Appendix 3 Summary of City/MPO Safety Work

RECENT PROGRESS IN TRANSPORTATION SAFETY

The City of Bend performed safety evaluations to identify priorities for transportation safety countermeasures prior to the 2019 Bend Transportation Safety Action Plan.

In 2012, the City completed a multimodal traffic safety plan 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.

From the 2012 multimodal traffic safety plan, the City of Bend make strides toward safety improvements in our area. Key improvement are shown in Figure 1.

Table 4.

Summary of 2012-2014 Crash Reduction Program Elements

Education	Enforcement	Engineering
Continue current education programs	Focus on high crash locations	Design and Construct CIP Project List
Supplement existing programs with focus on: • Biking (visibility at night, risk of vehicles turning across their path of travel, wrong way riding) • Walking (visibility at night, risk of vehicles turning across their path of travel on "WALK," multiple approach lane risk during roadway crossings) • Driving (speeding, DUII, red light running, turning across a bicyclists path of travel, yielding to people walking)	Focus on high crash causations: • Speeding • DUII • Red Light Running • Failure to Yield to bicyclists and pedestrians	Perform city-wide Curve Warning Assessment and Mitigation
	Continue Bike Diversion Program	Perform city-wide Roadside Hazard Identification and Mitigation
	Investigate Pedestrian Diversion Program	Update Standards and Specifications to reflect state of the art and technology usage to reduce crash risks
	Find ways to support more funding for traffic enforcement	Implement multi-modal count program to support future crash analysis efforts

FIGURE 1 SUMMARY OF 2012 MULTIMODAL TRAFFIC SAFETY PLAN - CRASH REDUCTION ELEMENTS

This plan also recommended enforcement and outreach efforts to mitigate driving while impaired and speed related crash trends. The planning and police staff presented to Bend City Council to request additional funding for enforcement activities to address these behaviors. The Presentation is included in the 2012 multimodal traffic safety plan attached.

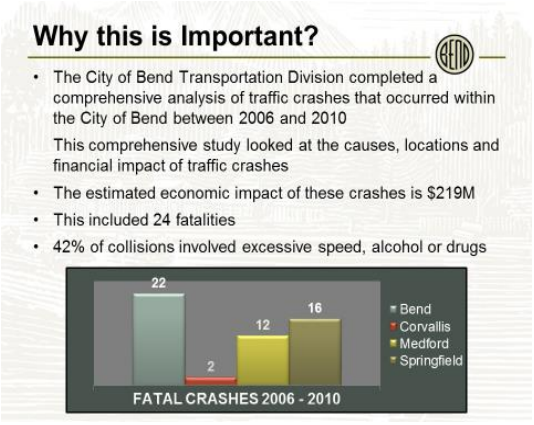


FIGURE 2 PRESENTATION TO BEND CITY COUNCIL 2012 MULTIMODAL TRAFFIC SAFETY PLAN ENFORCEMENT REQUEST

The 2012 multimodal traffic safety plan led to several implementation plans and grant applications.

Bend Safety Implementation Plan, June 2015

- This report summarizes the conceptual design of safety solutions at priority locations in the four corridors addressed by this project:
  - 3rd Street between Greenwood Avenue and Murphy Road
  - Colorado Avenue between Bend Parkway and Bond Street
  - Greenwood Avenue West between 3rd Street and Awbrey Road
  - Greenwood Avenue East between 3rd Street and 12th Street

Bend Roadway Departure Report, February 2015

- Describes the conditions and potential improvements at four locations identified by Planning efforts
  - Mt. Washington Drive East of Archie Briggs Road
  - Mt. Washington Drive West of Archie Briggs Road
  - Brookswood Boulevard South of Reed Market Road
  - Brosterhous Road at the BNSF Railroad Overcrossing

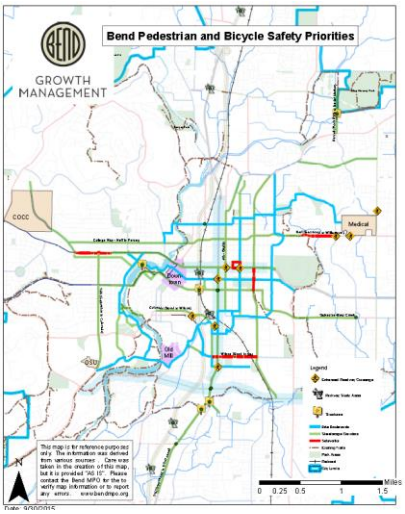


FIGURE 3 MAP OF IMPROVEMENT LOCATIONS FOR THE STRATEGIC IMPLEMENTATION PLAN FOR PEDESTRIAN AND BIKE INFRASTRUCTURE

Citywide Safety Improvements Report, April 2017

- Summary of project completed to date and proposed downtown area safety improvements.

Strategic Implementation Plan for Pedestrian and Bike Infrastructure, August 2015

- This report summarized the public process and project identified for a connected pedestrian and biking transportation system.
  - Pedestrian and bicycle facilities and identified improvement areas.

Bend Roundabout Assessment for 15th Street and Reed Market, March 2017

- This report presents the evaluation results of the field data collected at the study roundabout of 15th Street/Reed Market Road

- Details in the show an 84% reduction in the total reported collisions at the intersection of 15th Street/Reed Market Road as well as the calculated observed crash rates for both before and after the construction of the roundabout

TABLE 1 REED MARKET/15TH ROUNDABOUT SAFETY ASSESSMENT

Year	Reported Crashes				Average Crashes/ Year	Observed Crash Rate/Million Entering Vehicle (MEV)	% Total Reduction
	Fatal	Injury	PDO[2]	Total			
Before (2010 to 2014)[1]	0	26	65	91	18.2	1.9	84
After (2015)[1]	0	2	1	2	3	0.3	

Notes:
1. Before refers to the time before the roundabout was built. After refers to the time after the roundabout was built. The roundabout was opened November 21, 2014 and the "After" crash data is available only for the year 2015. The 2015 data is preliminary and subject to change.
2. PDO = Property Damage Only crashes

All Roads Transportation Safety Grant Proposals, May 2018

- Applications were submitted to ODOT including
  - Neighborhood Greenways
  - Butler Market Corridor
  - 3rd Street and Hwy 20 Enhanced Crossings
  - Franklin Avenue Lighting Improvements
  - Signal and Sign Improvements at several locations

There were several project proposed in these plans. The identified engineering projects are included in Table 2 with the status of each identified safety improvement location. Many improvements are planned or partially completed.

Major projects with a safety component that were not identified in the safety studies were included in the following table. Project codes that begin with #1XXXX are Capital Improvement Project codes from the City of Bend.

TABLE 2 IDENTIFIED SAFETY PROJECTS – PRESENT & PAST STUDIES (2010-2019)

Safety Project Location	2019 Transportation Safety Action Plan[1]	2012 Multimodal Traffic Safety Plan[2]	Project Status
14th Street Reconstruction (Galveston to Simpson) 1T14R			Completed
14th Street Reconstruction Sch B (Newport to Galveston) 1T14B			Completed
27th Street at Butler Market Road		X	Planned CIP
27th Street at Reed Market Road		X	Not Completed
NE 27th Street & NE Conners Ave			Completed
27th & Neff	x		Not Planned
3rd & Franklin ARTS Grant			Planned CIP
3rd St & COID Canal		X	In Design
3rd St & Pinebrook Blvd		X	In Design
3rd St & NE Franklin Ave		X	In Design
3rd St & NE Hawthorne Ave		X	In Design
3rd St & Brosterhous Road		X	Not Completed
3rd St & Franklin Avenue	x	X	Planned CIP
3rd St & Powers Road	x	X	Planned CIP
3rd St & Reed Market Road	x	X	Not Completed
3rd St & SE Roosevelt Ave		X	Completed
3rd St Pedestrian Improvements (Full Corridor)		X	Completed
3rd St & Olney	x	ODOT	ODOT Project
Hwy 20 Mt. Washington/Butler Market Intersection	x	ODOT	ODOT Project
3rd & Wilson	x		Not Planned
3rd & Miller			Not Planned
Arizona Avenue at Wall Street		x	Partial Completion
Bond Street at Colorado Avenue		x	Partial Completion
Colorado and Arizona Avenue Corridor Improvements	x	x	Partial Completion
NW Colorado Ave & US 97 (Bend Parkway)		x	In Design

[1] EPDO Locations – Equivalent Property Damage Only (EPDO) Crash Analysis performance measure assigns weighting factors to collisions by severity

[2] Bend Multimodal Traffic Safety Plan assessment was limited to City of Bend Arterials and Collector roadways. Assessment for ODOT facilities was not part of the analysis. Projects populated with ODOT in this column are on ODOT Facilities.

Safety Project Location	2019 Transportation Safety Action Plan[1]	2012 Multimodal Traffic Safety Plan[2]	Project Status
Bear Creek Road at Pettigrew Road	x	x	Partial Completion
Brookswood Boulevard at Pinebrook Boulevard		x	Completed
Brookswood Boulevard South of Reed Market Road		x	Not Completed
Powers and Brookswood RAB 1XGOB			Completed
Brosterhous Rd & BNSF railroad bridge		x	In Design
Brosterhous Road at the BNSF Railroad Crossing 1TCSI		x	Planned CIP
Butler Market Road (4th to Deschutes Market Road)			In Design

Attached are the referenced plan documents for additional details of the identified projects and programs.

Exhibit A – 2012 Multimodal Traffic Safety Plan
Exhibit B -- Bend Safety Implementation Plan June 2015
Exhibit C -- Bend Roadway Departure Report February 2015
Exhibit D -- Citywide Safety Improvements Report April 2017
Exhibit E -- Strategic Implementation Plan for Pedestrian and Bike Infrastructure August 2015
Exhibit F -- Bend Roundabout Assessment for 15th Street and Reed Market March 2017
Exhibit G – Bend CIP Transportation Project Lists 2018-2021 and 2019-2022

City of Bend

Multimodal Traffic Safety Study 2012-2014

The purpose of this multimodal traffic safety study is to determine the most significant causes, types and characteristics of crashes in the city and identify how best to mitigate for these crashes given very limited resources.

Goals:

Reduce crashes and community costs

Objectives:

- ***Conduct public outreach about safety program***
- ***Develop a list of highest priority traffic safety projects***
- ***Focus on injury crashes***
- ***Create on-going monitoring and safety assessment methodology***

TABLE OF CONTENTS

SUMMARY

The city has very limited staff resources to mitigate for multimodal crashes. Significant staff reduction in recent years has caused the transportation division and the Traffic Safety Advisory Committee to re-evaluate the crash program. With consulting services from Kittelson & Associates, staff reviewed current trends and practices. The national Highway Safety Manual, first published in 2010, has established a new methodology for addressing safety. This new methodology is data-driven and allows efficient resource allocation for improved transportation safety. The city is one of the first communities to implement this new approach to safety.

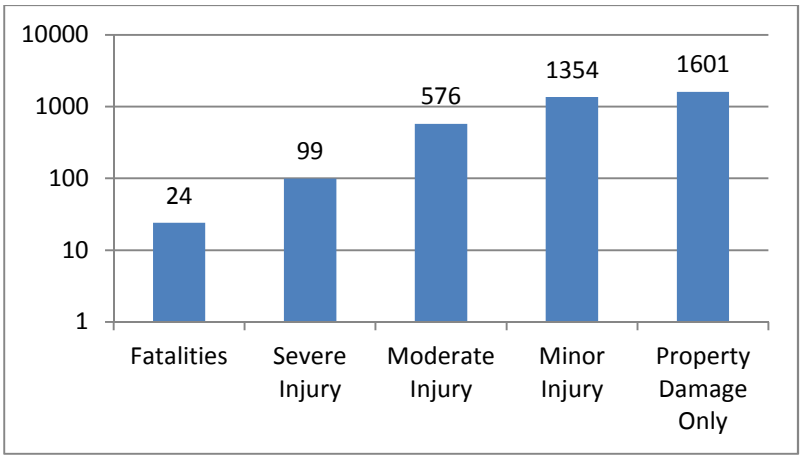


FIGURE 1. CRASHES BY SEVERITY
SOURCE: ODOT 2006-2010

As shown in Figure 1, crashes in the city from 2006 to 2010 included:

- 3,654 reported crashes – about 700 per year,
- 2,029 injury crashes,
- 1,601 property damage only crashes, and
- 24 fatalities.

Comprehensive Economic Impacts of Crashes			
Crash Severity	Property Damage Only (PDO)	Fatal & Severe Injury	Moderate and Minor Injury
Reported Crashes	1601	123	1930
Comprehensive Economic Value Assigned per Crash Severity	$15,000	$840,000	$47,900
Economic Impacts	$24,015,000	$103,320,000	$92,447,000
Five Year 06-10 Comprehensive Economic Value of Crashes $219,782,000			

TABLE 1. 5-YEAR TOTAL ECONOMIC IMPACTS OF CRASHES IN BEND
SOURCE: ODOT 2006-2010

The total economic cost of property damage, fatality and injury crashes for the 5-Year window was $219,782,000 (Table 1). Reported crashes cost our community roughly $44 million a year. Costs associated with crashes range from initial services such as emergency response and public works clean-

up to insurance costs, property repairs, and ultimately the costs to individuals and families. The community loses significant resources that are not typically accounted for or discussed. Loss of life permanently changes a family. Loss of income and medical costs are the largest financial losses associated with a crash.

Figure 2 provides a breakdown of the crashes by roadway functional classification. These crashes occurred on roadways under the jurisdiction of the city of Bend and did not include crashes on ODOT's Hwy 20 (3rd Street from Greenwood Avenue northward, Greenwood Avenue from 3rd Street eastward). Using the data from Figure 2, the city determined that a focus on Collector and Arterial (including Principal Arterial) crash reduction would have a greater impact on the community as they represented more than 85% of the total reported crashes.

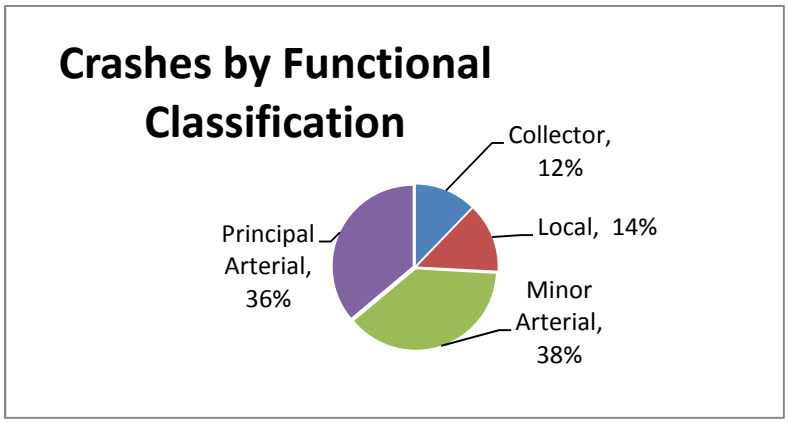


FIGURE 2. CRASHES BY ROADWAY FUNCTIONAL CLASSIFICATION

SOURCE: ODOT 2006-2010

ALCOHOL AND SPEED RELATED CRASHES:

Between 2006 and 2010, there were 315 alcohol or drug related crashes. Of these types of crashes 144 resulted in a fatality or an injury.

During the same time period, there were 1216 types of crashes related to speeds. Of these crashes, 325 resulted in a fatality or injury, and 103 resulted in a crash with a fixed object.

46% of alcohol or drug related crashes result in ***death or injury***.

Figure 3 identifies 42% of all crashes in Bend involved speeding or driving while under the influence of alcohol or drugs. Currently approximately 100 hours per week are provided to the community in the form of a police traffic team. These 100 hours are not dedicated to enforcement patrolling, however. These hours are also used for incident response, court preparation and appearances, training and, finally, also on enforcement patrolling. Additional police personnel are needed to impact speeding and DUII issues within our community. Enforcement is limited to "chance encounters" in most cases. This is also the case for DUII enforcement.

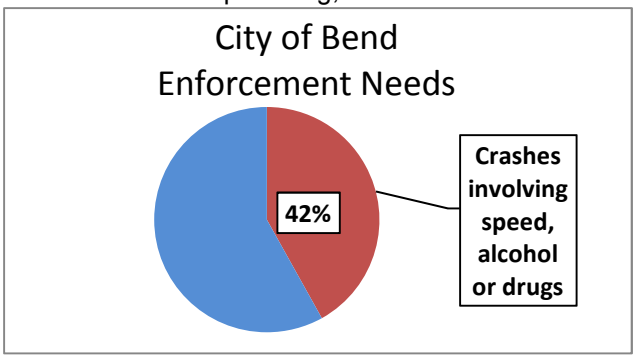
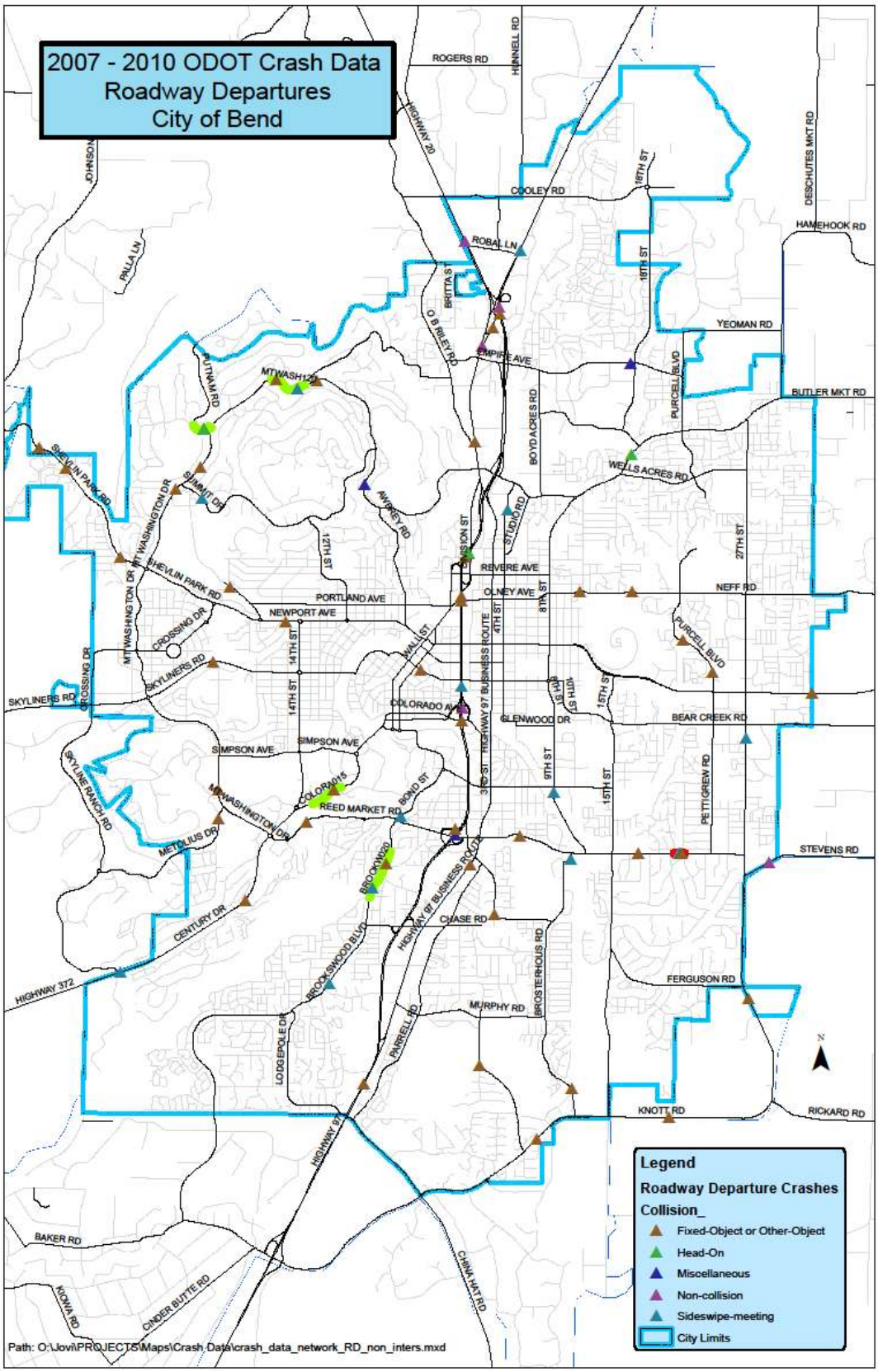
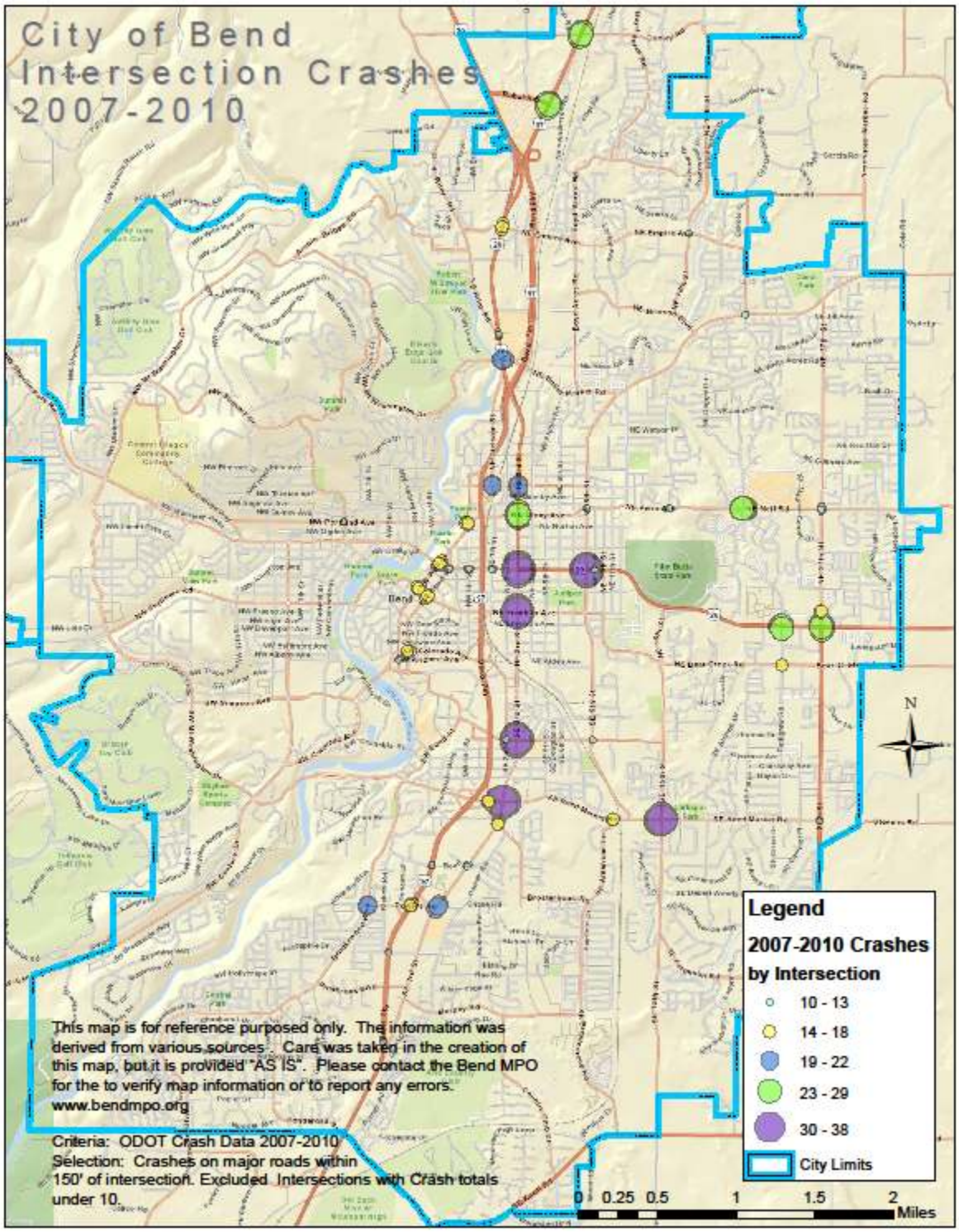


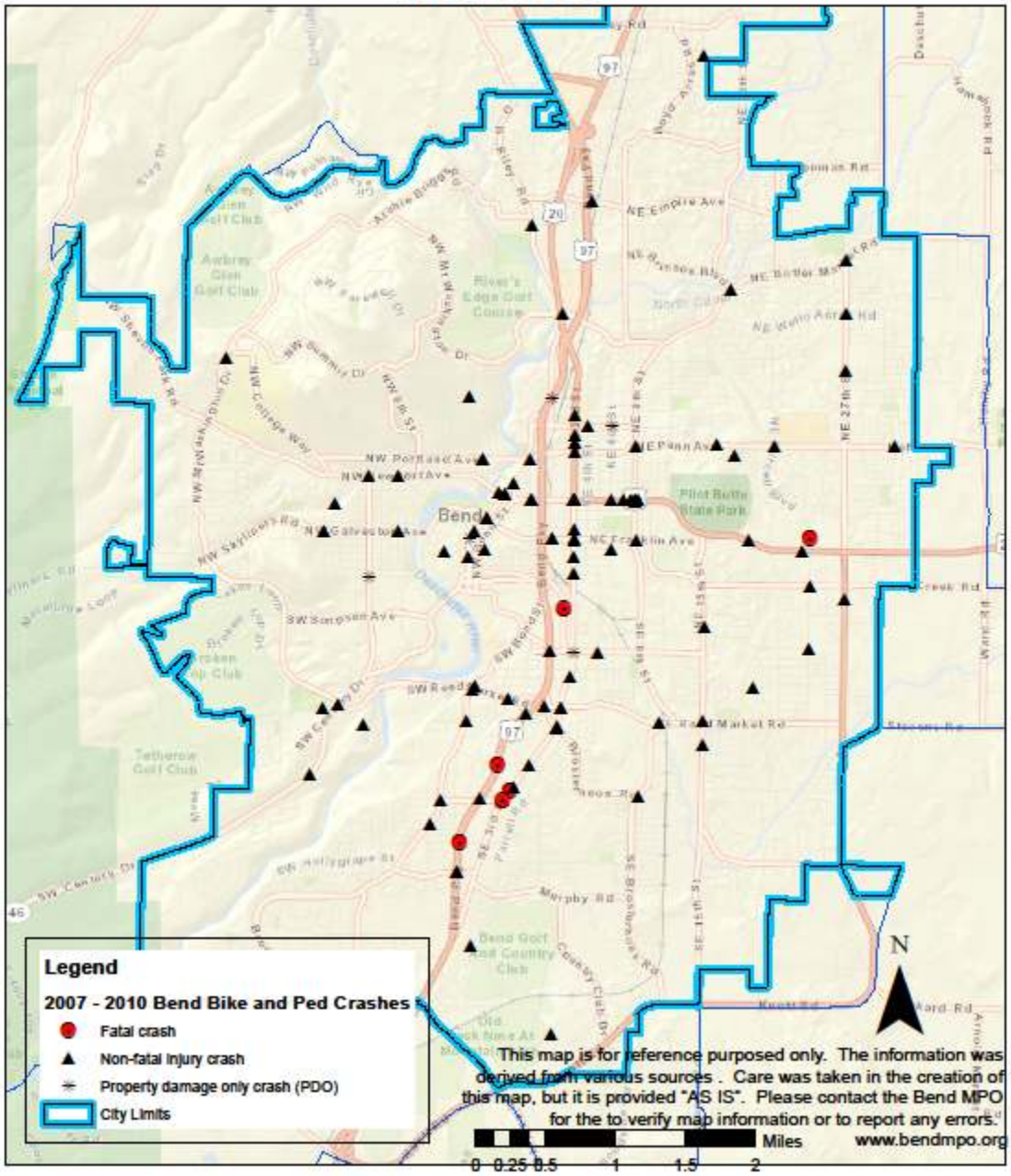
FIGURE 3. SPEED, ALCOHOL OR DRUG INVOLVEMENT

Source: ODOT 2006-2010


2007 - 2010 ODOT Crash Data
Roadway Departures
City of Bend
ROGERS RD
HUNNELL RD
HIGHWAY 20
COOLEY RD
15TH ST
DESCHUTES MKT RD
HAMEHOOK RD
ROBAL LN
BRITTA ST
O B RILEY RD
18TH ST
YEOMAN RD
EMPIRE AVE
PURCELL BLVD
BUTLER MKT RD
PILLA LN
PUTNAM RD
MTWASH12
BOYD ACRES RD
WELLS ACRES RD
SHEVLIN PARK RD
SUMMIT DR
MT WASHINGTON DR
AWBREY RD
12TH ST
BOND ST
STUDIO RD
27TH ST
REVERE AVE
NEFF RD
OLNEY AVE
8TH ST
PORTLAND AVE
NEWPORT AVE
CROSSING DR
14TH ST
HALL ST
4TH ST
HIGHWAY 97 BUSINESS ROUTE
SKYLINERS RD
10TH ST
15TH ST
COLORADO AVE
GLENWOOD DR
BEAR CREEK RD
SIMPSON AVE
SKYLINE RANCH RD
3RD ST
6TH ST
PETTIGREW RD
COLORADO
REED MARKET RD
METOLIUS DR
STEVENS RD
BROOKSWOOD
CENTURY DR
CHASE RD
BROOKSWOOD BLVD
BROSTERHOUS RD
HIGHWAY 372
FERGUSON RD
MURPHY RD
LODGEPOLE DR
PARRELL RD
KNOTT RD
RICKARD RD
HIGHWAY 97
BAKER RD
CHINA HAT RD
KIOWA RD
CINDER BUTTE RD
Legend
Roadway Departure Crashes
Collision_
Fixed-Object or Other-Object
Head-On
Miscellaneous
Non-collision
Sideswipe-meeting
City Limits
Path: O:\Jovi\PROJECTS\Maps\Crash_Data\crash_data_network_RD_non_inters.mxd


City of Bend
Intersection Crashes
2007-2010
N
Legend
2007-2010 Crashes
by Intersection
10 - 13
14 - 18
19 - 22
23 - 29
30 - 38
City Limits
0 0.25 0.5 1 1.5 2
Miles
This map is for reference purposed only. The information was derived from various sources. Care was taken in the creation of this map, but it is provided "AS IS". Please contact the Bend MPO for the to verify map information or to report any errors.
www.bendmpo.org
Criteria: ODOT Crash Data 2007-2010
Selection: Crashes on major roads within 150' of intersection. Excluded Intersections with Crash totals under 10.

City of Bend
Bike and Pedestrian Crashes
2007-2010



MAP: FATAL CRASHES 2007 TO 2010

METHODOLOGY

The city outlined a safety management program meeting the core requirements of the Highway Safety Manual.

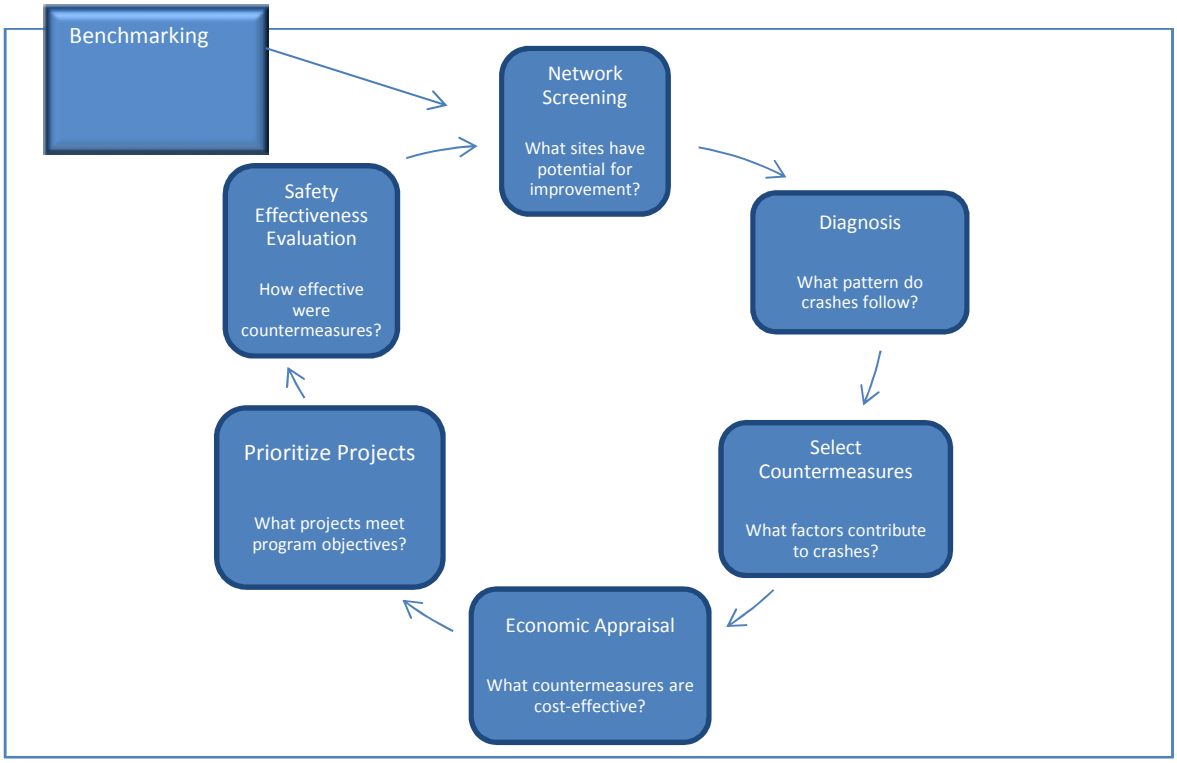


FIGURE 4. CITY OF BEND TRAFFIC SAFETY MANAGEMENT PROGRAM

The program is cyclical as shown in Figure 4 and can be repeated periodically. The Project Prioritization phase of the cycle could be performed to coincide with CIP planning work with the goal of implementing projects that would reduce crashes. During the Safety Effectiveness Evaluation phase, the city will determine how successful certain types of mitigations were on crash reduction and adjust the program accordingly.

The first step of this year's cycle added a Benchmarking phase. Benchmarking allowed us to look at other communities and see where Bend stood – *"were we a safer community or a less safe community than others of comparable size in Oregon?"* What we found shaped the development of our program's countermeasures to include enforcement

Bend has a higher amount of fatalities compared to other communities.

Bend 24

Vs.

Corvallis 2

Bend had a higher amount of speeding and DUII types of crashes than the comparison communities.

as well as education with our engineering countermeasures. For instance, Bend has a higher amount of speeding and DUII types of crashes, as compared to other comparable Oregon cities. We also found that we had a higher amount of fatal crashes, with a total of 24 fatalities between 2006 and 2010. One comparison community, Corvallis, had 2 fatalities during the same time period.

During the Benchmarking Phase, the city identified specific crash characteristics that appeared out of the norm when compared to three other Oregon communities (Springfield, Medford, Corvallis). These five crash characteristics became the program's 2012-2014 focus areas and are strategically prioritized for crash reduction in Bend:

- Fatal and injury crashes,
- Alcohol-involved crashes,
- Speed-involved crashes,
- Pedestrian and bicyclist crashes,
- Roadway Departure crashes.

TABLE 2 FOCUS AREA CRASH CAUSATION

Source: ODOT 2006-2010

Roadway Departure	**Bicyclist**	**Pedestrian**
201 Crashes	58 Crashes	25 Crashes
Contributing Factors	Contributing Factors	Contributing Factors
Alcohol	Wrong Way Riding	Multilane roadway crossings
Speed	Night time visibility	Non-exclusive "WALK" phase of signal
Fixed Object	Right turn hook	Night time visibility

As detailed in the Technical Memorandum entitled, *"Benchmarking and Identification of Focus Areas,"* provided in Appendix 2, other communities in Oregon had much fewer fatal crashes and much fewer crashes noting alcohol and speed as contributing factors. Because one third of the fatal crashes in Bend involved a pedestrian or a bicyclist, reducing crashes for those users became a focus area. Roadway Departure crashes are high throughout Deschutes County and ODOT Region 4, which includes Bend compared to other counties and ODOT regions.

The next three phases would be performed each time the cycle was repeated: Network Screening phase, Diagnosis phase and Project Ranking phase. The process to develop the program and a more detailed

description of each phase are provided in the Technical Memorandum entitled, "Transportation Safety Framework Plan," which is provided in Appendix 1.

The 2012-2014 Traffic Safety Program used statistical data analyses to screen the network to identify high crash locations within each of these focus areas. These locations are intersections or roadway segments with a high number of crashes or a higher number of crashes than expected. The Network Screening process followed the Highway Safety Manual Methodology. A detailed explanation of the process is provided in Appendix 3 in a technical memorandum entitled, *"Network Screening."* This network screening resulted in 20 locations identified for further study. A 21st location was added during the next steps when an additional crash occurred during the analysis period at one of the roadway departure locations mapped in network screening. This location was on Mt. Washington Drive just east of Archie Briggs Road.

The network screening process was used to identify a subset of all crash locations throughout the community that staff could focus on for crash reduction.

For each of these 21 locations, staff identified crash patterns using crash diagramming. Countermeasures were identified with the goal of eliminating specific patterns of crashes at each location. Each countermeasure has an identified effectiveness rating. The effectiveness rating is listed in terms of Crash Reduction Factor (CRF) which is the percentage of the crashes predicted to be eliminated based on the implementation of the countermeasure. CRFs published in the Highway Safety Manual were utilized whenever available. CRFs ranged from nearly fool proof (almost all crashes would be eliminated) to somewhat effective. Additional countermeasures, such as enforcement and/or education are needed to alter behavior (crashes with a causation of speed, DUII, Red Light Running, dark clothing, etc.) for those crash patterns/types that have a low CRF.

Appendix 4 provides the crash diagrams, engineering cost estimates, and calculation sheets used to tabulate the economic benefits of the countermeasures. Table 3 summarizes the detailed data provided in Appendix 4. Table 3 shows each of these locations, the crash trend summary, identified countermeasures, countermeasure cost and the estimated potential economic impact due to crash reduction.

TABLE 3. CAPITAL IMPROVEMENT PROGRAM (CIP) PROJECT LIST

Table 3. CIP Project List (alphabetical order, not ranked)				
Project Location	**Crash Trend**	**Countermeasures**	**Counter-measure Cost**	**Countermeasure Economic Impact via Crash Reduction**
1st Street at Greenwood Avenue[1]	NB EB angle crashes	**Curb extensions south side**	$ 44,376	$ 22,000
2nd Street at Wilson Avenue	Sidestreet crossing (poor visibility)	**Improve visibility by do not block intersection**	$ 18,480	$ 150,000
27th Street at Butler Market Road	System: Permitted Left turn crashes; System: Red Light Running; EB Thru v. EB right Rear End; System: T-intersection run off the road	**Protected Only Phasing** **Signal Timing and Phasing** **Add Bike Lane** **Improve warning signage**	$ 56,560	$ 200,000
27th Street at Reed Market Road (Implement with GO Bond project)	System: Permitted Left turn crashes System: T-intersection run off the road	**Protected Only Phasing** **Improve warning signage**	$ 96,740	$ 1,802,000

[1] Not proposed for ranking due to low Benefit-Cost Ratio

Project Location	Crash Trend	Countermeasures	Counter-measure Cost	Countermeasure Economic Impact via Crash Reduction
3rd Street at Franklin Avenue	**System: right turn hook with BIKE** **System: Red Light Running**	**Dutch Bike Crossings** **Signal Timing and Phasing**	$ 259,256	$ 998,000
3rd Street at Brosterhous Road	**System: Red Light Running** **System: Left hook with pedestrian**	**Signal Timing and Phasing** **Protected only phasing**	$469,000	$ 228,000
3rd Street at Powers Road	**System: Red Light Running** **System: Right Turn on Red Hit Ped** **Left hook with Ped**	**Signal Timing and Phasing**	$ 65,856	$ 834,000
3rd Street at Reed Market Road (seek implementation with GO Bond project)	**System: Red Light Running** **System: Right hook with Ped** **System: Right hook with BIKE**	**Signal Timing and Phasing** **Leading Ped Phase** **Dutch Bike Crossings**	$ 183,538	$ 1,350,000
Arizona Avenue at Wall Street	**System: Red Light Running**	**Signal Timing and Phasing and Signal Head visibility**	$ 83,266	$ 229,000

Project Location	Crash Trend	Countermeasures	Counter-measure Cost	Countermeasure Economic Impact via Crash Reduction
Awbrey Road at Portland Avenue	**Sidestreet crossing hit mainline bike** **System: Rear end in shared Left-Thru**	**Mini roundabout**	$ 98,883	$ 283,000
Bear Creek Road at Pettigrew Road	**Stop sign run NB & WB**	**Enhance visibility of stops**	$ 6,820	$ 657,000
Bond Street at Colorado Avenue	**System: Red Light Running**	**Signal Timing and Phasing and Signal Head visibility**	$ 58,776	$ 238,000
Bond Street at Reed Market[2]	**No crash trend**	**No countermeasure**	N/A	N/A
Brookswood Boulevard at Pinebrook Boulevard[3]	**Sidestreet left out**	**New roundabout at Murphy (100' south) will change patterns**	N/A	N/A
Country Club Road at Murphy Road	**Stop sign run NB**	**Enhance visibility of stop**	$ 6,160	$ 444,000
Division Street at Revere Avenue	**System: permitted lefts** **System: Rear End in shared Left-Thru** **System: Red Light Running**	**Protected Only Phasing** **Road Diet** **Signal Timing and Phasing**	$ 144,259	$ 1,393,000

[2] Not proposed for ranking due to no crash trend/no available countermeasure

[3] Not proposed for ranking due to short-term roadway network changes 100' south

Project Location	Crash Trend	Countermeasures	Counter-measure Cost	Countermeasure Economic Impact via Crash Reduction
Firerock Lane at OB Riley [4] Road	**No crash trend**	**No countermeasure**	N/A	N/A
Greenwood Avenue at Hill Street	**Pedestrian/Bicycle crossing safety**	**Add curb extensions, advance stop bars, illumination**	$ 167,655	$ 70,000
Franklin Avenue at Wall Street	**System: right turn on red crossing BIKE;** **System: right hook of peds** **Pedestrian compliance to Don't Walk**	**Eliminate southbound right turn lane** **Leading pedestrian phase** **Wait Audible Message**	$ 80,663	$ 101,000
Mt. Washington at Archie Briggs Road	**Roadway Departure**	**Curve warning signs, guard rail**	$ 182,160	$ 349,000
Neff Road at Purcell Boulevard	**System: right turn on red crossing BIKE** **Rear End northbound (mis-understanding of single lane approach)** **Permitted Left Turn crashes**	**No RTOR** **Provide bike lanes, clearly sign and stripe single lane approach** **Protected Only Phasing**	$ 100,390	$ 848,000
Totals			**$ 2,123,838**	**$ 10,196,000**

[4] Not proposed for ranking due to no crash trend/no countermeasure available

As noted in the table 3 footnotes, some locations did not have crash trends, or the crash trend might be altered by a nearby eminent project, or the predicted benefit cost ratio was negative.

Some projects can be grouped together for cost savings. These include the 3rd Street signalized corridor, Bear Creek/Purcell paired with the Country Club/Murphy stop sign improvements, and the Arizona/Wall Street signal paired with the Bond/Colorado Signal. Each of these project pairings has similar countermeasures, so design and construction efficiency should be achieved when combined.

As noted in Table 3 above, allocating approximately $2,123,838 to the CIP program for engineering fixes has an estimated economic benefit of $10,196,000. As further discussed below, there is an additional $16 million in economic impacts that could be further reduced by implementing education and enforcement countermeasures as well.

A Broad Based Safety Program is Necessary

The case for increased enforcement, education and changes to standards and specifications:

As noted earlier, many crashes are caused by unsafe behaviors and choices of drivers. DUII, excessive speed, and red light running each need increased enforcement in the community. Engineering countermeasures can only go so far to reduce those crashes. Therefore, enforcement and education is critical.

Unsafe behaviors and choices of pedestrians and bicyclists also contributed to crashes. Chief among these were dark clothing, lack of headlights/reflectors at night, and wrong way riding. Engineering countermeasures can help wrong way riding where a lack of safe roadway crossings or bike facilities encourage wrong way riding. However, the vast majority of these crashes will need to be tackled through education and enforcement.

As noted during the crash identification phase, engineering solutions could be identified for many of the crash types. This means that our previous system designs have built in conflicts which result in built in crash risk. The Safety Program therefore also recommends changes to the City's standards and specifications to implement state of the art and technology solutions so that crash risk is prevented through design. Table 4 summarizes each aspect of the 3E (Education, Enforcement, Engineering) approach that makes up the foundation of the Transportation Division's Safety Program.

TABLE 4. SUMMARY OF 2012-2014 CRASH REDUCTION PROGRAM ELEMENTS

Table 4.

Summary of 2012-2014 Crash Reduction Program Elements

Education	Enforcement	Engineering
Continue current education programs	Focus on high crash locations	Design and Construct CIP Project List
Supplement existing programs with focus on: • Biking (visibility at night, risk of vehicles turning across their path of travel, wrong way riding) • Walking (visibility at night, risk of vehicles turning across their path of travel on "WALK," multiple approach lane risk during roadway crossings) • Driving (speeding, DUII, red light running, turning across a bicyclists path of travel, yielding to people walking)	Focus on high crash causations: • Speeding • DUII • Red Light Running • Failure to Yield to bicyclists and pedestrians	Perform city-wide Curve Warning Assessment and Mitigation
	Continue Bike Diversion Program	Perform city-wide Roadside Hazard Identification and Mitigation
	Investigate Pedestrian Diversion Program	Update Standards and Specifications to reflect state of the art and technology usage to reduce crash risks
	Find ways to support more funding for traffic enforcement	Implement multi-modal count program to support future crash analysis efforts

APPENDIX 1

TECHNICAL MEMORANDUM

Bend Arterial and Collector Safety Project Program Development

Transportation Safety Framework Plan

http://bendoregon.gov/modules/showdocument.aspx?documentid=10377

APPENDIX 2

TECHNICAL MEMORANDUM

City of Bend Arterial and Collector Safety Project Program Development

Phase B Memorandum: Benchmarking and Identification of Focus Areas

http://bendoregon.gov/modules/showdocument.aspx?documentid=10376

APPENDIX 3

TECHNICAL MEMORANDUM

Bend Arterial and Collector Safety Project Program Development

Network Screening

http://bendoregon.gov/modules/showdocument.aspx?documentid=10375

APPENDIX 4

TECHNICAL MEMORANDUM

Bend Arterial and Collector Safety Project Program Development

Diagnosis and Project Ranking

http://bendoregon.gov/modules/showdocument.aspx?documentid=10374

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING
354 SW Upper Terrace Drive, Suite 101, Bend, Oregon 97702 P 541.312.8300 F 541.312.4585

TECHNICAL MEMORANDUM

Bend Arterial and Collector Safety Project Program Development

Transportation Safety Framework Plan

Date: July 9, 2012 Project #: 11645.0
To: Robin Lewis, PE, City of Bend
From: Casey Bergh, PE and Brian Ray, PE

The City of Bend and Kittelson & Associates, Inc. (KAI) are developing and implementing a data-driven transportation safety management program. This memorandum summarizes the framework plan that serves as the structure of the program. The framework plan outlines the purpose and desired outcomes of four program phases that will ultimately lead to a prioritized list of projects to reduce crash frequency and severity on arterial and collector streets in Bend.

As each phase of the program is completed, KAI will prepare a separate memorandum to document the evaluations conducted and the findings and recommendations of that phase.

BACKGROUND

This transportation safety framework plan was informed by the current status of the City's transportation safety program:

- The City does not have a formal and documented transportation system safety program and has lost 1.5 full-time equivalent staff (for budgetary reasons) that once focused on crash analysis and traffic safety.
- Multiple citizens and advisory committees in Bend want to help improve safety, but their goals often vary and the groups are not coordinated in their efforts.
- Past safety projects have been identified through citizen service requests or observations from City staff. These projects reflect perceived safety concerns and were not based on objective analysis because objective analysis tools have not been available.
- The City is in the process of creating a collector and arterials streets program and a separate bike and pedestrian program; these were previously combined. No safety project lists have been developed since this division.
- No formal criteria have been developed to prioritize projects for funding.
- The City is developing a traffic volume database and volume management program that will provide data needed to apply many of the tools and methods in the Highway Safety Manual (HSM).

Based on the City's desire for a comprehensive, systematic, and objective safety program, KAI has developed a program framework that applies crash analysis tools and methods provided in the HSM.

PROJECT GOALS

Goal #1: Systematically identify and prioritize safety projects

Goal #2: Establish a proactive approach to reducing crashes on Collector and Arterial Streets

Goal #3: Support a safety culture

Goal #4: Establish safety thresholds and measurable near- and long-term goals

Goal #5: Establish an objective process that can be repeated annually with input from the City of Bend Traffic Safety Advisory Committee (TSAC)

Goal #6: Apply engineering, education, enforcement, emergency response, and evaluation (a broad base of strategies) to achieve safety goals

FRAMEWORK PLAN

The overall framework includes four key phases, which can be performed as part of a cyclical process. The core phases of the safety management cycle are described in the flow chart in Figure 1. After an initial benchmarking phase is completed, benchmarking may not need to be repeated every cycle.

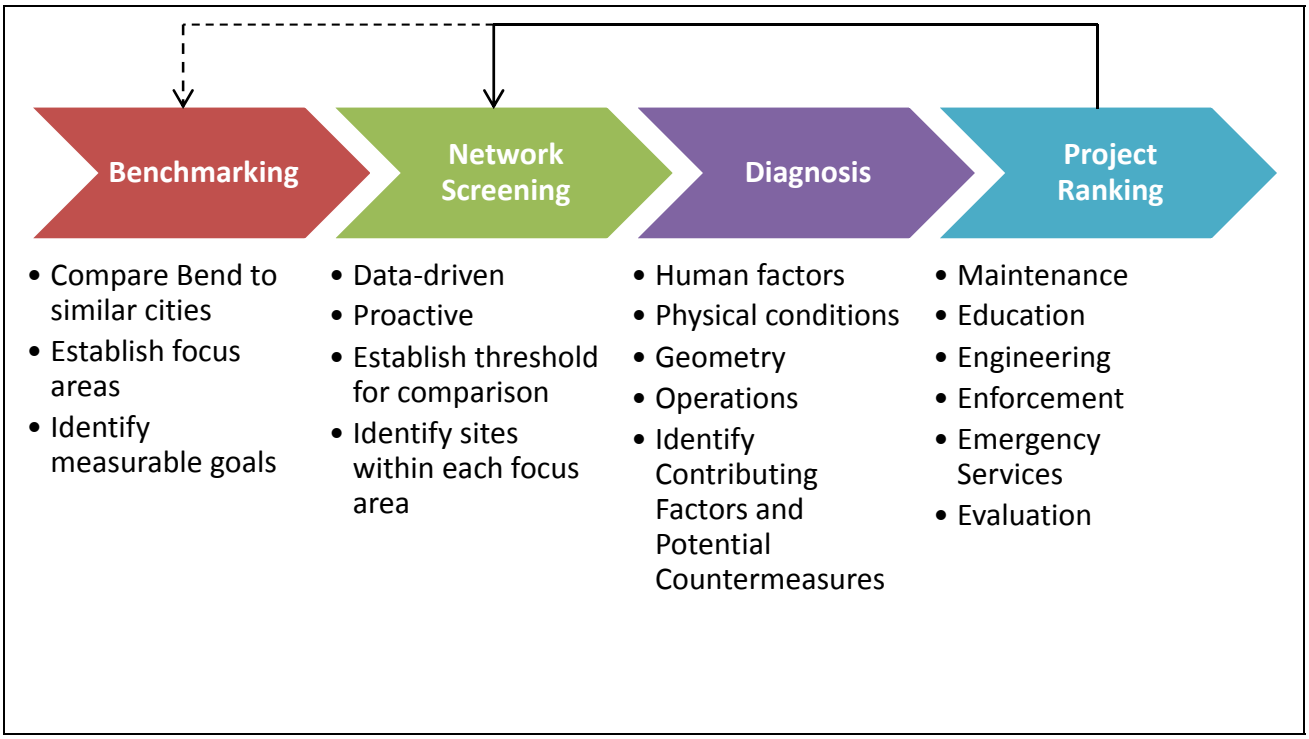


Figure 1 – Safety Program Management Framework

KAI will support the City of Bend in applying the safety management process on a limited basis to demonstrate the tools and methods. The goal and desired outcome of each phase shown in Figure 1 are described below.

