CITY OF BEND

BEND AREA TRANSPORTATION SAFETY ACTION PLAN

DRAFT

June 24, 2019

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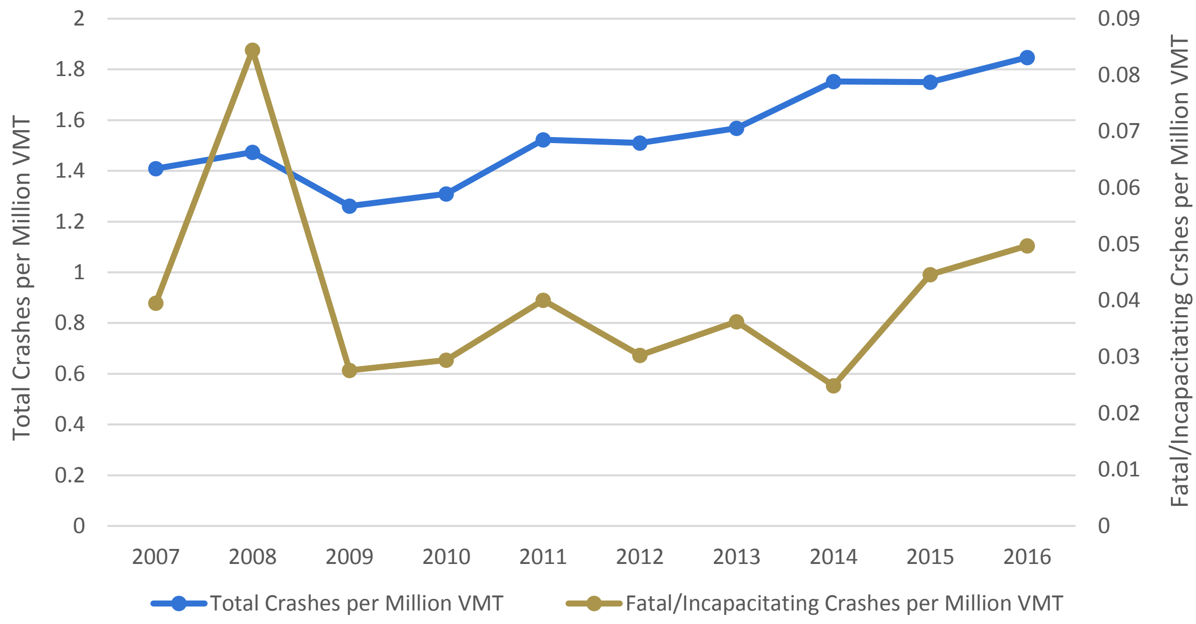
SECTION 1

INTRODUCTION

1. INTRODUCTION

1.1 INTRODUCTION

Between 2012 and 2016, there were 92 reported crashes within the Bend Urban Growth Boundary (UGB) that resulted in fatal or incapacitating (potentially life-changing) injuries. A review of reported crashes per year stretching back to 2007 shows that the crash rate, which normalizes the number of crashes by vehicle miles traveled, has been on an increasing trend over the past seven years, as shown in Figure 1. These statistics emphasize the need for a comprehensive, multidisciplinary action plan to reduce transportation related injuries for area residents and visitors in the Bend Area. This Bend Area Transportation Safety Action Plan (TSAP) is based on reported crash data from 2012 to 2016.



*VMT estimates are provided for the MPO Area. Number of reported crashes includes crashes within the Bend UGB.

Figure 1. Bend Area Crash Rates per Year

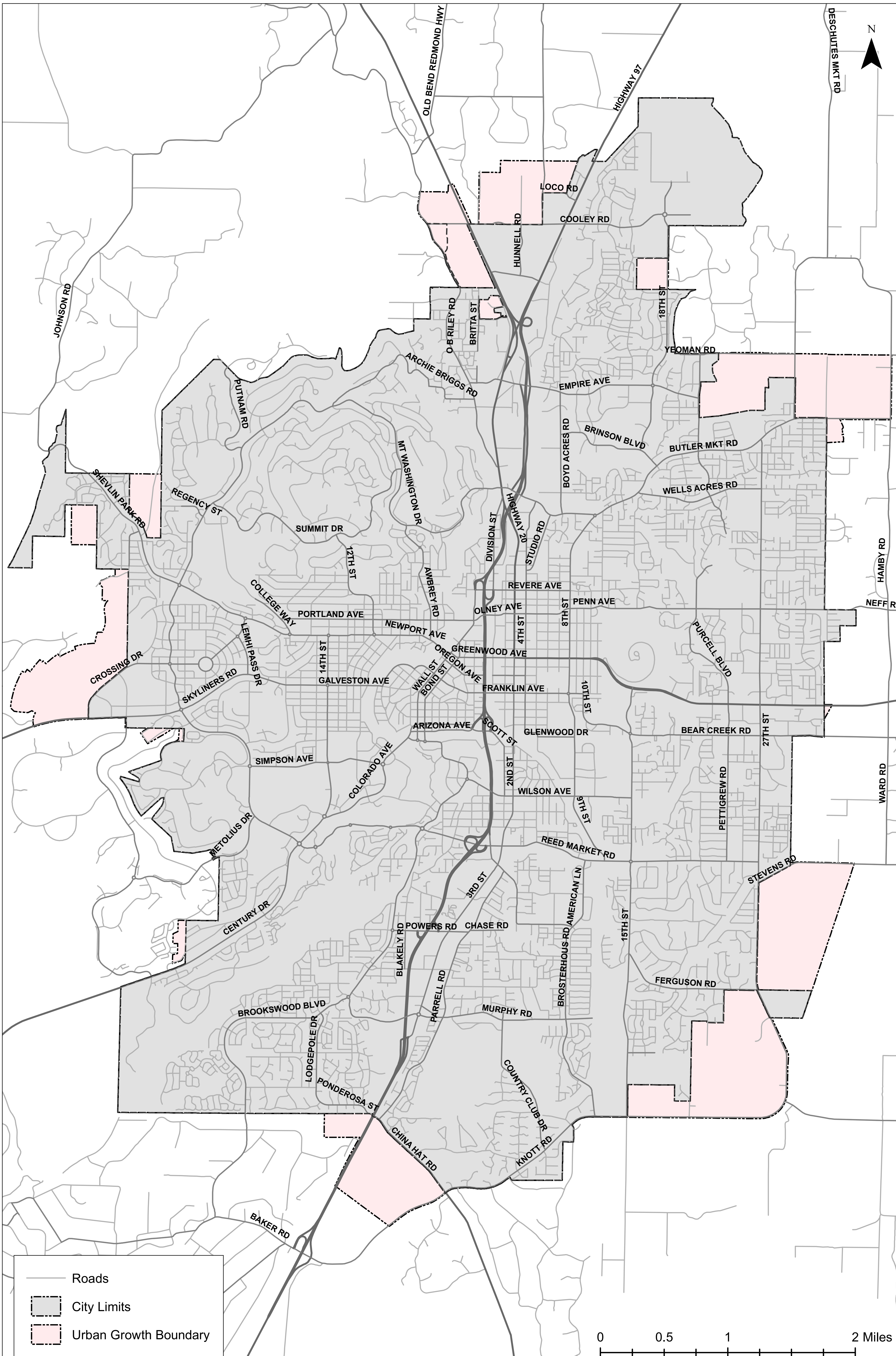
The state of Oregon has developed a statewide TSAP and set a goal of zero fatal and incapacitating injuries on Oregon's transportation system by 2035. The Bend Area TSAP is Bend's specific action plan developed to help the City protect people traveling within Bend from injuries. This also contributes to ODOT's work to protect travelers statewide. This Bend Area TSAP reevaluates crash trends and issues based on current data and identifies a broad range of treatments including projects, policies, and programs, to address identified issues.

1.1.1 Study Area

The Bend Area TSAP focuses on the area within the Bend Urban Growth Boundary (UGB), as shown by the study area in Figure 2. Deschutes County concurrently developed its own TSAP for the area outside the Bend UGB, which included the area within the Bend Metropolitan Planning Organization (MPO). The simultaneous development of the County and City/MPO TSAPs allowed for coordination between the two jurisdictions and an understanding of City-specific safety performance. The Framework Memorandum, provided as Appendix 1, summarizes how the two Plans were coordinated.

Although this Bend Area TSAP focuses on the area within the Bend UGB, additional information is provided to summarize recommendations and performance measures relevant to the MPO area:

- The Performance Measures chapter, Section 7 of the TSAP, provides the performance measures for the Bend UGB area and the MPO area to assist with reporting requirements.
- Appendix 2 provides a summary of the recommendations from the Deschutes County TSAP that are located within the MPO area.



Study Area
City of Bend
Boundaries

Figure
2

H:\23\23156 - Bend Area TSAP\gis\location prioritization maps\Bend Study Area.mxd - ahunter - 12:28 PM 7/2/2019

KITTELSON & ASSOCIATES

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl

1.2 RECENT PROGRESS IN TRANSPORTATION SAFETY

The City of Bend (City) has successfully implemented quantitative safety evaluations to identify priorities for transportation safety countermeasures. In 2012, the City completed a multimodal traffic safety program that identified several focus areas for the City including alcohol-involved crashes, speed-involved crashes, roadway departure crashes, fatal and injury crashes, and pedestrian and bicycle crashes. The City has invested in projects to address these issues over the past six years. As shown in Figure 1, however, the severe injury and fatal crashes have continued to increase at a rate that outpaces growth in population and mileage. This TSAP effort, therefore, includes reevaluating crash trends and issues based on current data and identifies a broad range of treatments that can be applied comprehensively in Bend including projects, policies, and programs, to address identified issues causing injuries and fatalities.

A summary of past plans and projects complete is provided in Appendix 3.

1.3 BEND TSP TRANSPORTATION SAFETY GOALS

During the development of the TSAP, Bend was concurrently updating its Transportation System Plan (TSP). Policies, projects, programs, and actions identified in the TSAP will be incorporated into the TSP as a reference document.

The Bend TSP includes Goals, Policies, and Actions that set the overall direction for how we will implement and manage our transportation system into the future. The Goals, Policies, and Action Items will be part of the Bend TSP. The following are the Draft Transportation Safety Goals, Policies, and Actions as of July 2019. These may be updated prior to adoption of the Bend TSP. This section of the TSAP will be updated to reflect the adopted Transportation Safety Goals.

Many of the Goals, Policies, and Actions have direct safety implications. This section only summarizes those that were specifically identified by the Transportation Safety Policy Subcommittee of the CTAC:

Introduction: The City of Bend aspires to have zero serious injuries or fatal crashes on its transportation system. The City recognizes that we must design and manage our transportation system with this goal in mind.

1. The City will balance safety, connectivity, and travel time reliability for all modes of transportation in design and construction of transportation projects, and in transportation program implementation.
   Actions:
   - Adopt and implement the 2019 Transportation Safety Action Plan, including mapping identified crash emphasis areas.
   - Amend the Bend Development Code to ensure that safety mitigation is included as part of development.
2. The City aspires to have no transportation-related fatalities or serious injuries by reducing the number and severity of crashes through design, operations, maintenance, and enforcement.
   Actions:
   - By 2021, the City will develop and adopt an action plan to move the City towards zero traffic deaths or serious injuries (e.g. Vision Zero). The plan will set a clear goal of eliminating traffic deaths and serious injuries among all road users within an explicit timeframe (i.e. 10 years) and actively engage key City departments.
3. The City will consider the needs and safety for all users in transportation projects, programs, and funding decisions, to improve safety for vulnerable users. Vulnerable users are transportation system users most at risk in traffic, such as pedestrians, cyclists, and public transportation users – children, older people, and disabled people may be in this category.

Actions:

- The City will plan for, design, construct, and/or reconstruct streets to achieve consistency between motorists' speeds and target speed limits, and prioritize speeding and reckless driving enforcement programs on problematic routes.
- Identify, prioritize, and/or allocate funding for projects and programs to improve safety for vulnerable users.

4. The City's policy is to achieve consistency between motorists' speeds and target speed limits.
   Actions:
   - Create a citywide speed management program to address safety issues related to speed.
   - Review street design in coordination with emergency services; amend Standards and Specifications accordingly.
5. The City will provide transparent, easy to understand, and effective communication programs to encourage safe travel on the transportation system.
   Action:
   - Develop a comprehensive public dashboard of data to capture the user experience of the City's Transportation System in a system that integrates data from existing sources, not limited to crash data, with data from new and emerging street monitoring technology and public input.

1.4 SUMMARY OF CITY COUNCIL GOALS

The City Council for Bend sets goals that reflect community priorities. Several of the Transportation & Infrastructure Strategies and action items are directly aimed at improving transportation safety. The City's 2019 – 2021 Transportation & Infrastructure Strategies are provided below, with those directly related to the TSAP actions in **bold**.

- Complete the TSP by end of May 2020.
  - Complete an updated Transportation System Development Charge (TSDC)
  - **Create a neighborhood traffic safety plan and policies that guide investment.**
  - **Implement TSP metrics and key performance indicators (KPIs).**
- Leverage multiple funding sources to enhance and improve transportation infrastructure resulting in a funding package that addresses both housing and mobility challenges on the May 2020 ballot.
  - **Prioritize short term transportation projects that relieve congestion, improve safety, including emergency response times, and increase options for all modes of transportation.**
  - Develop a transportation funding plan that is equitable, balanced, and resilient.
  - Create/implement communication plan aligning community values with transportation projects to ensure sustainable funding.
  - Participate in development of comprehensive transit plan that improves service levels and is integrated with the TSP.
- Improve the condition and functionality of City sewer, stormwater, transportation and water infrastructure to keep pace with community needs.
  - Improve the average pavement condition index to 75 by 6/30/2021.
  - Develop a bridge maintenance and **traffic signal plan**.

    - Continue investments in water, stormwater and waste water treatment systems to keep pace with demand, regulatory requirements and maintenance needs.
    - **Create a sidewalk plan and program that shares responsibilities between the City and adjacent property owners.**
    - **Complete phase one of neighborhood greenways & create plan/funding source for future phases integrated with the TSP.**

- **Increase events focused on traffic safety by 20% by 6/30/2021 when compared to 6/30/2019.**
    - **Conduct focused DUII enforcement programs or details.**
    - **Conduct focused distracted driving enforcement programs or details.**
    - **Conduct crash reduction enforcement programs or details.**
    - **Conduct public education and awareness programs.**

1.5 PLAN DEVELOPMENT PROCESS

A comprehensive approach to transportation safety acknowledges that policy, planning, programming, and projects are multidisciplinary and involve "the 7Es" of safety. The seventh "E" represents a dedication to transportation safety through a commitment to evaluate progress and continue to adapt future safety plans to meet identified future needs:

- Engineering;
- Emergency Medical Services (EMS);
- Enforcement;
- Education;
- Encouragement;
- Equity; and
- Evaluation.

By including elements from the 7Es that complement each other, the TSAP provides a multidisciplinary approach that could support policy, programs, and project recommendations to achieve a vision of zero transportation fatalities or serious injuries on roads within the City of Bend. This would be consistent with the Oregon statewide vision zero objectives. To achieve this multidisciplinary plan, input was obtained from a variety of stakeholders throughout the project:

- Project Management Team (PMT) – The PMT included key staff from the City of Bend, the Bend MPO, and the Oregon Department of Transportation (ODOT) who met regularly throughout the project to provide technical input at key steps throughout the project.
- Technical Advisory Committee (TAC) – The MPO TAC met three times during the TSAP project to provide input on the project framework and goals; the existing conditions analysis and emphasis areas; and the TSAP's policy, program, and project recommendations.
- Citywide Transportation Advisory Committee (CTAC) – The CTAC is a committee of community members that provides policy recommendations and guidance to the Bend City Council on the update of Bend's Transportation Plan, including transportation-related policies and funding strategies. The CTAC has a sub-

group focused on transportation safety policies. This subgroup met to develop recommended transportation safety policies for the City.

- Brownbag Meeting – There was one brownbag, informational meeting in which all CTAC members, as well as the general public, were invited to attend to learn more about ways to reduce injuries and fatalities through infrastructure countermeasures (e.g. design, operations, and maintenance).
- Multidisciplinary Stakeholder Group – This group included representatives from a variety of stakeholders, including the Deschutes County Department of Public Health, Bend Police and Fire, Deschutes County Sheriff, Bend La Pine School District, and the District Attorney's Office to provide input on non-infrastructure countermeasures. This group was invited to participate in two of the MPO TAC meetings to discuss and identifying non-engineering solutions to further support crash reductions.

1.6 HOW TO USE THE TSAP

The TSAP is organized into seven sections. The following overview summarizes the content of each section and how it is intended to be used.

- **Section 1: Introduction** – This section provides an overview of the Plan's purpose and development, the City Council's transportation safety goals, and the study area. This section should orient the user to the Plan document.
- **Section 2: Crash Data Summary** – This section provides an overview of the key findings from the crash analysis and the identified emphasis areas for Bend.
- **Section 3: Systemic Solutions –** This section is a toolbox of systemic solutions, summarizing the solutions, planning level cost estimates, and effectiveness at reducing injuries. This toolbox is meant to be referenced to identify appropriate solutions to address various safety issues throughout the City. These treatments can often be incorporated into the City's regular maintenance practices.
- **Section 4: Speed Management Toolbox –** This section provides a toolbox of treatments that can be implemented to help reduce travel speeds which can reduce the severity of injuries.
- **Section 5: Location Specific Applications –** This section summarizes the specific locations identified for safety treatments during the TSAP development. Section 5.1 identifies the intersections with the highest crash frequency and severity in the City; Section 5.2 identifies four areas where specific recommendations were produced; and Section 5.3 provides summarizes the locations where specific risk factors were identified. Section 5.3 helps guide the implementation of systemic solutions presented in Section 3.
- **Section 6: Non-Infrastructure Recommendations –** This section summarizes the educational, enforcement, programmatic, and policy action items developed to support the engineering recommendations of the TSAP.
- **Section 7: Performance Measures –** This section summarizes performance measures for the City and MPO to use in tracking progress towards implementing the TSAP.

1.7 UPDATING THE TSAP

Implementing the TSAP actions in concert with other Bend and MPO safety, land use, and transportation plans should result in measured decreases in fatal and severe injuries for the corresponding emphasis areas. Measuring safety benefits will require reassessing crash data to consider the TSAP effectiveness and then generate revised programs to meet future identified safety performance needs. The MPO TAC recommends this TSAP be assessed in 3 to 5 years as new crash data is available and sufficient time has passed to measure the effectiveness of the various safety, land use, and transportation plans.

SECTION 2

CRASH DATA SUMMARY

2. CRASH DATA SUMMARY

Kittelson obtained roadway, traffic, and crash data from the Oregon Department of Transportation (ODOT), Deschutes County, and the Bend MPO. Reported crash data for Deschutes County was from ODOT's database for January 1, 2012 through December 31, 2016. Reported crashes include those resulting in an injury or fatality, as well as those resulting in over $1,500 of property damage.[1] ODOT's crash database provides reported crash characteristics such as date, time, crash type, light conditions, roadway conditions, etc. that Kittelson used to analyze and document factors associated with crashes. Additional roadway characteristics, such as number of lanes and intersection control type, were assigned to the crash data based on the GIS information received from the Bend MPO or Deschutes County.

Crashes are assigned one of five severity levels based on the most severe injury associated with that crash:

- Fatal;
- Incapacitating injury (Injury A);
- Moderate Injury (Injury B);
- Possible Injury (Injury C); or
- Property damage only (PDO).

More extensive discussion of analysis and findings is included in the *Existing Conditions Summary* memo, which is included as Appendix 4.

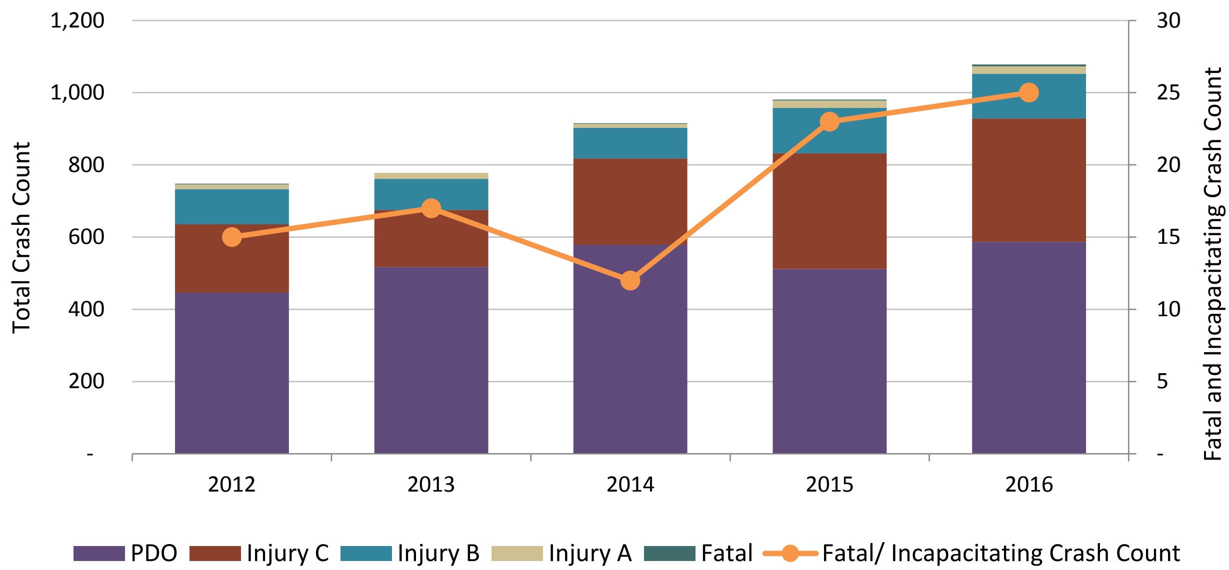
2.1 YEAR AND SEVERITY

Figure 3 presents the year-over-year crash frequency in Bend including the number of crashes resulting in death or incapacitating injury. The annual number of reported crashes has increased yearly since 2012, with an average annual increase of nine percent. This average annual growth in reported crash frequency exceeds the average annual population growth (1.6 percent) and the average annual VMT growth (3.6 percent) during the same time period.

Table 1 presents crashes by severity. Among the 4,500 crashes analyzed, a relatively small share (two percent) were fatal or Injury A crashes while over 41 percent of these crashes resulted in an injury of some sort. The number of fatal crashes dropped in 2014 and then continued their upward trend in 2015. A crash classified as injury "A" describes severe injuries including skull fractures, internal injuries, broken or distorted limbs, unconsciousness, severe lacerations, and severe burns. The crash victim is unable to leave the scene without assistance.

[1] ODOT increased the property damage threshold for reporting crashes from $1,500 to $2,500 as of January 1, 2018. However, the data reflected in this analysis corresponds to a reporting threshold of $1,500 of damage. (Source: https://content.govdelivery.com/accounts/ORDOT/bulletins/1cbed84)

Figure 3: Crashes by Year, Bend 2012-2016



Source: ODOT

Table 1: Crashes by Severity, Bend, 2012-2016

	Fatal	Injury A	Injury B	Injury C	PDO	Total
Count	11	81	518	1,249	2,641	**4,500**
Share	<1%	2%	12%	28%	59%	**100%**

Source: ODOT

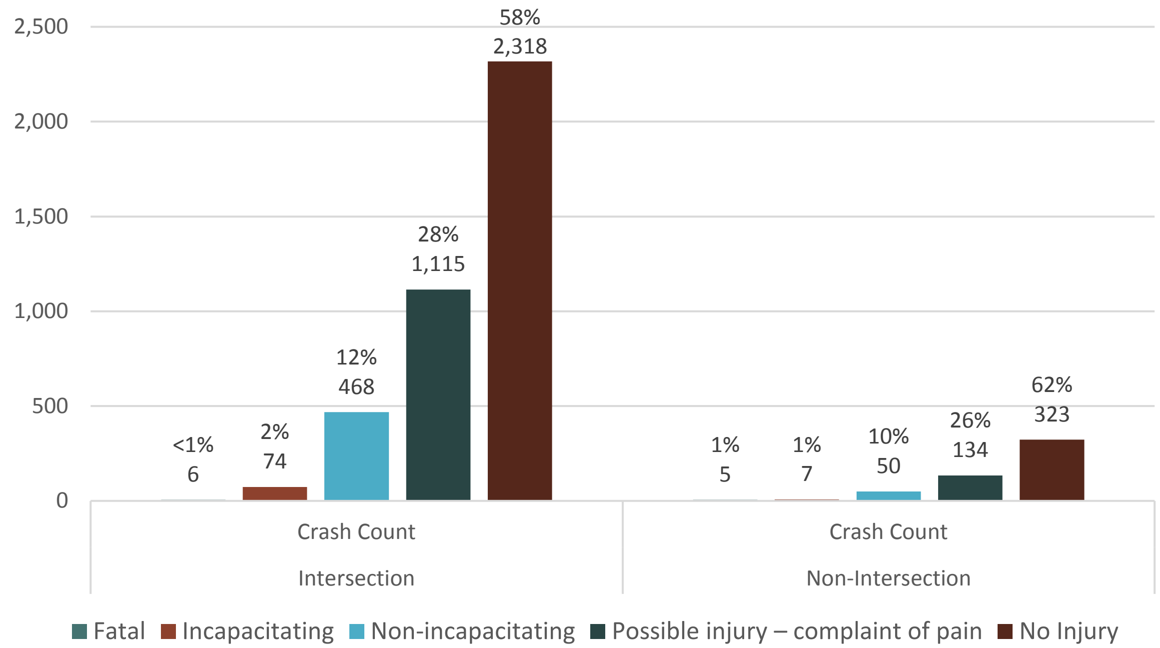
2.2 LOCATION OF REPORTED CRASHES

Kittelson analyzed crashes by location (intersection or segment crashes) and by mode (including motor vehicle, bicyclist, or pedestrian crashes). Crashes within 250 feet of an intersection were considered *intersection crashes* and constituted most crashes within Bend (88%), as shown in Figure 4.

Intersections in the City are typically either stop-controlled, signalized, or roundabouts. Stop-controlled intersections may be two-way stop-controlled (referred to as "stop" in the table below), in which the major road traffic does not stop, or all-way stop-controlled (referred to as "4-way stop-controlled" below), in which every approach is required to stop. Using the City's GIS database of intersection control devices, Kittelson assigned the reported crash data with the corresponding intersection traffic control configuration. Table 2 shows the distribution of intersection crashes by traffic control type. Almost half of fatal/incapacitating intersection crashes occurred at stop-controlled intersections, 28 percent at traffic signals, five percent at all-way stop-controlled intersections, and three percent at roundabouts. Figure 5 illustrates the location of the fatal and incapacitating crashes in Bend between 2012 and 2016.

The next section describes the major emphasis areas for Bend based on further analysis.

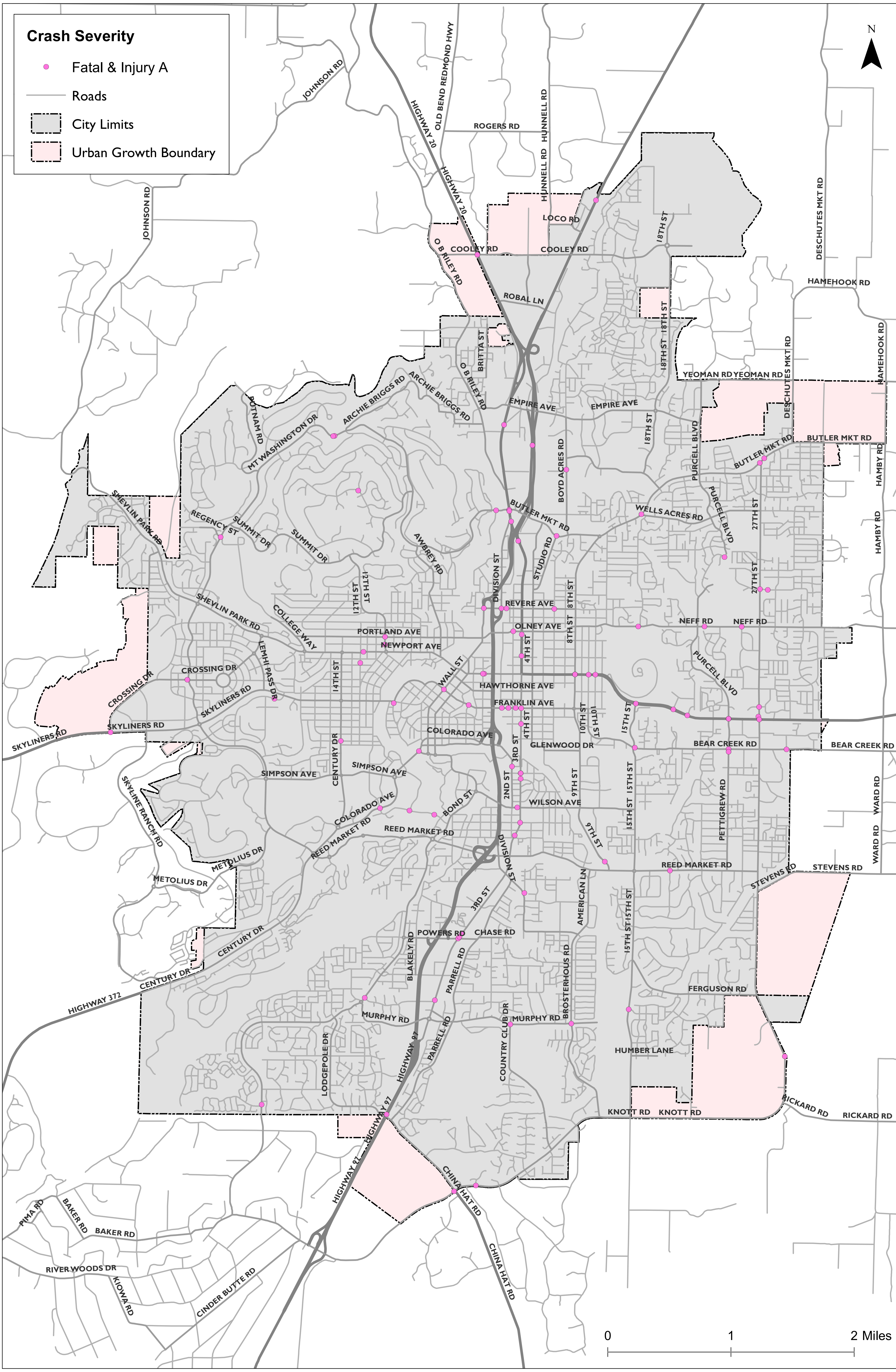
Figure 4: Crashes by Location (Intersection and Non-Intersection), Bend 2012-2016



Source: ODOT

Table 2. Summary of Distribution by Intersection Control Type

Intersection Control	Percentage of Reported Crashes (Total)	Percentage of Fatal/Incapacitating Intersection Crashes
4-Way Stop-Controlled	4%	5%
Stop-Controlled	43%	49%
Traffic Signal	32%	28%
Roundabout	6%	3%
Other	1%	1%
Unknown	14%	15%



Fatal & Injury A Crashes (2012 - 2016)
Bend Area TSAP

Figure
5

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.

2.3 EMPHASIS AREAS

Based on the crash analysis, Kittelson identified several emphasis areas for the City of Bend. These emphasis areas reflect the crash characteristics, such as crash type, behavior, or infrastructure, that were associated with fatal and incapacitating injury crashes. By addressing these emphasis areas, the City has the greatest potential to reduce fatal and incapacitating crashes. The following sections summarize these emphasize areas.

2.3.1 Crash Types

Fatal/incapacitating crash types. The five crash types most frequently associated with fatal/incapacitating outcomes include these types (which collectively account for 89 percent):

- Turning movement crashes (26% of fatal/incapacitating crashes)
- Rear-end crashes (21%)
- Angle crashes (17%)
- Pedestrian crashes (13%)
- Fixed object or other object crashes (12%)
- Bicyclist crashes (9%) (Bicyclists crashes are assigned a collision type that is not unique to bicyclists and are therefore also included in the percentages above, as appropriate)

2.3.2 Intersections

Eighty-eight percent of collisions in Bend occurred within 250 feet of an intersection. Key trends include:

- **Arterial roadways.** Among fatal/incapacitating crashes, 78 percent occurred on arterials or at intersections that included at least one arterial roadway.
- **Traffic Control.** Among fatal/incapacitating crashes at intersections, 49 percent occurred at stop-controlled intersections, and 28 percent occurred at traffic signals.
- **Intersection collision types.** The predominant share of fatal/incapacitating crashes were collision types most commonly occurring at intersections: turning movement, angle, and rear-end crashes.

2.3.3 Roadway Segments

Twelve percent of collisions in Bend occurred outside of intersection influence areas. Key trends include:

- **Segment collision types.** 21% percent of fatal/incapacitating crashes were fixed object, sideswipe, head-on, or overturn crashes; and
- **Arterial roadways.** 58% percent of fatal/incapacitating crashes occurred on arterial roadways or at intersections with arterial roadways.
- **Five-lane roadways.** 32% percent of fatal/incapacitating crashes occurred on five-lane roadways.

2.3.4 Pedestrians

Although pedestrian crashes accounted for less than one percent of reported crashes in Bend's UGB, they accounted for 13 percent of fatal/incapacitating crashes in the UGB boundary. Key trends include:

- **Severe outcomes.** Ninety-four (94%) percent of pedestrian collisions resulted in injury or death. Twenty-four percent (24%) resulted in death or incapacitating injury.
- **Evening/nighttime crashes.** Fatal and incapacitating pedestrian collisions predominantly occurred in the evening/nighttime hours as well, with eight of 12 such collisions occurring between 5:00 p.m. and 11:00 p.m. Four fatal pedestrian collisions (and eight of 12 fatal/incapacitating crashes) occurred in darkness with the absence of streetlights.
- **Number of lanes on roadway.** Almost half of pedestrian collisions (48 percent) occurred on roadways with four or five lanes.
- **Motorists proceeding straight.** Nine of the 12 (75%) fatal/incapacitating pedestrian collisions involved motorists proceeding straight (rather than turning).

2.3.5 Bicyclists

Bicycle crashes accounted for two percent of reported crashes in the Bend UGB and nine percent of fatal/incapacitating crashes between 2012 and 2016. Key trends include:

- **Severe outcomes.** Among the 112 reported collisions involving people on bikes in the five-year period analyzed, 90 percent resulted in injury or death. Seven percent of collisions resulted in incapacitating injury or death.
- **High-stress roadways.** Seventy percent of bicycle collisions occurred either on roadways with a level of traffic stress (LTS)[2] score of 3 or 4, or at an intersection including such a street. To put this into perspective, roads with an LTS score of 3 or 4 constitute approximately 18 percent of Bend's roadway network. Therefore, bicycle crashes are over-represented on such roadways.
- **Intersection crashes.** Ninety-three (93%) percent of bicyclist collisions in Bend occurred within an intersection's influence area (250 feet). Sixty-eight percent (68%) of intersection crashes occurred at an intersection with at least one high-stress (with a level of traffic stress, LTS, of 3 or 4) roadway.
- **"Left Hook" crashes.** Twenty-three percent (23%, 26 crashes) of bicycle crashes involved vehicles turning left and bicyclists traveling straight in the opposing direction. The majority of these (23 of 26) occurred at intersections. The risk is created primarily by standard intersection design practices in Bend.

