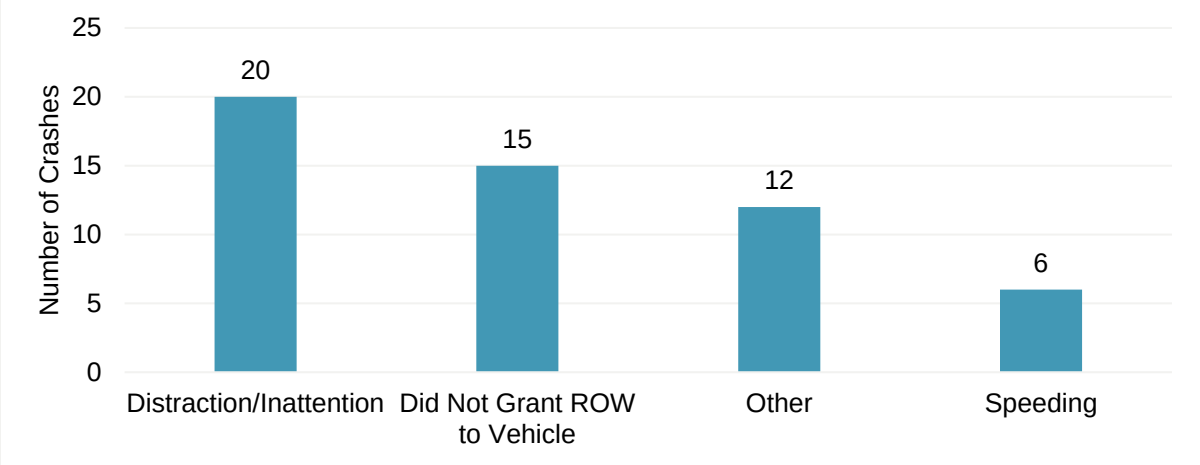
The number of young driver focus crashes on roadway segments by time of day is shown below in Figure 55; 60 of the young driver focus segment crashes occurred between 9:00 a.m. and 3:00 p.m. – similar to the intersection crashes.

Figure 55. Young Driver Focus Segment Crashes by Time of Day (2012-2016)



The most common contributing factors to the young driver focus segment crashes were distraction/inattention, not granting ROW to a vehicle, “Other”, and speeding (Figure 56). These factors are consistent with young driver inexperience.

Figure 56. Young Driver Focus Segment Crashes by Contributing Factor (2012-2016)



4 Prioritization of Intersections and Roadway Segments

4.1 Intersection Prioritization

Crash frequency and severity was evaluated at signalized and unsignalized intersections. All intersections of city owned collector and arterial roads were considered in the analysis. The intersections were ranked according to three performance measures to identify locations with potential for safety performance improvement. The ranking was based on a combined index developed from the following safety performance measures:

- Crash Frequency – the total number of intersection crashes of all severities
- Fatal and Serious Injury Crashes – the number of crashes with a fatality or seriously injured person.
- Combined Pedestrian and Bicycle Crashes – The total number of crashes at an intersection that included a person-type coded as pedestrian (includes person on foot, roller skater/skateboarder, in wheelchair, flagger, roadway worker and emergency medical service personnel); or a person-type coded as bicyclist or other cyclist.

The intersections are ranked according to each performance measure, and the sum of the ranking is the combined index score. The intersections are then ranked according to the combined index score. A lower combined index score means there is more potential for safety improvement at the intersection.

In the prioritization analyses, the most recent five years of crash data (2012-2016) is used to base site prioritization on recent trends and roadway conditions. For the purposes of this analysis, because of the relatively close intersection spacing in the downtown area, a crash is defined as an intersection crash if it occurred within 100 feet of an intersection. Outside of downtown, a crash is defined as an intersection crash if the crash occurred within 250 feet of an intersection. The following analysis includes

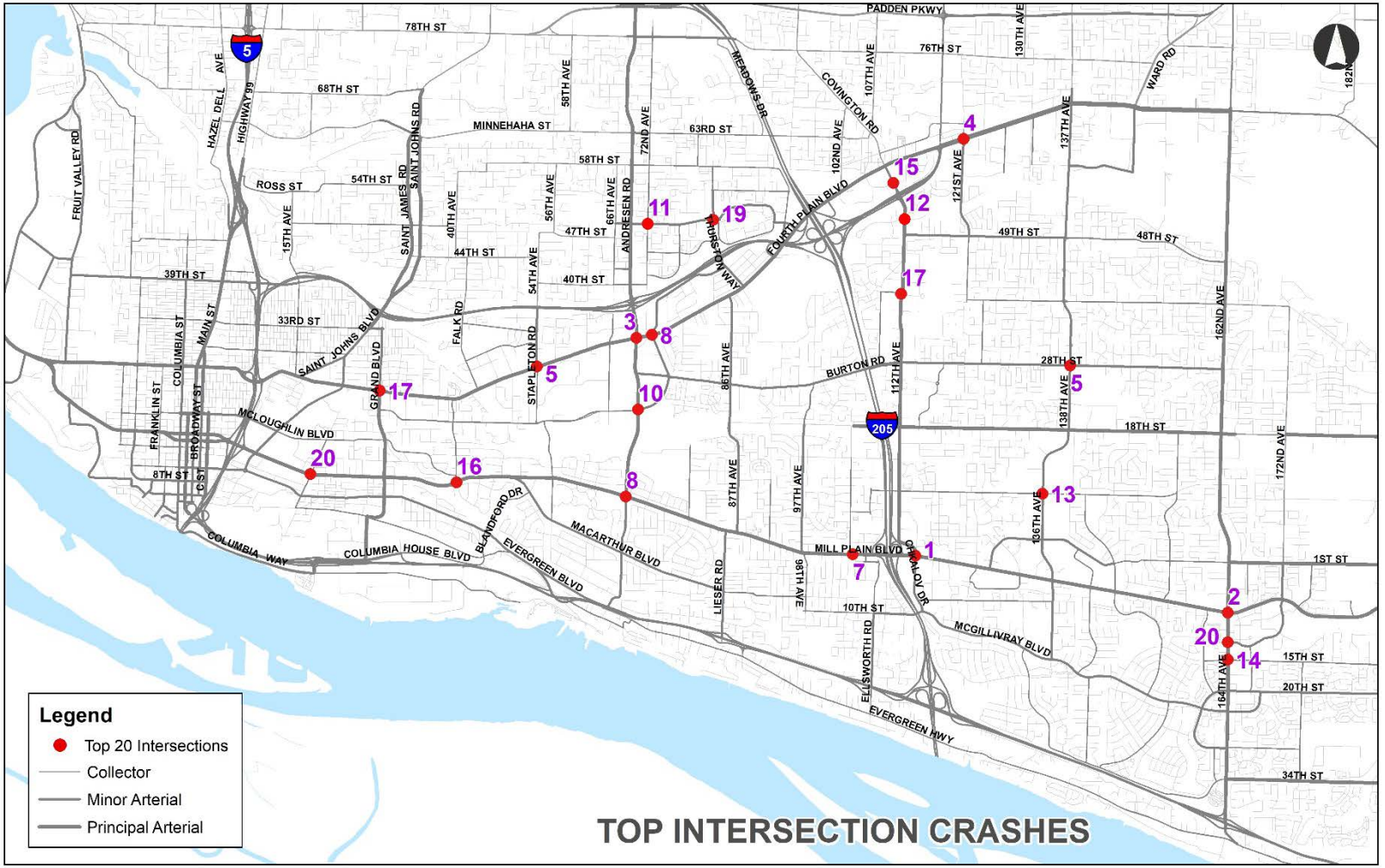
intersections of City-owned arterials and collectors and any intersections between arterials/collectors and state-owned roads, but does not include local roads.

Appendix B lists the 100 highest ranked crash intersections and Table 4 lists the top 20 intersections with ranking data. All intersections of city owned collector and arterial roads were considered in the analysis. Twenty-five percent (2,856) of all intersection crashes occur at these top 20 intersections. The intersection of Mill Plain Boulevard/Chkalov Drive has a combined index rank of one. Figure 57 shows the location and rank of the top 20 intersections.. As shown, the majority of the higher-ranked intersections are located on principal arterials where speeds are higher. Appendix B includes the full list of prioritized intersections.

Table 4. Intersection Ranking Results – Top 20 Intersections (2012-2016)

Intersection Name	Signalized or Unsignalized	Frequency		Fatal and Serious		Pedestrian and Bike		Combined Index Score	Combined Index Rank
	Type	Crashes	Rank (A)	Crashes	Rank (B)	Crashes	Rank (C)	(A+B+C)	
Mill Plain Blvd/Chkalov Dr	signalized	80	1	5	2	7	1	4	1
Mill Plain Blvd/SE 164th Ave	signalized	52	3	3	5	7	1	9	2
Fourth Plain Blvd/Andresen Rd	signalized	78	2	3	5	6	3	10	3
Fourth Plain Blvd/121st Ave	signalized	41	8	3	5	2	24	37	4
NE 28th St/NE 138th Ave	signalized	41	8	1	27	3	11	46	5
Fourth Plain Blvd/Stapleton Rd	signalized	27	21	2	14	3	11	46	5
Mill Plain Blvd/SE 104th Ave/105th Ave	signalized	40	10	1	27	3	11	48	7
Mill Plain Blvd/Andresen Rd	signalized	28	18	1	27	4	8	53	8
Fourth Plain Blvd/Burton Rd	signalized	24	28	2	14	3	11	53	8
NE 18th St/Andresen Rd	signalized	30	16	1	27	3	11	54	10
NE Vancouver Mall Dr/NE 72nd Ave	signalized	19	42	4	3	3	11	56	11
NE 51st St/NE 112th Ave	signalized	51	4	3	5	1	51	60	12
NE 9th St/NE 136th Ave	signalized	18	48	3	5	3	11	64	13
SE 15th St/ SE 164th Ave	signalized	32	14	1	27	2	24	65	14
Coxley Dr/Gher Rd	unsignalized	19	42	1	27	3	11	80	15
Mill Plain Blvd/Brandt Rd	signalized	15	68	3	5	3	11	84	16
Fourth Plain Blvd/Grand Blvd	signalized	43	7	1	27	1	51	85	17
NE 39th St/NE 112th Ave	signalized	13	76	3	5	5	4	85	17
Vancouver Mall Dr/Thurston Way	signalized	20	37	1	27	2	24	88	19
Tech Center Dr (SE 12th)/164th Ave	signalized	28	18	0	67	5	4	89	20
Mill Plain Blvd/Reserve St	signalized	17	51	1	27	3	11	89	20

Figure 57. Intersection Ranking Results — Location of Top 20 intersections (2012-2016)



4.2 Segment Prioritization

To prioritize the roadway segments, the criteria below were tabulated on each collector, minor arterial and principal arterial road in the City. The criteria are:

A. Pedestrian Crash Density – Score is equal to the number of locations with a high density of pedestrian crashes per segment. The pedestrian crash density heat map is shown in Figure 26.

B. Road/Lane Departure Crash Density – Score is equal to the number of locations with a high density of road/lane departure crashes per segment. The lane departure crash density heat map is also included in Figure 35.

C. Bicyclist Crash Density – Score is equal to the number of locations with a high density of bicyclist crashes per segment. The bicyclist crash density heat map is also included in Figure 41.

D. Young Driver Crash Density – Score is equal to the number of locations with a high density of young driver crashes per segment. The young driver crash density heat map is also included in Figure 50.

E. Four-Lane, Five-Lane or Six-Lane Undivided Road – Segments receive three points if the segment is a four-lane, five-lane, or six-lane undivided road (pedestrian, road/lane departure, bicyclist, and young driver risk factor). Segments receive zero points otherwise.

F. Posted Speed Limit – Segments are scored 0 points if speed is less than 30 miles per hour; 1 point if posted speed is 30 miles per hour; 2 points if posted speed is 35 miles per hour; and 3 points if posted speed is 40 miles per hour.

The results are shown in Figure 58. This figure also shows the location and rank of intersections in the top 20 list of intersections most likely to respond to safety improvements.

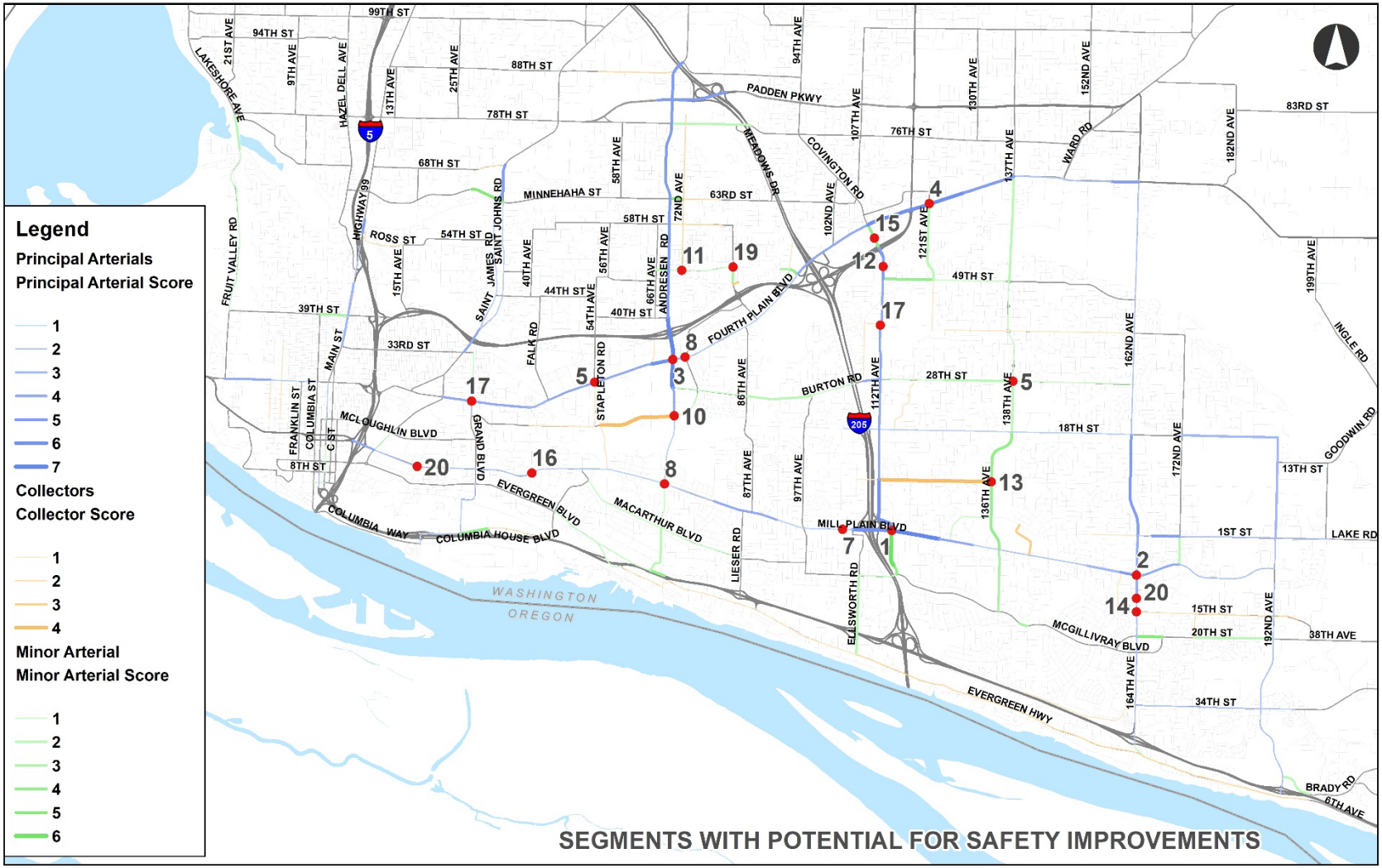
The higher ranking segments for each functional classification are:

- Principal Arterials:
  - SE Mill Plain Boulevard from NE Chkalov Drive to SE 123rd Ave;
  - NE Andresen from NE 25 St./Burton Road to NE Fourth Plain Blvd.
  - NE Andresen from NE Fourth Plain to NE 40th Street
  - SE Mill Plain Boulevard from 107th Ave to Chkalov Drive
  - NE 112th Ave from SE Mill Plain Blvd. to NE 9th Street
- Minor Arterials:
  - SE Chkalov Dr. from SE 7th Street to Mill Plain Boulevard
  - SE 20th Street from SE 167th Avenue to SE McGillivray Boulevard
  - SE 20th Street from SE 164th Avenue to SE 167th Avenue.
  - NE Minnehaha from NE Saint James Rd to NE Saint Johns Rd

- NE 63rd from NE Andresen to NE 72nd Avenue

- Collectors:
  - NE 9th from NE 112th to NE 136th Avenue
  - E 18th Street from N Devine Rd. to NE 65th Avenue
  - E 18th Street from NE 65th Avenue to NE Andresen Rd.
  - SE Olympia Drive from SE Mill Plain Boulevard to SE 1st Street
  - NE Parkway from NE Thurston Way to NE Vancouver Mall Drive

Figure 58. Segment Prioritization Analysis (2012-2016)



5 Countermeasures

The countermeasures proposed for this analysis are a mix of treatments taken from the Washington State Target Zero plan and national best practice documents, such as NCHRP 500: Guidance for Implementation of the American Association of State Highway and Transportation Officials (AASHTO) Strategic Highway Safety Plan Volumes 1-23 (NCHRP, 2003-2009) and Countermeasures that Work (NHTSA, 9th Edition). Countermeasures are organized by focus area, and several categories of countermeasures are proposed for each focus area. Below are lists of countermeasure strategies and example countermeasures for each crash focus areas plus intersections. Segment level crash countermeasures are integrated in the pedestrian, bicycle and lane departure tables. Specific countermeasures associated with these strategies are included in Appendix D.