BENCHMARKING

Goal: Understand crash trends and develop a point of reference for establishing safety priorities.

Benchmarking allows the City of Bend to compare its crash history with other cities of similar size. Although the safety program will focus on reducing specific crash types that have been frequently reported in Bend, this will provide an overall reference point for Bend. Overall, the City will use these comparisons and crash data analysis to determine crash trends that indicate opportunities to reduce frequency or severity of crashes. Those crash trends may reflect crash type (e.g., left-turn, angle, rear-end, etc.), severity (e.g., injury, fatality, property damage), or contributing factors (e.g., weather, aggressive driving, driving under the influence of alcohol, etc.).

This phase will inform the City and establish safety priorities (herein referred to as "focus areas") to define subsequent phases of the safety program for the duration of one or more program cycles. The benchmarking phase is not required to be completed every cycle and serves as an optional starting point. Benchmarking could also be conducted three to five years after implementation of the first round of safety countermeasures, as one measure of progress.

A two-tiered approach to benchmarking was developed to 1) qualitatively compare Bend crash experience with that of other cities and 2) evaluate specific crash characteristics and patterns for Bend to establish its focus.

While it is helpful to generally compare Bend with other Oregon cities, the primary value of the Bend crash data review is to identify opportunities to implement the 5 E's (engineering, education, enforcement, emergency response, and evaluation) to reduce the frequency or severity of crashes. The most valuable outcome of benchmarking is to identify three to five crash trends that indicate opportunities to reduce crash frequency and severity.

NETWORK SCREENING

Goal: apply objective methods to evaluate the City's network of arterial and collector streets to identify sites with potential for reducing crash frequency or severity

Network screening methods are described in detail in Chapter 4 of the HSM. The methods from the HSM have been adapted to fit the context of the City of Bend and the scope of this project. In general network screening includes the following steps:

1) Establish focus
2) Identify reference populations
3) Select performance measures
4) Screen and evaluate results

Establish Focus

Network screening is guided by the focus areas identified through the benchmarking phase. Once focus areas are established, they can be retained for multiple program cycles. Retaining the same focus areas for multiple cycles allows the City to apply adequate resources to address one area before moving onto another. New focus areas may be identified by City staff or through future benchmarking activities.

Identify Reference Populations

Network screening could be applied to all intersections on the arterial and collector street network, and it is likely that the screening would identify signalized intersections with the highest volumes as the top sites with potential to reduce crashes. Those screening results do not identify opportunities to improve crashes at unsignalized intersections or roundabouts, which may be more cost-effective. Therefore, several distinct subsets of the City's network (i.e., reference populations) will be established and network screening will be conducted for each to identify more opportunities to reduce crash frequency and severity throughout the City.

The HSM identifies the following as potential characteristics that can be used to establish reference populations:

- Traffic Control (e.g., signalized, unsignalized, roundabout, etc.);
- Number of approaches (e.g., three-leg or four-leg intersection);
- Cross-section (e.g., number of through lanes and turning lanes);
- Functional Classification (e.g., principal arterial, collector, local, etc.);

- Area type (e.g., urban, rural, suburban); and,
- Terrain (e.g., flat, rolling, mountainous).

Traffic control and functional classification data is available from the City of Bend GIS department, but at this time other reference populations cannot be established due to lack of GIS inventory data (e.g., roadway cross-section, posted speed, terrain, etc.).

Performance Measures

Performance measures are used to evaluate the crash data and result in a quantitative "score" at each site. The HSM identifies 13 performance measures that can be used in network screening. Selecting one or more performance measures is based on data available, desired statistical rigor, and the focus areas. Performance measures with the greatest statistical rigor apply crash prediction models to account for "regression to the mean" bias, which is commonly evident in safety evaluations. Although those methods provide the greatest reliability of the screening results, they require the greatest amount of data. Performance measures included in the HSM are summarized in Table 1.

While the statistical rigor of the performance measures influences the accuracy of the network screening, the accuracy of the crash data may have a greater influence on results. The crash data used in the network screening is provided by the Oregon Department of Transportation (ODOT). The ODOT crash database relies on individual drivers involved in a crash or local police departments to report the crash details if an injury results or damage exceeds $1,500. Therefore, many crashes are not reported and are not included in the network screening. Additionally, the crash details are not always consistently input, which further reduces the reliability of the data.

The City does not have traffic volume data in an electronic format from the last five years for all arterial and collector streets. Without average daily traffic volumes on all roadways the City is limited to applying the first four performance measures shown in Table 1. There are limitations to each of the four performance measures (e.g., some over emphasize severe crashes). Therefore, multiple measures can be applied to each focus area and the results factored together identify sites with the greatest potential for reducing crash frequency or severity.

The City is working with DKS Associates, Inc. to develop a model for collecting and managing traffic volume. The electronic volume data format will reflect the data needs of network screening to minimize data input efforts. As the volume database is populated (data will likely be obtained over a period of several years) and becomes available for use in network screening, additional network screening methods can be applied.

Table 1 Summary of Network Screening Performance Measures

Statistical Bias/Data Requirement Continuum*	City of Bend Implementation Category	Network Screening Performance Measure
	Short-Term – Data is available	Crash Frequency
		Equivalent Property Damage Only Crash Frequency
		Relative Severity Index
		Crash Type Performance Threshold
		Excess Proportion of Specific Crash Types
	Mid-Term – Requires volume data	Critical Rate
		Method of Moments
	Long-Term – Requires calibrated safety performance functions and detailed geometric information	Excess Predicted Crashes Using SPFs
		Level of Service of Safety
		Expected Crash Frequency with EB Adjustment
		EPDO Crash Frequency with EB Adjustment
		Excess Expected Crash Frequency with EB Adjustment

* Performance measures are sorted by implementation category, which generally reflects a reduction in statistical bias as additional data is included in analysis.

As shown in Table 1, three implementation categories have been identified for the City of Bend, which reflect data availability. The performance measures in the short-term implementation category will be considered in network screening. The City could begin applying performance measures from the mid-term implementation category as soon as volume data is available.

ODOT has developed calibration factors for Safety Performance Functions provided in Part C of the HSM. Although the models may be available from ODOT, application of these SPFs within network screening will require electronic inventory data including geometric information including: lane width, shoulder width, horizontal curve radius, etc.

Screen and Evaluate Results

Screening methods using data from the City of Bend and ODOT can help to identify sites having the greatest potential for reducing crash frequency and severity. The top four to six sites from each focus area can be identified for diagnosis and countermeasures selection.

Network screening methods can be applied to rank crash locations on roadway segments and at intersections (collectively referred to as "sites"). The most effective screening method can be determined based on the specific focus area. For example, left-turn crashes are most likely to occur at intersections, so intersection-based screening is most applicable.

DIAGNOSIS

Goal: Identify factors contributing to crashes and specific countermeasures to reduce the frequency and severity of those crashes.

Identify Contributing Factors

The diagnosis can include desktop and field reviews for those sites selected through network screening. For each site diagnosis could include reviewing the following three elements:

1) Crash data
2) Site history
3) Field conditions

Crash patterns and trends for each individual site should consider a five-year period. This data should be cross-checked with City records of construction or other factors that may have impacted the site over the same period. These activities are intended to identify factors that may have contributed to an increase or decrease in reported crashes over the five-year period. A list of questions and data to consider when reviewing historic information is provided in Appendix 5B of the HSM.

Field reviews following the desktop review can confirm contributing factors identified in the data and, potentially, identify other factors that may influence crashes. A comprehensive field review includes, as a minimum, travel through the site from all directions, considering elements of all travel modes. Specific items to consider during a field review are provided in Chapter 5, Section 5.4 of the HSM. A field review checklist provided in Appendix 5D of the HSM can serve as a reminder of various considerations and assessments that can be made in the field.

Identify Countermeasures

The contributing factors identified through the desktop and field reviews can be tied to countermeasures having the potential to reduce the number and/or severity of the crashes associated with contributing factors. In general, this step requires considering a range of countermeasures and narrowing the options to consider and select preferred countermeasures that have a documented ability (through empirical study) to reduce a specific crash type. This step uses Crash Modification Factors (CMFs) in the HSM and those identified in the Federal Highway Administration's (FHWA) website (www.cmfclearinghouse.org).

PROJECT RANKING

Goal: Evaluate the benefits and costs of identified safety improvement projects and rank each project to prioritize those that are expected to result in the greatest reduction in crash frequency and/or severity for the least cost.

Chapter 7 and 8 of the HSM outlines a variety of methods for ranking projects. The ranking is based on benefit-cost ratios for each project. Therefore, ranking requires monetary costs and benefits be identified for each project. Project cost estimates can be prepared based on unit costs established by the City. The CMFs identified for countermeasures can be used to estimate benefits in terms of crash reductions. Crash reductions are converted to monetary benefits based on estimates of design life and societal crash costs by crash severity.

When no quantitative estimates are available documenting the effectiveness of a countermeasure or project, the project may not be ranked. Therefore the ranked project list will only represent those projects with proven countermeasures having the greatest potential to reduce crash frequency or severity. Those projects that do not have proven countermeasures could still be implemented and their effectiveness in Bend could be studied through a before-and-after study.

NEXT STEPS

KAI will support the City of Bend in applying the safety management process outlined in this framework plan on a limited basis to demonstrate the tools and methods. As each phase of the program is completed, KAI will prepare a separate memorandum to document the evaluations conducted and the findings and recommendations of that phase.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING
354 SW Upper Terrace Drive, Suite 101, Bend, Oregon 97702 P 541.312.8300 F 541.312.4585

TECHNICAL MEMORANDUM

City of Bend Arterial and Collector Safety Project Program Development

Phase B Memorandum: Benchmarking and Identification of Focus Areas

Date: September 4, 2012 Project #: 11645.0
To: Robin Lewis, PE, City of Bend
From: Casey Bergh, PE and Brian Ray, PE

The City of Bend and Kittelson & Associates, Inc. (KAI) are developing and implementing a data-driven transportation safety management program. The framework for the program was documented by KAI in our July 9, 2012 memo (draft prepared in June 2012) and is generally illustrated in Figure 1. Benchmarking, the first program phase, is described in this memorandum. The Benchmarking phase is intended to help the City understand crash trends and identify safety priorities. This memorandum summarizes the analysis conducted and outcomes of benchmarking that will inform network screening.

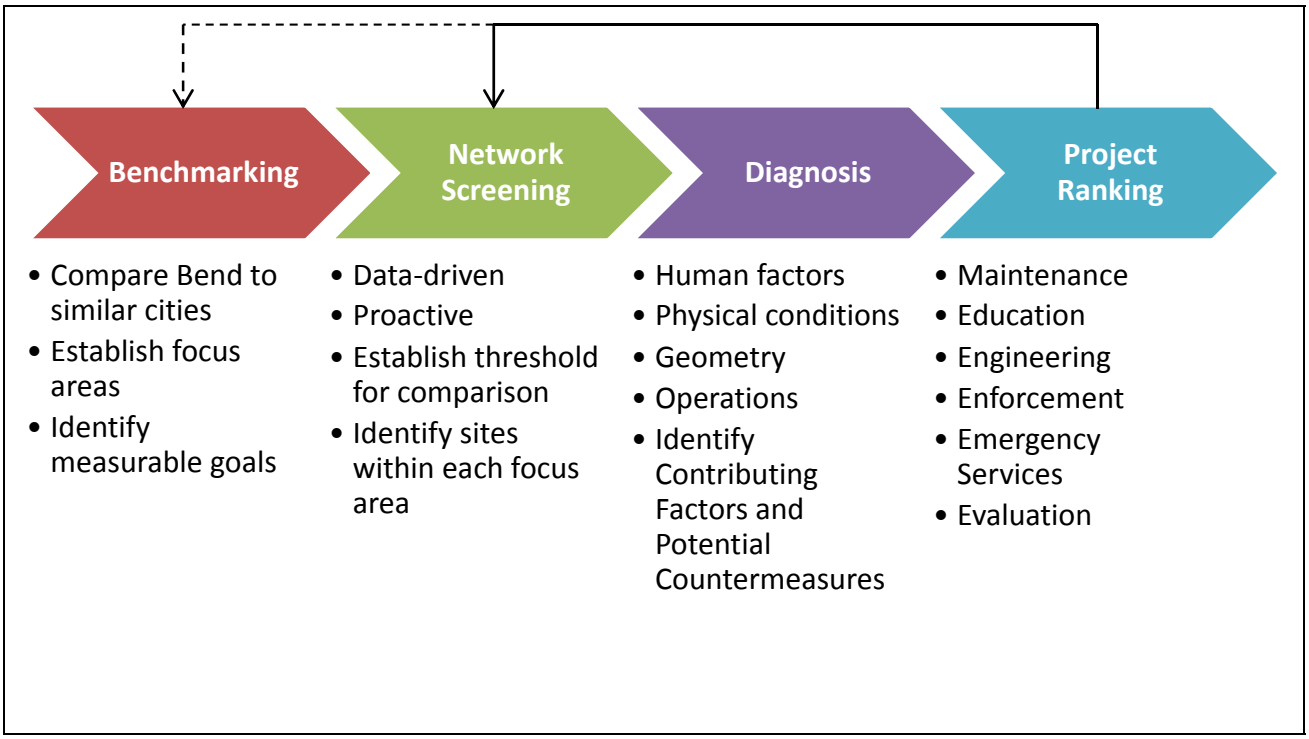


Figure 1 City of Bend Arterial and Collector Safety Project Program Framework

OVERVIEW

Crash data analyses conducted as part of Benchmarking ultimately resulted in five crash characteristics (or "focus areas") the City will prioritize to reduce crash frequency and severity. The crash analysis allowed the City to compare its crash history with other cities of similar size and provide a general point of reference with regards to traffic safety. Conducting these comparisons and analyzing reported crashes within the City of Bend yielded the following five focus areas:

- Fatal crashes,
- Alcohol-involved crashes,
- Speed-involved crashes,
- Pedestrian and bicycle crashes, and
- Roadway Departure crashes.

TIER I CRASH DATA ANALYSIS

Tier I benchmarking activities qualitatively compared Bend crash experience with that of other Oregon cities of similar size, as reflected by their population. The cities of Corvallis, Medford, and Springfield had similar populations as Bend from 2006 to 2010[1]. The cities and their respective annual populations are shown in Figure 2.

Each city differs from Bend in terms of roadway characteristics (e.g., percent of roadway system composed of principle arterials), driver behavior (e.g., percent of drivers that exceed the speed limit by more than 10 miles per hour), and land use (e.g., percent of roadways fronted by commercial developments). These factors are inherently reflected in the crash reports from each city. Therefore, the crash data comparisons between cities are not a direct indication one city has a "safety issue" if that city has more crashes of one type or severity than another city.

Data was provided by the Oregon Department of Transportation for reported crashes on all roads within the city limits of each comparison city for a five-year period from 2006 through 2010. Data includes crashes reported by individuals or police when a crash results in injury, fatality, or at least $1,500 in damage. ODOT provided latitude and longitude coordinates of all crashes from 2007 to 2010.

Table 1 describes crash trends observed through multiple comparisons of crash characteristics (i.e., type, severity, contributing factors, etc.).

[1] Population estimates prepared by the Population Research Center at Portland State University.

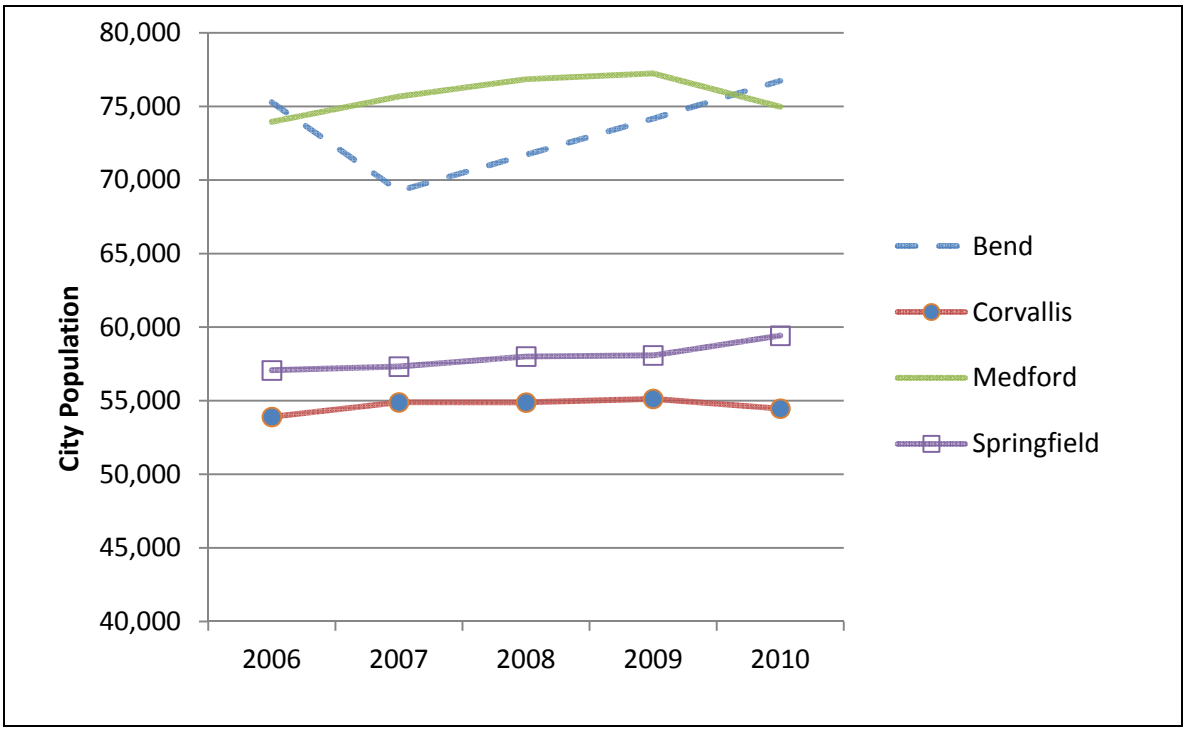


Figure 2 City Population by Year (2006-2010)

Table 1 Summary of Bend Crash Trends vs. Comparison Cities

Crash Comparison Category	Observed Trend
Crash Frequency	Fewer crashes were reported in Bend per year than Medford, but Bend has more reported crashes than Springfield and Corvallis each year in the study period. These trends are generally reflective of estimated populations of each city.
Fatal Crash Frequency	More fatal crashes have been reported in Bend than any of the other three comparison cities over the 5-year study period.
Crash Frequency by Contributing Factors	Speed has been cited as a factor in more crashes in Bend than any of the other three comparison cities over the 5-year study period. Alcohol has been cited as a factor in more crashes in Bend than any of the other three comparison cities over the 5-year study period.
Pedestrian and Bicycle Crashes	Fewer crashes in Bend have involved pedestrians than any of the other three comparison cities over the 5-year study period. Only Springfield had fewer reported crashes involving bicyclists than Bend over the 5-year study period.
Crash Frequency by Crash Type	More fixed-object and sideswipe-meeting crashes occurred in Bend than other cities over the 5-year study period. Collectively these crash types will be referred to as “roadway departure” crashes.

Tier I Findings

As described in Table 1, there appears to be more fatal crashes, alcohol-involved crashes, speed-involved crashes, and roadway departure crashes in Bend than the other three comparison cities over the 5-year period from 2006 through 2010. These trends were identified for further evaluation. Although Bend has fewer bicycle and pedestrian crashes than most of the comparison cities, the City desires to identify opportunities to reduce the frequency of those crashes in order to encourage use of non-motorized transportation modes in Bend. Therefore, pedestrian and bike crashes were evaluated in greater detail as part of the Tier II analysis.

TIER II CRASH DATA ANALYSIS

Five crash trends were identified through the Tier I analysis. Overall, the Tier II analysis confirmed the crash trends identified in Tier I represent opportunities to reduce crash frequency and severity within the City of Bend. Tier II analysis built on Tier I analysis that included five years of crash data from 2006 through 2010. Where trends were identified within the City limits on arterial and collector streets, the data was limited to 2007 through 2010, when ODOT's crash database includes coordinates of all reported crashes. The trends observed within the City of Bend are described below.

Fatal Crashes

There were 22 reported fatal crashes in the City over the 5-year study period. Due to the limited number of fatal crashes, no clear patterns were identified. Figure 8 shows a variety of crash types have resulted in fatal crashes. Fixed-object and turning crashes are the most commonly-reported crash types while three pedestrian crashes resulted in fatalities. The 5 fixed-object crashes and 1 head-on crash were grouped for analysis as "roadway departure" crashes. Roadway departure crashes are being evaluated separately, but the correlation with fatal crashes emphasizes the need to evaluate them.

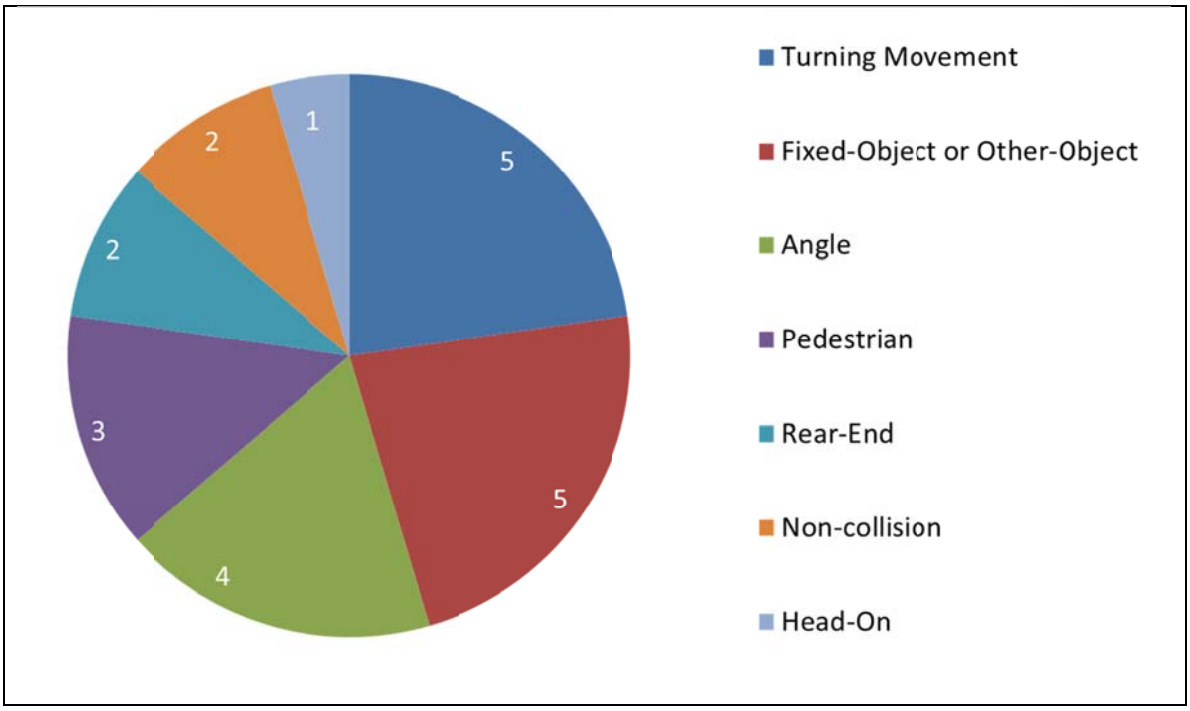


Figure 3 Reported Fatal Crash Types (2006-2010)

Approximately 13 of the 22 reported fatal crashes in Bend occurred on state highways; these will not be evaluated in detail as part of this project. At least 9 occurred on City arterial and collector streets. Of those on City arterial and collector streets, 5 occurred at intersections or driveways, 3 occurred on roadway segments, and 1 was a not related to a collision (i.e., involved a single vehicle). The crash types at intersections or driveways include 3 turning, 1 fixed object, and 1 pedestrian. Speed was noted as a factor in 4 of the 9 crashes.

Given the correlation between fatal crashes and two other observed crash trends (roadway departure and speed-involved crashes), and the significant impact of every fatal crash, fatal crashes were identified as a focus area and will be subjected to additional analysis, diagnosis, and countermeasure selection.

Alcohol-involved Crashes

There were 145 reported crashes on all streets within the Bend city limits involving alcohol over the five-year study period. Over 65 percent (100 crashes) were on City streets. Five crashes on city arterial and collector streets resulted in fatalities. 67 crashes resulted in injury. The locations of the reported crashes on City arterial and collector streets from 2007 through 2010, when ODOT has geocoded crash locations, are shown in Figure 4. The map includes crashes at intersections between city facilities and ODOT facilities. The map indicates alcohol-involved crashes are occurring throughout the city and on all types of roadway facilities.

Given the majority of alcohol-involved crashes result in fatality or injury, this area was identified as a focus area.

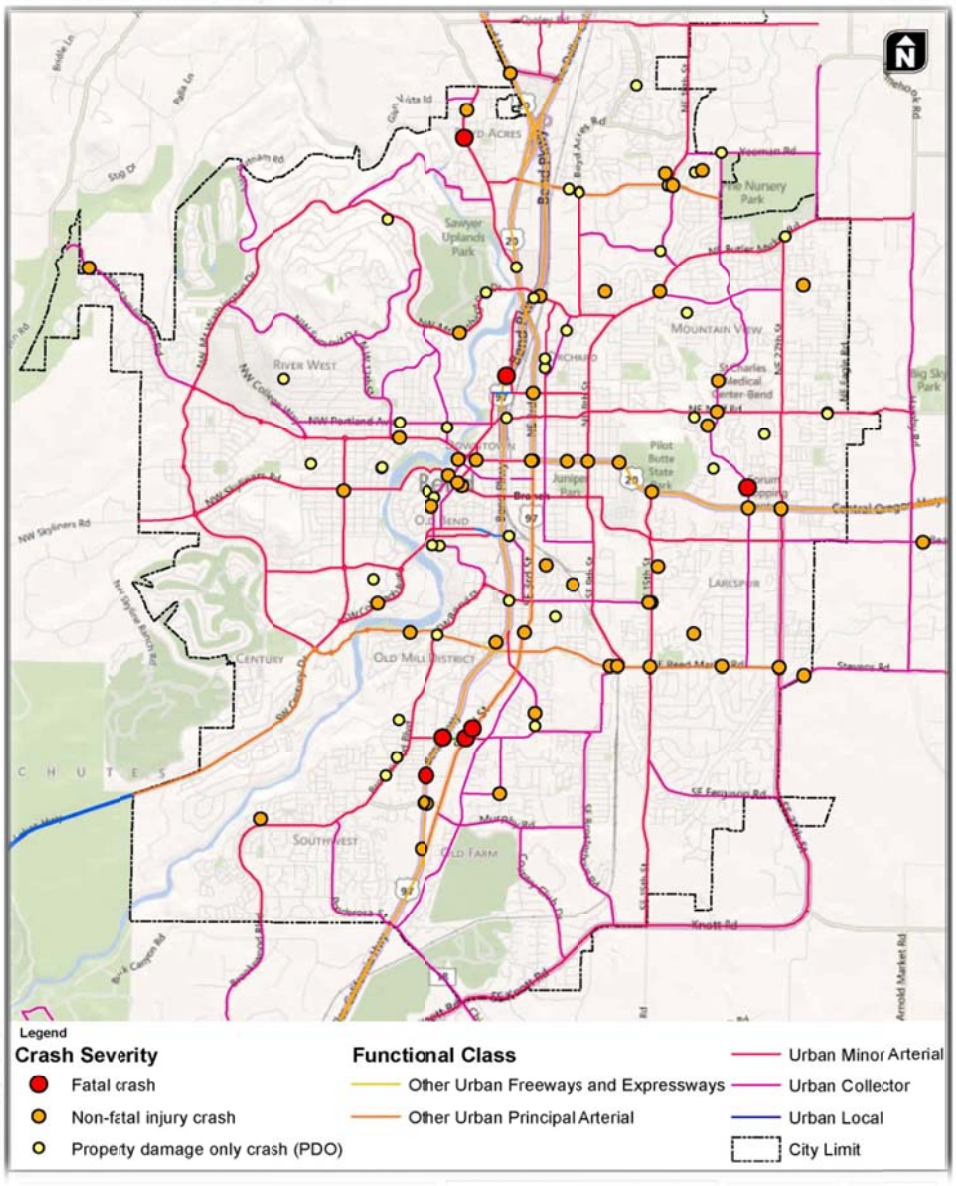


Figure 4 Reported Crashes Involving Alcohol by Severity (2007-2010)

Speed-involved Crashes

Speed was cited as a factor in 331 crashes on City of Bend arterial and collector roadways over the 5-year study period. The 331 speed-involved crashes resulted in 4 fatalities and 123 non-fatal injury crashes. The primary crash types associated with these crashes are rear-end (110 crashes) and fixed-object (103 crashes). Based on the frequency of crashes involving speed and the potential to apply non-engineering resources to address these crashes, this was identified as a focus area.

Pedestrian and Bicycle Crashes

The City desires to identify opportunities to reduce the pedestrian and bicycle crash frequency to encourage and expand non-motorized travel modes. There were 58 bicycle crashes and 25 pedestrian crashes on Bend arterial and collector streets from 2007-2010. Pedestrian and bicycle volumes are not available to estimate the level of exposure associated with these crash types.

Figure 5 illustrates the frequency of bicycle crashes by type. As shown, the majority of bicycle crashes have occurred as part of turning movement and angle crashes.

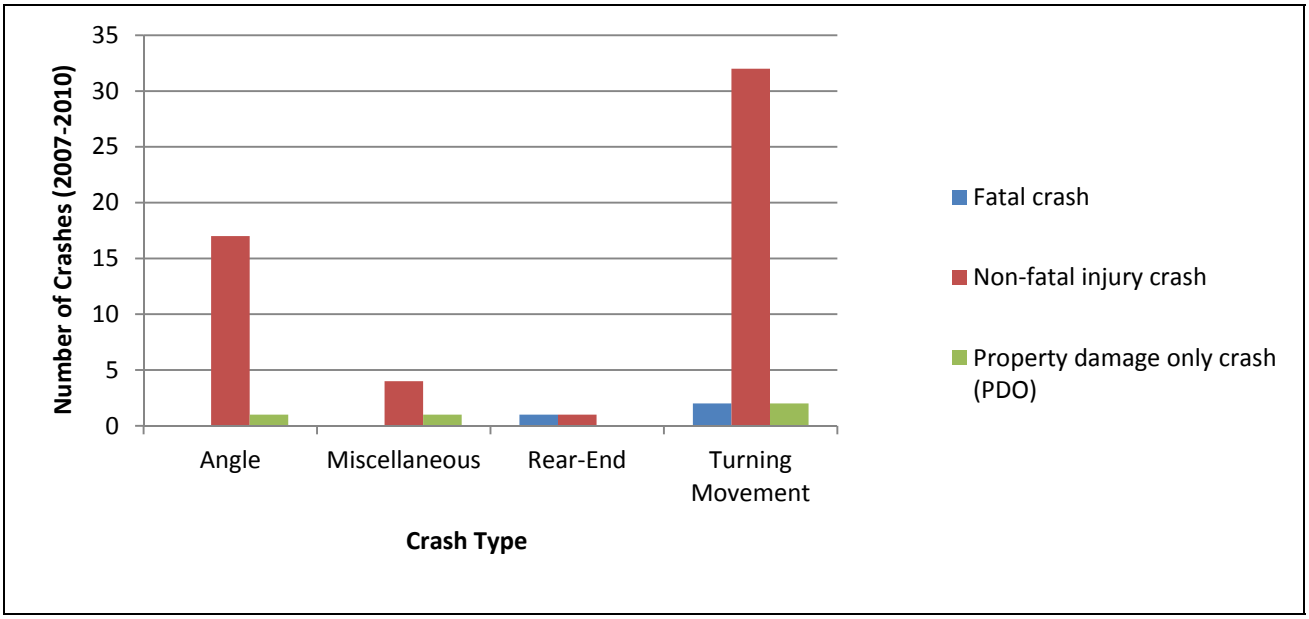


Figure 5 Reported Crash Types Involving a Bicycle (2007-2010)

Bicycle and pedestrian crashes are mapped in Figure 6. The map shows bicycle and pedestrian crashes have occurred throughout the city at intersections and along roadway segments. Pedestrian and bicycle crashes will be a focus area of network screening and individual crash locations will be identified for reducing these types of crashes.

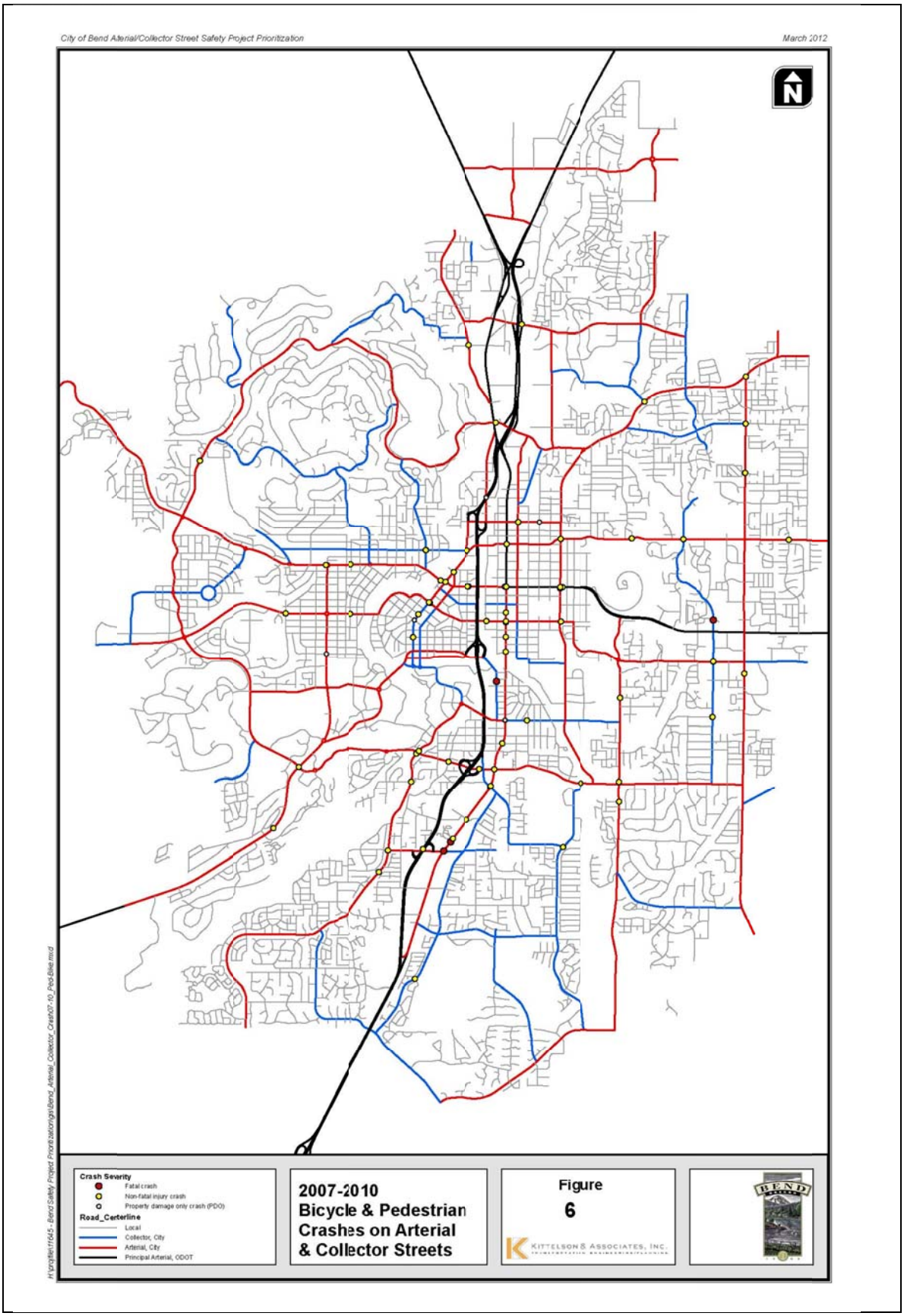


Figure 6 Bicycle and Pedestrian Crashes by Severity on Arterial and Collector Streets (2007-2010)

Roadway Departure Crashes

Roadway departure crashes include those where a vehicle leaves its travel lane, to the left or the right, and collides with another vehicle, fixed object, or overturns. ODOT crash data provides crash type and collision type descriptions that include one or more of the following descriptors: fixed object, overturned, other non-collision, fixed-object, other-object, head-on, and sideswipe-meeting. The number of roadway departures reported within the City limits on arterial and collector streets are summarized by crash severity in Table 2, based on the collision type and crash type descriptors from the ODOT database. Figure 7 illustrates the locations of the crashes by type.

Table 2 Summary of Roadway Departure Crash Types and Collision Types by Severity (2007-2010)

Collision Type/ Crash Type	Fatal crash	Non-fatal injury crash	Property damage only crash (PDO)	Total
Fixed-Object or Other-Object	**2**	**51**	**88**	***141***
Head-On		**2**	**9**	***11***
From opposite direction - both going straight		2	4	*6*
From opposite direction - one stopped			4	*4*
Parked motor vehicle			1	*1*
Miscellaneous		**5**	**2**	***7***
Other non-collision		1	1	*2*
Overturned		4	1	*5*
Non-Collision		6	1	*7*
Other non-collision		2		*2*
Overturned		4	1	*5*
Sideswipe-Meeting		**10**	**25**	***35***
From opposite direction - both going straight		9	20	*29*
From opposite direction - one stopped			2	*2*
Parked motor vehicle		1	3	*4*
Grand Total	***2***	***74***	***125***	***201***

There were 201 roadway departure crashes reported on City of Bend arterial and collector streets from 2007 to 2010. The majority of these crashes resulted in property damage only (125), 74 resulted in injury, and 2 resulted in fatalities. Of the 201 reported crashes, 110 roadway departure crashes were associated with “speed too fast for conditions.”

KAI recommends roadway departure crashes be included as a focus area and that the City conduct additional analysis to identify specific sites where enforcement and other types of treatments can be applied.

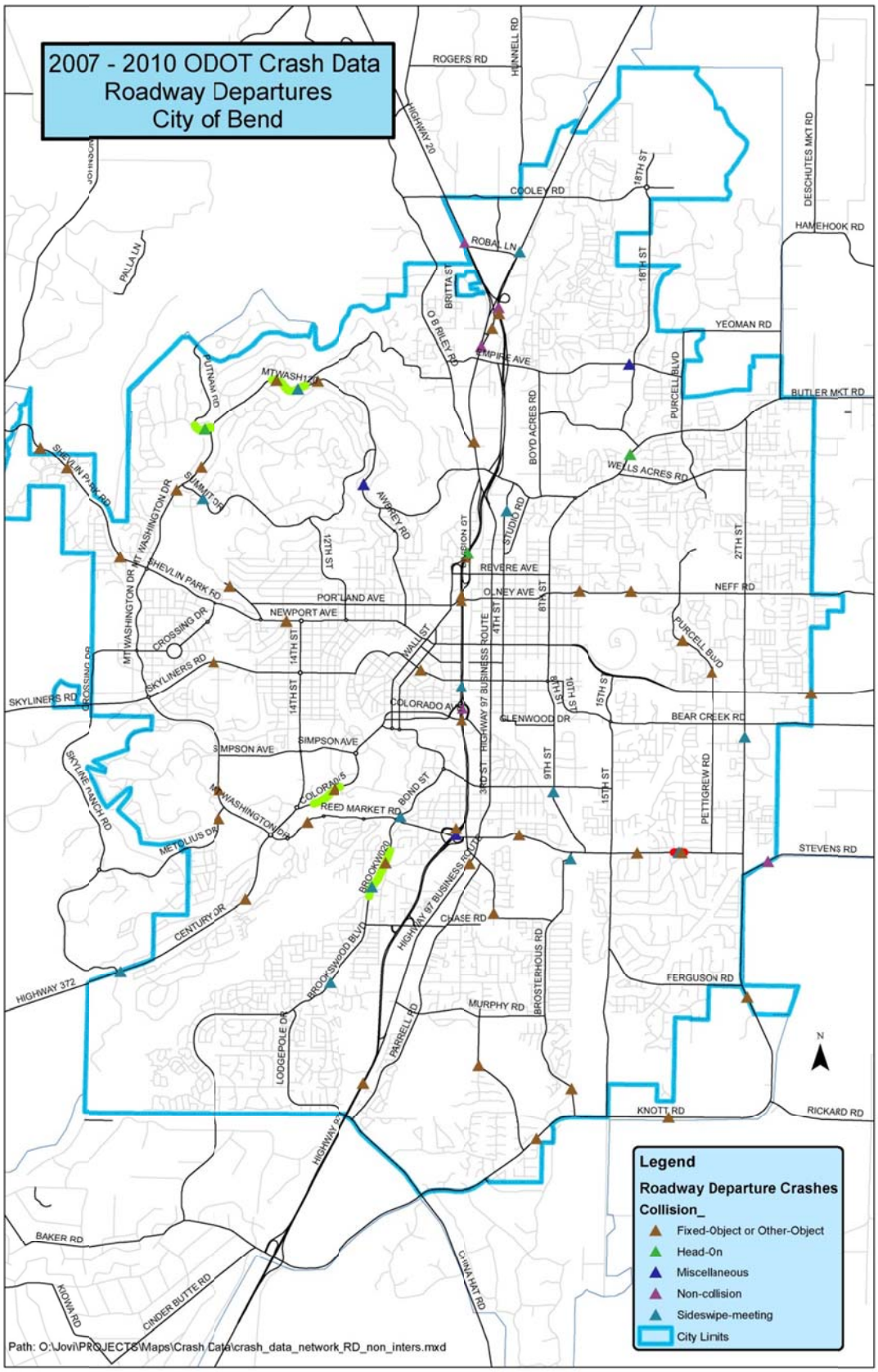


Figure 7 Reported Roadway Departure Crashes by Crash Type (2007-2010)

FINDINGS

Benchmarking and crash data analysis resulted in five crash characteristic focus areas:

- Fatal crashes,
- Alcohol-involved crashes,
- Speed-involved crashes,
- Pedestrian and bicycle crashes, and
- Roadway departure crashes.

The focus areas represent a range of crash types and contributing factors that will allow the City to consider engineering and non-engineering resources to reduce crash frequency and severity. The "5-E's" (Engineering, Education, Enforcement, Emergency Response, and Evaluation) allow for customized approaches to reduce crash severity and frequency and emergency response while using a data-informed process to evaluate the effectiveness of the safety program. For example, enforcement may be the most effective treatment to address alcohol and speed-involved crashes, and education may be the most effective treatment for addressing the frequency of pedestrian and bicycle crashes. Collaboration with emergency responders can maximize the benefit of this safety net to treat injuries. Evaluating the effectiveness of specific treatments and the program as a whole provides a comprehensive roadway safety management approach.

NEXT STEPS

The focus areas identified through Benchmarking will inform the second phase of the Bend Arterial and Collector Safety Program. The second phase includes identifying the factors contributing to crash types within the focus areas and evaluating a range of countermeasures to address them.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING
354 SW Upper Terrace Drive, Suite 101, Bend, Oregon 97702 P 541.312.8300 F 541.312.4585

TECHNICAL MEMORANDUM

Bend Arterial and Collector Safety Project Program Development

Network Screening

Date: September 4, 2012 Project #: 11645.0
To: Robin Lewis, PE, City of Bend
From: Casey Bergh, PE and Brian Ray, PE

The City of Bend and Kittelson & Associates, Inc. (KAI) are developing and implementing a data-driven transportation safety management program. The framework for the program was documented by KAI in our July 9, 2012 memorandum (draft prepared in June 2012) and is generally illustrated in Figure 1. Network Screening, described in this memorandum, is intended to apply objective methods to evaluate the City's arterial and collector streets to identify sites with high crash frequency or severe crashes where countermeasures could be applied.

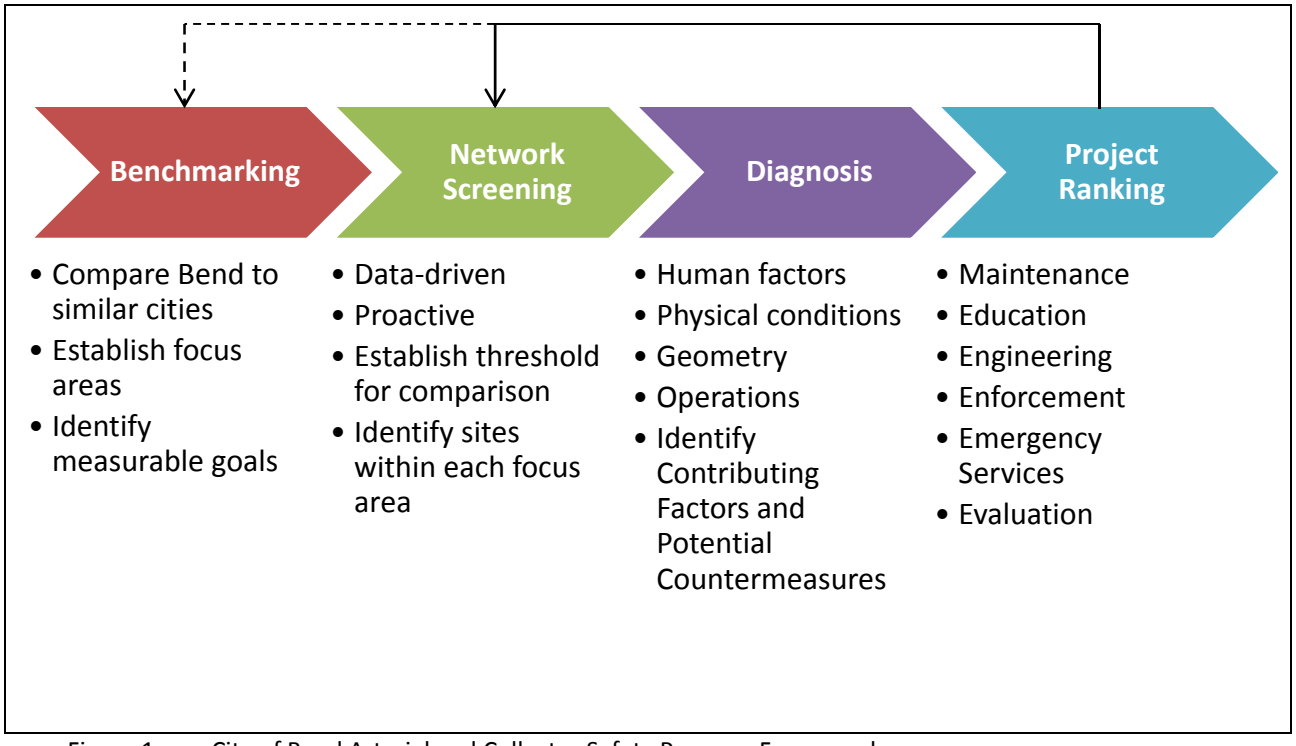


Figure 1 City of Bend Arterial and Collector Safety Program Framework

OVERVIEW

Network screening methods are described in detail in Chapter 4 of the AASHTO *Highway Safety Manual* (HSM). The methods from the HSM have been adapted to the goals of the City of Bend Safety Program and the scope of this project. Network screening generally includes the following steps:

1) Establish focus
2) Identify reference populations
3) Select performance measures
4) Screen and evaluate results

1. Establish Focus

Network screening is guided by the focus areas identified through the benchmarking phase, including:

- Fatal crashes
- Roadway Departure crashes
- Alcohol-involved crashes
- Speed-involved crashes
- Pedestrian and bicycle crashes

There were less than 25 fatal crashes reported in Bend over the study period (January 1, 2006 through December 31, 2010) and a manual review of each crash report is feasible. KAI expanded the fatal crash focus area to include injury crashes to apply objective analysis tools and demonstrate network screening.

The City's safety program is set up as a cyclical process. The City has the flexibility to determine how often the cycle is repeated and whether to include benchmarking each time they repeat the process. Focus areas identified through previous benchmarking efforts can be retained for multiple program cycles, if Benchmarking is not repeated each cycle. Maintaining the same focus areas for subsequent program cycles allows more time for the City to apply resources to address one area before moving onto another.

2. Identify Reference Populations

KAI divided the sites within each focus area into several distinct subsets of the City's network (i.e., reference populations). The sites identified for diagnosis include a range of facility types presenting a wide range of opportunities to apply crash countermeasures.

KAI considered a range of potential characteristics to establish reference populations, as outlined in Chapter 4 of the HSM. Due to data limitations, traffic control was the primary characteristic used to establish reference populations. The City provided GIS data identifying traffic control for all

intersections and traffic control reference populations were grouped as signalized, unsignalized (including roundabouts), and other (railroad crossing gates, yield signs, etc.).

3. Select Performance Measures

The HSM identifies 13 performance measures that can be used in network screening. Performance measures that reflect crash frequency and severity can be used to evaluate the crash data and determine a quantitative "score" at each site. However, the City does not have a complete database of traffic volume and roadway geometry data that is required for the advanced methods for all arterial and collector streets. Until the City completes their project to develop a traffic volume database and collects data to populate it, the City is limited to applying the first five performance measures shown in Table 1. The performance measures that can be applied do not account for statistical bias. In addition, the Relative Severity Index (RSI) and Equivalent Property Damage Only (EPDO) methods may emphasize sites where a fatal crash has occurred. Therefore, two or more measures can be applied on each reference population and the results can be compared to identify sites with the greatest potential for reducing crash frequency or severity.

Table 1 Summary of Network Screening Performance Measures

Statistical Bias/Data Requirement Continuum*	City of Bend Implementation Category	Network Screening Performance Measure
	Short-term – Data is available	**Crash Frequency**
		Equivalent Property Damage Only Crash Frequency
		Relative Severity Index
		Crash Type Performance Threshold
		Excess Proportion of Specific Crash Types
	Medium-term – Requires volume data	Critical Rate
		Method of Moments
	Long-term – Requires calibrated safety performance functions and detailed geometric information	Excess Predicted Crashes Using SPFs
		Level of Service of Safety
		Expected Crash Frequency with EB Adjustment
		EPDO Crash Frequency with EB Adjustment
		Excess Expected Crash Frequency with EB Adjustment

* Performance measures are sorted by implementation category. Implementation categories generally reflect a reduction in statistical bias as additional data is included in analysis.

The three performance measures, shown in **BOLD TEXT** in Table 1, account for severity and crash type, but do not account for changes in traffic volume (i.e., exposure).

Definitions of each measure and step-by-step instructions are provided in Chapter 4 of the HSM. The Relative Severity Index (RSI) measure reflects crash type and traffic control. It applies a monetary value to crashes categorized by crash type and traffic control. The values used in this study are provided in Table 2.

The monetary factors reflect the societal cost (in dollars) of each crash. They were developed by FHWA and are published in the HSM in 2001 dollars. Because the analysis is relative (one site is compared to another), the sheer values do not impact the results, but the differences between categories determine the difference in score. An update of these values is not necessary, but as FHWA publishes an update the City could update their reference values.