2.3.6 Road User Behavior

Key trends include:

- **Excessive speeds.** Thirteen percent (13%) of fatal/incapacitating crashes involved excessive speeds; 10 percent of excessive speed crashes resulted in fatality or incapacitating injury.
- Impaired driving. Alcohol/drug involvement was reported in six percent (6%) of reported collisions but in 20 percent (20%) of the fatal/incapacitating subset of collisions.

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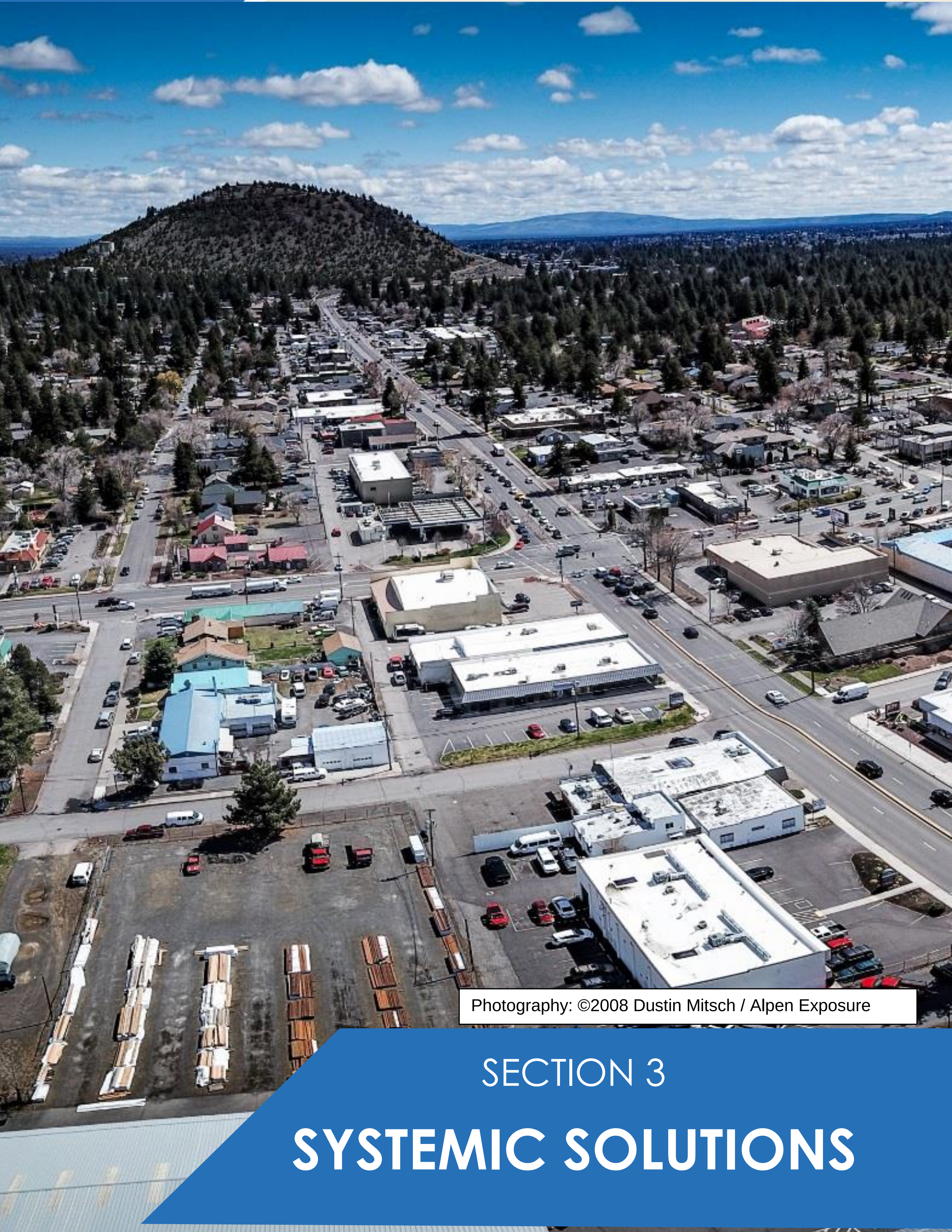
[2] Level of Traffic Stress (LTS) measures the relative traffic stress a bicyclist experiences on the roadway. It is based on posted speed limit, number of lanes, traffic volume, and available bicycle facilities/separation from vehicular traffic.

2.3.7 Lighting

Key trends include:

- **Dark, unlit conditions.** Twenty-two percent (22%) of fatal/incapacitating crashes occurred in dark, unlit conditions. Four percent (4%) of crashes in dark, unlit conditions resulted in fatality or incapacitating injury.
- **Relative share compared to peer cities.** A substantively higher proportion of collisions in Bend (13 percent) occurred in darkness with no street lights compared to Corvallis, Medford, and Springfield.



Photography: ©2008 Dustin Mitsch / Alpen Exposure

SECTION 3

SYSTEMIC SOLUTIONS

3. SYSTEMIC SOLUTIONS

This section presents recommended systemic engineering countermeasures. Systemic solutions can often be applied on a wide-scale (same treatment at many different locations) for relatively low-cost. Many of these may be incorporated into capital projects as well as ongoing maintenance activities to maximize cost-effectiveness.

We have presented the countermeasures in four groups and summarized the documented effectiveness at reducing crashes through the Crash Reduction Factor (CRF), when available:

- **Spot Treatment Vehicle Countermeasures**, which may be more expensive and can be applied at individual locations rather than on a systemic basis;
- **Systemic Intersection Countermeasures**, which may be applied in a systemic fashion and for relatively low cost at intersections;
- **Roadway Departure Countermeasures,** which are treatments to reduce lane departure and run-off-the-road crashes;
- **Bicycle or Pedestrian Countermeasures**, which are treatments to improve conditions for one or both sets of users; and,
- **Enhanced Pedestrian Crossing Treatments**, which are a subset of *bicycle and pedestrian countermeasures* and represent various techniques that all improve safety conditions for marked crossings.

Table 3 summarizes the solutions that are presented in the following sections and provides the documented effectiveness of each treatment at reducing crashes through the Crash Reduction Factor (CRF), when available.[3] Section 5.3 of the TSAP provides maps summarizing locations where specific characteristics, such as light conditions or crash types, were most common. This section should be used to help focus priorities for implementation of the systemic recommendations.

Table 3. Summary of Systemic Solutions

Countermeasure	Intersection or Segment	Applicable Crash Types	Crash Reduction Factor (CRF)	Planning -Level Cost*
Spot Treatment Vehicle Countermeasures				
Roundabouts	Intersection	All crash types	19-82%[1,2]	$2.5M-3.5M*
Intersection Lighting	Intersection	Nighttime	31 – 38%[1,2]	$10,000 per pole*
Lane reconfiguration	Segment	All	29%[1,2]	$20,000 per mile (striping only)
Systemic Intersection Countermeasures				
FHWA Basic Set of Signal and Sign Improvements for Signalized Intersections	Intersection (Signalized)	All crash types	30%[6]	$5,000 - $30,000 per intersection
Convert Left Turn Permissive to Protected Phasing	Intersection (Signalized)	Left-turn crashes	6 - 99%[1,2]	$25,000 per intersection

[3] When possible, CRF's were obtained from ODOT's list of approved CRF's, which is provided in Appendix 7.

Countermeasure	Intersection or Segment	Applicable Crash Types	Crash Reduction Factor (CRF)	Planning -Level Cost*
Increase All-Red Clearance Interval	Intersection (Signalized)	All crash types	20%[6]	$3,000 per intersection
Increase Intersection Warning with Signing and Striping	Intersection (Unsignalized)	All	11 – 55%[1,7]	Varies ($400 per new sign; $700 per oversized sign; $1,000 per Stop Ahead legend)
Provide Flashing Beacons at Stop-Controlled Intersections	Intersections (Unsignalized)	Angle crashes	5-58%[1,2]	$5,000 per mount
Install Raised Divider on Stop Approach (Splitter Island)	Intersections (Unsignalized)	All crashes	15%[1]	$7.55 per sq ft
Increase Sight Distance	Intersections (Signal and Unsignalized)	All injury crashes	11-56%[1,3]	Varies
Roadway Departure Countermeasures				
Install Shoulder Rumble Strips	Segment	Run off the road	16-42%[1,3]	$850 per mile
Install Centerline Rumble Strips	Segment	All injury crashes	9-45%[1,3]	$3,000 per mile
Widen Paved Shoulder	Segment	All crashes	3-18%[1,3]	Varies
Install Chevron Signs on Horizontal Curves	Segment	Run off the road injury crashes	4-25%	$600 per sign*
Install Dynamic Feedback Sign on Curves	Segment	All crashes	39-44%[1,3]	Varies
Increase Pavement Friction	Segment	Crashes on wet roads	20-68%[1,3]	$30 per sq yd
Remove, Relocate, or Protect Fixed Objects Adjacent to Road	Segment	All crashes	38%[3]	Varies
Install Wider Edge-lines	Segment	Run off Road	11 – 13%[1,3]	$0.20 per ft (paint); $0.80 per ft (thermoplastic); $2.00 per ft (MMA)
Systemic Bicyclist or Pedestrian Countermeasures				
Pedestrian-Scale Lighting	Intersection	Nighttime Pedestrian & Bicycle	42%[1,2]	$15,000 per pole*
Install Pedestrian Countdown Timer	Intersection	Pedestrian	70%[1,3]	$500 per signal head
Leading Pedestrian Interval at Signal	Intersection	Pedestrian	37 – 45%[1,3]	$15,000
Protected Intersection	Intersection	Pedestrian, Bicyclist	Not quantified[8]	$200,000 - $3,000,000*

Countermeasure	Intersection or Segment	Applicable Crash Types	Crash Reduction Factor (CRF)	Planning -Level Cost*
Install, buffer, or separate bicycle lanes	Segment	Bicycle	47-59%	$4,000 - $110,000 per mile*
Neighborhood Greenway	Segment	Bicycle	63%[3]	$300,000 per mile*
Install Green Bike Lanes at Conflict Points	Segment/Intersection	Bicycle	39%[1,3]	$9/SF
Bike Box / Advanced Stop Bar	Intersection	Bicycle	35%[1]	$9/SF
Two-Stage Turn Boxes	Intersection	Bicycle	Not quantified[8]	$9/SF
Enhanced Pedestrian Crossing Treatments				
Curb Extension	Segment/Intersection	Pedestrian	37%[1]	$20,000
Pedestrian Refuge Island	Segment/Intersection	Pedestrian	26 – 31%[4]	$25,000
Rapid Rectangular Flashing Beacon	Segment	Pedestrian	10 – 56%[1,4]	$20,000 - $50,000
Pedestrian Hybrid Beacon	Segment	Pedestrian	55 – 69%[1,4]	$70,000
Pedestrian Signal	Segment	Pedestrian	15 – 69%[5]	$250,000

*Planning-level cost estimates were obtained from ODOT's list of approved CRFs, unless marked with an asterisk (*). Those marked with an asterisk (*) were provided by the City of Bend.
Crash Reduction Factor Sources:
[1] ODOT ARTS
[2] Highway Safety Manual
[3] CMF Clearinghouse
[4] NCHRP Report 841
[5] Caltrans Local Roadway Safety Manual
[6]FHWA
[7]Caltrans / Intersection Implementation Plan / ODOT
[8]In this case, there is insufficient research to identify a crash reduction factor.
[9]"A Complete and Attractive System of Bikeways Toolbox." Bend, Oregon, 2014.
[10]"Safety Effects of Blue Cycle Crossings: A Before-After Study," Accident Analysis & Prevention, (2008)

3.1 SPOT TREATMENT COUNTERMEASURES

This category of countermeasures includes items that can be applied at individual locations based on identified crash history or site conditions. These countermeasures may be of substantial cost. An overview of the countermeasures, and the existing conditions findings that led to their selection, is provided in Table 2.

Table 4: Stop Treatment Countermeasures and Rationale for Selection

Why was this countermeasure selected for Bend?	**Roundabout**	**Intersection Lighting**	**Lane Reconfiguration**
Angle, turning movement, and rear-end collisions are among the most common collision types, together accounting for 64 percent of fatal/incapacitating crashes in Bend	X		
Nearly half (49 percent) of fatal/incapacitating injury collisions at intersections occurred at two-way stop-controlled intersections, and 28 percent of fatal/incapacitating crashes occurred at traffic signals. In contrast, three percent of fatal/incapacitating crashes occurred at roundabouts.	X		
Bend has a relatively high proportion of collisions in darkness with no street lights compared to peer cities evaluated. 20 percent of fatal/incapacitating crashes in Bend occurred in dark conditions without street lights		X	
45 percent of fatal/incapacitating crashes in Bend occurred on, or at the intersections of, four- or five-lane roads			X

Roundabouts

Roundabouts	
Roundabouts feature channelized approaches and a central island to move traffic through an intersection. At roundabouts, entering traffic yields to vehicles already circulating, leading to improved operational performance. Single-lane roundabouts are typically designed so that drivers must approach the intersection at speeds below 25 miles per hour. The approach speed can reduce the severity of crashes when compared to other intersection forms. Roundabouts can be used in place of a two-way and all-way stop controlled intersection, and potentially traffic signals depending on volume. Replacing a rural two-way stop-controlled intersection with a single-lane roundabout has been shown to reduce injury crashes as much as 87 percent.	
Intersection or Segment	*Intersection*
Applicable Collision Types	*All*
Potential Collision Reduction	*19 – 82%*
Planning-Level Cost	*$2.5M - $3.5M*

Source: FHWA

Intersection Lighting

Intersection Lighting	
Adding intersection lighting for signalized and non-signalized intersections helps improve the visibility of the intersection and potential conflicts. Intersection illumination, including pedestrian crossings, helps illuminate crossing pedestrians for approaching motorists and assists pedestrians in navigating the crossing.	
Intersection or Segment	*Intersection*
Applicable Collision Types	*Nighttime*
Potential Collision Reduction	*31 – 38%*
Planning-Level Cost	*$10,000 per pole*

Source: Traffic Safety Supply Company

Lane Reconfiguration

Lane Reconfiguration	
A roadway reconfiguration often adds dedicated left-turn lanes (sometimes right turn lanes are added) by re-allocating roadway space. Roadway reconfigurations are considered when the road is not operating efficiently, when there are rear-end or crossing crashes, or when a system element is missing and needs to be added. A typical situation occurs when left-turns are accommodated in the through travel lane and the number of left-turns is great enough to cause delay to drivers trying to continue straight. When this situation occurs in both directions, it is more efficient to provide a dedicated left-turn lane. The pavement space that is freed up can be used for on-street parking, on-street parking buffer space (so people have more space to exit their parked cars), or adding bike lanes or widening sidewalk. The treatment aims to reduce conflicts, increase system efficiency and increase safety benefits for each road user.	
Intersection or Segment	*Segment*
Applicable Collision Types	*All collisions*
Potential Collision Reduction	*29%*
Planning-Level Cost	*$20,000 per mile (striping only)*

Source: FHWA

3.2 SYSTEMIC INTERSECTION COUNTERMEASURES

Most crashes in Bend occurred within 250 feet of an intersection, and the most common collision types in Bend are those associated with intersections. These systemic intersection countermeasures, presented in Table 3 and provided in further detail in the following pages, are intended to provide a toolbox of low-cost options that are proven to help reduce crash risk at signalized or unsignalized intersections. Because most fatal and incapacitating crashes occurred at traffic signals and two-way stop-controlled intersections, these treatments focus on enhancements to these two intersection control types.

Table 5. Systemic Intersection Countermeasures and Rationale for Selection

Why was this countermeasure selected for Bend?	FHWA Basic Signalized Intersection Improvements	Convert Left Turn Permissive to Protected Phasing	Increase All-Red Clearance Interval	Increase Intersection Warning with Signing and Striping	Provide Flashing Beacons at Stop-Controlled Approaches	Install Raised Divider on Stop Approach	Increase Sight Distance
Angle, turning movement, and rear-end collisions are among the most common collision types, together accounting for 64 percent of fatal/incapacitating crashes in Bend	X	X	X	X	X	X	X
Nearly half (49 percent) of fatal/incapacitating injury collisions at intersections occurred at two-way stop-controlled intersections.				X	X	X	
28 percent of fatal/incapacitating crashes at intersections occurred at traffic signals.	X	X	X				
87 percent of fatal/incapacitating crashes in Bend occurred within 250 feet of an intersection	X	X	X	X	X	X	X
Bend has a relatively high proportion of collisions in darkness with no street lights compared to peer cities evaluated. 20 percent of fatal/incapacitating crashes in Bend occurred in dark conditions without street lights	X			X	X		

FHWA Basic Set of Signal and Sign Improvements for Signalized Intersections

FHWA Basic Set of Signal and Sign Improvements for Signalized Intersections

This countermeasure refers to a package of treatments to improve safety performance at signalized intersections. The improvements include the following:

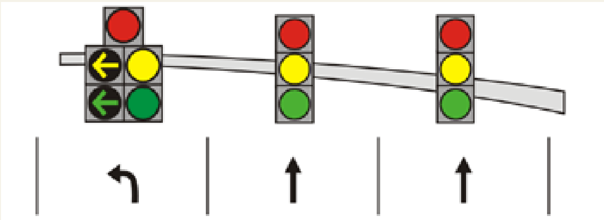
- Installing back plates on all signal heads
- Adding reflective tape to increase visibility
- 12-inch LED signal lenses
- Adding at least one signal head per approach lane
- Adjusting signal clearance timing
- Eliminating flashing operation during night conditions.

These changes make traffic signals more visible to motorists approaching intersections, helping motorists identify potential conflicts and reduce the risk of conflicts at the intersection.

Intersection or Segment	*Intersection (signalized)*
Applicable Collision Types	*All collision types*
Potential Collision Reduction	*30%*
Planning-Level Cost	*$5,000 - $30,000 per intersection*

Source: FHWA

Convert Left turn Permissive to Protected Phasing

Convert Left Turn Permissive to Protected Phasing		
This countermeasure converts signalized intersections that have permissive left-turn phasing to protected phasing. Permissive left-turn movements are among the highest risk at signalized intersections because of the potential conflicts with crossing vehicular and pedestrian traffic. Protected left-turn phasing can reduce left-turn collisions by creating an exclusive movement for left-turning motorist.		
Intersection or Segment	*Intersection (signalized)*	 Source: FHWA
Applicable Collision Types	*Left-turn collisions*	
Potential Collision Reduction	*16%*	
Planning-Level Cost	*$25,000 per intersection*	

Increase All-Red Clearance Interval

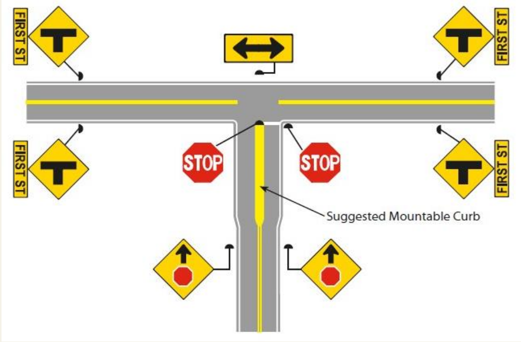
Increase All-Red Clearance Interval		
Increasing the all-red signal phase provides additional clearance time for vehicles who have entered an intersection prior to opposing movements receiving a green indication. Increasing all-red clearance intervals provides more time for vehicles to move through the intersection before the start of the next green movement. This can reduce the crash frequency related to late-entering vehicles or motorists running a red light. The treatment is most effective at locations where the existing red-clearance time is relatively short (2 seconds or less).		
Intersection or Segment	*Intersection*	 Source: FHWA
Applicable Collision Types	*All collision types*	
Potential Collision Reduction	*20%*	
Planning-Level Cost	*$3,000 per intersection*	

Increase Intersection Warning with Signing and Striping

Increase Intersection Warning with Signing and Striping

Implementing a package of low-cost treatments can be used to increase intersection warning and improve safety performance at unsignalized intersections. The improvements include doubled (left and right) oversize warning signs, doubled STOP signs, a raised splitter island on the stop approach (if feasible), street name signs, stop bars, removing any limitations to sight distance, and double warning arrow at the stem of T-Intersections. This set of enhancements combines multiple treatments to make the approach of two-way stop-controlled intersections more visible to the driver and increase awareness and visibility of potential conflicts. These treatments can help slow approaching vehicles and increase stop compliance on the controlled approaches.

Intersection or Segment	*Intersection (Unsignalized)*
Applicable Collision Types	*All collisions*
Potential Collision Reduction	*11-55%*
Planning-Level Cost	*Varies: $400 per new sign; $700 per oversized sign; $1,000 per Stop Ahead legend*



Source: FHWA

* *FHWA, "Low-Cost Safety Enhancements for Stop-Controlled and Signalized Intersections," (2014)*

Provide Flashing Beacons at Stop-Controlled Intersections

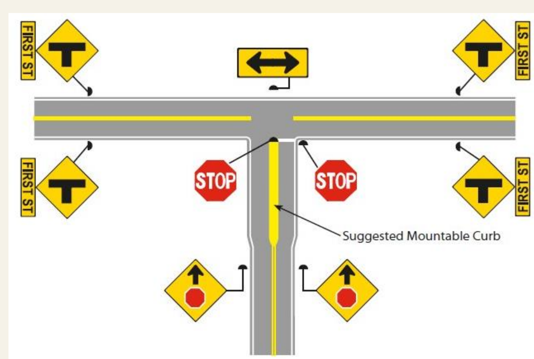
Provide Flashing Beacons at Stop-Controlled Intersections	
Flashing beacons can be placed above stop-signs, as well as above stop-ahead warning signs, to raise intersection visibility and awareness. Flashing beacons may flash continuously or be actuated when a vehicle approaches the intersection. This treatment may help reduce angle collisions at intersections where driver awareness of the approaching intersection is a challenge.	
Intersection or Segment	*Intersection (Unsignalized)*
Applicable Collision Types	*Angle collisions*
Potential Collision Reduction	*5-58%*
Planning-Level Cost	*$5,000 per mount*

Source: FHWA

* *FHWA, "Safety Evaluation of Flashing Beacons at Stop-Controlled Intersections," (2008) https://www.fhwa.dot.gov/publications/research/safety/08048/index.cfm*

Install Raised Divider on Stop Approach (Splitter Island)

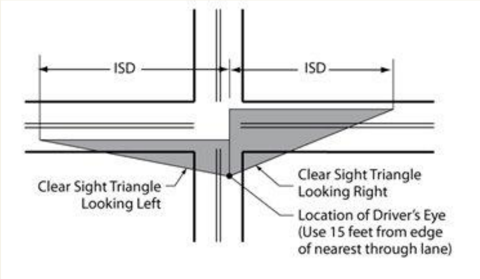
Install Raised Divider on Stop Approach (Splitter Island)	
Installing a raised divider (with mountable curb) on a stop-controlled approach to an intersection can increase intersection visibility by adding a left-side stop sign and better delineate vehicle paths at the intersection. Where possible, a minimum width of 6-feet should be used for the splitter island.	
Intersection or Segment	*Intersection (Unsignalized)*
Applicable Collision Types	*All collisions*
Potential Collision Reduction	*15%*
Planning-Level Cost	*$7.55 per sq ft*



Source: FHWA

* *FHWA, "Low-Cost Safety Enhancements for Stop-Controlled and Signalized Intersections," (2014)*

Increase Sight Distance

Increase Sight Distance		
Increasing intersection sight distance may involve a variety of actions to increase the line of sight including clearing vegetation and embankments, relocating objects, implementing parking restrictions. By increasing intersection sight distance, drivers are provided with a greater distance to see potential conflicts and complete maneuvers to avoid potential collisions.		
Intersection or Segment	*Intersection (Signal and Unsignalized)*	 Source: FHWA
Applicable Collision Types	*All injury collisions*	
Potential Collision Reduction	*11-56%*	
Planning-Level Cost	*Varies*	

** FHWA, "Intersection Safety: A Manual for Local Rural Road Owners,"*
https://www.fhwa.dot.gov/publications/research/safety/08048/index.cfm

3.3 ROADWAY DEPARTURE COUNTERMEASURES

The roadway departure countermeasures are summarized in Table 4 and provided in further detail on the following pages. Although most crashes in Bend occurred within intersection influence areas, the crash analysis also revealed a substantial percentage of roadway departure crashes, as noted in Table 4. These countermeasures are appropriate for roadway segments, particularly curves. Roadway departure crashes can often be reduced by reducing travel speeds. The Speed Management Toolbox, provided in Section 4, provides treatments to help reduce speeds.

Table 6. Roadway Departure Countermeasures and Rationale for Selection

Why was this countermeasure selected for Bend?	Install Shoulder Rumble Strips	Install Centerline Rumble Strips	Widen Paved Shoulder	Install Chevron Signs on Horizontal Curves	Install Dynamic Feedback Signs on Curves	Increase Pavement Friction	Remove, Relocate, or Protect Fixed Objects Adjacent to Road	Install Wider Edge-lines
13 percent of fatal/incapacitating crashes in Bend were fixed-object/other object or rollover	X	X	X	X	X	X	X	X
Five percent of fatal/incapacitating crashes in Bend were head-on or side-swipe meeting crashes		X						
Head-on crashes were more likely to result in fatal/incapacitating injury, compared to rear-end, angle, turning movement, sideswipe, and fixed object crashes		X						
13 percent of fatal/incapacitating crashes involved excessive speed					X			

Install Shoulder Rumble Strips

Install Shoulder Rumble Strips		
Shoulder rumble strips provide auditory and tactile feedback to motorists when they begin to exit the outside of the travel lane. Shoulder rumble strips can help reduce run-off-the-road crashes by alerting drivers that they are traveling beyond the designated lane.		
Intersection or Segment	*Segment*	 Source: FHWA Proven Safety Countermeasures
Applicable Collision Types	*Run off the road collisions*	
Potential Collision Reduction	*16-42%*	
Planning-Level Cost	*$850 per mile*	

Install Centerline Rumble Strips

Install Centerline Rumble Strips		
Centerline rumble strips provide auditory and tactile feedback to motorists when they have begun to cross over the centerline of the roadway. Centerline rumble strips can reduce head-on and other crossover crash types on horizontal curves of undivided roadway segments by alerting drivers they are crossing over the centerline into the opposing direction of traffic.		
Intersection or Segment	*Segment*	 Source: FHWA
Applicable Collision Types	*All injury collisions*	
Potential Collision Reduction	*9-45%*	
Planning-Level Cost	*$3,000 per mile*	

** Persaud, B. N., Retting, R. A., and Lyon, C., "Crash Reduction Following Installation of Centerline Rumble Strips on Rural Two-Lane Roads." Arlington, Va., Insurance Institute for Highway Safety, (2003)*

Widen Paved Shoulder

Widen Paved Shoulder	
Widen the paved shoulder adjacent to travel lanes. Paved shoulders may increase safety performance when navigating horizontal curves by providing a paved recovery area for motorists who have left the travel lane. The shoulder can help a driver maintain control and correct the vehicle path. Widening the outside shoulder of a curve provides the greatest benefit on roads where existing space is limited.	
Intersection or Segment	*Segment*
Applicable Collision Types	*All collisions*
Potential Collision Reduction	*3-18%*
Planning-Level Cost	*Varies*

Source: FHWA

Install Chevron Signs on Horizontal Curves

Install Chevron Signs on Horizontal Curves	
Chevron signs along horizontal curves provide a visual que to alert and guide motorists through an approaching curve. Chevron signs alert drivers to reduce speeds and prepare to enter a curve. Chevron placement also helps guide drivers through the curve by providing a visual cue to the approaching curve's radius.	
Intersection or Segment	*Segment*
Applicable Collision Types	*Run off the road injury collisions*
Potential Collision Reduction	*4-25%*
Planning-Level Cost	*$300 per sign*

Source: FHWA

Install Dynamic Feedback Sign on Curves

Install Dynamic Feedback Sign on Curves

Dynamic speed warning signs alert drivers of their speed into the approach of a curve when their speed is above the curve design speed. Dynamic speed warning signs can reduce curve-related crashes by providing visual feedback to the driver that speeds should be reduced when approaching a curve.

Intersection or Segment	*Segment*
Applicable Collision Types	*All collisions*
Potential Collision Reduction	*5%*
Planning-Level Cost	*Varies*

Source: FHWA

Increase Pavement Friction

Increase Pavement Friction

High friction surface treatments apply aggregate to the pavement to increase or maintain the pavement friction at a site. Increasing or maintaining appropriate pavement friction through a curve can reduce the potential for motorists to lose control of their vehicle or skid when navigating a curve. Increased pavement friction has been shown to reduce crash frequency during wet conditions and in locations with high friction demand caused by vehicle speeds or roadway geometrics.

Intersection or Segment	*Segment*
Applicable Collision Types	*Collisions on wet roads*
Potential Collision Reduction	*20-68%*
Planning-Level Cost	*$30 per sq yd*

Source: FHWA

Remove, Relocate, or Protect Fixed Objects Adjacent to Road

Remove, Relocate, or Protect Fixed Objects Adjacent to Road	
Remove or relocate fixed objects adjacent to the roadway to increase the unpaved shoulder clear zone. Clearing or moving fixed-objects away from the roadway can reduce fixed-object crashes by providing a clear zone that gives drivers more space and time to correct their path should they leave the road.	
Intersection or Segment	*Segment*
Applicable Collision Types	*All collisions*
Potential Collision Reduction	*38%*
Planning-Level Cost	*Varies*

Source: Florida Vegetation Management Association

Install Wider Edge-lines

Install Wider Edge-lines	
Restripe edge-lines to increase their width to improve visibility for drivers. Wider edge-lines more clearly define the edge of the roadway. This increased visibility of the edge of roadway can reduce the incidence of vehicles leaving the roadway.	
Intersection or Segment	*Segment*
Applicable Collision Types	*Run off the road collisions*
Potential Collision Reduction	*11-13%*
Planning-Level Cost	*$0.20 per ft (paint); $0.80 per ft (thermoplastic); $2.00 per ft (MMA)*

Source: Texas A&M Transportation Institute

3.4 PEDESTRIAN AND BICYCLE COUNTERMEASURES

This section includes countermeasures proposed to improve conditions specifically for bicyclists and pedestrians. We have proposed the countermeasures based on existing conditions findings relevant to these road user groups, as presented in Table 5.

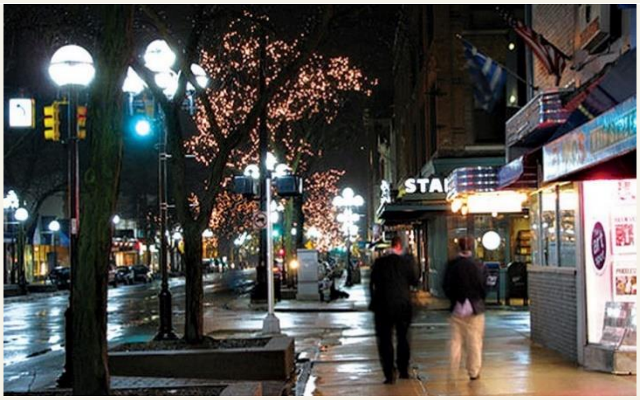
Table 7. Pedestrian and Bicycle Countermeasures and Rationale for Selection

Why was this countermeasure selected for Bend?	Pedestrian-Scale Lighting	Install Pedestrian Countdown Timer	Leading Pedestrian Interval at Signal	Install, buffer, or separate bicycle lanes	Bike Box	Two-Stage Turn Queue Box	Lane Reconfiguration
Bend has a relatively high proportion of reported collisions in darkness with no street lights compared to peer cities.	X						
Pedestrian Findings							
94 percent of pedestrian crashes resulted in some level of injury or fatality. 24 percent of pedestrian crashes resulted in fatality or incapacitating injuries.	X	X	X				X
90 percent of pedestrian crashes occurred within 250' of intersections. 28 percent of pedestrian crashes occurred at traffic signals.		X	X				
36 percent of pedestrian crashes occurred on, or at intersections with, five-lane roads. 12 percent of pedestrian crashes occurred on, or at intersections with, four lane roads							X
Most fatal/incapacitating pedestrian collisions involved motorists continuing straight (not turning) (9 of 12 crashes)	X	X	X				
12 of the 16 fatal/incapacitating pedestrian crashes occurred in dark conditions without street lights	X						
Bicyclists Findings							
93% of bicyclist collisions within 250 feet of an intersection				X	X	X	X
44 percent of bicycle crashes occurred at two-way stop-controlled intersections				X			X
25 percent of bicycle crashes occurred at traffic signals				X	X	X	X
68% of intersection bicycle collisions were along high-stress (LTS 3 or 4) roadways. 75% of fatal/incapacitating bicycle crashes occurred on, or at intersections of, high-stress roadways.				X	X	X	X

Why was this countermeasure selected for Bend?	Pedestrian-Scale Lighting	Install Pedestrian Countdown Timer	Leading Pedestrian Interval at Signal	Install, buffer, or separate bicycle lanes	Bike Box	Two-Stage Turn Queue Box	Lane Reconfiguration
32% of bicyclist collisions at intersections occurred at intersections with 5-lane roads							X
49 percent of bicycle crashes were turning-movement crashes. 37 percent of bicycle crashes were angle crashes.				X	X	X	
50% of bicycle collisions at intersections were cited as *motorist failure to yield right-of-way*.				X	X	X	X
23 percent (26 crashes) of bicycle crashes involved vehicles turning left and bicyclists traveling straight in the opposing direction. The majority of these (23 of 26) occurred at intersections.				X	X	X	X
8 percent of bicycle crashes involved right-hooks, in which a right-turning vehicle and a bicycle traveling through the intersection from the same direction, collided				X	X	X	X

Pedestrian-Scale Lighting

Pedestrian Scale Lighting	
Pedestrian-scale lighting is lower to the ground and more closely spaced than street or intersection lighting. Pedestrian-scale lighting illuminates sidewalks, increases perception of personal security and comfort for pedestrians, and increase driver awareness and visibility of pedestrians.	
Intersection or Segment	*Intersection/segment*
Applicable Collision Types	*Nighttime Pedestrian and Bicycle Collisions*
Potential Collision Reduction	*42%*
Planning-Level Cost	*$15,000 per pole*



Source: NACTO

Leading Pedestrian Interval

Leading Pedestrian Interval	
Leading Pedestrian Intervals (LPIs) give pedestrians a head-start when making crossings and reduce crashes by making pedestrians more visible to right- or left-turning vehicles. LPIs should be considered at all signalized intersections and especially those with significant pedestrian volumes.	
Intersection or Segment	*Intersection (signalized)*
Applicable Collision Types	*Pedestrian collisions*
Potential Collision Reduction	*37 – 45%*
Planning-Level Cost	*$15,000*

Source: FHWA

Protected Intersection

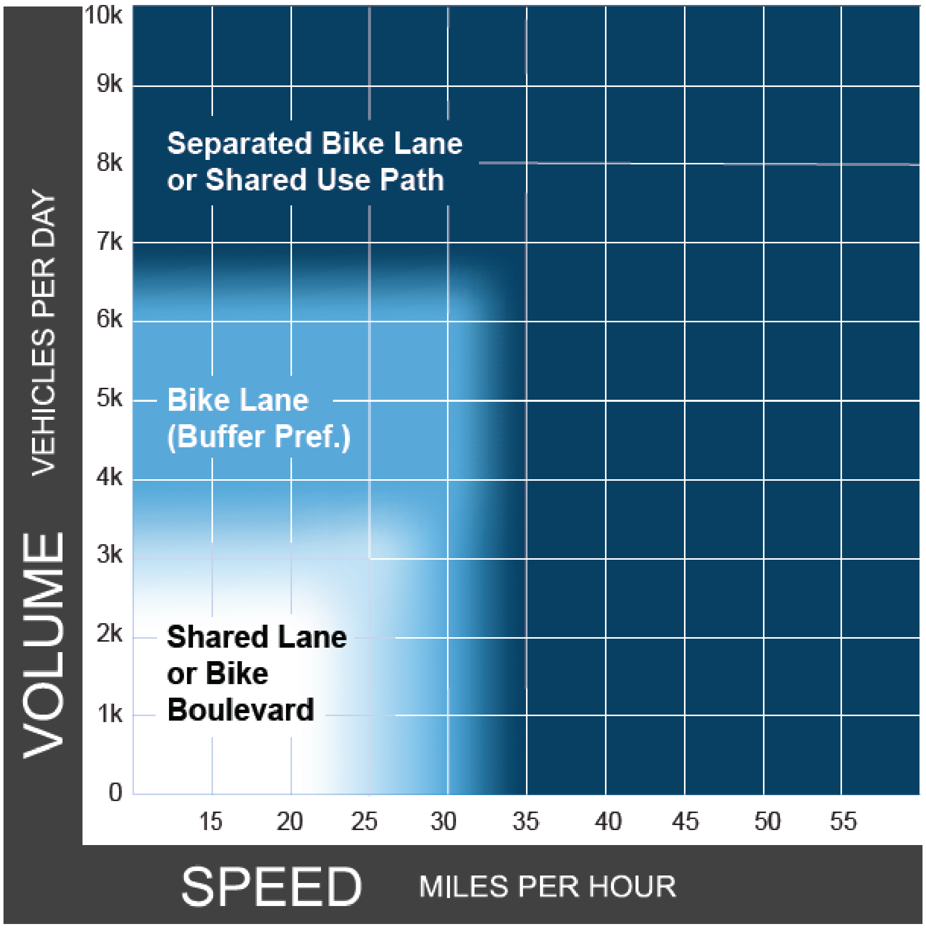
Protected Intersection	
Protected intersections provide physical separation for bicyclists up to and through an intersection. Key design elements (shown in the image below) include: • A corner refuge island • A yield zone for turning motorists • A pedestrian refuge between separated bike lanes and motor vehicle lanes • An advanced stop bar for bicyclists to queue in locations visible to motorists These elements are intended to control speeds, promote visibility, and reduce conflicts among motorists, cyclists, and pedestrians.	
Intersection or Segment	*Intersection (signalized)*
Applicable Collision Types	*Bicyclist and Pedestrian collisions*
Potential Collision Reduction	*Not documented*
Planning-Level Cost	$200,000 - $3,000,000

Source: People for Bikes

Bicycle Lanes

This plan recommends *in general* that either bike lanes be added or enhanced based on each location context. The FHWA *Bikeway Selection Guide* makes recommendations for the type of bikeway appropriate given the level of motor vehicle volume and prevailing speeds on a given roadway (see Figure 6). Refer also to the *Bend Draft Bikeway Design Guidelines* (Bend BDG) (see Appendix 8).