Pedestrians

- Align vehicle speeds with adjacent land use and built environment: design/modify roads to reduce speeds, implement speed feedback signs.
- Improve pedestrian safety awareness and behaviors among all users: conduct pedestrian safety campaigns, provide education about the impact of speed on pedestrian safety.
- Increase enforcement of driving and walking laws, when and where possible, to reduce potential conflicts between modes: deploy targeted and publicized enforcement, provide training for law enforcement officers.
- Expand and improve pedestrian facilities: construct refuge islands, shorten crossing distances with curb extensions; at signalized intersections, provide leading pedestrian indicator; install rectangular rapid flashing beacons and pedestrian hybrid beacons.
- Improve safety for children walking to schools: conduct high visibility enforcement near schools, provide enhanced signing and striping in schools zones, develop and conduct education programs.
- Improve data systems and analysis tools for more timely and accurate investigations: collect, store and utilize pedestrian volumes and travel distances.

Lane Departure

- Reduce opposite direction crashes: install raised medians or other access control on multilane arterials
- Reduce number of vehicles leaving the roadway: implement profiled center and edge lines
- Minimize consequences of leaving the roadway: construct separated bicycle and walking facilities, design and implement safe urban design features.
- Improve roadway to accommodate turning traffic: implement road diets, add turn lanes at intersections.

- Improve corridor access management: reduce driveway density along a corridor or at intersections.
- Set appropriate speed limits: design roads for desired speeds; implement traffic calming to reduce speeds
- Communicate appropriate speeds through the use of traffic control devices: implement speed feedback signs, coordinate traffic signals for a desired speed.
- Reduce speeding through enforcement: deploy targeted high visibility enforcement, implement speed reader boards.
- Build partnerships to increase support for speed reducing measures: develop public education campaigns about the dangers of speeding or the effects of weather on the driving environment.

Bicyclists

- Improve bicyclist and driver safety awareness and behavior: promote bicycle safety clothing and equipment, develop and provide bicycle safety awareness education for motorists
- Enact policies/laws to improve bicycle safety: encourage bicycle helmet usage; provide law enforcement training of bicycle laws.
- Improve bicyclist facilities: construct more bike lanes, implement separated bicycle lanes, and separated bicycle facilities, install colored bicycle boxes at intersections
- Improve safety for children bicycling to schools: deploy high visibility enforcement near schools, provide bicycle education for students
- Improve data systems and analysis tools for more timely and accurate investigations: collect bicycle volume and travel distance data.

Young Driver

- Foster compliance with Washington State's Intermediate Driver License: provide resources to law enforcement to comply
- Strengthen Intermediate Driver License restrictions: coordinate with statewide activities to enhance/maintain graduated driver's license laws and enforcement
- Improve young driver education and intervention: provide high school education programs about risks associated with speeding and distraction
- Improve enforcement of high risk behaviors among young drivers: provide funding for targeted high visibility enforcement programs
- Enforce compliance with laws pertaining to intoxicated driving; provide funding for targeted high visibility enforcement programs

Intersections

- Modify intersection control and features: provide/improve left- and right-turn channelization, consider protected left turns signal phasing, prohibiting right turn on red, right turn signal, or removing turns

- Improve driver compliance at intersections: provide funding for speed and intersection enforcement
- Improve driver awareness of intersections; explore opportunities for automated enforcement or targeted high visibility enforcement
- Modify intersection control and features for pedestrians and bicyclists: provide pedestrian refuge islands, install leading pedestrian intervals or signal countdown timers; maintain sight distance

6 Near-term Projects

Using the results from the intersection/segment prioritization analysis and with input from the Technical Advisory Committee and the City, the following locations were identified for more detailed investigation. In addition to selecting locations based on rank, the City selected locations that could be used as examples for other similar locations in the City. Therefore the optional projects included in the following pages, can be considered as options for use at other similar locations in the city.

- Intersections
  - SE Mill Plain Boulevard/SE Chkalov Drive (Figure 59)
  - NE Fourth Plain Boulevard/NE 121st Avenue (Figure 60)
  - NE 28th Street/NE 138th Avenue (Figure 61)
  - SE 15th Street/SE 164th Avenue (Figure 62)
  - NE Fourth Plain Boulevard/NE Stapleton Road (Figure 63)
  - SE Mill Plain Boulevard/SE 164th Avenue (Figure 64)
- Segments
  - E Fourth Plain Boulevard – Ft. Vancouver Way to Falk Road (Figure 65)
  - NE Andresen Road – NE 47th Street to NE Burton Road (Figure 66)
  - NE 9th Street – NE 112th Avenue to NE 136th Avenue (Figure 67)
  - E 18th Street – N Devine Road to NE Andresen Road (Figure 68)

The objective of the investigation was to conduct a detailed site and crash evaluation to identify opportunities and constraints, and develop a list of optional low-cost countermeasures that could be implemented at the site.

The investigations and analysis revealed a few countermeasures that could be implemented throughout the city:

- **Implement Leading Pedestrian Interval Phasing–** A leading pedestrian interval allocates signal time for pedestrians to start into the intersection in advance of the through or right turn movements in the same direction. This makes pedestrians more visible to right-turning motorists or cyclists, potentially reducing conflicts between these modes. This treatment could be added to signals to enhance pedestrian safety throughout the city.

- **Increase Driver Compliance with Traffic Signals –** A number of crashes throughout the city were attributed to drivers disregarding traffic signals. There are a wide variety of treatments that can be used to enhance visibility of traffic control devices: improving signing and delineation, larger signs, managing sight distance, improving lighting (if nighttime crashes are relevant), and reducing delay and/or travel speed. There are also human factors that could contribute to this issue: “visual clutter” or inconsistent roadside features, or traffic control features, can contribute to driver distraction. A multi-pronged approach to addressing this issue includes infrastructure treatments, road design, driver education about distractions, and enforcement (potentially including automated enforcement).
- **Improve Wayfinding –** Particularly in the vicinity of interchanges, way-finding to orient drivers into the most appropriate travel lane is critical. As new infrastructure is planned and implemented, particular attention should be given to evaluating whether the appropriate information is being provided to drivers in sufficient time to successfully navigate the system.
- **Reduce Speeding –** The east side of Vancouver is characterized by higher-speed multi-lane arterials. Reducing travel speeds and congestion on these facilities can reduce the severity of crashes when crashes do occur. As streets are retrofitted or modified, design speed and resulting road features should be considered to reduce operating speeds, yet provide for efficient travel through the system.
- **Evaluate Opportunities to Reduce Roadway Cross-Sections –** Reducing the number of lanes on a roadway can reduce travel speeds, lane changing maneuvers, provide specific locations for left turns and provide space for bicyclists, and/or sidewalks. In specific condition traffic operations may not degrade, providing a net safety benefit and more facilities for all modes.

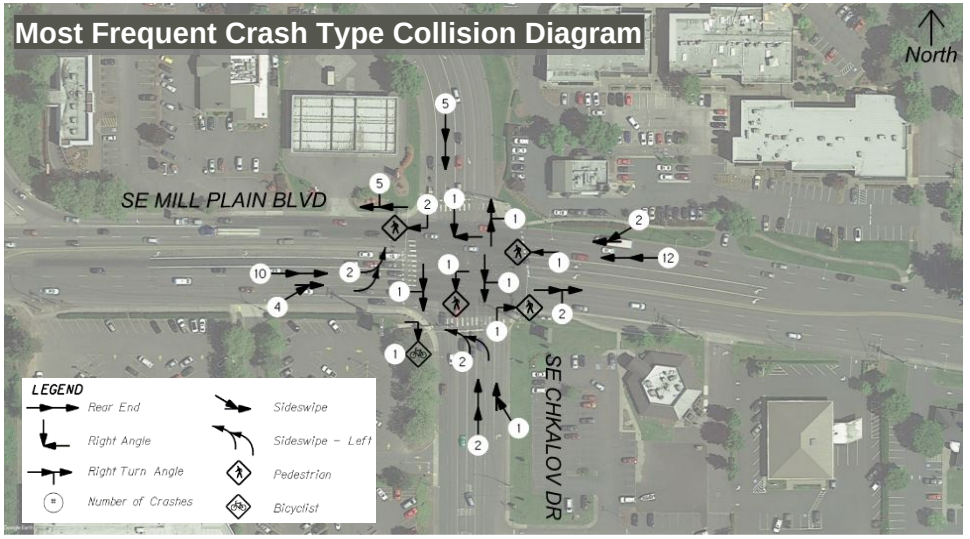
The following pages provide a brief description of conditions at each site, a summary of observed constraints, crash data and potential countermeasures. A collision diagram of the most frequent crash types at the location is also provided. The potential countermeasures shown on each sheet are presented as options for further consideration when improvements at these sites are planned and designed

SE Mill Plain Blvd. / SE Chkalov Dr.

The intersection of SE Mill Plain Blvd. / SE Chkalov Dr. is a crucial decision point for motorists, as the I-205 interchange lies adjacent to the west. Safe travel through the intersection requires familiarity and early lane selection in order to avoid last-minute maneuvers. Access to parking for the Fred Meyer grocery store is present on the south side of Mill Plain Blvd. to the west of the intersection, further increasing weaving movements.

Constraints

- Sight distance and gap selection difficult for right-turn-on-red maneuvers.
- Numerous access points in close proximity to the intersection, particularly to the west side.
- Limited way-finding and constrained lane access for motorists traveling to northbound I-205.



Crash Types

Crash Type	Number of Crashes[1]
Rear-End	29
Angle	21
Sideswipe	11
Pedestrian	5
Bicyclist	1

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	0
Injury	36
Property Damage Only	43

Contributing Factors

Contributing Factor	Number of Crashes[3]
Other	15
Distraction/Inattention	14
Did Not Grant ROW to Vehicle	9
Improper Turn	8
Follow Too Closely	8

Potential Countermeasures

Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Prohibit southbound and northbound right-turn-on-red	Low	Short	F(x)[3]
Restrict access to properties on westbound Mill Plain Blvd. west of the intersection	Low	Short	NA
Improve way-finding signage and add advance street name signs	Low	Short	0.99
Include leading pedestrian interval phase at all approaches	Low	Short	0.99
Add retroreflective sheeting to signal backplates	Low	Short	0.85
Construct additional westbound right turn only lane	Moderate	Medium	0.91

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

[3] A crash modification factor is given by an equation developed in the Highway Safety Manual, 1st Edition. The equation is $CMF=0.98^{n_{prohib}}$ where n_{prohib}=number of approaches for which the right turn on red (RTOR) is prohibited. For example, assuming the north and south approaches prohibit RTOR, the CMF would be $0.98^2=0.96$.

[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection.

[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.

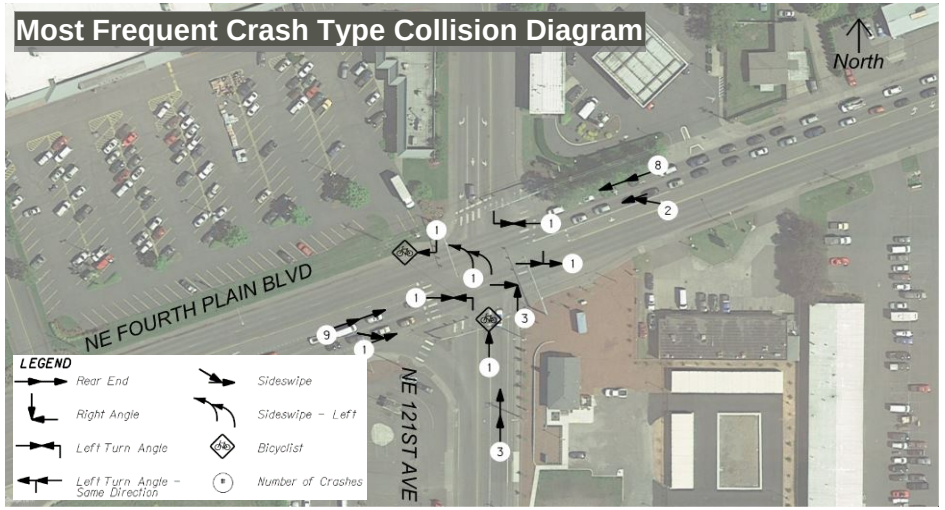
[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

NE Fourth Plain Blvd. / NE 121st Ave.

The intersection of NE Fourth Plain Blvd. & NE 121st Ave. is located in a light industrial area. There is moderate access density to and from NE Fourth Plain Blvd. In many cases the access points are designed to accommodate truck turning movements. The intersection has a high skew angle. Heavy westbound traffic causes vehicle queues contributing to the westbound rear-end crashes. Evaluation of existing ADA ramps is recommended to determine appropriate improvements.

Constraints

- Westbound right turning vehicles blocked by westbound through queuing in shared thru/right lane.
- Access to gas station at east approach may cause abrupt lane changes and braking.
- Lane utilization unequal for two westbound through lanes.
- High skew angle may constrain sight distance for eastbound right turn from NE Fourth Plain Blvd. to southbound NE 121st Ave.
- Eastbound pullout lane in southwest corner may lead to sudden unexpected maneuvers between buses and vehicles.



Crash Types

Crash Type	Number of Crashes[1]
Rear-End	20
Angle	7
Sideswipe	4
Bicyclist	2

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	0
Injury	16
Property Damage Only	22

Contributing Factors

Contributing Factor	Number of Crashes[3]
Distraction/Inattention	15
Follow Too Closely	7
Other	4
Alcohol and/or Drugs	2
Speeding	2

Potential Countermeasures

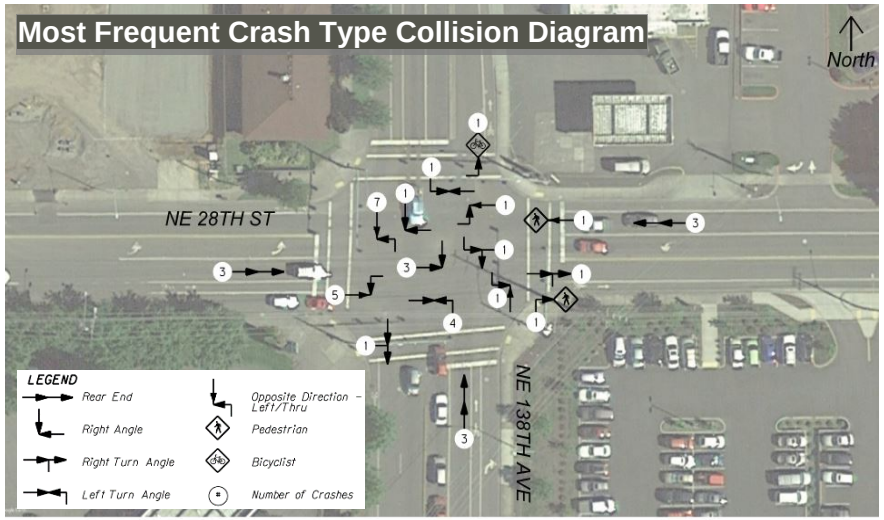
Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Construct separate westbound right turn only lane	High	Medium	0.91
Close access point to gas station on east approach, limit access to NE 121st Ave	Moderate	Medium	NA
Relocate bus stop near southeast corner further east of the intersection	Low	Short	NA
Increase line of sight for northbound right turning vehicles by improving ADA ramps and moving the stop bar	Moderate	Medium	0.41
Reconstruct SW corner of intersection to eliminate eastbound pull-out lane	Moderate	Medium	NA
Include leading pedestrian interval phase at all approaches	Low	Short	0.99
Add retroreflective sheeting to signal backplates	Low	Short	0.85

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000
[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection. A
[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.
[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

NE 28th St. / NE 138th Ave.