Table 2 RSI Crash Cost Estimates by Crash Type (Reference 1)

Crash Type, Traffic Control	Crash Cost
Rear-end, signalized	$26,700
Rear-end, unsignalized	$13,200
Side-swipe opposing	$34,000
Angle, signalized	$47,300
Angle, unsignalized	$61,100
Pedestrian/Bicycle	$158,900
Head-on, signalized	$24,100
Head-on, unsignalized	$47,500
Fixed object	$94,700
Other	$55,100

The Equivalent Property Damage Only (EPDO) measure reflects crash severity. It applies weighting factors to each crash based on the reported severity, based on values summarized in Table 3.

Table 3 Societal Crash Costs by Severity (Reference 1)

Severity	Cost	Weight
Fatal	$4,008,900	542
Injury	$82,600	11
PDO	$7,400	1

4. Screen and Evaluate Results

The HSM describes multiple methods for applying network screening tools. Implementation of those methods required developing a custom spreadsheet and GIS-based tools to reflect the City's safety program goals. The tools will be provided to the City for future program cycles.

KAI applied the network screening tools on three focus areas to demonstrate their use. The application informed the City on how to vary the method based on differing goals of each focus area. KAI's customized screening method includes the following general steps for conducting the screening:

1. Obtain crash data for all reported crashes in Bend city limits for a period of 3 to 5 years
2. Map crashes in GIS and filter out crashes not on the City arterial and collector street network
3. Use GIS to summarize those crashes occuring within 150 feet of an intersection on the collector and arterial network.
4. Use GIS to query crash database and export subsets of crashes by focus area
5. Use PivotTables in Excel to summarize crashes by reference populations
6. Apply performance measures in Excel to rank sites within each reference population

KAI conducted network screening for three of the five focus areas: fatal and injury crashes, speed-involved crashes, and pedestrian and bicycle crashes. The City conducted network screening of the additional focus areas: alcohol-involved crashes and roadway departure crashes.

Sites within ODOT's jurisdiction or where improvements are planned and funded through the General Obligation (GO) Bond Program were ranked by KAI, but not selected for diagnosis. These sites include intersections and segments on US 20, US 97, Reed Market Road (East of 3rd Street to West of 27th Street), Brookswood Avenue/Powers Road, and 18th Street/Empire Avenue.

Fatal and Injury Crashes

The ten highest-ranked signalized and unsignalized intersections (ranked based on RSI and EPDO performance measures) are summarized in Table 4 and Table 5, respectively.

Sites selected for diagnosis are highlighted with bold text and are color-coded to illustrate each site's ranking across performance measures. Grey text indicates sites that are within ODOT's jurisdiction or included in the GO Bond.

Table 4 Fatal and Injury Crash Network Screening Results at Signalized Intersections

Site Rank	High Ranking Intersections by Performance Measure		
	RSI	EPDO	Frequency
1	HIGHWAY 20/ NE 8TH ST	HIGHWAY 97/ POWERS RD	HIGHWAY 97/ POWERS RD
2	HIGHWAY 20/ NE GREENWOOD AVE	HIGHWAY 20/ SE 27TH ST	HIGHWAY 20/ NE 8TH ST
3	HIGHWAY 97/ POWERS RD	**POWERS RD/ SE 3RD ST**	HIGHWAY 20/ NE GREENWOOD AVE
4	**REED MARKET RD/ SE 3RD ST**	REED MARKET RD/ SE 27TH ST	HIGHWAY 97/ ROBAL LN
5	BROSTERHOUS RD/ SE 3RD ST	HIGHWAY 20/ NE 8TH ST	**REED MARKET RD/ SE 3RD ST**
6	**NE NEFF RD/ NE PURCELL BLVD**	HIGHWAY 20/ NE GREENWOOD AVE	**NE NEFF RD/ NE PURCELL BLVD**
7	**POWERS RD/ SE 3RD ST**	HIGHWAY 97/ ROBAL LN	**NE 3RD ST/ NE FRANKLIN AVE**
8	**NE 3RD ST/ NE FRANKLIN AVE**	**REED MARKET RD/ SE 3RD ST**	HIGHWAY 20/ NE PURCELL BLVD
9	NW OLNEY AVE/ NW WALL ST	**NE 3RD ST/ NE FRANKLIN AVE**	NE 3RD ST/ NE OLNEY AVE
10	NW FRANKLIN AVE/ NW WALL ST	**NE NEFF RD/ NE PURCELL BLVD**	COOLEY RD/ HIGHWAY 97
		HIGHWAY 20/ NE PURCELL BLVD	

As shown in Table 4, four signalized intersection sites ranked in the top ten under RSI and EPDO performance measures. Those sites will be advanced for further diagnosis.

Table 5 Fatal and Injury Crash Network Screening Results at Unsignalized Intersections

Site Rank	High Ranking Intersections by Performance Measure		
	RSI	EPDO	Frequency
1	**BEAR CREEK RD/ PETTIGREW RD**	EMPIRE AVE/ O B RILEY RD	**BEAR CREEK RD/ PETTIGREW RD**
2	EMPIRE AVE/ NE 18TH ST	SE 2ND ST/ SE DAVIS AVE	EMPIRE AVE/ NE 18TH ST
3	BROOKSWOOD BLVD/ POWERS RD	FIREROCK RD/ O B RILEY RD	BROOKSWOOD BLVD/ POWERS RD
4	AMERICAN LN/ REED MARKET RD	**BEAR CREEK RD/ PETTIGREW RD**	AMERICAN LN/ REED MARKET RD
5	**NW GREENWOOD AVE/ NW HILL ST**	EMPIRE AVE/ NE 18TH ST	**NW GREENWOOD AVE/ NW HILL ST**
6	**SW REED MARKET RD/ SW BOND ST**	BROOKSWOOD BLVD/ POWERS RD	HIGHWAY 97/ NW HAWTHORNE AVE
7	NE 1ST ST/ NE FRANKLIN AVE	AMERICAN LN/ REED MARKET RD	DIVISION ST/ SW REED MARKET RD
8	NW AWBREY RD/ NW PORTLAND AVE	**NW GREENWOOD AVE/ NW HILL ST**	**NE 1ST ST/ NE GREENWOOD AVE**
9	**SE 2ND ST/ SE WILSON AVE**	**NE 1ST ST/ NE GREENWOOD AVE**	**SE 2ND ST/ SE WILSON AVE**
10	COUNTRY CLUB DR/ MURPHY RD	**SE 2ND ST/ SE WILSON AVE**	NW NEWPORT AVE/ NW 14TH ST
		HIGHWAY 97/ NW HAWTHORNE AVE	**SW REED MARKET RD/ SW BOND ST**
		DIVISION ST/ SW REED MARKET RD	
		NW NEWPORT AVE/ NW 14TH ST	
		SW REED MARKET RD/ SW BOND ST	

As shown in Table 5, the Bear Creek/ Pettigrew intersection was the highest-ranked unsignalized intersection under RSI. This reflects one or more severe crashes. That intersection and four others highlighted in bold text will be included in the diagnosis.

Speed-involved Crashes

Signalized and unsignalized intersections were ranked based on RSI and EPDO performance measures to identify those intersections with high crash frequency or severe crashes. The 10 highest-rank sites are summarized in Table 6 and Table 7, respectively. Sites selected for diagnosis are highlighted with bold text and are color-coded to illustrate each site's ranking across by performance measures. Grey text indicates sites that are within ODOT's jurisdiction or included in the GO Bond.

Table 6 Speed-involved Crash Network Screening Results at Signalized Intersections

Site Rank	High Ranking Intersections by Performance Measure		
	RSI	EPDO	Frequency
1	**NE NEFF RD/ NE PURCELL BLVD**	**NE NEFF RD/ NE PURCELL BLVD**	**NE NEFF RD/ NE PURCELL BLVD**
2	HIGHWAY 20/ SE 27TH ST	**REED MARKET RD/ SE 3RD ST**	**REED MARKET RD/ SE 3RD ST**
3	**BUTLER MKT RD/ NE 27TH ST**	COOLEY RD/ HIGHWAY 97	COOLEY RD/ HIGHWAY 97
4	**REED MARKET RD/ SE 27TH ST**	**NW BOND ST/ NW COLORADO AVE**	**NW BOND ST/ NW COLORADO AVE**
5	SE 3RD ST/ SE WILSON AVE	**REED MARKET RD/ SE 27TH ST**	HIGHWAY 20/ ROBAL LN
6	HIGHWAY 97/ POWERS RD	HIGHWAY 97/ POWERS RD	SE 3RD ST/ SE WILSON AVE
7	NW OLNEY AVE/ NW WALL ST	HIGHWAY 20/ SE 27TH ST	HIGHWAY 20/ SE 27TH ST
8	SW COLORADO AVE/ SW INDUSTRIAL WAY	NE 3RD ST/ NE FRANKLIN AVE	NE 3RD ST/ NE FRANKLIN AVE
9	**NW BOND ST/ NW COLORADO AVE**	NE 3RD ST/ NE GREENWOOD AVE	NE 3RD ST / NE GREENWOOD AVE
10	HIGHWAY 97/ SE 3RD ST	REED MARKET RD/ SE 15TH ST HIGHWAY 97/ SE 3RD ST	WILSON AVE/ SE 15TH ST HIGHWAY 97/ SE 3RD ST

As shown in Table 6, the Neff Road/ Purcell Boulevard intersection represents a location where speed-related crashes have resulted in frequent or severe crashes. Diagnosis will be conducted on that intersection and four others identified in the table in bold text.

Table 7 Speed-involved Crash Network Screening Results at Unsignalized Intersections

Site Rank	High Ranking Intersections by Performance Measure		
	RSI	EPDO	Frequency
1	BROOKSWOOD BLVD/ POWERS RD	**FIREROCK RD/ O B RILEY RD**	**BROOKSWOOD BLVD/ PINEBROOK BLVD**
2	**BROOKSWOOD BLVD/ PINEBROOK BLVD**	**COUNTRY CLUB DR/ MURPHY RD**	BROOKSWOOD BLVD/ POWERS RD
3	**COUNTRY CLUB DR/ MURPHY RD**	**BEAR CREEK RD/ PETTIGREW RD**	**COUNTRY CLUB DR/ MURPHY RD**
4	15TH ST/ SHERWOOD FOREST DR	SW REED MARKET RD/ SW CENTURY DR	SW COLORADO AVE/ SW COLUMBIA ST
5	**BEAR CREEK RD/ PETTIGREW RD**	SE 15TH ST/ SE WILSON AVE	15TH ST/ SHERWOOD FOREST DR
6	NW RIVERSIDE BLVD/ NW TUMALO AVE	EMPIRE AVE/ NE 18TH ST	**BEAR CREEK RD/ PETTIGREW RD**
7	NW KANSAS AVE/ NW WALL ST	NE 27TH ST/ NE CONNERS AVE	SW REED MARKET RD/ SW CENTURY DR
8	SE 2ND ST/ SE SCOTT ST	NW NEWPORT AVE/ NW 14TH ST	NW RIVERSIDE BLVD/ NW TUMALO AVE
9	MT WASHINGTON DR/ SKYLINERS RD	SW REED MARKET RD/ ALDERWOOD CIR	SE 2ND ST/ SE SCOTT ST
10	BROSTERHOUS RD/ CLAY PIGEON CT	**BROOKSWOOD BLVD/ PINEBROOK BLVD**	BROSTERHOUS RD/ CLAY PIGEON CT

As shown in Table 7, four unsignalized intersections with speed-related crashes have resulted in frequent or severe crashes. Diagnosis will be conducted on all four intersections identified in the table.

Pedestrian and Bicycle Crashes

Signalized and unsignalized intersections were ranked based on the RSI performance measures to identify those intersections with high crash frequency or severe crashes. Given the frequency of crashes per site, the five highest-rank sites are summarized in Table 8 and Table 9. The EPDO method cannot be applied because all crashes involve pedestrians and are weighted with the same value.

Table 8 Pedestrian and Bicycle Crash Network Screening Results at Signalized Intersections

Site Rank	High Ranking Intersections by Performance Measure	
	RSI	Frequency
1	**POWERS RD/ SE 3RD ST**	**NE 3RD ST/ NE GREENWOOD AVE**
2	**NE 3RD ST/ NE GREENWOOD AVE**	HIGHWAY 20/ NE 8TH ST
3	HIGHWAY 20/ NE 8TH ST	**BROSTERHOUS RD/ SE 3RD ST**
4	**BROSTERHOUS RD/ SE 3RD ST**	**POWERS RD/ SE 3RD ST**
5	**NW FRANKLIN AVE/ NW WALL ST**	**NW FRANKLIN AVE/ NW WALL ST**
	NW GREENWOOD AVE/ NW WALL ST	NW GREENWOOD AVE/ NW WALL ST
	REED MARKET RD/ SE 3RD ST	REED MARKET RD/ SE 3RD ST
	NE 3RD ST/ NE FRANKLIN AVE	NE 3RD ST/ NE FRANKLIN AVE

Table 9 Pedestrian and Bicycle Crash Network Screening Results at Unsignalized Intersections

Site Rank	High Ranking Intersections by RSI	
	RSI	Frequency
1	SE 2ND ST/ SE DAVIS AVE	**NW AWBREY RD/ NW PORTLAND AVE**
2	**NW AWBREY RD/ NW PORTLAND AVE**	**NW GREENWOOD AVE/ NW HILL ST**
	NW GREENWOOD AVE/ NW HILL ST	**NE 1ST ST/ NE FRANKLIN AVE**
	NE 1ST ST/ NE FRANKLIN AVE	SW REED MARKET RD/ SW BOND ST
	SW REED MARKET RD/ SW BOND ST	

As shown in Table 8 and Table 9, four signalized and three unsignalized intersections were identified for diagnosis, based on the RSI performance measure. There was strong correlation between Frequency and RSI performance measures reflecting the low frequency of crashes per site.

Alcohol-involved Crashes

Roadway Departure Crashes

What types of crashes were included? How did we rank and choose top few sites for diagnosis?

NETWORK SCREENING FINDINGS

The RSI and EPDO performance measures applied to screen the network for fatal and injury crashes, speed-involved crashes, and bicycle and pedestrian crashes resulted in identifying three to five sites for diagnosis per reference population. Table 10 and 0 summarize intersection selected for diagnosis at signalized and unsignalized intersections, respectively.

Table 10 Summary of Signalized Intersections Selected for Network Screening

Intersection	Focus Areas
REED MARKET RD/ SE 3RD ST	Fatal and injury, speed-involved
NE NEFF RD/ NE PURCELL BLVD	Fatal and injury, speed-involved
POWERS RD/ SE 3RD ST	Fatal and injury, bicycle and pedestrian
NE 3RD ST/ NE FRANKLIN AVE	Fatal and injury
BUTLER MKT RD/ NE 27TH ST	Speed-involved
REED MARKET RD/ SE 27TH ST	Speed-involved
NW BOND ST/ NW COLORADO AVE	Speed-involved
NE 3RD ST/ NE GREENWOOD AVE	Bicycle and pedestrian
BROSTERHOUS RD/ SE 3RD ST	Bicycle and pedestrian
NW FRANKLIN AVE/ NW WALL ST	Bicycle and pedestrian
	Alcohol-involved
	Roadway departure

Table 11 Summary of Unsignalized Intersections Selected for Network Screening

Intersection	Focus Areas
SE 2ND ST/ SE WILSON AVE	Fatal and Injury
BEAR CREEK RD/ PETTIGREW RD	Fatal and Injury, Speed-involved
NW GREENWOOD AVE/ NW HILL ST	Fatal and Injury, Bicycle and Pedestrian
NE 1ST ST/ NE GREENWOOD AVE	Fatal and Injury
SW REED MARKET RD/ SW BOND ST	Fatal and Injury
BROOKSWOOD BLVD/ PINEBROOK BLVD	Speed-involved
COUNTRY CLUB DR/ MURPHY RD	Speed-involved
FIREROCK RD/ O B RILEY RD	Speed-involved
NW AWBREY RD/ NW PORTLAND AVE	Bicycle and Pedestrian
NE 1ST ST/ NE FRANKLIN AVE	Bicycle and Pedestrian

NEXT STEPS

The sites identified through network screening will be subjected to diagnosis to determine factors contributing to crash frequency or severity.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING / PLANNING
354 SW Upper Terrace Drive, Suite 101, Bend, Oregon 97702 P 541.312.8300 F 541.312.4585

DRAFT TECHNICAL MEMORANDUM

Bend Arterial and Collector Safety Project Program Development

Diagnosis and Project Ranking

Date: September 24, 2012 Project #: 11645.0
To: Robin Lewis, PE, City of Bend
From: Casey Bergh, PE and Brian Ray, PE

The City of Bend and Kittelson & Associates, Inc. (KAI) are developing and implementing a data-driven transportation safety management program. The framework for the program was documented by KAI in our July 9, 2012 memorandum (draft prepared in June 2012) and is generally illustrated in Figure 1. The Diagnosis and Project Ranking components are described in this memorandum. Diagnosis involves identifying factors potentially contributing crashes at each site identified in the Network Screening phase and selecting countermeasures to reduce those crashes. The effectiveness of the countermeasures is used to rank projects for implementation.

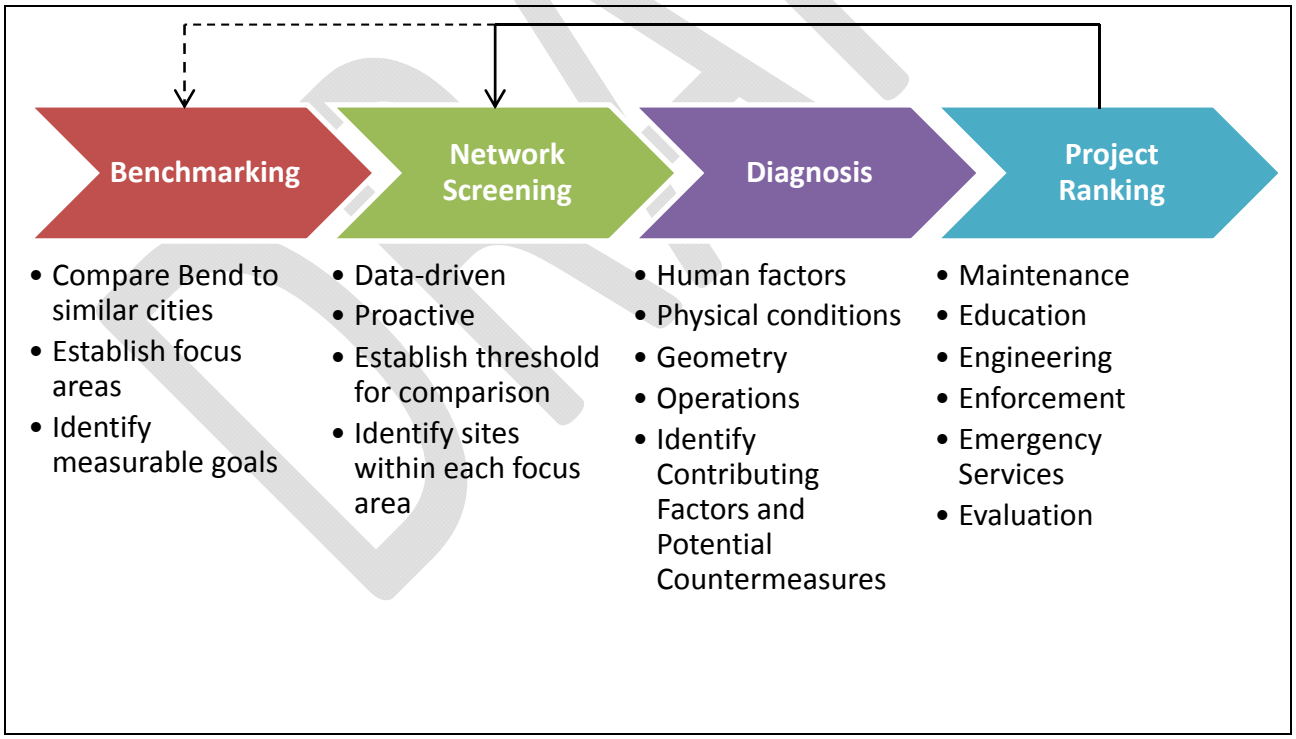


Figure 1 City of Bend Arterial and Collector Safety Program Framework

OVERVIEW

KAI and the City of Bend established a process for conducting diagnosis and summarizing the findings to allow projects (including one or more countermeasures) to be ranked for implementation. The key elements recommended to be conducted at each site as part of Diagnosis are described in detail in Chapters 5 and 6 of the Highway Safety Manual (HSM) and generally include the following:

1) Office review of data and background information,
2) Field review,
3) Identify contributing factors, and
4) Identify countermeasures.

The four general steps of diagnosis precede Project Ranking that generally includes the following:

1) Quantify the benefit of each countermeasure identified through Diagnosis,
2) Group countermeasures into projects and estimate the cost of each project,
3) Calculate a benefit-cost ratio for a 20-year design life, and
4) Rank projects based on benefit-cost ratios.

The resources and data used to conduct each step are described in further detail below.

KAI and the City diagnosed 5 of 20 sites identified through Network Screening. The sites were selected to represent sites from different focus areas (e.g., fatal and injury, bicycle and pedestrian, etc.) and with various cross-section and traffic control. The diagnosis and project benefit-cost ratios for the five projects are summarized in Attachment A. The City of Bend independently diagnosed the remaining sites and has compiled the project benefit-cost ratios for all sites.

SUMMARY OF DIAGNOSIS AND PROJECT RANKING AT SELECTED SITES

The following provides more details regarding the steps taken to diagnose, select countermeasures, and establish a measure for ranking projects. The process was applied to five sites by KAI as a means to refine the process and to provide examples for the City as they apply it to additional sites in 2012 and future years.

1) Office Review of Data and Background Information

Detailed crash summaries based on Oregon Department of Transportation crash reports from January 2006 through December 2010 (same data used in the network screening phase) were used to develop crash diagrams for each site. The crash diagrams showed direction of travel, crash type, and other details on a single map and were helpful for understanding and identifying crash patterns. Additional data, including traffic volumes, signal timing data, and some local police crash reports were reviewed, where appropriate, to learn more about why these trends may be occurring. An example crash diagram for the Greenwood Avenue/Hill Street intersection is shown

in Figure 2. Additional elements to consider during the Office Review step are outlined in Appendix 5B (Chapter 5) of the HSM.

2) Field Review

Observations of traffic flow, driver behavior, and existing geometry were recorded at each site during two days in July 2012. On the second day of field reviews, local City of Bend Police officers accompanied KAI and the City of Bend. Mini-audits of each site were conducted using field prompt lists provided in Appendix 5C and 5D of the HSM. The prompt lists help field reviewers observe and document a range of geometric, traffic control, and driver behavioral elements.

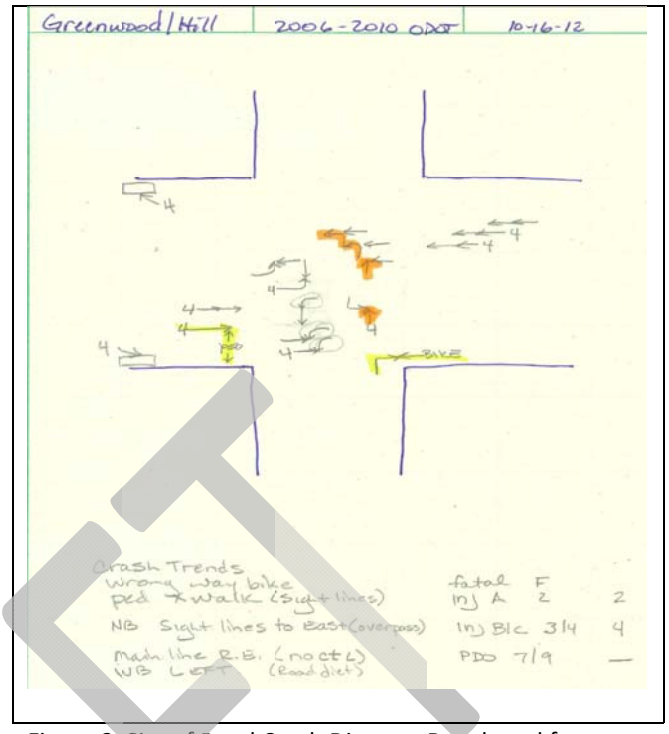


Figure 2 City of Bend Crash Diagram Developed for Office Review

3) Identify Contributing Factors

The crash patterns identified in the office review were considered and potential contributing factors were discussed based on the observations made during the field review.

4) Identify Countermeasures

For each contributing factor identified, a range of countermeasures were considered to address the potential for crashes. Several reference documents are available identifying a range of countermeasures to address particular contributing factors. Those reference documents include: NCHRP Report 500 series documents, NCHRP Report 705: *Evaluation of Safety Strategies at Signalized Intersections*, and other documents available through FHWA's Office of Safety (i.e., *Desktop Reference for Crash Modification Factors and Guidance Memorandum on Promoting the Implementation of Proven Safety Countermeasures* – see http://safety.fhwa.dot.gov/tools/).

Countermeasures with crash modification factors (CMFs) indicating a crash reduction based on empirical studies were preferred over those not having quantitative estimates of their effectiveness.

5) Quantify the benefit of each countermeasure

When available, CMFs in Part D of the HSM or those with a star rating of three or more in FHWA's CMF Clearinghouse (www.cmfclearinghouse.org) were applied to estimate the benefit of a countermeasure. Some countermeasures do not have reliable CMFs and others have no quantifiable measure of effectiveness because they are a relatively new countermeasure or have not been applied widely and studied. Some treatments do not have CMFs, but there are documented trends indicating an increase or decrease is expected. If a trend was documented, engineering judgement was applied to estimate a conservative CMF in some cases. If a treatment did not have a quantifiable estimate of effectiveness or documented trend, engineering judgment was applied to identify a CMF based on the documented effectiveness of similar proven countermeasures. In many cases, there are no similar treatments with reliable CMFs so the treatment benefit was not included in the project benefit-cost ratios.

6) Estimate the cost of each countermeasure

Cost estimates were developed by the City of Bend based on standard unit costs of materials and are provided for the five sample sites in Appendix C.

7) Identify one or more effective countermeasures and combine into a project

Countermeasures that were found to have a reliable CMF indicating a reduction in crash frequency or severity were combined into groups as "projects." At some sites multiple projects were identified that range in cost or that made sense to provide as phases.

8) Calculate a cost-benefit ratio for a 20-year design life

ODOT's cost-benefit spreadsheet computed the estimated cost-benefit ratio of each project. This spreadsheet estimates benefits in terms of crash reduction based on CMFs. The CMFs were applied only to crash types expected to be impacted by each countermeasure.

The spreadsheet provides a method for estimating the economic benefit based on the Comprehensive Economic Costs associated with the number of crashes reduced. The comprehensive economic costs of crashes were estimated by severity using monetary values provided in FHWA's Technical Advisory "Motor Vehicle Accident Costs"[1] [2]. Unless the values are

[1] Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

[2] PDO crash values of $7,500 per crash were adjusted by a factor of 2.0 to account for under-reporting. Reference: National Safety Council, 2005 estimates of value per crash.

updated to current year values, the project benefit-cost ratios are only valid for relative comparison purposes.

CONCLUSION

Once benefit-cost ratios are developed for all projects, the projects can be ranked and those projects with the highest benefit-cost ratios indicate the most cost-effective projects. The City may choose to implement those projects having the highest benefit-cost ratio first, or implement them in another order if total project costs exceed available funding, or if an opportunity arises to fund a safety project concurrently with other City projects.

Appendix A Site Diagnosis Summary Worksheets

Table A-1 Site Diagnosis Summary at Greenwood Avenue/Hill Street

GREENWOOD AVENUE/ HILL STREET	**Diagnosed by: Casey Bergh (KAI), Julia Wellner and Robin Lewis**
Traffic Control: Two-way stop	**Focus Area: Fatal & Injury**

OFFICE REVIEW FINDINGS

The City receives a high volume of calls requesting a striped cross-walk across Greenwood Avenue. However, pedestrian must cross 4 lanes of traffic and two lanes of parking. Zegeer, et. al. found there is a negative safety benefit associated with marking crosswalks on a 4-lane roadway with volumes greater than 12,000 vehicles/day. Greenwood carries about 12,000 vehicles per day.

There is a requirement for an easement from two properties, and ideally a conversion from 4 to 3 lanes. On the bright side: a 3 lane diet mitigates all operational issues at this intersection.

One pedestrian crash occurred in the marked crosswalk on the west leg of the intersection. One bike crash occurred when a bicyclist crossed the south leg in the wrong way direction and was hit by a northbound right turning vehicle. This is a classic wrong way crash. Greenwood does not have any bike facilities so wrong way riding through the sidewalk tunnels are frequent and common.

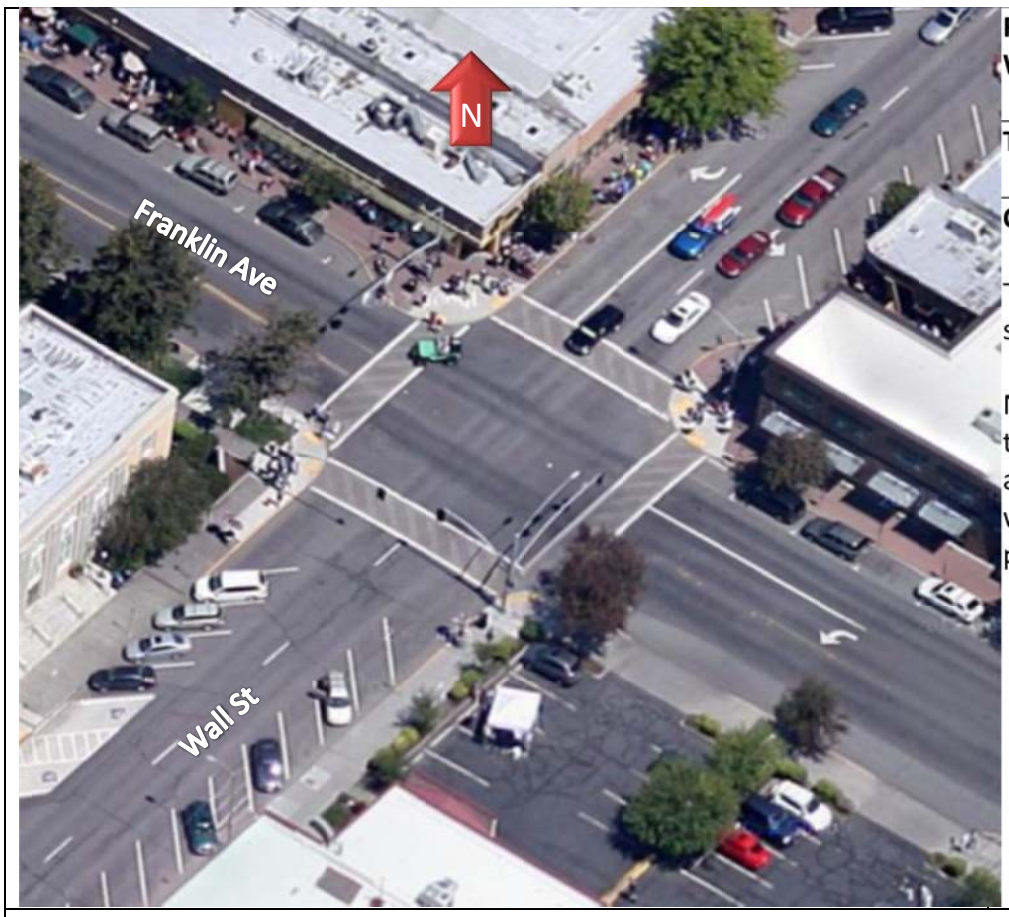
FIELD REVIEW OBSERVATIONS AND FINDINGS

Contributing Factors	**Potential Countermeasures**	**Crash Modification Factor (CMF)**	**Source of CMF**
1) Multi-lane pedestrian crossing (north-south)	• Road diet (reduce cross-section to three lanes with center left-turn lane and bike lanes) • Provide striped crossing and advanced warning signage • Provide intersection illumination	• 0.71 • 0.58-0.62 • 0.58 (nighttime crashes), 0.62 (nighttime pedestrian crashes)	• HSM 13.4.2.3 • HSM 14A.4.2.2 • HSM Table 14-18
2) On-street parking reduces pedestrian sight distance	• Extend on-street parking restriction 10-15 feet upstream of crosswalks • Provide bulb-outs to improve pedestrian sight distance at intersection	• 0.80* • 0.80*	• N/A
3) No major-street left-turn lanes	Road diet (reduce cross-section to three lanes with center left-turn lane and bike lanes)	• 0.71	• HSM 13.4.2.3
4) No bike lanes provided	Remove on-street parking, provide bike lanes	Unknown	

PROJECT RANKING CALCULATIONS

Projects	**Estimated Benefit ($/Year)**	**Estimated Construction Cost**	**B/C (20-year life)**
1) Curb extensions only	$18,000	$167,000	1.34
2) Road Diet with bike lanes and intersection illumination	$52,000	$273,868	2.37

Table A-2 Site Diagnosis Summary at Franklin Avenue/Wall Street



FRANKLIN AVENUE/ WALL STREET	**Diagnosed by: Casey Bergh (KAI) and Robin Lewis**
Traffic Control: Signal	**Focus Area(s): Pedestrian & Bicycle Crashes**

OFFICE REVIEW FINDINGS

Two crashes involved westbound bicyclists hit by southbound right-turning vehicles turning on red.

N-S pedestrian on west leg crosswalk hit by westbound through. Pedestrians can see the eastbound signal heads are red, may assume westbound signal heads are red as well. Westbound has a lagging through and left-turn phase.

FIELD REVIEW OBSERVATIONS AND FINDINGS

Contributing Factors	**Potential Countermeasures**	**Crash Modification Factor (CMF)**	**Source of CMF**
1) Southbound vehicles turning right on red not yielding to westbound bicyclists in travel lane	• Restrict southbound right-turn on red	• 0.61 (bike crashes)*	• Average of 3 and 4-start CMFs from Clearinghouse (Preusser 1982)
2) No southbound bike lane. Recreational cyclists use outside of right-turn lane at red light.	• Provide sharrows in southbound through lane and green bike box for bike storage in front of vehicle queue	• Unknown	
3) Pedestrians disregard pedestrian signal	• Signage to obey pedestrian signal • Modify westbound left-turn phasing to eliminate lagging left phase	• Unknown	

PROJECT RANKING CALCULATIONS

Projects	**Estimated Benefit ($/Year)**	**Estimated Construction Cost**	**B/C (20-year life)**
1) Bike box and sharrows on southbound approach	$3,000	$33,000	1.1
2) Remove southbound right turn lane	$10,000	$80,663	1.5

* CMF estimated as opposite of CMF provided in HSM (1.43 to 1.82).

Table A-3 Site Diagnosis Summary at Franklin Avenue/1st Street

FRANKLIN AVENUE/ 1st STREET	**Diagnosed by: Casey Bergh (KAI) and Robin Lewis**
Traffic Control: Unsignalized	**Focus Area(s): Pedestrian and Bicycle**

OFFICE REVIEW FINDINGS

Intersection is just east of an underpass that provides two travel lanes and no bike lanes. Pedestrian tunnels provide off-street undercrossing and are accessed via the sidewalk. East of 1st Street Franklin widens to a five-lane section. Similar to discussions on 3rd/Burnside - this area has a diverge within the intersection and poorly defined merge areas on the westbound approach.

The previous solution at 2nd Street, to eliminate lefts out, reduces the grid and connectivity, forcing lefts onto 1st/Les Schwab, where sight lines are worse. The main issue was probably the five lane cross-section; is this turn restriction still warranted?

Two reported crashes involved a bicyclist and one involved a pedestrian during the study period.

FIELD REVIEW OBSERVATIONS AND FINDINGS

Contributing Factors	**Potential Countermeasures**	**Crash Modification Factor (CMF)**	**Source of CMF**
1) Eastbound diverge in intersection encourages acceleration through intersection	• Road diet to reduce Franklin to 3-lane section east to 3rd Street and beyond. • Maintain a single lane with constant lane width eastbound through intersection. Define point of diverge east of intersection.	• 0.71 • Unknown	• HSM 13.4.2.3
2) Bicyclists move from bike lane to crosswalk to get on sidewalk into pedestrian tunnel, and vice versa.	• Install “walk bike” signs on sidewalks through tunnel and install ramps for bicyclists to rejoin traffic east of 1st Street. • Transition westbound bike lane to outside of the through lane (between right-turn lane and through lane). Define a clear decision point where bicyclists choose to ride with traffic or dismount and use sidewalk. • Add sharrows in travel lanes through underpass.	• 0.98* • 0.95* • Unknown	
3) No pedestrian facilities for crossing Franklin limit driver expectation	• Stripe crosswalk • RRFB or other pedestrian-activated device • Intersection illumination	• Unknown • Unknown • 0.58 (nighttime crashes), 0.62 (nighttime pedestrian crashes)	• HSM Table 14-18

PROJECT RANKING CALCULATIONS

Projects	**Estimated Benefit ($/Year)**	**Estimated Construction Cost**	**B/C (20-year life)**
1) Road diet, define diverge, add sharrows, illuminate intersection	$9,000	$208,000	0.5

Table A-4 Site Diagnosis Summary at Franklin Avenue/3rd Street

FRANKLIN AVENUE/ 3rd STREET	Diagnosed by: Casey Bergh (KAI) and Robin Lewis
Traffic Control: Signalized	Focus Area(s): Fatal and Injury

OFFICE REVIEW FINDINGS

On Franklin Ave the roadway is limited to two lanes at the RR undercrossing to west of 3rd Street, and east of 4th Street. Need counts to confirm need for five-lane section east-west; need video of outside lane usage. South of Franklin at railroad undercrossing 3rd street narrows to two lanes.

Six bike and pedestrian crashes reported in study period (2006-2010). Westbound right-turn with bike accounted for two of six. Two westbound bicycle crashes reported in south leg approach crosswalk - struck by southbound through vehicles. One crash involved a southbound pedestrian and an eastbound vehicle. One crash involved a southbound bicyclist and an eastbound right-turn.

Two other crashes involved a pedestrian and a bicyclist at the 7-11 driveway on southbound approach.

FIELD REVIEW OBSERVATIONS AND FINDINGS

Contributing Factors	Potential Countermeasures	Crash Modification Factor (CMF)	Source of CMF
1) Signal clearance interval	• Review clearance interval timing on 3rd Street and compare to Franklin Avenue/3rd Street signal timing. Adjust clearance interval timing, as necessary.	• 0.91*	• Referenced to adjustment for ITE standards
2) Drivers not yielding to pedestrians or bicyclists	• Install green bike lanes, bike boxes, install signs or dutch style cycle crossing	• Unknown	
3) Drivers disregard red signal	• Evaluate signal timing, adjust clearance intervals per ITE standards • Add 3-inch retro-reflective yellow sheeting on signal backplates • Road Diet on Franklin from 1st to 4th Street	• 0.91 • 0.85 • 0.71	• 3-star CMF from Clearinghouse • 4-star CMF from Clearinghouse • HSM - 13.4.2.3

PROJECT RANKING CALCULATIONS

Projects	Estimated Benefit ($/Year)	Estimated Construction Cost	B/C (20-year life)
1) Signal timing, signage, striping	$50,000	$50,000	12.46
2) Road Diet (5-lane to 3-lane section) & signal timing, dutch bike**	$161,000	$259,256	7.74

* CMF estimated based on engineering judgment with reference to CMFs for similar treatments

** Project includes larger area than single intersection. Project limits included curb work within the intersection and within 100' of Franklin approaches with paint to 4th Street and to RR Undercrossing.

Table A-5 Site Diagnosis Summary at Neff Road/Purcell Boulevard

NEFF ROAD/ PURCELL BOULEVARD	**Diagnosed by: Casey Bergh (KAI) and Robin Lewis**
Traffic Control: Signalized	**Focus Area(s): Fatal and Injury, Speed-involved**

OFFICE REVIEW FINDINGS

Nine rear-end crashes reported on the EB approach, which has a downgrade to signal.

Seven crashes of types that can be associated with red-light-running, primarily NB with EB.

Two NB right-turn on red crashes with EB bicycles.

Six EB/WB left-turn crashes may be associated with permissive phase.

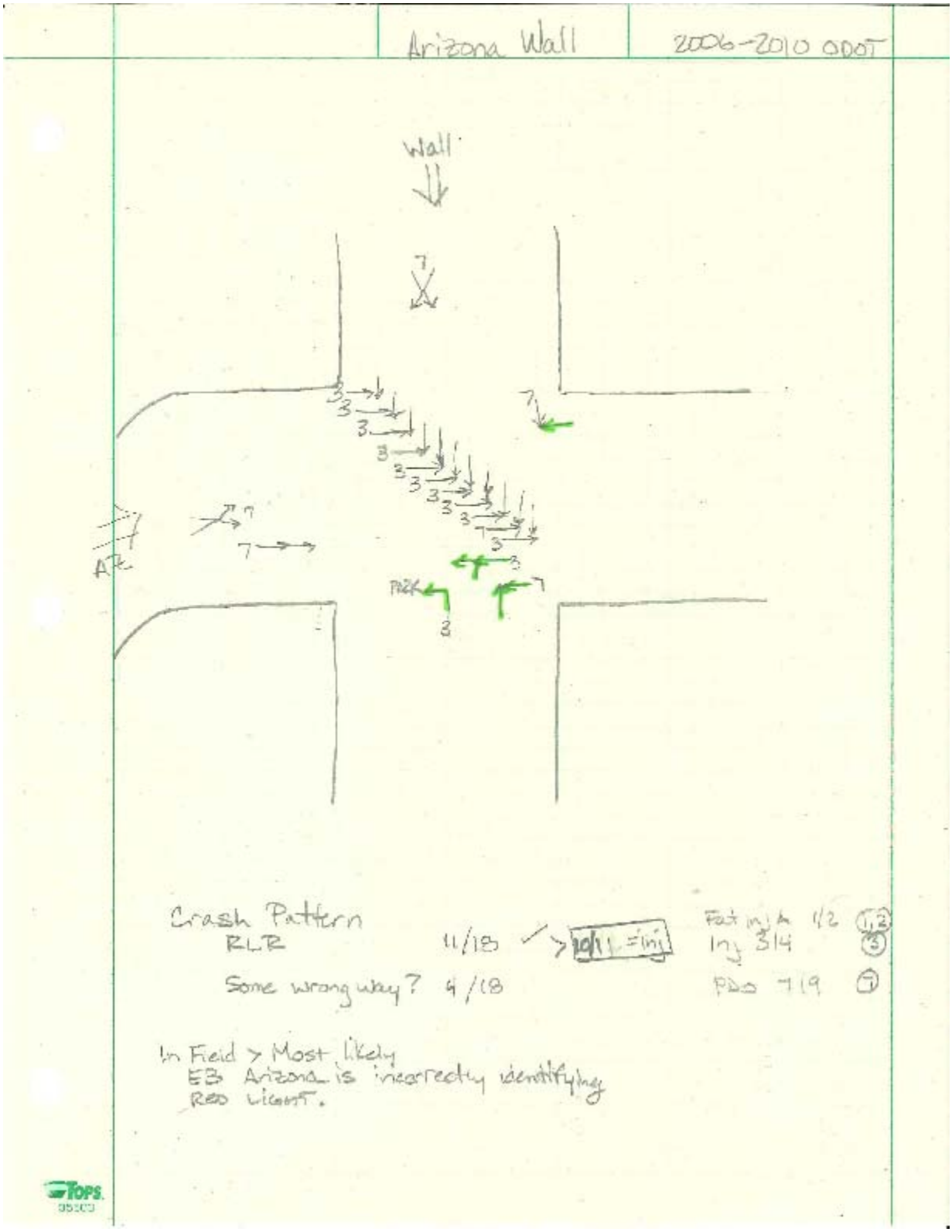
FIELD REVIEW OBSERVATIONS AND FINDINGS

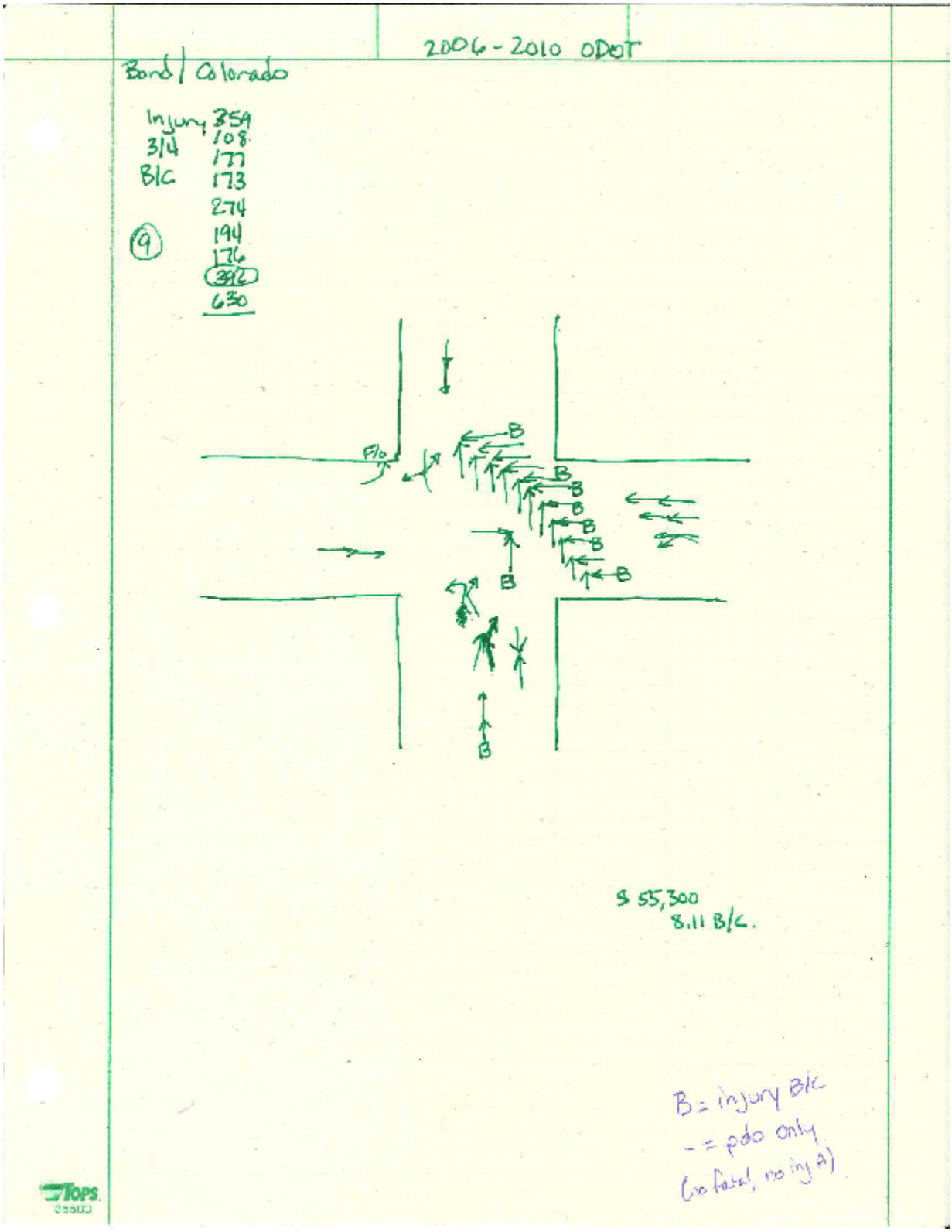
Contributing Factors	**Potential Countermeasures**	**Crash Modification Factor (CMF)**	**Source of CMF**
1) EB/WB permitted left-turn phase	• Convert left-turn phase to protected-only or PPLT with flashing yellow arrow.	• 0.01 (left-turn crashes only)	• HSM 14.7.2.4
2) Northbound right-turn vehicles use bike lane as second approach lane	• Restrict right-turn on red. • Restripe bike lanes, reinforce single-lane approach.	• 0.61 (bike crashes)* • Unknown	• Average of 3 and 4-start CMFs from Clearinghouse (Preusser 1982)
3) Drivers form two lanes on north and south approaches, although only one exists. Drivers see two signal heads and assume two lanes.	• Restripe approach lanes, define approach configuration. • Realign one signal head in the center of the lane and place one on far side pole	• Unknown	• N/A