Bicycle Facility Selection for Urban or Suburban Areas (Figure 9 from *Bikeway Selection Guide*)



Notes

1 Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.

2 Advisory bike lanes may be an option where traffic volume is <3K ADT.

3 See page 32 for a discussion of alternatives if the preferred bikeway type is not feasible.

Figure 6. Bicycle Facility Selection for Urban or Suburban Areas (Figure 9 from Bikeway Selection Guide)

A detailed description of bikeway treatments is provided below.

Level of Traffic Stress 1 Facilities

Bike Path / Shared-Use Path		
Bike paths provide a separated facility for exclusive bicyclist and pedestrian use. They have minimal or no conflicting motor vehicle traffic. Generally, bike paths serve corridors not served by streets (e.g., river paths or converted rail rights-of-way) or may be parallel to roadways where right-of-way is available (sidepaths). Bike paths provide recreational and commute routes for bicyclists. Shared-use paths are typically installed along independent rights-of-way (for example, along greenways or abandoned rail trails). Path crossings may be designed with yield, signal, or stop control depending on path volume and traffic volume on the crossing street. Refer to MUTCD 9C.04 for more information.		
Intersection or Segment	*Segment*	 Source: Kittelson
Applicable Collision Types	*Bicycle Collisions*	
Potential Collision Reduction	*Varies*	
Planning-Level Cost	*$200 per linear foot*	

Bike Lanes / Buffered Bike Lanes

Bike Lanes / Buffered Bike Lanes	
Bike lanes are on-street facilities. This facility type includes bike lanes with a painted buffer (stripe) but no physical (horizontal and vertical) separation between vehicle travel lanes and bicycle travel lanes. Buffered bike lanes provide extra lateral separation visually but without vertical elements. In general, a buffer is preferred where possible.	
Intersection or Segment	*Segment*
Applicable Collision Types	*Bicycle Collisions*
Potential Collision Reduction	*0 – 53%*
Planning-Level Cost	*$4,000 per mile(buffered)*

Source: Kittelson

Neighborhood Greenways

Neighborhood Greenways / Bicycle Boulevards	
Bike routes (which may be designated as "bicycle boulevards" or "neighborhood greenways") provide shared use of right-of-way among bicyclists and motorists, as designated by signs or permanent markings along a route. Roadways designated as neighborhood greenways should have enough width to accommodate motorists and bicyclists together. Shared-lane markings ("sharrows") can be used to alert users of the shared roadway environment. Because the right-of-way is shared, speed management is essential (see the *Speed Management Toolbox* later in this Plan).	
Intersection or Segment	*Segment*
Applicable Collision Types	*Bicycle Collisions*
Potential Collision Reduction	*Varies*
Planning-Level Cost	*$300,000 per mile*

Source: NACTO

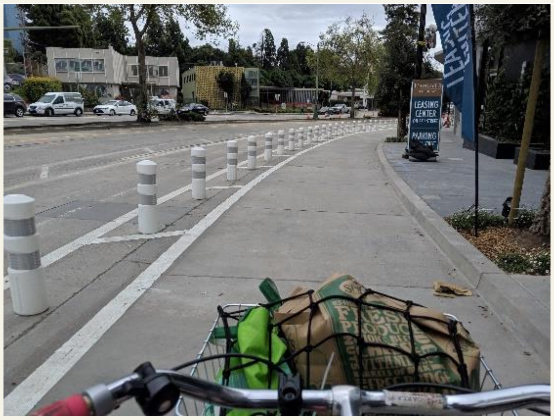
Separated Bikeways

Separated Bikeways

Separated bikeways provide a physical separation from vehicular traffic. This separation may include grade separation (slightly elevated bike lane), flexible posts, planters or other inflexible physical barriers, or on-street parking. These bikeways provide bicyclists a greater sense of comfort and security, especially in the context of high-speed roadways. Separated facilities can provide one-way or two-way travel and may be located on either side of a one-way roadway.

Separated bikeways are appropriate at speeds and volumes where bike lanes or buffered bike lanes do not adequately address the comfort needs of a majority of the candidate biking population. These facilities are more appropriate than shared-use paths if pedestrian and bicyclist volumes are expected to be relatively high (i.e., separation of bicyclists and pedestrians is encouraged).

Intersection or Segment	*Segment*
Applicable Collision Types	*Bicycle Collisions*
Potential Collision Reduction	*Varies*
Planning-Level Cost	*$110,000*



Source: Kittelson

Install Green Bike Lanes at Conflict Points

Install Green Bike Lanes at Conflict Points

Colored pavement can be used to call attention and increase visibility of potential conflict areas. Colored bike facilities can be used as a spot treatment (i.e., across a turning movement as shown below) or along the length of a bike lane. Colored pavement has been shown to increase motorist yielding.[1] The MUTCD specifies that colored paint for bicycle facilities must be green to avoid confusion with other traffic control markings.

Intersection or Segment	*Segment/Intersection*
Applicable Collision Types	*Bicycle Collisions*
Potential Collision Reduction	*39%*
Planning-Level Cost	*$9 per square foot*

Source: Kittelson

[1]*Sources: NACTO* Urban Bikeway Design Guide; *Hunter, WW et al (2000). Evaluation of Blue Bike-Lane Treatment in Portland, Oregon.* Transportation Research Record, *1705, 107-115.*

Bike Box / Advanced Stop Bar

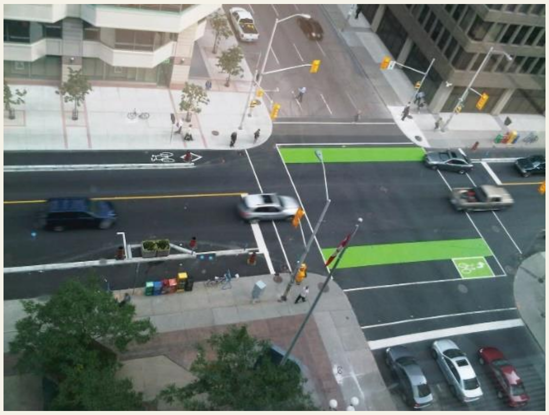
Bike Box / Advanced Stop Bar

A bike box or advanced stop bar provides dedicated space for cyclists at the head of a traffic lane. Bike boxes enhance cyclist visibility, reduce the risk of "right hook" collisions, and provide opportunities for cyclists to position themselves for left turns. The bike box is still an experimental treatment per FHWA. A bike box that extends across an entire approach can be used to help position left-turning cyclists, or to transition from a right-side bike lane to a left-side bike lane. Alternatively, two-stage turn queue boxes can be used when multiple through lanes are present. Bike boxes are appropriate at signalized intersections with high volumes of bicyclists and right-turning vehicles, typically along a bike lane or urban greenway.

Intersection or Segment	*Intersection*
Applicable Collision Types	*Bicycle Collisions*
Potential Collision Reduction	*35%*
Planning-Level Cost	*$9 per square foot*

Source: Marc Caswell, San Francisco Bicycle Coalition

Two-Stage Turn Queue Boxes

Two-Stage Turn Queue Boxes		
Two-stage turn queue boxes provide cyclists with an opportunity to turn (usually left) across multiple lanes of traffic by providing formal space to make turn maneuvers. They increase the time it takes a cyclist to make an associated turn because the cyclist must wait through multiple signal phases. The two-stage turn box is an experimental treatment per FHWA. They may also be used for turns at midblock crossing locations or for right turns from a left-side bike lane.		
Intersection or Segment	*Intersection*	 Source: NACTO
Applicable Collision Types	*Bicycle Collisions*	
Potential Collision Reduction	*None documented (Qualitatively: allows bike riders to reduce conflicts and improve angle of approach to an intersection)*	
Planning-Level Cost	-	

Lane Reconfiguration

<table>
<tr><th colspan="3">Lane Reconfiguration</th></tr>
<tr><td colspan="3">A roadway reconfiguration often adds dedicated left-turn lanes (sometimes right turn lanes are added) by re-allocating roadway space. Roadway reconfigurations are considered when the road is not operating efficiently, when there are rear-end or crossing crashes, or when a system element is missing and needs to be added. A typical situation occurs when left-turns are accommodated in the through travel lane and the number of left-turns is great enough to cause delay to drivers trying to continue straight. When this situation occurs in both directions, it is more efficient to provide a dedicated left-turn lane. The pavement space that is freed up can be used for on-street parking, on-street parking buffer space (so people have more space to exit their parked cars), or adding bike lanes or widening sidewalk. The treatment aims to reduce conflicts, increase system efficiency and increase safety benefits for each road user.</td></tr>
<tr><td>Intersection or Segment</td><td>Segment</td><td rowspan="4">

Source: FHWA</td></tr>
<tr><td>Applicable Collision Types</td><td>All collisions</td></tr>
<tr><td>Potential Collision Reduction</td><td>29%</td></tr>
<tr><td>Planning-Level Cost</td><td>$20,000 per mile</td></tr>
</table>

3.5 ENHANCED PEDESTRIAN CROSSINGS

Within the recommended countermeasures that address safety issues for pedestrians, a subset provides options for enhancing pedestrian crossings. These treatments are summarized in Table 6 and include the following:

- Curb extension
- Pedestrian refuge island
- Rapid rectangular flashing beacon
- Pedestrian hybrid beacon
- Pedestrian signal

The strategies improve pedestrian crossings in ways that range from increasing pedestrian visibility and increasing driver awareness of the crossing to providing a refuge to allow the pedestrian to cross in two stages.

Table 8. Enhanced Pedestrian Crossing Treatments and Rationale for Selection

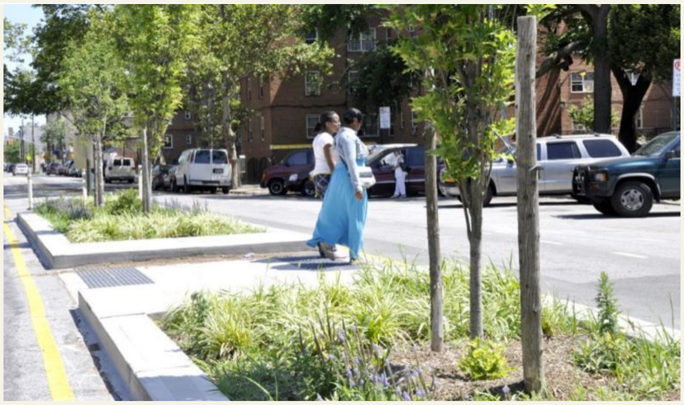
Why was this countermeasure selected for Bend?	Curb Extension	Pedestrian Refuge Island	Rapid Rectangular Flashing Beacon	Pedestrian Hybrid Beacon	Pedestrian Signal
94 percent of pedestrian crashes resulted in some level of injury or fatality. 24 percent of pedestrian crashes resulted in fatality or incapacitating injuries.	X	X	X	X	X
The most common contributing factors in pedestrian collisions were failure for the motorists to yield the right-of-way, non-motorists illegally in roadway, and non-motorist clothing not visible.	X	X	X	X	X
90 percent of pedestrian crashes occurred within 250' of intersections. 48 percent of pedestrian crashes occurred at two-way stop-controlled intersections. 28 percent of pedestrian crashes occurred at traffic signals.	X	X	X	X	X
36 percent of pedestrian crashes occurred on, or at intersections with, five-lane roads. 12 percent of pedestrian crashes occurred on, or at intersections with, four lane roads.	X	X	X	X	X
Most fatal/incapacitating pedestrian collisions involved motorists continuing straight (not turning) (9 of 12 crashes)	X	X	X	X	X

Curb Extensions

Curb Extensions		
Curb extensions visually and physically narrow the roadway at pedestrian crossing locations and provide additional space to wait at street corners while reducing crossing distances for pedestrians. Curb extensions increase visibility of pedestrians by bringing the crossing further into the roadway. This is especially beneficial with the presence of on-street parking at the approach to the crossing. Curb extensions can also serve as transit stop locations to support bus priority in not leaving the traffic stream.		
Intersection or Segment	*Intersection/Segment*	 Source: Kittelson
Applicable Collision Types	*Pedestrian Collisions*	
Potential Collision Reduction	*37%*	
Planning-Level Cost	*$20,000*	

Pedestrian Safety Island

Pedestrian Safety Island	
Median refuge islands are physical crossing enhancements that allow for two-stage crossings (where people only need to cross one direction of travel at a time). This effectively shortens the crossing distance and reduces exposure to vehicles. Median refuge islands are most suitable for locations where pedestrians must cross three or more vehicle travel lanes (but may also be considered in other locations, space permitting). Medians may also support speed management on high-speed roadways at uncontrolled or midblock crossing locations.	
Intersection or Segment	*Intersection/Segment*
Applicable Collision Types	*26 – 31%*
Potential Collision Reduction	*37%*
Planning-Level Cost	*$25,000*



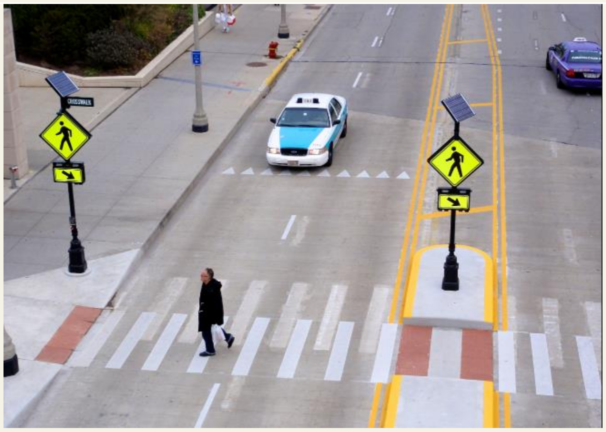
Source: New York City DOT

Rectangular Rapid Flashing Beacon (RRFB)

Rectangular Rapid Flashing Beacon

Rectangular rapid-flashing beacons (RRFBs) are pedestrian-actuated warning signs supplemented with high-visibility LED lights. When activated, RRFBs flash a high-visibility strobe-like light warning drivers when pedestrians are crossing. RRFBs have shown to reduce pedestrian collisions by up to 47%. RRFBs should be used in locations with high pedestrian safety issues as over-use may diminish their effectiveness. Installing median safety islands with RRFBs can further increase effectiveness.

Intersection or Segment	*Segment*
Applicable Collision Types	*Pedestrian Collisions*
Potential Collision Reduction	*10 – 56%*
Planning-Level Cost	*$20,000 - $50,000*



Source: FHWA

Pedestrian Hybrid Beacon (PHB)

Pedestrian Hybrid Beacon (PHB)	
Pedestrian Hybrid Beacons (PHBs) are traffic control devices that provide dedicated time for pedestrians to cross the street. PHBs can reduce pedestrian crashes by requiring vehicles to stop at a crossing location. PHBs are typically installed at locations where pedestrians need to cross a multilane roadway and vehicle speeds or volumes are high. PHBs are suitable for locations where major street volume or speed limits inhibit safe pedestrian crossing, or if pedestrian delay is excessive. PHBs should be considered for locations that do not meet the traffic signal warrant based on vehicle or pedestrian volume criteria, or locations where a traffic signal warrant is met but is chosen to not be installed. PHBs may be appropriate at multi-lane roundabouts.	
Intersection or Segment	*Intersection/Segment*
Applicable Collision Types	*Pedestrian Collisions*
Potential Collision Reduction	*55 – 69%*
Planning-Level Cost	*$70,000*

Source: Kittelson

Pedestrian Signal

Pedestrian Signal		
Pedestrian signals are pedestrian crossing treatments for previously uncontrolled locations that have significant pedestrian volumes. Pedestrian signals provide an exclusive signal phase that stops conflicting vehicular movements. Pedestrian signals may be activated by a push-button or actuated through pedestrian detection.		
Intersection or Segment	*Segment*	 Source: Kittelson
Applicable Collision Types	*Pedestrian Collisions*	
Potential Collision Reduction	*15 – 69%*	
Planning-Level Cost	*$250,000*	

SECTION 4

SPEED MANAGEMENT TOOLBOX

4. SPEED MANAGEMENT TOOLBOX

Kittelson identified aggressive driving, which includes excessive speeding, as an emphasis area for the City and identified a programmatic recommendation for a speed management program (see action item A-13 in Section 6: Non-Infrastructure Recommendations). Excessive speed can exacerbate risks when a crash occurs, especially for bicyclists and pedestrians. As such, managing speeds is an area of continued interest for the City. Kittelson developed a secondary set of treatments for managing speeds, either by reducing the frequency of unsafe speeds by motorists and/or by clearly indicating to drivers when speeds need to be reduced to prepare for a change in roadway conditions, such as a stop-controlled intersection or curve. Kittelson focused on low-cost treatments that may be implemented in a systemic manner.

The types of treatments and other strategies presented in the Speed Management Toolbox are organized into the following three categories:

- Pavement markings;
- Physical roadway improvements; and,
- Signage.

For each treatment, a description is provided as well as guidance on typical application.

4.1 PAVEMENT MARKINGS

This section describes speed management treatments that use pavement to provide visual cues and messaging.

Transverse Lane Marking

Description: Transverse lane markings are horizontal markings placed on the roadway. There are many types of transverse lane markings including optical bars and chevron marking. They may extend partially into a lane or be placed fully across the lane.

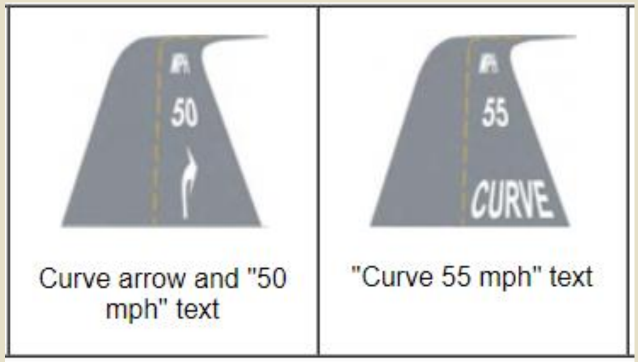
Application Guidance: Transverse markings are especially useful for transition zones and can be used in locations where there is an approaching change in roadway character such as an intersection or curve. Markings may be spaced increasingly closer on the approach to an intersection to give the appearance so a driver is more aware of their speed. Transverse lane markings support decreased speeds on intersection approaches or other roadway transition. Optical speed bars are an additional type of transverse marking. MUTCD Section 3B.22 provides guidance on placement of optical speed bars.

Source: FHWA

Speed Advisory Markings in Lane (“Slow”, “Curve”, or “Speed Limit XX”)

Description: Advisory markings provide information before curves and other advisory zones. Markings may include the speed limit or a warning of an approaching curve.

Application Guidance: NCHRP Report 600: *Human Factors Guidelines for Road Systems* contains guidelines for effective markings. The report found that usage of speed advisory markings may lower speeds by up to 4 MPH and showed an 11% reduction in vehicles exceeding the speed limit. Speed advisory markings can supplement other signage such as curve advisory signs. MUTCD Section 3B.20 provides design and placement criteria for pavement advisory markings.



Source: FHWA

Colored Pavement Advisory Markings

Description: Adding color to advisory pavement markings may make the markings more visible to the driver.

Application Guidance: Colored pavement markings are typically used in transition zones but may be appropriate for rural roadways in general or where there is a change in roadway character, such as an approaching curve. Studies have study found colored pavement markings reduced mean speeds between 2.3 and 7.4 MPH.

Source: Iowa State University, Speed Management Toolbox for Rural Communities

Shoulder Widening to Narrow Travel Lanes

Description: Shoulders in rural areas can be widened to visually narrow the roadway. The example figure shows an example of shoulders with transverse striping. Shoulders can be colored to further define the roadway edge and further the appearance of lane narrowing.

Application Guidance: This treatment is most applicable in areas where there is the right-of-way available to widen the shoulder. Narrowing lanes can reduce excessive speeding, but lanes that are too narrow for larger vehicles may increase crashes.

Source: Iowa State University, Speed Management Toolbox for Rural Communities

Wider Edge-Lines

Description: Edge-lines are a visual pavement marking that guide drivers when navigating a roadway. Wider edge-lines further delineate the roadway path, make the roadway appear narrower, and can increase driver perception of speed.

Application Guidance: Edge-lines can be placed along roadways with curves or long straight segments. Although the specific effect of wider edge-lines on speed is not available, studies have shown that widening edge-lines has reduced crashes on rural roadway segments. Wide edge-lines can only be installed on roadways where there is sufficient right-of-way. See the countermeasure treatment toolbox for more information on wider edge-lines.

Source: FHWA

4.2 PHYSICAL ROADWAY IMPROVEMENTS

This section describes speed management treatments that alter the physical roadway. The treatments range from relatively low-cost treatments, like vertical centerline posts to more expensive construction projects, such as installing a roundabout.

Splitter Islands at Intersections

Description: Splitter islands are a treatment for stop-controlled intersections that may on the approach to an intersection to increase the intersection visibility and add left-side stop sign. They can also be used to provide deflection on the intersection approach to support speed reduction. They help channelize and guide turning vehicles from the major roadway.

Application Guidance: Splitter islands have been shown to be effective at decreasing traffic speed and reducing intersections crashes. Splitter islands can be combined with doubled-up stop signs for increased visibility. NCHRP Report 279 covers splitter island design and placement.

Source: FHWA

Horizontal Deflections

Description: Horizontal deflections are a type of physical roadway or curb enhancement to narrow or otherwise break up a roadway's straight design character. A horizontal deflection requires the motorist to navigate a curvilinear alignment stay on the roadway path.

Application Guidance: Horizontal deflections can provide a visual endpoint for the roadway along curves. Lateral shifts, chicanes, and roundabouts are examples of horizontal deflections. Horizontal deflections are more common in populated areas and can be integrated as a part of other roadway infrastructure such as medians, pedestrian islands, or curb extensions. Center islands are an additional type of horizontal defection that provides separation from traffic and can reduce the risk of a head-on collision occurring.

Source: City and County of San Francisco

Vertical Centerline Posts

Description: Vertical centerline posts are a type of vertical treatment that delineates the centerline. This treatment is also known as a longitudinal channelizer.

Application Guidance: Vertical delineators can be used for lane narrowing. Delineators may be between 18-36 inches tall and spaced 32 inches apart. Posts should only be applied where there is enough room in the roadway to accommodate larger vehicles. This treatment can help reduce speed along long straight roadways. Centerline vertical delineators placed on rural roads have been shown to reduce average speed by as much as 3 MPH. Delineators also have the benefit of separating oncoming traffic and potentially reducing the risk of head-on collisions.

Source: Iowa State University, Speed Management Toolbox for Rural Communities

Sinusoidal Transverse Rumble Strips

Description: Rumble strips provide an auditory warning to drivers of an approaching change in roadway character. Sinusoidal rumble strips are a type of rumble strip that has a sine wave milled into the pavement. This design reduces the amount exterior noise of the rumble strips and vibration while still providing interior noise and rumble.

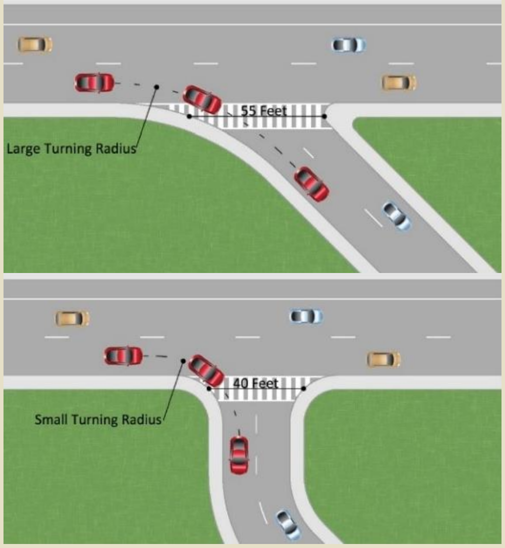
Application Guidance: Sinusoidal rumble strips can be applied in the same way that transverse rumble strips are installed. The grooves of transverse rumble strips are installed perpendicular to the roadway travel lane. Transverse rumble strips are most effective at locations before an intersection, transition zone, or other change in roadway character. The sinusoidal design allows the speed management benefits of transverse rumble strips without the noise.

Source: Caltrans

Intersection Realignment

Description: Realigning a skewed intersection to meet at a right angle can improve safety performance and decrease speed in the approach to the intersection by making the intersection more visible.

Application Guidance: In an intersection realignment, the straight-through movement should become the top of the 'T' and approaches should be as perpendicular as possible, given site conditions. Intersection realignment also improves sight distance for drivers approaching the intersection.



Source: FHWA, *Pedestrian Safety Guide and Countermeasure Selection System*

Speed Tables

Description: Speed tables are flat-top mounds that cover the full width of the roadway to create vertical deflection. Speed tables are similar in design to speed humps with an elongated top that covers the wheelbase of a passenger car.

Application Guidance: Speed tables can target speeds as high 25 MPH. Speed tables are most effective in transition zones or community-focused streets. Consideration should be given to accommodate trucks, emergency responders, or other larger vehicles.

Source: FHWA

4.3 SIGNAGE

This section describes treatments that manage speed through improved communications with drivers. The treatments are generally targeted at locations, such as prior to a curve, where changing roadway conditions reduce the appropriate roadway speed.

Dynamic Speed Displays and Vehicle-Actuated Signs / Speed Trailers

Description: Dynamic speed feedback signs display the speed of approaching vehicles. Dynamic signs can display other information or signage that is triggered by an approaching vehicle.

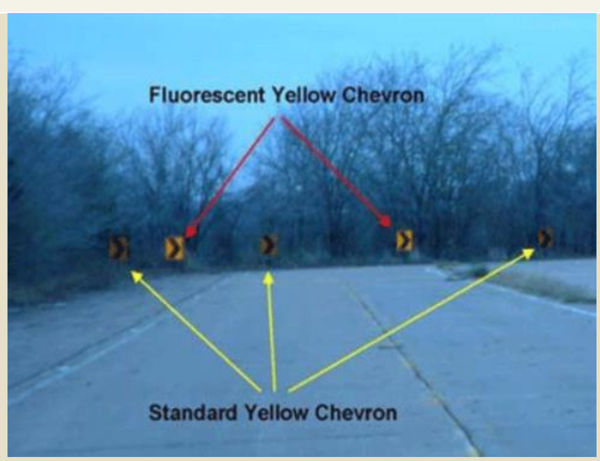
Application Guidance: Dynamic speed feedback signs on rural roadways may reduce 85th percentile speeds by 2 – 7 MPH. Typical applications include paring a dynamic speed feedback sign with a speed limit sign or curve advisory sign.

Source: FHWA

Enhanced Signing

Description: A number of enhanced signing techniques can be applied to rural roadways, including oversized and fluorescent signage. Other techniques include placing retroflected strips on existing signage, such as chevrons or curve advisory signs.

Application Guidance: Fluorescent or retroreflective sheeting on signage makes signage more visible, especially in low-light conditions. Retroreflective strips on signage may help reduce the number of vehicles exceeding the speed limit and a reduction in overall mean speed.



Source: Texas Transportation Institute

Curve Warning Sign with Flashing Beacon

Description: Flashing beacons supplement curve warning signs at the approach to a horizontal curve by attracting driver attention to the curve.

Application Guidance: The 2009 MUTCD contains guidance on curve warning signs and the use of flashing beacons. Studies of speed-activated beacons have shown an average speed reduction of 1 – 8 MPH. Beacons can also be placed overhead the roadway to improve visibility.

Source: Michigan Department of Transportation

LEDs in Pavement Markings or Signs

Description: LEDs can be embedded in delineators or any warning or regulatory sign. MUTCD Section 2A.08 contains guidance on the installation of signage with embedded LEDs.

Application Guidance: LEDs can draw driver attention and improve comprehension of signage on curves. This treatment has also been applied LEDs experimentally by placing LEDs in the roadway serving the function of roadway advisory pavement markings. LEDs may also be embedded in speed limit signs. LEDs on speed limit signs have been shown to reduce the number of vehicles that were traveling over the speed limit.

Source: Marc Hutchins and Nick Hutchins

Community Gateway Signage

Description: Gateways are a type of sign or other visual cue that indicates that the motorist is entering a community or more urbanized area.

Application Guidance: Gateways may be placed overhead and completely span roadway or may simply be placed to the right of the road. Gateways are most effective when placed at transition zones into urban areas. Gateways have shown effectiveness at reducing speed in studies performed outside of the United States.

Source: Iowa State University, Speed Management Toolbox for Rural Communities

Photography: ©2008 Dustin Mitsch / Alpen Exposure

SECTION 5

LOCATION SPECIFIC APPLICATIONS

5. LOCATION SPECIFIC APPLICATIONS

After identifying emphasis areas based on reported crashes in Bend, Kittelson implemented a network screening approach to identify priority locations for recommendations. *Network screening* refers to a process to review a roadway network for the purpose of identifying and ranking locations that would benefit from safety countermeasures. Kittelson used two network screening performance measures to identify locations, as described below. The performance measures identified locations with high collision frequency and severity (equivalent property damage only, or EPDO, screening) and locations with a high concentration of particular collision types (excess proportions of specific crash types screening).

5.1 EQUIVALENT PROPERTY DAMAGE ONLY (EPDO) SCREENING

The EPDO performance measure assigns weighting factors to collisions by severity. The weighting factors generally reflect an order of magnitude difference between societal costs of fatal and incapacitating collisions versus less severe injury collisions. The weighting factors, shown below, are based on the Oregon Safety Priority Index System (SPIS) scoring method, which assign scores of 100 to fatal and incapacitating collisions, 10 to Injury B and C collisions, and one to property damage only (PDO) collisions:

- Fatal and Injury A Collisions: 100 points
- Injury B and Injury C Collisions: 10 points
- PDO collisions: 1 point

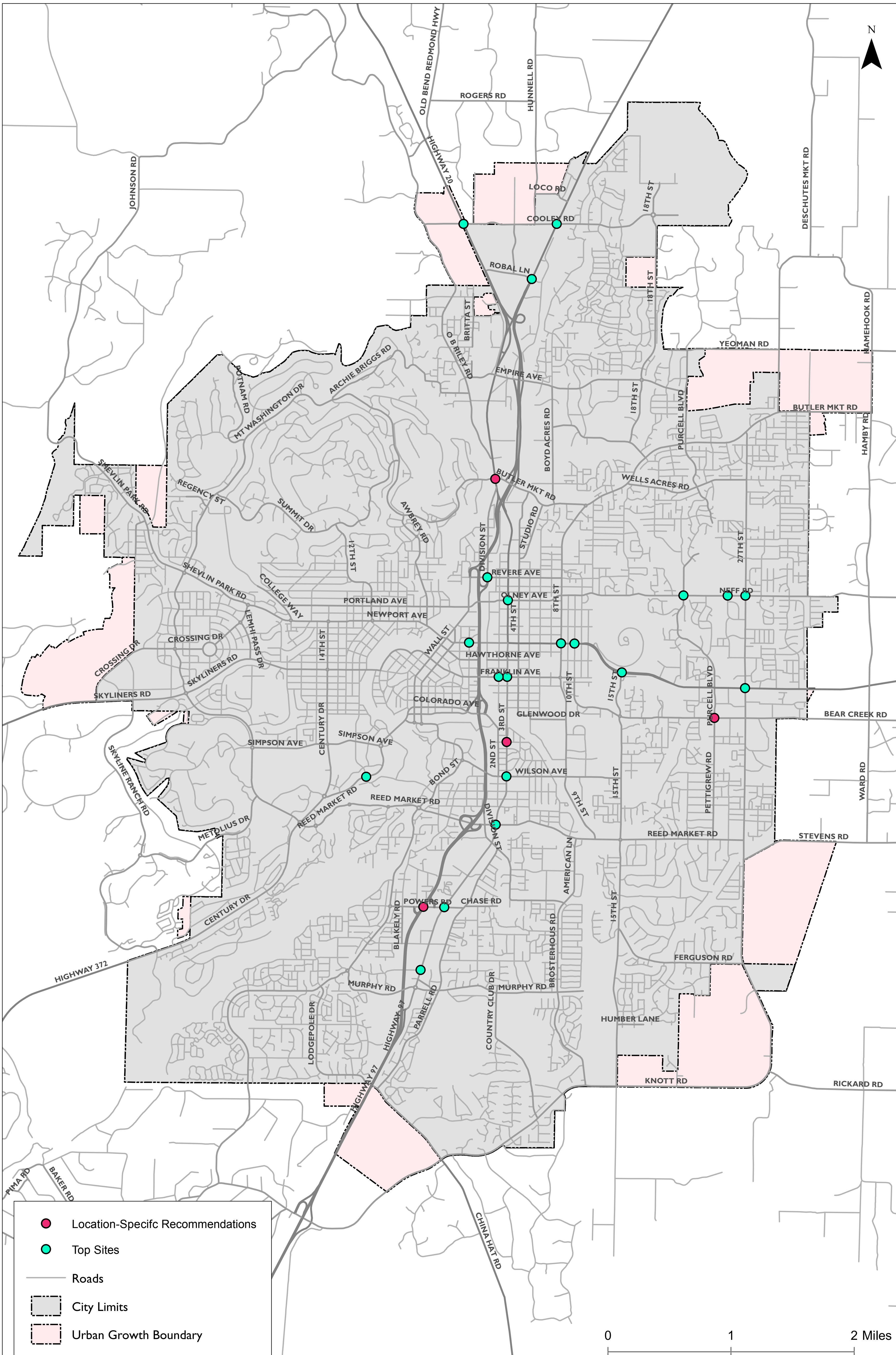
Kittelson used EPDO as the primary performance measure to prioritize site-specific recommendations because it captures the overall frequency and severity of collisions. We identified the intersections with the top 25 EPDO scores in the City, shown in Table 9 and Figure 7. Based on input from City staff, 12 locations were identified for further crash analysis. Kittelson prepared crash diagrams for these intersections. Crash diagrams are provided in Appendix 5 and referenced in Table 9 below. Of these intersections, the City selected four, shown in bold in Table 9 for further recommendations.