The intersection of NE 28th St. / NE 138th Ave. is surrounded by residential neighborhoods to the north and Evergreen High School to the southeast. Opposite direction left turn / thru crashes were most frequent and were mostly caused by left turning vehicles not granting right-of-way to thru vehicles. Considering the proximity of the intersection to the high school and neighborhoods and the presence of four roundabouts directly north, a roundabout could be an effective, though high-cost, countermeasure.



Constraints

- Right-of-way for converting the intersection to a roundabout may be limited.
- Protected/permissive left turns are in operation during nighttime hours but restricted during daytime
- Possible driver confusion with four section signal heads but restricted permissive left turns

Crash Types

Crash Type	Number of Crashes[1]
Opposite Direction – Left Turn/Thru	15
Angle	12
Rear-End	9
Pedestrian	2
Bicyclist	1

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	0
Injury	25
Property Damage Only	13

Contributing Factors

Contributing Factor	Number of Crashes[3]
Did Not Grant ROW to Vehicle	9
Distraction/Inattention	8
Other	7
Improper Turn	5
Follow Too Closely	3

Potential Countermeasures

Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Convert signalized intersection into single lane roundabout	High	Medium	0.74
Change flashing yellow arrow left turn phase to protected left turn phase for all approaches	Low	Short	0.58
Add retroreflective sheeting to signal backplates	Low	Short	0.85
Include leading pedestrian interval phase at all approaches	Low	Short	0.99

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

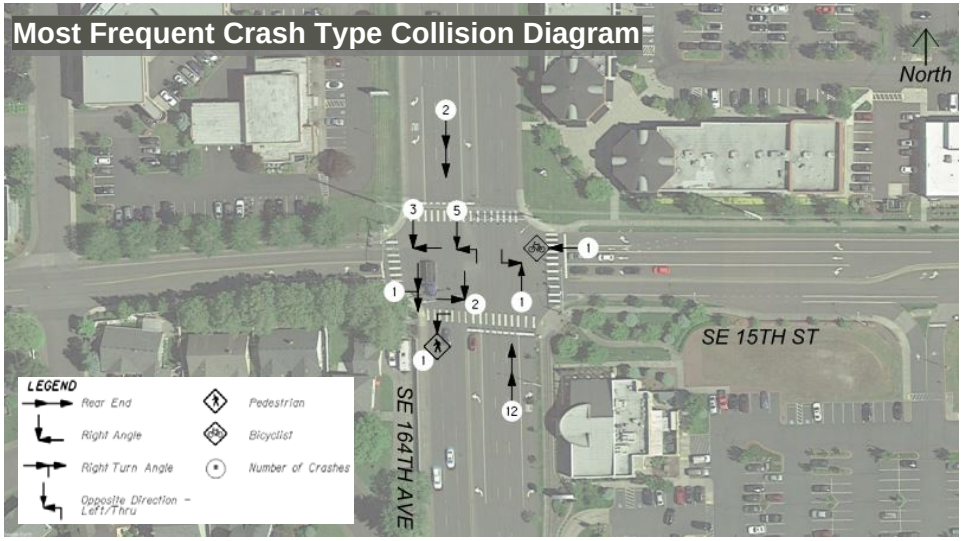
[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection.

[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.

[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

SE 15th St. / SE 164th Ave.

Numerous retail outlets surround this intersection. There were a relatively high number of rear-end crashes south of the intersection and a relatively high number of northbound left turn collisions with southbound through movements. There is potential to reduce northbound rear-end crashes by improving way-finding and signage for northbound access to the retail in the southeast corner of the intersection.



Constraints

- Northbound right-turn lane access to retail and separate right-turn lane at the intersection may cause driver confusion and unpredictable weaving movements.
- Noncompliance with red light signal indications leading to opposite direction left turn / thru crashes and angle crashes.
- Limited sight distance for eastbound and westbound left-turning vehicles during the flashing yellow arrow phase of the signal cycle.
- Limited sight distance for eastbound vehicles looking north during right-turn-on-red maneuver due to retail signage northwest of the intersection.

Crash Types

Crash Type	Number of Crashes[1]
Rear-End	14
Angle	7
Opposite Direction – Left/Thru	6
Pedestrian	1
Bicyclist	1

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	0
Injury	15
Property Damage Only	17

Contributing Factors

Contributing Factor	Number of Crashes[3]
Distraction/Inattention	12
Disregard Traffic Signal	7
Did Not Grant ROW to Vehicle	4
Alcohol and/or Drugs	3
Follow too Closely	2

Potential Countermeasures

Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Improve signage to retail access for northbound right turn lane	Low	Short	NA
Increase all-red clearance interval	Low	Short	0.80
Add retroreflective sheeting to signal backplates	Low	Short	0.85
Add "Left Turn Only" signs adjacent to northbound/southbound left turn signal heads	Low	Short	0.96
Include leading pedestrian interval phase at all approaches	Low	Short	0.99

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection.

[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.

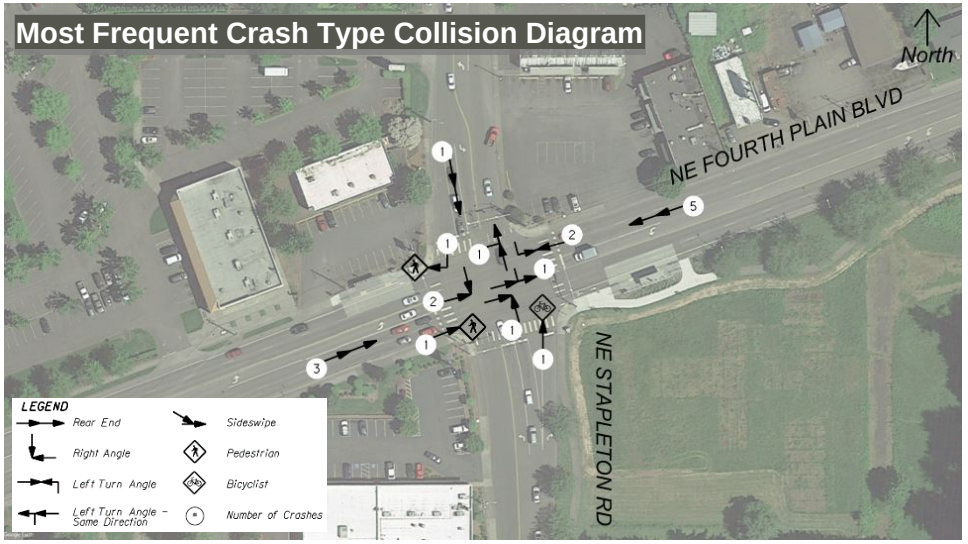
[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

NE Fourth Plain Blvd. / NE Stapleton Rd.

Vancouver Market Center, a small retail development, is located on the northeast corner of the intersection of NE Fourth Plain Blvd. / NE Stapleton Rd. and there is a transit stop at the southeast corner of the intersection. Rear-end crashes were most frequent on NE Fourth Plain Blvd. The intersection skew angle, as well as noncompliance with signal indications, contributed to the number of angle crashes between northbound vehicles from the south approach.

Constraints

- Intersection skew angle limits sight distance for northbound right turning vehicles.
- Red light running contributed to 50 percent of angle crashes.
- High proportion of non-motorized crashes – 10 percent of total intersection crashes.
- Bus rapid transit stop on eastbound NE Fourth Plain Blvd. southeast of intersection; recommend managing signal timing and red indication times to minimize conflicts.



Crash Types

Crash Type	Number of Crashes[1]
Angle	10
Rear-End	9
Pedestrian	2
Bicyclist	1

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	0
Injury	13
Property Damage Only	14

Contributing Factors

Contributing Factor	Number of Crashes[3]
Disregard Traffic Signal	6
Did Not Grant ROW to Vehicle	4
Distraction/Inattention	4
Follow Too Closely	2
Other	1

Potential Countermeasures

Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Restripe northbound approach to the intersection to reduce skew angle	Moderate	Medium	0.56
Prohibit southbound and northbound right turn on red	Low	Short	F(x) [3]
Increase all-red clearance interval	Low	Short	0.80
Install pedestrian countdown timer signals	Low	Short	0.30
Include leading pedestrian interval phase at all approaches	Low	Short	0.99
Add retroreflective sheeting to signal backplates	Low	Short	0.85

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

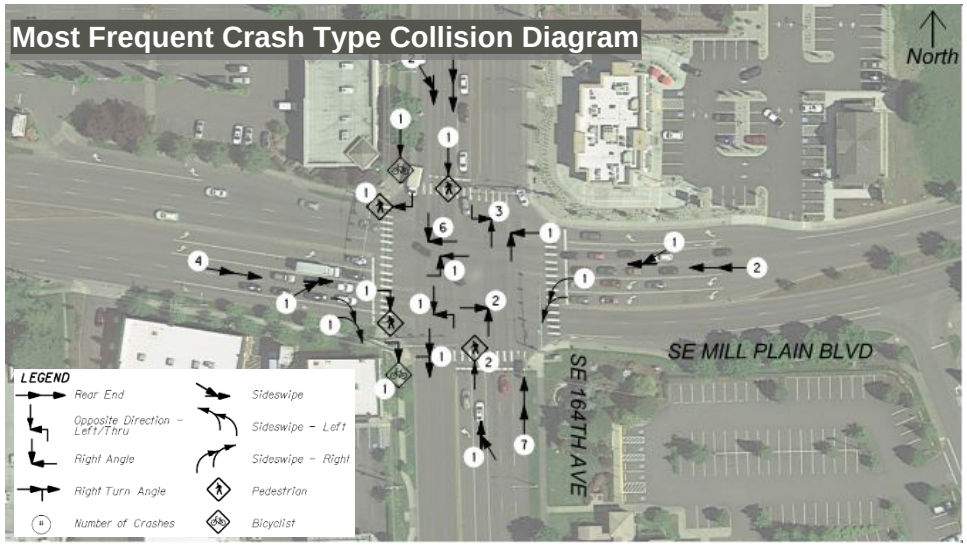
[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

[3] A crash modification factor is given by an equation developed in the Highway Safety Manual, 1st Edition. The equation is $CMF=0.98^{nprohib}$ where n_{prohib}=number of approaches for which the right turn on red (RTOR) is prohibited. For example, assuming the north and south approaches prohibit RTOR, the CMF would be $0.98^2=0.96$.

[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection.
[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.
[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

SE Mill Plain Blvd. / SE 164th Ave.

Numerous large department stores are present to the southeast of the intersection of SE Mill Plain Blvd. / SE 164th Ave. with access from eastbound Mill Plain and northbound 164th Ave. The majority of angle crashes were caused by disregarding a traffic signal indicators, and most pedestrian/bicyclist crashes were caused by the vehicle not granting right-of-way. Complex lane configuration transitions at the intersection may lead to driver confusion and unpredictable driver behavior.



Constraints

- Noncompliance with red light signal indicators contribute to angle crashes.
- No receiving bike lane on westbound SE Mill Plain Blvd. west of intersection; bike lane ends at east approach. Consider terminating bike lane further east in advance of intersection.
- Access points in close proximity to northwest corner of the intersection.
- Transition from two-lanes to three-lanes for westbound traffic at the intersection.
- Right turn only access on westbound SE Mill Plain Blvd. northwest of intersection combined with bus stop.
- Dual right turn lanes from eastbound Mill Plain Blvd to southbound 164th Ave.

Crash Types

Crash Type	Number of Crashes[1]
Rear-End	17
Angle	10
Sideswipe	7
Opposite Direction – Left/Thru	5
Pedestrian	5
Bicyclist	2

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	1
Injury	27
Property Damage Only	23

Contributing Factors

Contributing Factor	Number of Crashes[3]
Distraction/Inattention	15
Disregard Traffic Signal	7
Other	7
Alcohol and/or Drugs	5
Follow Too Closely	4

Potential Countermeasures

Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Extend lane striping through the intersection	Low	Short	NA
Close retail access at bus stop in northwest corner of intersection	Low	Short	NA
Re-evaluate dual right turn warrant for eastbound Mill Plain Blvd	Low	Short	NA
Increase all-red clearance interval	Low	Short	0.80
Install pedestrian countdown timer signals	Low	Short	0.30
Add "Left Turn Only" signs adjacent to northbound/ southbound left turn signal heads	Low	Short	0.96
Include leading pedestrian interval phase at all approaches	Low	Short	0.99
Add retroreflective sheeting to signal backplates	Low	Short	0.85

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

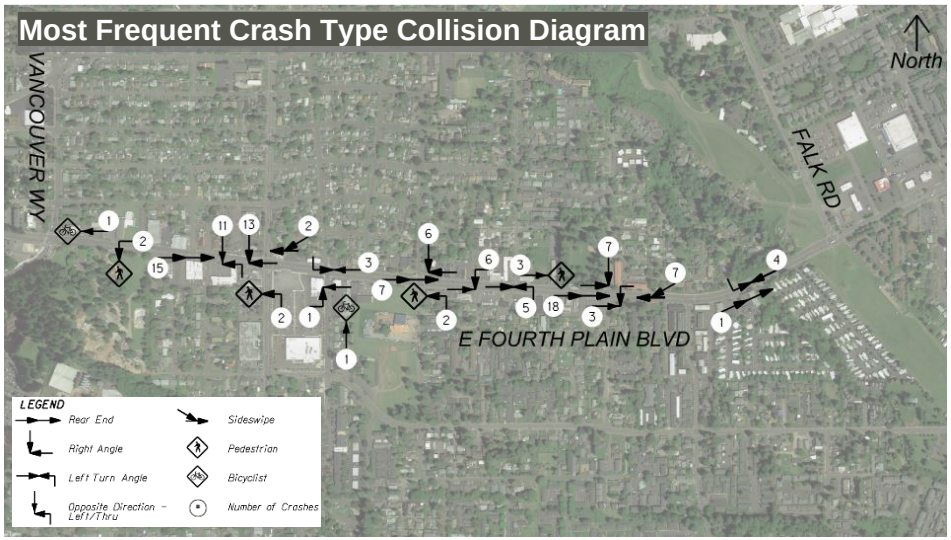
[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection.

[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.

[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

E Fourth Plain Blvd. from Ft. Vancouver Way to Falk Rd.

E Fourth Plain Blvd. from Ft. Vancouver Way to Falk Rd. is a high volume corridor providing access to I-5 to the west and is surrounded by residential neighborhoods to the north and south. Rear-end crashes are the most frequent crash type, particularly for eastbound vehicles, potentially due to the high density of access points, side streets, higher speeds and traffic volumes. The majority of crashes occurred at intersections.



Constraints

- Inconsistency of lane widths, “sharrows,” pedestrian crossings, and presence of medians throughout corridor.
- Intersection at Norris Rd. has single signal head for major movement and five-section “doghouse” signal head for left turn movement, inconsistent with other intersections along segment.

Crash Types

Crash Type	Number of Crashes[1]
Rear-End	41
Angle	38
Opposite Direction – Left/Thru	21
Sideswipe	9
Pedestrian	9
Bicyclist	2

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	1
Injury	61
Property Damage Only	77

Contributing Factors

Contributing Factor	Number of Crashes[3]
Distraction/Inattention	46
Did Not Grant ROW to Vehicle	16
Alcohol and/or Drugs	14
Other	13
Disregard Traffic Signal	8

Potential Countermeasures

Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Reduce access points from 26-48 to 10-24 per mile	Moderate	Medium	0.69
Reduce 5-lane cross section to 3-lane cross section with bike lanes	High	Medium	NA[3]
Change flashing yellow arrow left turn phase to protected left turn phase for all approaches	Low	Short	0.58
Add through movement signal heads at intersection of Vancouver Wy. / Norris Rd.	Low	Short	0.72
Increase all-red clearance interval	Low	Short	0.80
Add retroreflective sheeting to signal backplates	Low	Short	0.85
Include leading pedestrian interval phase at all approaches	Low	Short	0.99

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000
[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years
[3] High Safety Manual safety performance functions for urban and suburban arterials show three-lane sections have lower crash frequency than five-lane sections.