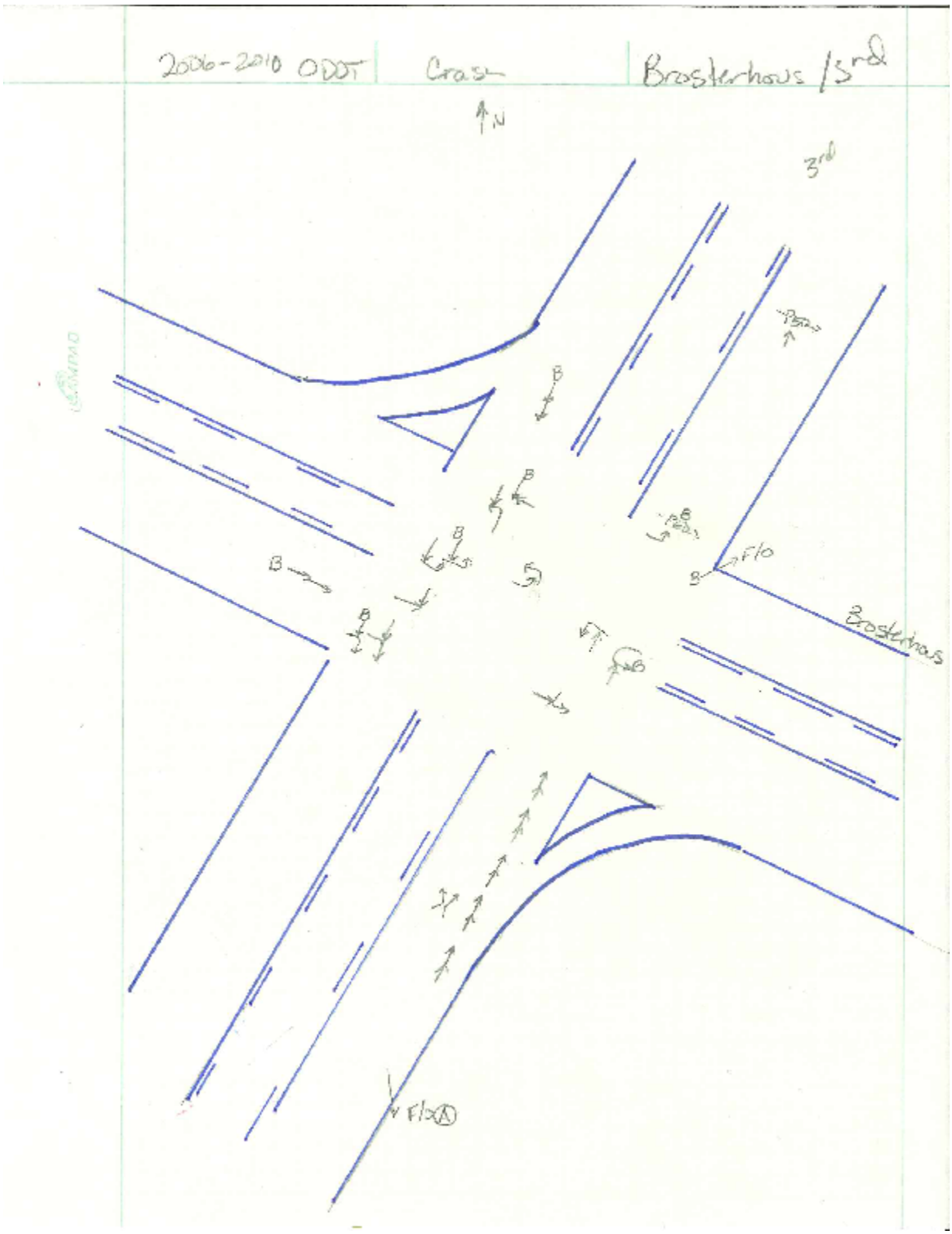
PROJECT RANKING CALCULATIONS

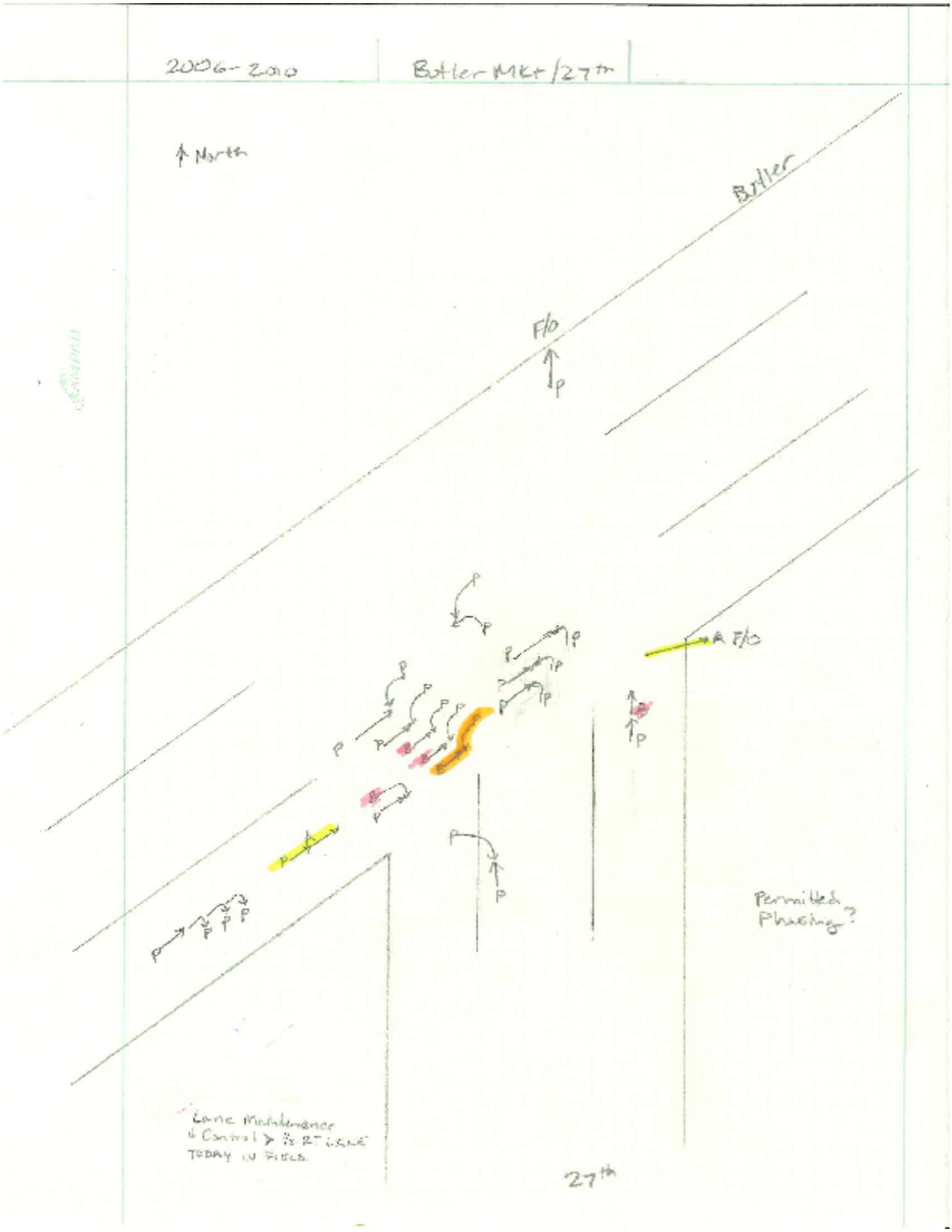
Projects	**Estimated Benefit ($/Year)**	**Estimated Construction Cost**	**B/C (20-year life)**
1) Restrict northbound right-turn on red, convert to protected only left-turn phasing east and west approaches, restripe approach lanes	$60,000	$100,390	7.5

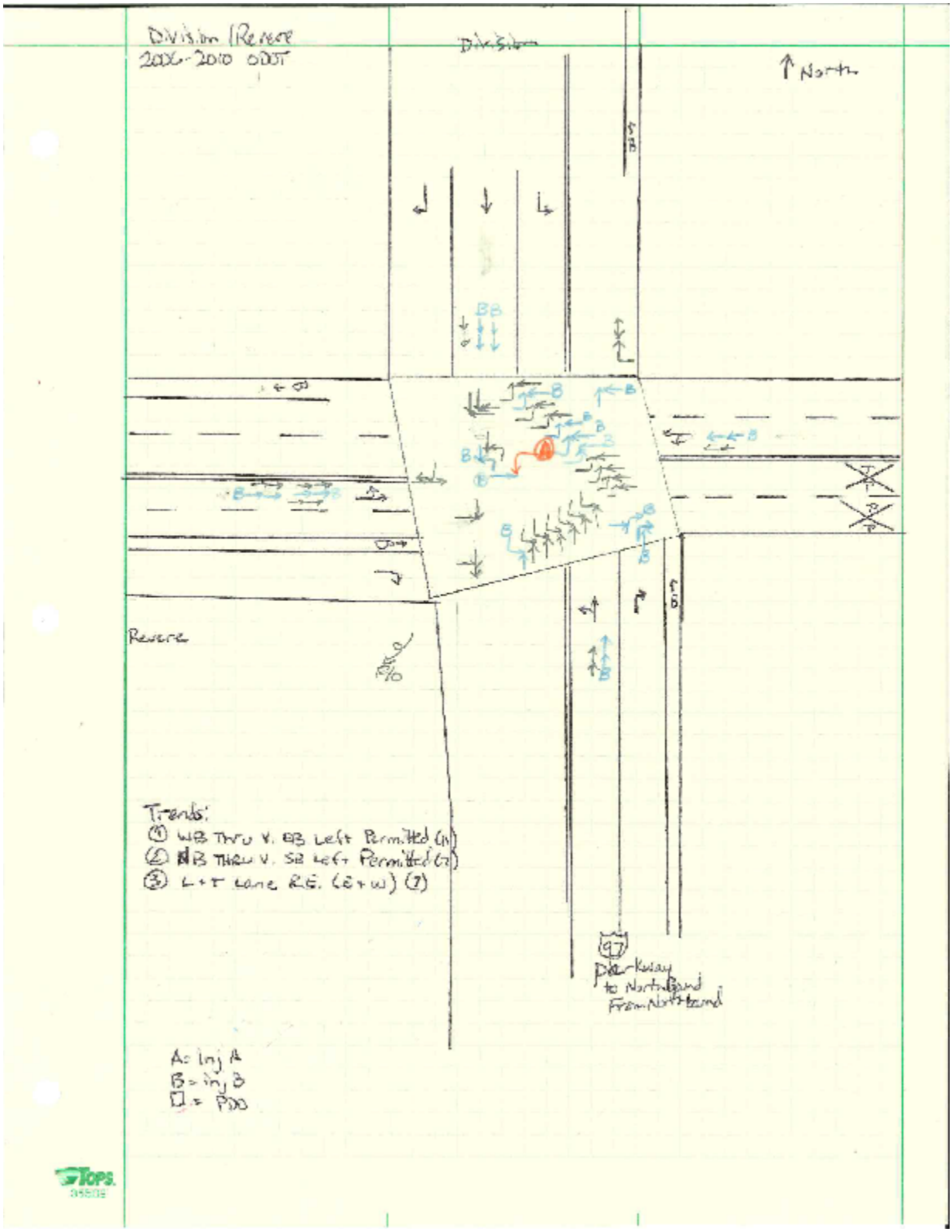
Appendix B Crash Diagrams

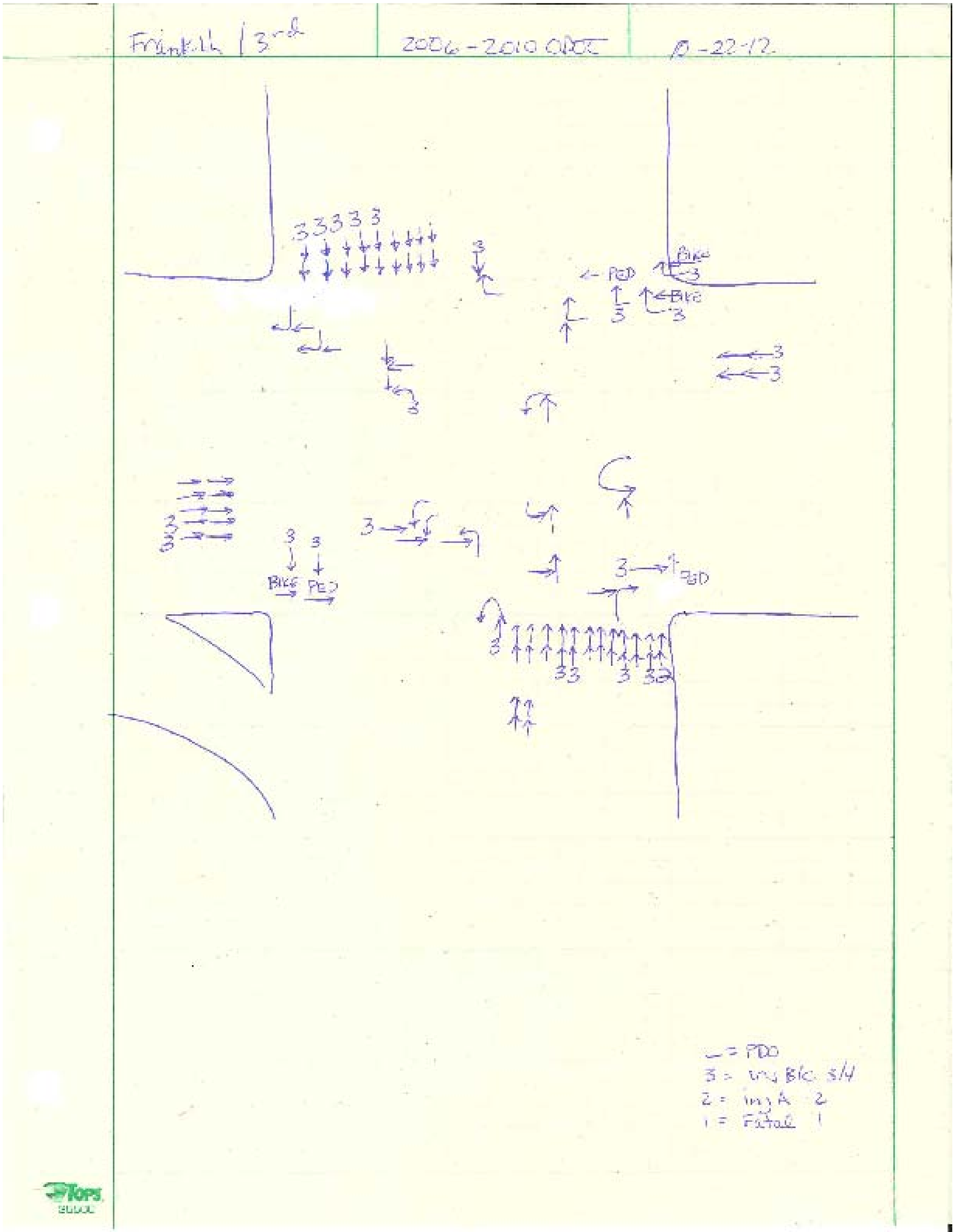

Arizona Wall
2006-2010 ODOT
Wall
Crash Pattern
RLR
11/18
Some wrong way? 4/18
Fat inj A 1/2
Inj 3/4
PDO 7/9
In Field > Most likely
EB Arizona is incorrectly identifying
Red Light.

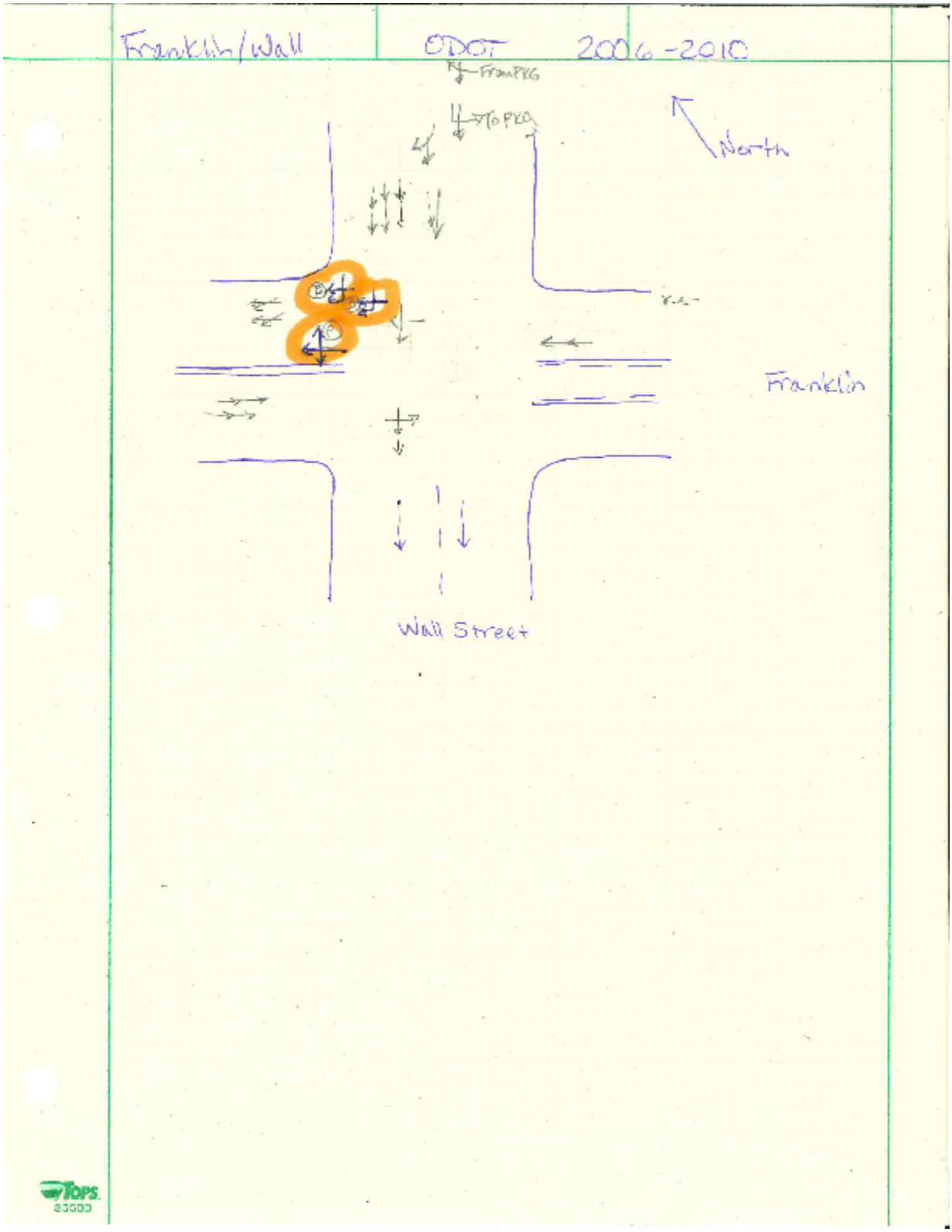

2006 - 2010 ODOT
Bond / Colorado
Injury 359
3/4 108
B/C 177
173
274
194
176
630
F/O
B
$ 55,300
8.11 B/C.
B = injury B/C
- = pdo only
(no fatal, no inj A)

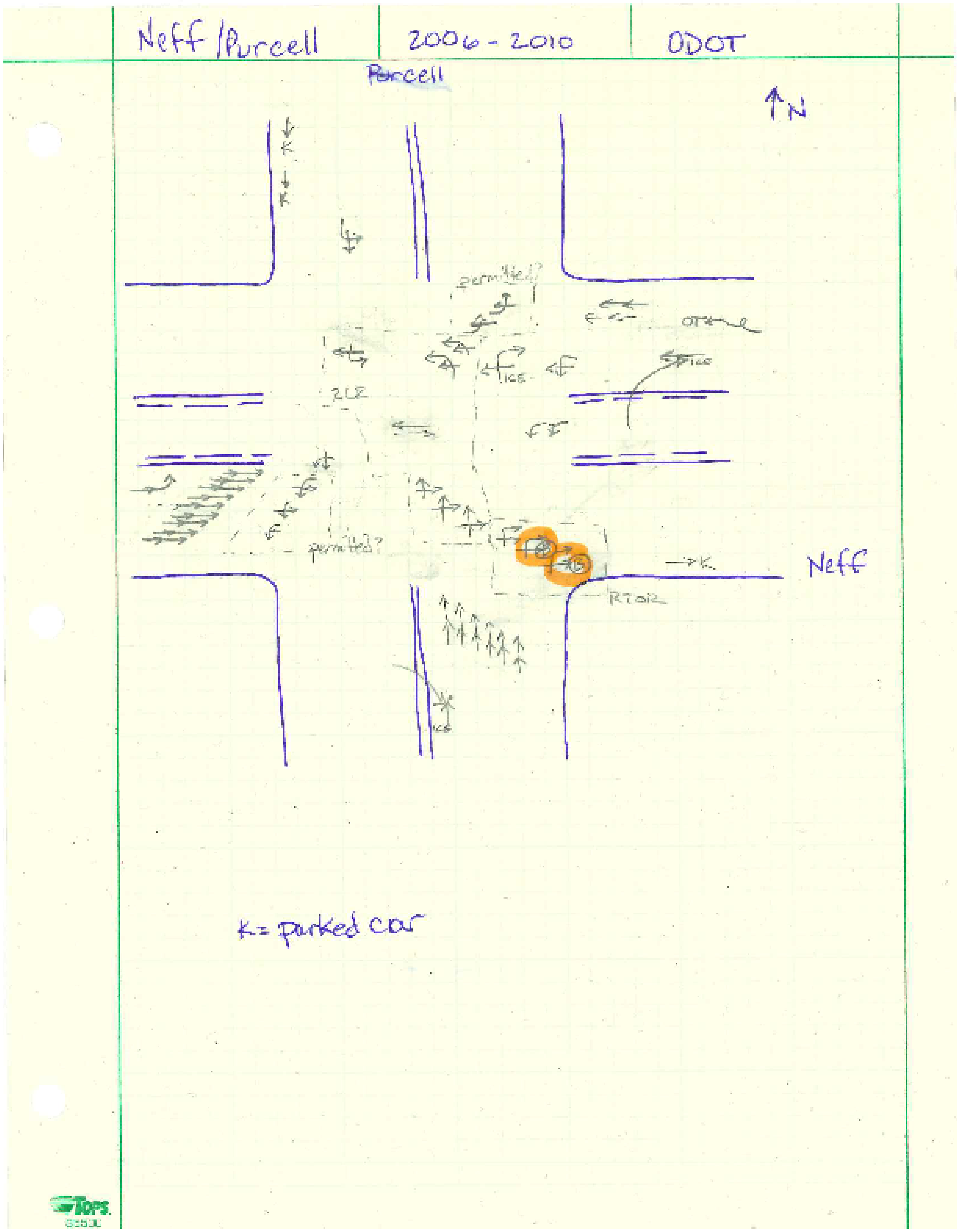

2006-2010 ODOT
Crash
Brosterhous / 3rd
N
3rd
B
F10
Brosterhous
F/A

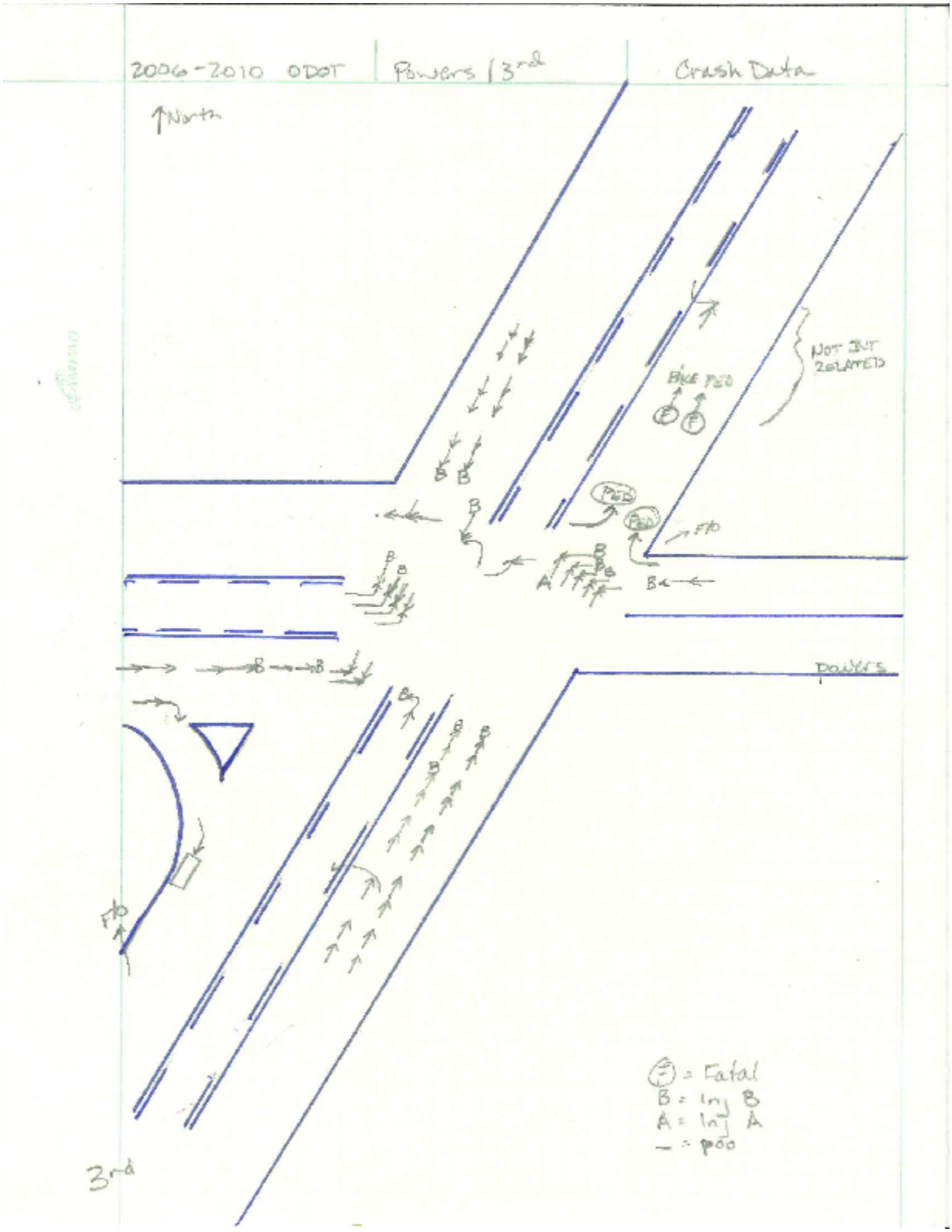

2006-2010
Butler Mkt/27th
North
Butler
F/O
P
A F/O
Permitted Phasing?
Lane Maintenance
& Control > 1/2 RT LANE
TODAY IN FIELD
27th

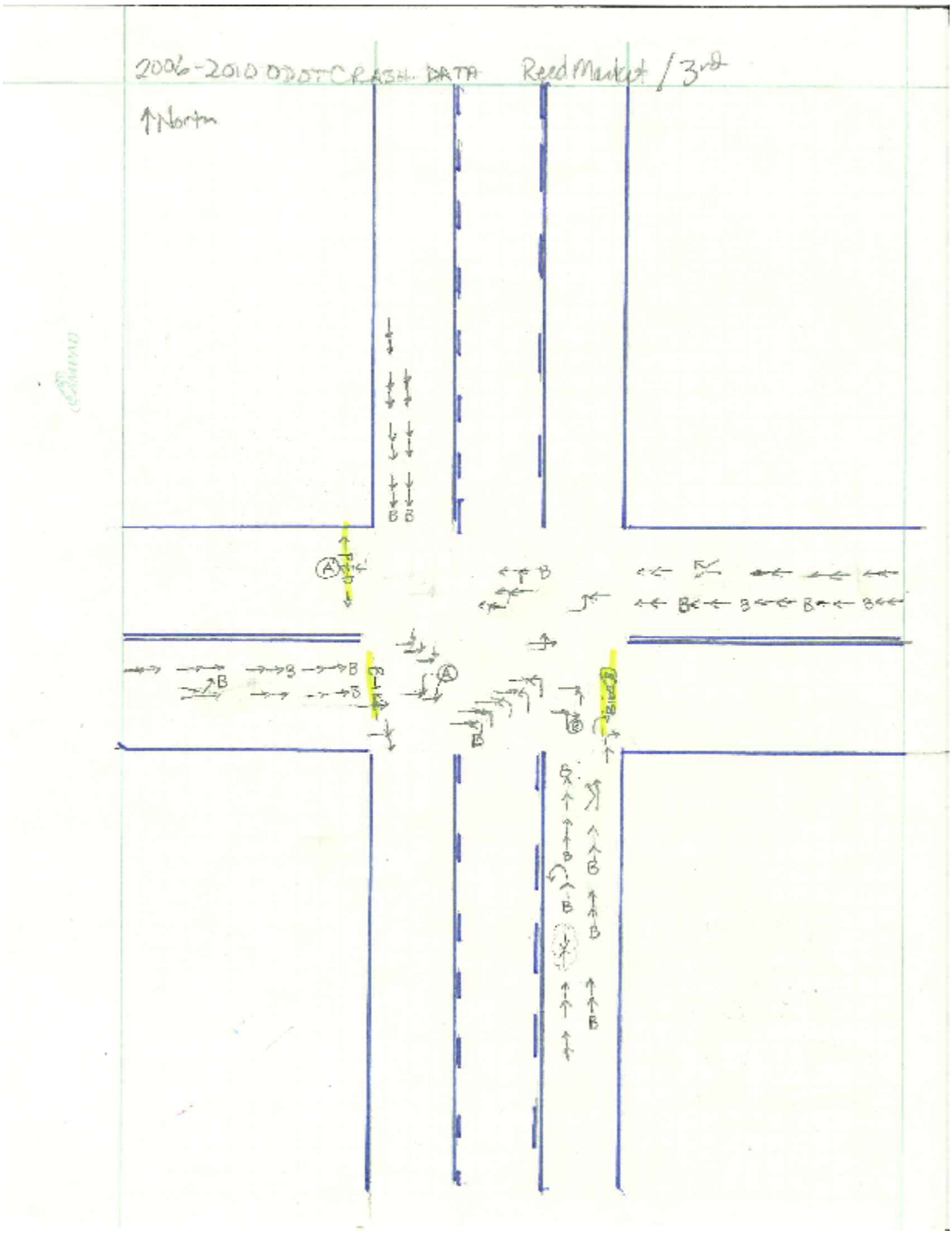

Division (Revere
2006-2010 ODOT
Division
North
Revere
Trends:
① WB Thru V. EB Left Permitted (1)
② NB Thru V. SB Left Permitted (2)
③ L+T Lane RE. (2+1) (7)
A = Inj A
B = Inj B
□ = PDO
97
Parkway
to Northbound
From Northbound

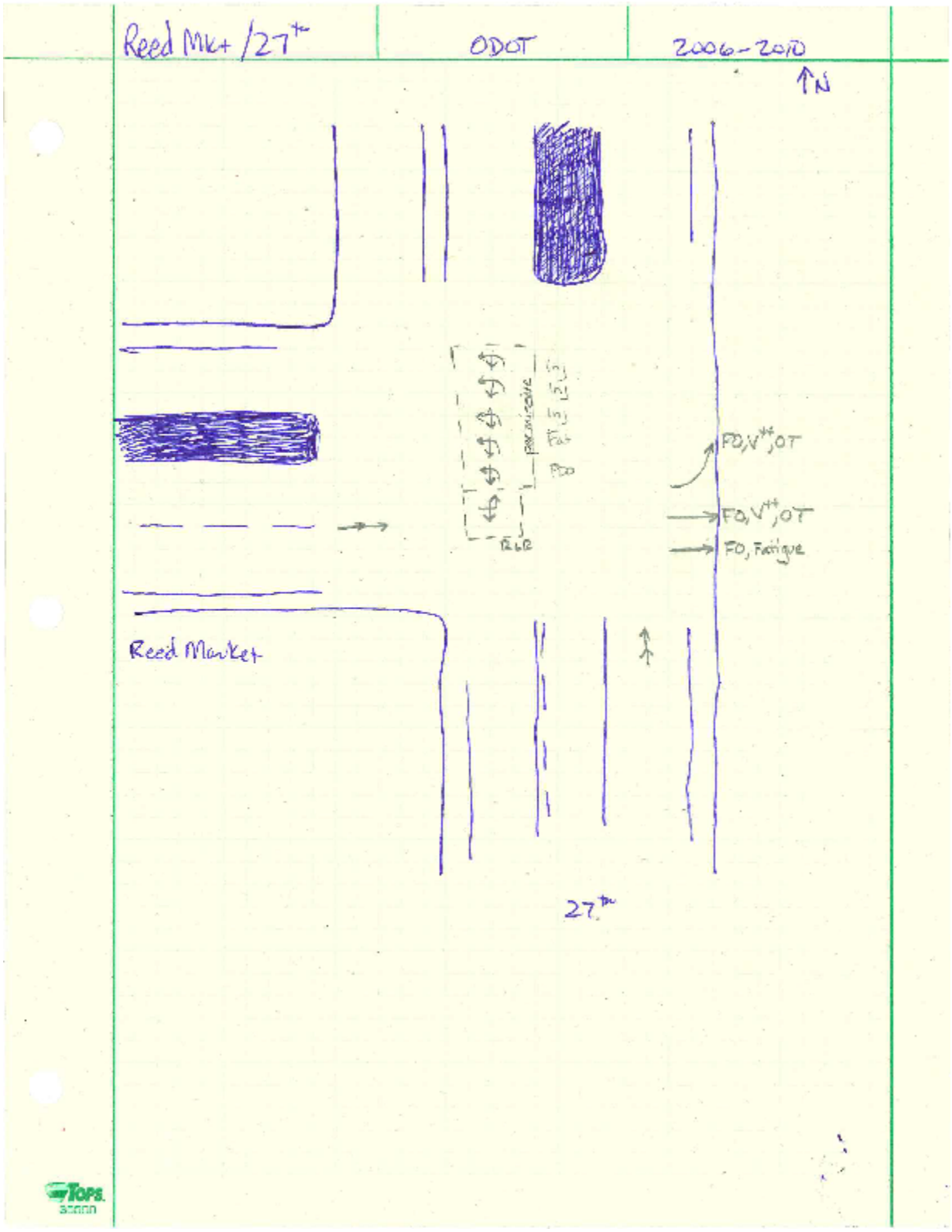

2006-2010 ODOT
BIKE
PED
= PDO
3 = inj B/C 3/4
2 = inj A 2
1 = Fatal 1

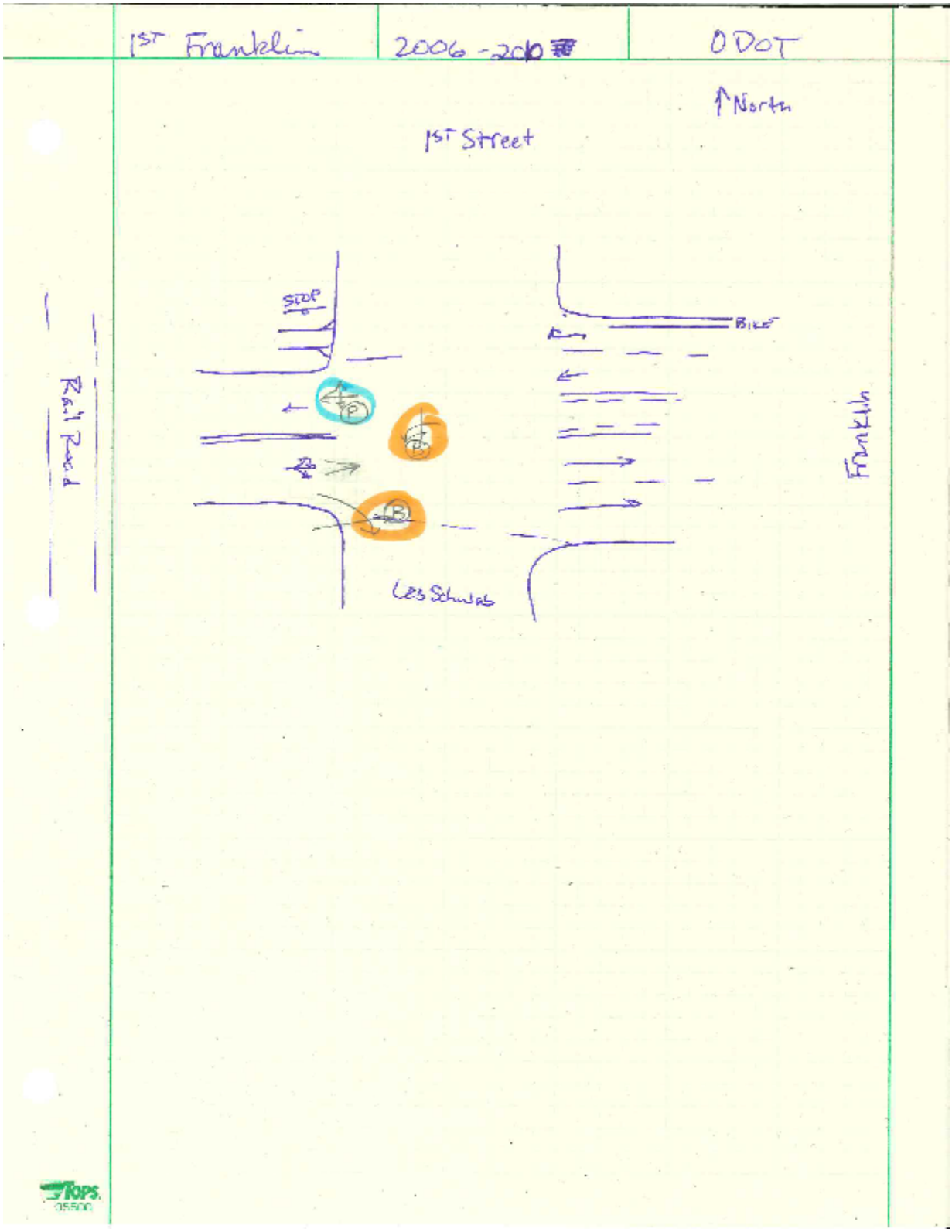

Franklin/Wall
ODOT
2006 -2010
From PED
To PED
North
Franklin
Wall Street

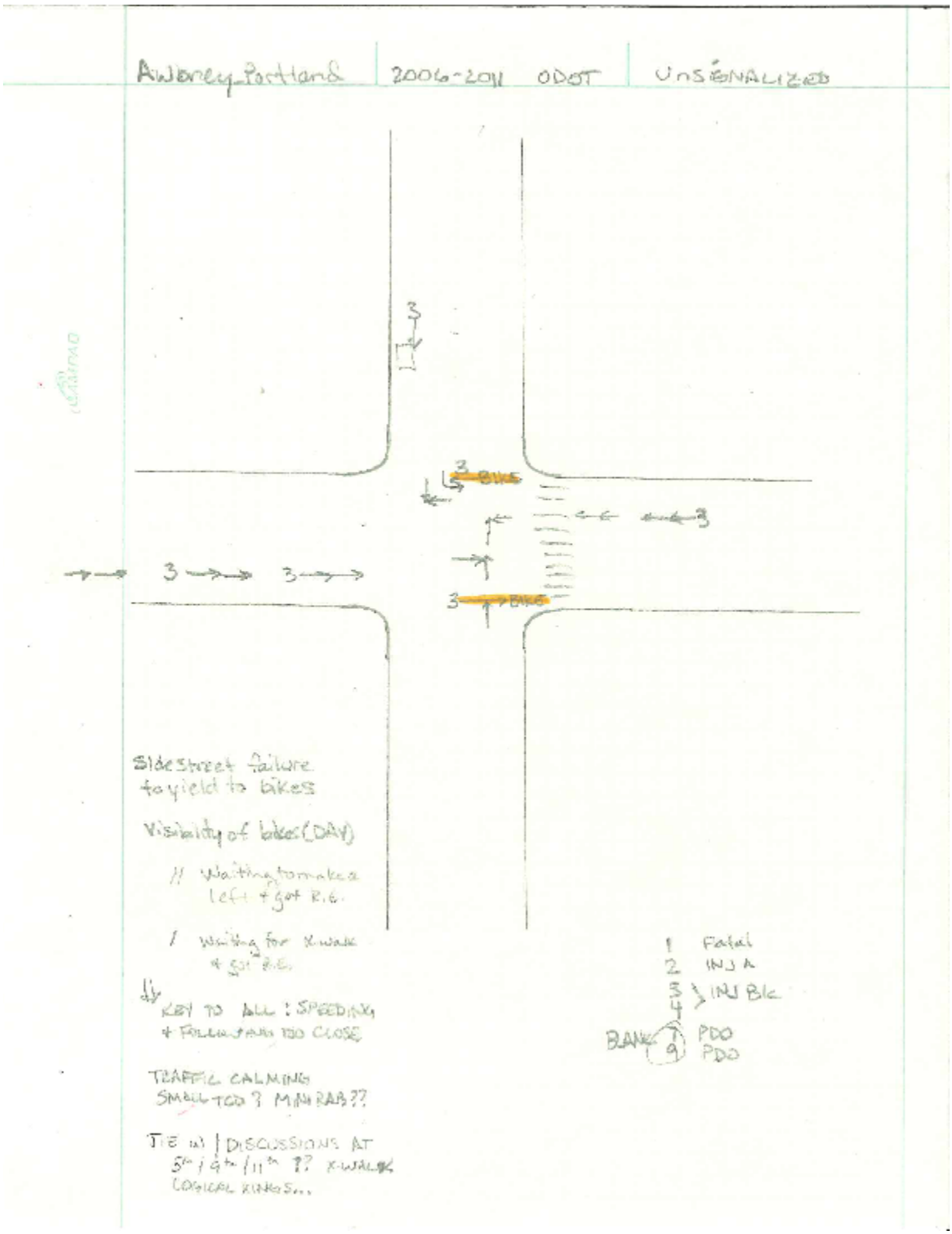

Neff /Purcell
2006 - 2010
ODOT
Purcell
N
permitted?
Neff
RTOR
K = parked car

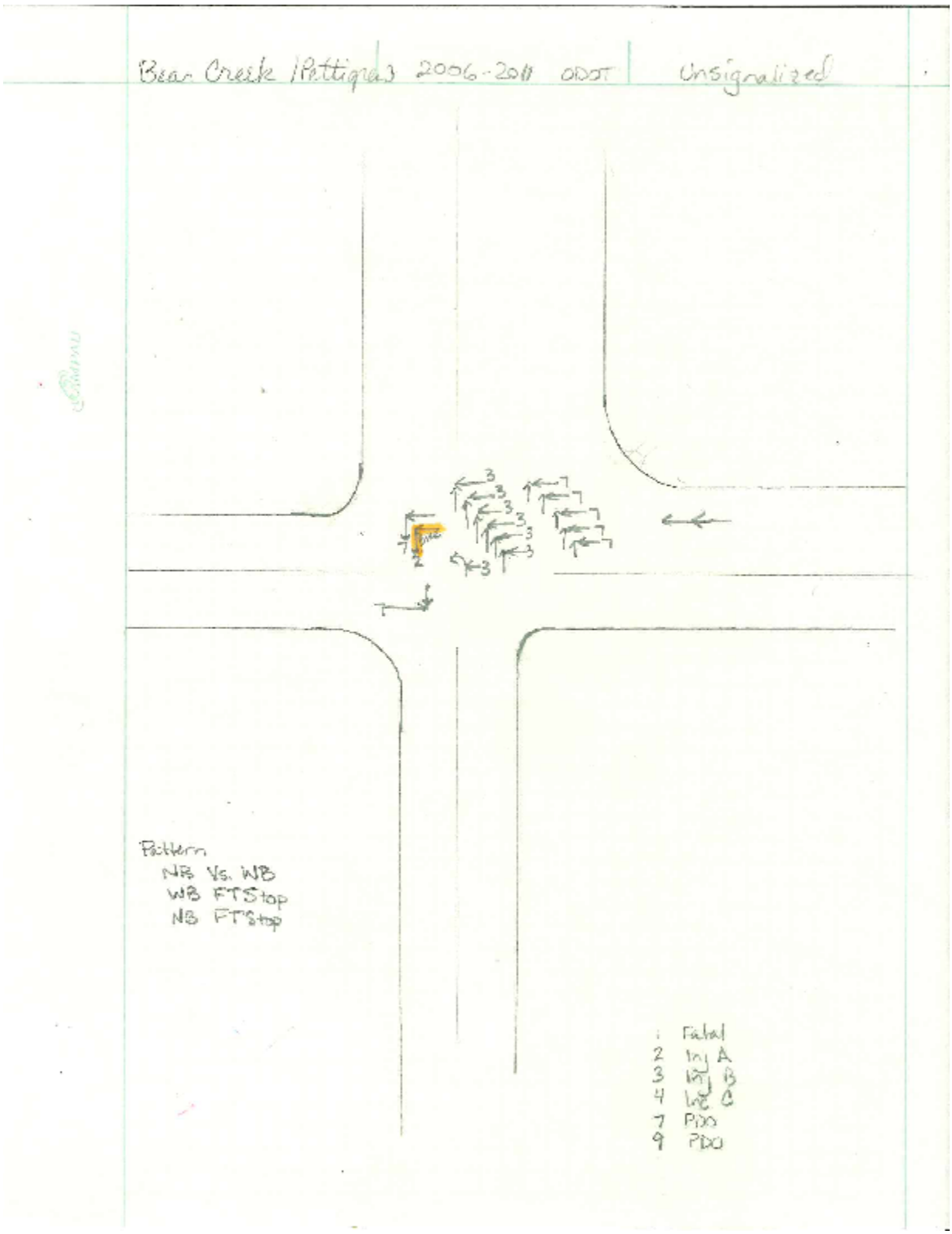

2006-2010 ODOT
Powers / 3rd
Crash Data
North
NOT INT RELATED
BIKE PED
PED
PED
PED
POWERS
3rd
F = Fatal
B = Inj B
A = Inj A
– = PDO

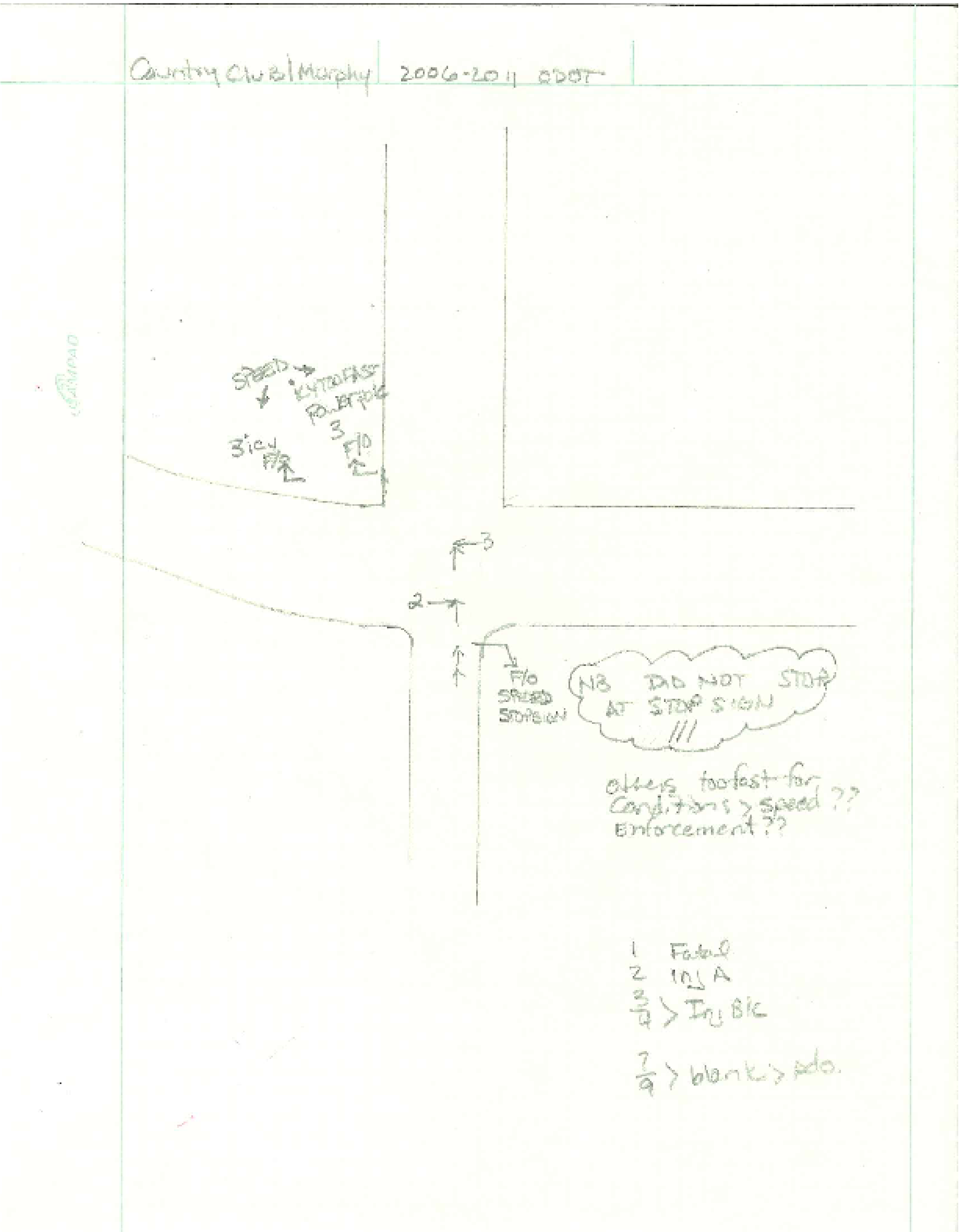

2006-2010 ODOT CRASH DATA Reed Market / 3rd
↑North

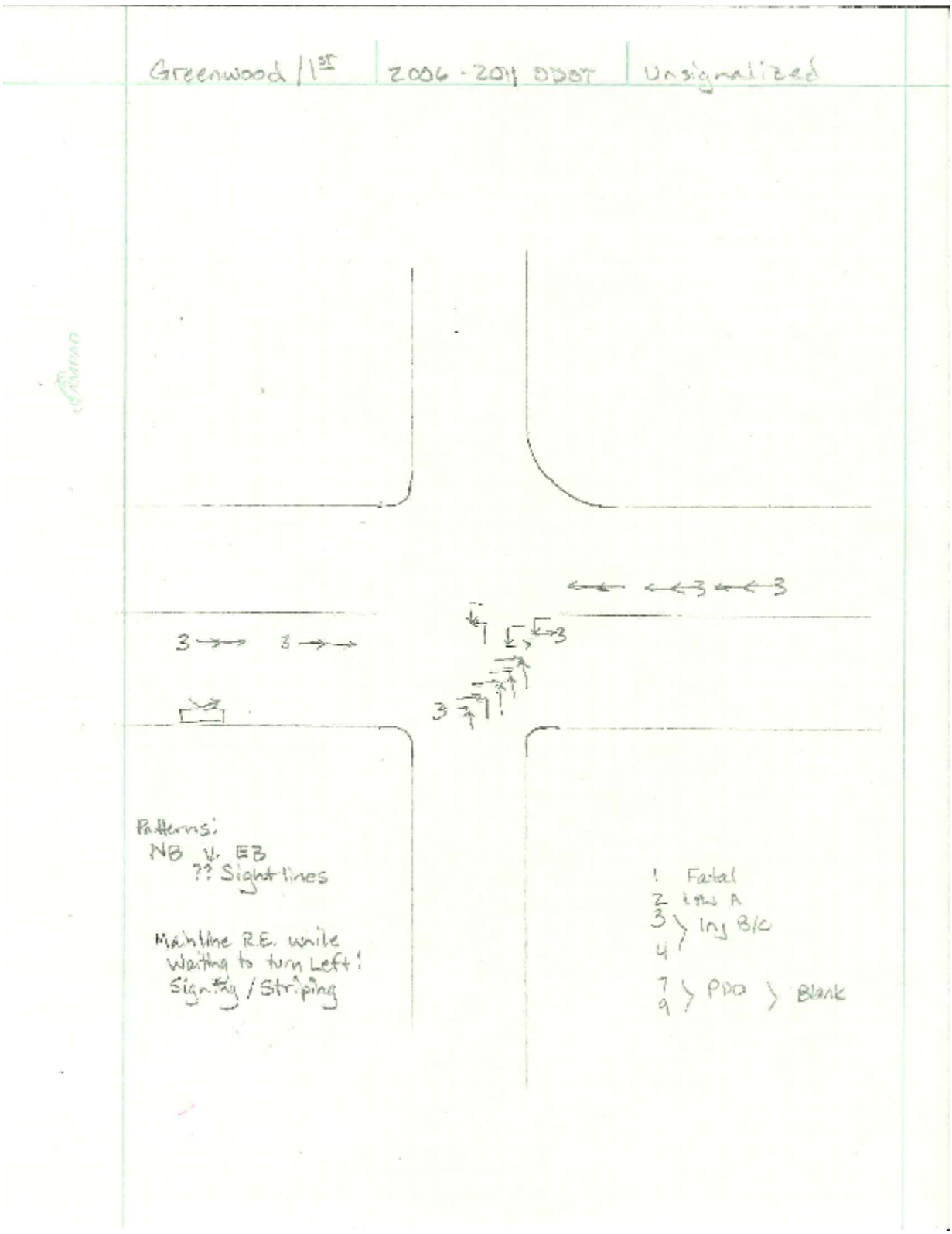

Reed Mkt / 27th
ODOT
2006-2010
N
FO, V++, OT
FO, V++, OT
FO, Fatigue
Reed Market
27th


1ST Franklin
2006 - 2010
ODOT
North
1ST Street
STOP
Rail Road
BIKE
Franklin
Les Schwab

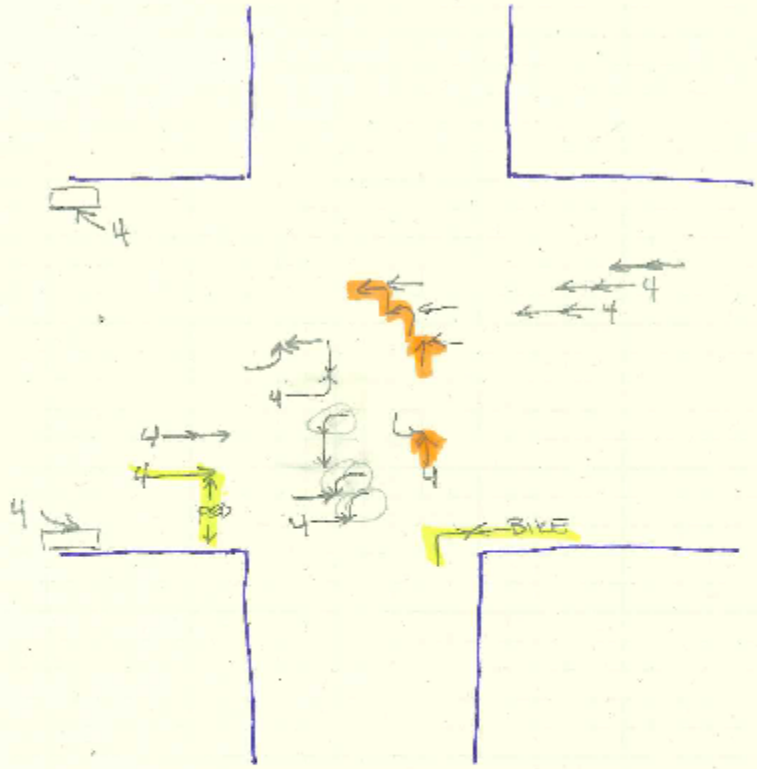

Alderey-Portland
2006-2011
ODOT
UNSIGNALIZED
3
3 BIKE
3
3
3
3 BIKE
Sidestreet failure to yield to bikes
Visibility of bikes (DAY)
// Waiting to make a left + got R.E.
/ waiting for X-walk + got R.E.
KEY TO ALL: SPEEDING + FOLLOWING TOO CLOSE
TRAFFIC CALMING SMALL TCD? MINI RAB??
TIE in | DISCUSSIONS AT 5th / 9th / 11th ?? X-WALK LOGICAL KINKS..
1 Fatal
2 INJ A
3 } INJ Blc
4
BANK 1
9 PDO
PDO