Table 9: Top Sites for Safety Improvement, Identified with EPDO Performance Measure

*Intersection Location**	Intersection Involves an ODOT Facility?	Crash Diagram Reference (Appendix 5)**	Number of Reported Crashes, 2012-2016	Annualized EPDO Score
Highway 20 & 27th Street	Yes	Figure 5-1	61	87.8
Highway 20 & 8th Street	Yes	Figure 5-2	37	77.6
Purcell Boulevard & Pettigrew Road & Bear Creek Road	**No**	Figure 5-3	**32**	**71.2**
NE Third Street & Butler Market Road & Mt Washington Drive	**No**	Figure 5-4	**36**	**66.6**
NE Third Street & NE Olney Avenue	Yes	Figure 5-5	41	65.8
SE Third Street & Reed Market Road	No	Figure 5-6	56	63.4
Highway 97 & Powers Road	**Yes**	Figure 5-7	**47**	**59.8**
NE Third Street & NE Franklin Avenue	No	Figure 5-8	47	58.0
Highway 20 & NE Purcell Boulevard	Yes	No	21	56.4
SE Wilson Avenue & SE Third Street	No	No	45	55.8
Third Street & Powers Road	No	Figure 5-9	25	55.4
Miller Avenue & Third Street	**No**	Figure 5-10	**14**	**53.2**
Neff Road & Purcell Boulevard	No	No	50	53.2
NW Greenwood Avenue & NW Hill Street	No	No	17	50.2
Second Street & Franklin Avenue	No	No	9	48.6
NE 27th Street & Neff Road	No	Figure 5-11	37	47.0
Highway 97 & Robal Lane	Yes	No	42	46.2
NE 15th Street & Highway 20	Yes	No	25	42.8
Highway 97 & Cooley Road	No	No	43	39.2
3rd/Pinebrook	No	No	17	37.6
NE Medical Center Drive & NE Neff Road	No	No	17	37.6
Highway 20 & NE 10th Street	Yes	No	16	37.4
SW Columbia Street & SW Colorado Street	No	No	15	37.2
Cooley Road & Highway 20	Yes	No	11	36.4
3rd Street & Division Street/NE Revere Avenue	Yes	Figure 5-12	28	36.2

*Note: Bolded entries indicate that concepts have been developed for these sites; the following section discusses these sites and presents the crash diagram.

**Crash diagrams at several locations were expanded to include the area(s) near the intersection. Multiple figures are provided for these locations.



Top 25 Sites for Safety Improvements
Intersection Screening Results
Bend Area, 2012-2016

Figure 7

H:\23\23156 - Bend Area TSAP\gis\Project Development\Top Sites.mxd - openpdx - 12:27 PM 5/15/2019

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.

5.2 SITE SPECIFIC EVALUATION

Kittelson developed high-level concepts for the four sites identified through the EPDO screening with the City's input. This section summarizes the site-specific characteristics, collision patterns, and recommendations at these sites.

In some cases, near-term and long-term concepts are provided. Near-term concepts are typically lower-cost, easy to implement solutions and often include elements from the Systemic Toolbox. Long-term concepts are typically higher-cost and need additional project development to further refine.

5.2.1 Purcell Boulevard/Pettigrew Road & Bear Creek Road

Purcell Boulevard, Pettigrew Road, and Bear Creek Road are two-lane roadways with a posted speed limit of 35 mph. Bear Creek Road is classified as a minor arterial road that runs parallel to Highway 20 and serves as an east-west connection through the City of Bend to Highway 97. Purcell Boulevard/Pettigrew Road is a north-south major collector road. There is a westbound bike lane on Bear Creek Road east of Purcell Boulevard/Pettigrew Road; no other bike lanes are present. Sidewalk is also discontinuous on both streets. Without bike lanes or sidewalks, people are walking and bike riding on the edge of the motor-vehicle travel lane.

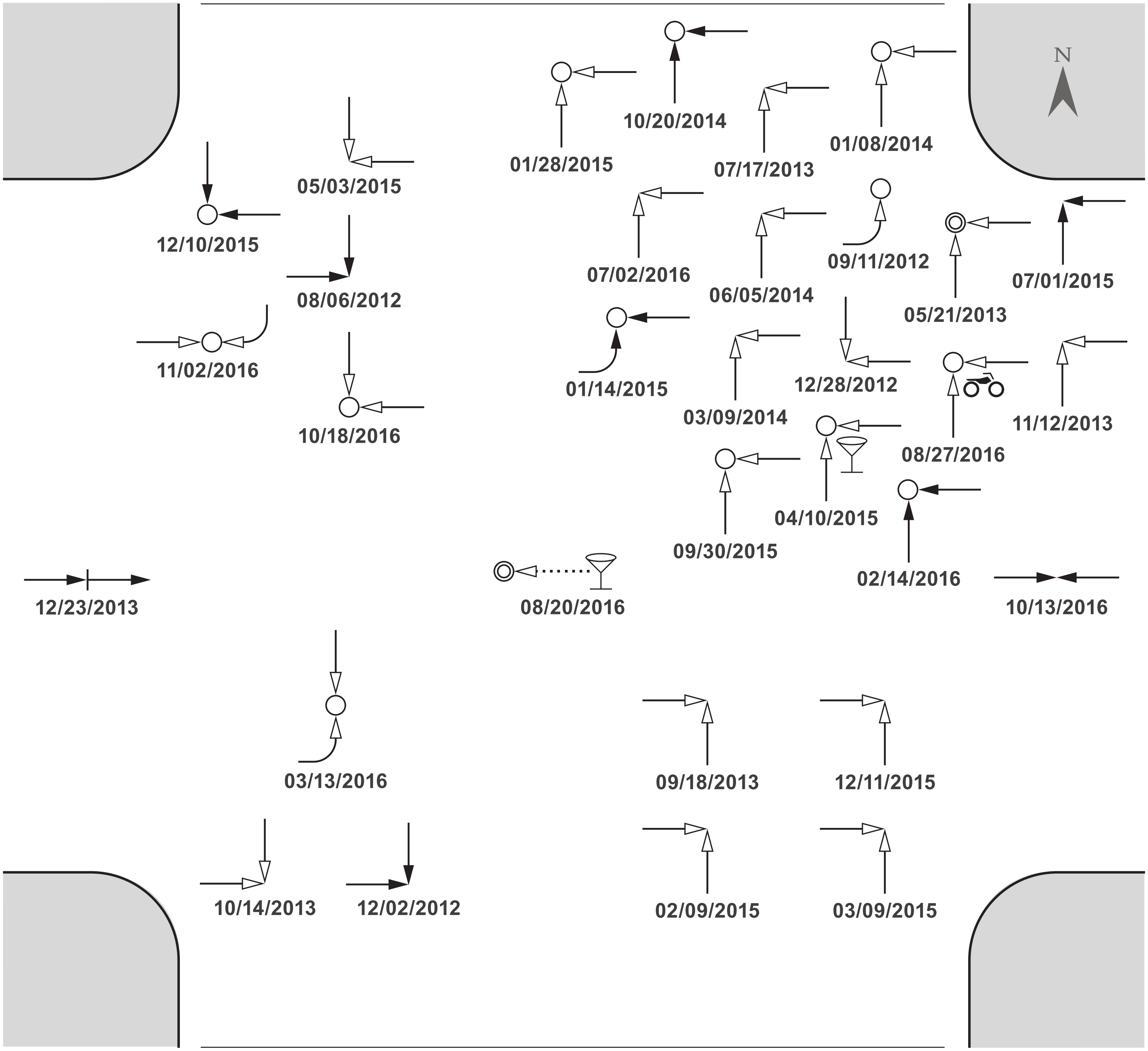
Approximately 78 percent of crashes reported at this intersection were angle crashes, as shown in Figure 8. Half of all crashes resulted in some level of injury. Nearly one-third (28 percent) of all crashes occurred in dark, dusk, or dawn lighting conditions.

The near-term concept is summarized in Figure 9 and includes properly placing stop bars, enhancing signing by doubling up and/or installing larger signs, and assessing sight lines. The systemic recommendations for stop-controlled intersections provide additional information about low-cost treatments.

The longer-term recommendation is to complete both streets and control crossing and turning movements with a single lane roundabout as shown in Figure 10, to reduce angle crashes and injury crashes. The geometry of roundabouts eliminates crossing conflicts, thus reducing conflict points between these road users. The complete street treatments should include storm water management as well as walking and bicycling facilities.

East-West Street **Bear Creek Road** From: **01/01/2012** To: **12/31/2016**

North-South Street: **Purcell Boulevard** Date Prepared: **04/02/2019**



Number of Collisions

16	Property Damage Only
14	Non-incapacitating Injury Collisions
2	Fatal and Incapacitating Injury Collisions
32	Total Collisions

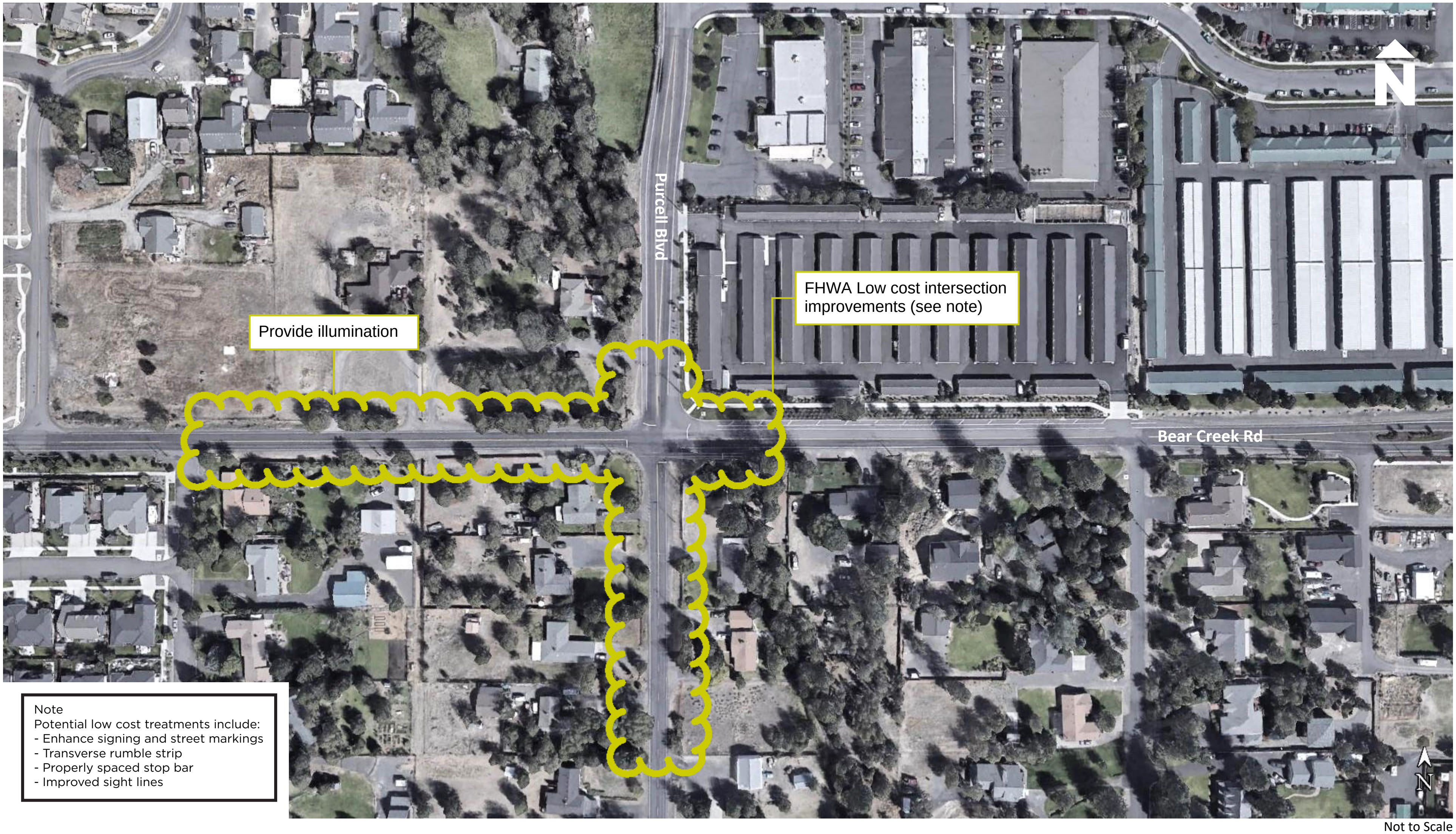
Moving Vehicle
Stopped Vehicle
Backing Vehicle
Ran Off Road
Movement Unknown

Right Turn
Left Turn
Sideswipe
Night
Day

Pedestrian
Fixed Object
Bicycle
Motorcycle
DUI
Non-Incapacitating
Fatal/Incapacitating

City of Bend, Deschutes County, Oregon
DUI represents a collision where alcohol and/or drugs were reported

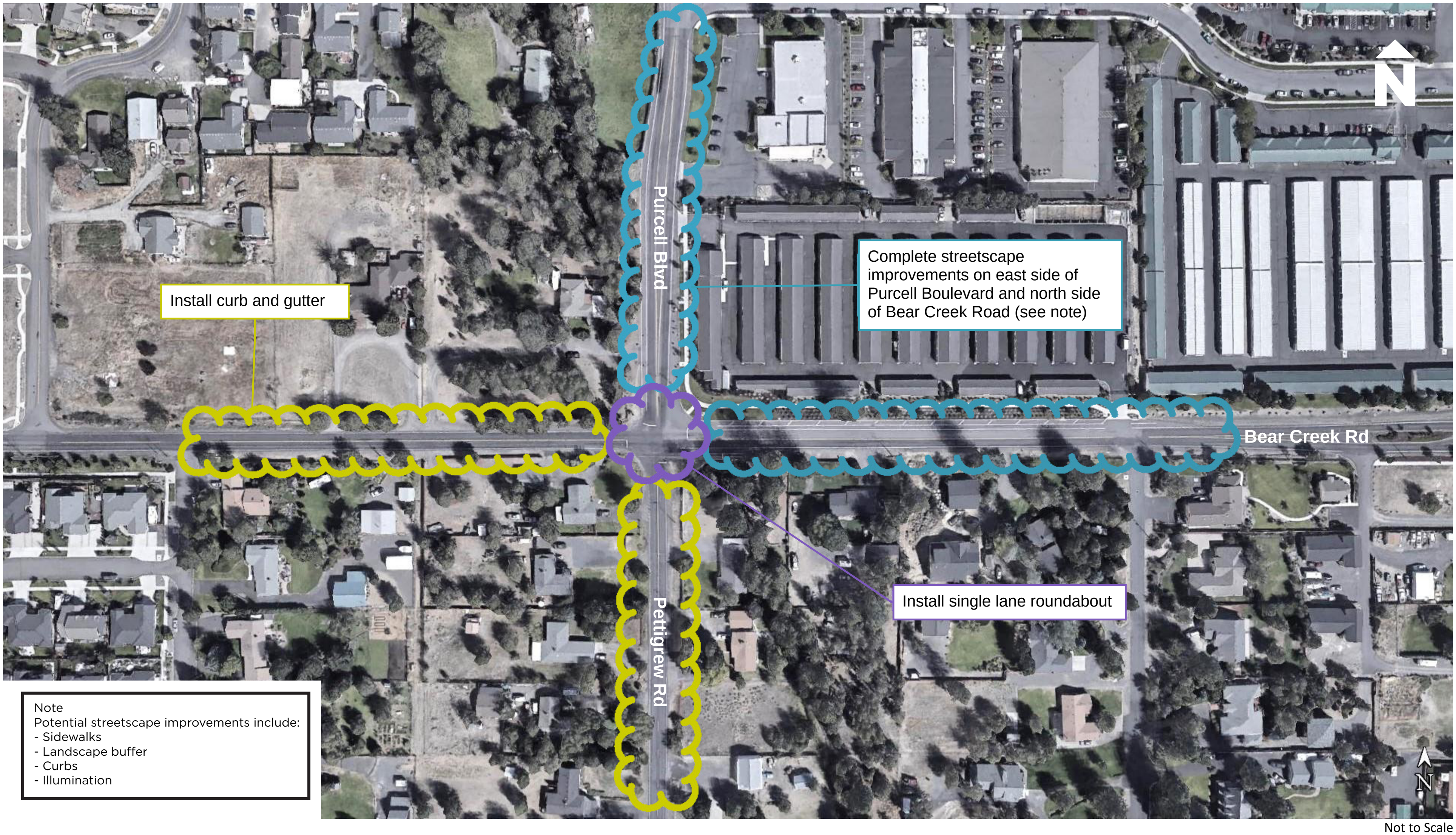
Figure 8
Crash Diagram



KITTELSON & ASSOCIATES

Location-Specific Concept
Bear Creek & Purcell Blvd
Near Term: Low Cost

Figure 9


Purcell Blvd
Complete streetscape improvements on east side of Purcell Boulevard and north side of Bear Creek Road (see note)
Install curb and gutter
Bear Creek Rd
Install single lane roundabout
Pettigrew Rd
N
Note
Potential streetscape improvements include:
- Sidewalks
- Landscape buffer
- Curbs
- Illumination
Not to Scale

5.2.2 3rd Street & Butler Market Road/Mount Washington Drive Area

The 3rd Street & Butler Market Road/Mount Washington Drive intersection near the Division Street intersection and the southbound entrance ramp to US 97. The intersection's operation is, therefore, influenced by these other intersections. For this reason, the analysis and review of this location included the surrounding areas, north to O.B. Riley Road and south to the US 97 entrance ramp.

3rd Street has a five-lane cross-section and is classified as a principal arterial. Posted speeds north of Butler Market Road/Mt Washington Drive are 35 mph and 45 mph south of Butler Market Road/Mt Washington Drive. The posted speed limit for Mount Washington Drive is 30 mph. Bike lanes are provided on the four approaches to the intersection.

Approximately half (49 percent) of reported crashes in this area were reported as rear-end crashes and 36 percent were turning crashes, as shown in Figure 11 through Figure 16.

Concepts at this location are provided for information. However, coordination with ODOT is needed to pursue these. The on-going ODOT Parkway Study is further evaluating these options.

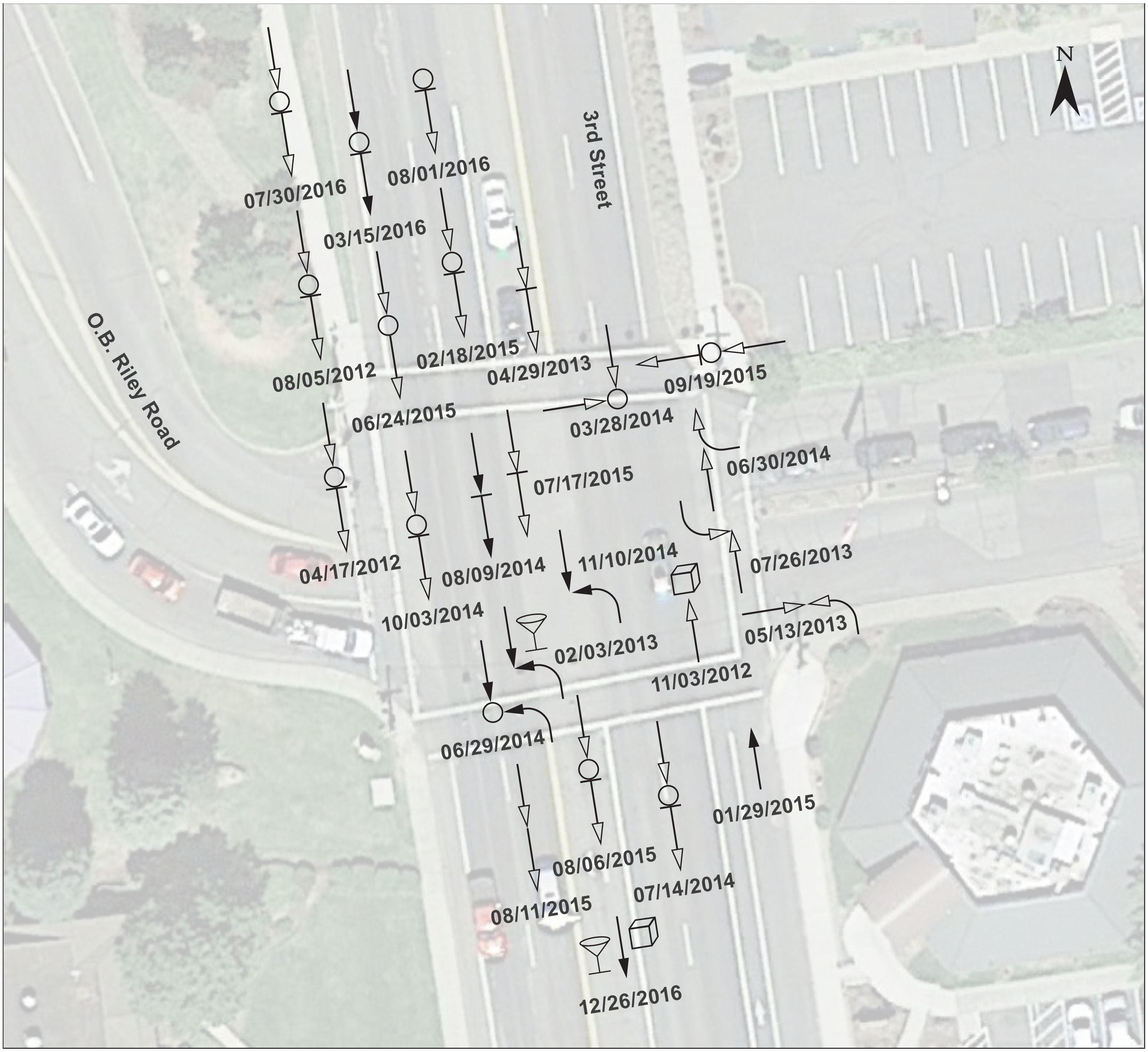
There are two concepts developed to show different options for reducing injuries. Both concepts include an additional connection between Highway 97 and 3rd Street, as shown in Figure 17 and Figure 18. The overall intent of either concept is to reduce traffic volume at the Butler Market Road/Mt. Washington Drive intersection by increasing overall network connectivity to provide more and direct route choices.

In addition, each concept realigns the US 97 southbound exit ramp from 3rd Street onto Division Street and Highway 97. This realignment helps to formalize the intersections at Division Street and Highway 97, helping to reduce wayfinding confusion for southbound vehicles. Concept 1, shown in Figure 17, is based on a new one-way connection, and Concept 2, shown in Figure 18, is based on a two-way connection. The two-way connection would provide a direct connection from Division Street to Butler Market Road.

3rd Street & O.B. Riley Road

From: **01/01/2012** To: **12/31/2016**

Date Prepared: **04/12/2019**



Number of Collisions

12	**Property Damage Only**
13	**Non-incapacitating Injury Collisions**
0	**Fatal and Incapacitating Injury Collisions**
25	**Total Collisions**

Moving Vehicle
Stopped Vehicle
Backing Vehicle
Ran Off Road
Movement Unknown
Right Turn
Left Turn
Sideswipe
Night
Day
Pedestrian
Fixed Object
Bicycle
Motorcycle
DUI
Non-Incapacitating
Fatal/Incapacitating

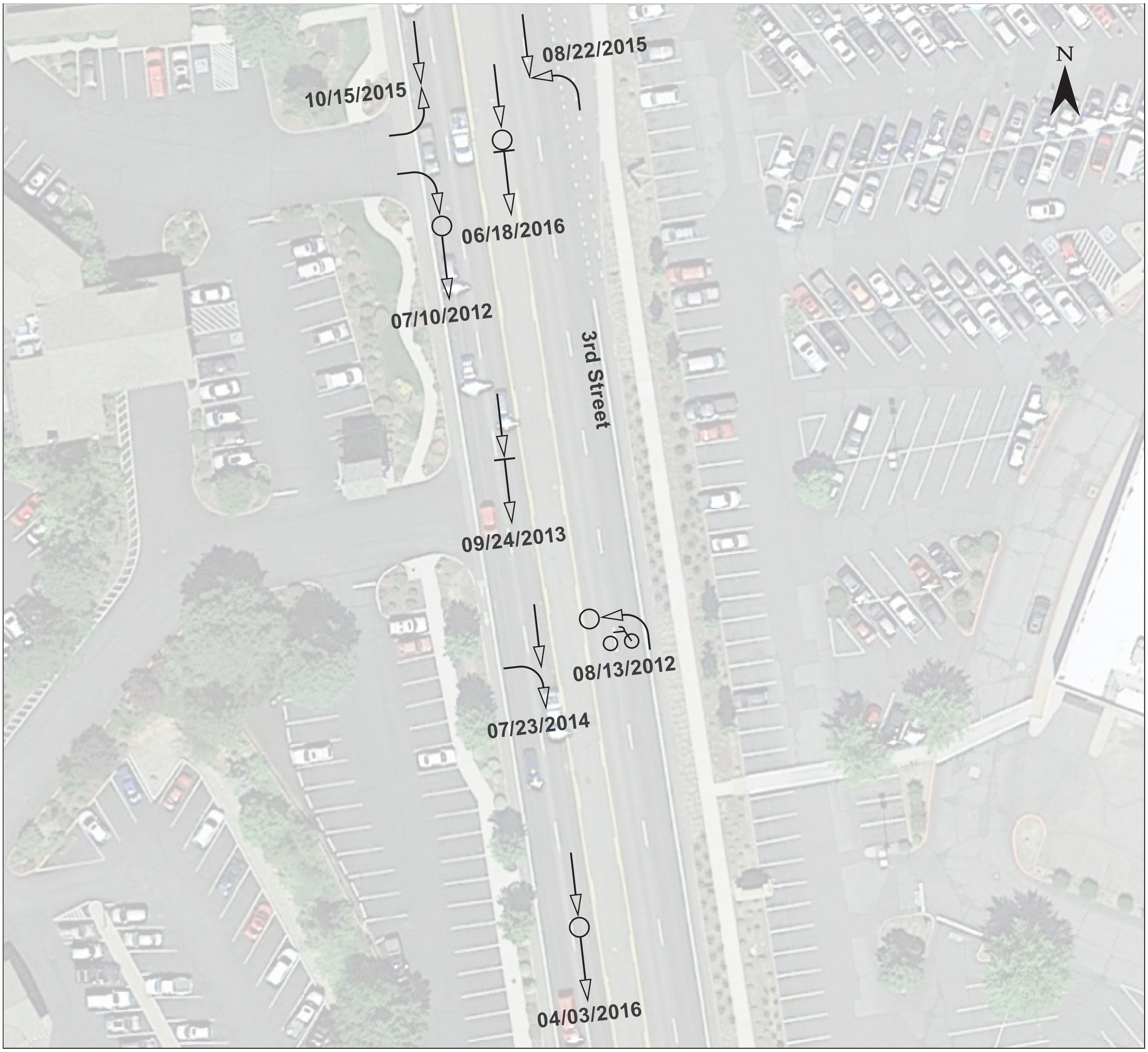
City of Bend, Deschutes County, Oregon
DUI represents a collision where alcohol and/or drugs were reported
*Not to scale

Figure 11
Crash Diagram

3rd Street (between O.B. Riley Road & Mt Washington)

From: **01/01/2012** To: **12/31/2016**

Date Prepared: **04/12/2019**



Number of Collisions

4	**Property Damage Only**
4	**Non-incapacitating Injury Collisions**
0	**Fatal and Incapacitating Injury Collisions**
8	**Total Collisions**

Moving Vehicle
Stopped Vehicle
Backing Vehicle
Ran Off Road
Movement Unknown

Right Turn
Left Turn
Sideswipe
Night
Day

Pedestrian
Fixed Object
Bicycle
Motorcycle
DUI
Non-Incapacitating
Fatal/Incapacitating

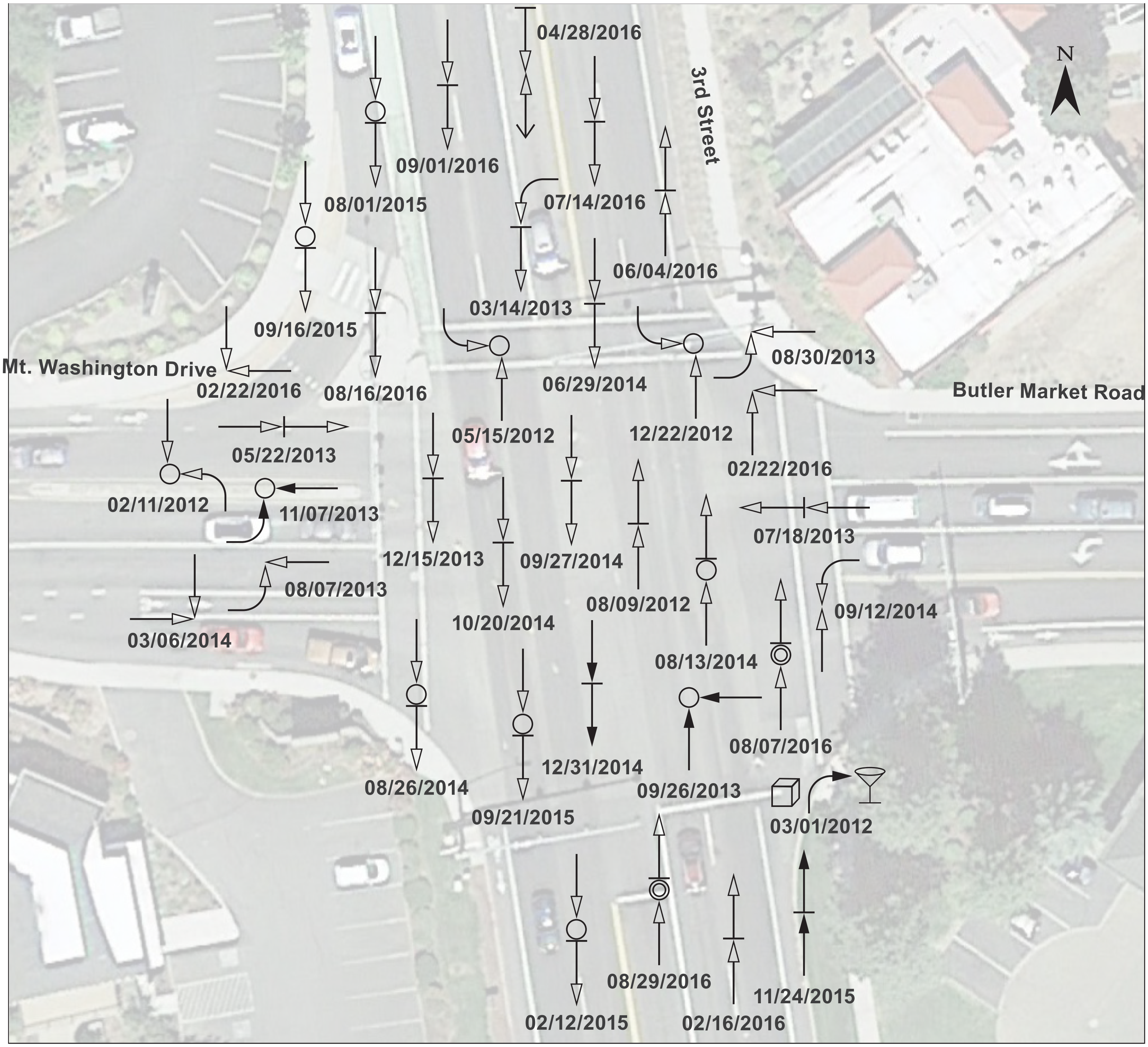
City of Bend, Deschutes County, Oregon
DUI represents a collision where alcohol and/or drugs were reported
*Not to scale

Figure 12
Crash Diagram

3rd Street & Butler Market Road / Mt Washington

From: **01/01/2012** To: **12/31/2016**

Date Prepared: **04/12/2019**



Number of Collisions

23	Property Damage Only
11	Non-incapacitating Injury Collisions
2	Fatal and Incapacitating Injury Collisions
36	Total Collisions

Moving Vehicle
Stopped Vehicle
Backing Vehicle
Ran Off Road
Movement Unknown

Right Turn
Left Turn
Sideswipe
Night
Day

Pedestrian
Fixed Object
Bicycle
Motorcycle
DUI
Non-Incapacitating
Fatal/Incapacitating