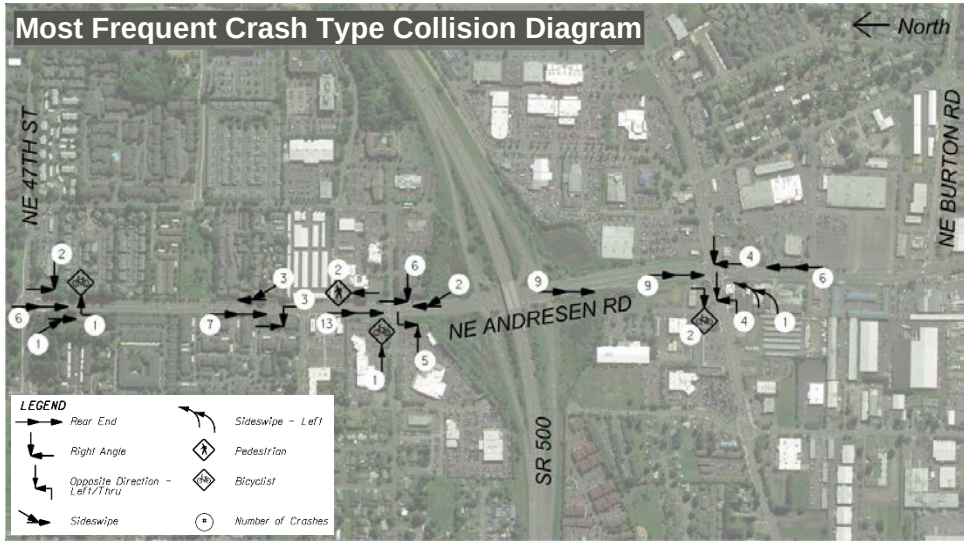
[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection.
[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.
[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

NE Andresen Rd from NE 47th St. to NE Burton Rd.

NE Andresen Rd. from NE 47th St. to NE Burton Rd. crosses under SR-500 and provides access to numerous car dealerships to the east and retail and commercial properties to the west. The majority of crashes along the segment occurred at the intersections. Rear-end crashes were the most frequent crash type, potentially due to high access density and sudden braking, as well as a high density of bus stops.

Constraints

- Approximately 15 access points (northbound and southbound) on 1500' section from NE Fourth Plain Blvd. to NE Burton Rd. – density of 46 access points per mile.
- No existing signal head backplates at SR-500 interchange – low visibility of traffic signals.



Crash Types

Crash Type	Number of Crashes[1]
Rear-End	50
Angle	12
Opposite Direction – Left/Thru	12
Sideswipe	7
Bicyclist	4
Pedestrian	2

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	0
Injury	52
Property Damage Only	44

Contributing Factors

Contributing Factor	Number of Crashes[3]
Distraction/Inattention	42
Other	13
Disregard Traffic Signal	10
Follow Too Closely	8
Did Not Grant ROW to Vehicle	5

Potential Countermeasures

Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Reduce access points per mile from 48 to 26-48	Moderate	Medium	0.71
Provide targeted public information and education for motorists concerning public transit operations	Low	Short	NA
Increase all-red clearance interval	Low	Short	0.80
Add signal backplates to signal heads at SR-500 underpass interchange	Low	Low	0.94
Add retroreflective sheeting to signal backplates	Low	Short	0.85
Include leading pedestrian interval phase at all approaches	Low	Short	0.99

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

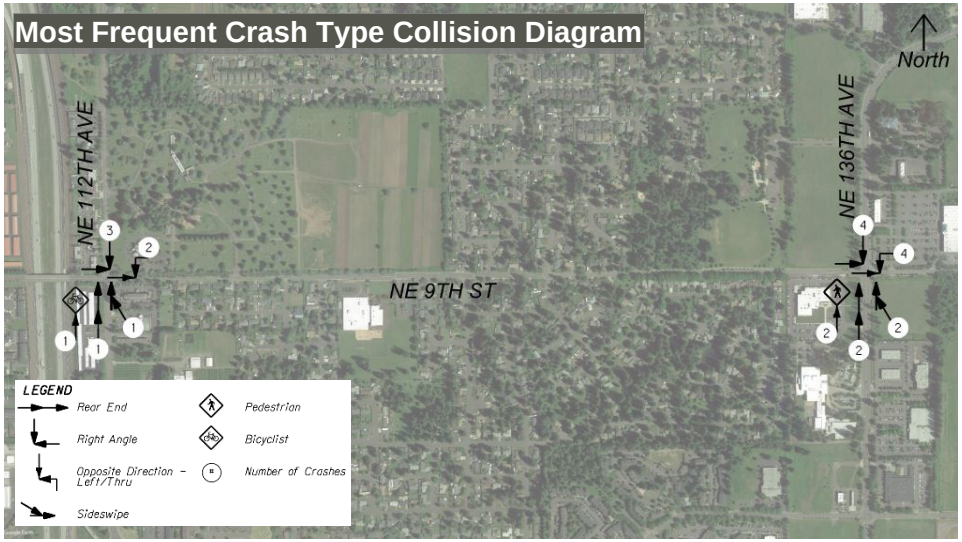
[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection.

[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.

[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

NE 9th St. from NE 112th Ave. to NE 136th Ave.

NE 9th St. from NE 112th Ave. to NE 136th Ave. is surrounded by residential neighborhoods and Fir Crest Elementary School to the south. Multiple marked mid-block crossings exist along the corridor. The majority of crashes occurred at the intersections of NE 112th Ave. / NE 9th St. and NE 136th Ave. / NE 9th St., with angle crashes being the most frequent. There were very few crashes along the corridor.



Constraints

- Noncompliance with traffic signals contributed to angle crashes.
- Existing midblock crossings do not have flashing beacons, potentially lowering the frequency at which vehicles stop for pedestrians.
- Limited sight distance due to trees and other vegetation throughout corridor and at intersections.

Crash Types

Crash Type	Number of Crashes[1]
Angle	7
Opposite Direction – Left/Thru	6
Rear-End	3
Sideswipe	3
Pedestrian	2
Bicyclist	1

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	0
Injury	16
Property Damage Only	14

Contributing Factors

Contributing Factor	Number of Crashes[3]
Disregard Traffic Signal	5
Other	4
Distraction/Inattention	5
Alcohol and/or Drugs	3
Improper Turn	3

Potential Countermeasures

Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Increase all-red clearance interval	Low	Short	0.80
Review sight distance triangles at intersections. Consider trimming vegetation to reduce occlusion issues	Low	Short	0.53
Add retroreflective sheeting to signal backplates	Low	Short	0.85
Add "Left Turn Only" signs adjacent to eastbound/westbound left turn signal heads at NE 136th Ave.	Low	Short	0.96
Install rectangular rapid flashing beacons at marked pedestrian crossings	Low	Short	0.93
Include leading pedestrian interval phase at all approaches	Low	Short	0.99

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection.

[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.

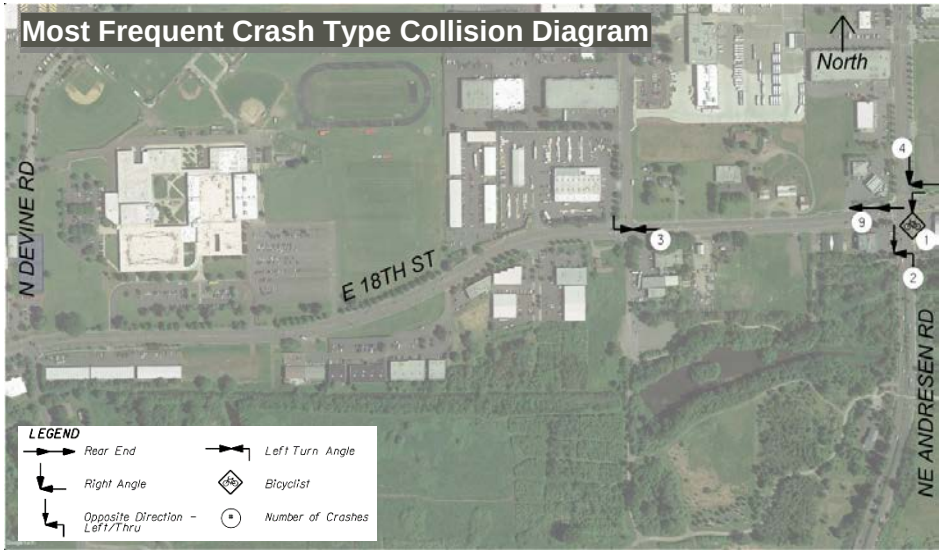
[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

E 18th St. from N Devine Rd. to NE Andresen Rd.

E 18th St. from N Devine Rd. to NE Andresen Rd. is surrounded by Fort Vancouver High School to the northwest and commercial properties to the northeast. The majority of crashes occurred at the intersection of NE Andresen Rd. / E 18th St. Rear-end crashes are the most frequent crash type, the majority of which are due to inattention. Along the corridor, outside of intersections, entering at angle crashes were the most frequent.

Constraints

- Noncompliance with traffic signals and not granting right-of-way to vehicles contribute to angle crashes.
- Closest pedestrian crossing at N Devine Rd., 800 feet away from Fort Vancouver High School.
- Westbound rear-end crashes may be related to bus stop on NW corner of intersection at NE Andresen Rd.



Crash Types

Crash Type	Number of Crashes[1]
Rear-End	9
Angle	7
Opposite Direction – Left/Thru	2
Bicyclist	1

Crash Severity

Crash Severity	Number of Crashes[2]
Fatal	0
Injury	10
Property Damage Only	12

Contributing Factors

Contributing Factor	Number of Crashes[3]
Distraction/Inattention	6
Other	3
Alcohol and/or Drugs	3
Disregard Traffic Signal	2
Did Not Grant ROW to Vehicle	2

Potential Countermeasures

Treatment	Cost[1]	Timeframe for Implementation[2]	Crash Modification Factor
Reduce 5-lane cross section to 3-lane cross section with bike lanes	Moderate	Medium	NA[3]
Increase all-red clearance interval	Low	Short	0.80
Add retroreflective sheeting to signal backplates	Low	Short	0.85
Upgrade existing mid-block pedestrian crossing with HAWK signal	Low	Short	NA[4]
Include leading pedestrian interval phase at all approaches	Low	Short	0.99

[1] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[2] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

[3] High Safety Manual safety performance functions for urban and suburban arterials show 3 lane sections have lower crash frequency than 5 lane sections.

[4] Existing site conditions are not consistent with CMF specified prior conditions.

[1] Only the most common crash types with pedestrian and bicyclist crashes are shown. The sum is slightly less than the total number of crashes at the intersection.

[2] The sum is approximately equal to the total number of crashes at the intersection. A small number of crashes may not have a severity listed in the crash data.

[3] The five most common contributing factors are listed. The sum is not equal to the total number of crashes at the intersection.

7 Safety Integration

The City plans to proactively integrate safety into the upcoming TSP update. Options to do this include:

- The TSP update could include a vision, goal and performance measures related to reducing transportation related fatalities and serious injuries in Vancouver. The performance measures could be evaluated annually, with progress reported to Council and the public.
- The TSP could include policies and programs to develop a "Safe System" approach to road safety. This approach to road safety recognizes that people will make errors when using the transportation system; however, the transportation system should be planned, modified and designed to lessen the severity of crashes when people make errors. A major element of the safe system approach to road safety is managing the force of impacts by reducing speed.[5]
- Projects and programs identified in the TSP could specifically consider implications to the crash focus areas identified in this TSSA report: pedestrians, bicyclists, young drivers and lane departure crashes.
    - Priority could be given to improvements which decrease crash frequency and severity for these focus areas.
    - Include safety countermeasures associated with each of the focus areas in new "non-safety" projects as appropriate.

In addition, it is recommended the City:

- Regularly evaluate major contributing factors to crashes on City streets. Report on findings and apply findings to ongoing planning and project development activities.
- Develop and support state Target Zero Plan policies and legislative actions, as well as local legislation and policy, and local legislation and policy to reduce speeding. Explore opportunities for automated enforcement programs beyond work zones, school zones, and signalized intersections.
- Support State Target Zero Plan policies and legislative actions and local policies to support young driver education programs and Safe Routes to Schools programs.
- Collaborate with City of Vancouver Police Department to develop a shared action plan for improving road safety related to impairment, speeding and distraction.

[5] More information about this approach can be found at https://roadsafety.piarc.org/en/road-safety-management/safe-system-approach

8 Summary and Conclusions

The TSSA for the City of Vancouver is a proactive effort to establish ongoing programs to address transportation safety needs. The project analysis identifies existing safety trends, high-priority crash locations, countermeasures or treatments to address safety, and identifies project improvement options at high-priority locations. In addition recommendations for future policy considerations within the upcoming TSP are provided.

This analysis assesses current (2010-2016) crash conditions on City-owned roadways only, identifying high-priority crash types and prioritized locations for potential improvements to reduce crash frequency and severity for all transportation modes. This analysis also provides a starting point for the City to proactively address priority collision locations and crash types in Vancouver.

Evaluating crash history between 2010 and 2016, crashes have resulted in:

- 41 fatalities from traffic crashes, or an average of approximately six fatalities per year.
    - The rolling average five-year trend for fatalities is increasing due to the relatively higher number of fatalities in 2013 and 2014.
- 285 serious injuries due to traffic crashes, or an average of approximately 41 serious injuries per year.
    - While the number of serious injuries is varying from year to year, the rolling average five-year trend for serious injuries is relatively flat.
- A total of 110 non-motorized fatalities and serious injuries combined.
    - The rolling average five-year trend for number of fatalities and serious injuries associated with pedestrian and bicycle travel is increasing slightly, due to the higher number of fatalities and injuries in 2014 and 2015.

Some high-level trends that emerged from the crash analysis are:

- The majority of crashes in Vancouver are no injury or possible injury.
- More men than women are involved in fatal and serious injury crashes.
- Young drivers (16-25) are most frequently road user group involved in crashes.
- Crashes that involved a pedestrian most frequently resulted in fatal or serious injury crashes.
- Distraction/Inattention led to the most crashes, considering all severities.
- Distraction, speeding, alcohol and unrestrained occupants led to the most fatal and serious injury crashes.
- The majority of all crashes and fatal or serious injury crashes are occurring at intersections.
- The most common crash types are rear-end, angle and fixed object.

Applying the State Target Zero Plan prioritization process, the City of Vancouver Priority Level One areas are: speeding, distraction, intersection-related, pedestrians and young

driver. Through discussions with the Technical Advisory Committee and City Staff, the focus areas for this plan were: pedestrians, lane departure, bicyclists, and young drivers.

The remainder of the project analysis used 2012-2016 crash data so the analysis focused on most recent trends, roadway conditions, land use and drivers. Considering roadway classifications, crash analysis shows undivided collector roads experienced a higher proportion of bicycle crashes on three-lane and five-lane collectors. Four-lane and six-lane collectors had a disproportionately higher percentage of pedestrian crashes. Total crashes are roughly proportionate for collectors with all lane configurations.

Undivided minor arterials have experienced a higher proportion of total, pedestrian, and bicycle crashes on roadways with four and five-lane configurations.

Undivided principal arterials experienced a higher proportion of pedestrian crashes on three-lane and six-lane configurations, and particularly on five-lane configurations. Four-lane and five-lane configurations have experienced a disproportionately high number of bicycle crashes. For total crashes, four-lane to six-lane configurations experienced higher proportion numbers of crashes.

Using this analysis, and with input from the Technical Advisory Committee and the City, the following locations are identified for more detailed investigation (and projects will be identified in the final stages of the project).

- Intersections
    - Mill Plain Boulevard/Chkalov Drive
    - Fourth Plain Boulevard/NE 121st Avenue
    - NE 28th Street/NE 138th Avenue
    - SE 164th Avenue/SE 15th Street
    - Stapleton Road/Fourth Plain Boulevard
    - Mill Plain Boulevard/164th Avenue
- Segments
    - Fourth Plain Boulevard – Ft. Vancouver Way to Falk Road
    - Andresen Road – Burton Road to 47th Street
    - NE 9th Street – NE 112th Avenue to NE 136th Avenue
    - E 18th Street – Devine Road to Andresen Road

To maintain momentum towards implementation, in addition to focusing on locations and near-term projects, this analysis also recommends integrating safety-related policy changes into the upcoming TSP update. To that end, the analysis recommends:

- The TSP update should include a vision, goals and set of performance measures related to reducing transportation related fatalities and serious injuries in Vancouver. The performance measures should be evaluated annually, with progress reported to City Council and the public.
- The TSP should develop policies and programs to develop a safe system approach to road safety. This approach to road safety recognizes that people will

make errors when using the transportation system; however, over time the transportation system should be planned, modified and designed to lessen the severity of crashes when people make errors, progressing towards eliminating fatalities and serious injuries associated with transportation. A major element of the safe system approach to road safety is managing the force of impacts by reducing speed.[6]

- Projects and programs identified in the TSP should specifically consider implications to the crash focus areas identified in this TSSA: pedestrians, bicyclists, young drivers and lane departure crashes.