Bear Creek / Pettigrew 2006-2010 ODOT Unsignalized
Pattern
NB Vs. WB
WB FTStop
NB FTStop
1 Fatal
2 Inj A
3 Inj B
4 Inj C
7 PDO
9 PDO


Country Club/Murphy
2006-2011 ODOT
SPEED
3
F/O
2
3
F/O
SPEED
STOPSIGN
NB DID NOT STOP
AT STOP SIGN
///
others too fast for
Conditions > speed ??
Enforcement ??
1 Fatal
2 Inj A
3/4 > Inj B/C

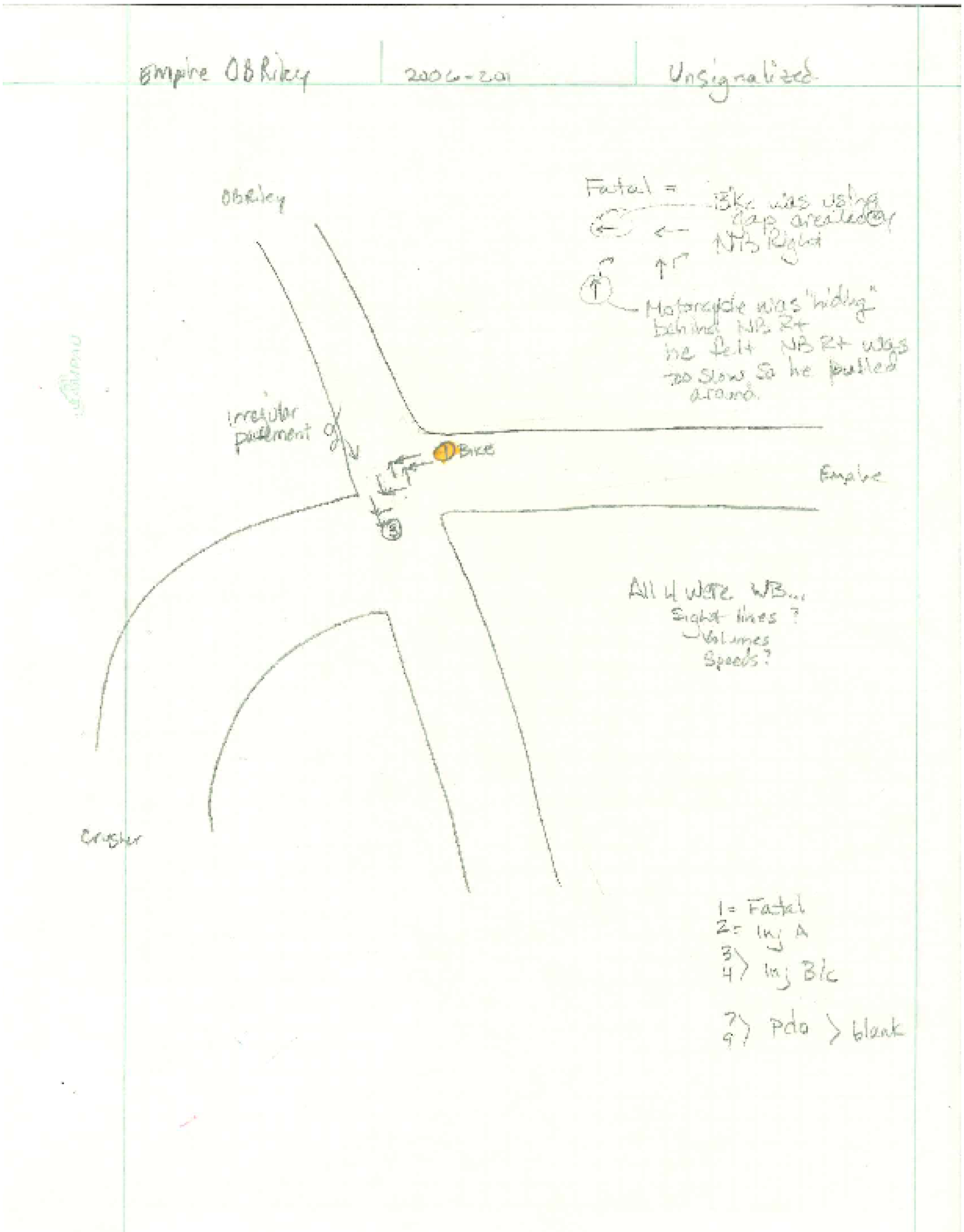

Greenwood / 1st
2006 - 2011 ODOT
Unsignalized
3
3
3
3
3
Patterns:
NB v. EB
?? Sight lines
Mainline R.E. while
Waiting to turn Left!
Signing / Striping
! Fatal
2 Inj A
3 > Inj B/C
4
7
9 > PDO > Blank

Greenwood/Hill | 2006-2010 ODOT | 10-16-12

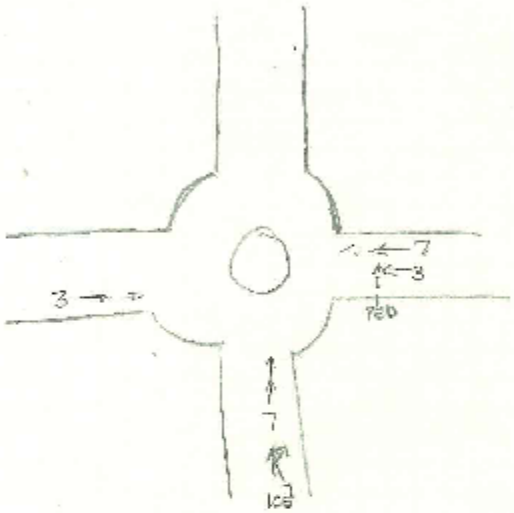


Crash Trends

Wrong way bike	fatal F	
ped walk (sight lines)	inj A 2	2
NB Sight lines to east (overpass)	inj B/C 3/4	4
Main line R.E. (noctl)	PDO 7/9	—
WB LEFT (Road diet)		


Empire O B Riley
2006-201
Unsignalized
OBRiley
Fatal =
Bk. was using gap created by NB Right
Motorcycle was "hiding" behind NB Rt
he felt NB Rt was too slow so he pulled around.
irregular pavement
Bike
Empire
All 4 were WB...
Sight lines?
Volumes
Speeds?
Crusher
1 = Fatal
2 = Inj A
3, 4 Inj B/C
7, 9 pdo
blank

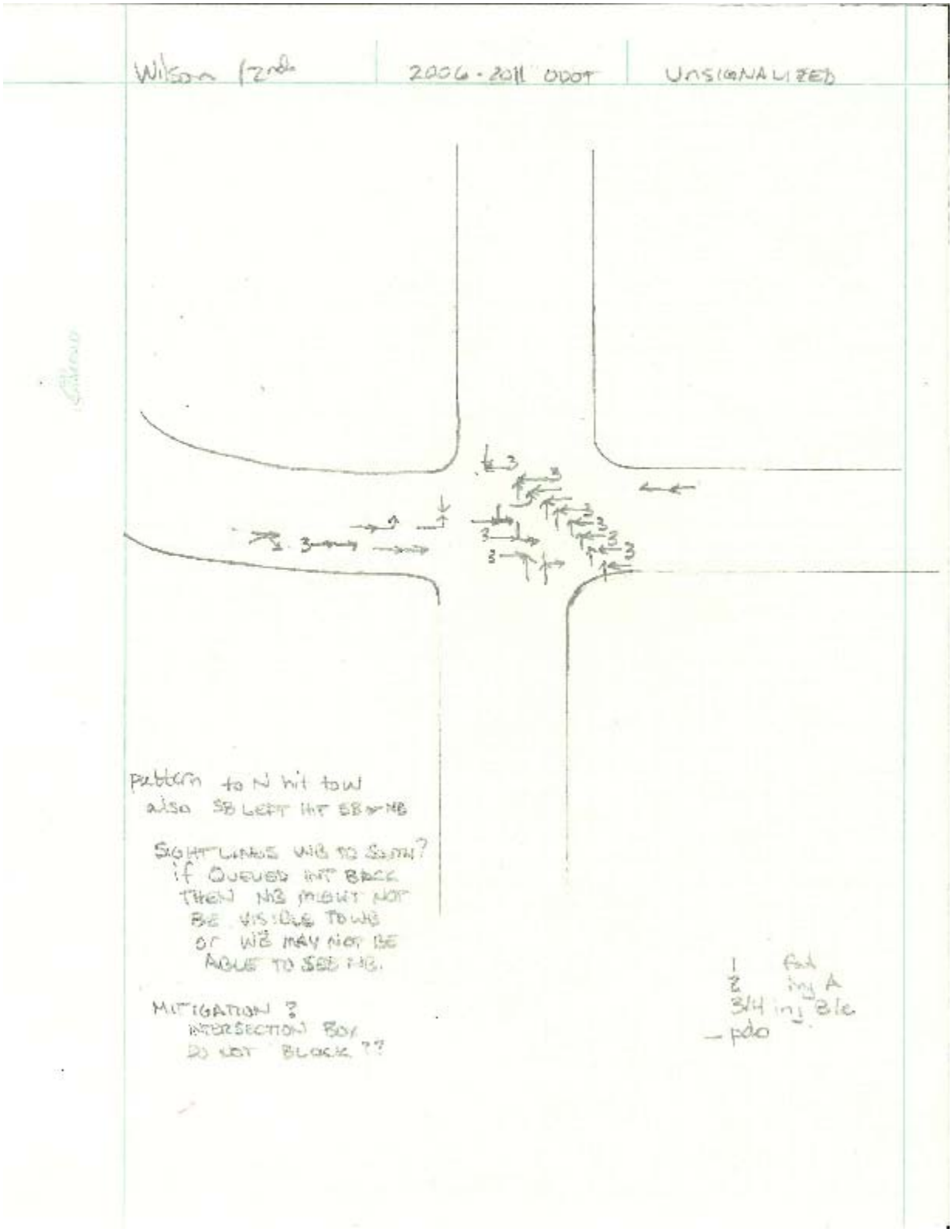
Reed Mkt / Bond	2006-2011 ODOT	Unsignalized



NO ISSUES TO MITIGATE
EDUCATION: WALK IN X-WALKS (HE WAS RIDING SKATEBOARD)
? YIELD TO PEDS IN X-WALK

RESEARCH YIELD TO PED SIGNS 21-6

1 fatal
2 inj A
3 inj B
4 inj C
7 PDO
9 PDO


Wilson (2nd)
2006 - 2011 ODOT
UNSIGNALIZED
pattern to N hit tow
also SB LEFT HIT EB & NB
SIGHT LINES WB TO SBTH?
if QUEUED INT BACK
THEN NB MIGHT NOT
BE VISIBLE TO WB
OR WB MAY NOT BE
ABLE TO SEE NB.
MITIGATION ?
INTERSECTION BOX
DO NOT BLOCK ??
1 fat
2 inj A
3/4 inj B/C
- pdo

Appendix C Cost Estimates

City of Bend CIP
Arizona Wall and Colorado Bond
Cost Estimate

MARK-UPS	Percent				
ELEC/I&C	0%			Prepared By:	Robin Lewis
MECHANICAL	0%			Proj. Manager:	Robin Lewis
ALLOWANCE	30%			Project No:	ST0614
MOB/BOND/INS	8%			Date:	September 17, 2012
CONTINGENCY	20%				
ENGINEERING	25%				
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED			
COB INTERNAL CHARGES	5%	COB PROVIDED			
OTHER COB COSTS	0%	COB PROVIDED			
ADMIN/LEGAL	3%	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$2,000.00	$2,000	
B	Work Zone TC	1	LS	$10,000.00	$10,000	
C	Erosion Control	1	LS	$1,000.00	$1,000	
D	Survey Staking	1	LS	$2,000.00	$2,000	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	Install mountable islands	0	LF	$2.00	$0	
H	Add one Near Left Signal Head	1	EA	$15,000.00	$15,000	1 Near Left Signal Head
I	Improved Detection and Interconnect	1	LS	$20,000.00	$20,000	Signal Coordination and Timing as a group of signals.
J	Add Signal Backplates	3	EA	$500.00	$1,500	Hi Vis Yellow
K	ADA Ramp (incl. truncated dome)	0	EA	$3,000.00	$0	
L		0	SF	$1.00	$0	
M		0	SF	$10.00	$0	
N	Signing	4	EA	$300.00	$1,200	Improved One-way signing and Signal Ahead Signing
O	Pavement Green Bike Box Markings	0	SF	$20.00	$0	
P	Pavement Legends (thermoplastic)	0	EA	$300.00	$0	
Q	Pavement marking - thermoplastic	0	LF	$3.00	$0	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$52,700**	
R	Allowance	30%			$15,810	
S	Mob/Bond/Ins	8%			$4,216	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	20%			$10,540	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$30,566**	
V	Engineering	25%			$18,000	Includes signal audit for phasing and timing, turning movement counts
W	COB Internal Charges	5%			$2,635	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$1,581	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$22,216	
	TOTAL ESTIMATED PROJECT COST				**$83,266**	

City of Bend CIP
Colorado Bond
Cost Estimate

MARK-UPS	Percent				
ELEC/I&C	0%			Prepared By:	Robin Lewis
MECHANICAL	0%			Proj. Manager:	Robin Lewis
ALLOWANCE	30%			Project No:	ST0614
MOB/BOND/INS	8%			Date:	September 17, 2012
CONTINGENCY	20%				
ENGINEERING	30%				
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED			
COB INTERNAL CHARGES	5%	COB PROVIDED			
OTHER COB COSTS	0%	COB PROVIDED			
ADMIN/LEGAL	3%	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$2,000.00	$2,000	
B	Work Zone TC	1	LS	$10,000.00	$10,000	
C	Erosion Control	1	LS	$1,000.00	$1,000	
D	Survey Staking	1	LS	$2,000.00	$2,000	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	Install mountable islands	0	LF	$2.00	$0	
H	New signal heads, to improve conspicuity	0	EA	$5,000.00	$0	
I	New signal backplates (hi vis yellow)	2	EA	$500.00	$1,000	
J	Improved detection and interconnect between all 4 signals	1	LS	$20,000.00	$20,000	unknown improvements - this is a baseline guess
K	ADA Ramp (incl. truncated dome)	0	EA	$3,000.00	$0	
L		0	SF	$1.00	$0	
M		0	SF	$10.00	$0	
N	Signing	4	EA	$300.00	$1,200	Improved One-way and Signal Ahead Signing; next signal signing
O	Pavement Green Bike Box Markings	0	SF	$20.00	$0	
P	Pavement Legends (thermoplastic)	0	EA	$300.00	$0	
Q	Pavement marking - thermoplastic	0	LF	$3.00	$0	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$37,200**	
R	Allowance	30%			$11,160	
S	Mob/Bond/Ins	8%			$2,976	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	20%			$7,440	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$21,576**	
V	Engineering	30%			$18,000	Includes signal audit for phasing and timing, turning movement counts
W	COB Internal Charges	5%			$1,860	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$1,116	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$20,976	
	TOTAL ESTIMATED PROJECT COST				**$58,776**	

City of Bend CIP
Brosterhous 3rd
Cost Estimate

MARK-UPS	Percent				
ELEC/I&C	0%			Prepared By:	Robin Lewis
MECHANICAL	0%			Proj. Manager:	Robin Lewis
ALLOWANCE	0%			Project No:	ST0614
MOB/BOND/INS	8%			Date:	September 11, 2012
CONTINGENCY	30%				
ENGINEERING	25%				
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED			
COB INTERNAL CHARGES	5%	COB PROVIDED			
OTHER COB COSTS	0%	COB PROVIDED			
ADMIN/LEGAL	3%	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$2,000.00	$2,000	
B	Work Zone TC	1	LS	$10,000.00	$10,000	
C	Erosion Control	0	LS	$1,000.00	$0	
D	Survey Staking	0	LS	$2,000.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	Install mountable islands		LF	$2.00	$0	
H	New ped push button poles and buttons		EA	$2,500.00	$0	
I		0	LF	$20.00	$0	
J		0	LF	$60.00	$0	
K	ADA Ramp (incl. truncated dome)	0	EA	$3,000.00	$0	
L	Convert to Protected Only E-W turns (Brost)	4	EA	$3,000.00	$12,000	Operate as Exclusive Walk Phase; operate as flashing yellow arrow lefts when permitted phasing is run.
M	Signal timing, dilema zone audit and change implementation	1	EA	$10,000.00	$10,000	Red Light running is an issue as is EB to SB rights - NOT ADEQUATE ISD to north due to roadway curvature and parked cars back of sidewalk. NO RTOR EB to SB.
N	Add Video Detection EB, SB	2	EA	$8,000.00	$16,000	already has 2070 and NB, WB video
O	Pavement Green Bike Box Markings	0	SF	$20.00	$0	
P	Pavement Legends (thermoplastic)	0	EA	$300.00	$0	
Q	Pavement marking - thermoplastic	0	LF	$3.00	$0	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$50,000**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	8%			$4,000	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	30%			$15,000	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$19,000**	
V	Engineering	25%			$20,000	Includes signal audit for phasing and timing, turning movement counts
W	COB Internal Charges	5%			$2,500	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$1,500	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$24,000	
	TOTAL ESTIMATED PROJECT COST				**$69,000**	

City of Bend CIP						
Butler Market at 27th Street		**Convert to protected Wb left; add NB double headed black on yellow warning sign; add EB bike lane; change timing/ph**				
Cost Estimate	**Add turn arrow sections rather than green balls for NB**					
	MARK-UPS	**Percent**			**Prepared By:**	**Robin Lewis**
	ELEC/I&C	**0%**			**Proj. Manager:**	**Robin Lewis**
	MECHANICAL	**0%**			**Project No:**	**ST0614**
	ALLOWANCE	**0%**			**Date:**	**September 11, 2012**
	MOB/BOND/INS	**10%**				Convert to Protected, turn arrows, change phasing
	CONTINGENCY	**30%**				
	ENGINEERING	**25%**				
	CAPITALIZED INTEREST (BOND)	**0%**	COB PROVIDED			
	COB INTERNAL CHARGES	**8%**	COB PROVIDED			
	OTHER COB COSTS	**0%**	COB PROVIDED			
	ADMIN/LEGAL	**5%**	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$5,000.00	$5,000	
B	Work Zone TC	1	LS	$15,000.00	$15,000	
C	Erosion Control	0	LS	$3,000.00	$0	
D	Survey Staking	0	LS	$5,000.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	removal of curbs	0	LF	$2.00	$0	
H	Concrete inlet catchbasin with Sump	0	LS	$2,500.00	$0	
I	Concrete Curb 16"	0	LF	$20.00	$0	
J	Parkstrip construction (curb tight becomes buffered)	0	LF	$60.00	$0	
K	ADA Ramp (incl. truncated dome)	0	EA	$2,500.00	$0	
L	Concrete Sidewalk	0	SF	$4.00	$0	
M	Concrete Driveway Apron	0	SF	$10.00	$0	
N	Signing	4	EA	$600.00	$2,400	Add double headed arrow up to span wire for NB; add ground mounted double headed arrow, add 2 type 3 barricades, one left lane one right lane projection
O	Striping	300	LF	$3.00	$900	Add bike lane stripe back in EB; add bike lane stripe westbound through intersection (thermo)
P	Pavement Legends (thermoplastic)	6	EA	$350.00	$2,100	Add bike lane legends two places EB to help remove Right turners from using bike lane to double stack for signal.; add two sets of elongated left and right arrows on NB approach
Q	Carbon Slurry Seal	0	SY	$2.60	$0	
R	Pedestrian poles + push buttons	0	EA	$2,500.00	$0	
S	Changes to WB heads	1	EA	$2,000.00	$2,000	Add left turn signal head
T		0	LF	$50.00	$0	
U		0	LS	$2,000.00	$0	
V	Change to video detection	0	EA	$24,000.00	$0	Already has Video Detection
W		0	EA	$10,000.00	$0	left turn head already in place (new this week)
X	Changes to NB Heads	3	EA	$2,000.00	$6,000	Change out green ball signal indication for 4 section FYA heads; two mounted on Mast Arm, 1 mounted on far left post of existing NW corner pole.
Y	Change signal phasing and timing	1	LS	$2,000.00	$2,000	execute signal timing and phasing changes incl. clearance and All Red adjustments
Z	Change controller to a 2070	1	EA	$5,000.00	$5,000	This includes the 2070 and a modem/switch
	SUBTOTAL CONSTRUCTION QUANTITIES				**$40,400**	
T	Allowance	0%			$0	
U	Mob/Bond/Ins	10%			$4,040	
V	Capitalized Interest (Bond)	0%			$0	
W	Contingency	30%			$12,120	
2	SUBTOTAL SOFT CONSTRUCTION COSTS				**$16,160**	
X	Engineering	25%			$30,000	
Y	COB Internal Charges	8%			$3,232	
Z	Other COB Charges	0%			$0	
AA	Admin/Legal	5%			$2,020	
AB	Property Costs (ROW/Easements)	$0			$0	
AC	Utilities Costs	$0			$0	
AD	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$35,252	
	TOTAL ESTIMATED PROJECT COST				**$56,560**	

City of Bend CIP
Revere at Division
Cost Estimate

MARK-UPS	Percent	
ELEC/I&C	0%	
MECHANICAL	0%	
ALLOWANCE	0%	
MOB/BOND/INS	10%	
CONTINGENCY	30%	
ENGINEERING	35%	
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED
COB INTERNAL CHARGES	8%	COB PROVIDED
OTHER COB COSTS	0%	COB PROVIDED
ADMIN/LEGAL	5%	COB PROVIDED

Prepared By: Robin Lewis
Proj. Manager: Robin Lewis
Project No: ST0614
Date: September 11, 2012

Road Diet with new signal equipment/head alignment/paint/carbon seal

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$10,000.00	$10,000	
B	Work Zone TC	1	LS	$15,000.00	$15,000	
C	Erosion Control	1	LS	$3,000.00	$3,000	
D	Survey Staking	0	LS	$5,000.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	2nd to 3rd new curb north and south sides
F	Removal of surfacings	0	SY	$5.00	$0	2nd to 3rd new curb north and south sides
G	removal of curbs	0	LF	$2.00	$0	2nd to 3rd new curb north and south sides
H	Concrete inlet catchbasin with Sump	0	LS	$2,500.00	$0	There are no cb 2nd to 3rd where new curb goes
I	Concrete Curb 16"	0	LF	$20.00	$0	2nd to 3rd new curb north and south sides
J	Parkstrip construction (curb tight becomes buffered)	0	LF	$60.00	$0	2nd to 3rd new curb north and south sides
K	ADA Ramp (incl. truncated dome)	0	EA	$2,500.00	$0	Division to 3rd: division, lytle, 2nd, 3rd (will require new ped pushbuttons)
L	Concrete Sidewalk	0	SF	$4.00	$0	no sidewalk replacement
M	Concrete Driveway Apron	0	SF	$10.00	$0	Division to 3rd 5 driveway aprons to replace at new curb line
N	Signing	4	EA	$200.00	$800	Division to 3rd new stop signs/street name signs
O	Striping	5600	LF	$0.75	$4,200	Division to 3rd restripe 4 lines (bike, lft edge twltl, rt edge twltl, bike)
P	Pavement Legends (thermoplastic)	24	EA	$350.00	$8,400	Wall to 3rd Restripe
Q	Carbon Slurry Seal	7466.66667	SY	$2.60	$19,413	Wall to 3rd Carbon Seal Prep for Restripe
R	Pedestrian poles + push buttons	0	EA	$2,500.00	$0	3rd Street signal changes - west leg ped
S	Signal Poles, Mast Arms, Heads	4	EA	$10,000.00	$40,000	3rd Street signal changes - westbound receive
T	Install median Wall to Division to create lane reduction	0	LF	$50.00	$0	Wall to Division - keep curbs, add median
U	Sawcut for median install Wall to Division	0	LF	$1.00	$0	Wall to Division - keep curbs, add median
V	Removal of surfacings Wall to Division	0	SY	$5.00	$0	Wall to Division - keep curbs, add median
W	Striping	0	LF	$0.75	$0	Wall to Division - keep curbs, add median
X	Changes to NB Off Ramp - signal head	1	EA	$2,000.00	$2,000	NB Off Ramp convert to L + TR (signal head change)
Y	Changes to NB Off Ramp - striping changes	305	LF	$0.75	$229	NB Off Ramp convert to L + TR (striping change)
Z	Signal Detection, Timing and Phasing Audit	1	EA	$10,000.00	$10,000	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$113,042**	
T	Allowance	0%			$0	
U	Mob/Bond/Ins	10%			$11,304	
V	Capitalized Interest (Bond)	0%			$0	
W	Contingency	30%			$33,913	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$45,217**	
X	Engineering	35%			$39,565	
Y	COB Internal Charges	8%			$9,043	
Z	Other COB Charges	0%			$0	
AA	Admin/Legal	5%			$5,652	
AB	Property Costs (ROW/Easements)	$0			$0	
AC	Utilities Costs	$0			$0	
AD	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$54,260	
	TOTAL ESTIMATED PROJECT COST				**$158,259**	

City of Bend CIP

Franklin at 3rd Street — **Long Term - Road Diet East-West**

Cost Estimate

MARK-UPS	Percent	
ELEC/I&C	0%	
MECHANICAL	0%	
ALLOWANCE	0%	
MOB/BOND/INS	8%	
CONTINGENCY	30%	
ENGINEERING	25%	
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED
COB INTERNAL CHARGES	15%	COB PROVIDED
OTHER COB COSTS	0%	COB PROVIDED
ADMIN/LEGAL	10%	COB PROVIDED

Prepared By: Robin Lewis
Proj. Manager: Robin Lewis
Project No: ST0614
Date: July 17, 2012

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$20,000.00	$20,000	
B	Work Zone TC	1	LS	$10,000.00	$10,000	
C	New ped push button poles	4	LS	$3,000.00	$12,000	
D	Signal timing, dilemma zone audit and change implementation	1	EA	$10,000.00	$10,000	
D	Add 2070 Controller	1	EA	$8,000.00	$8,000	
D	Survey Staking	1	LS	$15,000.00	$15,000	
E	Asphalt Pavement Saw Cutting	3000	LF	$1.00	$3,000	
F	Removal of surfacings	533	SY	$5.00	$2,667	
G	removal of curbs	400	LF	$2.00	$800	
H	Concrete inlet catchbasin with Sump	2	LS	$2,500.00	$5,000	
I	Concrete Curb 16"	400	LF	$20.00	$8,000	Curbing within 100' of intersection only; rest done with paint (and future redevelopment or grant funding)
J	Vegetated Swale	0	LF	$60.00	$0	Reconnect to the catchbasins.
K	ADA Ramp (incl. truncated dome)	8	EA	$2,500.00	$20,000	Just at the intersection for now.
L	Concrete Sidewalk	0	SF	$1.00	$0	no new sidewalk
M	Concrete Driveway Apron	3240	SF	$10.00	$32,400	no new driveway aprons
N	Signing	10	EA	$200.00	$2,000	
O	Striping (thermoplastic)	12000	LF	$3.00	$36,000	Highlight any remaining conflict areas (3rd Street).
P	Pavement Legends (thermoplastic)	10	EA	$300.00	$3,000	bike lane symbol, turn lane arrows, stop bars, crosswalks
	SUBTOTAL CONSTRUCTION QUANTITIES				**$187,867**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	8%			$15,029	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	30%			$56,360	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$71,389**	
V	Engineering	25%			$46,967	
W	COB Internal Charges	15%			$28,180	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	10%			$18,787	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$93,933	
	TOTAL ESTIMATED PROJECT COST				**$259,256**	

City of Bend CIP						
Franklin at Wall Street	**Immediate - Install turning vehicles yield to bikes/peds; NO RTOR; FYA head, no lag left, WAIT message**					
Cost Estimate						
	MARK-UPS	**Percent**			**Prepared By:**	**Robin Lewis**
	ELEC/I&C	**0%**			**Proj. Manager:**	**Robin Lewis**
	MECHANICAL	**0%**			**Project No:**	**ST0614**
	ALLOWANCE	**0%**			**Date:**	**June 28, 2012**
	MOB/BOND/INS	**8%**				
	CONTINGENCY	**30%**				
	ENGINEERING	**10%**				
	CAPITALIZED INTEREST (BOND)	**0%**	COB PROVIDED			
	COB INTERNAL CHARGES	**5%**	COB PROVIDED			
	OTHER COB COSTS	**0%**	COB PROVIDED			
	ADMIN/LEGAL	**3%**	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$5,000.00	$5,000	
B	Work Zone TC	1	LS	$10,000.00	$10,000	
C	Erosion Control	0	LS	$0.00	$0	
D	Survey Staking	1	LS	$2,000.00	$2,000	Remove SB right turn lane - create thru-right.
E	Asphalt Pavement Saw Cutting	100	LF	$1.00	$100	These are all for adding a curb extension for SB Wall
F	Removal of surfacings	89	SY	$10.00	$889	This eliminates the high conflicts from SB rights and ped/bike
G	removal of curbs	100	LF	$2.00	$200	activity. The area is downtown and pedestrian/bike has
H	Concrete inlet catchbasin with Sump	1	LS	$2,500.00	$2,500	greater priority than traffic flow
I	Concrete Curb 16"	100	LF	$20.00	$2,000	This adds 7 parking spaces into the downtown inventory
J	Add Curb Extension	89	SY	$60.00	$5,340	Pavers on top
K	ADA Ramp (incl. truncated dome)	2	EA	$2,500.00	$5,000	assume 2 ADA ramps (may only be 1)
L	Paver sidewalk	89	SY	$25.00	$2,222	this completes the curb extension
M	new signal pole NW corner	1	EA	$10,000.00	$10,000	
N	Signing	4	EA	$300.00	$1,200	turning vehicles yield to bikes/peds (modified R10-15)
O	Pavement Green Bike Box Markings	0	SF	$20.00	$0	
P	New Fully ADA Ped Signals (including message)	8	EA	$1,000.00	$8,000	This is only for west leg. - include audible WAIT message during DON"T WALK PHASE; animated eyes, leading ped phases
Q	Signal Phasing Changes	0	EA	$20,000.00	$0	
R	Convert to Flashing Yellow Arrow signal head	2	EA	$2,000.00	$4,000	remove dog house signal head
	SUBTOTAL CONSTRUCTION QUANTITIES				**$58,451**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	8%			$4,676	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	30%			$17,535	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$22,211**	
V	Engineering	10%			$20,000	
W	COB Internal Charges	5%			$2,923	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$1,754	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$24,676	
	TOTAL ESTIMATED PROJECT COST				**$80,663**	

City of Bend CIP		**Change signal phasing E-W to Protected ONLY and NO RTOR NB and SB.**				
Neff at Purcell		**Exclusive Walk Phase & No RTOR**				
Cost Estimate		**Stripe crosswalks on all approaches. Stripe bike lanes on Purcell to cross-walk.**				
	MARK-UPS	**Percent**			**Prepared By:**	**Robin Lewis**
	ELEC/I&C	**0%**			**Proj. Manager:**	**Robin Lewis**
	MECHANICAL	**0%**			**Project No:**	**ST0614**
	ALLOWANCE	**0%**			**Date:**	**July 6, 2012**
	MOB/BOND/INS	**8%**				
	CONTINGENCY	**30%**				
	ENGINEERING	**10%**				
	CAPITALIZED INTEREST (BOND)	**0%**	COB PROVIDED			
	COB INTERNAL CHARGES	**5%**	COB PROVIDED			
	OTHER COB COSTS	**0%**	COB PROVIDED			
	ADMIN/LEGAL	**3%**	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$2,000.00	$2,000	
B	Work Zone TC	1	LS	$10,000.00	$10,000	
C	Erosion Control	0	LS	$0.00	$0	
D	Survey Staking	0	LS	$0.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	removal of curbs	0	LF	$2.00	$0	
H	Concrete inlet catchbasin with Sump	0	LS	$2,500.00	$0	
I	Concrete Curb 16"	0	LF	$20.00	$0	
J	Signal Timing, Detection, Phasing Audit	1	LS	$10,000.00	$10,000	
K	Changes to E-W signal heads	6	EA	$2,000.00	$12,000	Change out dog houses; lefts = 4 section FYA heads; thrus = 3 section standard heads
L	Changes to N-S signal heads	4	EA	$2,000.00	$8,000	Change out 4 section green arrow head for a xxx section FYA head ONE over the lane, the second req'd far left. Include red arrow for right turns (No RTOR). Just center one over the lane, and put another far left (assuming lefts are considered the more major move). The heads will be different. Red ball, green ball on both, but Red Arrow and FYA arrows for both left and right on one centered over the lane.
M	Add 2070 controller	0	SF	$10.00	$0	Already has a 2070
N	Signing	2	EA	$300.00	$600	No RTOR
O	Pavement Green Bike Box Markings	1176	SF	$20.00	$23,520	Modified Green Bike Lanes (to minimize wear) x 4 approaches
P	Pavement Legends (thermoplastic)	8	EA	$300.00	$2,400	bike lane symbol,
Q	Pavement stop bar marking - thermoplastic	128	LF	$2.60	$333	outline of the green bike lane
R	Crosswalk Striping 12" thermoplastic	336	LF	$2.60	$874	
S	Bike Lane Striping 8" thermoplastic	700	LF	$2.60	$1,820	50' on all approaches (in and out of approach) + 200' on north leg
T	Implement protected only phasing E-W lefts	1	LS	$1,200.00	$1,200	0.01 cmf
	SUBTOTAL CONSTRUCTION QUANTITIES				**$72,746**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	8%			$5,820	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	30%			$21,824	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$27,644**	
V	Engineering	10%			$20,000	
W	COB Internal Charges	5%			$3,637	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$2,182	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$25,820	
	TOTAL ESTIMATED PROJECT COST				**$100,390**	

City of Bend CIP
Powers at 3rd
Cost Estimate

MARK-UPS	Percent				
ELEC/I&C	0%			Prepared By:	Robin Lewis
MECHANICAL	0%			Proj. Manager:	Robin Lewis
ALLOWANCE	30%			Project No:	ST0614
MOB/BOND/INS	8%			Date:	September 11, 2012
CONTINGENCY	30%				
ENGINEERING	25%				
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED			
COB INTERNAL CHARGES	5%	COB PROVIDED			
OTHER COB COSTS	0%	COB PROVIDED			
ADMIN/LEGAL	3%	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$2,000.00	$2,000	
B	Work Zone TC	1	LS	$10,000.00	$10,000	
C	Erosion Control	0	LS	$1,000.00	$0	
D	Survey Staking	0	LS	$2,000.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	Install mountable islands		LF	$2.00	$0	
H	New combined pole/mast arm with illumination NW Corner	1	EA	$4,000.00	$4,000	
I	Add 1 additional video detection	1	EA	$8,000.00	$8,000	
J	Add 2070 controller	0	EA	$5,000.00	$0	Already has a 2070 controller
K	ADA Ramp (incl. truncated dome)	0	EA	$3,000.00	$0	
L	East and West - change to 4 section heads	2	EA	$2,000.00	$4,000	Shall run exclusive Walk Phase (no permitted crossing lefts)
M	Signal timing, dillema zone audit and change implementation	1	EA	$10,000.00	$10,000	
N	Signing	4	EA	$300.00	$1,200	No Right Turn on Red for WB to NB rights
O	Pavement Green Bike Box Markings	0	SF	$20.00	$0	
P	Pavement Legends (thermoplastic)	0	EA	$300.00	$0	
Q	Pavement marking - thermoplastic	0	LF	$3.00	$0	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$39,200**	
R	Allowance	30%			$11,760	
S	Mob/Bond/Ins	8%			$3,136	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	30%			$11,760	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$26,656**	
V	Engineering	25%			$20,000	Includes signal audit for phasing and timing, turning movement counts
W	COB Internal Charges	5%			$1,960	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$1,176	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$23,136	
	TOTAL ESTIMATED PROJECT COST				**$65,856**	

City of Bend CIP
Reed Market at 3rd
Cost Estimate

MARK-UPS	Percent				
ELEC/I&C	0%			Prepared By:	Robin Lewis
MECHANICAL	0%			Proj. Manager:	Robin Lewis
ALLOWANCE	0%			Project No:	ST0614
MOB/BOND/INS	8%			Date:	September 12, 2012
CONTINGENCY	30%				
ENGINEERING	25%				
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED			
COB INTERNAL CHARGES	5%	COB PROVIDED			
OTHER COB COSTS	0%	COB PROVIDED			
ADMIN/LEGAL	3%	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$2,000.00	$2,000	
B	Work Zone TC	1	LS	$10,000.00	$10,000	
C	Erosion Control	1	LS	$1,000.00	$1,000	
D	Survey Staking	1	LS	$2,000.00	$2,000	
E	Asphalt Pavement Saw Cutting	400	LF	$1.00	$400	sawcut for mountable islands
F	Removal of surfacings	44	SY	$5.00	$222	remove for mountable islands
G	Install mountable islands	400	LF	$2.00	$800	mountable islands at corners for bike dutch intersection
H	New ped push button poles and buttons	8	EA	$2,500.00	$20,000	the ramps are separated now.
I		0	LF	$20.00	$0	
J		0	LF	$60.00	$0	
K	ADA Ramp (incl. truncated dome)	8	EA	$3,000.00	$24,000	will need 8 new ADA ramps
L		0	SF	$1.00	$0	
M		0	SF	$10.00	$0	
N	Signing	4	EA	$300.00	$1,200	
O	Pavement Green Bike Box Markings	3120	SF	$20.00	$62,400	Modified Green Bike Lanes (to minimize wear) x 3 approaches
P	Pavement Legends (thermoplastic)	8	EA	$300.00	$2,400	bike lane symbol,
Q	Pavement marking - thermoplastic	2192	LF	$3.00	$6,576	Ladder cross-walk+transverse cross-walk+bike cross-walk ladder
	SUBTOTAL CONSTRUCTION QUANTITIES				**$132,998**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	8%			$10,640	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	30%			$39,899	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$50,539**	
V	Engineering	25%			$33,250	Includes signal audit for phasing and timing, turning movement counts
W	COB Internal Charges	5%			$6,650	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$3,990	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$43,889	
	TOTAL ESTIMATED PROJECT COST				**$183,538**	

City of Bend CIP						
Reed Market at 27th Street	**Convert to protected nb left; add turn arrow sections rather than green balls for EB L + R; change timing/phasing**					
Cost Estimate	**Add 2070 controller**					
	MARK-UPS	**Percent**			**Prepared By:**	**Robin Lewis**
	ELEC/I&C	**0%**			**Proj. Manager:**	**Robin Lewis**
	MECHANICAL	**0%**			**Project No:**	**ST0614**
	ALLOWANCE	**30%**			**Date:**	**September 10, 2012**
	MOB/BOND/INS	**10%**				Convert to Protected, turn arrows, change phasing
	CONTINGENCY	**0%**				
	ENGINEERING	**25%**				
	CAPITALIZED INTEREST (BOND)	**0%**	COB PROVIDED			
	COB INTERNAL CHARGES	**8%**	COB PROVIDED			
	OTHER COB COSTS	**0%**	COB PROVIDED			
	ADMIN/LEGAL	**5%**	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$5,000.00	$5,000	
B	Work Zone TC	1	LS	$15,000.00	$15,000	
C	Erosion Control	0	LS	$3,000.00	$0	
D	Survey Staking	0	LS	$5,000.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	removal of curbs	0	LF	$2.00	$0	
H	Concrete inlet catchbasin with Sump	0	LS	$2,500.00	$0	
I	Concrete Curb 16"	0	LF	$20.00	$0	
J	Parkstrip construction (curb tight becomes buffered)	0	LF	$60.00	$0	
K	ADA Ramp (incl. truncated dome)	0	EA	$2,500.00	$0	
L	Concrete Sidewalk	0	SF	$4.00	$0	
M	Concrete Driveway Apron	0	SF	$10.00	$0	
N	Signing	4	EA	$600.00	$2,400	Add 1 double headed black on yellow arrow to mast arm; add 2 red/white type 3 barricades behind sidewalk; (one aligned with each lane); relocate existing ground mounted double headed black on yellow arrow to be directly below the mast arm mounted double yellow arrow. relocate the hospital sign to the far right signal post, towards the top, so the top of the Hospital Sign aligns with the top of the street name sign.
O	Striping	100	LF	$3.00	$300	Thermoplastic the bike lane across the top of the T.
P	Pavement Legends (thermoplastic)	4	EA	$350.00	$1,400	Install elongated left and right turn arrows - 2 sets EB
Q	Carbon Slurry Seal	0	SY	$2.60	$0	
R	New signal pole, mast arm, combination luminaire mast arm and luminaire	1	EA	$4,000.00	$4,000	This will be located at the NE 'corner' of the intersection and replace the mast arm that the existing dog house is on to extend the arm to allow a head to be centered over the NB left turn lane.
S	Changes to EB heads	3	EA	$2,000.00	$6,000	Change out green ball signal indication for 4 section FYA heads; two mounted on mast arm, 1 mounted on far left post of new pole.
T	Change controller to a 2070.	1	EA	$5,000.00	$5,000	This includes the 2070 and a modem/switch
U	Changes to NB head	1	EA	$2,000.00	$2,000	Change out doghouse for a 4 section FYA Head.
V		0	SY	$5.00	$0	
W	Add second NB thru head	1	EA	$2,000.00	$2,000	Now we need a second thru head.
X	Change to Video Detection	1	EA	$24,000.00	$24,000	Can coordinate with GO Bond overlay to remove loops with a grind
Y	Change signal phasing and timing	1	LS	$2,000.00	$2,000	execute signal phasing changes
Z						
	SUBTOTAL CONSTRUCTION QUANTITIES				**$69,100**	
T	Allowance	30%			$20,730	
U	Mob/Bond/Ins	10%			$6,910	
V	Capitalized Interest (Bond)	0%			$0	
W	Contingency	0%			$0	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$27,640**	
X	Engineering	25%			$20,000	
Y	COB Internal Charges	8%			$5,528	
Z	Other COB Charges	0%			$0	
AA	Admin/Legal	5%			$3,455	
AB	Property Costs (ROW/Easements)	$0			$0	
AC	Utilities Costs	$0			$0	
AD	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$28,983	
	TOTAL ESTIMATED PROJECT COST				**$96,740**	

City of Bend CIP						
Franklin Avenue Hill to 1st Safety Mitigation		**Near Term: Restripe, add crosswalks (stop approaches), bike lanes, sharrows thru tunnel, lane organization to**				
Cost Estimate		**eliminate lane slop**				
	MARK-UPS	**Percent**			**Prepared By:**	**Robin Lewis**
	ELEC/I&C	**0%**			**Proj. Manager:**	**Robin Lewis**
	MECHANICAL	**0%**			**Project No:**	**ST0614**
	ALLOWANCE	**0%**			**Date:**	**July 16, 2012**
	MOB/BOND/INS	**8%**				
	CONTINGENCY	**20%**				PAINTED ONLY ROAD DIET
	ENGINEERING	**25%**				
	CAPITALIZED INTEREST (BOND)	**0%**	COB PROVIDED			
	COB INTERNAL CHARGES	**10%**	COB PROVIDED			
	OTHER COB COSTS	**0%**	COB PROVIDED			
	ADMIN/LEGAL	**5%**	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$4,000.00	$4,000	
B	Work Zone TC	1	LS	$10,000.00	$10,000	
C	Erosion Control	1	LS	$1,000.00	$1,000	
D	Survey Staking	0	LS	$1,000.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	removal of curbs	0	LF	$2.00	$0	
H	Concrete inlet catchbasin with Sump	4	LS	$2,500.00	$10,000	
I	Concrete Curb 16"	0	LF	$20.00	$0	
J	Vegetated Swale	0	LF	$60.00	$0	
K	ADA Ramp (incl. truncated dome)	8	EA	$2,500.00	$20,000	
L	Concrete Sidewalk	0	SF	$4.00	$0	
M	Carbon Seal Overlay for striping prep	10478	SY	$2.60	$27,243	
N	Signing	2	EA	$200.00	$400	
O	Striping (thermoplastic)	16840	LF	$3.00	$50,520	
P	Pavement Legends (thermoplastic)	5	EA	$300.00	$1,500	Thermo xwalks - 2 ea per crossing assumed; + bike + sharrow
Q	Illumination	1	EA	$15,000.00	$15,000	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$139,663**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	8%			$11,173	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	20%			$27,933	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$39,106**	
V	Engineering	25%			$34,916	
W	COB Internal Charges	10%			$13,966	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	5%			$6,983	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$55,865	
	TOTAL ESTIMATED PROJECT COST				**$178,769**	

City of Bend CIP

Awbrey at Portland — **Convert 2-way stop to mini-roundabout**

Cost Estimate

MARK-UPS	Percent	
ELEC/I&C	0%	
MECHANICAL	0%	
ALLOWANCE	0%	
MOB/BOND/INS	0%	
CONTINGENCY	25%	
ENGINEERING	10%	
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED
COB INTERNAL CHARGES	5%	COB PROVIDED
OTHER COB COSTS	0%	COB PROVIDED
ADMIN/LEGAL	3%	COB PROVIDED

Prepared By: Robin Lewis
Proj. Manager: Robin Lewis
Project No: ST0614
Date: September 13, 2012

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$5,000.00	$5,000	
B	Work Zone TC	1	LS	$5,000.00	$5,000	
C	Clearing and Grubbing	0	LS	$3,000.00	$0	
D	Survey Staking	1	LS	$3,000.00	$3,000	
E	Asphalt Pavement Saw Cutting	480	LF	$1.00	$480	
F	Removal of surfacings	213	SY	$5.00	$1,067	
G	removal of curbs	0	LF	$2.00	$0	
H	Concrete inlet catchbasin with Sump	0	LS	$2,500.00	$0	
I	Concrete Curb mountable	480	LF	$15.00	$7,200	
J	bike ramp	8	ea	$1,500.00	$12,000	
K	ADA Ramp (incl. truncated dome)	8	EA	$2,000.00	$16,000	
L	Concrete Sidewalk	3200	SF	$5.00	$16,000	
M	Bright Side Strips	0	EA	$50.00	$0	
N	Signing	4	EA	$200.00	$800	Yield Signs
O	Striping (thermoplastic)	600	LF	$2.60	$1,560	crosswalks, circulating line
P	Pavement Legends (thermoplastic)	12	EA	$300.00	$3,600	yield bar, (2) bike symbols each leg
Q	Colored ACP	240	SF	$10.00	$2,400	colored/stamped ACP truck apron
R	Traffic circle incl. landscaping	1	EA	$5,000.00	$5,000	central island = traffic circle
	SUBTOTAL CONSTRUCTION QUANTITIES				**$79,107**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	0%			$0	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	25%			$19,777	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$19,777**	
V	Engineering	10%			$20,000	
W	COB Internal Charges	5%			$3,955	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$2,373	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$26,329	
	TOTAL ESTIMATED PROJECT COST				**$98,883**	

City of Bend CIP

Bear Creek Pettigrew **Increase awareness of stops/intersection. Clear Sight Line.**

Cost Estimate

MARK-UPS	Percent			
ELEC/I&C	0%		Prepared By:	Robin Lewis
MECHANICAL	0%		Proj. Manager:	Robin Lewis
ALLOWANCE	0%		Project No:	ST0614
MOB/BOND/INS	0%		Date:	August 31, 2012
CONTINGENCY	10%			
ENGINEERING	0%			
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED		
COB INTERNAL CHARGES	5%	COB PROVIDED		
OTHER COB COSTS	0%	COB PROVIDED		
ADMIN/LEGAL	3%	COB PROVIDED		

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	0	LS	$2,000.00	$0	
B	Work Zone TC	1	LS	$2,000.00	$2,000	
C	Clearing and Grubbing	1	LS	$3,000.00	$3,000	Clear SE corner of bounders, grasses.
D	Survey Staking	0	LS	$0.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	removal of curbs	0	LF	$2.00	$0	
H	Concrete inlet catchbasin with Sump	0	LS	$2,500.00	$0	
I	Concrete Curb 16"	0	LF	$20.00	$0	
J	Vegetated Swale	0	LF	$60.00	$0	
K	ADA Ramp (incl. truncated dome)	0	EA	$2,500.00	$0	
L	Concrete Sidewalk	0	SF	$1.00	$0	
M	Bright Side Strips	4	EA	$50.00	$200	Install one on each stop (WB, NB). Install one on each Adv Stop (WB, NB)
N	Signing	4	EA	$200.00	$800	2 oversize stop signs. 2 adv street name plaques on Adv. Stop Warnings (all 4 need new posts (taller posts).
O	Striping	40	LF	$5.00	$200	Transverse Peripheral (2' bar, 5 each side of lane, last set at Stop Ahead Sign)
P	Pavement Legends (thermoplastic)	0	EA	$300.00	$0	bike lane symbol, turn lane arrows, stop bars, crosswalks
Q	Carbon Slurry Seal	0	EA	$2.60	$0	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$6,200**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	0%			$0	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	10%			$620	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$620**	
V	Engineering	0%			$0	
W	COB Internal Charges	5%			$310	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$186	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$496	
	TOTAL ESTIMATED PROJECT COST				**$6,820**	

City of Bend CIP

Country Club at Murphy **Increase awareness of stops/intersection. Clear Sight Line.**

Cost Estimate

MARK-UPS	Percent			
ELEC/I&C	0%		Prepared By:	Robin Lewis
MECHANICAL	0%		Proj. Manager:	Robin Lewis
ALLOWANCE	0%		Project No:	ST0614
MOB/BOND/INS	0%		Date:	August 31, 2012
CONTINGENCY	10%			
ENGINEERING	0%			
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED		
COB INTERNAL CHARGES	5%	COB PROVIDED		
OTHER COB COSTS	0%	COB PROVIDED		
ADMIN/LEGAL	3%	COB PROVIDED		

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	0	LS	$2,000.00	$0	
B	Work Zone TC	1	LS	$2,000.00	$2,000	
C	Clearing and Grubbing	1	LS	$3,000.00	$3,000	Clear SE corner of boulders, grasses.
D	Survey Staking	0	LS	$0.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	removal of curbs	0	LF	$2.00	$0	
H	Concrete inlet catchbasin with Sump	0	LS	$2,500.00	$0	
I	Concrete Curb 16"	0	LF	$20.00	$0	
J	Vegetated Swale	0	LF	$60.00	$0	
K	ADA Ramp (incl. truncated dome)	0	EA	$2,500.00	$0	
L	Concrete Sidewalk	0	SF	$1.00	$0	
M	Bright Side Strips	2	EA	$50.00	$100	Install one on each stop (NB). Install one on each Adv Stop (NB)
N	Signing	2	EA	$200.00	$400	1 oversize stop signs. 1 adv street name plaques on Adv. Stop Warnings (all 2 need new posts (taller posts).
O	Striping	20	LF	$5.00	$100	Transverse Peripheral (2' bar, 5 each side of lane, last set at Stop Ahead Sign)
P	Pavement Legends (thermoplastic)	0	EA	$300.00	$0	
Q	Carbon Slurry Seal	0	EA	$2.60	$0	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$5,600**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	0%			$0	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	10%			$560	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$560**	
V	Engineering	0%			$0	
W	COB Internal Charges	5%			$280	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$168	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$448	
	TOTAL ESTIMATED PROJECT COST				**$6,160**	