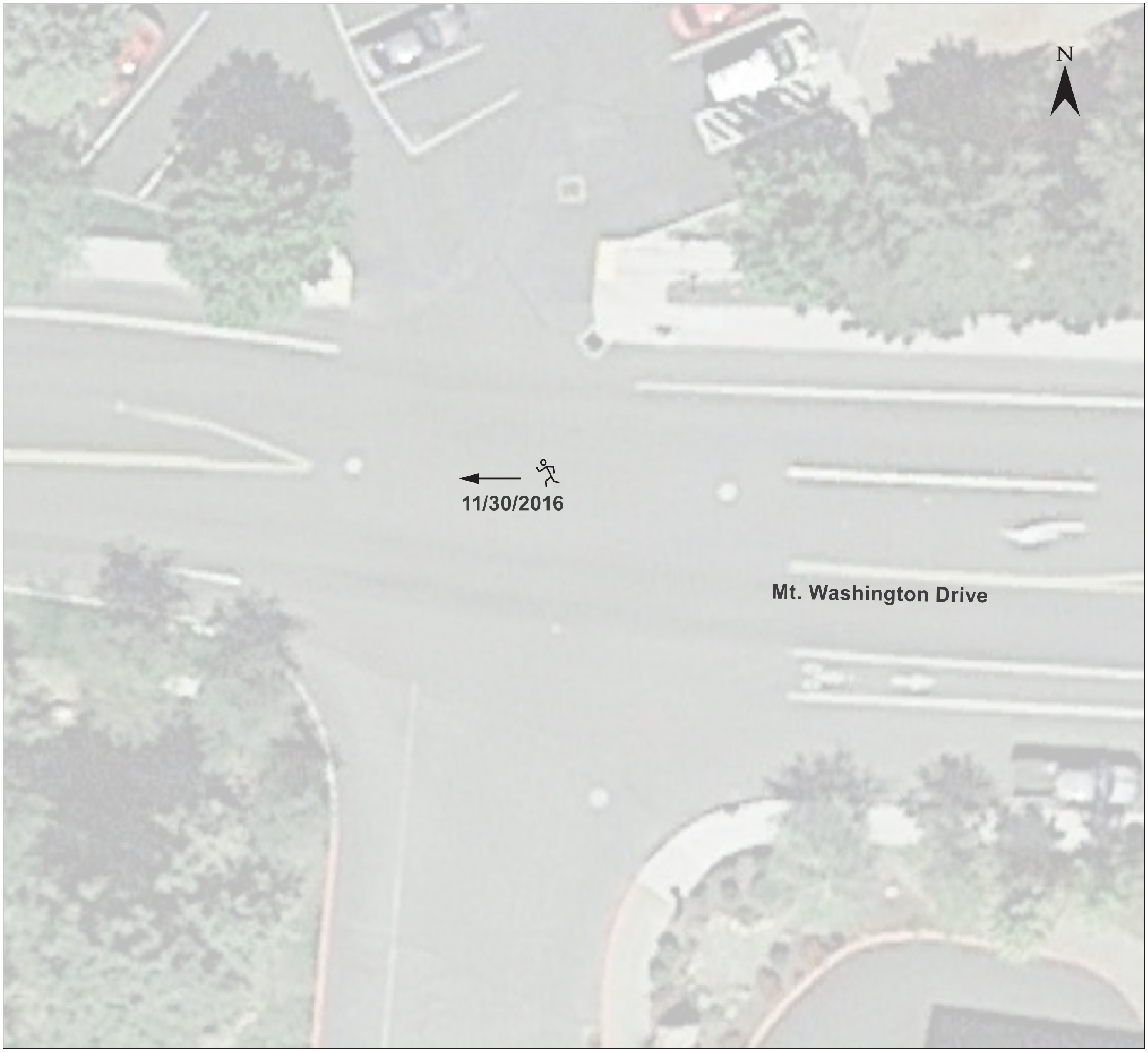
City of Bend, Deschutes County, Oregon
DUI represents a collision where alcohol and/or drugs were reported
*Not to scale

Figure 13
Crash Diagram

Mt Washington Drive & Riverhouse Driveway

From: **01/01/2012** To: **12/31/2016**

Date Prepared: **04/12/2019**



Number of Collisions

1	Property Damage Only
0	Non-incapacitating Injury Collisions
0	Fatal and Incapacitating Injury Collisions
1	Total Collisions

Moving Vehicle
Stopped Vehicle
Backing Vehicle
Ran Off Road
Movement Unknown

Right Turn
Left Turn
Sideswipe
Night
Day

Pedestrian
Fixed Object
Bicycle
Motorcycle
DUI
Non-Incapacitating
Fatal/Incapacitating

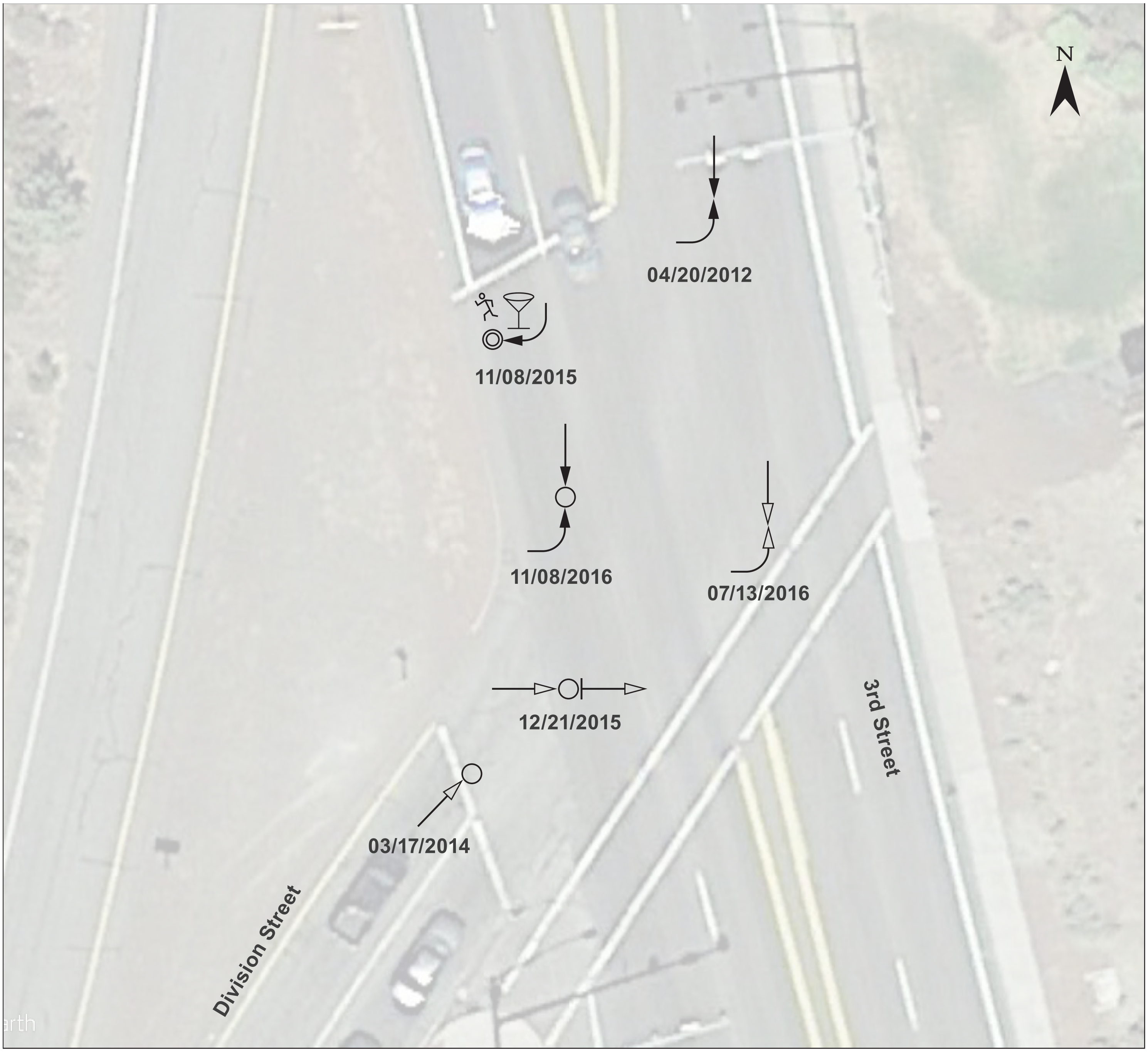
City of Bend, Deschutes County, Oregon
DUI represents a collision where alcohol and/or drugs were reported
*Not to scale

Figure 14
Crash Diagram

3rd Street & Division Street

From: **01/01/2012** To: **12/31/2016**

Date Prepared: **04/12/2019**



Number of Collisions

2	Property Damage Only
3	Non-incapacitating Injury Collisions
1	Fatal and Incapacitating Injury Collisions
6	Total Collisions

Moving Vehicle
Stopped Vehicle
Backing Vehicle
Ran Off Road
Movement Unknown

Right Turn
Left Turn
Sideswipe
Night
Day

Pedestrian
Fixed Object
Bicycle
Motorcycle
DUI
Non-Incapacitating
Fatal/Incapacitating

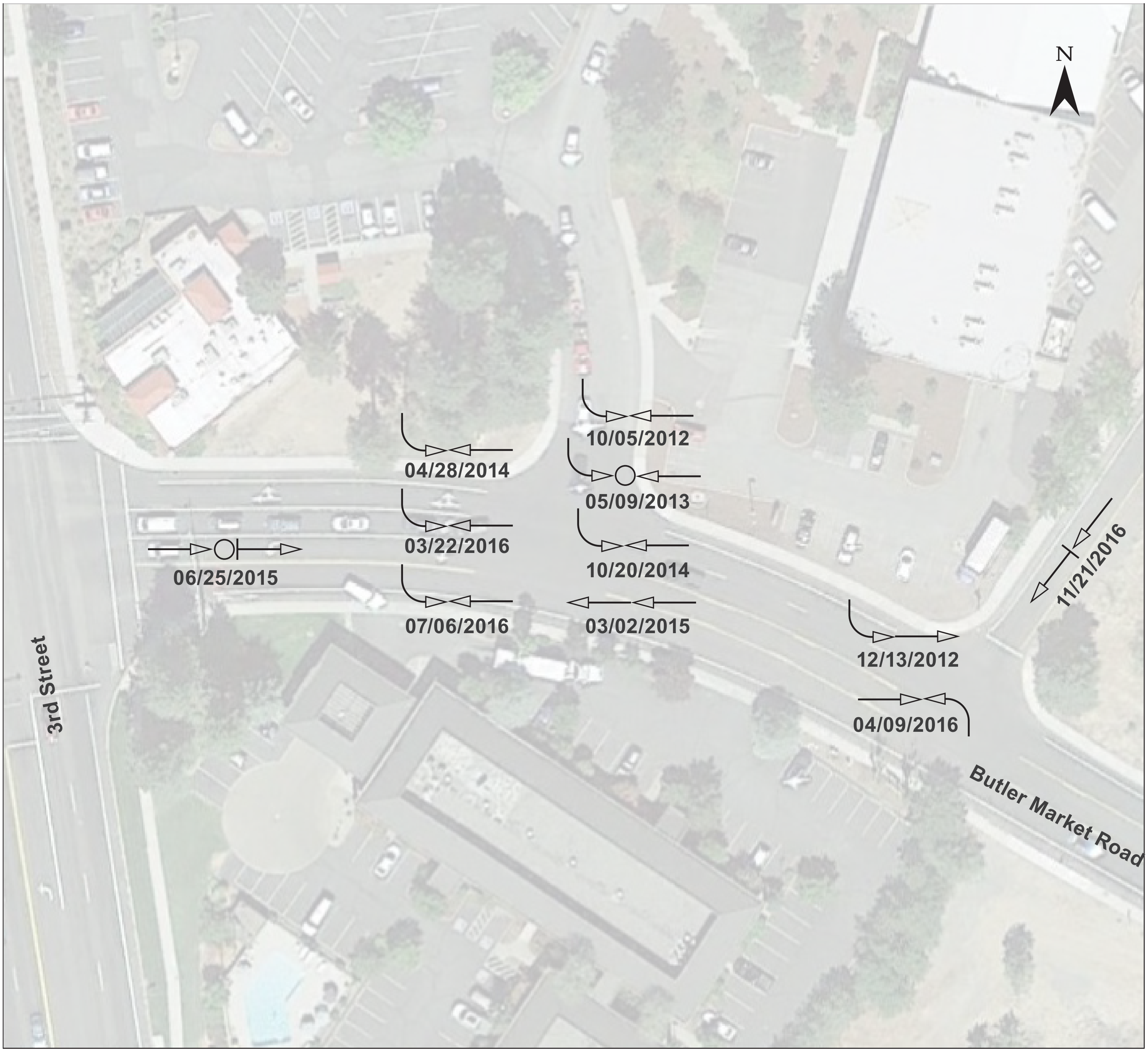
City of Bend, Deschutes County, Oregon
DUI represents a collision where alcohol and/or drugs were reported
*Not to scale

Figure 15
Crash Diagram

3rd Street & Butler Market Road (East)

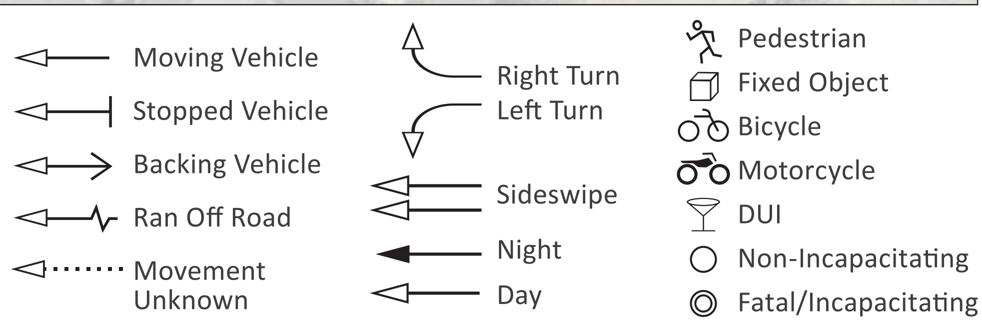
From: **01/01/2012** To: **12/31/2016**

Date Prepared: **04/12/2019**



Number of Collisions

9	Property Damage Only
2	Non-incapacitating Injury Collisions
0	Fatal and Incapacitating Injury Collisions
11	Total Collisions

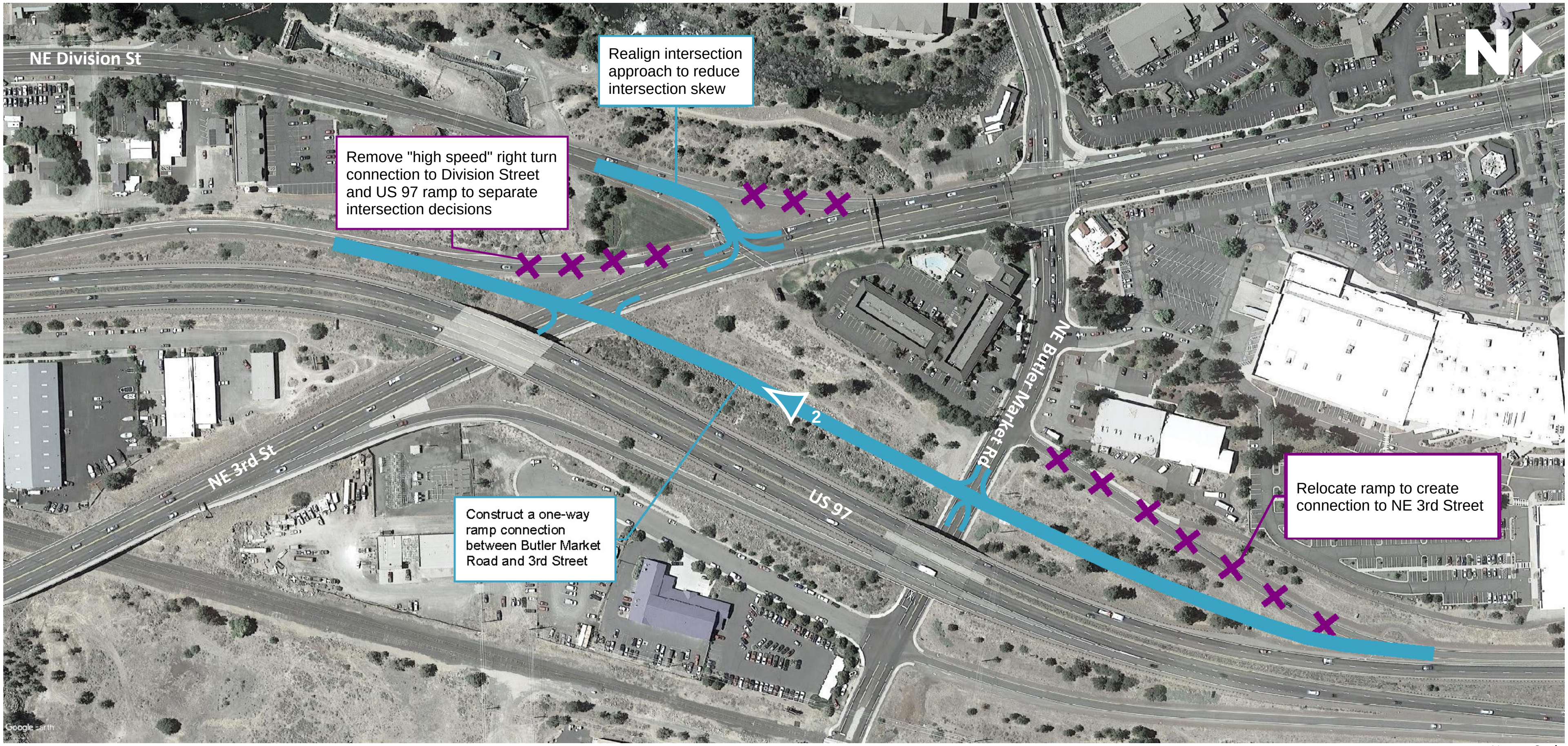


City of Bend, Deschutes County, Oregon

DUI represents a collision where alcohol and/or drugs were reported

*Not to scale

Figure 16
Crash Diagram

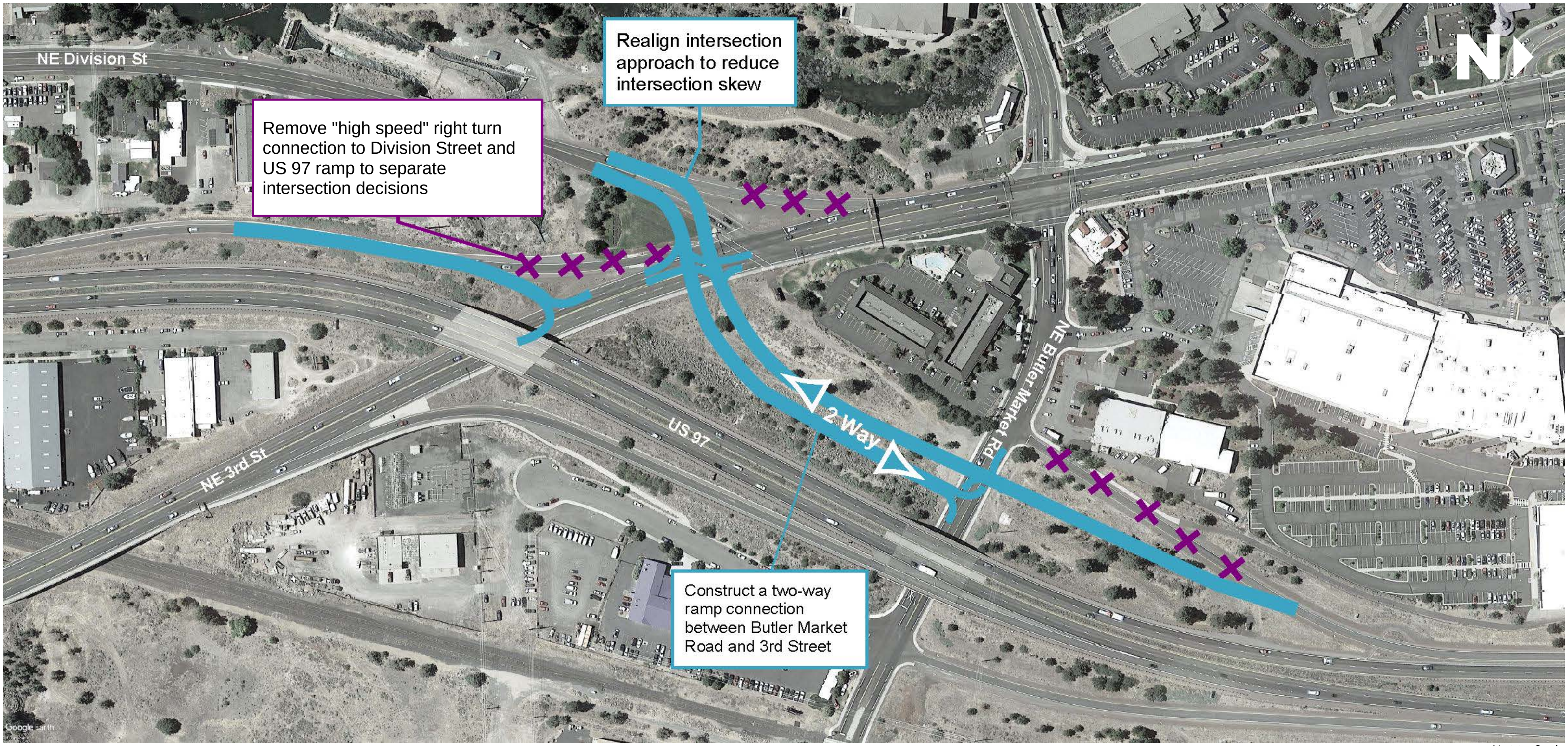


Not to Scale

KITTELSON & ASSOCIATES

Location-Specific Concepts
Bend Pkwy & NE Butler Market Rd
System Concept 1: One-Way Connector

Figure 17


NE Division St
Realign intersection approach to reduce intersection skew
Remove "high speed" right turn connection to Division Street and US 97 ramp to separate intersection decisions
2 Way
US 97
NE 3rd St
NE Butler Market Rd
Construct a two-way ramp connection between Butler Market Road and 3rd Street

Not to Scale

5.2.3 Highway 97 & Powers Road Area

The Highway 97 & Powers Road evaluation considered the ramps to/from Highway 97. Highway 97 is a four-lane state highway with a posted speed limit of 45 mph. Highway 97 serves as a major north-south connection through Bend as well as throughout Central Oregon. Powers Road is a minor arterial that serves as a connection between residential and commercial land uses. Marked bike lanes are provided in both directions on Highway 97 and Powers Road. The intersection is signalized with restricted movements; no left-turns are permitted at the intersection. Vehicles making left-turns must pass through the signal and make right-turn movements.

Approximately three-quarters (78 percent) of reported intersection crashes are rear-end crashes, as illustrated in Figure 19 through Figure 22. Approximately 15 percent of reported crashes occurred in dark, dusk, or dawn lighting conditions. Just over half (51 percent) of the reported crashes in the Highway 97 & Powers Road Area resulted in some level of injury. The highest concentration of crashes were reported at or near the northbound on-ramp to Highway 97.

Concepts at this location are provided for information. However, coordination with ODOT is needed to pursue these. The on-going ODOT Parkway Study is further evaluating these options.

Because the on-going Parkway Study is currently evaluating longer-term treatments at this location, this configuration focuses on near-term, interim solutions that may be considered by ODOT until funding for longer-term treatments becomes available. Concepts for the Highway 97 & Powers Road Area are summarized in Figure 23. Based on the crash patterns around Highway 97 & Powers Road, installing a deceleration lane (shown in the figure as a parallel exit lane) should be considered. The parallel lane provides a deceleration lane for vehicles exiting Highway 97 to Powers Road and removes turning traffic from the through traffic stream at higher speeds compared to existing conditions.

Because the highest number of crashes were reported at the Highway 97 northbound on-ramp, Kittelson suggests realigning the entrance ramp to reduce intersection skew and improve sight distance to the left for right turning drivers to see northbound Highway 97 vehicles.

In addition, The TSAP suggests evaluating additional illumination levels in this area and integrating enhanced cross walk marking (such as continental stipes) to maximize the visibility of the pedestrian crosswalks.

Highway 97 (NB Ramp) / Powers Road

From: **01/01/2012** To: **12/31/2016**

Date Prepared: **04/12/2019**

Number of Collisions

30	Property Damage Only
29	Non-incapacitating Injury Collisions
0	Fatal and Incapacitating Injury Collisions
59	Total Collisions

- Moving Vehicle
- Stopped Vehicle
- Backing Vehicle
- Ran Off Road
- Movement Unknown
- Right Turn
- Left Turn
- Sideswipe
- Night
- Day
- Pedestrian
- Fixed Object
- Bicycle
- Motorcycle
- DUI
- Non-Incapacitating
- Fatal/Incapacitating

City of Bend, Deschutes County, Oregon

DUI represents a collision where alcohol and/or drugs were reported

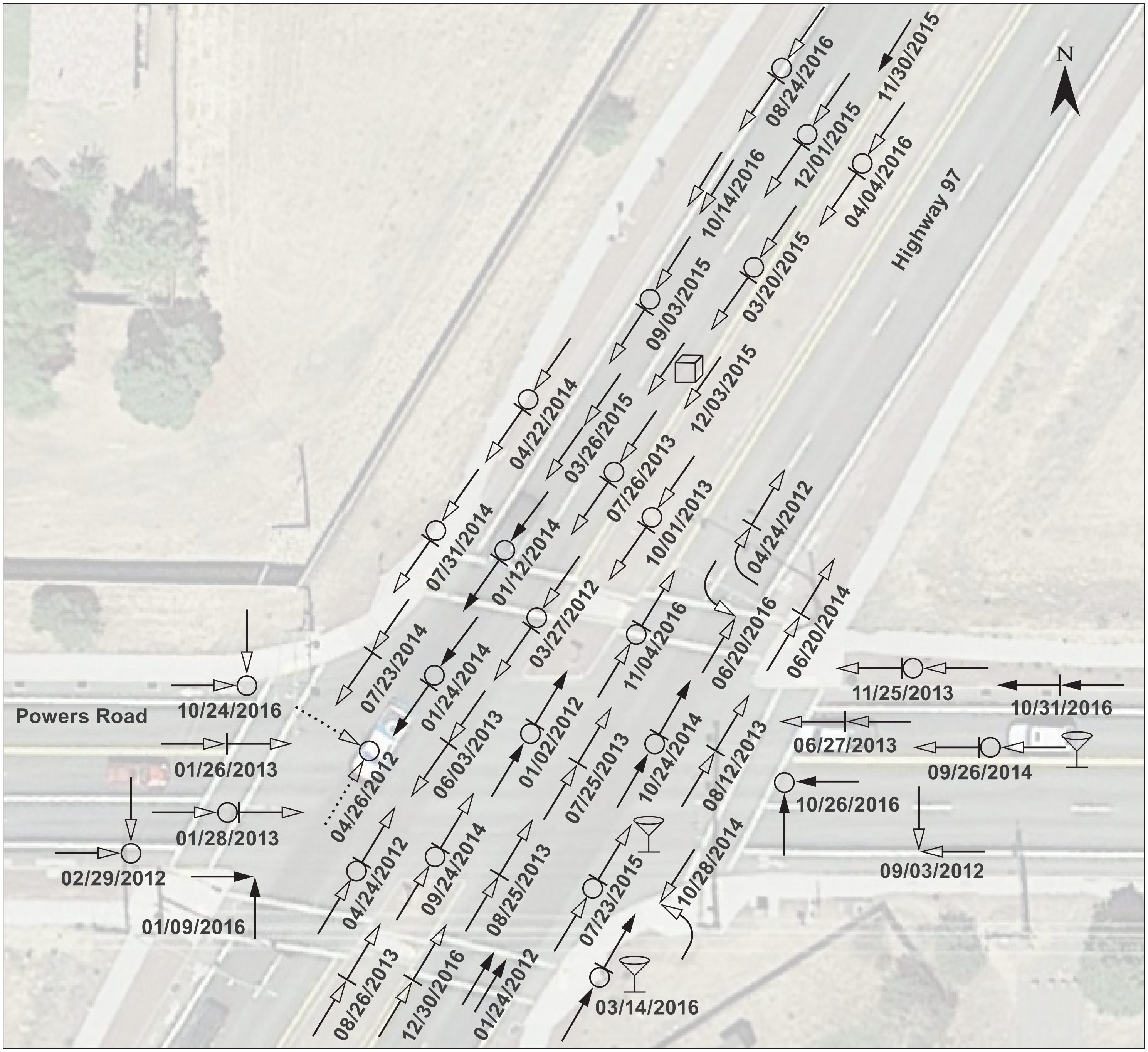
*Not to scale

Figure 19
Crash Diagram

Highway 97 and Powers Road

From: 01/01/2012 To: 12/31/2016

Date Prepared: 04/12/2019



Number of Collisions

21	**Property Damage Only**
26	**Non-incapacitating Injury Collisions**
0	**Fatal and Incapacitating Injury Collisions**
47	**Total Collisions**

Moving Vehicle
Stopped Vehicle
Backing Vehicle
Ran Off Road
Movement Unknown
Right Turn
Left Turn
Sideswipe
Night
Day
Pedestrian
Fixed Object
Bicycle
Motorcycle
DUI
Non-Incapacitating
Fatal/Incapacitating

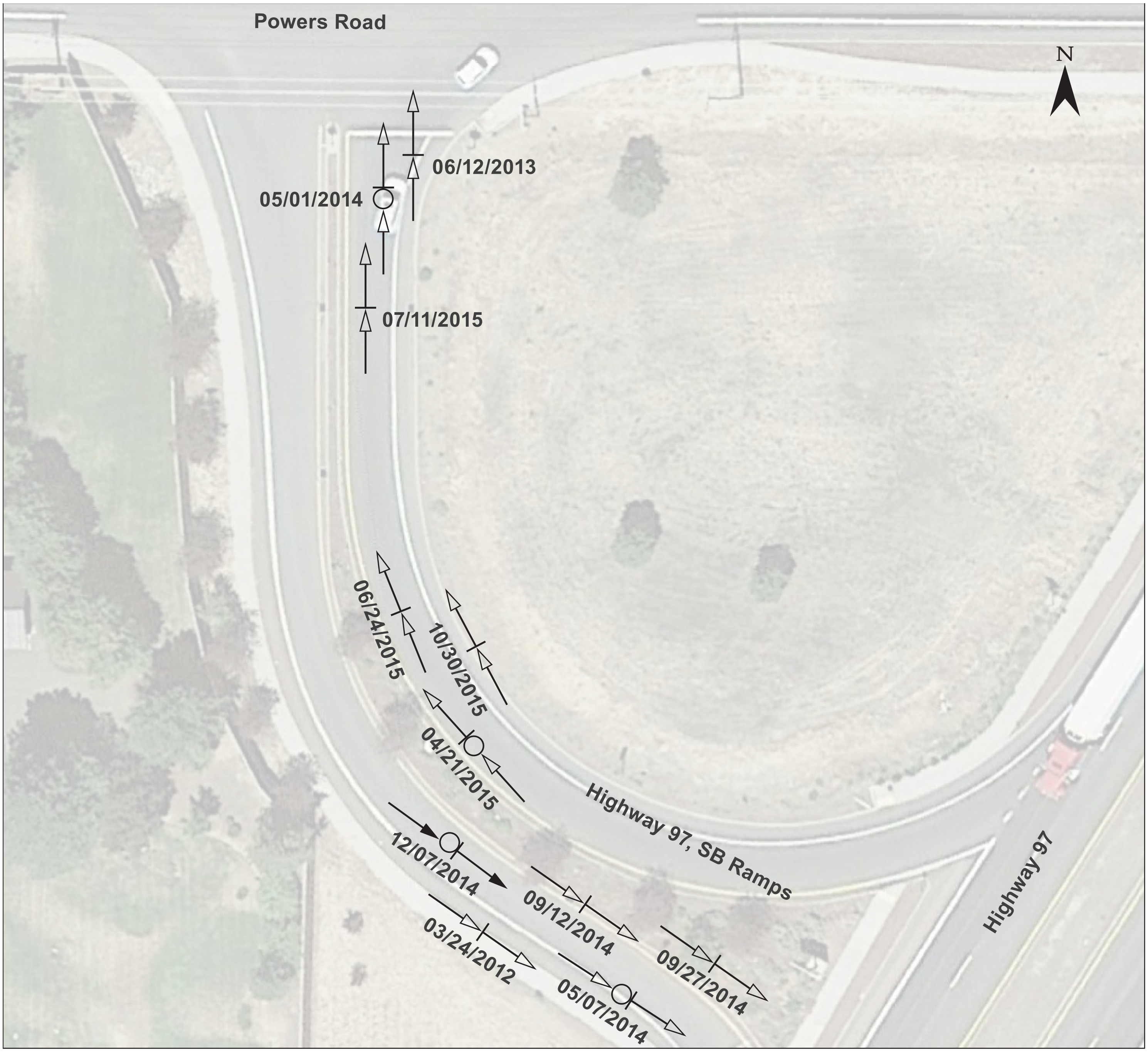
City of Bend, Deschutes County, Oregon
DUI represents a collision where alcohol and/or drugs were reported
*Not to scale

Figure 20
Crash Diagram

Highway 97 (SB Ramps) and Powers Road

From: **01/01/2012** To: **12/31/2016**

Date Prepared: **04/12/2019**



Number of Collisions

7	**Property Damage Only**
4	**Non-incapacitating Injury Collisions**
0	**Fatal and Incapacitating Injury Collisions**
11	**Total Collisions**

Moving Vehicle
Stopped Vehicle
Backing Vehicle
Ran Off Road
Movement Unknown
Right Turn
Left Turn
Sideswipe
Night
Day
Pedestrian
Fixed Object
Bicycle
Motorcycle
DUI
Non-Incapacitating
Fatal/Incapacitating

City of Bend, Deschutes County, Oregon

DUI represents a collision where alcohol and/or drugs were reported

*Not to scale

Figure 21
Crash Diagram

Highway 97 NB Ramps and Powers Road

From: **01/01/2012** To: **12/31/2016**

Date Prepared: **04/12/2019**

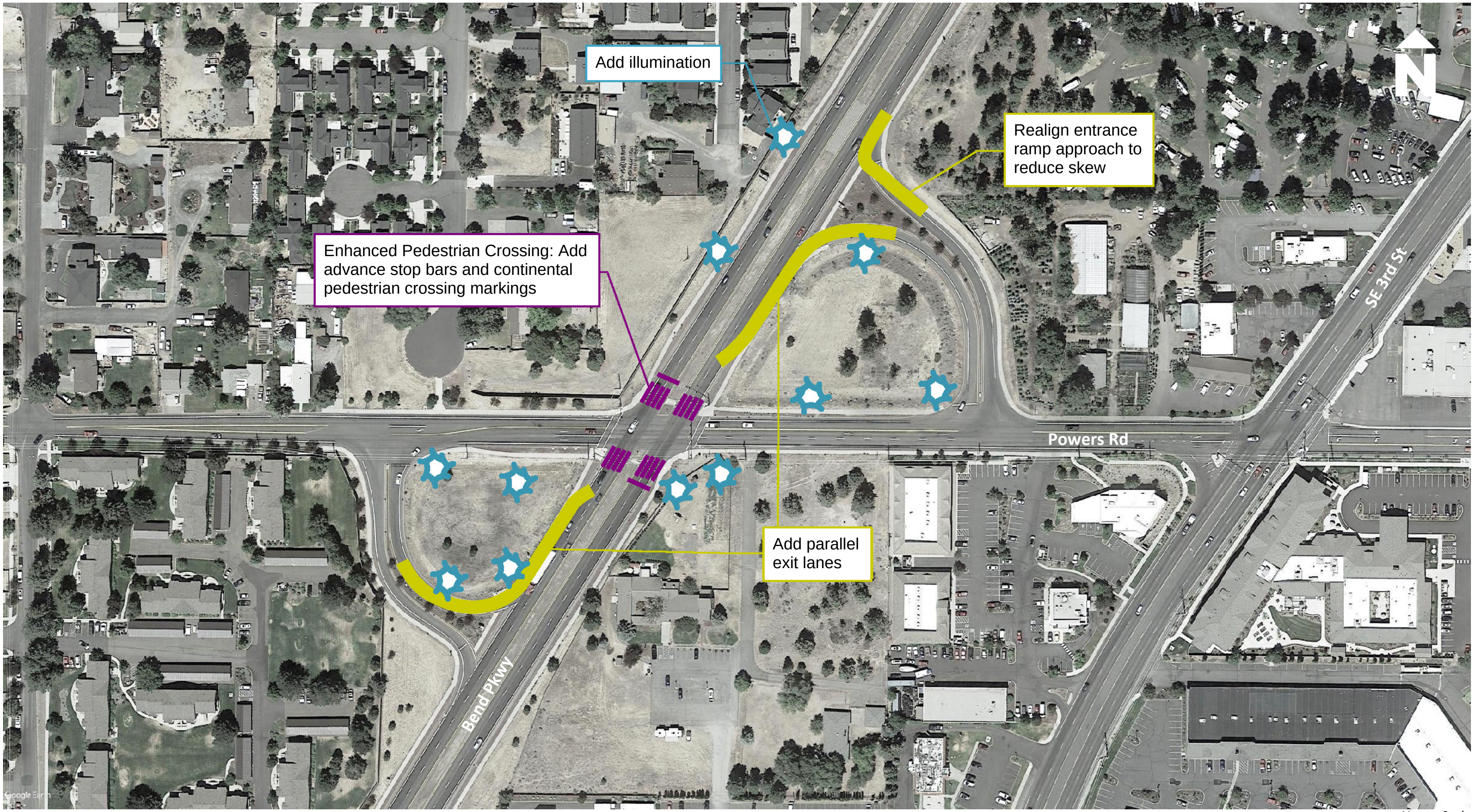
Number of Collisions

1	Property Damage Only
1	Non-incapacitating Injury Collisions
0	Fatal and Incapacitating Injury Collisions
2	Total Collisions

Moving Vehicle
Stopped Vehicle
Backing Vehicle
Ran Off Road
Movement Unknown
Right Turn
Left Turn
Sideswipe
Night
Day
Pedestrian
Fixed Object
Bicycle
Motorcycle
DUI
Non-Incapacitating
Fatal/Incapacitating

City of Bend, Deschutes County, Oregon
DUI represents a collision where alcohol and/or drugs were reported
*Not to scale

Figure 22
Crash Diagram



Add illumination
Realign entrance ramp approach to reduce skew
Enhanced Pedestrian Crossing: Add advance stop bars and continental pedestrian crossing markings
SE 3rd St
Powers Rd
Add parallel exit lanes
Bend Pkwy

Not to Scale

5.2.4 3rd Street Area

3rd Street is a five-lane roadway classified as a principal arterial that runs north-south through Bend, parallel to Highway 97. Although the intersection of 3rd Street and Miller Avenue was identified through the EPDO screening process, Kittelson's review of this location was expanded to consider the adjacent intersection and surrounding area. Many intersections along this section of 3rd Street share similar characteristics with Miller Avenue. In addition, the issues exhibited at 3rd Street and Miller Avenue are somewhat a function of the network in this area. Therefore, several of the concepts include larger network considerations.