[6] More information about this approach can be found at https://roadsafety.piarc.org/en/road-safety-management/safe-system-approach

Appendix A. Technical Advisory Committee

Members:

M. Hassan Abdalla, City of Vancouver

Camille Alexander, HDR

Jennifer Campos, City of Vancouver

Chris Christofferson, City of Vancouver

Bob Hart, RTC

Rebecca Kennedy, City of Vancouver

Theresa Kubala, City of Vancouver

Scott Langer, WSDOT

Ryan Lopossa, City of Vancouver

Melissa Martin, Clark County

Chris Malone, City of Vancouver

Jackie Phillips, HDR

Ryan Sullivan, Paste in Place

Beth Wemple, HDR

Michael Williams, WSDOT

Appendix B. Highest Ranked Crash Intersections

Real Intersection Names	Frequency	Fatal and Serious Injury	Pedestrian and Bicycle	Rank
	Crashes	Crashes	Crashes	All Intersections (combined index)
Mill Plain/Chkalov	80	5	7	1
Mill Plain/164th	52	3	7	2
Fourth Plain/Andresen	78	3	6	3
Fourth Plain/121st	41	3	2	4
28th/138th	41	1	3	5
Fourth Plain/Stapleton	27	2	3	5
Mill Plain/105th	40	1	3	7
Mill Plain/Andresen	28	1	4	8
Fourth Plain/Burton	24	2	3	8
18th/Andresen	30	1	3	10
Van Mall/72nd	19	4	3	11
51st/112th	51	3	1	12
9th/136th	18	3	3	13
15th/164th	32	1	2	14
Coxley/Gher	19	1	3	15
Mill Plain/Brandt	15	3	3	16
Fourth Plain/Grand	43	1	1	17
39th/112th	13	3	5	17
Vancouver Mall/Thurston	20	1	2	19
Tech Center/164th	28	0	5	20
Mill Plain/Reserve	17	1	3	20
Mill Plain/Hearthwood	31	0	4	22
Minnehaha/Johns	23	2	1	23
40th/Andresen	27	1	1	24
63rd/Andresen	20	2	1	25
McGillivray/164th	17	1	2	25
28th/112th	26	0	3	27
Padden Parkway/Andresen	50	8	0	28
Fourth Plain/Gher	28	0	2	28
Vancouver Mall/Andresen	16	1	2	30
18th/138th	27	0	2	31
39th/162nd	17	2	1	32
Fourth Plain/Kauffman	10	2	4	33
Burton/86th	22	0	2	34
Mill Plain/124th	15	3	1	35
Mill Plain/Lieser	18	0	3	36

Real Intersection Names	Frequency	Fatal and Serious Injury	Pedestrian and Bicycle	Rank
	Crashes	Crashes	Crashes	All Intersections (combined index)
Fourth Plain/Vancouver	13	1	2	37
58th/Andresen	20	0	2	38
49th/122nd	20	0	2	38
Mill Plain/136th	33	2	0	40
Parkway/Thurston	19	0	2	41
78th/Andresen	50	1	0	42
McLoughlin/Grand	12	1	2	43
McGillivray/136th	12	1	2	43
Mill Plain/97/98th	27	0	1	45
Washington St / 6th St	15	0	5	45
88th/Andresen	37	1	0	47
63rd/72nd	13	2	1	47
Vancouver/Johns	17	0	2	49
Fourth Plain/131st	25	2	0	50
Mill Plain/172nd	25	0	1	51
NE 87th Ave / Mill Plain Blvd	24	0	1	52
Fourth Plain/86th	15	1	1	52
Mill Plain/160th	13	0	5	54
18th/162nd	22	0	1	55
4th/136th	19	3	0	55
Mill Plain/Grand	16	0	2	57
25th/Andresen	16	0	2	57
MacArthur/Andresen	13	0	3	59
Mill Plain/Vancouver	19	0	1	60
Helens/Lieser	8	1	2	61
29th/164th	17	0	1	62
Andressen Rd / 42nd St	17	0	1	62
Fourth Plain/Thurston	16	2	0	64
Fourth Plain/65th	12	0	2	64
18th/112th	17	1	0	66
49th/112th	36	0	0	67
39th/Columbia	9	1	1	67
Van Mall/94th	9	1	1	67
49th/137th	29	0	0	70
Burton/109th	10	0	2	71
Mill Plain/126th	16	1	0	72

Real Intersection Names	Frequency	Fatal and Serious Injury	Pedestrian and Bicycle	Rank
	Crashes	Crashes	Crashes	All Intersections (combined index)
Mill Plain/Olympia	14	0	1	72
Mill Plain/Park Plaza	14	0	1	72
7th/Chkalov	13	0	1	75
9th/112th	13	0	1	75
Fourth Plain/F	13	0	1	75
McLoughlin/Vancouver	9	0	2	78
155th Ave / NE 18th St	7	1	1	79
34th/164th	23	0	0	80
39th/Main	22	0	0	81
1st/164th	22	0	0	81
Vancouver Plaza/Thurston	12	0	1	83
78th/72nd	21	0	0	84
Fourth Plain/Simpson	3	2	2	85
Fourth Plain/137th	20	0	0	86
Fourth Plain/Broadway	11	0	1	87
Fourth Plain/Franklin	11	0	1	87
Poplar/162nd	11	0	1	87
15th/Tech Center	11	0	1	87
Fourth Plain/Ward	19	0	0	91
Evergreen/Washington	7	0	2	91
Evergreen/Broadway	6	1	1	93
Mill Plain/155th	6	1	1	93
23rd/162nd	6	1	1	93
Fourth Plain/Main	18	0	0	96
Mill Plain/Devine	17	0	0	97
1st/172nd	17	0	0	97
Fourth Plain / 157th Ave	9	2	0	97
1st/192nd	9	0	1	100

Appendix C. Prioritized Segments

To prioritize the roadway segments, the criteria below were tabulated on each collector, minor arterial and principal arterial road in the City. The criteria are:

A. Pedestrian Crash Density – Score is equal to the number of locations with a high density of pedestrian crashes per segment. The pedestrian crash density heat map is shown in Figure 26.

B. Road/Lane Departure Crash Density – Score is equal to the number of locations with a high density of road/lane departure crashes per segment. The lane departure crash density heat map is also included in Figure 35.

C. Bicyclist Crash Density – Score is equal to the number of locations with a high density of bicyclist crashes per segment. The bicyclist crash density heat map is also included in Figure 41.

D. Young Driver Crash Density – Score is equal to the number of locations with a high density of young driver crashes per segment. The young driver crash density heat map is also included in Figure 50.

E. Four-Lane, Five-Lane or Six-Lane Undivided Road – Segments receive three points if the segment is a four-lane five-lane or six-lane undivided road (pedestrian, road/lane departure, bicyclist, and young driver risk factor). Segments receive zero points otherwise.

F. Posted Speed Limit – Segments are scored 0 points if speed is less than 30 miles per hour; 1 point if posted speed is 30 miles per hour; 2 points if posted speed is 35 miles per hour; and 3 points if posted speed is 40 miles per hour.

Each segment was scored according to the criteria, the total score was tallied, and the segments ranked according to the score. Subsequent field reviews accounted for any over-emphasis of intersection crashes.

Table C-1. Principal Arterial Road Segment Ranking Results

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
SE Mill Plain Blvd	NE Chkalov Dr to SE 123rd Ave	1	0	0	2	3	1	7
NE Andresen Rd	NE 25th St/Burton Rd to NE Fourth Plain Blvd	0	0	2	1	3	1	7
NE Andresen Rd	NE Fourth Plain Blvd to NE 40th St	0	0	1	1	3	2	7
SE Mill Plain Blvd	107th Ave to Chkalov Dr	1	0	0	1	3	1	6
NE 112th Ave	SE Mill Plain Blvd to NE 9th St	1	0	0	1	3	1	6
NE Fourth Plain Rd	NE Covington Rd to NE 121st Ave	0	0	0	1	3	2	6
NE Fourth Plain Blvd	NE 66th Ave to NE Andresen Rd	0	0	1	1	3	1	6
NE Fourth Plain Rd	NE 121st Ave to NE 127th Ave	0	0	0	1	3	2	6
NE 162nd Ave	SE 1st St to NE 18th St	0	0	0	0	3	2	5
NE Padden Pkwy	approx NE 64th Ave to Andresen Rd	0	0	0	0	3	2	5
NE Andresen Rd	NE 63rd St to NE 78th St	0	0	0	0	3	2	5
NE Padden Pkwy	NE Andresen Rd to I-205	0	0	0	0	3	2	5
NE Andresen Rd	NE Padden Pkway to NE 88th St	0	0	0	0	3	2	5
Highway 99	NE Ross St to NE 59th St (approx.)	0	0	0	0	3	2	5
NE St Johns Rd	NE Minnehana St to NE 68th St	0	0	0	0	3	2	5
SE Mill Plain Blvd	SE 160th to SE 164th	1	0	1	1	0	2	5
SE 1st St	SE 166th Ave to NE 172nd Ave	0	0	0	0	3	2	5
NE Fourth Plain Rd	NE 157th Ave to 162nd Ave	0	0	0	0	3	2	5
NE Fourth Plain Rd	NE 131st Ave to NE 137th Ave	0	0	0	0	3	2	5

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
NE Fourth Plain Rd	NE 127th Ave to NE 131st Ave	0	0	0	0	3	2	5
NE Andresen Rd	NE 40th St to NE 42nd St	0	0	0	0	3	2	5
NE Andresen Rd	42nd St to Vancouver Mall Dr	0	0	0	0	3	2	5
NE Andresen Rd	Vancouver Mall Drive to NE 58th St	0	0	0	0	3	2	5
NE Andresen Rd	NE 58th St to NE 63rd St	0	0	0	0	3	2	5
NE Andresen Rd	NE 78th St to NE Padden Pkwy	0	0	0	0	3	2	5
NE Andresen Rd	NE 88th St to I-205	0	0	0	0	3	2	5
NE 112th Ave	NE 49th St to SR 500	0	0	0	1	3	1	5
SE 164th Ave	Mill Plain Blvd to SE 1st St	1	0	0	1	0	2	4
SE Mill Plain Blvd	NE 87th Ave to NE 92nd Ave	0	0	0	0	3	1	4
NE Fourth Plain Blvd	Fort Vancouver Way to Grand Blvd	0	0	0	1	3	0	4
NE burton Rd	NE 109th Ave to NE 112th Ave	0	0	0	0	3	1	4
NE 112th Ave	NE 18th St to Burton Rd	0	0	0	0	3	1	4
NE Fourth Plain Blvd	Stapleton Rd to NE 65th Ave	0	0	0	0	3	1	4
St Johns Blvd	E 33rd St to NE Petticoat Lane	0	0	0	0	3	1	4
NE 112th Ave	NE 39th St to NE 49th St	0	0	0	0	3	1	4
W Fourth Plain Blvd	NE Vancouver Mall Dr to Gher Rd	0	0	0	0	3	1	4
W Fourth Plain Blvd	Fruit Valley Rd to Lincoln Ave	0	0	0	0	3	1	4
E Fourth Plain Blvd	Grand Blvd to Brandt Rd	0	0	0	1	3	0	4
NE Fourth Plain Blvd	Falk Rd to Stapleton Rd	0	0	0	0	3	1	4
SE Mill Plain Blvd	N Garrison Rd to Lieser Rd	0	0	0	0	3	1	4
SE Mill Plain Blvd	N Lieser Rd to NE 87th Ave	0	0	0	0	3	1	4

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
SE Mill Plain Blvd	SE 124th to SE 126th Ave	0	0	0	0	3	1	4
SE Mill Plain Blvd	SE 126th Ave to SE 131st Ave	0	0	0	0	3	1	4
SE Mill Plain Blvd	SE 164th Ave to E 172nd Ave	1	0	0	1	0	2	4
NE 112th AVE	NE 28th St to NE 39th St	0	0	0	0	3	1	4
NE Andresen Rd	NE 18th St to NE 25th St/Burton Rd	0	0	0	0	3	1	4
SE 164th Ave	SE Tech Center to Mill Plain Blvd	1	0	0	1	0	2	4
SE Mill Plain Blvd	I-5 to Fort Vancouver Way	0	0	0	0	3	1	4
NE 112th Ave	NE 9th St to NE 18th St	0	0	0	0	3	1	4
SE Mill Plain Blvd	SE 155th Ave to SE 160th Ave	0	0	1	0	0	2	3
Ne 192nd Ave	SE 1st St to NE 18th St	0	1	0	0	0	2	3
NE 18th St	NE 172nd Ave to 192nd Ave	0	1	0	0	0	2	3
Main St	E 33rd St to E 39th St	0	0	0	0	3	0	3
Main St	E 40th St to NE 45th St	0	0	0	0	3	0	3
Main St	E 39th St to E 40th St	0	0	0	0	3	0	3
E Fourth Plain Blvd	Brandt Rd to Falk Rd	0	0	0	0	3	0	3
E Fourth Plain Blvd	NE Andresen Rd to NE Burton Rd	0	0	1	1	0	1	3
SE 192nd Ave	SE Brandy Rd to SE 34th St	0	0	0	0	0	2	2
SE 34th St	SE 192nd Ave to SE 196th Ave	0	0	0	0	0	2	2
SE 164th	SR 14 to SE 34th ST	0	0	0	0	0	2	2
SE 34th St	SE 176th Ave to SE 192nd Ave	0	0	0	0	0	2	2
SE 164th Ave	SE 29th to SE McGillivray Blvd	0	0	0	0	0	2	2
SE 192nd Ave	SE 34th St to SE 20th St	0	0	0	0	0	2	2

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
E Mill Plain Blvd	SE 177th Ave to SE 182nd (approx.)	0	0	0	0	0	2	2
SE 192nd Ave	SE Mill Plain Blvd to SE 1st St	0	0	0	0	0	2	2
SE 1st St	SE 192nd Ave to SE Westridge Blvd	0	0	0	0	0	2	2
SE 1st St	SE 177th Ave to SE 192nd Ave	0	0	0	0	0	2	2
E Mill Plain Blvd	Reserve St to Grand Blvd	0	1	0	0	0	1	2
E Mill Plain Blvd	Fort Vancouver Way to Reserve St	0	1	0	0	0	1	2
NE 162nd Ave	NE 28th St to NE 39th St	0	0	0	0	0	2	2
NE 162nd Ave	NE Poplar St to Fourth Plain Blvd	0	0	0	0	0	2	2
W Fourth Plain Blvd	Lincoln Ave to Kauffman Ave	1	0	0	0	0	1	2
E Mill Plain Blvd	SE 136th Ave to SE Olympia Dr	0	0	0	0	0	2	2
E Mill Plain Blvd	SE Olympia Dr to SE Jeartwood Blvd	0	0	0	0	0	2	2
E Mill Plain Blvd	SE Heartwood Blvd to SE 155th Ave	0	0	0	0	0	2	2
E Mill Plain Blvd	SE 172nd Ave to SE 177th Ave	0	0	0	0	0	2	2
E Mill Plain Blvd	SE 184th Ave to SE 192nd Ave	0	0	0	0	0	2	2
SE 1st St	SE 164th Ave to SE 166th Ave	0	0	0	0	0	2	2
SE 1st St	SE 172nd Ave to SE 177th Ave	0	0	0	0	0	2	2
SE 1st St	SE Westridge Blvd to SE 202nd Ave	0	0	0	0	0	2	2
NE Fourth Plain Blvd	NE 147th Ave to NE 157th Ave	0	0	0	0	0	2	2
NE Fourth Plain Blvd	NE 137th Ave to NE 147th Ave	0	0	0	0	0	2	2
SE 192nd Ave	SE 15th St to SE Westridge Blvd	0	0	0	0	0	2	2

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
SE 192nd Ave	SE 20th St to SE 15th St	0	0	0	0	0	2	2
SE 34th St	SE 164th Ave to SE 176th Ave	0	0	0	0	0	2	2
SE 192nd Ave	SR 14 to Brady Rd	0	0	0	0	0	2	2
SE 164th Ave	SE 15th St to SE Tech Center	0	0	0	0	0	2	2
SE164th Ave	SE 20th to SE 15th St	0	0	0	0	0	2	2
SE 164th Ave	SE McGillvray Blvd to SE 20th St	0	0	0	0	0	2	2
SE 164th Ave	SE 34th St to SE 29th St	0	0	0	0	0	2	2
NE 162nd Ave	NE 39th to NE Poplar St	0	0	0	0	0	2	2
NE 162nd Ave	NE 18th St to NE 28th St	0	0	0	0	0	2	2
SE Mill Plain Blvd	NE 97th Ave to NE 104th Ave	0	0	0	0	0	1	1
Columbia House Blvd	SE Columbia Way to Grand Blvd	0	0	0	0	0	1	1
E Mill Plain Blvd	N Devine to Andresen Rd	0	0	0	0	0	1	1
NE 18th St	NE 138th Ave to NE 155th Ave	0	0	0	0	0	1	1
NE 18th St	NE 105th to NE 112th Ave	0	0	0	0	0	1	1
Main St	E McLoughlin Blvd to Fourth Plain Blvd	0	1	0	0	0	0	1
NE Fourth Plain Blvd	Kauffman Ave to Columbia St	1	0	0	0	0	0	1
NE Andresen Rd	E Mill Plain Blvd to E 18th St	0	0	0	0	0	1	1
NE Fourth Plain Blvd	NE Burton Rd to NE 86th Ave	0	0	0	0	0	1	1
Main St	NE 45th to I-5	0	0	0	0	0	1	1
St. James Rd	NE 54th St to Minnehaha St	0	0	0	0	0	1	1
St. James Rd	St. Johns Rd to NE 49th St	0	0	0	0	0	1	1
Washington St	W 6th St to W 8th St	1	0	0	0	0	0	1
Washington St	W 5th St to W 6th St	1	0	0	0	0	0	1