City of Bend CIP
Greenwood Avenue at 1st Street Safety Mitigation
Cost Estimate

CURB EXTENSIONS SOUTH SIDE

MARK-UPS	Percent	
ELEC/I&C	0%	
MECHANICAL	0%	
ALLOWANCE	0%	
MOB/BOND/INS	0%	
CONTINGENCY	20%	
ENGINEERING	25%	
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED
COB INTERNAL CHARGES	8%	COB PROVIDED
OTHER COB COSTS	0%	COB PROVIDED
ADMIN/LEGAL	5%	COB PROVIDED

Prepared By:	Robin Lewis
Proj. Manager:	Robin Lewis
Project No:	ST0614
Date:	September 13, 2012

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$1,500.00	$1,500	
B	Work Zone TC	1	LS	$5,000.00	$5,000	
C	Erosion Control	1	LS	$1,000.00	$1,000	
D	Survey Staking	1	LS	$1,000.00	$1,000	
E	Asphalt Pavement Saw Cutting	160	LF	$1.00	$160	curb ext SW, SE corners extension Greenwood and 1st (bulbs)
F	Removal of surfacings	1280	SY	$5.00	$6,400	
G	removal of curbs	160	LF	$2.00	$320	
H	Concrete inlet catchbasin with Sump	3	LS	$2,500.00	$7,500	
I	Concrete Curb 16"	200	LF	$20.00	$4,000	
J	Vegetated Swale	0	LF	$60.00	$0	
K	ADA Ramp (incl. truncated dome)	4	EA	$2,500.00	$10,000	
L	Concrete Sidewalk	100	SF	$1.00	$100	
M	Concrete Driveway Apron	0	SF	$10.00	$0	
N	Signing		EA	$300.00	$0	
O	Striping		LF	$3.00	$0	
P	Pavement Legends (thermoplastic)		EA	$300.00	$0	
Q	Striping Removal		LF	$5.00	$0	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$36,980**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	0%			$0	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	20%			$7,396	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$7,396**	
V	Engineering	25%			$9,245	
W	COB Internal Charges	8%			$2,958	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	5%			$1,849	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$14,052	
	TOTAL ESTIMATED PROJECT COST				**$44,376**	

City of Bend CIP

Greenwood Avenue at Hill Street Safety Mitigation — **Add Curb Extensions**

Cost Estimate

MARK-UPS	Percent				
ELEC/I&C	0%			Prepared By:	Robin Lewis
MECHANICAL	0%			Proj. Manager:	Robin Lewis
ALLOWANCE	0%			Project No:	ST0614
MOB/BOND/INS	10%			Date:	June 28, 2012
CONTINGENCY	30%				
ENGINEERING	25%				Curb extensions at Hill Street (necessitates NE corner easement)
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED			Adv. Stop
COB INTERNAL CHARGES	8%	COB PROVIDED			Crosswalk markings
OTHER COB COSTS	0%	COB PROVIDED			Illumination Changes
ADMIN/LEGAL	5%	COB PROVIDED			

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	1	LS	$4,000.00	$4,000	
B	Work Zone TC	1	LS	$20,000.00	$20,000	
C	Erosion Control	1	LS	$1,000.00	$1,000	
D	Survey Staking	1	LS	$1,000.00	$1,000	
E	Asphalt Pavement Saw Cutting	580	LF	$1.00	$580	100 LF each corner; but NE corner = 220 LF 6' s/w; 280 LF curb/AC Cut; 2 d/w aprons; pkg stripes 150 LF;
F	Removal of surfacings	516	SY	$5.00	$2,578	
G	removal of curbs	580	LF	$2.00	$1,160	
H	Concrete inlet catchbasin with Sump	8	LS	$2,500.00	$20,000	
I	Concrete Curb 16"	580	LF	$20.00	$11,600	
J	driveway aprons	288	SF	$60.00	$17,280	
K	ADA Ramp (incl. truncated dome)	8	EA	$2,500.00	$20,000	
L	Concrete Sidewalk	3200	SF	$1.00	$3,200	
M	Concrete Driveway Apron	200	SF	$10.00	$2,000	
N	Signing	8	EA	$200.00	$1,600	xwalk ahead, stop for peds, walk zone, parking (2)
O	Striping (thermoplastic)	302	LF	$3.00	$906	adv 2' stop bars (20' each), sidestreet crosswalk (24' x 4), mainline crosswalk (9' long, 14 total bars)
P	Pavement Legends (thermoplastic)	8	EA	$300.00	$2,400	Look
Q	Illumination	2	EA	$5,000.00	$10,000	250 Watt
R	Parking striping	150	LF	$3.00	$450	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$119,754**	
S	Allowance	0%			$0	
T	Mob/Bond/Ins	10%			$11,975	
U	Capitalized Interest (Bond)	0%			$0	
V	Contingency	30%			$35,926	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$47,902**	
W	Engineering	25%			$29,938	
X	COB Internal Charges	8%			$9,580	
Y	Other COB Charges	0%			$0	
X	Admin/Legal	5%			$5,988	
AA	Property Costs (ROW/Easements)	1,500	EA	$ 15.00	$22,500	$15.00 per square foot x10' easement x 150 lf
AB	Utilities Costs	$0			$0	
AC	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$68,006	
	TOTAL ESTIMATED PROJECT COST				**$167,655**	

City of Bend CIP

Wilson & 2nd **Signal Queue Blocks Sight Lines**

Cost Estimate

MARK-UPS	Percent	
ELEC/I&C	0%	
MECHANICAL	0%	
ALLOWANCE	0%	
MOB/BOND/INS	0%	
CONTINGENCY	10%	
ENGINEERING	10%	
CAPITALIZED INTEREST (BOND)	0%	COB PROVIDED
COB INTERNAL CHARGES	5%	COB PROVIDED
OTHER COB COSTS	0%	COB PROVIDED
ADMIN/LEGAL	3%	COB PROVIDED

Prepared By: Robin Lewis
Proj. Manager: Robin Lewis
Project No: ST0614
Date: August 31, 2012

NO.	DESCRIPTION	QTY	UNIT	Unit Cost Unit $	TOTAL	RESOURCE
A	Mobilization	0	LS	$5,000.00	$0	
B	Work Zone TC	1	LS	$5,000.00	$5,000	
C	Clearing and Grubbing	0	LS	$3,000.00	$0	
D	Survey Staking	0	LS	$0.00	$0	
E	Asphalt Pavement Saw Cutting	0	LF	$1.00	$0	
F	Removal of surfacings	0	SY	$5.00	$0	
G	removal of curbs	0	LF	$2.00	$0	
H	Concrete inlet catchbasin with Sump	0	LS	$2,500.00	$0	
I	Concrete Curb 16"	0	LF	$20.00	$0	
J	Vegetated Swale	0	LF	$60.00	$0	
K	ADA Ramp (incl. truncated dome)	0	EA	$2,500.00	$0	
L	Concrete Sidewalk	0	SF	$1.00	$0	
M	Bright Side Strips	0	EA	$50.00	$0	
N	Signing	2	EA	$200.00	$400	do not block intersection EB reg. signal queue blocks sight lines NB Warning
O	Striping (thermoplastic)	2280	LF	$5.00	$11,400	
P	Pavement Legends (thermoplastic)	0	EA	$300.00	$0	
Q	Carbon Slurry Seal	0	EA	$2.60	$0	
	SUBTOTAL CONSTRUCTION QUANTITIES				**$16,800**	
R	Allowance	0%			$0	
S	Mob/Bond/Ins	0%			$0	
T	Capitalized Interest (Bond)	0%			$0	
U	Contingency	10%			$1,680	
	SUBTOTAL SOFT CONSTRUCTION COSTS				**$1,680**	
V	Engineering	10%			$1,680	
W	COB Internal Charges	5%			$840	
X	Other COB Charges	0%			$0	
Y	Admin/Legal	3%			$504	
Z	Property Costs (ROW/Easements)	$0			$0	
AA	Utilities Costs	$0			$0	
AB	Permit Fees	$0			$0	
	SUBTOTAL DESIGN, PERMITS AND ROW				$3,024	
	TOTAL ESTIMATED PROJECT COST				**$18,480**	

Appendix D Cost-Benefit Analysis Worksheets

For Office Use Only
File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Arizona at Wall			Region:	IV	Date:	9/12/12
Project on Local Agency Facility Route Number:		Street Name:	Arizona	MP Range or Cross Street:	Wall		
Project on State Highway Route Number:		Hwy Name:	RINGS	MP From:		to	
Road Character:		Facility Type:	WAY				
County:		City:		Crash Data From:	1/1/2006	to	12/31/2010
Project Description:	Adjust All Red Clearance Interval, add Dutch Bike lanes						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor
Countermeasure 1	Added visibility of the signal head, improved one-way signing; si	Angle, Head On	40%
Countermeasure 2	Improved one-way signage	Angle and Head On	20%
Countermeasure 3			
Countermeasure 4			

Collision Type	*Angle, Head On*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes	10	4.0	$47,500	=	$ 192,000
	PDO Crashes	2	0.8	$15,000	=	$ 12,000

Collision Type	*Angle and Head On*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes	2	0.4	$47,500	=	$ 19,000
	PDO Crashes	2	0.4	$15,000	=	$ 6,000

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$55,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$55,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 229,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 46,000

Estimated Project Cost = $ 83,266

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 46,000 x 12.46 [2] = 6.88

$ 83,266

Notes

1 Composite crash reducion factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. NationalSafety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP impicit

For Office Use Only

File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Colorado at Bond			Region:	IV	Date: 9/12/12
Project on Local Agency Facility Route Number:		Street Name:	Colorado	MP Range or Cross Street:	Bond	
Project on State Highway Route Number:		Hwy Name:	PRINGS	MP From:		to
Road Character:		Facility Type:	WAY			
County:		City:		Crash Data From:	1/1/2006	to 12/31/2010
Project Description:	Improve visibility of the signal heads (yellow backplates; signal ahead warning sign; next signal signing; tree trimming; coordinated signals)					
Prepared By:	Robin Lewis			Title:	Transportation Engineer	

		Collision Type	Crash Reduction Factor
Countermeasure 1	Added visibility of the signal head, improved one-way signing	Angle, Head On	40%
Countermeasure 2			
Countermeasure 3			
Countermeasure 4			

Collision Type	Angle, Head On	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes	9	3.6	$47,900	=	$ 172,000
	PDO Crashes	11	4.4	$15,000	=	$ 66,000

Collision Type	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes	0	0.0	$55,000	=	$ -
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$55,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$55,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,300
Other State Highway	$47,900	$55,300
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,469,000
Other State Highway	$840,000	$1,509,000

Total Crash Value for 60 Months = $ 238,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 48,000

Estimated Project Cost = $ 58,776

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 48,000 x 12.46 [2] / $ 58,776 = **10.18**

For Office Use Only
File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Brosterhous at 3rd			Region:	IV	Date:	9/12/12
Project on Local Agency Facility							
Route Number:		Street Name:	Brosterhous	MP Range or Cross Street:	3rd Street		
Project on State Highway							
Route Number:		Hwy Name:	PRINGS	MP From:		to	
Road Character:		Facility Type:	NAY				
County:		City:		Crash Data From:	1/1/2006	to	12/31/2010
Project Description:	Adjust All Red Clearance Interval, add R10-15						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor
Countermeasure 1	Adjust signal timng and phasing for rear end, RLR	Angle, Head On, Rear End	40%
Countermeasure 2	Convert to Exclusive Walk Phases	Ped angle	99%
Countermeasure 3			
Countermeasure 4			

Collision Type	*Angle, Head On, Rear End*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Tota Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - injury B & C Crashes	6	2.4	$47,900	=	$ 115,000
	PDO Crashes	11	4.4	$15,000	=	$ 66,000

Collision Type	*Ped angle*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Tota Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - injury B & C Crashes	1	1.0	$47,900	=	$ 47,000
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Tota Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - injury B & C Crashes		0.0	$55,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Tota Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - injury B & C Crashes		0.0	$55,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,440,000
Other State Highway	$840,000	$1,560,000

Total Crash Value for 60 Months = $ 228,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 46,000

Estimated Project Cost = $ 69,000

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 46,000 x 12.46 [2] / $ 69,000 = **8.31**

For Office Use Only

File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Butler Market at 27th		Region: IV	Date:	9/10/12
Project on Local Agency Facility Route Number:		Street Name: 27th Street	MP Range or Cross Street: Butler Market		
Project on State Highway Route Number:		Hwy Name: IN	MP From:	to	
Road Character:		Facility Type:			
County:		City:	Crash Data From: 1/1/2006	to	12/31/2010
Project Description:	Convert permitted phasing to protected only phasing by changing signal head/timing. Add double arrow sign to NB span wire. Add bike lane EB				
Prepared By:	Robin Lewis		Title: Transportation Engineer		

		Collision Type	Crash Reduction Factor
Countermeasure 1	Convert to Protected only phasing from permitted	Angle	99%
Countermeasure 2	Add double headed arrow to span wire	Run off Road - Fixed Object	20%
Countermeasure 3	Add bike lane eastbound	Right turn rear end	20%
Countermeasure 4	Adjust All Red and Clearance Intervals	Angle	20%

Collision Type	*Angle*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Miror - Injury B & C Crashes	3	3.0	$47,900	=	$ 142,000
	PDO Crashes	2	2.0	$15,000	=	$ 30,000

Collision Type	*Run off Road - Fixed Object*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Miror - Injury B & C Crashes	0	0.0	$47,900	=	$ -
	PDO Crashes	1	0.2	$15,000	=	$ 3,000

Collision Type	*Right turn rear end*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Miror - Injury B & C Crashes	1	0.2	$47,900	=	$ 10,000
	PDO Crashes	1	0.2	$15,000	=	$ 3,000

Collision Type	*Angle*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Miror - Injury B & C Crashes	0	0.0	$47,900	=	$ -
	PDO Crashes	4	0.8	$15,000	=	$ 12,000

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 200,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 40,000

Estimated Project Cost = $ 56,560

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 40,000 x 12.46 [2] / $ 56,560 = **8.81**

For Office Use Only
File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Division at Revere			Region:	IV	Date:	9/10/12
Project on Local Agency Facility							
Route Number:		Street Name:	Revere Street Road Diet		MP Range or Cross Street:	Division Street	
Project on State Highway							
Route Number:		Hwy Name:	IN		MP From:		to
Road Character:		Facility Type:					
County:		City:			Crash Data From:	1/1/2006	to 12/31/2011
Project Description:	Convert permitted phasing to protected only phasing by creating left turn lanes; road diets.						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor
Countermeasure 1			
Countermeasure 2	Adjust All Red Phasing	RLR	40%
Countermeasure 3	Protected Only Phasing & Road Diet	L v. T	99%
Countermeasure 4			

Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	5	0.0	$47,900	=	$ -
	PDO Crashes	4	0.0	$15,000	=	$ -

Collision Type	*RLR*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	2	0.8	$47,900	=	$ 38,000
	PDO Crashes	5	2.0	$15,000	=	$ 30,000

Collision Type	*L v T*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	1	1.0	$840,000	=	$ 832,000
	Mod and Minor - Injury B & C Crashes	6	5.9	$47,900	=	$ 285,000
	PDO Crashes	14	13.9	$15,000	=	$ 208,000

Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
	PDO [3]	
All facilities	$15,000	$15,000
	Moderate (Injury B) and Minor (Injury C) Injury [4]	
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
	Fatal and Severe (Injury A) Injury [4]	
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 72 Months = $ 1,393,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 232,000

Estimated Project Cost = $ 158,259

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 232,000 x 12.46 [2] = **18.27**

$ 158,259

For Office Use Only

File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Franklin at 3rd Street			Region:	IV	Date:	7/25/12
Project on Local Agency Facility							
Route Number:		Street Name:	Franklin Avenue		MP Range or Cross Street:	3rd Street	
Project on State Highway							
Route Number:		Hwy Name:	PRINGS	MP From:		to	
Road Character:		Facility Type:	WAY				
County:		City:		Crash Data From:	1/1/2006	to	1/1/2010
Project Description:	Install Dutch Bike Lane Design & Signal Upgrade for Angle/Rear End crashes & road diet -E-W						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor	
Countermeasure 1	Dutch Bike Lane Design	Right Turn Hooks	99%	No CMF Estimated***
Countermeasure 2	Angle Crashes at Signal/Rear End Crashes	Angle/Rear End	15%	clearing house
Countermeasure 3	Road Diet	All	29%	13.4.2.3
Countermeasure 4				

Collision Type	*Right Turn Hooks*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	3	3.0	$47,900	=	$ 142,000
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type	*Angle/Rear End*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	1	0.2	$840,000	=	$ 126,000
	Mod and Minor - Injury B & C Crashes	13	2.0	$47,900	=	$ 93,000
	PDO Crashes	12	1.8	$15,000	=	$ 27,000

Collision Type	*All*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	14	4.1	$47,900	=	$ 194,000
	PDO Crashes	14	4.1	$15,000	=	$ 61,000

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$55,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,440,000
Other State Highway	$840,000	$1,540,000

Total Crash Value for 48 Months = $ 643,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 161,000

Estimated Project Cost = $ 259,256

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 161,000 x 12.46 [2] / $ 259,256 = **7.74**

For Office Use Only

File Code PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Franklin at Wall Street		Region: IV	Date:	8/8/12
Project on Local Agency Facility Route Number:		Street Name: Franklin Avenue		MP Range or Cross Street:	Wall Street
Project on State Highway Route Number:		Hwy Name: IN	MP From:	to	
Road Character:		Facility Type:			
County:		City:	Crash Data From:	1/1/2006 to	12/31/2010
Project Description:	Signage, Signal timing and phasing audit and changes				
Prepared By:	Robin Lewis		Title:	Transportation Engineer	

		Collsion Type	Crash Reduction Factor	
Countermeasure 1	Signal Changes, Signs (eliminate SB Dedicated Right turn lane); sign no RTOR	Right turn Hooks with Bikes	39%	Preusser 1982
Countermeasure 2				
Countermeasure 3				
Countermeasure 4				

Collision Type	*Right turn Hooks with Bikes*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	2	0.8	$47,900	=	$ 37,000
	PDO Crashes	2	0.8	$15,000	=	$ 12,000

Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	0	0.0	$47,900	=	$ -
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$479,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 49,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 10,000

Estimated Project Cost = $ 80,663

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 10,000 x 12.46 [2] = $ 80,663 = **1.54**

For Office Use Only
File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Neff Road at Purcell Boulevard		Region:	ODOT Region 4	Date: 7/11/12
Project on Local Agency Facility Route Number:		Street Name: Neff		MP Range or Cross Street:	Purcell
Project on State Highway Route Number:		Hwy Name: PRINGS		MP From:	to
Road Character:		Facility Type: WAY			
County:		City: Bend	Crash Data From:	1/1/2006	to 12/31/2010
Project Description:	RTOR, Protected Only Lefts, signing and striping; signal, timing, detection, phasing audit				
Prepared By:			Title:		

		Collision Type	Crash Reduction Factor	
Countermeasure 1	Eliminate RTOR	RTOR with Bikes	39%	Preusser 1982 (bikes only)
Countermeasure 2	Protected only lefts	Permitted Lefts	99%	14.7.2.4 lefts only
Countermeasure 3				CMF
Countermeasure 4	Signal Timing, Detection and Phasing Audit	Red Light Running; Rear End	9%	

Collision Type	RTOR with Bikes	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	2	0.8	$47,900	=	$ 37,600
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type	Permitted Lefts	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	2	2.0	$47,900	=	$ 95,800
	PDO Crashes	3	3.0	$15,000	=	$ 45,000

Collision Type	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	0	0.0	$47,900	=	$ -
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type	Red Light Running; Rear End	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	1	0.1	$840,000	=	$ 76,000
	Mod and Minor - Injury B & C Crashes	7	0.6	$47,900	=	$ 30,000
	PDO Crashes	14	1.3	$15,000	=	$ 19,000

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 302,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 60,000

Estimated Project Cost = $ 100,390

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 60,000 x 12.46 [2] = **7.45**

$ 100,390

For Office Use Only
File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Powers at 3rd			Region:	IV	Date: 9/11/12
Project on Local Agency Facility						
Route Number:		Street Name: Powers		MP Range or Cross Street:	3rd Street	
Project on State Highway						
Route Number:		Hwy Name: PRINGS		MP From:		to
Road Character:		Facility Type: WAY				
County:		City:		Crash Data From:	1/1/2006	to 12/31/2010
Project Description:	Adjust All Red Clearance Interval, add R10-15					
Prepared By:	Robin Lewis			Title:	Transportation Engineer	

		Collision Type	Crash Reduction Factor	
Countermeasure 1	Adjust Signal Timing, phasing and detection incl. all red	Angle, Head On	40%	
Countermeasure 2	Controller Timing to create exclusive walk phase	Ped angle	99%	14A-5 HSM +T
Countermeasure 3				
Countermeasure 4				

Collision Type	*Angle, Head On*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	1	0.4	$840,000	=	$ 336,000
	Mod and Minor - Injury B & C Crashes	16	6.4	$47,900	=	$ 307,000
	PDO Crashes	16	6.4	$15,000	=	$ 96,000

Collision Type	*Ped angle*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	2	2.0	$47,900	=	$ 95,000
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 834,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 167,000

Estimated Project Cost = $ 65,856

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 167,000 x 12.46 [2] = 31.60
$ 65,856

For Office Use Only

File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Reed Market at 3rd Street			Region:	IV	Date:	9/12/12
Project on Local Agency Facility							
Route Number:		Street Name:	ReedMarket	MP Range or Cross Street:	3rd Street		
Project on State Highway							
Route Number:		Hwy Name:	PRINGS	MP From:		to	
Road Character:		Facility Type:	WAY				
County:		City:		Crash Data From:	1/1/2006	to	12/31/2010
Project Description:	Adjust All Red Clearance Interval, add Dutch Bike lanes						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor
Countermeasure 1	Adjust All Red Clearance Interval	Angle, Head On	40%
Countermeasure 2	Add Dutch Bike Lanes	Right turn hook (bike and ped)	99%
Countermeasure 3			
Countermeasure 4			

Collision Type	Angle, Head On	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	1	0.4	$840,000	=	$ 336,000
	Mod and Minor - Injury B & C Crashes	3	1.2	$47,900	=	$ 57,000
	PDO Crashes	13	5.2	$15,000	=	$ 78,000

Collision Type	Right turn hook (bike and ped)	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	1	1.0	$840,000	=	$ 832,000
	Mod and Minor - Injury B & C Crashes	1	1.0	$47,900	=	$ 47,000
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$55,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$55,000	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [1]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 1,350,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 270,000

Estimated Project Cost = $ 183,538

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 270,000 x 12.46 [2] = **18.33**

$ 183,538

For Office Use Only
File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	27th at Reed Market		Region: IV	Date:	9/10/12
Project on Local Agency Facility Route Number:		Street Name: 27th Street	MP Range or Cross Street: Reed Market		
Project on State Highway Route Number:		Hwy Name: IN	MP From:	to	
Road Character:		Facility Type:			
County:		City:	Crash Data From: 1/1/2006	to	12/31/2010
Project Description:	Convert permitted phasing to protected only phasing bychanging signal head/timing. Convert to arrow heads EB with Lane Assignment signs				
Prepared By:	Robin Lewis		Title: Transportation Engineer		

		Collision Type	Crash Reduction Factor	
Countermeasure 1	Convert to Protected only phasing from permitted	Angle	99%	CMF
Countermeasure 2	Convert to Arrow heads EB with Laneassignment signs	Run off Road - Fixed Object	20%	est
Countermeasure 3				
Countermeasure 4				

Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Angle					
	Fatal and Severe - Fat & Inj A Crashes	2	2.0	$840,000	=	$ 1,663,000
	Mod and Minor - Injury B & C Crashes	2	2.0	$47,900	=	$ 95,000
	PDO Crashes	1	1.0	$15,000	=	$ 15,000
Collision Type	Run off Road - Fixed Object	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	3	0.6	$47,900	=	$ 29,000
	PDO Crashes	0	0.0	$15,000	=	$ -
Collision Type	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -
Collision Type	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
	PDO [3]	
All facilities	$15,000	$15,000
	Moderate (Injury B) and Minor (Injury C) Injury [4]	
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
	Fatal and Severe (Injury A) Injury [4]	
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 1,802,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 360,000

Estimated Project Cost = $ 96,740

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 360,000 x 12.46 [2] = **46.37**

$ 96,740

For Office Use Only

File Code: PRO 08 -_______-_______

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Franklin at 1st Street Crash Mitigation	Region:	IV	Date:	7/23/12
Project on Local Agency Facility					
Route Number:		Street Name: Franklin Avenue		MP Range or Cross Street:	
Project on State Highway					
Route Number:		Hwy Name: PRINGS		MP From:	to
Road Character:		Facility Type: WAY			
County:		City: Bend		Crash Data From: 1/1/2006	to 12/31/2010
Project Description:	Road Diet to eliminate 2 to 5 road widening without proper tapers; project will sequentially organize 2 to 3 to 5 lane widening and accommodate				
Prepared By:	Robin Lewis	Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor	
Countermeasure 1	Road Diet	All	29%	hsm 13.4.2.3
Countermeasure 2				
Countermeasure 3				
Countermeasure 4				

Collision Type All	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
Mod and Minor - Injury B & C Crashes	3	0.9	$47,900	=	$ 42,000
PDO Crashes	1	0.3	$15,000	=	$ 4,000

Collision Type	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
PDO Crashes		0.0	$15,000	=	$ -

Collision Type	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
PDO Crashes		0.0	$15,000	=	$ -

Collision Type	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
PDO Crashes		0.0	$15,000	=	$ -

Total Crash Value for 60 Months = $ 46,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 9,000

Estimated Project Cost = $ 207,531

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = $ 9,000 x 12.46 [2] / $ 207,531 = **0.54**

For Office Use Only
File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Awbrey at Portland			Region:	IV	Date:	9/10/12
Project on Local Agency Facility Route Number:		Street Name:	Portland	MP Range or Cross Street:	Awbrey		
Project on State Highway Route Number:		Hwy Name:	IN	MP From:		to	
Road Character:		Facility Type:					
County:		City:		Crash Data From:	1/1/2006	to	12/31/2010
Project Description:	Do not block intersection regulatory/signal blocks sight lines warning						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor
Countermeasure 1	mini roundabout, illumination, marked crosswalks	all	78%
Countermeasure 2			
Countermeasure 3			
Countermeasure 4			

Collision Type	all	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	6	4.7	$47,900	=	$ 224,000
	PDO Crashes	5	3.9	$15,000	=	$ 59,000

Collision Type	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	3	0.0	$47,900	=	$ -
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Collision Type	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 283,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 57,000

Estimated Project Cost = $ 98,883

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 57,000 x 12.46 [2] = **7.18**

$ 98,883

For Office Use Only

File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Bear Creek at Pettigrew			Region:	IV	Date:	9/10/12
Project on Local Agency Facility Route Number:		Street Name:	Bear Creek	MP Range or Cross Street:	Pettigrew		
Project on State Highway Route Number:		Hwy Name:	IN	MP From:		to	
Road Character:		Facility Type:					
County:		City:		Crash Data From:	1/1/2006	to	12/31/2010
Project Description:	Awareness of Stop Sign - Northbound and Westbound						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor
Countermeasure 1	stop sign compliance/awareness	Angle	50%
Countermeasure 2			
Countermeasure 3			
Countermeasure 4			

		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Collision Type	*Angle*					
	Fatal and Severe - Fat & Inj A Crashes	1	0.5	$840,000	=	$ 420,000
	Mod and Minor - Injury B & C Crashes	8	4.0	$47,900	=	$ 192,000
	PDO Crashes	6	3.0	$15,000	=	$ 45,000
Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	3	0.0	$47,900	=	$ -
	PDO Crashes	0	0.0	$15,000	=	$ -
Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -
Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
	PDO [3]	
All facilities	$15,000	$15,000
	Moderate (Injury B) and Minor (Injury C) Injury [4]	
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
	Fatal and Severe (Injury A) Injury [4]	
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 657,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 131,000

Estimated Project Cost = $ 6,820

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 131,000 x 12.46 [2] / $ 6,820 = **239.33**

For Office Use Only

File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Country Club at Murphy			Region:	IV	Date:	9/18/12
Project on Local Agency Facility							
Route Number:		Street Name:	Country Club		MP Range or Cross Street:	Murphy	
Project on State Highway							
Route Number:		Hwy Name:	IN	MP From:		to	
Road Character:		Facility Type:					
County:		City:		Crash Data From:	1/1/2006	to	12/31/2010
Project Description:	Awareness of Stop Sign - Northbound						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor
Countermeasure 1	stop sign compliance/awareness	Angle	50%
Countermeasure 2			
Countermeasure 3			
Countermeasure 4			

Collision Type:	Angle	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	1	0.5	$840,000	=	$ 420,000
	Mod and Minor - Injury B & C Crashes	1	0.5	$47,900	=	$ 24,000
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type:	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	0	0.0	$47,900	=	$ -
	PDO Crashes	0	0.0	$15,000	=	$ -

Collision Type:	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Collision Type:	0	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
	PDO [3]	
All facilities	$15,000	$15,000
	Moderate (Injury B) and Minor (Injury C) Injury [4]	
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
	Fatal and Severe (Injury A) Injury [4]	
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 444,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 89,000

Estimated Project Cost = $ 6,160

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 89,000 x 12.46 [2] / $ 6,160 = **180.02**

For Office Use Only
File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Greenwood at 1st			Region:	IV	Date:	9/13/12
Project on Local Agency Facility Route Number:		Street Name:	Greenwood Avenue		MP Range or Cross Street:	1st	
Project on State Highway Route Number:		Hwy Name:	PRINGS	MP From:		to	
Road Character:		Facility Type:	WAY				
County:		City:		Crash Data From:	1/1/2006	to	1/1/2010
Project Description:	Curb Extensions						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor	
Countermeasure 1	Curb Extensions	Angle	20%	NO CMF - estimated based on improved
Countermeasure 2				
Countermeasure 3				
Countermeasure 4				

		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Collision Type	*Angle*					
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$1,500,000	= $	-
	Mod and Minor - Injury B & C Crashes	1	0.2	$47,900	= $	10,000
	PDO Crashes	4	0.8	$15,000	= $	12,000
Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	= $	-
	Mod and Minor - Injury B & C Crashes	3	0.0	$47,900	= $	-
	PDO Crashes	2	0.0	$15,000	= $	-
Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	= $	-
	Mod and Minor - Injury B & C Crashes	2	0.0	$47,900	= $	-
	PDO Crashes	4	0.0	$15,000	= $	-
Collision Type		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$1,500,000	= $	-
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	= $	-
	PDO Crashes		0.0	$15,000	= $	-

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 48 Months = $ 22,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 6,000

Estimated Project Cost = $ 44,376

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 6,000 x 12.46 [2] = **1.68**

$ 44,376

For Office Use Only
File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Greenwood Hill			Region:	IV	Date:	7/23/12
Project on Local Agency Facility							
Route Number:		Street Name:	Greenwood Avenue		MP Range or Cross Street:	Hill Street	
Project on State Highway							
Route Number:		Hwy Name:	PRINGS	MP From:		to	
Road Character:		Facility Type:	WAY				
County:		City:		Crash Data From:	1/1/2006	to	1/1/2010
Project Description:	Curb Extensions						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor	
Countermeasure 1	Curb Extensions	Ped Crossing	20%	NO CMF - estimated based on improved
Countermeasure 2	Illumination on Curb Extensions	all night	38%	cmf
Countermeasure 3	Curb Extensions	sidestreet due to visibility	10%	NO CMF - estimated based o
Countermeasure 4				

		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Collision Type	*Ped Crossing*					
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	1	0.2	$47,900	=	$ 10,000
1 rear end (did not ht ped)	PDO Crashes	1	0.2	$15,000	=	$ 3,000

		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Collision Type	*all night*					
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	2	0.8	$47,900	=	$ 36,000
	PDO Crashes	1	0.4	$15,000	=	$ 6,000

		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Collision Type	*sidestreet due to visibility*					
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	2	0.2	$47,900	=	$ 10,000
	PDO Crashes	3	0.3	$15,000	=	$ 5,000

		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Collision Type						
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
	PDO [3]	
All facilities	$15,000	$15,000
	Moderate (Injury B) and Minor (Injury C) Injury [4]	
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
	Fatal and Severe (Injury A) Injury [4]	
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for	48	Months =	$	70,000
Annual Benefits =	Total Crash Value / Total Months / 12	=	$	18,000
	Estimated Project Cost	=	$	167,655

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = $ 18,000 x 12.46 [2] / $ 167,655 = **1.34**

For Office Use Only

File Code: PRO 08 -_____-_____

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name:	Wilson at 2nd			Region:	IV	Date:	9/10/12
Project on Local Agency Facility Route Number:		Street Name:	Wilson	MP Range or Cross Street:	2nd		
Project on State Highway Route Number:		Hwy Name:	IN	MP From:		to	
Road Character:		Facility Type:					
County:		City:		Crash Data From:	1/1/2006	to	12/31/2010
Project Description:	Do not block intersection regulatory/signal blocks sight lines warning						
Prepared By:	Robin Lewis			Title:	Transportation Engineer		

		Collision Type	Crash Reduction Factor
Countermeasure 1	do not block intersection	Angle	50%
Countermeasure 2			
Countermeasure 3			
Countermeasure 4			

		Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Collision Type	*Angle*					
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	5	2.5	$47,900	=	$ 120,000
	PDO Crashes	4	2.0	$15,000	=	$ 30,000
Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes	0	0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes	0	0.0	$47,900	=	$ -
	PDO Crashes	0	0.0	$15,000	=	$ -
Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -
Collision Type	*0*	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
	Fatal and Severe - Fat & Inj A Crashes		0.0	$840,000	=	$ -
	Mod and Minor - Injury B & C Crashes		0.0	$47,900	=	$ -
	PDO Crashes		0.0	$15,000	=	$ -

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for 60 Months = $ 150,000

Annual Benefits = Total Crash Value / Total Months / 12 = $ 30,000

Estimated Project Cost = $ 18,480

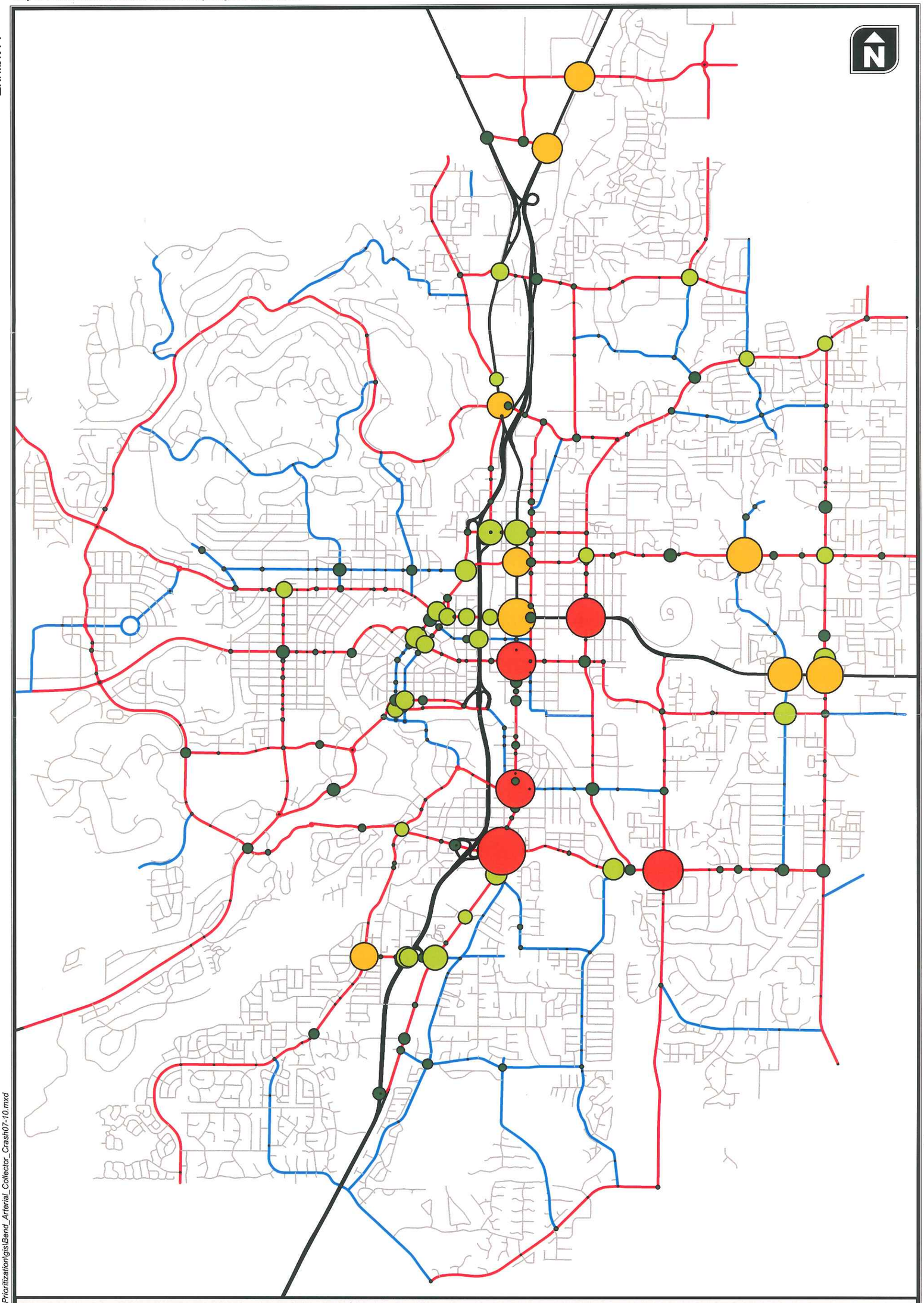
Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 30,000 x 12.46 [2] = **20.23**

$ 18,480

Exhibit A



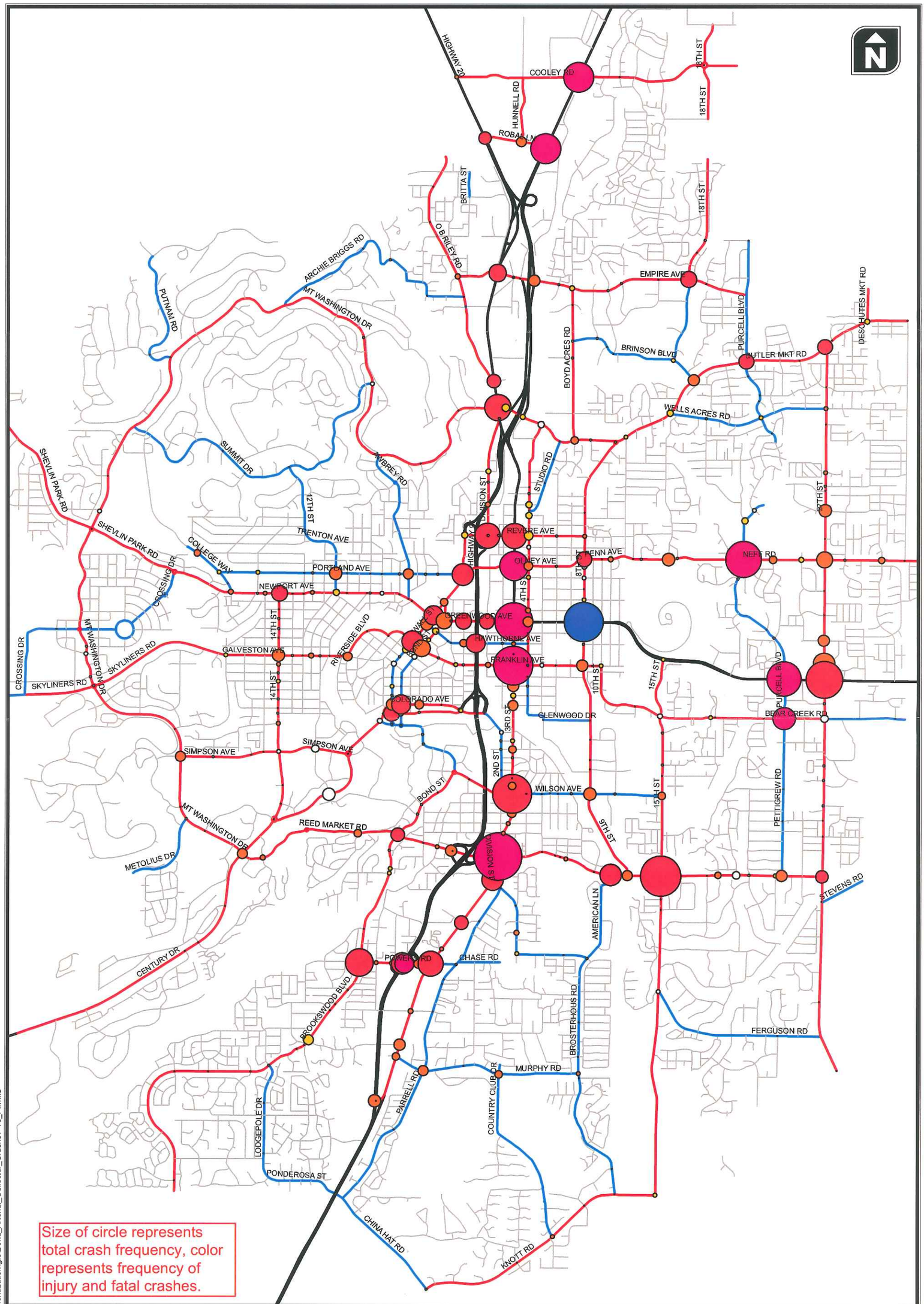
2007-2010 Total Crashes on Arterial & Collector Streets

Figure 1-1

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

H:\profile\11645 - Bend Safety Project Prioritization\gis\Bend_Arterial_Collector_Crash07-10.mxd

Exhibit A



Size of circle represents total crash frequency, color represents frequency of injury and fatal crashes.

Number of FI Crashes at Intersection
- 0
- 1
- 2-5
- 6-10
- 11-15
- 16-20

Roadway Functional Class
- Local
- Collector, City
- Arterial, City
- Principal Arterial, ODOT

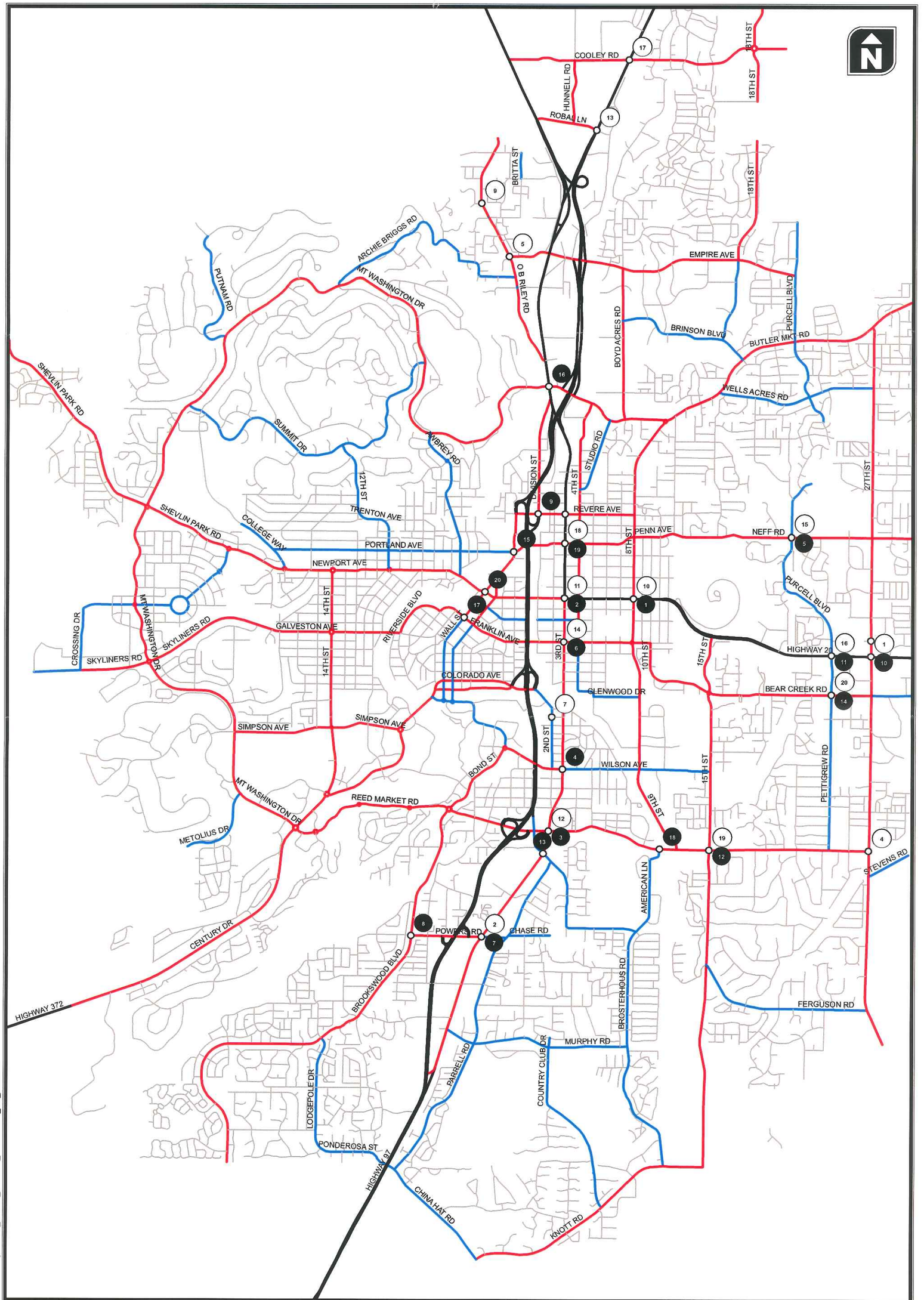
2007-2010 Total and FI Crash Frequency on Arterial & Collector Streets

Figure 1-1

KITTELSON & ASSOCIATES, INC.

H:\proj\file\11645 - Bend Safety Project Prioritization\gis\Bend_Arterial_Collector_Crash07-10_FI.mxd

Exhibit A



Relative Severity Index Ranking
Equivalent PDO Ranking
Ranked Intersection

Roadway Functional Class
Local
Collector, City
Arterial, City
Principal Arterial, ODOT

2007-2010 Intersection Ranking on Arterial & Collector Streets

Figure
1-X

KITTELSON & ASSOCIATES, INC.

H:\proj\file\11645 - Bend Safety Project Prioritization\gis\Bend_Arterial_Collector_Crash07-10_NS_results.mxd

Traffic Safety

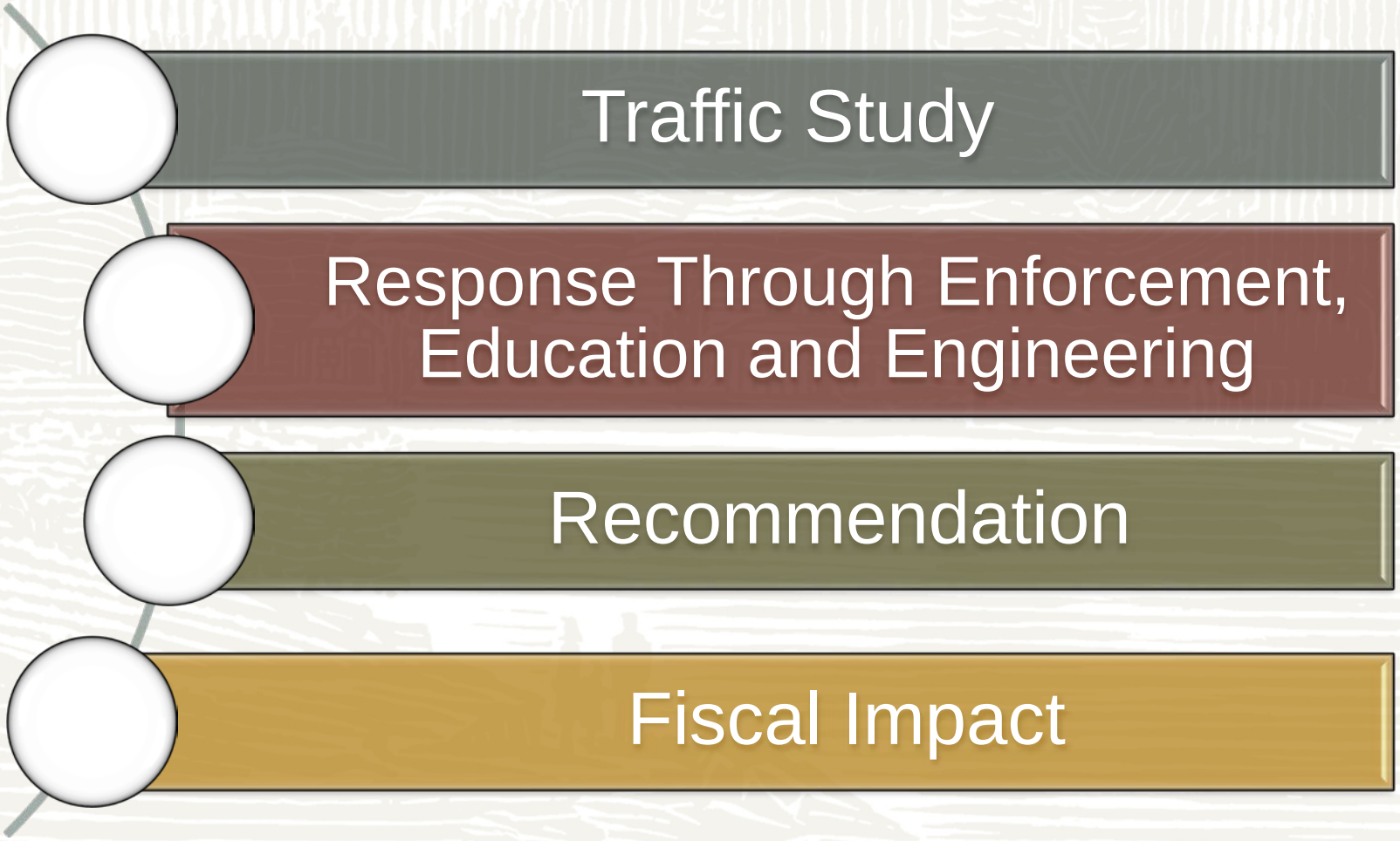
Council Presentation

Jeff Sale, Chief of Police

September 18, 2013

Exhibit A

Traffic Safety Overview



Why this is Important?