Crash Analysis

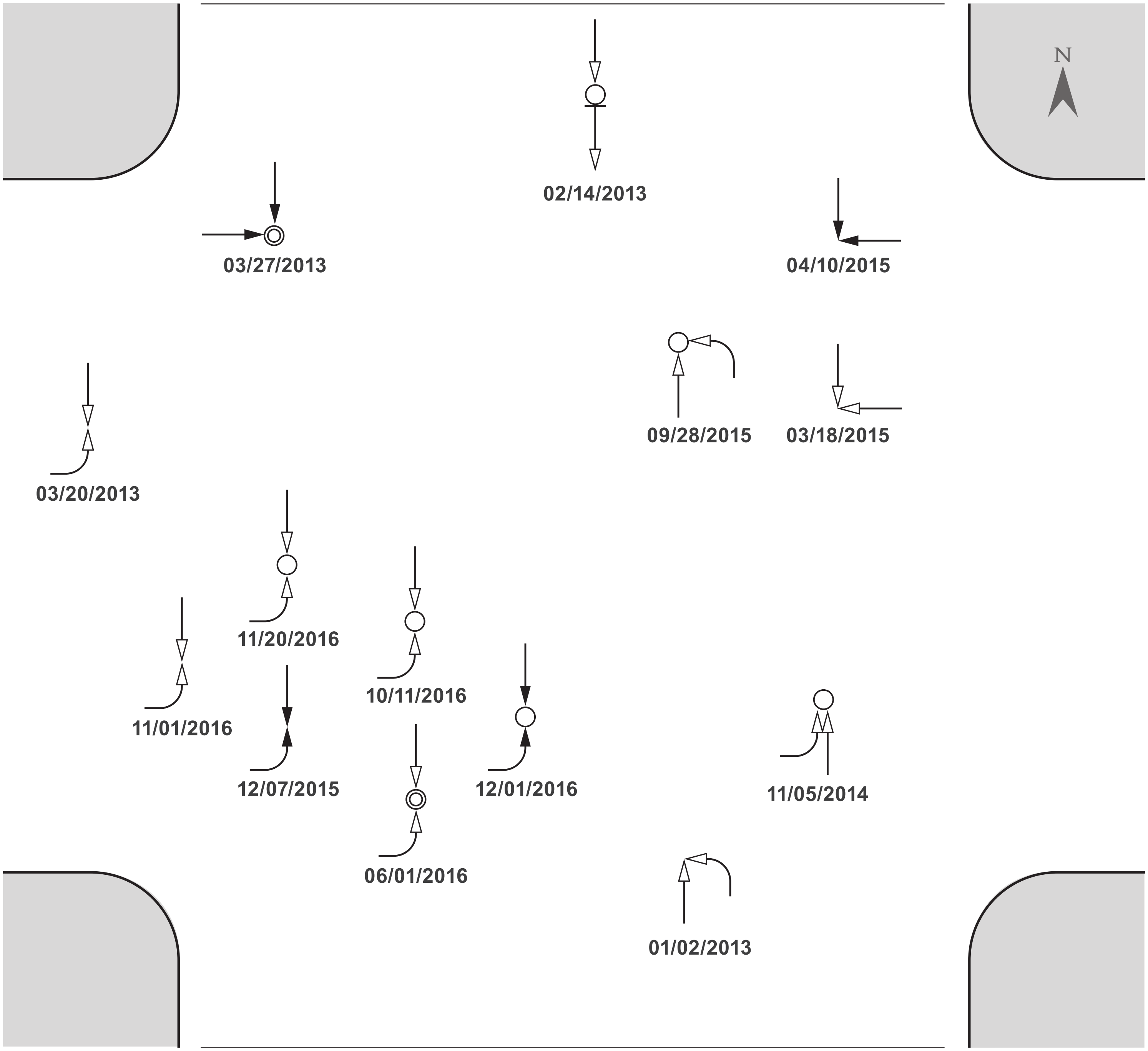
Miller Avenue & 3rd Street

Miller Avenue is one of several short east-west connections between 3rd Street and 2nd Street, which provides a connection to Colorado Avenue and Highway 97. On-street parking is permitted on both sides of Miller Avenue. 3rd Street and Miller Avenue is a minor-street stop-controlled intersection, located immediately south of the 3rd Street railroad undercrossing, where 3rd Street narrows from five-lanes to two-lanes.

As shown in Figure 24, nearly three-fourths (71 percent) of reported crashes at 3rd Street and Miller Avenue were turning movement, and of those, 80 percent were eastbound to northbound left-turning movements. Approximately 21 percent of the crashes were reported as angle crashes. Over half (57 percent) of all reported crashes resulted in some level of injury, two of which resulted in a fatal/incapacitating injury. Approximately 29 percent of reported crashes occurred in dark, dusk, or dawn conditions.

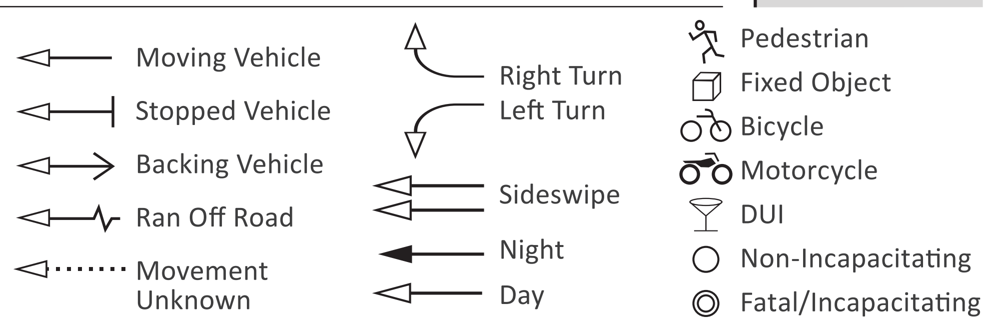
East-West Street **Miller Avenue** From: **01/01/2012** To: **12/31/2016**

North-South Street: **3rd Street** Date Prepared: **04/02/2019**



Number of Collisions

6	**Property Damage Only**
6	**Non-incapacitating Injury Collisions**
2	**Fatal and Incapacitating Injury Collisions**
14	**Total Collisions**



City of Bend, Deschutes County, Oregon

DUI represents a collision where alcohol and/or drugs were reported

Figure 24
Crash Diagram

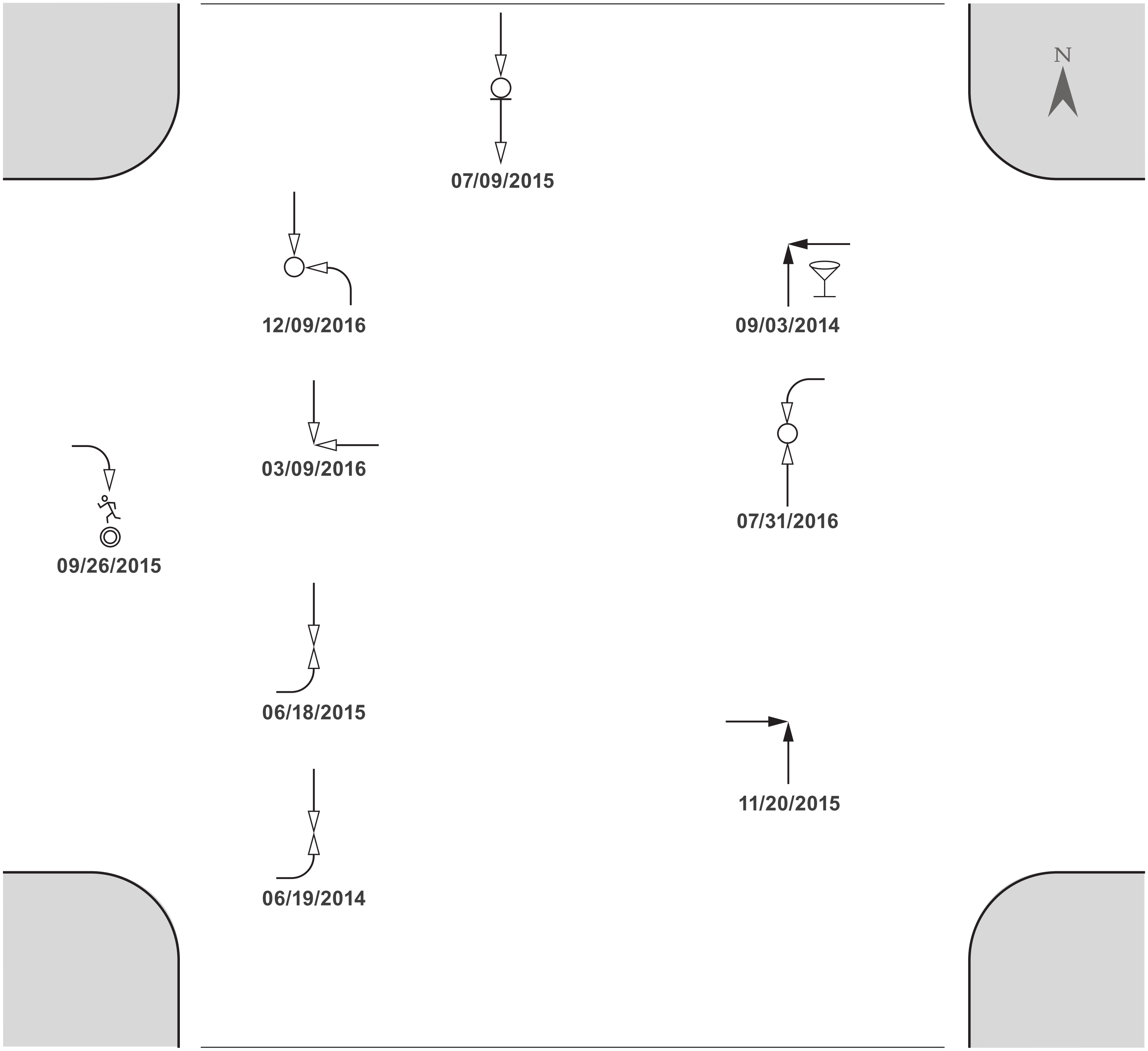
Woodland Boulevard & 3rd Street

Woodland Boulevard & 3rd Street is a minor-street stop-controlled intersection, located immediately south of Miller Avenue. Woodland Boulevard is an east-west local roadway with parking on both sides that also provides a connection to 2nd Street.

Approximately 56 percent of crashes at this intersection were reported as turning-movement crashes, including one that involved a pedestrian and resulted in a fatality, as shown in Figure 25. One-third (33 percent) of reported crashes were angle crashes. Out of the reported crashes, approximately 44 percent involved some level of injury.

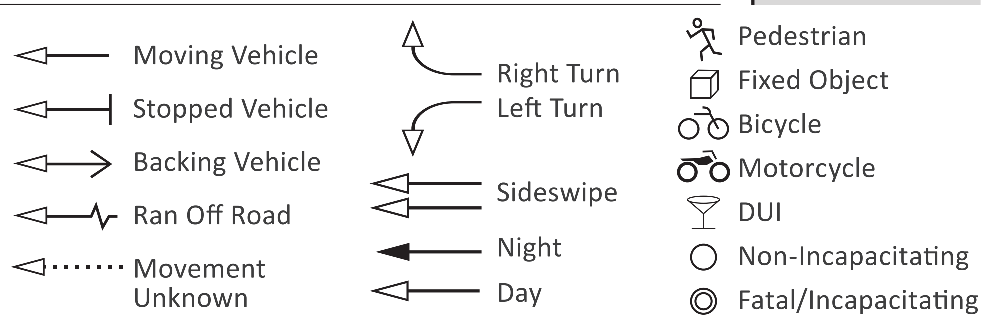
East-West Street **Woodland Boulevard** From: **01/01/2012** To: **12/31/2016**

North-South Street: **3rd Street** Date Prepared: **04/02/2019**



Number of Collisions

5	Property Damage Only
3	Non-incapacitating Injury Collisions
1	Fatal and Incapacitating Injury Collisions
9	Total Collisions



City of Bend, Deschutes County, Oregon

DUI represents a collision where alcohol and/or drugs were reported

Figure 25
Crash Diagram

Concepts

As noted in the introduction to this location, some of the issues exhibited at this location are likely similar at other nearby intersections and are a product of network traffic circulation conditions. In addition, the 3rd Street traffic is funneled into a two-lane railroad undercrossing of 3rd Street, which expands back to five-lanes on either side of the crossing in the vicinity of these study intersections. With congestion in the area and limited east-west connections, the local east-west connections to 2nd Street, including Miller Avenue and Woodland Boulevard, are frequently used by motorists to avoid congestion at the Wilson Avenue signalized intersection.

The concepts for this area include localized concepts in the Miller Avenue vicinity, as well as some larger network considerations. These larger network considerations are intended to serve as conceptual ideas for further discussion and exploration in the future. Given the network context, any localized intersection treatments should be part of a broader study of 3rd Street between SE Cleveland Avenue and the railroad undercrossing.

Localized Concepts Near 3rd Street and Miller Avenue

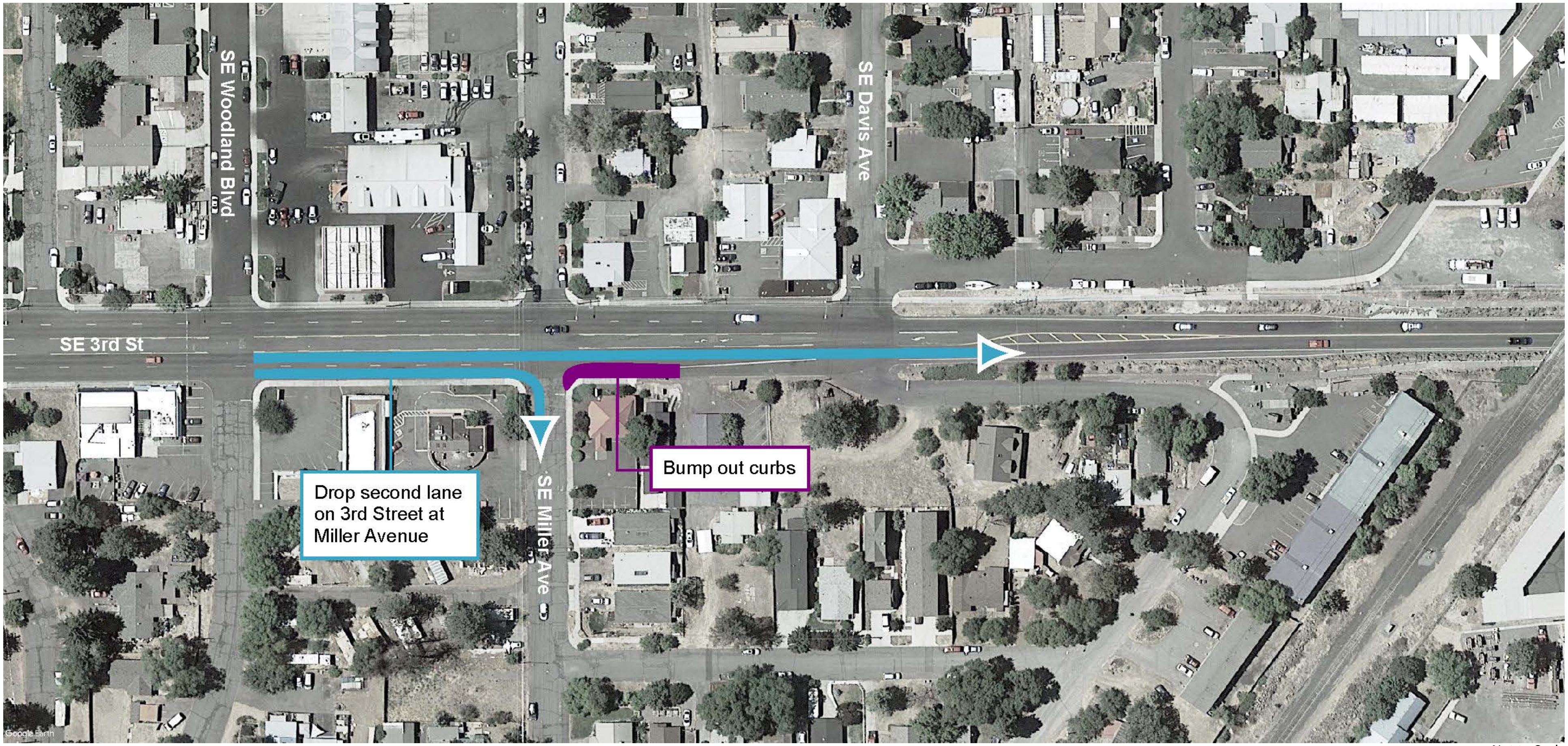
Figure 26 through Figure 29 show four localized concept options for 3rd Street between the railroad bridge and Urania Lane. These options are described below.

The current location and length of the 3rd Street northbound lane drop has a long transition lane that occurs through the intersection with Miller Avenue where there are several potential points of conflict. This lane drop represents conditions dating back to the time 3rd Street was the primary highway through Bend and volumes were lower. Two of the four small scale options address the northbound lane drop between Woodland Boulevard and Davis Avenue. The overall intent of northbound schemes is to eliminate lane changing associated with the lane drop in the location of turning traffic to and from Miller Avenue.

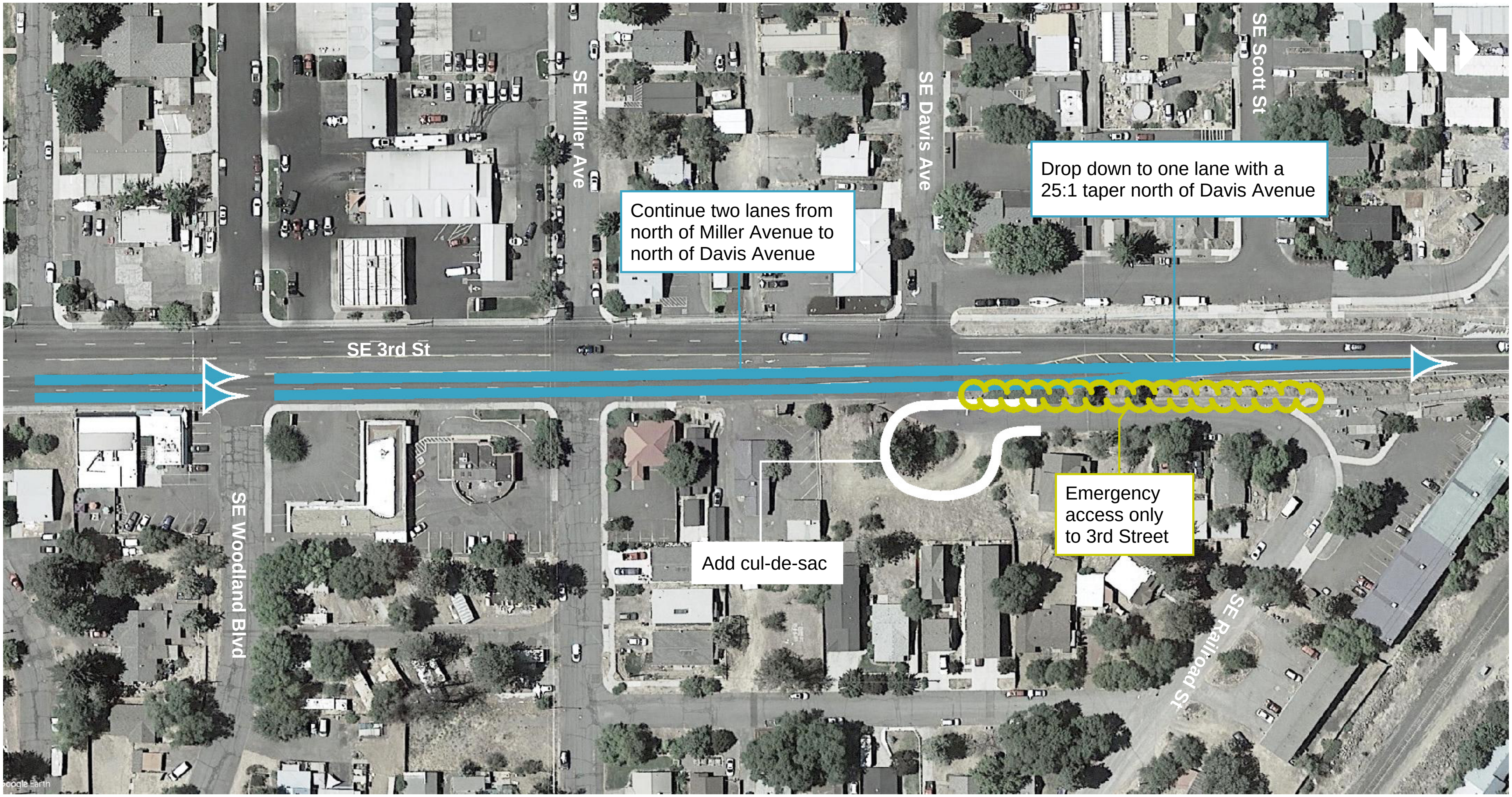
Figure 26 presents one option of dropping the second northbound lane at Miller Avenue by converting the outside lane to a right-turn only lane and installing curb bump-outs at Miller Avenue. The curb bump outs reinforce the lane drop and shorten the crossing distance of 3rd Street for pedestrians. The lane drop could occur at any number of locations south of Miller Avenue depending upon area circulation patterns and needs. In any case, it eliminates the existing condition of northbound drivers focusing on the impending lane drop in an area of intersection and driveway conflicts near Miller Avenue.

A second northbound lane drop option involves shifting the lane drop to occur entirely north of Davis Avenue, as shown in Figure 27. This option maintains the two-lanes of travel and avoids dropping the lane through an intersection. In addition to shifting the lane drop, SE Railroad Street may need to be converted to a cul-de-sac and restrict access to emergency vehicles only. The concept relocates the lane drop northward outside adjacent intersection and driveway conflict areas. This concept may require widening of 3rd Street to the east and cutting the rock face as the grade change begins downward.

City staff observations of traffic proceeding north from Wilson Avenue show that most drivers are already traveling in the inside northbound lane as early as Yew Lane and few drivers merge from the outside northbound lane between Woodland and Davis. This early merging behavior allows for a variation on these first two concepts by moving the merge further south closer to Wilson Avenue. Providing a 20:1 merge taper rate would match the 35 mph posted travel speeds (220 feet for an 11' travel lane merge). Fitting this taper between Lee Lane and Woodland Boulevard has the benefit that there are no driveway accesses on the east side of 3rd Street between these streets. This reduces conflicts in the vicinity of both Woodland and Miller and allows safer crossings to be created at both Woodland and Miller.


SE Woodland Blvd
SE Davis Ave
SE 3rd St
SE Miller Ave
Drop second lane on 3rd Street at Miller Avenue
Bump out curbs
N

Not to Scale



SE Miller Ave
SE Davis Ave
SE Scott St
SE 3rd St
SE Woodland Blvd
SE Railroad St
N
Continue two lanes from north of Miller Avenue to north of Davis Avenue
Drop down to one lane with a 25:1 taper north of Davis Avenue
Emergency access only to 3rd Street
Add cul-de-sac

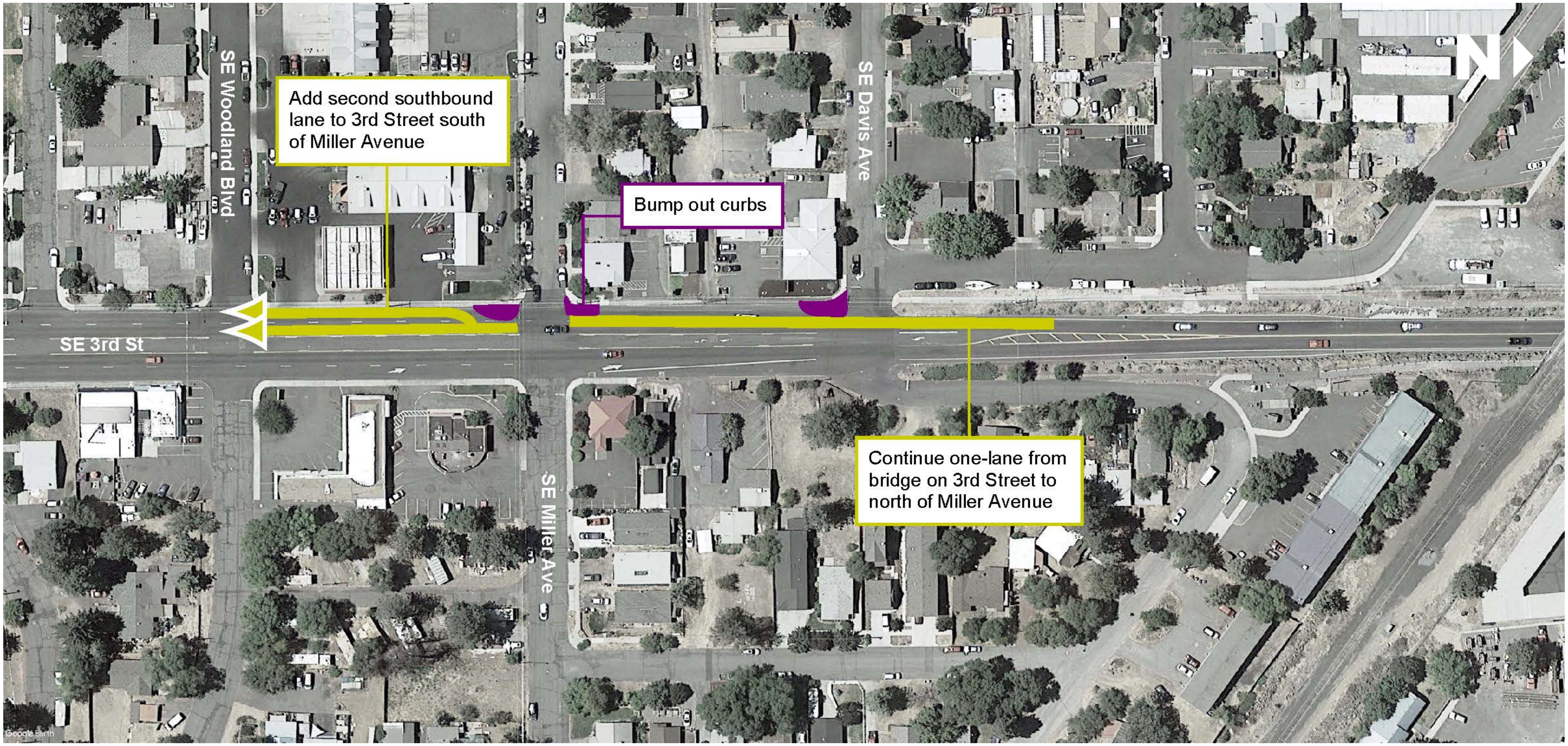
Not to Scale

Figure 28 illustrates the third localized configuration, which addresses the southbound lane on 3rd Street. This concept would carry the existing single southbound lane on 3rd Street south of Miller Avenue. Shifting the southbound lane addition south of Miller Avenue creates less conflicts for vehicles turning between 3rd Street and Miller Avenue.

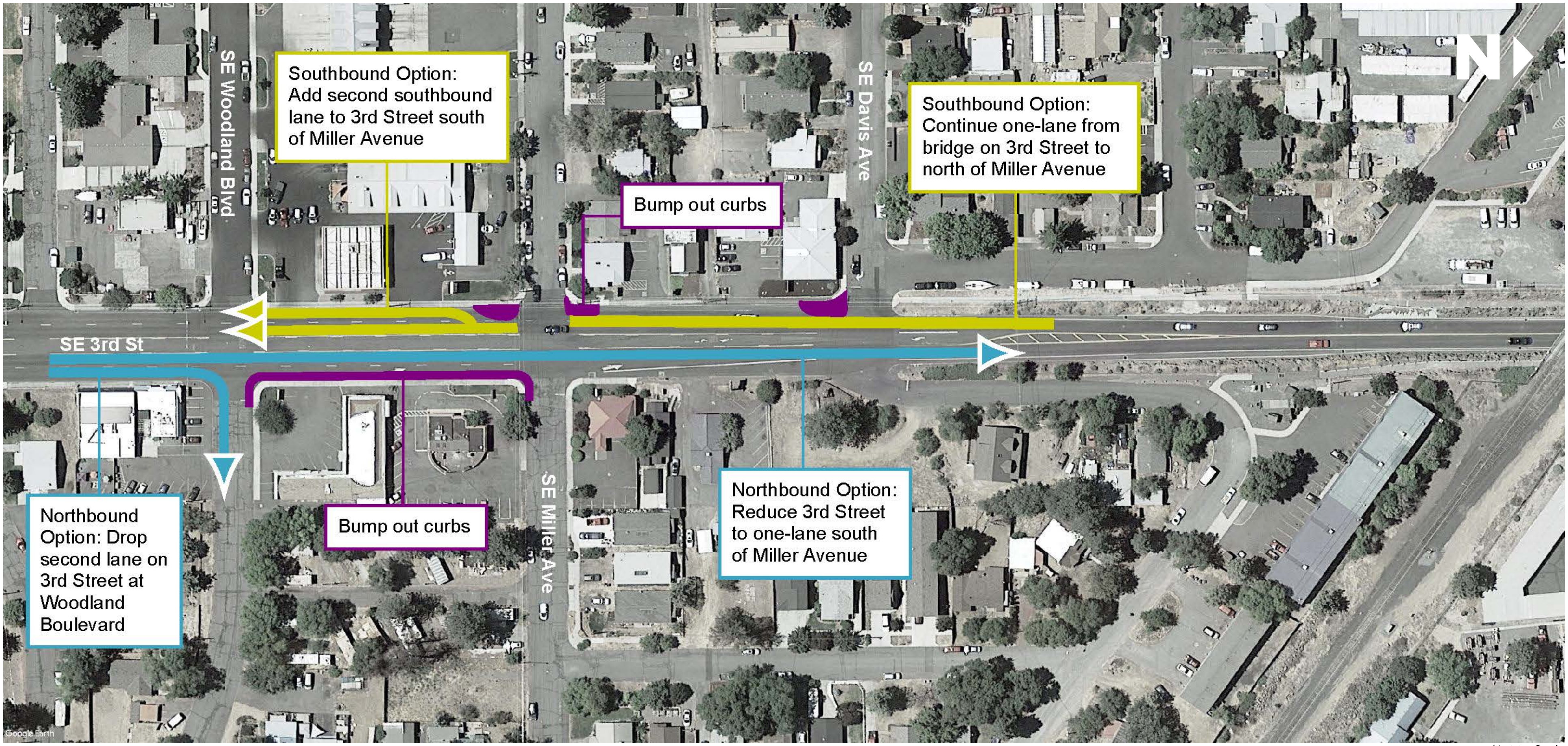
The single-lane continuation would address the high percentage of turning crashes revealed in the Miller Avenue & 3rd Street crash analysis by reducing the number of potential conflict points. To supplement the continued single southbound lane, installing curb bump outs at the northwest and southwest corners of Miller Avenue & 3rd Street and the southwest corner of Davis Avenue could help manage vehicle speeds and reduce pedestrian crossing lengths.

The fourth localized concept for 3rd Street between the railroad bridge and Urania Lane includes a hybrid of the three previously mentioned options, as shown in Figure 29. In this configuration, the second northbound lane is dropped and converted to a right-turn only at Woodland Boulevard, and a single southbound lane is continued from Davis Avenue to south of Miller Avenue. This option maximizes potential safety benefits by reducing the number of potential conflict points at Miller Avenue and reducing the crossing distance of 3rd Street for pedestrians.

A variation on this would be to add the second southbound travel lane south of Woodland, between Woodland and Urania. This would enable pedestrians to cross fewer travel lanes at both Miller and Woodland while still providing more than 1,000 feet of traffic signal storage on the Wilson Avenue signal approach.