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
St. Johns Rd	St. James Rd to NE 49th St	0	0	0	0	0	1	1
St. James Rd	NE 49th St to NE 54th St	0	0	0	0	0	1	1
St. James Rd	NE 54th St to NE Minnehaha St	0	0	0	0	0	1	1
St. James Rd	NE 49th St to NE 54th St	0	0	0	0	0	1	1
Grand Blvd	E 20th St to Fourth Plain Blvd	0	0	0	1	0	0	1
N Grand Blvd	E 5th St to Evergreen Blvd	0	0	0	0	0	1	1
Grand Blvd	Columbia House Blvd to 5th St	0	0	0	0	0	1	1
E Mill Plain Blvd	Grand Blvd to Brandt Rd	0	0	0	0	0	1	1
E Mill Plain Blvd	Brandt Rd to Boise Ave	0	0	0	0	0	1	1
E Mill Plain Blvd	Boise Ave to N Devine Rd	0	0	0	0	0	1	1
E Mill Plain Blvd	N Andresen Rd to N Garrison Rd	0	0	0	0	0	1	1
SE Mill Plain Blvd	NE 92nd Ave to NE 97th Ave	0	0	0	0	0	1	1
SE Mill Plain Blvd	NE 104th Ave to 107th Ave	0	0	0	0	0	1	1
SE Mill Plain Blvd	SE 131st Ave to SE 136th Ave	0	0	0	0	0	1	1
NE 18th St	NE 112th Ave to NE Four Seasons Ln	0	0	0	0	0	1	1
NE 18th St	NE Four Seasons Lane to NE 138th Ave	0	0	0	0	0	1	1
NE 18th St	NE 155th to NE 162nd Ave	0	0	0	0	0	1	1
NE Fourth Plain Rd	NE Thurston Way to NE Vancouver Mall Dr	0	0	0	0	0	1	1
NE Fourth Plain Rd	NE 86th Ave to NE Thurston Way	0	0	0	0	0	1	1

Table C-2. Minor Arterial Road Segment Ranking Results

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
SE Chkalov Dr	SE 7th St to SE Mill Plain Blvd	1	0	0	1	3	1	6
SE 20th St	SE 167th Ave to SE McGillivray Blvd	0	0	0	0	3	2	5
SE 20th St	SE 164th Ave to SE 167th Ave	0	0	0	0	3	2	5
NE Minnehaha St	NE Saint James Rd to NE Saint Johns Rd	0	0	0	0	3	2	5
NE 63rd Street	NE Andresen Rd to NE 72nd Ave	0	0	0	0	3	2	5
NE Minnehaha St	NE CSB Rd (approx) to NE St James Rd	0	0	0	0	3	2	5
Evergreen Blvd	S Andresen Rd to Sleret Ave	0	0	0	0	3	1	4
Chkalov Dr	SE McGillivray Blvd to SE 7th St	0	0	0	0	3	1	4
Columbia House Blvd	Grand Blvd to Grove St	0	0	0	0	3	1	4
NE 136th AVE	SE Mill Plain Blvd to NE 4th St	0	0	0	0	3	1	4
NE 136th AVE	NE 4th St to NE 9th St	0	0	0	0	3	1	4
NE 136th Ave	NE 9th St to NE 18th St	0	0	0	0	3	1	4
NE 49th St	NE 112th Ave to NE 122nd Ave	0	0	0	0	3	1	4
NE Vancouver Mall Dr	NE Fourth Plain Blvd to NE 94th Ave	0	0	0	0	3	1	4
NE Gher Rd	SR 500 to NE Fourth Plain Blvd	0	0	0	0	3	1	4
SE Mcgillivray Blvd	SE Olympia Dr to SE Bella Vista Rd	0	0	0	0	3	0	3
SE 136th Ave	McGillivray Blvd to SE 7th St	0	0	0	0	3	0	3
SE 136th Ave	SE 7th St to SE Mill Plain Blvd	0	0	0	0	3	0	3
NE 94th Ave	Columbia St to Main St	0	0	0	0	3	0	3

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
NE Vancouver Mall Dr	NE Vancouver Mall Dr to NE 94th Ave	0	0	0	0	3	0	3
NE Thurston Way	NE Parkway Dr to NE Vancouver Mall Dr	0	0	0	0	3	0	3
SE Brady Rd	SE 192nd to Grand Ridge Dr (approx.)	0	0	0	0	0	2	2
SE 20th St	SE 176th to SE 192nd Ave	0	0	0	0	0	2	2
SE Ellsworth	SE Evergreen Hwy to SE 10th St	0	0	0	0	0	2	2
S Andresen Rd	E Evergreen Blvd to MacArthur Blvd	0	1	0	0	0	1	2
SE 172nd Ave	Mill Plain Blvd to SE 1st Ave	0	0	0	0	0	2	2
NE Burton Rd	NE 86th Ave to NE 98th Ave	0	1	0	0	0	1	2
NE 138th Ave	NE 18th St to NE 28th St	0	0	0	1	0	1	2
NE 28th St	NE 124th Ave to NE 138th Ave	0	0	0	1	0	1	2
NE Vancouver Mall Dr	NE 66th Ave to NE Andresen Rd	0	0	0	0	0	2	2
NE 137th Ave	NE 49th St to NE 59th St	0	0	0	0	0	2	2
NE 121st Ave	NE 49th St to Fourth Plain Blvd	0	0	0	1	0	1	2
NE 147th Ave	Fourth Plain to NE 147th Ave	0	0	0	0	0	2	2
NE 137th Ave	NE 59th St to Fourth Plain Blvd	0	0	0	0	0	2	2
NE 78th St	NE 72nd Ave to I-205	0	0	0	0	0	2	2
78th St	NE Andresen Rd to NE 72nd St	0	0	0	0	0	2	2
NW Lakeshore Ave	NW Bernie Dr to NW 78th St	0	0	0	0	0	2	2
SE 164th Ave	Evergreen Hwy to SR 14	0	0	0	0	0	1	1
SE 10th St	SE Ellsworth to Chkalov Dr	0	0	1	0	0	0	1

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
Evergreen Blvd	SE Blair St (appox.) to Andresen Rd	0	0	0	0	0	1	1
Shorewood Dr	Evergreen Blvd to Riverside Dr	0	0	0	0	0	1	1
Evergreen Blvd	Shorewood Dr to SE Blair St (approx.)	0	0	0	0	0	1	1
Macarthur Blvd	S Andresen Rd to S Lieser Rd	0	0	0	0	0	1	1
Evergreen Blvd	E 5th St to SE Shorewood Dr	0	0	0	0	0	1	1
NE 126th Ave	Mill Plain Blvd to NE 136th Ave	0	0	0	0	0	1	1
Evergreen Blvd	N Blandford Dr to E 5th St	0	0	0	0	0	1	1
Macarthur Blvd	N Devine Rd to N Andresen Rd	0	0	0	0	0	1	1
N Andresen Rd	MacArthur Blvd to Mill Plain Blvd	0	0	0	0	0	1	1
W 6th St	Washington St to Main St	1	0	0	0	0	0	1
W 6th St	Columbia St to Washington St	1	0	0	0	0	0	1
Macarthur Blvd	N Devine Rd to N Blandford Dr	0	0	0	0	0	1	1
Main St	E 8th St to E Evergreen Blvd	0	1	0	0	0	0	1
Main St	E Evergreen Blvd to E 13th St	0	1	0	0	0	0	1
Fort Vancouver Way	E Mill Plain Blvd to E McLoughlin Blvd	0	0	0	0	0	1	1
NE 18th St	NE Andresen Rd to NE Burton Rd	0	0	0	0	0	1	1
NE Burton Rd	NE 18th St to NE 86th Ave	0	0	0	0	0	1	1
NE 25th St	NE Andresen Rd to NE Burton Rd	0	0	0	0	0	1	1
NE Burton Rd	NE 98th Ave to I-205	0	0	0	0	0	1	1
NE 28th St	NE 138th Ave to NE 162nd Ave	0	0	0	0	0	1	1
Grand Blvd	E Fourth Plain Rd to E 33rd St	0	0	0	1	0	0	1

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
NE 138th Ave	NE 28th St to NE 39th St	0	0	0	0	0	1	1
NW Fruit Valley Rd	W 39th to NW 41st (approx.)	0	0	0	0	0	1	1
NE 137th Ave	NE 39th St to NE 49th St	0	0	0	0	0	1	1
NE 49th St	NE 122nd Ave to NE 137th Ave	0	0	0	0	0	1	1
NE Vancouver Mall Dr	NE 72nd Ave to NE 77th Ave	0	0	0	0	0	1	1
NE Vancouver Mall Dr	NE Andresen Rd to NE 72nd Ave	0	0	0	0	0	1	1
NE 94th Ave	SR 500 (approx.) to NE Vancouver Mall Dr	0	0	0	0	0	1	1
NE Vancouver Mall Dr	NE 77th Ave to NE Thurston Way	0	0	0	0	0	1	1
NW Fruit Valley Rd	W 39th St to NW 61st St	0	0	0	0	0	1	1
NW Fruit Valley Rd	NW 61st St to NW Bernie Dr	0	0	0	0	0	1	1
NE 28th St	NE 112th Ave to NE 119th Ave	0	0	0	0	0	1	1
NE 28th St	NE 119th Ave to NE 124th Ave	0	0	0	0	0	1	1

Table C-3. Collector Road Segment Ranking Results

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
NE 9th St	NE 112th Ave to NE 136the Ave	0	0	0	0	3	1	4
E 18th St	N Devine Rd to NE 65th Ave	0	0	0	0	3	1	4
E 18th St	NE 65th Ave to NE Andresen Rd	0	0	0	0	3	1	4
SE Olympia Dr	SE Mill Plain Blvd to SE 1st St	0	0	0	0	3	0	3
NE Parkway Dr	NE Thurston Way to NE Vancouver Mall Dr	0	0	0	0	3	0	3
SE Evergreen Hwy	SE 164th Ave to SE 192nd Ave	0	0	0	0	0	2	2
SE Cascade Park Dr	SE 162nd Ave to SE 164th Ave	0	0	0	0	0	2	2
SE Evergreen Hwy	SE Ellsworth Rd to SE 164th Ave	0	0	0	0	0	2	2
SE 15th St	SE 192nd Ave to SE 196th Ave	0	0	0	0	0	2	2
SE 176th Ave	SE 20th St to SE 15th St	0	0	0	0	0	2	2
SE 15th St	SE 176th to SE 192nd Ave	0	0	0	0	0	2	2
NE 72nd Ave	NE Vancouver Mall Dr to NE 58th St	0	0	0	0	0	2	2
NE 58th St	NE 72nd Ave to NE 81st Ave	0	0	0	0	0	2	2
NE 58th St	NE Andresen Rd to NE 72nd Ave	0	0	0	0	0	2	2
NE 72nd Ave	NE 58th St to NE 63rd St	0	0	0	0	0	2	2
NE 72nd Ave	NE 63rd to NE 78th St	0	0	0	0	0	2	2
NE 72nd Ave	NE 78th St to Padden Parkway (approx.)	0	0	0	0	0	2	2
NE 88th St	NE 55th Ave (approx.) to NE Andresen Rd	0	0	0	0	0	2	2
NE 63rd St	NE 72nd Ave to NE 81st Ave	0	0	0	0	0	2	2
SE Cascade Park	SE Briarwood Dr to SE 162nd Ave	0	0	0	0	0	1	1

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
SE Cascade Park	SE Bella Vista Ave to SE Briarwood Dr	0	0	0	0	0	1	1
SE 15th St	SE 167th Ave to SE 176th Ave	0	0	0	0	0	1	1
SE 15th St	SE 164th Ave to SE Tech Center Pl	0	0	0	0	0	1	1
SE 160th Ave	SE 15th St to SE Mill Plain blvd	0	0	1	0	0	0	1
SE Evergreen Hwy	SE Shorewood Dr to SW Ellsworth Rd	0	0	0	0	0	1	1
SE 1st St	SE 155th Ave to SE 164th Ave	0	0	1	0	0	0	1
Columbia House Blvd	Grove St to E 5th St	0	0	0	0	0	1	1
NE 9th St	NE 108th Ave to 112th Ave	0	0	0	0	0	1	1
E 18th St	Brandt Rd to NE Stapleton Rd	0	0	0	0	0	1	1
N Devine Rd	E Mill Plain Blvd to E 18th St	0	0	0	0	0	1	1
NE Four Seasons Ln	NE 18th St to NE 28th St	0	1	0	0	0	0	1
NE Stapleton Rd	E 18th St to NE Fourth Plain Blvd	0	0	0	0	0	1	1
Kauffman Ave	W McLoughlin Blvd to W Fourth Plain Blvd	1	0	0	0	0	0	1
Lincoln Ave	W McLoughlin Blvd to W Fourth Plain Blvd	0	0	0	0	0	1	1
Kauffman Ave	W Fourth Plain Blvd to W 33rd St	1	0	0	0	0	0	1
NE 66th Ave	NE Fourth Plain Blvd to NE 34th St	0	0	0	0	0	1	1
NE 39th Ave	NE 137th Ave to NE 162nd Ave	0	0	0	0	0	1	1
NE 39th Ave	NE 124th Ave to NE 137th Ave	0	0	0	0	0	1	1
NE 109th Ave	NE Burton Rd to NE 39th St	0	0	0	0	0	1	1
NE 122nd	NE 39th St to ME 49th St	0	0	0	0	0	1	1

Street Name	From/To	Pedestrian Crash Density Score	Road/Lane Departure Crash Density Score	Bicyclist Crash Density Score	Young Driver Crash Density Score	Four/Five Lane Undivided Road Score	Posted Speed Score	Total Score
NE 94th Ave	NE Vancouver Mall Dr to NE 54th St	0	0	0	0	0	1	1
NE 54th St	NE Saint James Rd to NE Saint Johns Rd	0	0	0	0	0	1	1
NE Ross St	NE HWY 99 to NE 15th Ave	0	0	0	0	0	1	1
NE 68th	NE 28th Ave to NE Saint Johns Rd	0	0	0	0	0	1	1
NE 39th	NE 109th to NE 112th Ave	0	0	0	0	0	1	1

Appendix D. Countermeasures

Appendix D is a list of countermeasures addressing each of the crash focus areas in the plan: pedestrians, bicyclists, young drivers, and lane departure crashes, as well as signalized and unsignalized intersections. The countermeasures reflect a consolidation of solutions from both the Washington State Target Zero plan and HDR's experience in plan development for other various communities. Table C-1 provides a brief summary of the major sources for the countermeasures.

The following information is provided for each countermeasure:

- **Implementation Area**: education, enforcement, engineering, policy, etc.
- **Effectiveness**: As shown in Table 1, different sources of countermeasures use different categories of effectiveness. Where possible, quantitative countermeasures are provided in the toolbox below.
- **Cost to Implement and Operate**: specified as low = <$100,000; moderate = $100,000 to $500,000; high = >$500,000
- **Timeframe for Implementation**: specified as short: less than one year; medium: one to two years, or long: more than two years.