Exhibit A

- The City of Bend Transportation Division completed a comprehensive analysis of traffic crashes that occurred within the City of Bend between 2006 and 2010

  This comprehensive study looked at the causes, locations and financial impact of traffic crashes
- The estimated economic impact of these crashes is $219M
- This included 24 fatalities
- 42% of collisions involved excessive speed, alcohol or drugs

Exhibit A

Information Led Policing (ILP)

High Crash Locations within the City of Bend

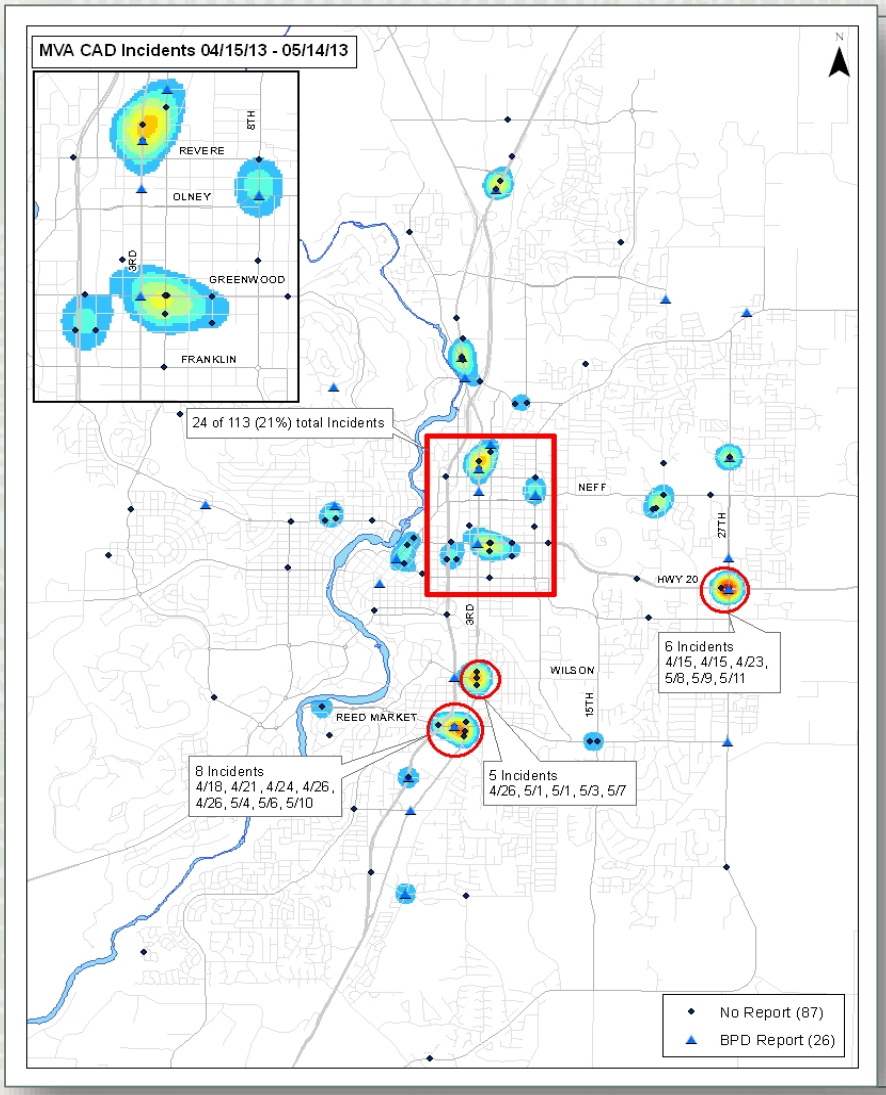
Collector Streets

High Commute Times

School Zone

Exhibit A

Hot Spot Mapping



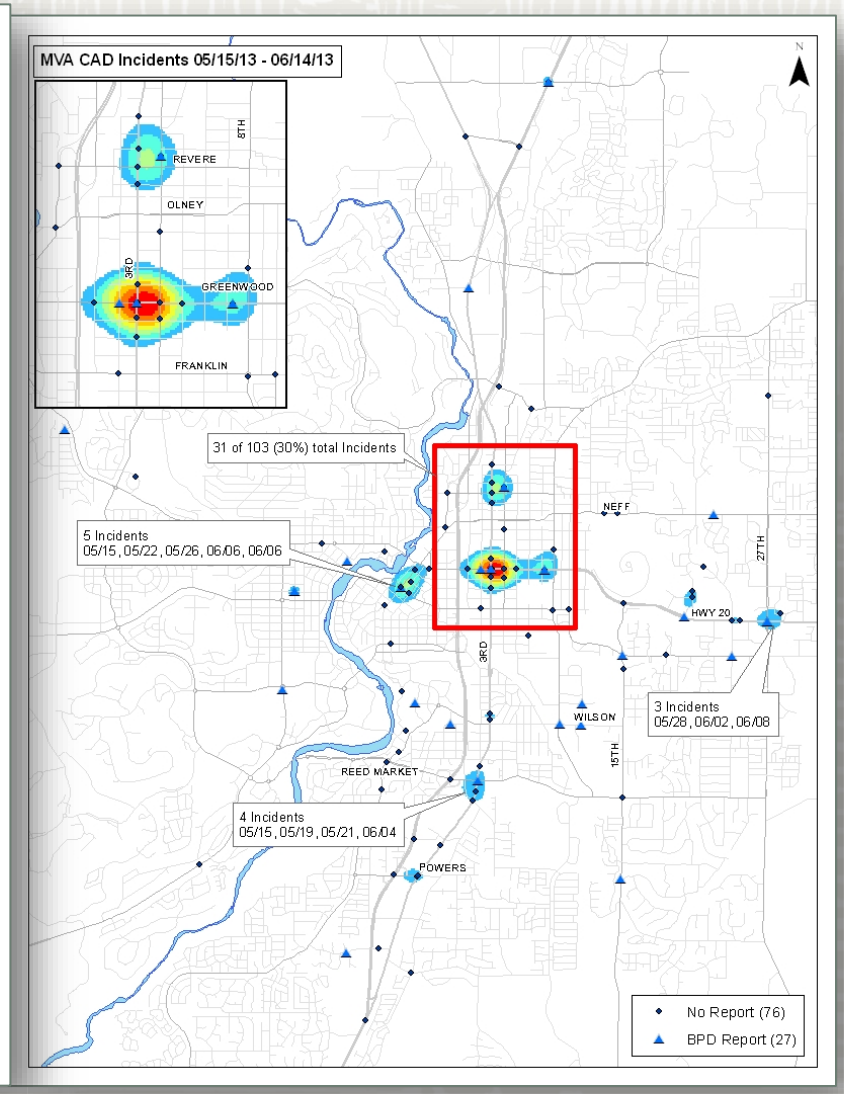


Exhibit A

Increase DUII Focus

- Increased DUII focus will provide daily DUII specific patrol.
- Should add an additional 261 plus DUII arrests annually.

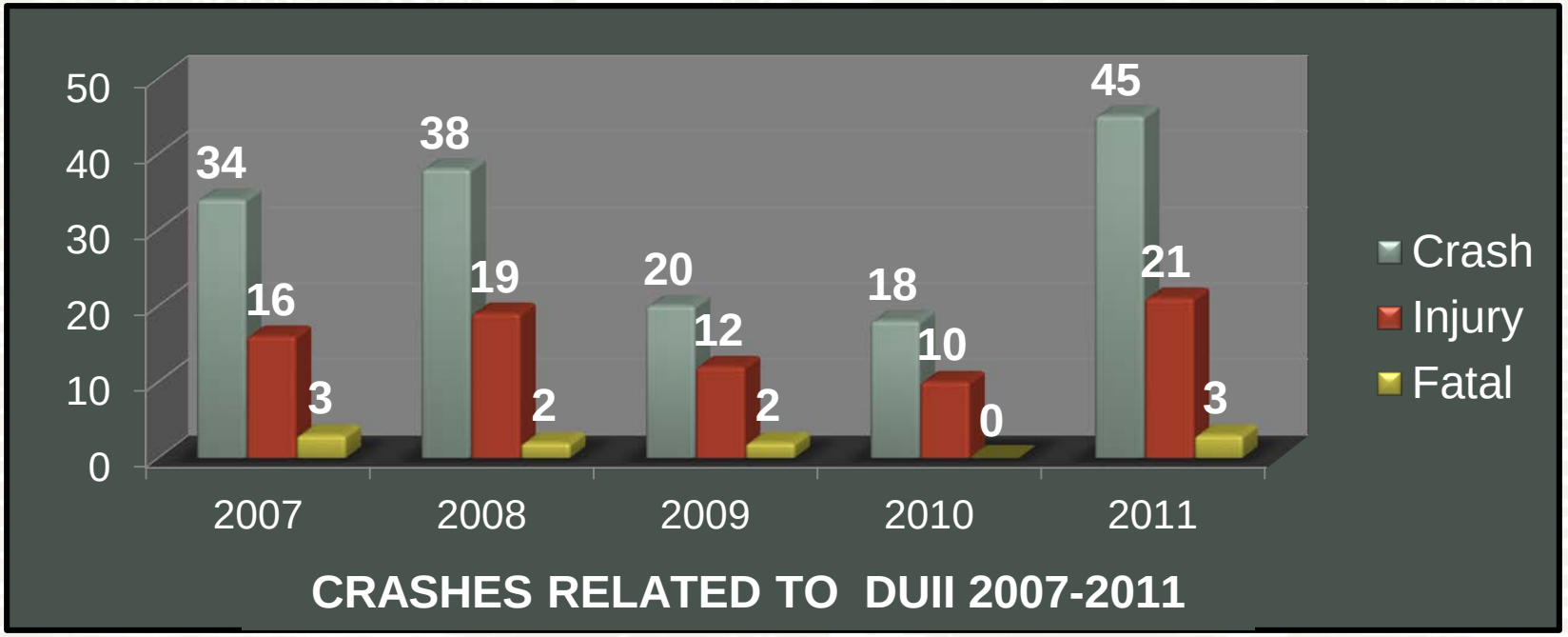


Exhibit A

Education

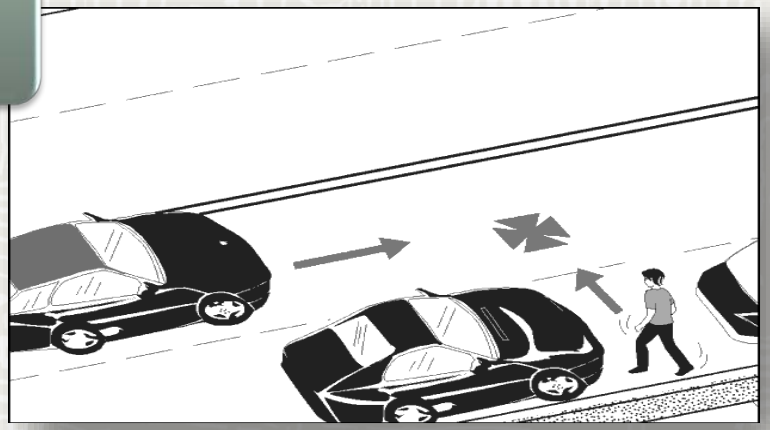
- Bicycle Diversion Program
- Speed Grants
- Media Outreach
- Pedestrian Safety Grants
- Traffic School
- DUII Grants
- High School Driver Education
- DUII Victims Impact Panel
- Three Speed Display Signs
- Seatbelt Grant

Engineering -Traffic Safety Program

Exhibit A

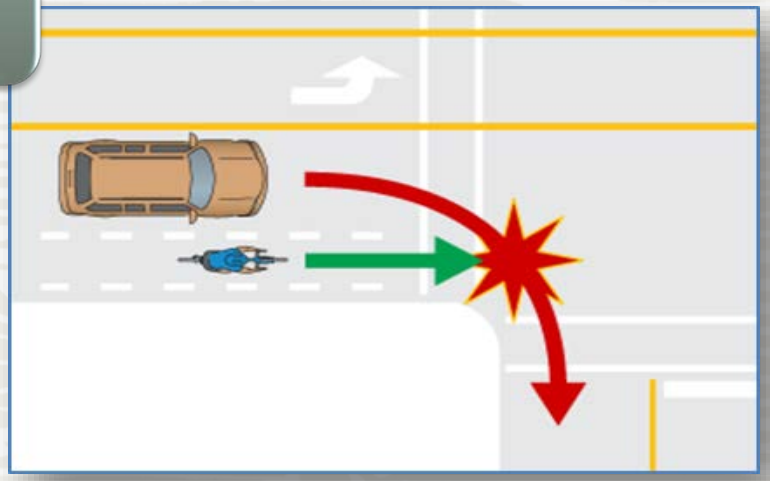
Multi-lane street crossings

- 3rd Street
- Greenwood Avenue



Countermeasure plan for bike/auto right turn crashes

- 3rd/Franklin
- Neff/Purcell
- 3rd/Reed Market



Engineering -Traffic Safety Program

Exhibit A

Speed Limit Analysis

- Speeds by state order
- Previously county jurisdiction
- Safety issues in rapidly urbanizing areas
  - Higher injury/fatal crashes
  - Limited safety facilities yet high speed postings

Engineering - Traffic Safety Program

Exhibit A

Injury Crash Reduction Program with ODOT

- New federally funded Safety Program
- Low cost but effective safety features
- Jurisdictionally blind (on Bend roadways)
- Needs IGA and 7.78% local match

Engineering - Traffic Safety Program

Low Cost Safety Measures

- Sight line/vegetation
- Lighting
- Signing
- Marking
- Roadside (trees, mailboxes, utility poles, drop offs)

Exhibit A

E-Ticketing

- Efficiency of drafting citation
- Reduction of errors
- Reduction in staff time for data entry
- Police and Municipal Court
- Improved legibility for Violator, Police, and Court staff

What do we need?

Staff

- 2 Patrol Officers
- 1 Corporal
- 1 Admin Assistant
- 1 Court Clerk

Equipment

- 2 Patrol Vehicles
- 1 Motorcycle
- Standard Patrol Equipment

Exhibit A

What is the benefit?

Proposed outcomes over next 5 years:

- 25% Reduction of overall crashes
- 35% Reduction in injuries
- 50% Reduction in fatalities

Exhibit A

Finance – Budget Proposal FY14-15

Traffic Team and Court Operations	
Additional Police Staffing and M&S	$434,100
Additional Court Staffing and M&S	64,400
One-Time Equipment/Vehicles	136,000
Total Budget Request	$634,500

Finance – Net Cost to General Fund

Exhibit A

Proposal (Based on a start date of 7/1/14)		
On-going Additional Expenses:		
3 Entry Level Patrol Officers + 1 Admin staff	$405,000	
Additional expense for 1 Corporal promotion	5,700	
Additional M&S	25,400	
Additional expense for Court staff	62,400	
Additional expense for Judge and court sessions	0	
Total		$498,500
Estimated Additional Revenues		$396,000
Estimated Net Cost to General Fund		$102,500

Exhibit A

Finance – Net Cost to General Fund

Traffic Team and Court Operations	Net Cost to General Fund
Current Net Cost	$187,000
Additional Estimated Net Cost with Proposed Staffing	102,500
Total Estimated Net Cost of Traffic Team and Court Operations	$289,500

Exhibit B

DRAFT
Final Concept Report

Bend Safety Implementation Plan

June 2015

alta PLANNING + DESIGN

KITTELSON & ASSOCIATES, INC. TRANSPORTATION ENGINEERING/PLANNING

CENTURY WEST ENGINEERING CORPORATION

Introduction

This report summarizes the conceptual design of safety solutions at priority locations in the four corridors addressed by this project:

- 3rd Street between Greenwood Avenue and Murphy Road
- Colorado Avenue between Bend Parkway and Bond Street
- Greenwood Avenue West between 3rd Street and Awbrey Road
- Greenwood Avenue East between 3rd Street and 12th Street

Corridor Concepts

The Alta team, which includes Kittelson Associates, Inc, and Century West, developed two to three street design concept alternatives for each corridor based on the findings of the Existing Conditions, Opportunities and Challenges memo. The recommended corridor crossing plans were based on input received during two public open house events, discussions with key stakeholders, and meetings with the Technical Advisory Committee (TAC).

Two priority projects from each corridor crossing plan, plus four additional projects pre-selected by City staff, were recommended for conceptual and preliminary design.

Concept Design

The team created two alternatives for each location, order of magnitude construction costs, and a schedule of maintenance requirements and costs. In April 2015, the concepts were shared with the TAC and the public at an open house. Based on those comments, as well as comments and questions from property owners and other stakeholders, City staff confirmed the TAC direction on the final concept for each location. The final concepts will move forward to preliminary engineering. The TAC and the public will continue to be involved in refining the design of improvements through the next phase of the project.

Selected Projects:

- 27th Street and Conners Avenue
- 3rd Street and Reed Market Road
- 3rd Street and Roosevelt Avenue
- 3rd Street and Hawthorne Avenue
- Colorado Avenue and Bend Parkway Approach Ramps
- Colorado Avenue - Bond Street to Bend Parkway
- Purcell Boulevard and Neff Road
- Franklin Avenue and 3rd Street
- Greenwood Avenue and 3rd Street
- Greenwood Avenue and 4th Street
- Greenwood Avenue and 6th Street
- Neff Road and Williamson Boulevard

Toolbox of Counter-Measures

Median Refuge

- Allow pedestrians a safe place to wait
- Improve visibility of pedestrian crossings, particularly at un-signalized intersections
- Provide space for supplemental signs on multi-lane roadways

Best Use:

- Curbed, multi-lane roadways
- More than 15,000 ADT on four lane roads
- Intermediate to high travel speeds
- Mixture of pedestrian and vehicle traffic

Four Options:

- Left Side Median
- Right Side Median
- Median with Bicycle Gap

Six Locations:

- 3rd Street & Hawthorne Avenue
- 3rd Street & Roosevelt Avenue
- Greenwood Avenue & 4th Street
- Greenwood Avenue & 6th Street
- Neff Road & Williamson Boulevard
- 27th Street & Conners Avenue

Corner Radii Modification

- Reduce crossing distance for pedestrians
- Improve visibility of pedestrians at intersections
- Reduce speed of turning vehicles

Best Use:

- Corners that were designed to accommodate larger turning vehicles than are now necessary
- Intersections where larger vehicles can turn across a painted median or into an adjacent travel lane
- Intersections with a high number of conflicts between right-turning vehicles and pedestrians

Corridor Modification

- Reduce crossing distance for pedestrians
- Repurpose space in the public right-of-way for people

Best Use:

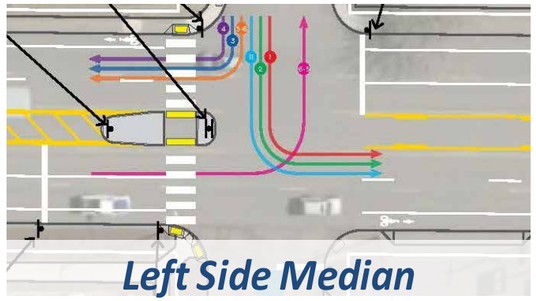
- Roads built wider than needed for existing traffic volumes and desired vehicle speeds
- Corridors with high volumes of pedestrians, or potential for higher pedestrian volumes
- Reducing the opportunity for multiple-threat crashes

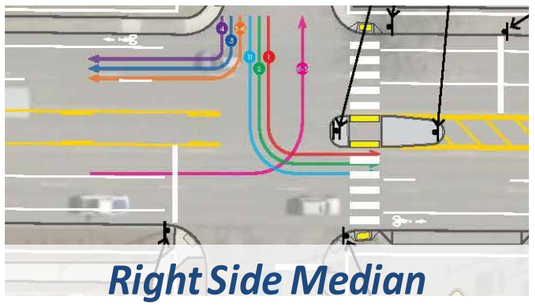
Bicycle Safety

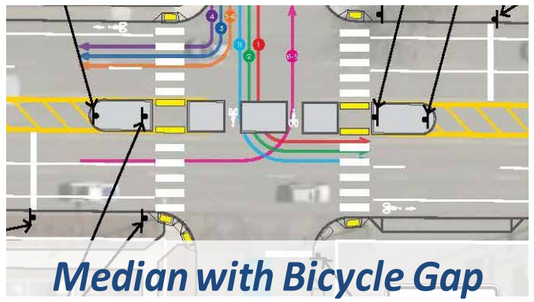
- Heighten the level of visibility and awareness of potential conflicts
- Denote a clear right-of-way

May include:

- Color (green)
- Pavement markings
- Signs
- Signal detection







Selection Considerations

The City of Bend Bike and Pedestrian Technical Advisory Committee (TAC) reviewed all of the concepts and identified the preferred option for each location. In reviewing and discussing the concepts, the TAC considered how the conceptual design performs with regard to the following considerations:

- Improved safety for all road users
- Cost efficiency
- Maintenance impacts relative to safety and community benefits
- Community support for each project
- Improvement of access to destinations
- Minimization of real estate property impacts
- Address universal accessibility at transit stops and adjacent destinations
- Coordination with current adopted plans (including the TSP), as well as anticipated development projects

This report presents the concepts developed for each project site. The Preferred Concept presented for each side reflects minor modifications to the design made by the City of Bend as a result of discussion with the TAC, and conversations at the Open House meetings in April 2015.

27th Street & Conners Avenue

TAC Preferred Concept Plan : Option 1

Countermeasures

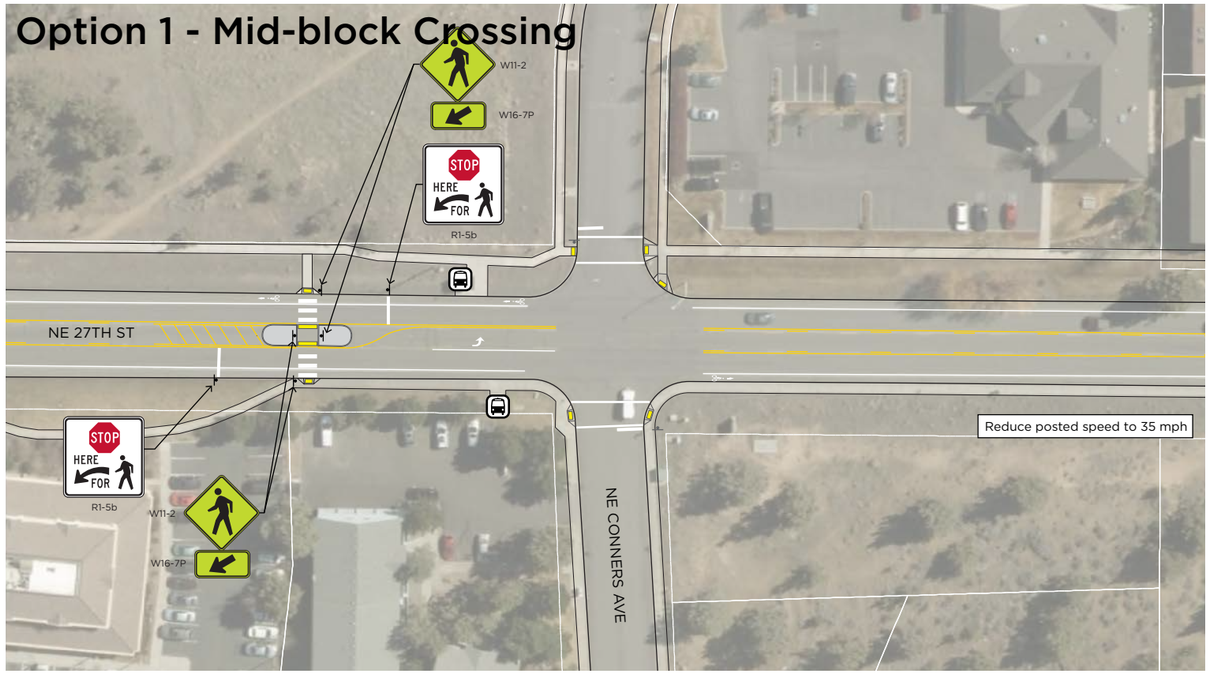
Option 1 features a marked crosswalk, median refuge island and mid-block crossing north of the intersection on 27th Street. Option 1 also includes appropriate pedestrian crossing warning signage (W11-2, W16-7P, and R1-5b). Option 2 calls for the installation of a full traffic signal at the intersection.

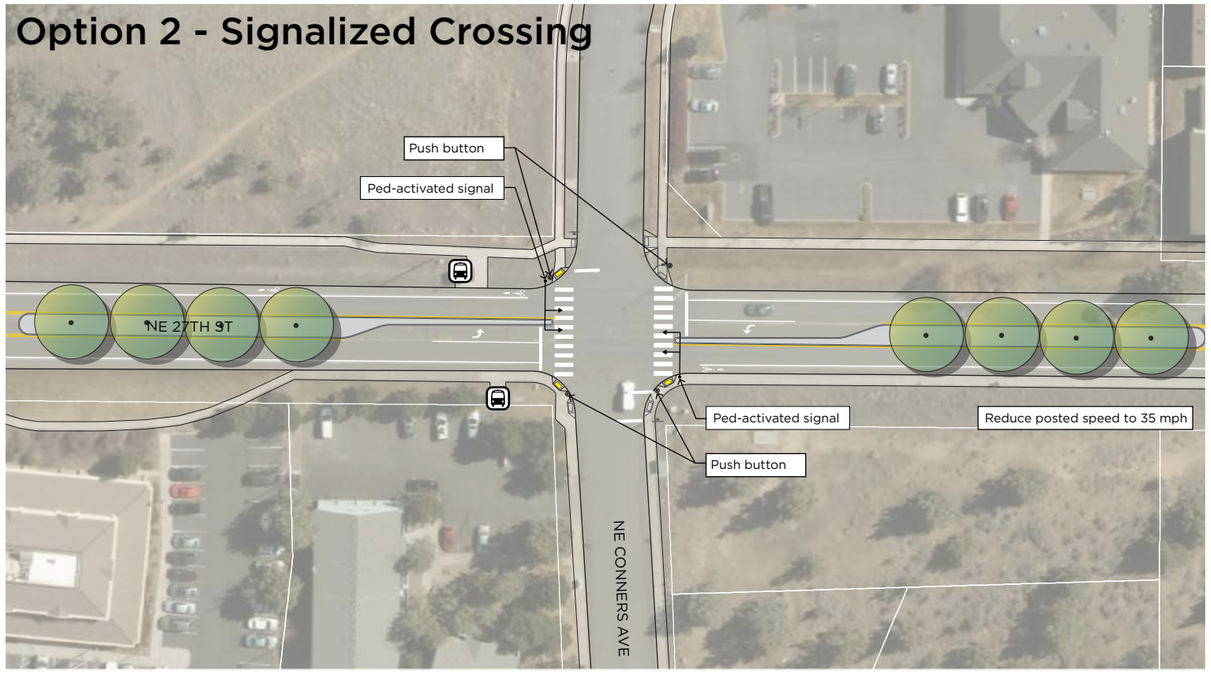
Summary of Recommended Improvements

- Add marked crosswalk, mid-block crossing and median refuge island on north leg of intersection

Next Steps

- Coordinate with CET regarding possible bus stop relocation





3rd Street & Reed Market Road

TAC Preferred Concept Plan

Countermeasures

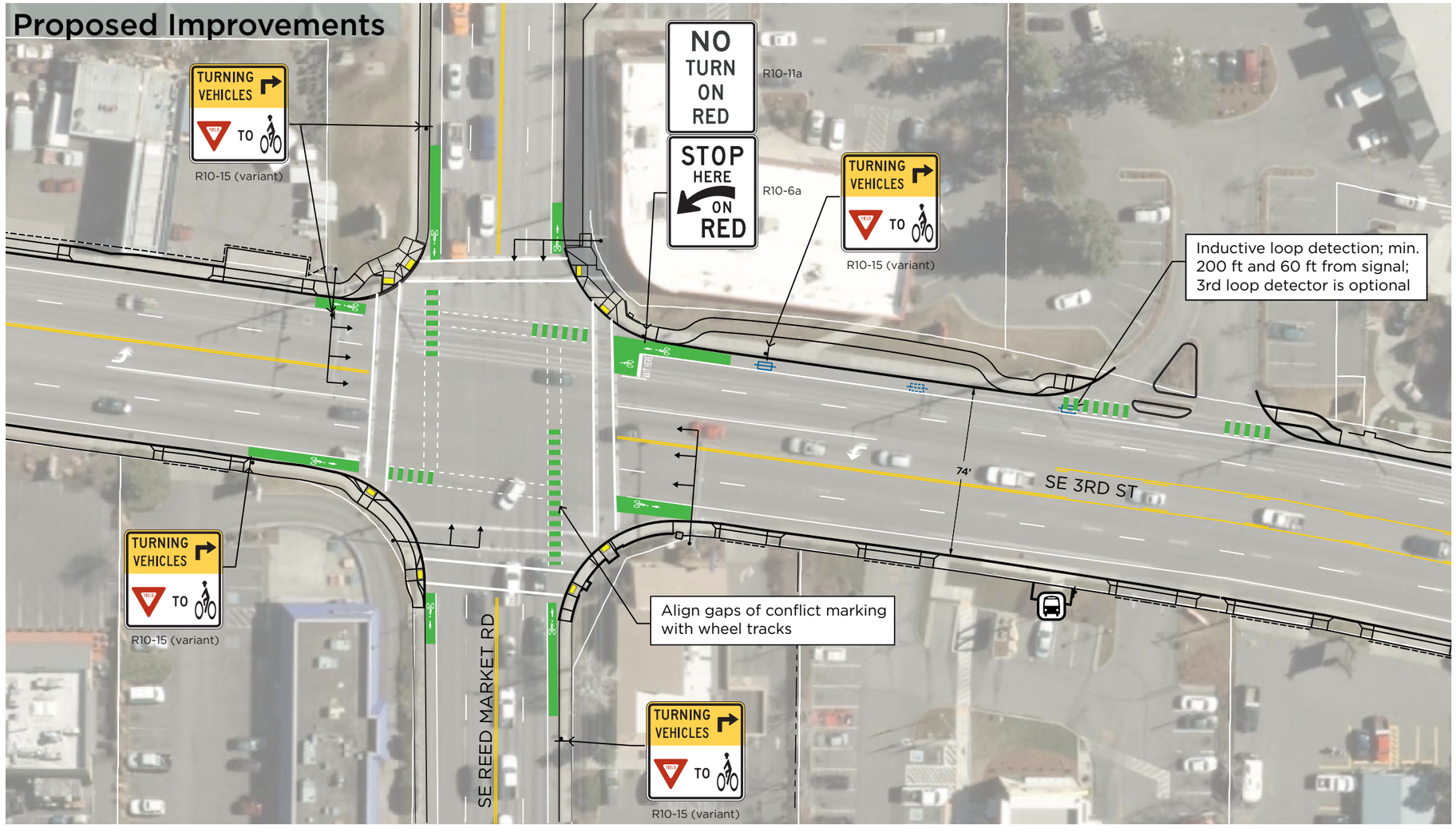
The proposed improvements include features bike lanes on all four legs of the intersection in each direction. The northbound approach on the south leg of the intersection features a green bike box. Bike lanes at intersection approaches are filled with green, and green bike lane line extensions are used in the intersection. Static warning signs are posted to alert right turning motorists of the presence of bicycles proceeding straight through the intersection.

Summary of Recommended Improvements

- Bicycle safety improvements through the intersection to reduce the potential for “right hook” crashes
- Add green fill in bike lanes at intersection approaches, and green bike box on south leg of intersection. No right turn allowed on red light.
- Add continuous bike lane line extension through intersection, supplemented with green fill between dashed line extension
- Add static warning signs (R10-15 Variant) to traffic signal mass arms and intersection approaches
- Add inductive loop detection; min. 200ft and 60 ft from signal; 3rd loop detector is optional.

Next Steps

- Consider a dynamic flashing warning sign in future phases



3rd Street & Roosevelt Avenue

TAC Preferred Concept Plan : Option 2

Countermeasures

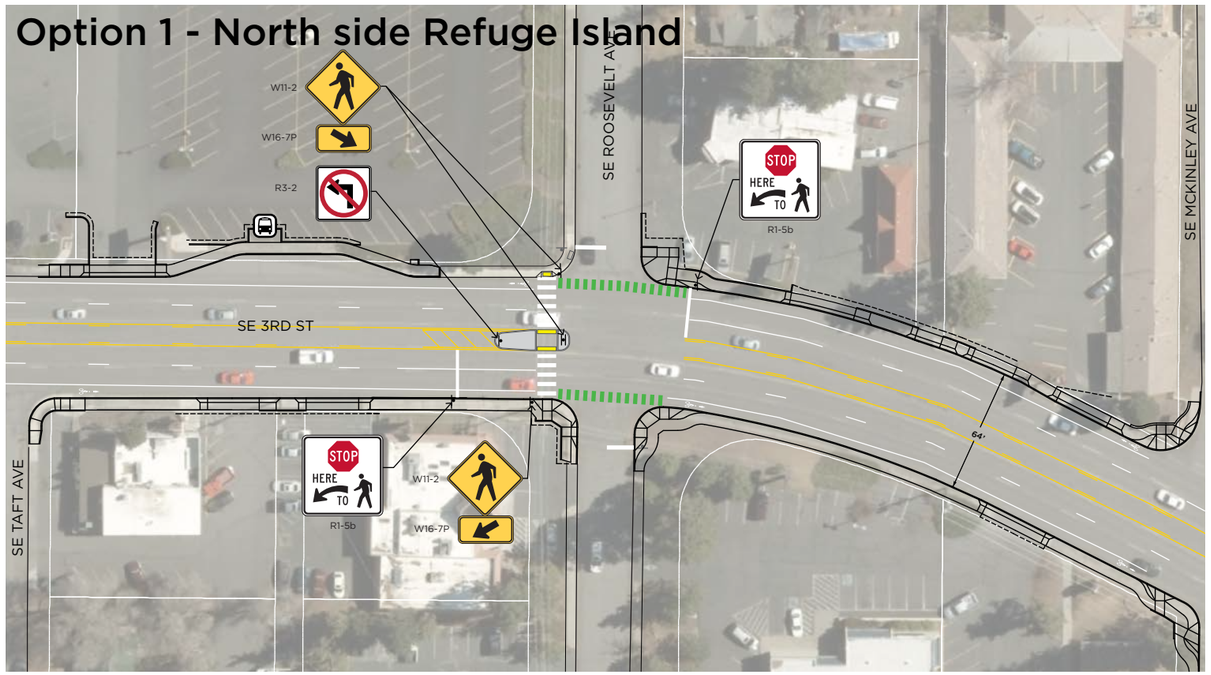
Option 1 features a marked crosswalk, median refuge island and warning signage on the north end of the intersection. Option 2 features a marked crosswalk, median refuge island, pedestrian crossing warning and Rectangular Rapid Flash Beacons (RRFB) on both the south and north sides of the intersection.

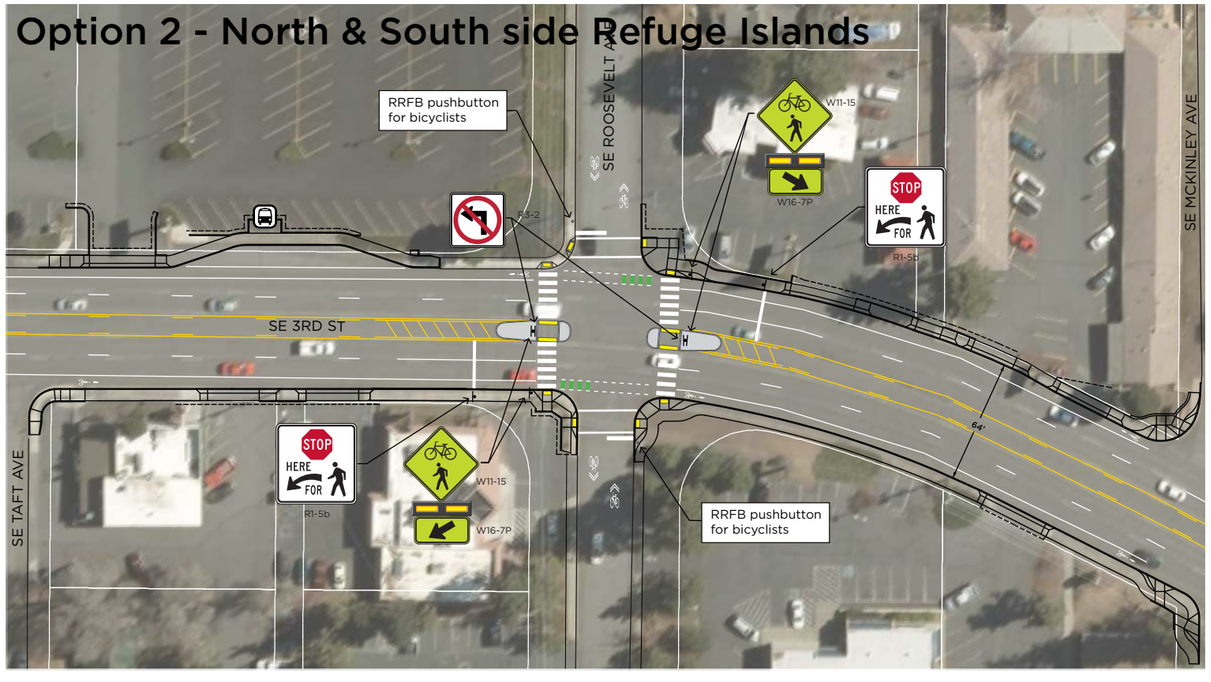
Summary of Recommended Improvements

- Add marked crosswalks, with refuge islands at Roosevelt
- Add median refuge island on north and south legs of intersection
- Add Rectangular Rapid Flash Beacons (RRFB)
- Add pedestrian crossing warning signage
- Add continuous bike lane line extension through intersection. Supplement with green fill between dashed line extensions

Next Steps

- Additional traffic study needed for RRFB





3rd Street & Hawthorne Avenue

TAC Preferred Concept Plan : Option 1B

Countermeasures

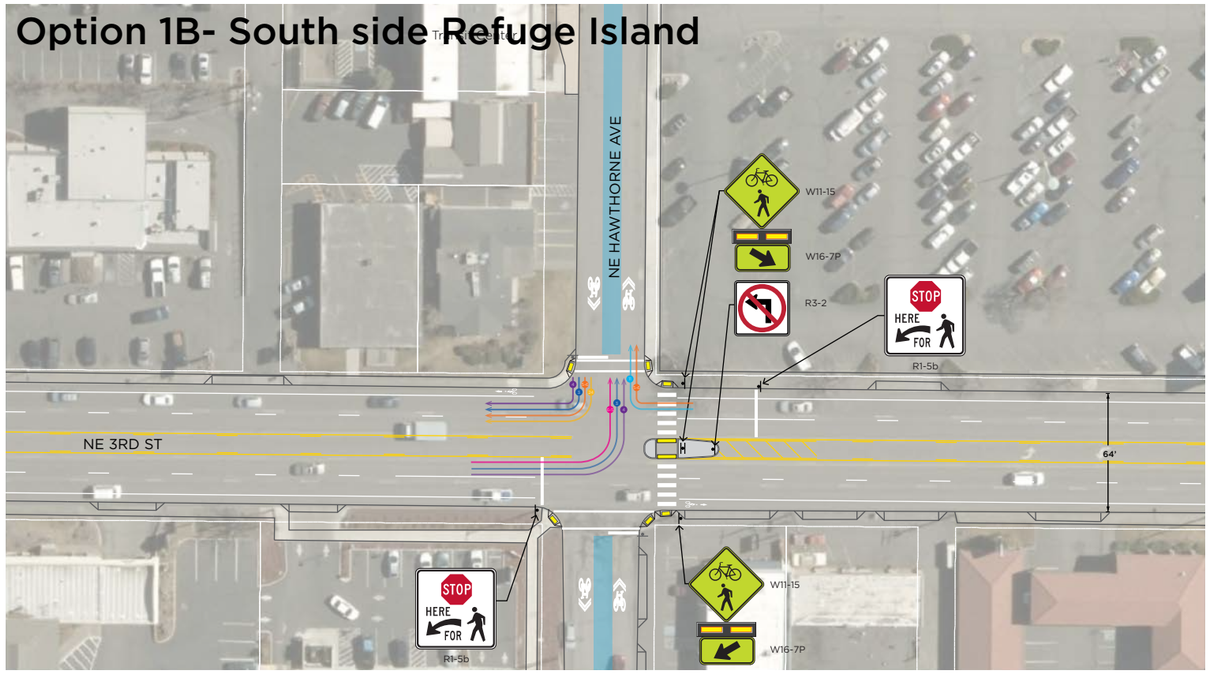
Option 1A features a median refuge island on the North side of the intersection. Option 1B features a median refuge island on the south side of the intersection. Option 2 features a full median refuge/diverter. Additionally, Option 1B features a Rectangular Rapid Flash Beacon (RRFB). Option 1B is preferred by CET for current bus turning movements.

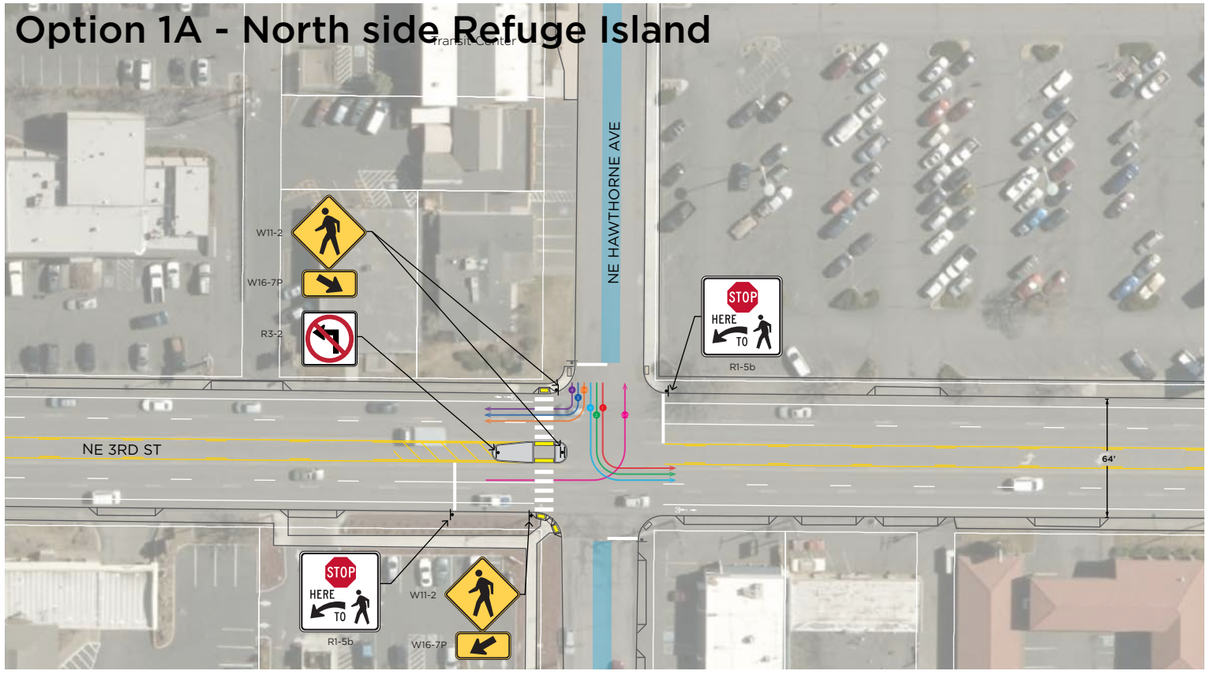
Summary of Recommended Improvements

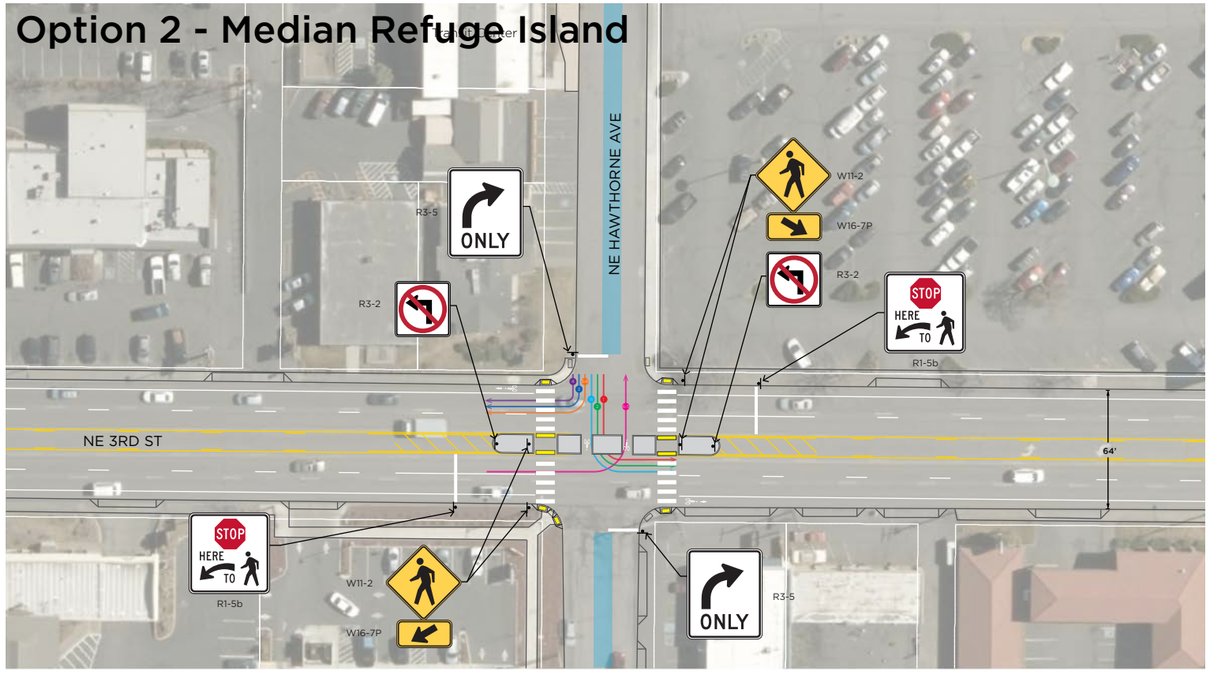
- Add marked crosswalk, with refuge island at Hawthorne
- Add median refuge island on south leg of intersection
- Add Rectangular Rapid Flash Beacon (RRFB)
- Add pedestrian crossing warning signage
- Add shared lane markings for Hawthorne Avenue Bike Boulevard

Next Steps

- Additional traffic study needed for RRFB







Colorado Avenue & Bend Parkway Ramps

TAC concept Plan : Option 1

Countermeasures

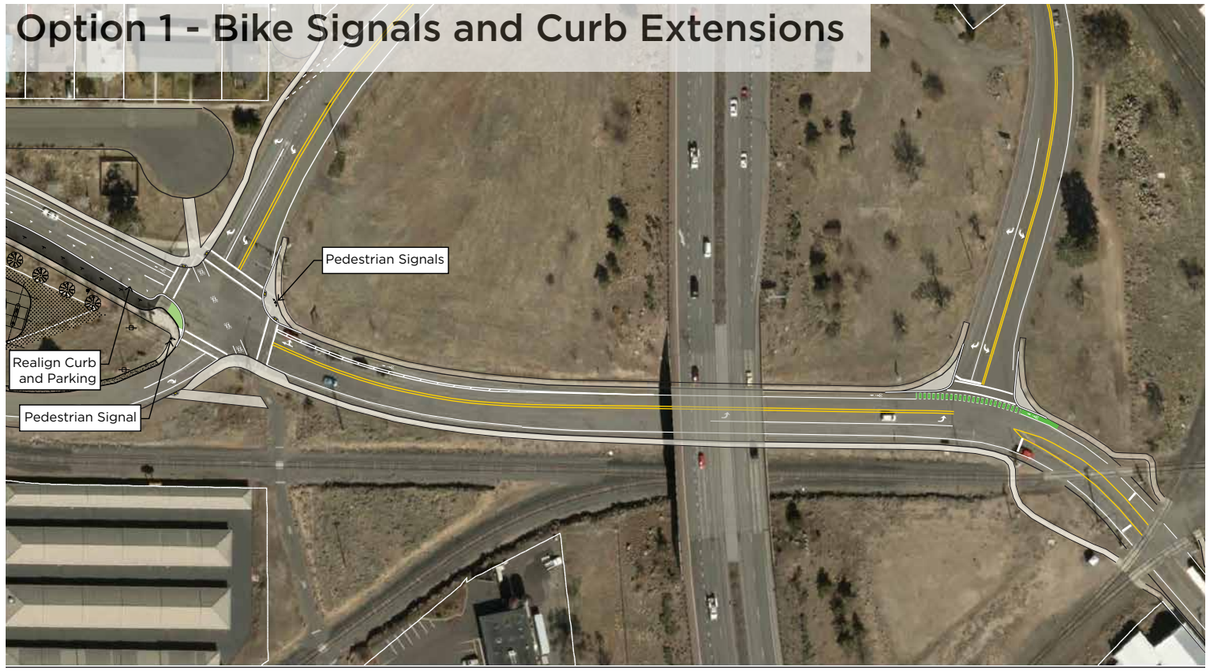
Option 1 features a bike signal for the diagonal intersection crossing and the addition of curb extensions to facilitate shorter pedestrian crossing distances and improved visibility. Option 1 also brings southbound cyclists onto the sidewalk path as they approach the intersection. Option 2 is a simpler version of Option 1 without a bike signal for the diagonal crossing or rerouting the bike lane to the sidewalk path. Option 2 also channelizes the bike lane with a concrete island at the west end the intersection.

Summary of Recommended Improvements

- Improve bicycle and pedestrian safety for crossing of Colorado Avenue and Parkway Ramps
- Add diagonal bike signal at NW corner of western ramp
- Tighten radius of SW corner and shorten diagonal crossing distance
- Move stop bars up, extend curbs to reduce crossing distances and increase visibility
- Add continuous bike lane line extension through intersection. Supplement with green fill between dashed line extension
- Add pedestrian signals to intersection
- Realign curb and parking

Next Steps

- Additional traffic analysis of freight mobility, signal design and change approvals needed



Colorado Avenue - Bond Street to Bend Parkway

TAC Preferred Concept Plan : Option 2

Countermeasures

Option 1 features a 7 ft buffered bike lane with one parking lane on the south side of the street. Option 2 features a protected bike lane with an additional row of parking adjacent to the protected bike lane.