Add second southbound lane to 3rd Street south of Miller Avenue
Bump out curbs
Continue one-lane from bridge on 3rd Street to north of Miller Avenue
SE Woodland Blvd
SE Davis Ave
SE Miller Ave
SE 3rd St
N

Not to Scale


SE Woodland Blvd
Southbound Option: Add second southbound lane to 3rd Street south of Miller Avenue
SE Davis Ave
Southbound Option: Continue one-lane from bridge on 3rd Street to north of Miller Avenue
Bump out curbs
SE 3rd St
Northbound Option: Drop second lane on 3rd Street at Woodland Boulevard
Bump out curbs
SE Miller Ave
Northbound Option: Reduce 3rd Street to one-lane south of Miller Avenue
N
Google Earth

Not to Scale

Larger Network Concepts

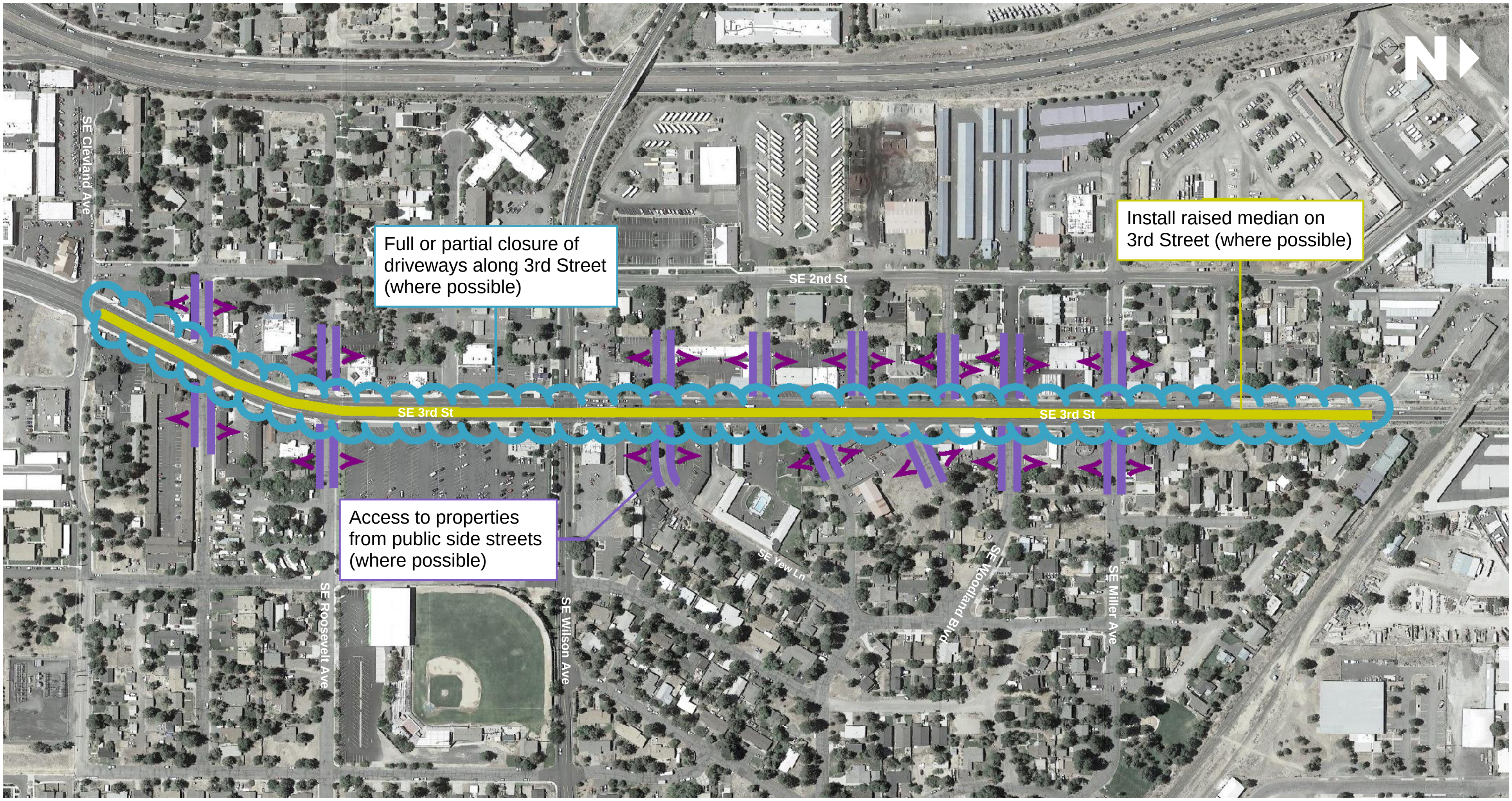
This section summarizes the larger network considerations, which may stretch from the railroad bridge south to Cleveland Avenue. These larger network considerations are intended to serve as conceptual ideas for further discussion and exploration in the future.

Currently, 3rd Street has many commercial access points, in addition to frequent intersections with local roads, along this segment. These frequent access points create tension between 3rd Street's dual purposes: providing direct access to local roads and commercial driveways and acting as an arterial for through traffic. The frequent access points create multiple potential conflict points along the corridor and increase crash risk. Access management along the corridor, as illustrated by the concept in Figure 30, is one way of improving 3rd Street's ability to serve through traffic while still accommodating access to commercial properties.

Corridor access management refers to consolidating, limiting, and removing access points along a roadway, when possible. Close coordination with property owners to provide alternate access onto side streets or through shared access points would be needed before considering implementation of access management concepts. Implementation of access management could reduce crash frequency and improve the safety of traffic flow. Specific access management treatments may include installing raised medians and full or partial closure of driveways along 3rd Street. Road users would be redirected to public side streets to access properties rather than providing direct access from 3rd Street.

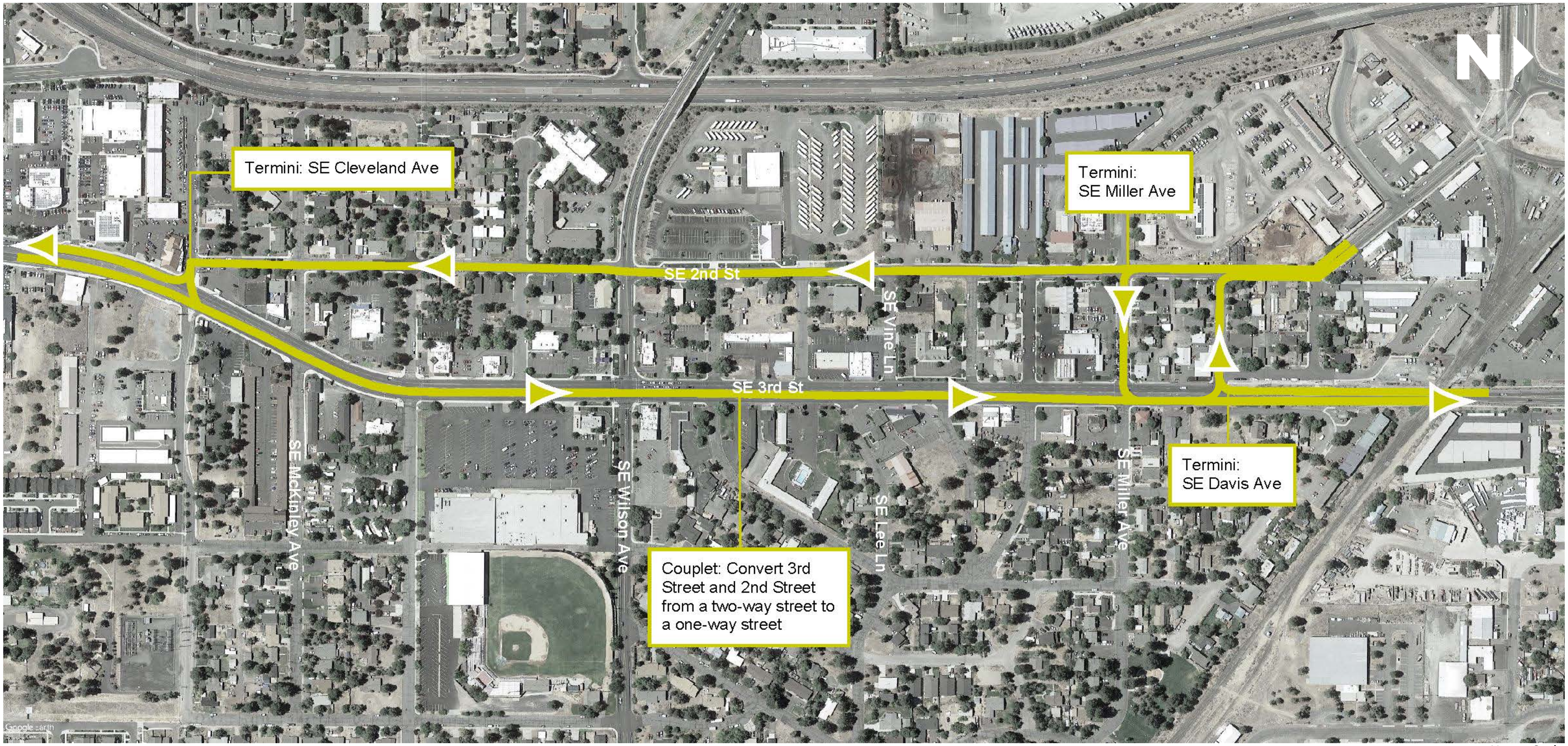
The second option for the 3rd Street corridor is a couplet, shown in Figure 31. A couplet consists of two parallel one-way streets that carry traffic in opposing directions. By reducing traffic to one-direction, potential conflicts at side streets are reduced and traffic can flow more uniformly without as many turning conflicts. This concept provides an additional benefit for 3rd Street by creating opportunities to install on-street parking to better serve the small commercial enterprises between Wilson Avenue and the railroad. It may also provide an opportunity to enhance the existing narrow bike lane to increase the appeal and safety of riding a bike to these commercial properties.

The couplet would run southbound on 2nd Street and northbound on 3rd Street between Cleveland and the railroad. There could be an entry feature at Cleveland northbound to facilitate the northbound split and facilitate the southbound merge. This entry can act as a visible gateway between the larger lot commercial format south of Cleveland and the smaller lot commercial enterprises north of Cleveland. The addition of on-street parking can serve to encourage economic vitality and provide on-lot flexibility for increased retail square footage.



Full or partial closure of driveways along 3rd Street (where possible)
Install raised median on 3rd Street (where possible)
Access to properties from public side streets (where possible)
SE 2nd St
SE 3rd St
SE 3rd St
SE Cleveland Ave
SE Roosevelt Ave
SE Wilson Ave
SE Yew Ln
SE Woodland Blvd
SE Miller Ave
N

Not to Scale


Termini: SE Cleveland Ave
Termini:
SE Miller Ave
SE 2nd St
SE Vine Ln
SE 3rd St
SE McKinley Ave
SE Wilson Ave
SE Lee Ln
SE Miller Ave
Termini:
SE Davis Ave
Couplet: Convert 3rd Street and 2nd Street from a two-way street to a one-way street
N

Not to Scale

5.3 EXCESS PROPORTION OF SPECIFIC CRASH TYPES SCREENING

The excess proportion performance measure quantifies, for a given location, the difference between the observed proportion of a specific collision type and the proportion among the relevant reference population (i.e., all intersections). The excess proportion is the difference between a site's proportion and the chosen threshold. For example, if 40 percent of reported intersection collisions are angle collisions, a site with 70 percent angle collisions would represent a 30 percent excess proportion. The largest such excess proportion represents the greatest potential for improvements targeting a specific collision type.

The analysis was performed by using an excess proportion screening to identify locations with a concentration of collision or environmental characteristics. The excess proportion screening helps to identify locations that would benefit from a particular countermeasure or suite of treatments (e.g., system locations with a high incidence of run-off road collisions would benefit from similar treatments). These locations are intended to help the City identify priority locations for implementation of systemic recommendation from the Systemic Solutions in Section 3, as well as focus some of the Non-Infrastructure Recommendations such as enforcement and education, summarized in Section 6.

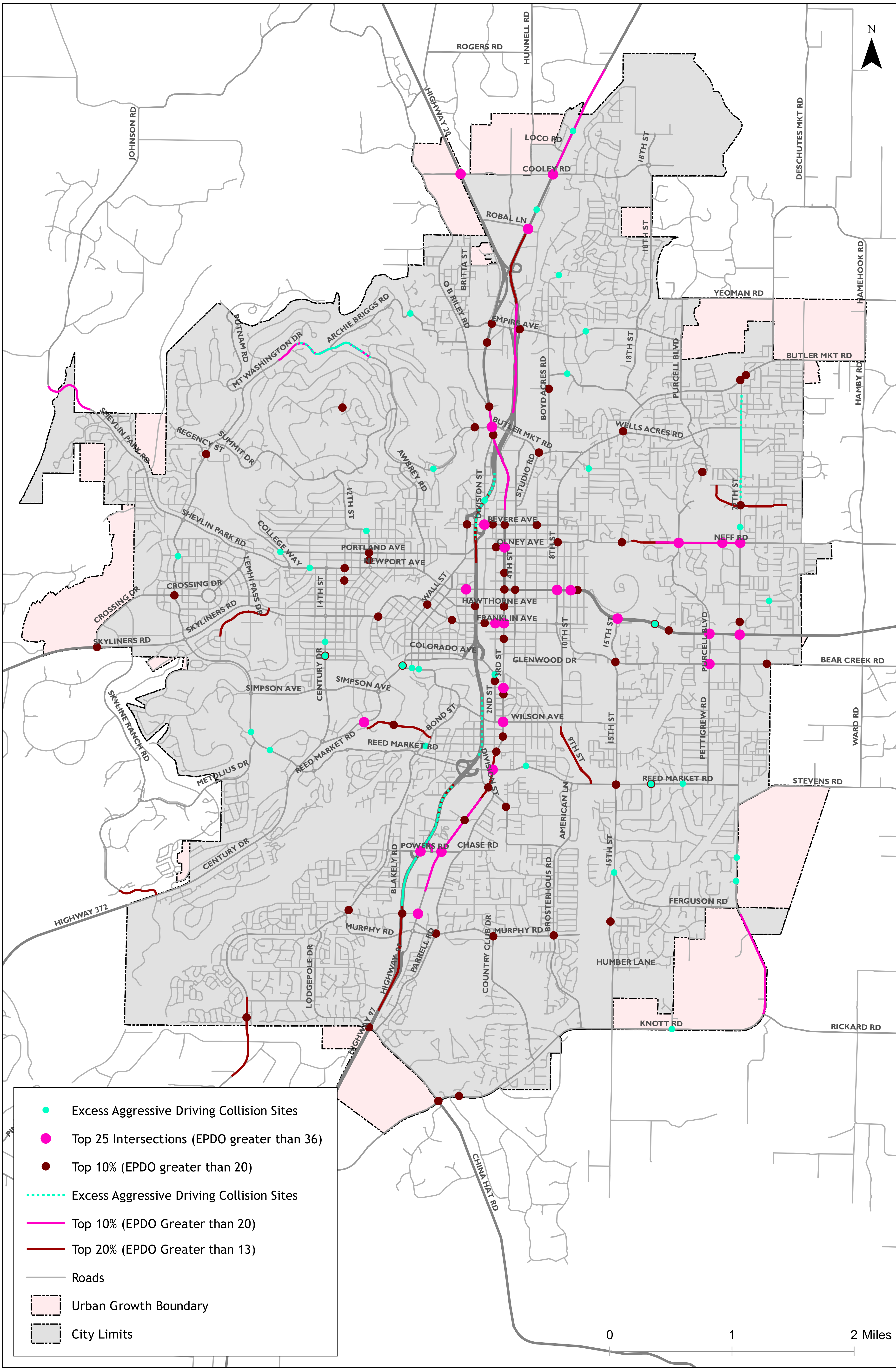
Analysis results identified the following emphasis areas in the existing conditions work to be associated with increased risk of severe outcomes and were therefore used for the excess proportion of specific crash types screenings:

- **Aggressive driving collisions:** Figure 32 illustrates the top intersections and segments with excess proportion of aggressive driving collisions. Aggressive driving collisions include those involving speed and following too closely. The Speed Management Toolbox, presented in Section 4, and the Education and Enforcement recommendations in Chapter 6 best address these crash types.
- **Dark, with no street lights present**: Figure 33 illustrates the top intersections and segments with excess proportion of crashes occurring during dark conditions with no street lights present, according to the crash reports. These locations may benefit from installing additional illumination and/or roadway delineation, as summarized in the Systemic Toolbox.
- **Angle collisions (includes angle and turning movement collisions)**[4]: Figure 34 illustrates the top intersections with excess proportion of angle and turning movement crashes. These locations may be good candidates for the systemic signalized and unsignalized intersection treatments, particularly those that increase intersection awareness.
- **Rear-end collisions**[4]: Figure 35 illustrates the top intersections with excess proportion of rear-end crashes. These locations may be good candidates for the systemic signalized and unsignalized intersection treatments, particularly those that increase intersection awareness.
- **Head-on collisions**[5]: Figure 36 illustrates the top segments with excess proportion of head-on collisions. These locations may be good candidates for the speed management toolbox, roadway departure systemic countermeasures, and increased enforcement.
- **Roadway departure (includes fixed object and non-collisions)**[5]: Figure 37 illustrates the top segments with excess proportion of roadway departure crashes. These locations may be good candidates for the roadway departure systemic toolbox and increased enforcement.

[4] This collision characteristic was only screened at intersection locations
[5] This collision characteristic was only screened along segments

- **Alcohol/drug involvement**: Figure 38 illustrates the top intersections and segments with excess proportion of alcohol/drug impaired crashes. These locations may be good to target for education outreach and enforcement actions.

The maps showing the results of each screening also include the top 10 percent of intersections and segments based on the EPDO screening to illustrate where the excess proportion of specific crash types also overlaps with high crash frequency and severity.



Equivalent Property Damage Only Scoring and Excess Proportion
Top EPDO Scores and Excess Aggressive Driving Collision Sites
Bend Area, 2012-2016

Figure
32

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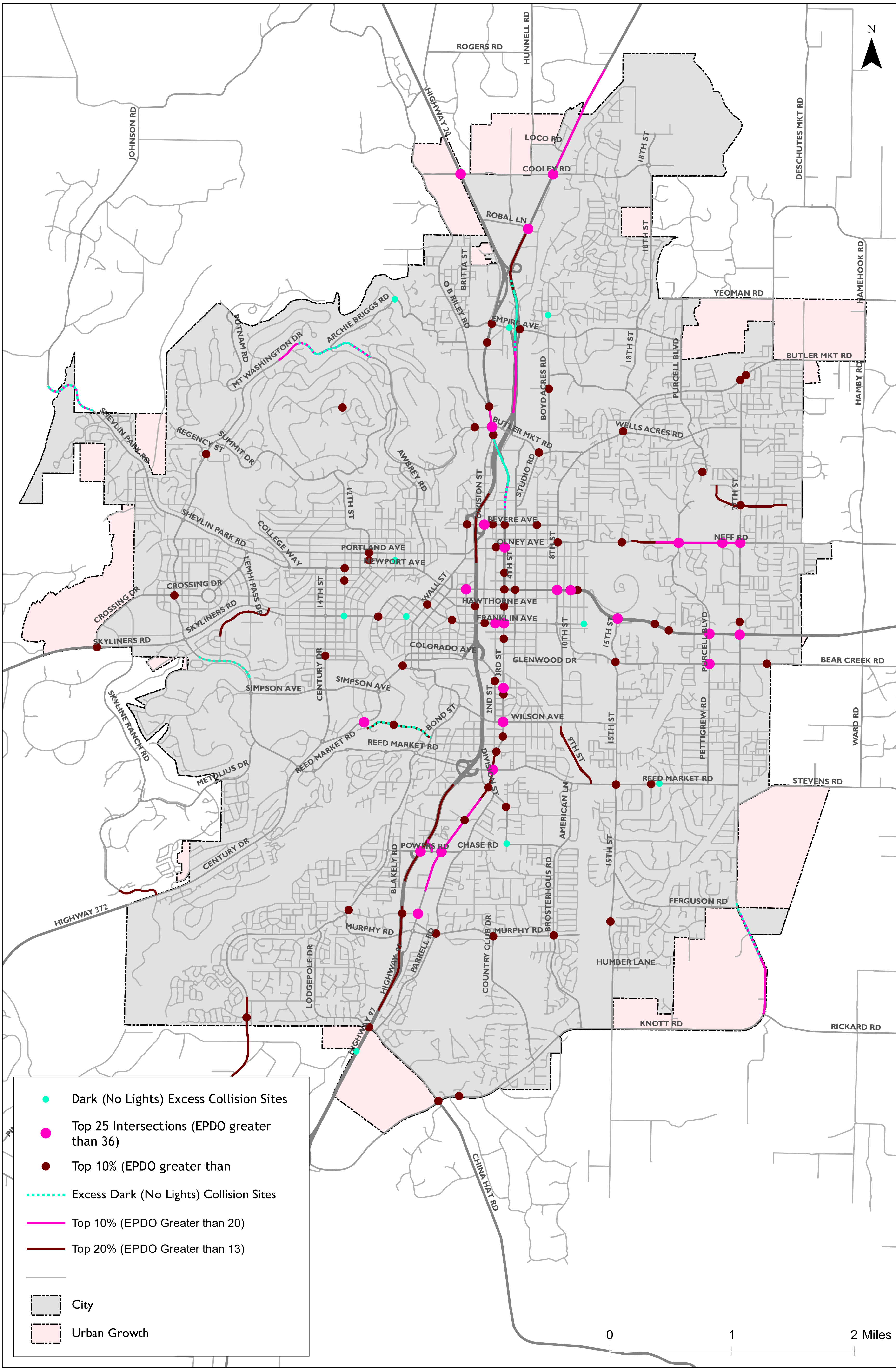
Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.



Equivalent Property Damage Only Scoring and Excess Proportion
Top EPDO Scores and Excess Dark (No Lights) Collision Sites
Bend Area, 2012-2016

Figure
33

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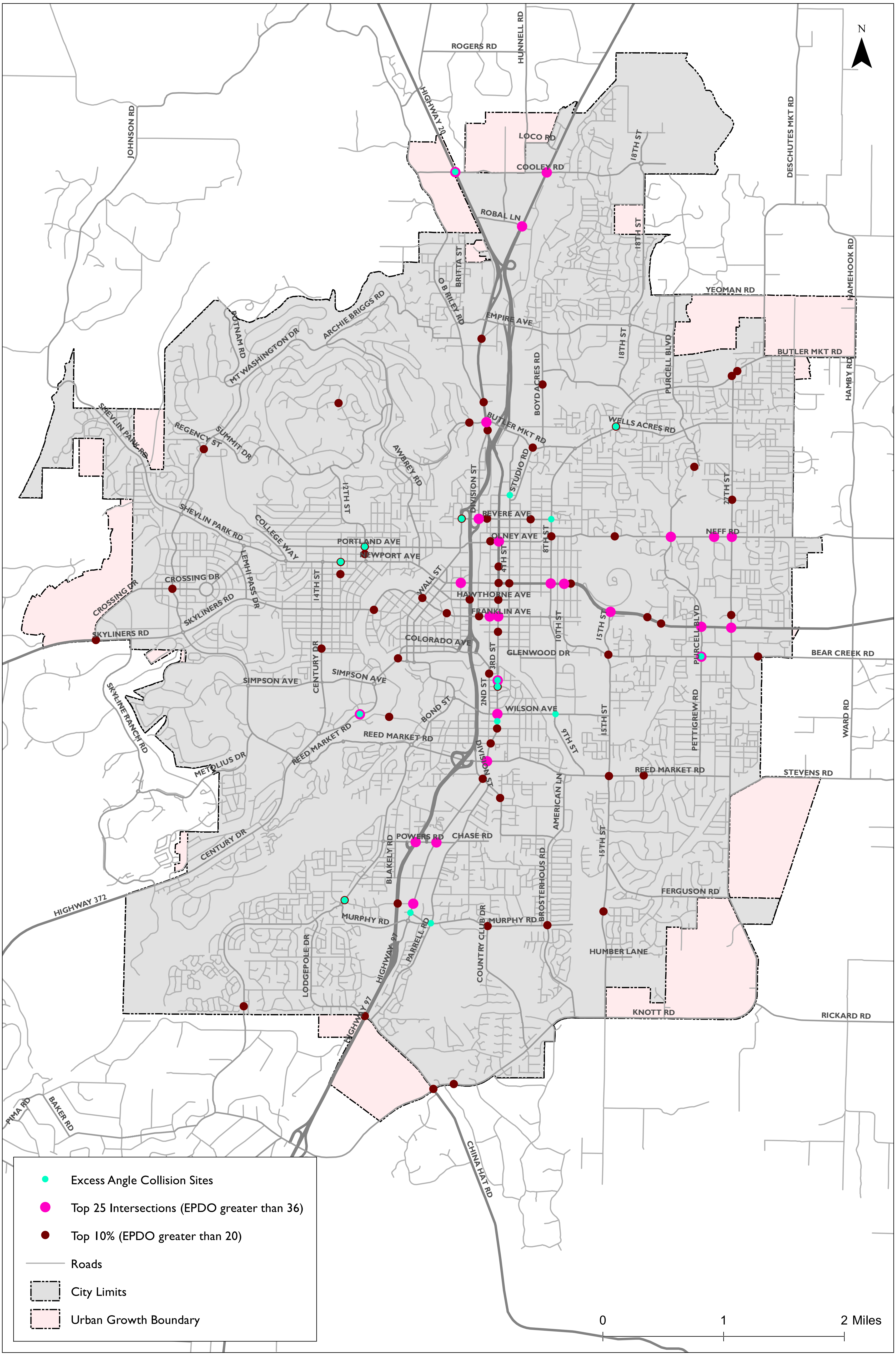
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.



Equivalent Property Damage Only Scoring and Excess Proportion
Top EPDO Scores and Excess Angle Collision Sites
Bend Area, 2012-2016

Figure 34

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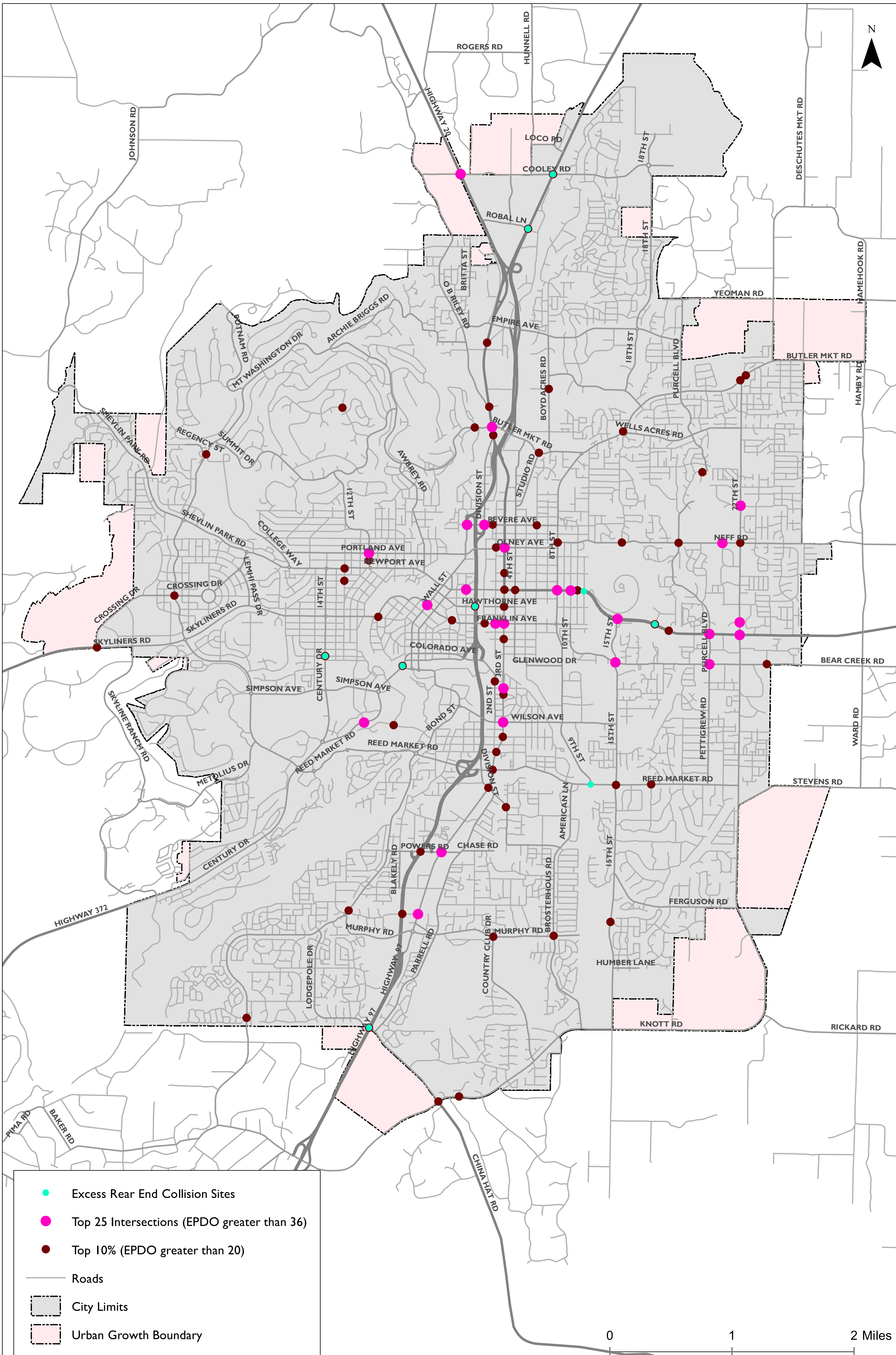
Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.



Equivalent Property Damage Only Scoring and Excess Proportion
Top EPDO Scores and Excess Rear End Collision Sites
Bend Area, 2012-2016

Figure
35

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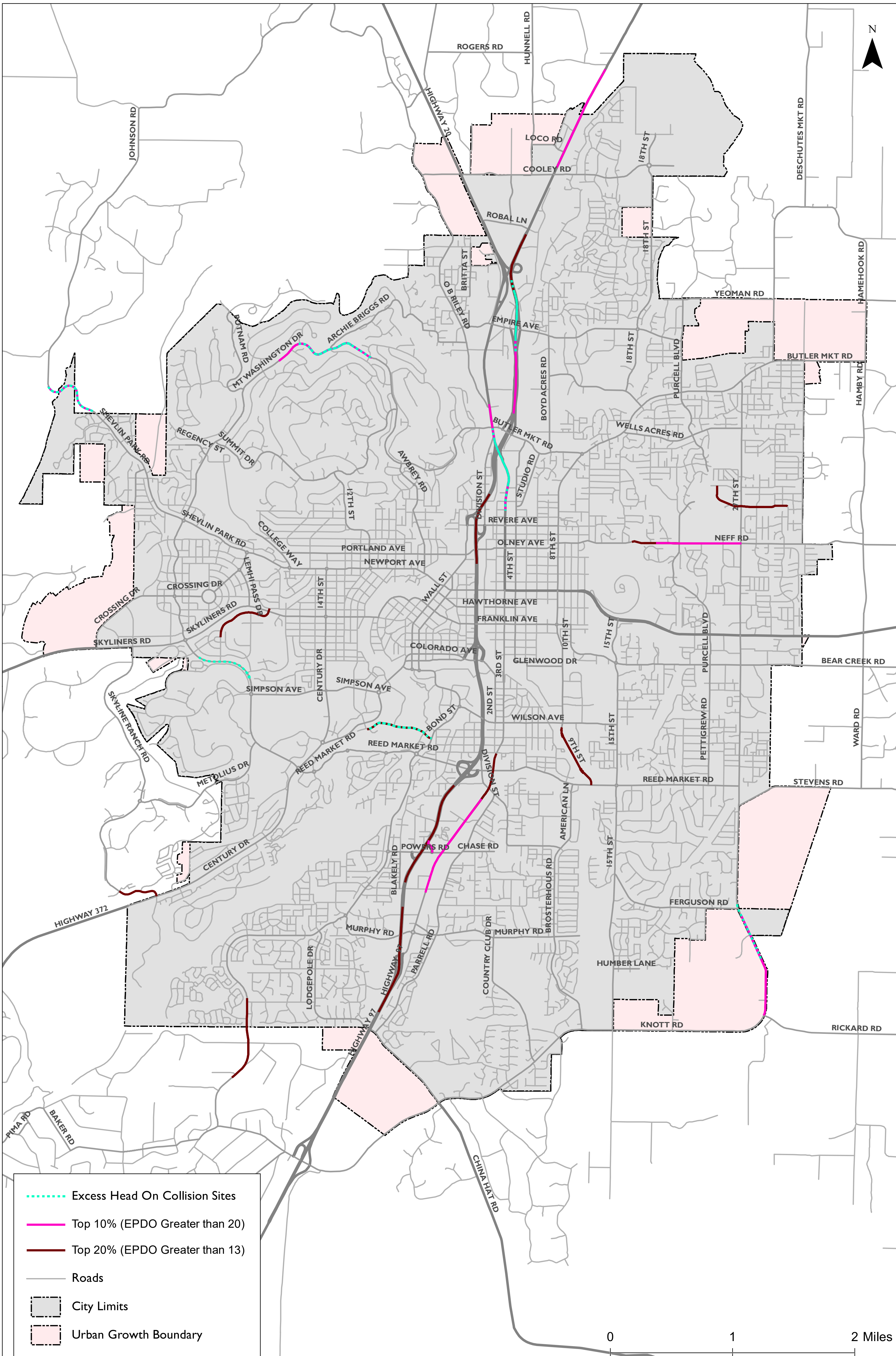
Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.



Equivalent Property Damage Only Scoring and Excess Proportion
Top EPDO Scores and Excess Head On Collision Sites
Bend Area, 2012-2016

Figure
36

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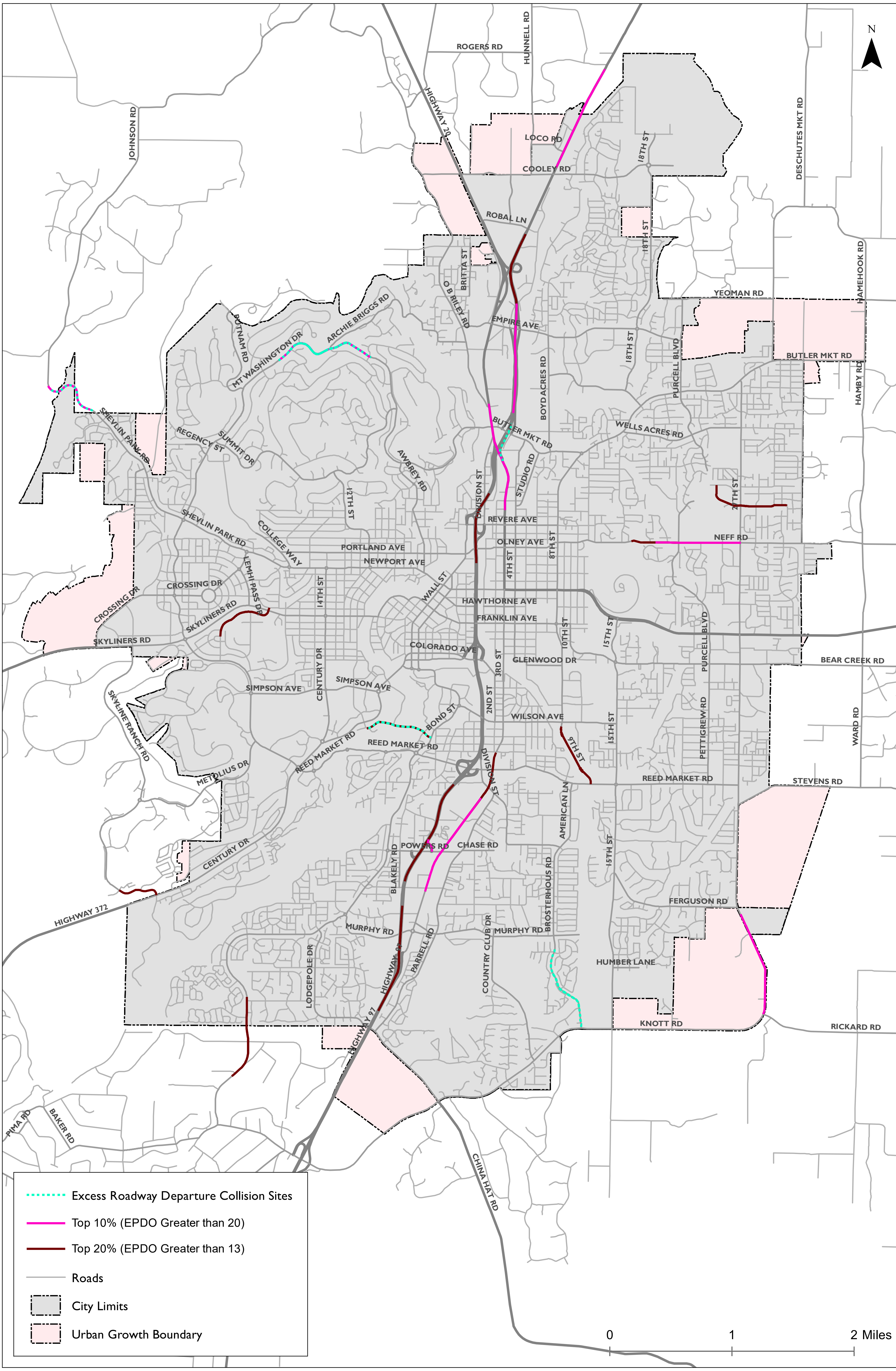
Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.