Table D-1. Summary of Resources for Countermeasures

Source	Description	Types of Countermeasures	Rating System
National Cooperative Highway Research Program 500: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan	Series of 22 guidebooks providing countermeasures for a variety of common issues: speeding, signalized intersections, young drivers, alcohol-related crashes, distraction, pedestrians, and horizontal curves. These documents were produced between 2003 and 2009. http://www.trb.org/Main/Blurbs/152868.aspx	The guidebooks provide recommendations for preventative engineering, education, enforcement, and policies.	Countermeasures are rated as proven, tried, and experimental. CMF values are not provided.
Countermeasures That Work	The National Highway Traffic Safety Administration regularly updates and publishes this reference document of behavior related countermeasures. https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812202-countermeasuresthatwork8th.pdf	The guidebook provides countermeasures related to: impaired driving; seat-belts and child restraints, speeding, distracted and drowsy driving, motorcycle safety, young drivers, older drivers, pedestrians, and cyclists.	Countermeasures are rated from one to five stars. Five stars is the best rating. CMF values are not provided.
FHWA Crash Modification Factor Clearinghouse	Online, regularly updated database presenting crash modification factors for a wide variety of treatments. http://www.cmfclearinghouse.org/	Mostly engineering related treatments.	Countermeasures are rated from one to five stars. Five stars is the best rating. CMF values are provided. Multiple CMFs may be available for each treatment.
AASHTO Highway Safety Manual	Part D of the Highway Safety Manual provides a catalog of countermeasures and CMF values. The Highway Safety Manual provides one CMF per treatment. The first edition of the manual was published in 2010. An update to the manual is currently in development.	Exclusively engineering improvements.	Substantial research was conducted to develop one CMF per treatment. Confidence intervals are also provided for each CMF.
DDACTS — Data-Driven Approaches to Crime and Traffic Safety	Law enforcement model overlapping areas of crime and crashes to identify areas for targeted enforcement.	Enforcement.	Not applicable.
General Literature	Review and evaluation of highway safety research available through Transportation Research International Documentation (TRID) or generally online.	All areas.	Varies by research; CMFs may be available.

Table D-2. Pedestrian Crashes

Strategies for Reducing Pedestrian Related Crashes					
Objectives	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
A. Align vehicle speeds with the adjacent land use and context to reflect the needs of all users.	A1 – Revise design practices to emphasize context and target speed to reflect the needs of all road users.	Engineering/Policy	AASHTO: P	Moderate	Medium
	A2 – Use roadway design features to change operating speeds to support reduction in posted speeds.	Engineering	NCHRP 500: P	High	Long
	A3 – Continue to use enforcement and speed feedback signs to help motorists change speeding behavior.	Enforcement	NCHRP 500: R	Moderate	Short
B. Improve pedestrian safety awareness and behaviors	B1 – Implement pedestrian safety campaigns.	Education	CTW: R	Moderate	Short
	B2 – Conduct communication and outreach efforts, including using the proven Brief Intervention and Screening approach to contact crash-involved impaired pedestrians, as well as with law enforcement agencies, alcohol servers, social and health service providers to reduce impairment as a factor in pedestrian-involved crashes https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/811836.pdf.	Education	WSDOT Target Zero: U	Moderate	Short
	B3 – Increase public awareness of the significance of speed on pedestrian injury severity.	Education	CTW: R	Low	Short
C. Increase enforcement of laws	C1 – Implement pedestrian safety zones, targeting geographic locations and audiences with pedestrian crash concerns.	Education, Enforcement, Engineering	CTW: P	Low	Short

Strategies for Reducing Pedestrian Related Crashes					
Objectives	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
pertaining to pedestrians	C2 – Expand targeted crosswalk enforcement and education for both motorists and pedestrians.	Education, Enforcement	CTW: R	Low	Short
	C3 – Improve training on pedestrian laws for law enforcement officers at state and local levels.	Education, Enforcement	WSDOT Target Zero: R	Low	Short
D. Expand and improve pedestrian facilities	D1 – Improve safety at pedestrian crossings by investing in and installing refuge islands, and shortening crossing distances with curb extensions where these crosswalk enhancements are needed.	Engineering	NCHRP 500: P	Low	Short
	D2 – Continue to invest in and increase the use of rectangular rapid flashing beacons and pedestrian hybrid beacons where these crosswalk enhancements are needed.	Engineering	CMF: R (CMF=0.53-all severities, 3 Stars, ID=9024)	Moderate	Short
	D3 – Implement programs that improve the built environment. Solutions should focus on appropriate zoning and pedestrian connections to public transit.	Engineering and land use planning	LIT: R	Low	Medium
	D4 – Improve sight distance and visibility at pedestrian crossings by clearing vegetation and removing parking, fencing or other objects.	Engineering	NCHRP 500: R	Low	Short
	D5 – Provide leading pedestrian intervals at signalized intersections.	Engineering	CMF: R (CMF=0.41-all severities, 3 Stars, ID=1993)	Low	Short
	D6 – Provide pedestrian scale lighting at high volume pedestrian locations.	Engineering	NCHRP 500: R	Moderate	Short

Strategies for Reducing Pedestrian Related Crashes					
Objectives	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	D7 – Implement Complete Streets policies to provide for all modes of transportation.	Leadership/Policy, Engineering	NCSC: R	Moderate	Medium
	D8 – Invest in and construct roadway reconfigurations, roundabouts and other FHWA proven safety countermeasures specific to pedestrian safety.	Engineering	FHWA: P	Moderate	Medium
	D9 – Provide more frequent pedestrian crossing opportunities.	Engineering	WSDOT Target Zero: U	Moderate	Short
	D10 – Continue to invest in and construct separated pedestrian facilities (sidewalks and multi-use paths).	Engineering	NCHRP 500: P	Moderate	Medium
	D11 – Continue to install pedestrian countdown timers.	Engineering	CMF: P (CMF=0.3-all severities, 4 Stars, ID=5272)	Low	Short
E. Improve safety for children walking to school	E1 – Expand high visibility speed enforcement in school zones, including automated speed photo enforcement.	Education, Enforcement	CTW: P/R	Low	Short
	E2 – Implement middle school pedestrian and bicycle safety training curricula in schools.	Education	WSDOT Target Zero: U	Low	Medium
	E3 – Apply consistent signing and other pedestrian crossing features in school zones as appropriate (based on the number of lanes, speeds, age of pedestrians, etc.).	Engineering	FHWA: R	Low	Short
	E4 – Distribute and encourage the use of "School Walk and Bike Routes: A Guide for Planning and Improving Walk and Bike to	Education, Engineering	WSDOT: R	Low	Short

Strategies for Reducing Pedestrian Related Crashes					
Objectives	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	School Options for Students" to assist schools in creating school walk route maps.				
	E5 – Encourage school districts to implement appropriate elements of the Safe Routes to School program, including walking campaigns such as Walking School Buses.	Education, Engineering	WSDOT Target Zero: U	Low	Short
	E6 – Invest in and implement the Safe Routes to School Program to construct pedestrian and bicycle facilities near schools.	Engineering	WSDOT Target Zero: U	Moderate	Medium
F. Improve data and performance measures	F1 – Collect miles walked data (similar to collecting VMT); continue to track pedestrian counts through Washington's Pedestrian and Bicycle Documentation Project.	Leadership/Policy	DDACTS: R	Moderate	Medium

[1] U=Unknown, T=Tried, R=Recommended, P=Proven

[2] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[3] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

Source: Washington State Target Zero and other HDR work

Strategies for Reducing Bicycling Related Crashes					
Objectives	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
A. Improve bicyclist and driver safety awareness and behavior	A1 – Promote the use of bicycle lights among bicyclists.	Education	CTW: R	Low	Short
	A2 – Increase the number of bicyclists to achieve safety in numbers.	Leadership/Policy, Education	LIT: R	Low	Medium
	A3 – Increase use of "Safe Routes to School Pedestrian and Bicycle Safety Education" curriculum in schools.	Education	WSDOT Target Zero: U	Low	Medium
	A4 – Provide bicycle safety awareness as part of driver education programs.	Education	WSDOT Target Zero: U	Low	Medium
B. Enact policies/laws to improve bicycle safety	B1 – Encourage bicycle helmet use for children and adults.	Leadership/Policy, Education	WSDOT Target Zero: U	Low	Short
	B2 – Improve training on bicycle laws for law enforcement officers at state and local levels.	Education	WSDOT: R	Low	Short
C. Improve bicyclist facilities	C1 – Implement traffic calming techniques.	Engineering	NCHRP 500: P	Moderate	Medium
	C2 – Implement speed management using target speeds and context sensitive solutions.	Engineering	AASHTO: P	Moderate	Medium
C. Improve bicyclist facilities	C3 – Utilize road reconfigurations/diets to improve safety for all roadway users.	Engineering	CMF: P (CMF=0.75-all severities, 4 Stars, ID=5553)	Moderate	Medium
	C4 – Implement national best practices on the use of reflective markings and sign materials.	Engineering	FHWA: R	Low	Medium

Strategies for Reducing Bicycling Related Crashes					
Objectives	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	C5 – Continue to construct more bike lanes, separated bicycle lanes, and separated bicycle facilities, especially in urban areas.	Engineering	CMF: R (CMF=0.41-level A/B/C injuries, 3 Stars, ID=4102)	Moderate	Medium
	C6 – Create bicycle boulevards on low volume, low speed streets.	Engineering	CMF: R (CMF=0.37-all severities, 3 Stars, ID=3092)	Moderate	Medium
	C7 – Implement Complete Streets policies to provide for all modes of transportation.	Leadership/Policy, Engineering	NCSC: R	Moderate	Medium
	C8 – Install bicycle boxes at intersections.	Engineering	WSDOT Target Zero: U	Low	Short
D. Improve safety for children bicycling to school	D1 – Expand high visibility speed enforcement in school zones, including automated speed photo enforcement.	Education, Enforcement	CTW: R	Low	Short
	D2 – Distribute and encourage the use of “School Walk and Bike Routes: A Guide for Planning and Improving Walk and Bike to School Options for Students” to assist schools in creating school biking route maps.	Education, Engineering	WSDOT: R	Low	Short
	D3 – Encourage school districts to implement the "Safe Routes to School" program.	Education, Engineering	WSDOT Target Zero: U	Low	Short
E. Improve data and performance measures	E1 – Collect Bicycle Miles Traveled (similar to collecting Vehicle Miles Traveled); continue to track bicycle counts through Washington’s Pedestrian and Bicycle Documentation Project.	Leadership/Policy	DDACTS: R	Medium	Moderate

Table D-3. Bicyclist Crashes

[1] U=Unknown, T=Tried, R=Recommended, P=Proven

[2] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[3] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

Source: Washington State Target Zero and other HDR work

Table D-4. Segment and Lane Departure Crashes

Strategies for Reducing Segment and Lane Departure Related Crashes					
Objectives	**Strategies**	**Implementation Areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
A. Reduce opposite direction crashes	A1 - Add raised medians or other access control on multilane arterials.	Engineering	CMF: P (CMF=0.61-all severities, 4 Stars, ID=3034)	Moderate	Medium
	A2 - Install median barriers for narrow-width medians on multilane roads.	Engineering	NCHRP 500: R	Moderate	Medium
	A3 - Improve centerline delineation by adding raised pavement markers or profiled center lines.	Engineering	NCHRP 500: R	Low	Short
	A4 - Increase the widths of center medians where possible.	Engineering	WSDOT Target Zero: U	Moderate	Short
B. Reduce the number of vehicles leaving the roadway	B1 - Improve roadway signing and shoulder delineation, especially in curves.	Engineering	NCHRP 500: P	Low	Short
	B2 - Improve roadway geometry to reduce roadway speed.	Engineering	NCHRP 500: P	Moderate	Medium
	B3 - Install/increase illumination at locations with night time crashes.	Engineering	FHWA: R	Moderate	Short
	B4 - Install optical speed markings at curves.	Engineering	LIT: R	Low	Short
	B5 - Install delineation on fixed objects that cannot be removed from the clear zone.	Engineering	WSDOT Target Zero: U	Low	Short
	B6 - Install profiled center and edge lines.	Engineering	WSDOT Target Zero: U	Moderate	Short
	B7 – Continue installing wider edge lines, where appropriate.	Engineering	WSDOT Target Zero: U	Low	Short
C. Minimize the consequences of	C1 - Install/maintain roadside safety hardware such as guardrail, cable barrier,	Engineering	NCHRP 500: P	Moderate	Short

Strategies for Reducing Segment and Lane Departure Related Crashes					
Objectives	**Strategies**	**Implementation Areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
leaving the roadway	concrete barriers, crash cushions, and others.				
	C2 - Design safer slopes and ditches to prevent rollovers.	Engineering	NCHRP 500: P	Moderate	Short
	C3 - Remove/relocate objects, such as trees and utility poles, in high risk locations in the clear zone.	Engineering	NCHRP 500: P	Low	Short
	C4 - Implement safe urban street designs.	Engineering	NACTO: P	Moderate	Medium
	C5 - Implement roadway design to be consistent with the surrounding context.	Engineering	NCHRP 500: R	Moderate	Medium
	C6 - Remove or replace existing barrier that is damaged or non-functional.	Engineering	FHWA: R	Moderate	Short
D. Improve roadway to accommodate turning traffic	D1 – Restripe roadway to a three-lane (road diet).	Engineering	NCHRP: T	Low	Medium
	D2 – Install left turn lanes at high volume driveways or minor intersections.	Engineering	NCHRP 500: P	Moderate	Medium
	D3 – Install right turn lanes at high volume driveways and minor intersections.	Engineering	NCHRP 500: P	Moderate	Medium
E. Improve corridor access management	E1 – Reduce driveway density from 48 to 26-48 driveways per mile.	Engineering	CMF: P (CMF=0.71-all severities, 5 Stars, ID=177)	Moderate	Medium
	E2 – Reduce driveway density from 26-48 to 10-24 driveways per mile.	Engineering	CMF: P (CMF=0.69-all severities, 5 Stars, ID=178)	Moderate	Medium

Strategies for Reducing Segment and Lane Departure Related Crashes					
Objectives	**Strategies**	**Implementation Areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	E3 - Restrict or eliminate turns at unsignalized intersections with 3/4 intersection design or adding a median (RI/RO).	Engineering	NCHRP 500: T	Low	Short
	E4 - Restrict or eliminate turns at driveways using minor street diverters, signed turn restrictions, or adding a median.	Engineering	NCHRP 500: T	Low	Short
F. Set Appropriate Speed Limits	F1 – Set speed limits to account for roadway design, traffic, and environment, including traffic volume, modal mixed-use, and local and regional function.	Engineering/Policy	NCHRP 500: T	Low	Medium
	F2 – Continue installing variable speed message signs in school zones.	Engineering	NCHRP 500: T	Low	Medium
G. Communicate Appropriate Speeds through Use of Traffic Control Devices	G1 – Implement dynamic speed feedback signs, including dynamic message boards at appropriate locations (e.g., speed limit transitions, school zones).	Engineering	NCHRP 500: T	Low	Medium
	G2 – Implement timed and coordinated traffic signals to improve traffic flow, reduce red-light running, and manage speeds.	Engineering	NCHRP 500: T	Moderate	Medium
H. Ensure that Roadway Supports Appropriate and Safe Speeds	H1 – Design and modify roadway modifications to achieve safe speed transitions on approaches to lower-speed areas.	Engineering	NCHRP 500: T	High	Long
	H2 – Separate motorized traffic from non-motorized traffic using shared-use paths, sidewalks, bridges, etc.	Engineering	NCHRP 500: P	High	Long
	H3 – Use traffic-calming and other design factors to influence driver speed	Engineering	NCHRP 500: T	Low to Moderate	Medium

Strategies for Reducing Segment and Lane Departure Related Crashes					
Objectives	**Strategies**	**Implementation Areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	(e.g., lane narrowing, chicanes, speed tables).				
	H4 – Install rectangular rapid flashing beacon at existing midblock marked crosswalk.	Engineering	CMF: R (CMF=0.61 (Rear-end only)-all severities, 3 Stars, ID=9125)	Low	Short
I. Reduce speeding through enforcement activities	I1 – Increase use of speed enforcement, including targeted speed enforcement at locations where speeding-related crashes are more prevalent.	Enforcement	NCHRP 500: P	Moderate	Medium
	I2 – Increase penalties for repeat and excessive speeding offenders	Enforcement/Policy	NCHRP 500: T	Low	Short
	I3 – Implement automated speed enforcement (cameras).	Enforcement	NCHRP 500: T	Low	Short
J. Build partnerships to increase support for speed- reducing measures	J1 – Educate the public about the dangers of excessive speed and speed too fast for conditions, and its role in traffic fatalities.	Education	NCHRP 500: T	Low	Medium
	J2 – Educate about the effects of weather on appropriate speed.	Education	NCHRP 500: T	Low	Medium
	J3 – Implement neighborhood speed watch/traffic management programs.	Education/Enforcement	NCHRP 500: T	Moderate	Medium
K. Roadway Improvements	K1 - Implement Complete Streets Policy.	Engineering/Policy	WSDOT: P	Moderate	Medium

[1] U=Unknown, T=Tried, R=Recommended, P=Proven

[2] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[3] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

Source: Washington State Target Zero and other HDR work

Table D-5. Young Driver Crashes

Strategies for Reducing Young Driver Involved Crashes					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
A. Foster compliance with Washington State's IDL laws	A1 - Provide resources to Young Driver Action Council to improve awareness — especially for parents and teens — and compliance with the IDL law. Highlight high-risk situations where clear parental limit-setting will be most effective.	Leadership/Policy	CTW: R	Low	Short
	A2 - Promote increased enforcement of IDL by passing legislation requiring a sticker program to identify vehicles used by IDL license holders.	Leadership/Policy/Legislative	LIT: R	Low	Medium
	A3 - Provide local Target Zero Task Forces with information and materials about IDL for teens, parents, law enforcement, and driver education programs.	Education/Leadership/Policy	WTSC: R	Low	Short
B. Strengthen Intermediate Driver License restrictions	B1 - Adjust curfew to include 9 p.m. – 5 a.m., the hours when young driver serious injury and fatality crashes are highest.	Leadership/Policy/Legislative	CTW: P	Low	Medium
	B2 - Lengthen permit holding period beyond six months.	Leadership/Policy/Legislative	CTW: R	Low	Medium
	B3 - Extend passenger restriction to one full year after licensed.	Leadership/Policy/Legislative	NCHRP: R	Low	Medium
	B4 - Strengthen requirements for parents around the documentation and certification of the 50-hour behind-the-wheel time young drivers are to complete before licensure.	Leadership/Policy/Legislative	WSDOT: U	Low	Medium
	B5 - Strengthen restrictions so penalties in effect with the first ticket IDL driver gets.	Leadership/Policy	WSDOT: U	Low	Medium

Strategies for Reducing Young Driver Involved Crashes					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
C. Improve young driver education and intervention	C1 – Support state efforts to review and revise the Driver Guide, testing process, curriculum guidelines, and training standards to construct an overall driver training package focused more on hazard identification and less on skill training.	Leadership/Policy	CTW: R	Moderate	Medium
	C2 - Conduct a recidivism study to assess the impact of the DOL early warning letter program for 18- to 21-year-olds.	Leadership/Policy	WSDOT: U	Moderate	Medium
	C3 - Consider expanding driver restrictions and driver education requirements to new drivers of all ages.	Leadership/Policy	WSDOT: U	Moderate	Medium
	C4 - Update model traffic safety education curriculum to match NHTSA standards.	Leadership/Policy	WSDOT: U	Moderate	Medium
	C5 – Identify and implement school education and outreach programs to educate young drivers about dangers of distracted and impaired driving.	Leadership/Policy	WSDOT: U	Moderate	Medium
	C6 - Promote teen/parent safe driving contract.	Education	WSDOT: U	Low	Medium
D. Improve enforcement of high risk behaviors among young drivers	D1 – Support high visibility enforcement and media campaigns focused on young drivers.	Enforcement, Education	WSDOT: U	Moderate	Medium
E. Enforce compliance with the state's underage drinking law	E1 – Conduct well-publicized enforcement aimed at underage drinking parties.	Education, Enforcement	CTW: R	Low	Short
	E2 – Publicize and enforce underage drinking and driving laws.	Education	CTW: R	Low	Short

[1] U=Unknown, T=Tried, R=Recommended, P=Proven

[2] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000 per intersection

[3] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

Source: Washington State Target Zero and other HDR work

Table D-6. Signalized Intersection Crashes

Strategies for Reducing Crashes at Signalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
A. Reduce motor vehicle crashes at intersections	A1 - Install or convert intersections to roundabouts.	Engineering	CMF: P (CMF=0.74-all severities, 4 Stars, ID=4196)	High	Medium
	A2 - Optimize traffic signal clearance intervals.	Engineering	NCHRP 500: P	Low	Short
	A3 - Increase all red clearance interval.	Engineering	CMF: P (CMF=0.80-all severities, 4 Stars, ID=4211)	Low	Short
	A4 – Construct additional right turn lane.	Engineering	CMF: P (CMF=0.91-K/A/B/C, 5 Stars, ID=288)	Moderate	Medium
	A4 - Provide/improve left- and right-turn channelization.	Engineering	NCHRP 500: P	Moderate	Short
	A5 - Install illumination at locations with nighttime crashes.	Engineering	NCHRP 500: P	Moderate	Short
	A6 - Convert permitted/protected left turns to protected only left turns at signals.	Engineering	CMF: R (CMF=0.58-all severities, 3 Stars, ID=340)	Low	Short
	A7 - Remove unwarranted signals.	Engineering	NCHRP 500: P	Low	Short
	A8 - Employ signal coordination.	Engineering	NCHRP 500: P	Low	Short
	A9 - Provide dynamic intersection warning (real-time) to drivers on mainline or side streets of conflicting vehicle traffic at rural intersections.	Engineering	NCHRP 500: R	Moderate	Short

Strategies for Reducing Crashes at Signalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	A10 - Restrict or eliminate left or right turning maneuvers at intersections.	Engineering	NCHRP 500: R	Low	Short
	A11 - Prohibit right-turn-on-red maneuvers.	Engineering	CMF: P (CMF=$0.98^{nprohib4}$ -all severities, Highway Safety Manual, ID=5194)	Low	Short
	A12 - Implement restricted access to properties/driveways adjacent to intersections using closures or turn restrictions.	Engineering	NCHRP 500: R	Moderate	Medium
	A13 - Provide skid resistance in intersections and on approaches.	Engineering	NCHRP 500: R	Moderate	Short
	A14 - Improve visibility of intersections by providing enhanced signing and delineation.	Engineering	NCHRP 500: R	Low	Short
	A15 - Improve wayfinding and lane markings to reduce confusion with access points	Engineering	CMF: P (CMF=0.99-K/A/B/C, 4 Stars, ID=2450)	Low	Short
	A16 - Revise design practices to emphasize context and target speed to reflect the needs of all road users.	Engineering/Policy	AASHTO: P	Moderate	Medium
B. Improve driver compliance at intersections	B1 - Explore implementing automated enforcement (photo red-light cameras) of red-light running at locations with angle crashes.	Enforcement, Engineering, Leadership/Policy	NCHRP 500: P	Low	Short

Strategies for Reducing Crashes at Signalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	B2 - Provide targeted speed enforcement.	Enforcement	NCHRP 500: P	Low	Short
	B3 - Consider providing targeted stop sign/signal enforcement at intersections and intersection approaches.	Enforcement	NCHRP 500: R	Low	Medium
C. Improve driver awareness of intersections	C1 - Redesign intersection approaches to improve sight distances.	Engineering	CMF: P (CMF=0.41-all severities, 4 Stars, ID=8498)	Moderate	Medium
	C2 - Add back plates with retro-reflective borders to signals.	Engineering	CMF: P (CMF=0.85-all severities, 4 Stars, ID=1410)	Low	Short
	C3 - Provide advance warning of intersections using dynamic signal warning flashers or actuated advance warning dilemma zone protection systems at high speed signalized intersections.	Engineering	CMF: P (CMF=0.82-all severities, 4 Stars, ID=4198)	Moderate	Short
	C4 - Improve visibility of intersections on approaches.	Engineering	NCHRP 500: R	Low	Short
	C5 - Improve visibility of signals and signs at intersections.	Engineering	NCHRP 500: R	Low	Short
	C6 – Add primary movement signal head.	Engineering	CMF: R (CMF=0.72-all severities, 3 Stars, ID=1414)	Low	Short
	C7 – Change 5-section “doghouse” signal head to flashing yellow arrow signal head.	Engineering	CMF: P (CMF=0.93-all severities, 4 Stars, ID=7694)	Low	Short

Strategies for Reducing Crashes at Signalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	C8 – Add “Left Turn Only” signs adjacent to left turn signal heads.	Engineering	CMF: P (CMF=0.96-all severities, 4 Stars, ID=8922)	Low	Short
	C9 - Install transverse rumble strips on intersection approaches.	Engineering	NCHRP 500: R	Low	Short
	C10 - Provide targeted public information and education about safety problems found at specific intersections.	Education	NCHRP 500: R	Low	Short
D. Reduce vehicle crashes involving pedestrians and bicyclists at intersections	D1 - Improve safety at pedestrian crossings by installing refuge islands, scale lighting, and shortening crossing distances.	Engineering	CMF: R (CMF=0.74-all severities, 4 Stars, ID=8800)	Low	Short
	D2 - Expand targeted crosswalk enforcement and education for both vehicles and pedestrians.	Enforcement, Education	CTW: R	Low	Short
	D3 - Improve sight distances and/or visibility between motor vehicles and pedestrians at high risk and high volume pedestrian crossings. Move the stop bar farther back from the intersection, clear vegetation, extend crossing times, and implement pedestrian lead intervals.	Engineering	WSDOT Target Zero: U	Low	Short
	D4 - Upgrade pavement markings using high visibility crosswalks and bicycle lanes.	Engineering	WSDOT Target Zero: U	Low	Short
	D5 - Install bicycle lanes and bicycle boxes.	Engineering	WSDOT Target Zero: U	Low	Short

Strategies for Reducing Crashes at Signalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	D6 - Implement Complete Streets policies to provide for all modes of transportation.	Leadership/Policy, Engineering	NCSC: R	Moderate	Medium
E. Reduce Frequency and Severity of Intersection Conflicts through Traffic Control and Operational Improvements	E1 – Optimize signal operation (phasing/timing, etc.).	Engineering	NCHRP 500: P/T	Low	Short
	E2 – Employ emergency vehicle preemption.	Engineering	NCHRP 500: P	Moderate	Medium
F. Reduce Frequency and Severity of Intersection Conflicts through Geometric Design Improvements	F1 - Provide offset turn lanes at intersections.	Engineering	NCHRP 500: P/T	Moderate to High	Medium
G. Improve Sight Distance	G1 – Clear sight triangle on approaches and in medians.	Engineering	CMF: R (CMF=0.53-A/B/C, 3 Stars, ID=307)	Low	Short
	G2 – Restripe intersection approaches to reduce or eliminate intersection skew.	Engineering	CMF: P (CMF=0.56-All severities, 4 Stars, ID=8428)	Moderate	Medium

Strategies for Reducing Crashes at Signalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
H. Improve Driver Awareness of Intersections as Viewed from the Intersection Approach	H1 – Install larger regulatory and warning signs at intersections, including the use of dynamic warning signs at appropriate intersections.	Engineering	NCHRP 500: T	Low	Short
	H2 – Call attention to the intersection by installing splitter islands on intersection approaches.	Engineering	NCHRP 500: T	Low to Moderate	Medium
I. Improve Driver Awareness of Intersections and Signal Control	I1 – Improve visibility of signals (use retro-reflective background shields, overhead indications, 12-inch lenses, LED's) and signs (mast arm mounted street names) at intersections.	Engineering	NCHRP 500: T	Low	Short
	I2 – Provide advance warning of intersections using dynamic signal warning flashers or actuated advance warning dilemma zone protection systems at high speed signalized intersections.	Engineering	NCHRP 500: T	Moderate	Medium
J. Improve Driver Compliance with Traffic Control Devices	J1 – Supplement conventional enforcement of red-light running with confirmation lights; include a public information campaign to increase awareness and compliance.	Engineering	NCHRP 500: T	Low	Short

Strategies for Reducing Crashes at Signalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
K. Improve Safety through other Infrastructure Treatments	K1 – Restrict or eliminate parking on intersection approaches	Engineering/Policy	NCHRP 500: P	Low	Short
L. Appropriate Intersection Traffic Control	L1 – Construct roundabouts at appropriate locations.	Engineering	NCHRP 500: T	High	Long
	L2 - Convert to all-way stop control.	Engineering	NCHRP 500: P	Low	Short

[1] U=Unknown, T=Tried, R=Recommended, P=Proven

[2] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[3] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

Source: Washington State Target Zero and other HDR work

[4] A crash modification factor is given by an equation developed in the Highway Safety Manual, 1st Edition. The equation is CMF=0.98nprohib where nprohib=number of approaches for which the right turn on red (RTOR) is prohibited. For example, assuming the north and south approaches prohibit RTOR, the CMF would be 0.982=0.96. (Countermeasure #A11)

Table D-7. Unsignalized Intersection Crashes

Strategies for Reducing Crashes at Unsignalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
A. Reduce motor vehicle crashes at intersections	A1 - Install or convert intersections to roundabouts.	Engineering	CMF: P (CMF=0.28-all severities, 4 Stars, ID=206)	High	Medium
	A2 - Provide/improve left- and right-turn channelization.	Engineering	NCHRP 500: P	Moderate	Short
	A3 - Install illumination at locations with nighttime crashes.	Engineering	NCHRP 500: P	Moderate	Short
	A4 - Restrict or eliminate turning maneuvers at intersections.	Engineering	NCHRP 500: R	Low	Short
	A5 - Implement restricted access to properties/driveways adjacent to intersections using closures or turn restrictions.	Engineering	NCHRP 500: R	Moderate	Medium
	A6 - Provide skid resistance in intersections and on approaches.	Engineering	NCHRP 500: R	Moderate	Short
	A7 – Revise design practices to emphasize context and target speed to reflect the needs of all road users.	Engineering/Policy	AASHTO: P	Moderate	Medium
	A8 - Improve visibility of intersections by providing enhanced signing and delineation.	Engineering	NCHRP 500: R	Low	Short
B. Improve driver compliance at intersections	B1 - Provide targeted speed enforcement.	Enforcement	NCHRP 500: P	Low	Short
	B2 - Provide targeted stop sign/signal enforcement at intersections and intersection approaches.	Enforcement	NCHRP 500: R	Low	Short

Strategies for Reducing Crashes at Unsignalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
C. Improve driver awareness of intersections	C1 - Redesign intersection approaches to improve sight distances.	Engineering	CMF: P (CMF=0.41-all severities, 4 Stars, ID=8498)	Moderate	Medium
	C2 - Improve visibility of intersections on approaches.	Engineering	NCHRP 500: R	Low	Short
	C3 - Improve visibility of signals and signs at intersections.	Engineering	NCHRP 500: R	Low	Short
	C4 - Install transverse rumble strips on intersection approaches.	Engineering	NCHRP 500: R	Low	Short
	C5 - Provide targeted public information and education about safety problems found at specific intersections.	Education	NCHRP 500: R	Low	Short
D. Reduce vehicle crashes involving pedestrians and bicyclists at intersections	D1 - Improve safety at pedestrian crossings by installing refuge islands, scale lighting, and shortening crossing distances.	Engineering	CMF: P (CMF=0.74-all severities, 4 Stars, ID=8800)	Low	Short
	D2 - Expand targeted crosswalk enforcement and education for both vehicles and pedestrians.	Enforcement, Education	CTW: R	Low	Short
D. Reduce vehicle crashes involving pedestrians and bicyclists at intersections	D3 - Improve sight distances and/or visibility between motor vehicles and pedestrians at high risk and high volume pedestrian crossings. Move the stop bar farther back from the intersection, clear vegetation, extend crossing times, and implement pedestrian lead intervals.	Engineering	WSDOT: U	Low	Short

Strategies for Reducing Crashes at Unsignalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
	D4 - Upgrade pavement markings using high visibility crosswalks and bicycle lanes.	Engineering	WSDOT: U	Low	Short
	D5 - Install bicycle lanes and bicycle boxes.	Engineering	WSDOT: U	Low	Short
	D6 - Implement Complete Streets to provide for all modes of transportation.	Leadership/Policy, Engineering	NCSC: R	Moderate	Medium
E. Reduce the Frequency and Severity of Intersection Conflicts through Geometric Design Improvements	E1 – Provide offset turn lanes at intersections.	Engineering	NCHRP 500: P/T	Moderate	Medium
F. Improve Sight Distance	F1 – Clear sight triangle on approaches and in medians.	Engineering	CMF: R (CMF=0.53-A/B/C, 3 Stars, ID=307)	Low	Short
	F2 – Restripe intersection approaches to reduce or eliminate intersection skew.	Engineering	CMF: P (CMF=0.56-All severities, 4 Stars, ID=8428)	Moderate	Medium
G. Improve Driver Awareness of Intersections as Viewed from the Intersection Approach	G1 – Install larger regulatory and warning signs at intersections, including the use of dynamic warning signs at appropriate intersections.	Engineering	NCHRP 500: T	Low	Short
	G2– Call attention to the intersection by installing splitter islands on intersection approaches.	Engineering	NCHRP 500: T	Low	Medium
H. Appropriate Intersection Traffic Control to Minimize Crash Frequency and Severity	H1 – Construct roundabouts at appropriate locations.	Engineering	NCHRP 500: T	High	Long

Strategies for Reducing Crashes at Unsignalized Intersections					
Objective	**Strategies**	**Implementation areas**	**Effectiveness1**	**Cost to Implement and Operate2**	**Timeframe for Implementation3**
I. Improve Safety through other Infrastructure Treatments	I1 – Restrict or eliminate parking on intersection approaches.	Engineering	NCHRP 500: P	Low	Short

[1] U=Unknown, T=Tried, R=Recommended, P=Proven

[2] Cost: Low = <$100,000; Moderate = $100,000 to $500,000; High = >$500,000

[3] Implementation: Short = <1 year; Medium = 1 to 2 years; Long = >2 years

Source: Washington State Target Zero and other HDR work