Equivalent Property Damage Only Scoring and Excess Proportion
Top EPDO Scores and Excess Roadway Departure Sites
Bend Area, 2012-2016

Figure
37

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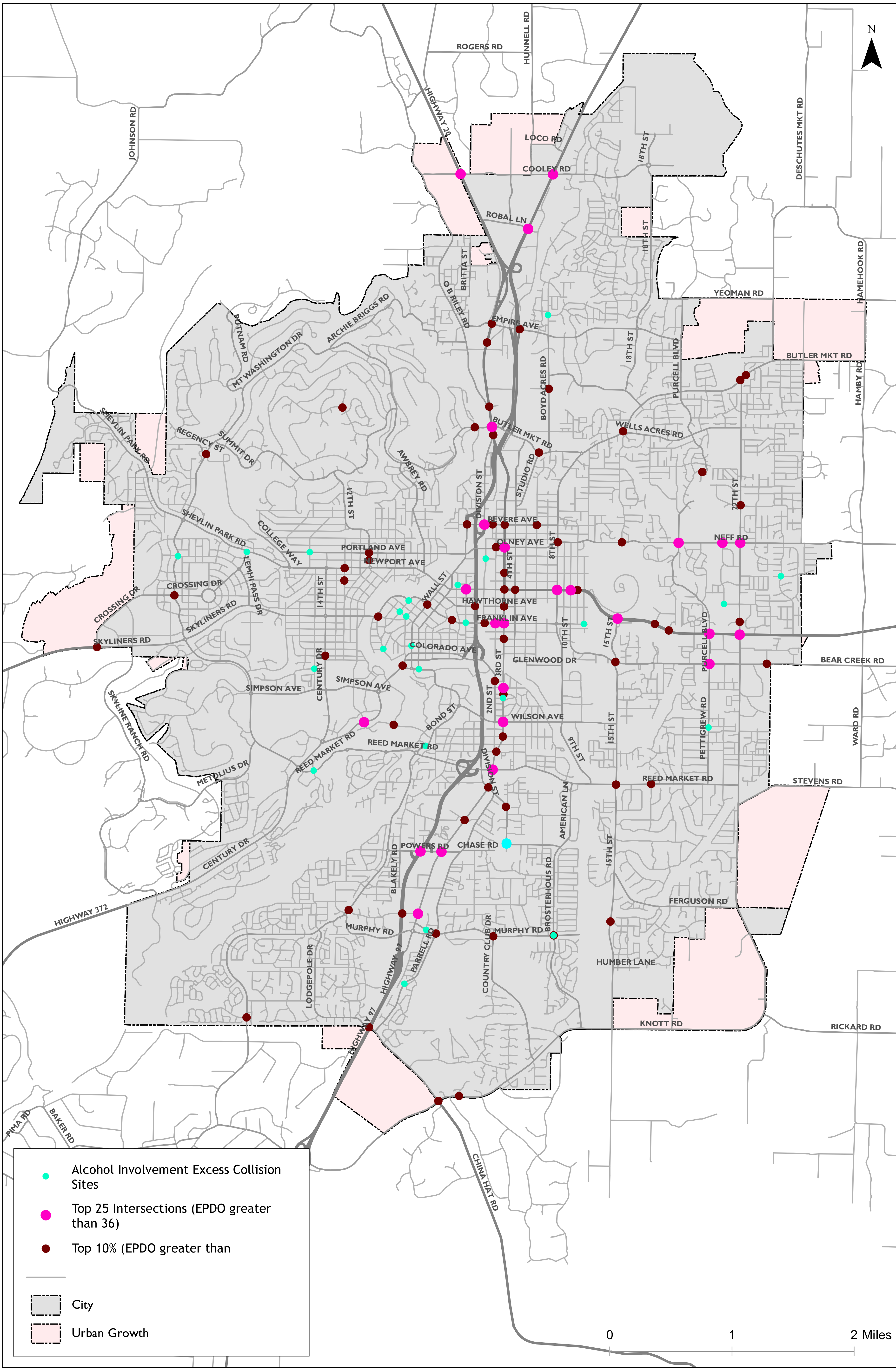
Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.



Equivalent Property Damage Only Scoring and Excess Proportion
Top EPDO Scores and Excess Alcohol Involvement Collision Sites
Bend Area, 2012-2016

Figure
38

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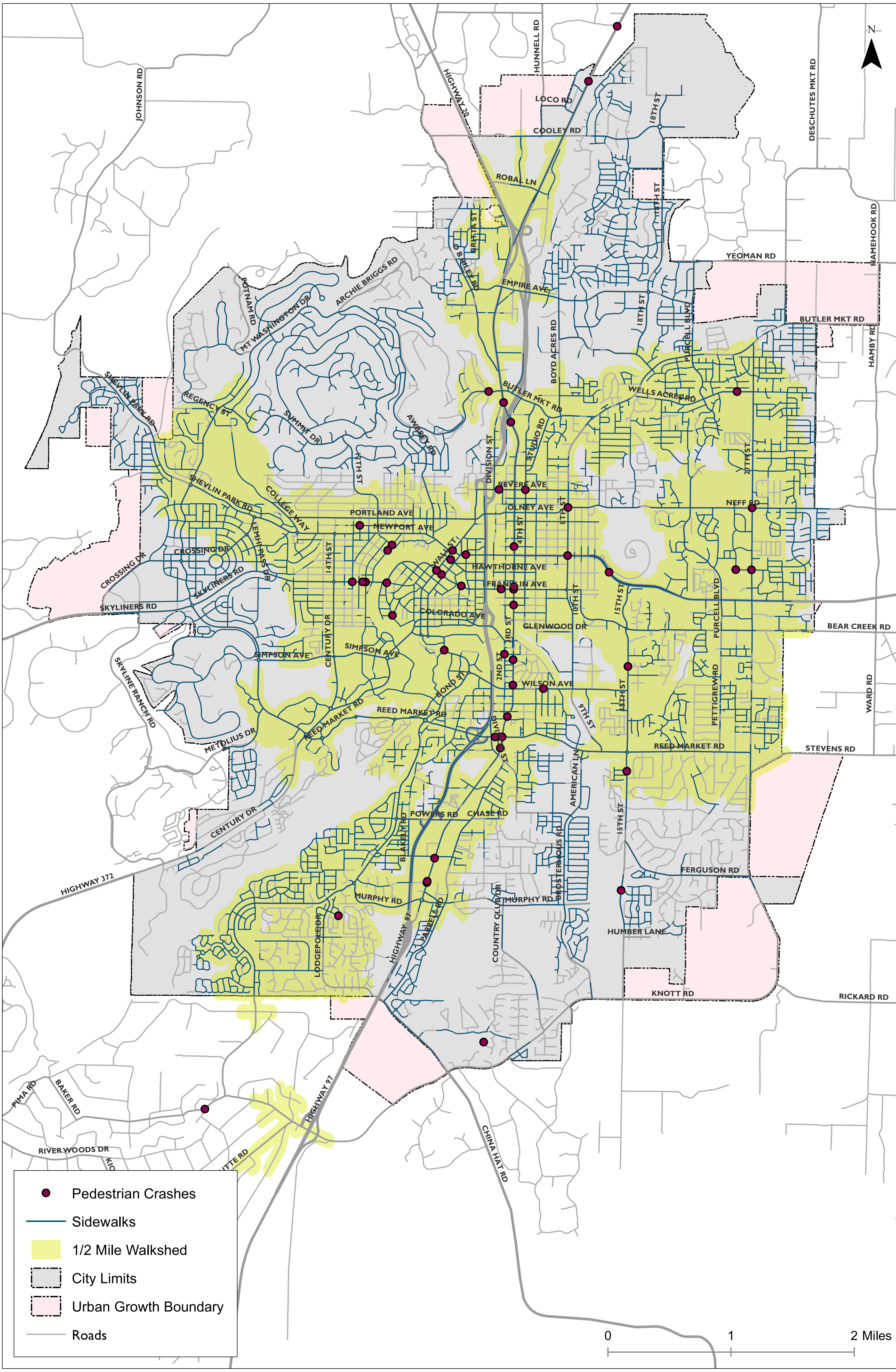
Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.

5.3.1 Pedestrian and Bicyclist Collisions

Pedestrian and bicyclist collisions are identified as an emphasis area for the City of Bend based on the severity of these crashes. However, because of their relatively low numbers of these reported crash types, the analysis did not include a specific excess proportion screening for pedestrian and bicyclist crashes. With 50 reported pedestrian collisions and 112 reported bicyclist collisions in the dataset, the comparison of proportions among sites with low collision frequency or only a single collision involving these road users is of limited value. Instead, the analysis assessed roadway conditions including speed and lane configurations as well as user behavior patterns that can be addressed systemically. These assessments are summarized in Sections 2, 3.4, and 3.5 of the TSAP and more thoroughly in Appendix 4.

To provide further resources for determining locations for systemic application of pedestrian and bicyclist treatments, Figure 39 illustrates the location of the reported pedestrian crashes in the Bend UGB, and Figure 40 illustrates the location of reported bicyclist crashes in the Bend UGB.



Pedestrian Crashes (2012 - 2016) & Sidewalks
Bend Area TSAP

Figure
39

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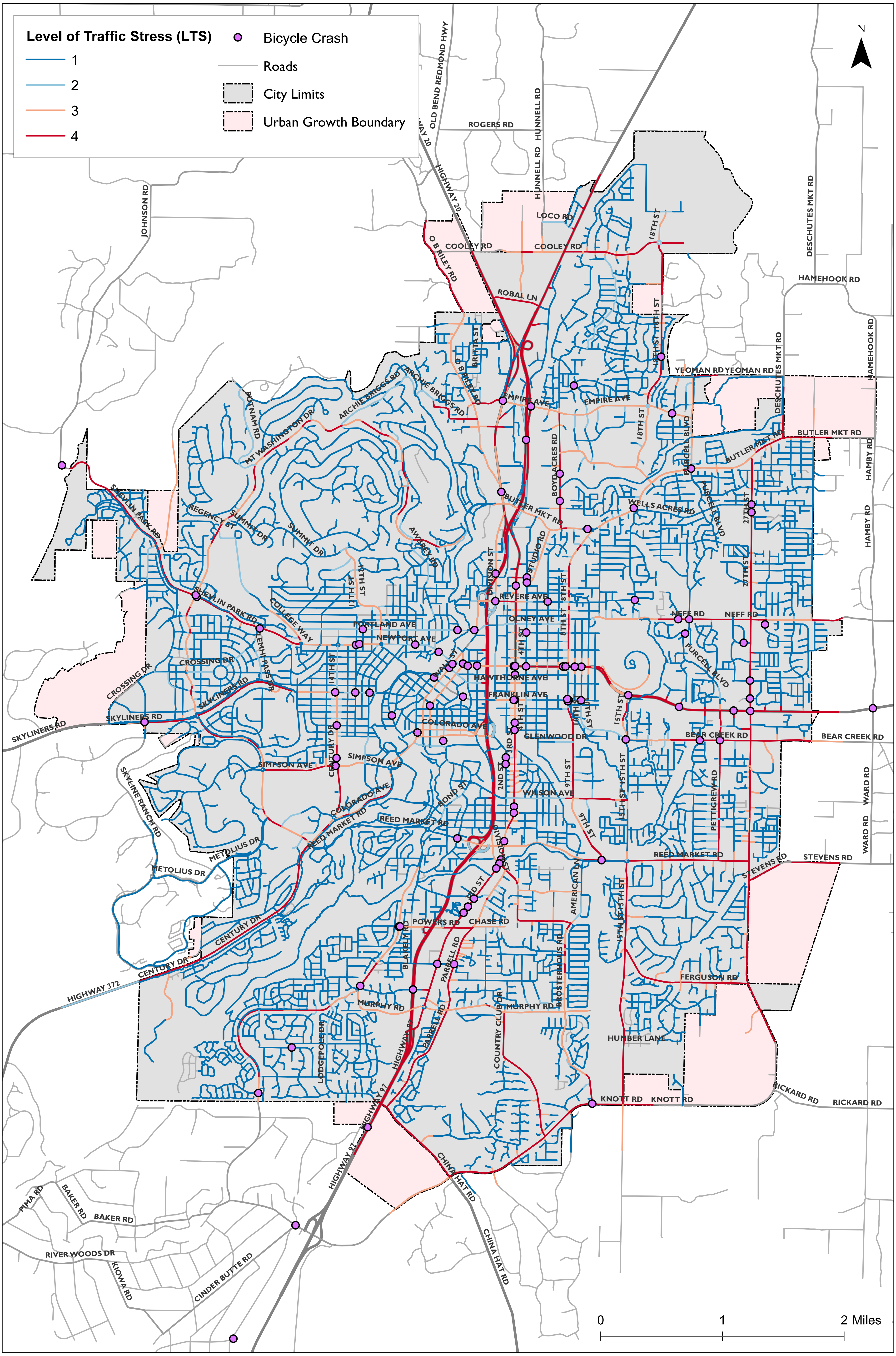
Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.



Bicycle Crashes (2012 - 2016) & Levels of Traffic Strees Bend Area TSAP

Figure 40

Coordinate System: NAD 1983 StatePlane Oregon South FIPS 3602 Feet Intl
Data Source: Bend MPO, City of Bend, Deschutes County, 2019.

SECTION 6

NON-INFRASTRUCTURE MEASURES

6. NON-INFRASTRUCTURE MEASURES

A comprehensive approach to transportation safety acknowledges that policy, planning, programming, and projects are multidisciplinary and involve "the 7Es" of safety:

- Engineering;
- Emergency Medical Services (EMS);
- Enforcement;
- Education;
- Encouragement;
- Equity; and
- Evaluation.

This section summarizes the additional programs and actions that are recommended to comprehensively address transportation safety in Bend. Many of the actions work towards helping Bend achieve a positive transportation safety culture. Therefore, Section 6.1 discusses transportation safety culture, and Section 6.2 provides the summary of the action items.

6.1 TRANSPORTATION SAFETY CULTURE

Safety Culture is the attitude residents share about safe driving and other forms of transportation. The Bend area recognizes the need to grow a positive safety culture and to have agreement within the community that serious injury and death from a vehicle crash is not acceptable. [i] [6]

6.1.1 NATIONAL EFFORTS RELATED TO SAFETY CULTURE

There are many national efforts to use as tools to develop a Safety Culture program in Bend. The report, *A Road to Zero: A vision for achieving zero roadway deaths by 2050*, was released in the midst of national discussions about motor vehicle safety issues, such as automated vehicles, investing in infrastructure, distracted driving, and alcohol- and drug-impaired driving. This report may help guide such programs for Bend. Another approach is through the Center for Health and Safety Culture from Montana State University. This program provides community training programs that includes a framework and messaging protocol that would help set up a program approach.

Positive Culture Framework from Montana University Center for Health and Safety Culture[1]

[1] Graphic courtesy Montana State Universtity

More national efforts include:

[6] National Highway Traffic Safety Administration (NHTSA) 2017 "USDOT Releases 2016 Fatal Traffic Crash Data." Press Release https://www.nhtsa.gov/press-releases/usdot-releases-2016-fatal-traffic-crash-data

- **The Road to Zero Coalition** is made up of 687 members ranging from advocacy organizations to government to public health experts. Its report on strategies to get to zero traffic deaths identifies creating a positive safety culture as one of the three key strategies. It provides several resources on its website covering a variety of topics.
- **The Toward Zero Deaths** national strategy details how to shift culture away from transportation risk acceptance. It brings together various state and local initiatives to pursue a highway system that is free of fatalities. Several cities, counties, and states around the country have adopted Vision Zero initiatives, including the City of Portland and the Oregon Department of Transportation (ODOT). The Vision Zero Network provides resources to help communities reach this goal.
- **The Transportation Research Board Safe Systems Committee** identifies research needs, explains research findings to the public, and creates partnerships between organizations focused on Safety Culture.

6.2 ACTION ITEMS

Table 10 summarizes Action Items for working towards a safety culture that promotes attentive driving, sober driving, and awareness of individual impact on roadway safety.

Table 10. General Safety Culture and Educational Action Items

Action Item	Description	Emphasis Area(s)	Lead Agency	Supporting Agencies	Funding Need
A1	Create and implement a Regional Transportation Safety Committee to coordinate on transportation safety and implement the Action Items identified in the TSAP. Other representatives from various outreach or advocacy groups will also be helpful to help with outreach. City staff participation from various departments such as police, streets, capital projects, engineering, and community development will help promote coordination across departments and the share of resources and data to coordinate transportation safety efforts. Regular meetings should occur at which the committee share data/resources, implements the Deschutes County and Bend Area TSAP Action Items, and identifies new actions needed based on more recent crash history.	Safety Culture	ODOT or City of Bend	Deschutes County, City of Bend, Bend MPO, Redmond, Sisters, La Pine, Police, Sheriff, District Attorney's office, Emergency Services, OLCC, Department of Public Health	$$$
A2	Create a staff position to lead the Regional Transportation Safety Committee and lead implementation of the Action Items in the TSAP. Staff may be part of Deschutes County or ODOT to better serve the full region. Seek funding for this position. ODOT Safety Division may have funding for first 2 years, local agencies may need to assist with funding after that.	Safety Culture	ODOT, Deschutes County	City of Bend, Bend MPO	$$
A3	Create a Bend Area Safety Communications Plan, including an education and public outreach system, that promotes a roadway safety culture that emphasizes attentive driving, sober driving, calm driving, driving at appropriate speeds, and awareness of individual impact on roadway safety. This should be a comprehensive and ongoing program that follows national as well as local messaging.	Safety Culture	Bend MPO, City of Bend	Deschutes County, ODOT	$$
A4	Develop a Safety Communications Calendar that provides monthly messages to emphasize in Bend. Develop a plan for recurring educational events throughout the year(s). Provide educational programs at community events.	Safety Culture	Bend MPO, City of Bend	Deschutes County, ODOT	$$
A5	Coordinate with the Bend Neighborhood (Associations) Leadership Alliance to provide	Safety Culture	Bend MPO, City of Bend	Bend Neighborhood Leadership Alliance	$$

Action Item	Description	Emphasis Area(s)	Lead Agency	Supporting Agencies	Funding Need
	outreach and additional funding for safety messaging.				
A6	Provide educational materials to visitors through partnerships with Visit Bend and local hotels/resorts.	Safety Culture	Bend MPO, City of Bend	Visit Bend	$$
A7	Provide educational materials to residents through partnerships with major employers and schools.	Safety Culture	Bend MPO, City of Bend	Major Employers and Schools	$$
A8	Develop and maintain policies to support the actions identified in the TSAP and to better incorporate safety into long-range planning and the project development process.	Safety Culture	Bend MPO, City of Bend		$
A9	Increase enforcement during highest risk times, based on the reported crash data patterns. Quarterly with time of day/day of week/changing trends to traffic team.	Safety Culture, Enforcement	Police	Bend MPO, City of Bend	$$
A10	Evaluate options for a pilot study for automated enforcement of speeding and red-light running in key locations.	Safety Culture, Enforcement, Aggressive Driving	Police	City of Bend, Deschutes County, ODOT	$
A11	Provide bystander training courses to the public to educate residents how to respond in an emergency event.	Emergency Response	Police, EMS, Hospitals		$$
A12	Reduce (optimize) response time to crashes. Work with the EMS Council and Oregon Area Trauma Advisory Board to complete this.	Emergency Response	EMS, Police		$
A13	Develop a speed management program that would work to implement best practices in setting design speeds and speed limits, including implementing risk-based speed limits. The program may include components such as: street design standards to promote lower speeds, a funded program for response to speed concerns submitted by citizens, and an expanded program for deployment of radar speed feedback signs and sharing of data with the police department, County, City staff, and the public.	Safety Culture, Aggressive Driving	City of Bend	Various departments within City of Bend, Police	$$
A14	Encourage employers and families to institute policies related to driving safely, including attentive driving, by sharing the National Safety Council's sample contract in its Distracted Driving Toolkit.	Safety Culture, Distracted Driving	City of Bend, Bend MPO	Employers	$
A15	Educate youth and adults on the importance of paying attention when using the transportation system.	Safety Culture, Distracted Driving	City of Bend, Bend MPO		$

Action Item	Description	Emphasis Area(s)	Lead Agency	Supporting Agencies	Funding Need
A16	Partner with other agencies such as Deschutes County to implement an unmarked car distracted driving program to increase compliance with distracted driving rules. Consider grants to do this.	Safety Culture, Distracted Driving, Enforcement	Police	OSP	$$
A17	Work with alcohol/marijuana retailers/servers to encourage compliance checks to deter underage sales and over serving and to promote Oregon Liquor Control Commission's Responsible Vendor Program.	Impaired Driving	OLCC		$
A18	Develop an educational campaign to promote sober driving. Provide educational posters, social media posts, and public service announcements to inform the public about the dangers of impaired driving, including alcohol and drugs. Work in schools to educate students on the consequences of impaired driving. Emphasize that driving while or after using marijuana is impaired driving.	Safety Culture, Impaired Driving	Bend MPO, City of Bend		$
A19	Increase Driving Under the Influence and impaired driving enforcement through data-driven saturation patrols and provide officers with Drug Recognition Expert Training and standardized field sobriety tests training.	Impaired Driving, Enforcement	Police, Sheriff		$$
A20	Partner with Deschutes County to support the Shared Future Coalition and increase education about the consequences of impaired driving (alcohol and drugs). Education should emphasize the effects of marijuana on the body to help drivers understand that driving while or after using marijuana is impaired driving. Grow partnerships and support existing efforts to reduce underage drinking, underage marijuana use, and drug use through funding, educational outreach, and coalition membership. Partner with substance abuse treatment programs.	Safety Culture, Impaired Driving	Deschutes County		$$
A21	Develop repeat DUI driver offender programs focused on treating the causes of DUI.	Impaired Driving	Deschutes County (Shared Future Coalition)		$
A22	Formalize rideshare locations in the downtown area and near locations with multiple restaurants, bars, and pubs to encourage greater use of cabs and rideshare options.	Safety Culture, Impaired Driving	Bend MPO, City of Bend	Downtown Bend, Restaurants and Bars, Cab	$$

Action Item	Description	Emphasis Area(s)	Lead Agency	Supporting Agencies	Funding Need
				and Rideshare companies	
A23	Coordinate with local bars, businesses, and rideshare companies to develop and offer a program that provides users with a discount for taking a cab or rideshare to or from drinking establishments.	Safety Culture, Impaired Driving	Bend MPO, City of Bend	Downtown Bend, Restaurants and Bars, Cab and Rideshare companies	$
A24	Coordinate with area business groups and event promoters to develop and offer a program that provides users with a discount for taking a cab or rideshare to or from special events (such as Bit of Bend, Summerfest, etc.).	Safety Culture, Impaired Driving	Bend MPO, City of Bend	Downtown Bend, Restaurants and Bars, Cab and Rideshare companies	$
A25	Conduct targeted outreach using various means, relationships, and venues to encourage a change in safety culture to convince motorcyclists to enact safe riding practices. Work with motorcycle shops to educate riders about the behaviors associated with higher risk such as discouraging group rides. Provide educational posters, social media posts, and educational placards to inform motorcyclists of the consequences of crashes and promote safe riding practices, safety equipment, and motorcycle handling skills and maintenance.	Safety Culture, Motorcycles	City of Bend, ODOT		$
A26	Encourage more education programs for riders who have taken a break from riding. Work with motorcycle retailers to encourage education for new riders.	Safety Culture, Motorcycles	City of Bend, ODOT		$
A27	Continue to support partnership with Commute Options and the Deschutes County Bicycle and Pedestrian Advisory Committee (BPAC).	Safety Culture, Pedestrians / Bicyclists	City of Bend, Bend MPO		$
A28	Continue to provide local educational programs at schools and other venues (safety fairs, community events, etc.) for both students and parents, including: educate parents about traffic safety, including safe parking locations when lining up for school pick-up; educate students and parents on safe pedestrian and bicycle practices including safe crossing practices and not playing behind vehicles or near streets; educate about the importance of adult supervision; provide educational materials for students to share with parents about the risks associated with	Safety Culture, Pedestrians / Bicyclists	Commute Options		$$

Action Item	Description	Emphasis Area(s)	Lead Agency	Supporting Agencies	Funding Need
	distracted driving, including distracted pedestrians.				
A29	Collaborate with the Department of Public Health to work on active transportation, safe routes to school, health impact assessments, and rural access to health care. Include transportation safety in public health education programming.	Safety Culture	Deschutes County Health Department		$
A30	Create Bend Area Safe Routes to School program.	Pedestrians / Bicyclists	Bend MPO, City of Bend	Commute Options	$$
A31	Continue the "Friendly Driver" program for truck drivers and expand it beyond truck drivers to include drivers associated with businesses and business activities. This program currently educates truck drivers on how to operate in the presence of people walking and biking. Offer incentive programs to encourage businesses to expand this program beyond truck drivers.	Safety Culture; Pedestrians/ Bicyclists	Commute Options	Local Businesses	$$
A32	Evaluate where opportunities exist for new educational and promotional programs for pedestrians and bicyclists over time.	Safety Culture; Pedestrians/ Bicyclists	Commute Options	Bend MPO, City of Bend	$
A33	Conduct adult pedestrian and bicycle outreach, such as safe crossing practices and new pedestrian/bicycle infrastructure education.	Safety Culture; Pedestrians/ Bicyclists	Commute Options	Bend MPO, City of Bend	$
A34	Educate drivers and bicyclists about bicycle transportation, including proper driver and bicyclist behavior and rules of the road for bicyclists, when to dismount, how to use sidewalks and crosswalks, how to ride through roundabouts, common crash types, etc.	Safety Culture; Pedestrians/ Bicyclists	Bend MPO, City of Bend		$
A35	Coordinate with BPAC to reintroduce placards with rules for bicyclists, pedestrians, and motor vehicle drivers.	Safety Culture; Pedestrians/ Bicyclists	BPAC		$
A36	Design roadways integrating pedestrian and bicyclist safety considerations by providing appropriate pedestrian and bicyclist infrastructure, encouraging slower motor vehicle speeds, and minimizing conflict points between pedestrians, bicyclists, and motorists. Treatments may include: Sidewalks, pathways, and other walkways separating pedestrians from motor vehicles along roadways; Enhanced roadway crossings; Shared lane markings, wayfinding, traffic calming for lower	Pedestrians/ Bicyclists	City of Bend; ODOT	Deschutes County	$$

Action Item	Description	Emphasis Area(s)	Lead Agency	Supporting Agencies	Funding Need
	speed and volume roadways, and enhanced striping (striping, buffers, rumble strips) to facilitate striping durability on higher volume roadways; Increasing physical separation between people biking and motor vehicles as motor vehicle volumes and speeds increase, including physical barriers at higher speeds and volumes.				
A37	Continue the neighborhood greenways program to implement the identified major corridors to encourage walking and biking and implement a low stress bicycle network.	Pedestrians/ Bicyclists	City of Bend; Bend MPO		$$
A38	Develop and promote a wayfinding system to educate bicyclists about the network and encourage use of lower stress routes instead of higher stress routes.	Pedestrians/ Bicyclists	City of Bend; Bend MPO	ODOT, Deschutes County	$$
A39	Develop a plan for closing gaps in the sidewalk system and providing appropriate designed crossings to work towards a long-term goal of completing the sidewalk system throughout the City.	Pedestrians/ Bicyclists	City of Bend	ODOT, Deschutes County	$$$
A40	Review procedures for maintaining bike lane markings to consider other treatments such as rumble strips or buffers where striping is commonly worn down by vehicles encroaching on the bike lane.	Pedestrians/ Bicyclists	City of Bend; ODOT		$
A41	Encourage conversations and expand a safety culture about safe driving between families of senior drivers, health care professionals, and community groups such as churches, meals on wheels, etc. Since seniors are more likely to be taking medications, teach people about the impact of medicines on their ability to think clearly and react quickly.	Safety Culture; Senior Drivers	Health Care Professionals and Community Groups		$
A42	Support training sessions through AARP, AAA, and insurance companies to help seniors maintain driving skills.	Senior Drivers	AAA, AARP, Insurance Companies		$
A43	Provide transportation options through infrastructure that allows for transit, walking, and other forms of transportation. Partner with transportation assistance programs to promote non-driving options for seniors.	Senior Drivers	COIC, CET, City of Bend, ODOT		$$
A44	Support driver education programs and safety education for younger drivers. Support peer-based safe driving marketing efforts and outreach	Safety Culture; Young Drivers	ODOT, Commute Options		$

Action Item	Description	Emphasis Area(s)	Lead Agency	Supporting Agencies	Funding Need
	programs in high schools to provide driver and non-motorized travel safety education. Support family-based driver education to leverage parental influence.				
A45	Begin safety education before young people reach driving age, as early as preschool. Partner with groups such as Safety Towns and school districts.	Safety Culture; Young Drivers	Commute Options, Safety Towns, School District		$
A46	Seasonally educate drivers about proper driving behavior and vehicle preparations for winter conditions.	Safety Culture; Winter Driving	ODOT, City of Bend	Deschutes County	
A47	Integrate technology advancements to improve transportation safety.	Technology	City of Bend, Bend MPO	ODOT, Deschutes County	$$
A48	Continue to monitor technology enhancements to reduce severe crashes at traffic signals.	Technology	City of Bend, Bend MPO	ODOT, Deschutes County	$
A49	Evaluate options to use traffic volume, near-misses, and other data to understand where perceived safety issues may exist	Technology	City of Bend, Bend MPO	ODOT, Deschutes County	$$
A50	Evaluate the ability to use crowdsourcing technology to identify risks and locations for additional assessment	Technology	City of Bend, Bend MPO	ODOT, Deschutes County	$$
A51	Evaluate opportunities or pilot studies to use lidar, radar, and/or photo enforcement	Technology	City of Bend, Bend MPO, Police	ODOT, Deschutes County	$$
A52	Implement the Annual Update Procedure, summarized in Section 8 of the TSAP.	Monitoring	City of Bend, Bend MPO		$

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SECTION 7

PERFORMANCE MEASURES

7. PERFORMANCE MEASURES

Performance measures are used to evaluate progress in completing the actions identified in the TSAP and in achieving the desired outcomes of the Plan. The Oregon TSAP identifies two general types of performance measures:

- **Effectiveness** Performance Measures track the **results** of a program or activity. For example, they track how many fatalities or injuries occurred, or number of non-motorist fatalities.
- **Efficiency** Performance Measures track **effort and output**. For example, they track how many activities were conducted, or miles of treatment were installed.

TRANSPORTATION SAFETY EFFECTIVENESS PERFORMANCE MEASURES

The Oregon Department of Transportation and the Bend MPO area have adopted the federally required performance measures, which are effectiveness performance measures, as summarized in the Transportation Safety Regulatory Memorandum, provided in Appendix 6.

MPOs and state departments of transportation (DOTs) are required to report annually on the following performance measures:

- Fatalities
- Fatality Rate
- Serious Injuries
- Serious Injury Rate
- Non-motorized Fatalities and Serious Injuries
- Rural Road Safety (DOT only)
- Older Driver and Pedestrian Safety (DOT only)

MPOs can choose to adopt the state established targets or establish targets specifically for the planning area for performance measures listed above (the first five bullets). The Bend MPO is currently using ODOT's established targets, which are based on an S-curve forecast trend using five-year averages to achieve the vision of zero fatalities and life-changing injuries by 2035. The targets are applicable to all public roads in the MPO and must be reported annually. For reference, Table 11 identifies each target baseline and five-year average target for the five performance measures from the baseline five-year average (either 2010-2014 or 2011-2015, depending on the data set) to 2017-2021 for the entire state of Oregon.

Table 11. ODOT Performance Targets (Five-Year Average)

Base Period	Fatalities (People) (2011-2015)	Fatality Rate (People per 100 Million VMT) (2011-2015)	Serious Injuries (People) (2011-2015)	Serious Injury Rate (People per 100 Million VMT) (2011-2015)	Non-motorized Fatalities and Serious Injuries (2011-2015)
Baseline	357	1.04	1,491	4.42	234
2013-2017	357	0.94	1,491	4.42	234
2014-2018	350	0.89	1,461	4.33	229
2015-2019	343	0.83	1,432	4.24	225
2016-2020	328	0.78	1,368	4.06	215
2017-2021	306	0.73	1,274	3.78	200

[a] 2014-2018 is the first period that targets must be established for the HSIP Program.

Table 12 summarizes the resulting performance measures based on the 2012 – 2016 reported crash data used in the TSAP. The table summarizes the performance measures for the Bend UGB area, which is the TSAP study area, and the entire MPO area. As shown in the table, Bend's 2012 – 2016 fatality rate and serious injury rate were below the state's targets for the 2013 – 2017 time period.

Table 12. Bend UGB Area and Bend MPO Area Performance Targets (2012-2016)

Base Period	Fatalities (People)	Fatality Rate (People per 100 Million VMT)	Serious Injuries (People)	Serious Injury Rate (People per 100 Million VMT)	Non-motorized Fatalities and Serious Injuries
Bend UGB Area					
2012-2016	12	0.45	88	3.31	19
Bend MPO Area					
2012-2016	13	0.49	102	3.84	20

Appendix 1 Framework Memorandum

Appendix 2 Summary of Deschutes County TSAP Recommendations in Bend MPO Area

Appendix 3 Summary of City/MPO Safety Work

Appendix 4 Existing Conditions Memorandum

Appendix 5 Collision Diagrams

Appendix 6 Transportation Safety Regulatory Memorandum

Appendix 7 ODOT's Approved Crash Reduction Factors

Appendix 8 Bend Bikeway Design Guide

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