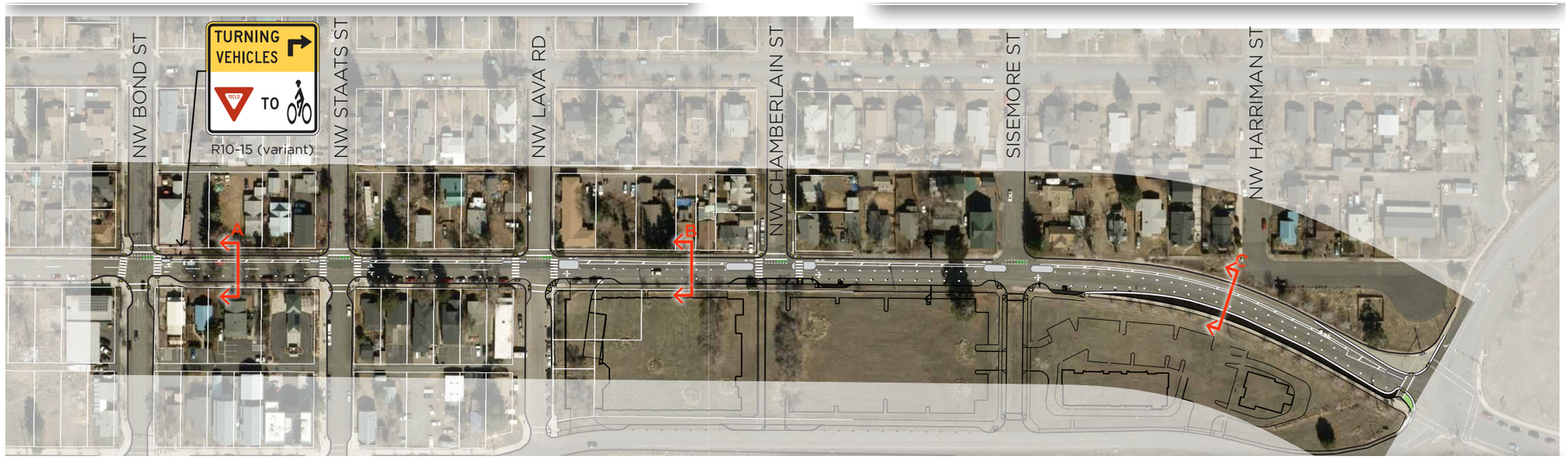
Summary of Recommended Improvements

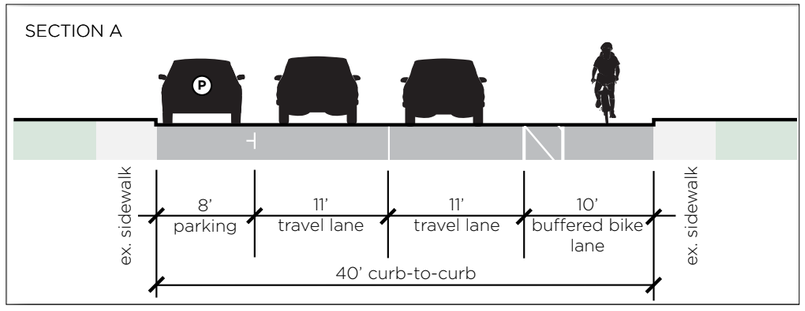
- Add protected bike lane on north side of Colorado Ave
- Add marked continental crosswalks and median refuge islands at all intersections
- Add continuous bike lane line extension through intersection. Supplement with green fill between dashed line extension
- Reduce posted speed limit from 30mph to 20-25 mph

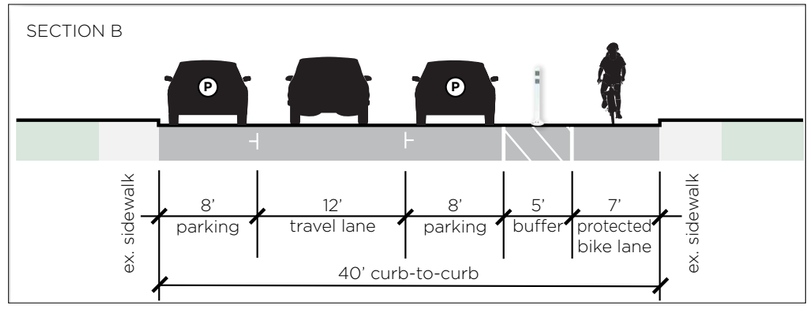
Next Steps

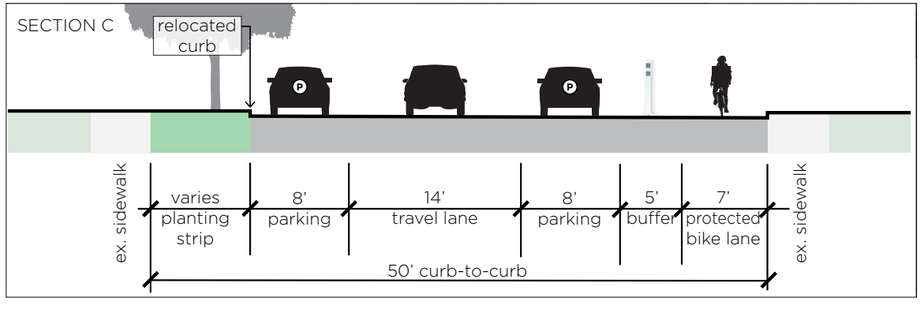
- Additional traffic analysis to study freight mobility
- Consider mixing zones for protected bike lane and right turning vehicles at east leg of each intersection

Option 2 - Protected Bike Lane/Buffered Bike Lane



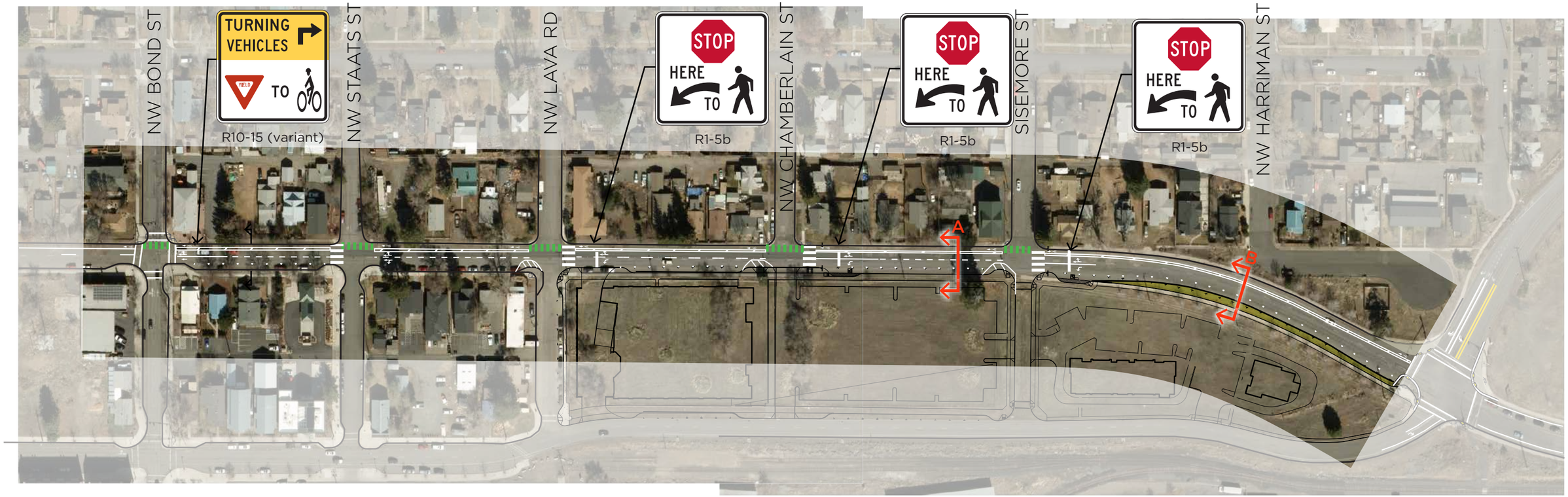


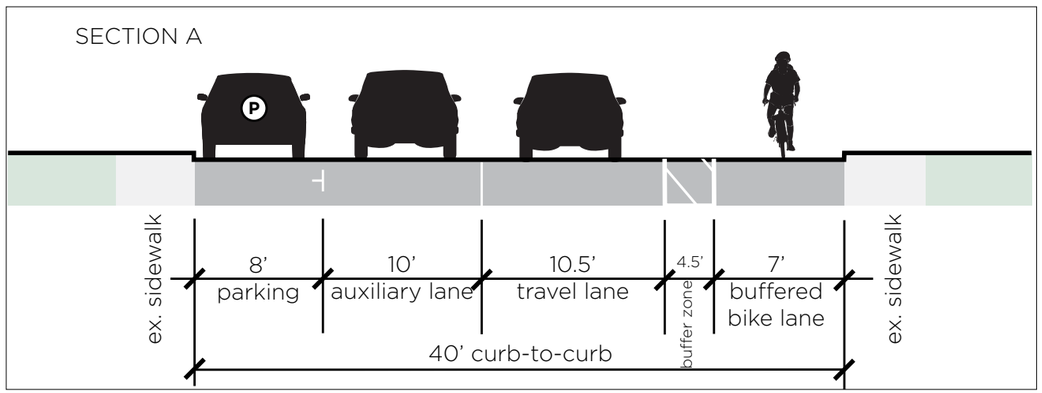


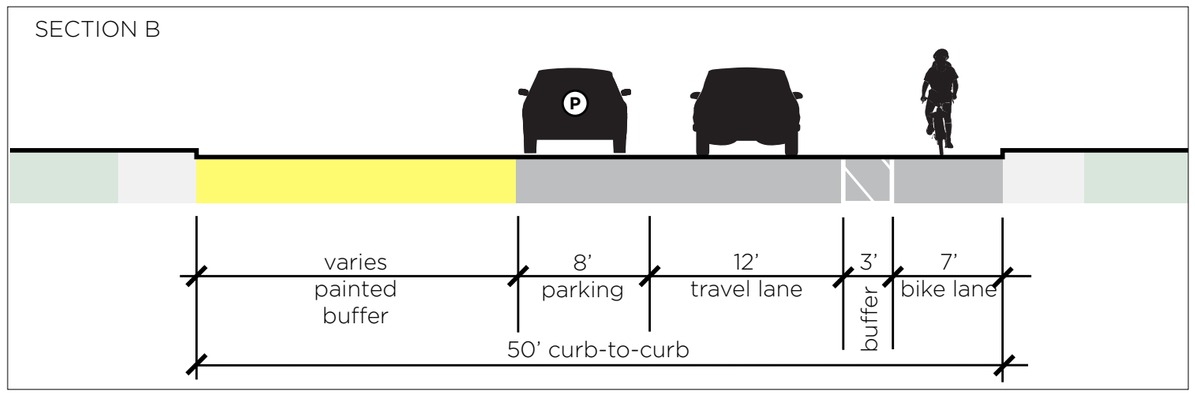


Colorado Avenue - Bond Street to Bend Parkway

Option 1 - Buffered Bike Lane







Purcell Boulevard & Neff Road

TAC Preferred Concept Plan : Option 1

Countermeasures

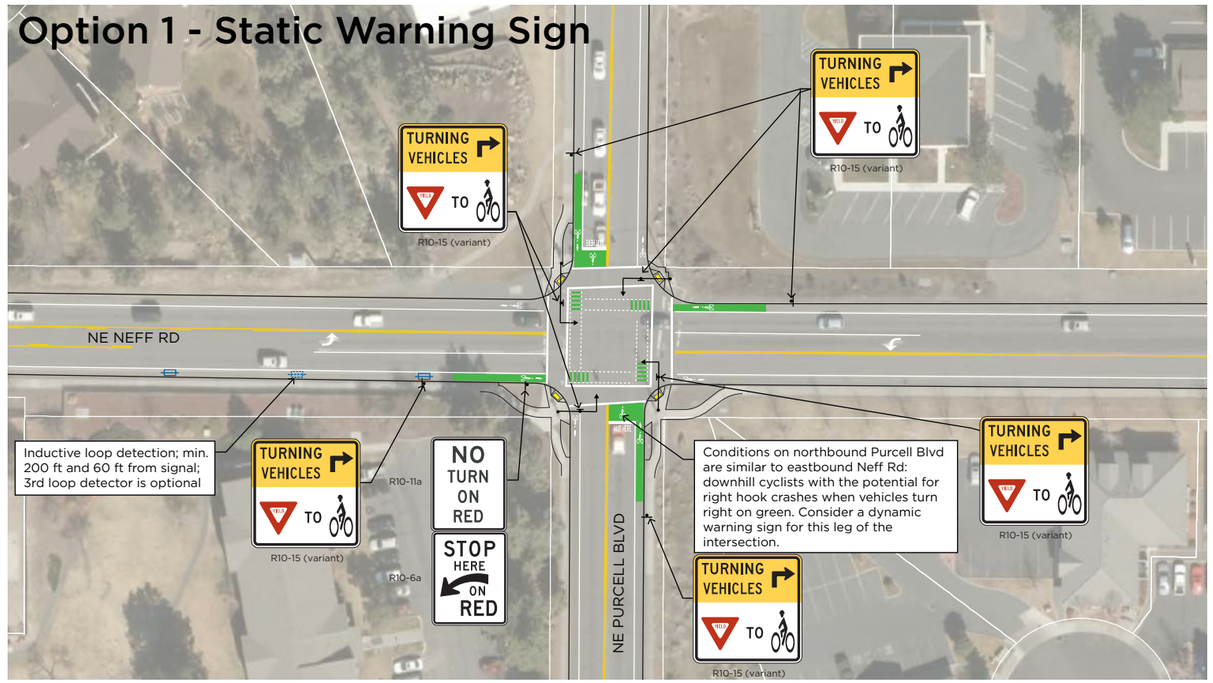
Option 1 features a bike lane on all four legs of the intersection in each direction. The eastbound approach on the west leg of the intersection features a green bike box. Green bike lane line extensions are used in the intersection to draw attention to conflict areas. A static warning sign is posted to alert right turning motorists of the presence of bicycles proceeding straight through the intersection. Option 2 features a shared turn lane on the eastbound approach of the west leg of the intersection, and bike lanes in all other directions.

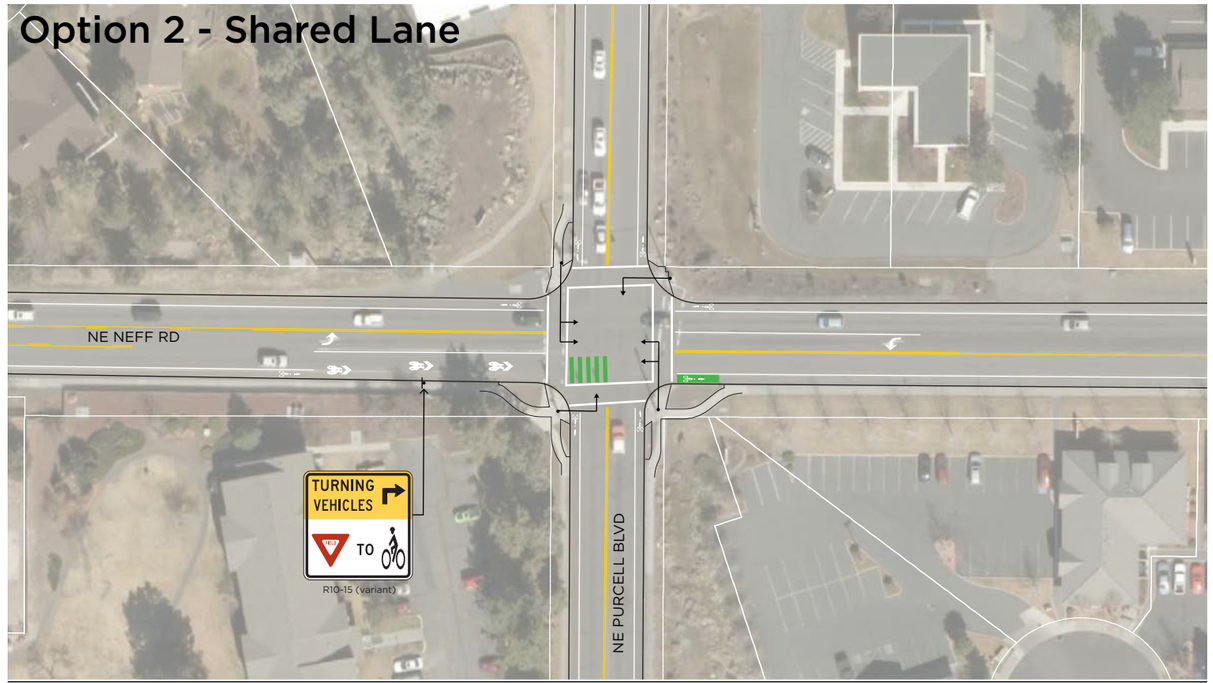
Summary of Recommended Improvements

- Add Green bike boxes on North and South legs of intersection only
- Add continuous bike lane line extension through intersection. Supplement with Green fill between dashed line extension.
- Add Stop Here on Red Signage (R10-6a) on SW corner of intersection
- Add No Turn on Red Signage (R10-11a) on SW corner of intersection
- Add static warning signs (R10-15 Variant) to traffic signal mass arms and intersection approaches

Next Steps

- Additional traffic analysis: Intersection Form Evaluation





Franklin Avenue & 3rd Street

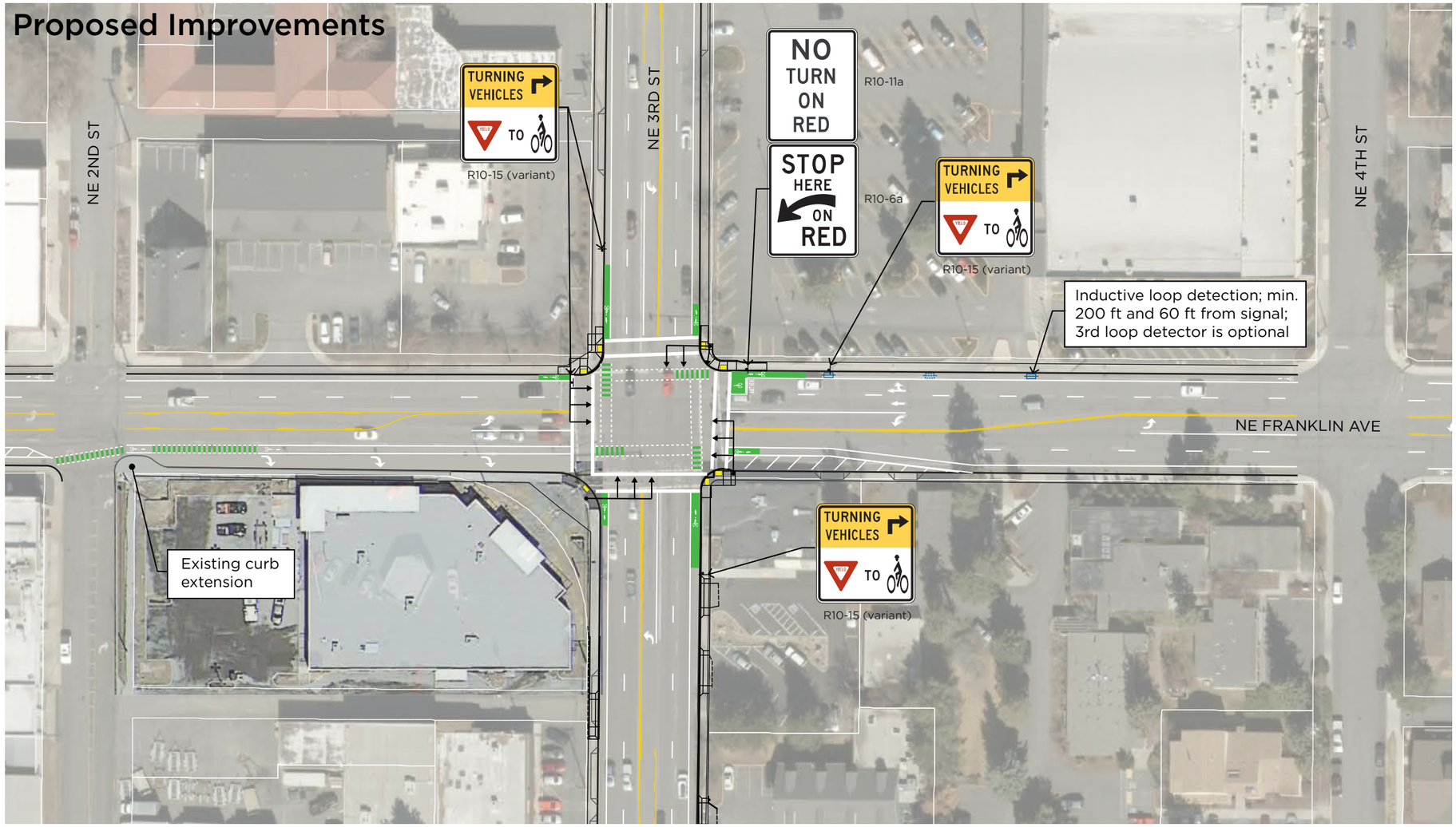
TAC Preferred Concept Plan

Countermeasures

The proposed improvements include features bike lanes on all four legs of the intersection in each direction. The westbound approach on the east leg of the intersection features a green bike box. Green bike lane line extensions are used in the intersection and along Franklin Ave to draw attention to conflict areas. Static warning signs are posted to alert right turning motorists of the presence of bicycles proceeding straight through the intersection.

Summary of Recommended Improvements

- Bicycle safety improvements through the intersection to reduce the potential for “right hook” crashes
- Add inductive loop detection; min. 200ft and 60 ft from signal; 3rd loop detector is optional
- Add continuous bike lane line extension through intersection. Supplement with green fill between dashed lane line extension
- Add continuous bike lane line extension across driveway. Supplement with green fill between dashed lane line extension
- Add static warning signs (R10-15 Variant) to traffic signal mass arms and intersection approaches



Greenwood Avenue and 3rd Street

TAC Preferred Concept Plan : Option 2

Countermeasures

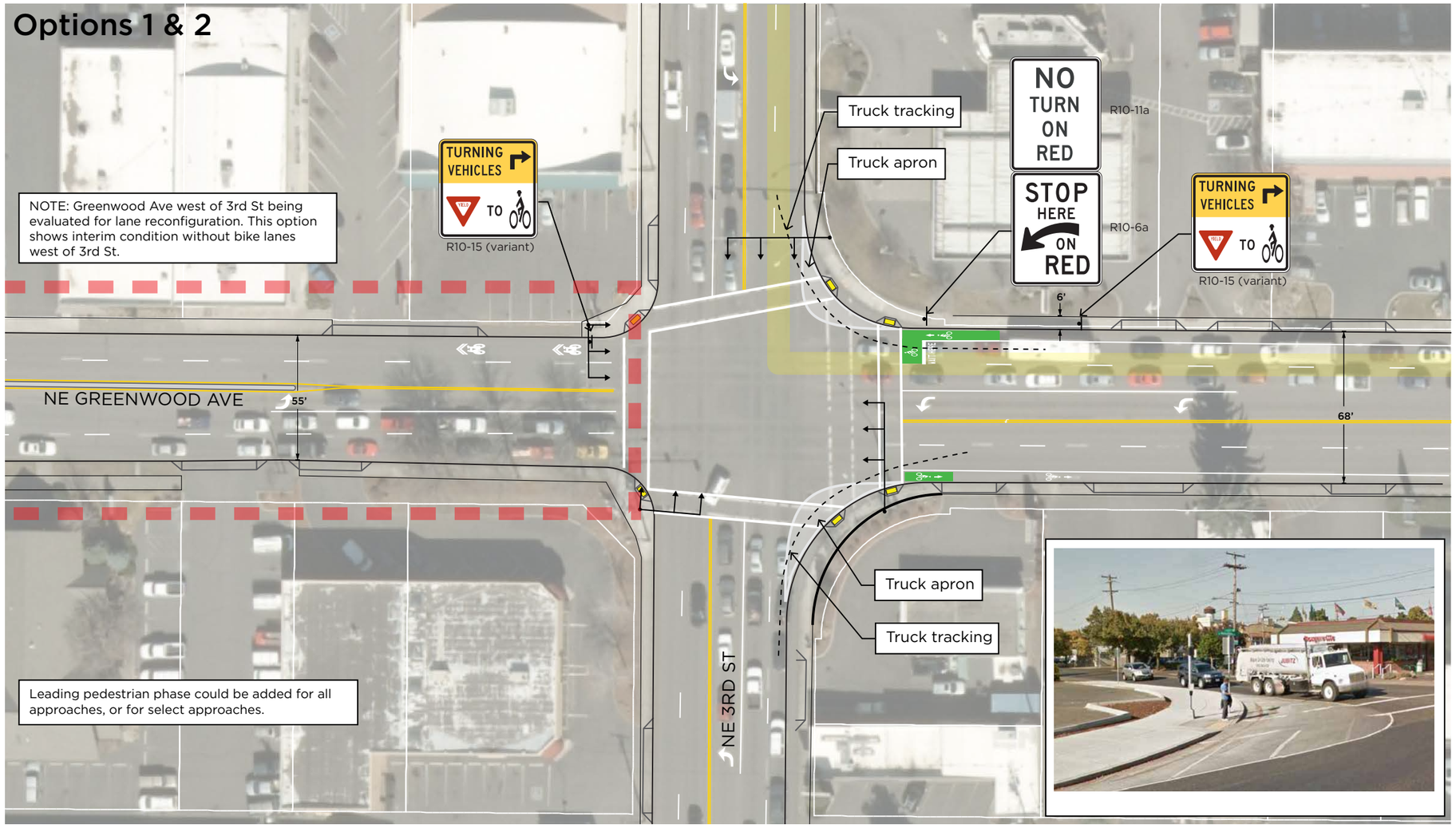
Option 1 features truck turning aprons on the NE and SE corners of the intersection to allow larger freight access while still providing a tighter turn radius for other vehicles. It also provides a bike lane on the east leg of the intersection. On the NE corner of the intersection (eastbound approach) is a bike box to provide cyclists a headstart after a red light and improve visibility. Option 2 is similar to Option 1 but also provides a leading pedestrian interval to give pedestrians a headstart and make them more visible to turning vehicles.

Summary of Recommended Improvements

- Modify intersection to improve safety for pedestrians while allowing for freight access and turning movements.
- Add truck turning aprons
- Add No Right Turn on Red signage (R10-11a)
- Add Leading Pedestrian Interval
- Add Stop Here on Red (R10-6a) and Turning Vehicles to Bicycles (R10-15 Variant) signage

Next Steps

- Additional traffic analysis including: freight mobility, crosswalk marking, queuing
- Perform traffic analysis for No Right Turn on Red movements



Greenwood Avenue & 4th Street

TAC Preferred Concept Plan : Option 2

Countermeasures

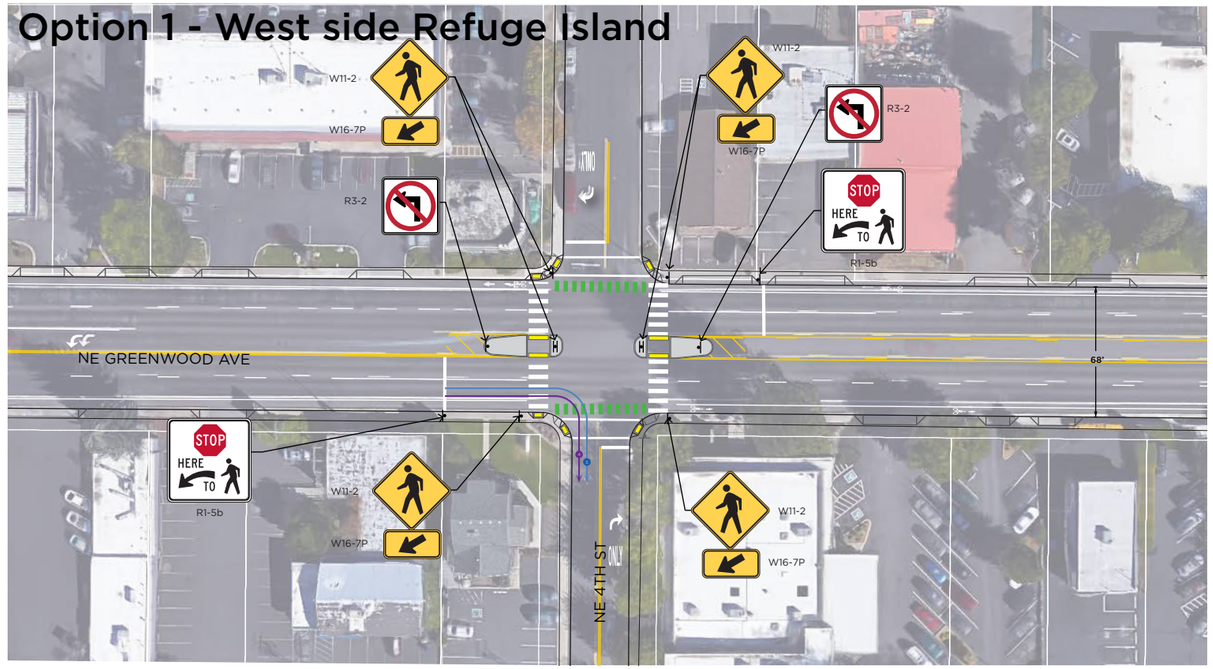
Option 1 features median islands on the east and west legs of the intersection. Option 2 features a full median refuge island/diverter prohibiting left turns and through traffic on 4th Street. The traffic diverter also has bicycle cut throughs for bicycle traffic on 4th Street.

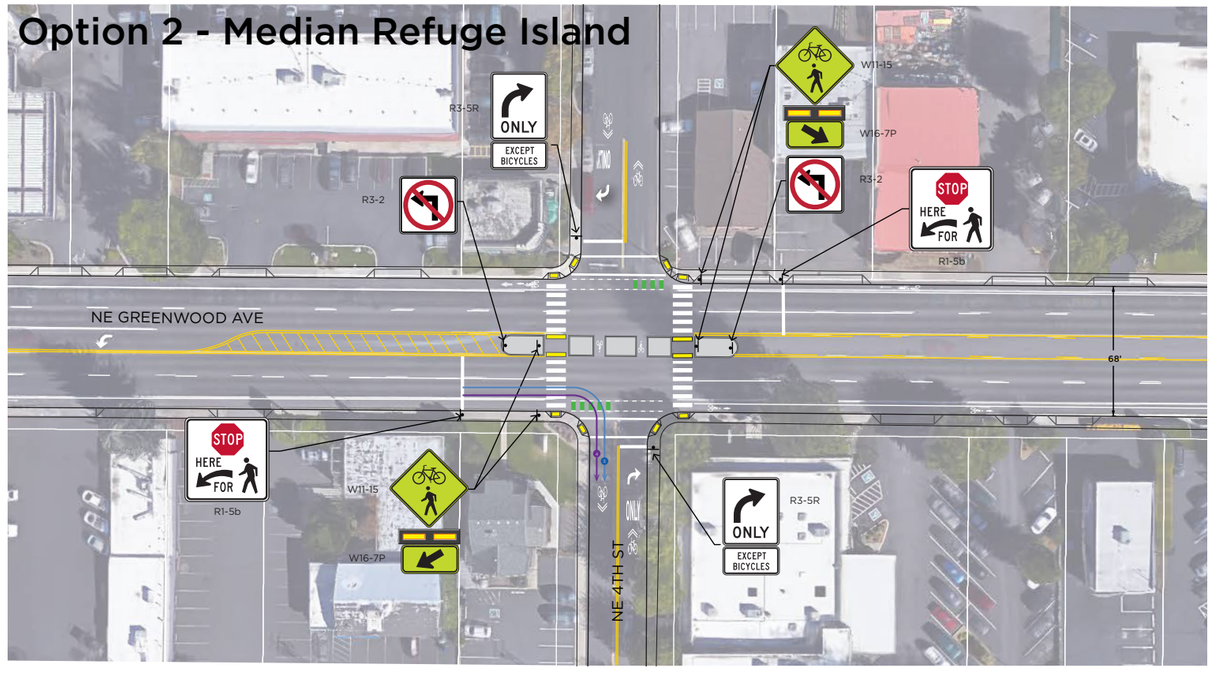
Summary of Recommended Improvements

- Add traffic diverter to prevent N-S through travel. Also add cut throughs for pedestrian refuge and N-S bike movements
- Add bike push buttons
- Add continuous bike lane line extension through intersection. Supplement with green fill between dashed line extension
- Add marked crosswalks at all intersection legs
- Add Rectangular Rapid Flash Beacons (RFFB) and pedestrian/bike warning signage (W11-15, W16-7P)
- Add No Right Turn on Red signage (R3-2)
- Add Stop Here for Pedestrians signage (R1-5b)

Next Steps

- Additional traffic analysis needed, including freight mobility, crosswalk marking, queuing, and the need for a Rectangular Rapid Flash Beacon (RRFB)





Greenwood Avenue & 6th Street

TAC Preferred Concept Plans

Countermeasures

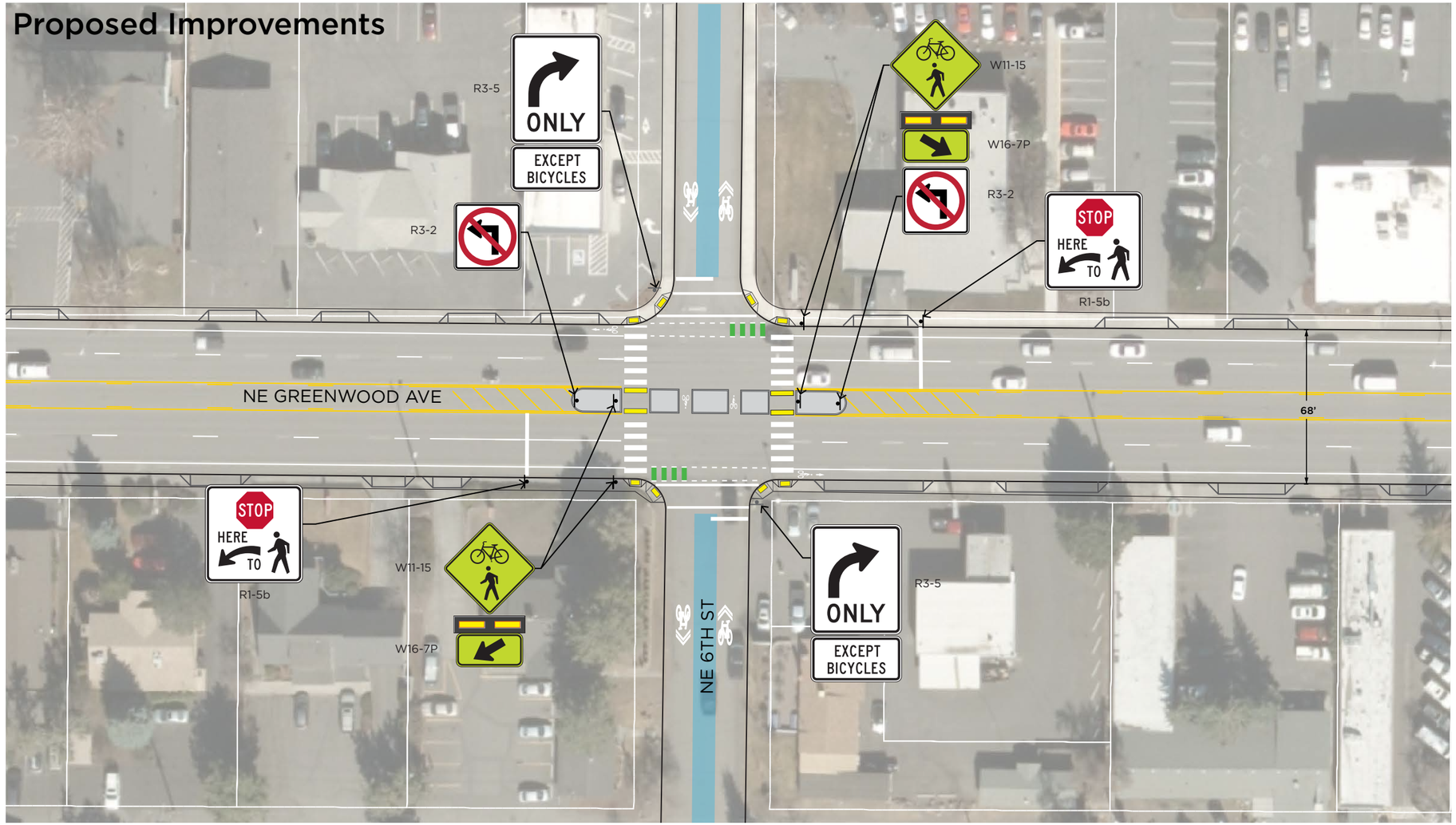
The proposed improvement includes the addition of a full median refuge island/traffic diverter prohibiting through vehicle travel on 6th Street. The diverter features cut throughs allowing bikes to continue traveling in the N-S direction. The median refuge island also features Rectangular Rapid Flash Beacons (RRFB) to warn drivers of pedestrians/bikes attempting to cross the street.

Summary of Recommended Improvements

- Add traffic diverter to prevent N-S through vehicle travel. Also add cut throughs for pedestrian refuge and N-S bike movements
- Add continuous bike lane line extension through intersection. Supplement with green fill between dashed line extension
- Add marked crosswalks at all intersection legs
- Add Rectangular Rapid Flash Beacons (RFFB) and pedestrian/bike warning signage (W11-15, W16-7P)
- Add No Right Turn on Red signage (R3-2)
- Add Stop Here for Pedestrians signage (R1-5b)
- Add Right Turn Only signage (R3-5) on NW and SE corners of intersection

Next Steps

- Additional traffic analysis needed including; freight mobility, crosswalk marking, queuing, and the need for a Rectangular Rapid Flash Beacon (RRFB)



Neff Road and Williamson Boulevard

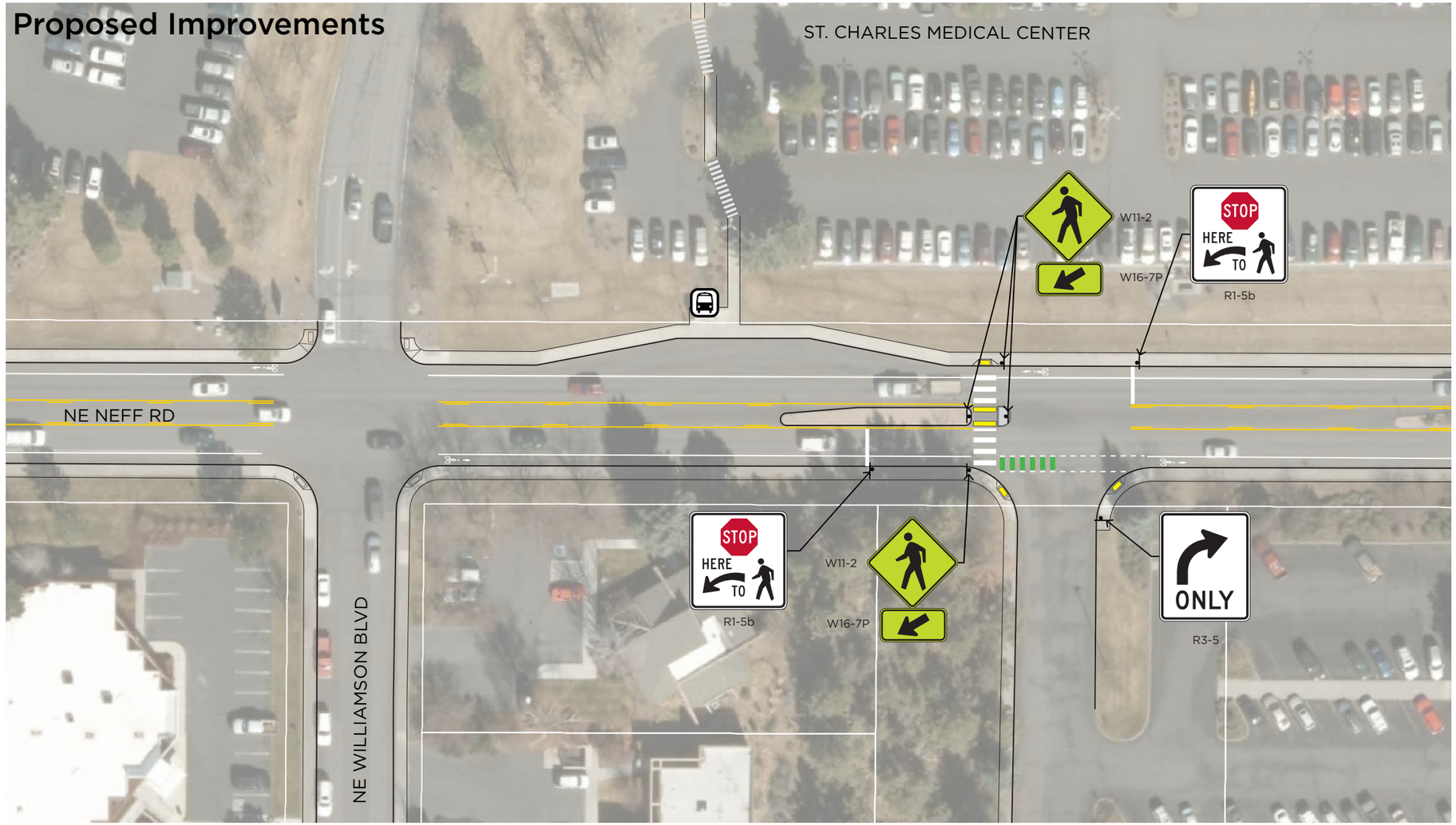
TAC Preferred Option Proposed Improvements

Countermeasures

The proposed improvement includes the addition of a full median refuge island/traffic diverter prohibiting through vehicle travel on 6th Street. The diverter features cut throughs allowing bikes to continue traveling in the N-S direction. The median refuge island also features Rectangular Rapid Flash Beacons (RRFB) to warn drivers of pedestrians/bikes attempting to cross the street.

Summary of Recommended Improvements

- Add median refuge island and marked crosswalk on the west leg of intersection
- Add Pedestrian crossing warning signage (W11-2, W16-7P)
- Add Stop Here for Pedestrian signage (R1-5b)
- Add Right Turn Only signage (R3-5) on SE corner of intersection
- Add continuous bike lane line extension through intersection. Supplement with green fill between dashed line extension



Cost Estimate Summary

Prepared by Century West

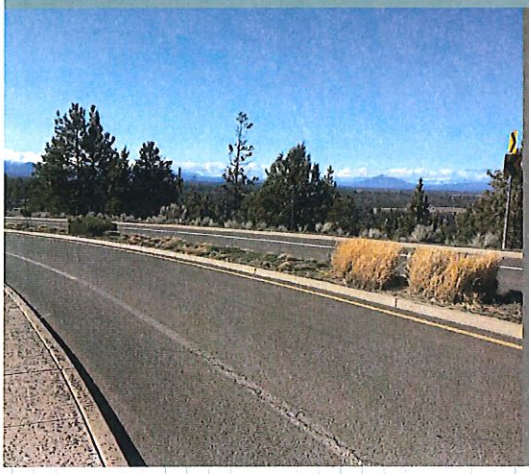
City of Bend Safety Implementation Plan

Conceptual Cost Estimate Summary of Options

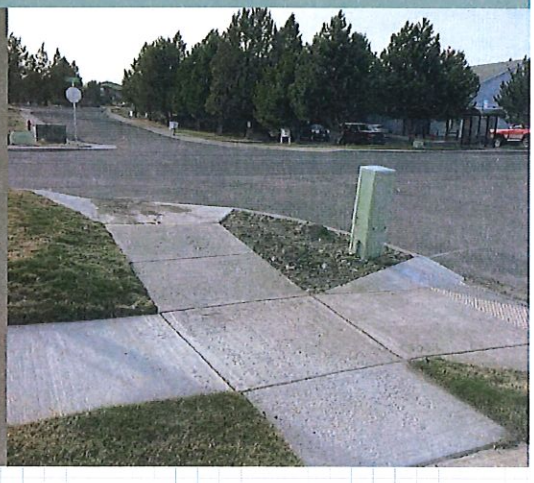
	Construction Cost Estimate
3rd St. & Hawthorne Ave.	
Option 1a - North Side Refuge Island	$140,500
Option 1b - South Side Refuge Island	$139,200
Option 2 - Median Refuge Island	$198,300
3rd St. & Roosevelt Ave.	
Option 2 - North & South Side Refuge Islands	TBD
Greenwood Ave. & 4th St.	
Option 1 - West Side Refuge Island	$153,000
Option 2 - Median Refuge Island	$182,300
Greenwood Ave. & 6th St.	
Option 1 - Median Refuge Island	$178,400
Greenwood Ave. & 3rd St.	
Option 1 - Truck Apron	$293,000
Option 2 - Leading Pedestrian Interval	$2,600
Colorado Ave. - Bond St. to Chamberlain St.	
Option 1 - Protected Bike Lane / Buffered Bike Lane	$273,100
Option 2 - Raised Bike Lane	$440,400.00
Colorado Ave. - Chamberlain St. to Bend Parkway	
Option 1 - Protected Bike Lane	$358,600.00
Option 2 - Raised Bike Lane	$339,100.00
Purcell Blvd. & Neff Rd.	
Option 1 - Dynamic Warning Sign	$155,300.00
Option 2 - Shared Lane	$16,800.00
3rd St. & Franklin Ave.	
Option 1 - Reconfigure Lanes/Dynamic Warning Sign	$188,000.00
3rd St. & Reed Market Rd.	
Option 1 - Dynamic Warning Sign	$190,800.00
Option 2 - Protected Intersection	
Neff Rd. & Williamson Blvd.	
Option 1 - West Side Refuge Island	$56,200.00
27th St. & Conners Ave	
Option 1 - Mid-Block Crossing	$176,200.00
Option 2 - Signalized Crossing	$847,600.00
Colorado Ave. & Bend Parkway Ramps	
Option 1 - Bike Signals and Curb Extensions	$514,700.00
Option 2 - Curb Extensions	$495,400.00

Exhibit C

Memorial



CITY OF BEND
SAFETY IMPLEMENTATION PLAN PROJECT
(ST14EA)



(DRAFT)
ROADWAY DEPARTURE ANALYSIS REPORT

FEBRUARY 16, 2015

CENTURY WEST
ENGINEERING CORPORATION

Contents

Appendix

Overview

The City of Bend Safety Implementation Plan Project (#ST14EA) is identifying opportunities to improve roadway safety throughout the City. This memorandum describes the conditions and potential improvements of four locations chosen by City staff where multiple single-vehicle roadway departure crashes have been reported. The Federal Highway Administration (FHWA) defines a roadway departure crash as: "a non-intersection crash which occurs after a vehicle crosses an edge line or a center line, or otherwise leaves the traveled way." The four roadway departure locations examined are:

1. Mt. Washington Drive East of Archie Briggs Road
2. Mt. Washington Drive West of Archie Briggs Road
3. Brookswood Boulevard South of Reed Market Road
4. Brosterhous Road at the BNSF Railroad Crossing

As detailed below in each location description, there have been no fatal crashes at these locations between 2007 and 2014. Therefore, the countermeasures proposed are all low-cost treatments widely used across the country for reducing roadway departures. Non-standard (per the MUTCD) countermeasures such as oversized flashing signage and large in-lane pavement markings were not considered. This memo also does not examine costly reconstructions to improve the geometric design features, such as degree and length of curve, super elevation, cross section, and shoulders.

This memo used several sources as guidance, including AASHTO's "Roadside Design Guide," FHWA's "Low Cost Treatments for Horizontal Curve Safety," ODOT/FHWA's "Roadway Departure Safety Implementation Plan," and the MUTCD.

Location 1: Mt. Washington Drive East of Archie Briggs Road

Mt. Washington Drive has a horizontal curve to the east of Archie Briggs Road where several crashes have been reported off the road. The City of Bend recently added several chevrons indicating the curve, however, more measures may be needed.

CHEVRONS - DONE

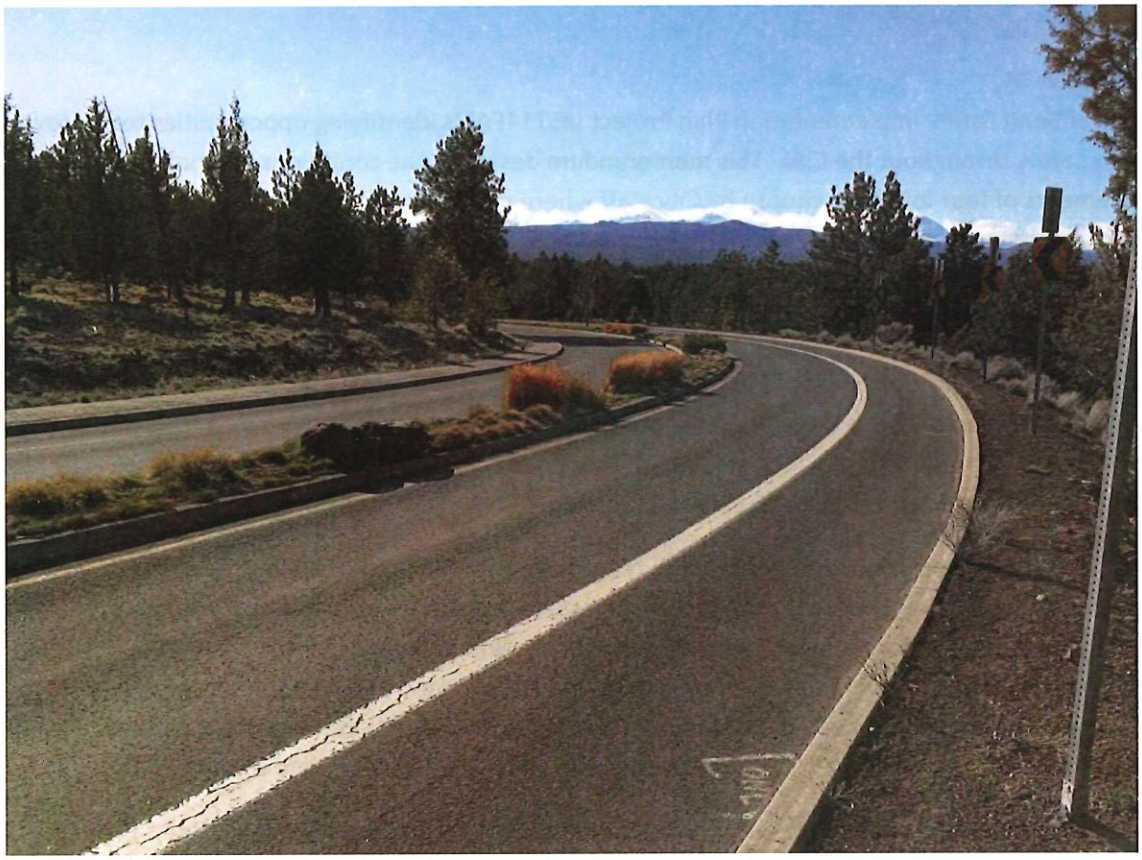


Figure 1: Curve on Mt. Washington Drive east of Archie Briggs Road

Existing Conditions

Mt. Washington Drive is classified as a minor arterial in the City of Bend's Transportation System Plan (TSP) and was constructed in the early 2000s to city standards. The posted speed limit is 35 mph. Mt. Washington Drive in the vicinity of this horizontal curve has 12-foot wide lanes in each direction, 6-foot wide bike lanes, a 6-foot wide raised and landscaped center median, and curb tight sidewalks on the south side only.

Beyond the roadway cross section are steep side slopes with native landscaping. There are several juniper trees and boulders just behind the curb. The area surrounding this location is residential, however most houses are significantly set back from the road.

The as-built drawings for this segment of roadway (Appendix A) reveal that the horizontal curve to the east of Archie Briggs Road has a 300-foot radius with a 3% super elevated cross slope. This curve does not meet current AASHTO standards for the posted 35 mph speed limit. Per AASHTO standards, the minimum horizontal curve at this speed limit with this super elevated cross slope should be 388 feet.

The City of Bend recently installed chevrons, pointing in both directions, on the north side of the roadway to alert motorists to the oncoming curve. These chevrons were installed in 2013 after the roadway departure crashes were reported.

Crash History

Based on the traffic accident history supplied by ODOT for the years 2007 through 2013, there were several crashes along this stretch of roadway. Of these crashes, three were classified as roadway departures:

Date and Time	Type	Notes
Friday, October 26, 2007 Night	Non-fatal roadway departure approx. 600 feet east of Archie Briggs Road	• Clear weather • Dry surface • Speed too fast for conditions (limit not exceeded). • Fixed object crash - tree, stump, or shrubs • No alcohol or drugs involved • ID# 1913
Wednesday, June 27, 2012 Darkness	Non-fatal roadway departure 740 feet east of Archie Briggs Road.	• Clear weather • Dry conditions • Property damage crash only • No control • Reckless Driving • Speed too fast for conditions (not exceeding limit) • No alcohol or drugs involved • ID# 807
Sunday, December 18, 2011 Darkness	Non-fatal roadway departure approx. 800 feet east of Archie Briggs Road.	• Clear weather • Dry conditions • Property damage only crash • No control • Speed too fast for conditions (not exceeding limit) • Alcohol involved

Potential Countermeasures

There are several potential countermeasures that could be installed to heighten drivers' awareness of the horizontal curve. The cost of redesigning and reconstructing the existing roadway to meet current AASHTO standards for minimum curve radius and super elevation is presumed to be excessive due to the fact that no fatalities have occurred on this segment. The countermeasures examined are listed below.

Improved Signage

The City of Bend recently installed chevrons (MUTCD W1-8 L/R) on the north side of the curve. In addition to the chevrons, adding advanced curve warning signs (MUTCD W1-1) with advisory speed signs (MUTCD W13-1P) indicating a speed of 30 mph is recommended in both directions.

DONE W1-2L

Recent bid tabulations in Deschutes County have an average bid price of $20 per square foot for W type signs. The installation of these two signs would cost approximately $500 total.

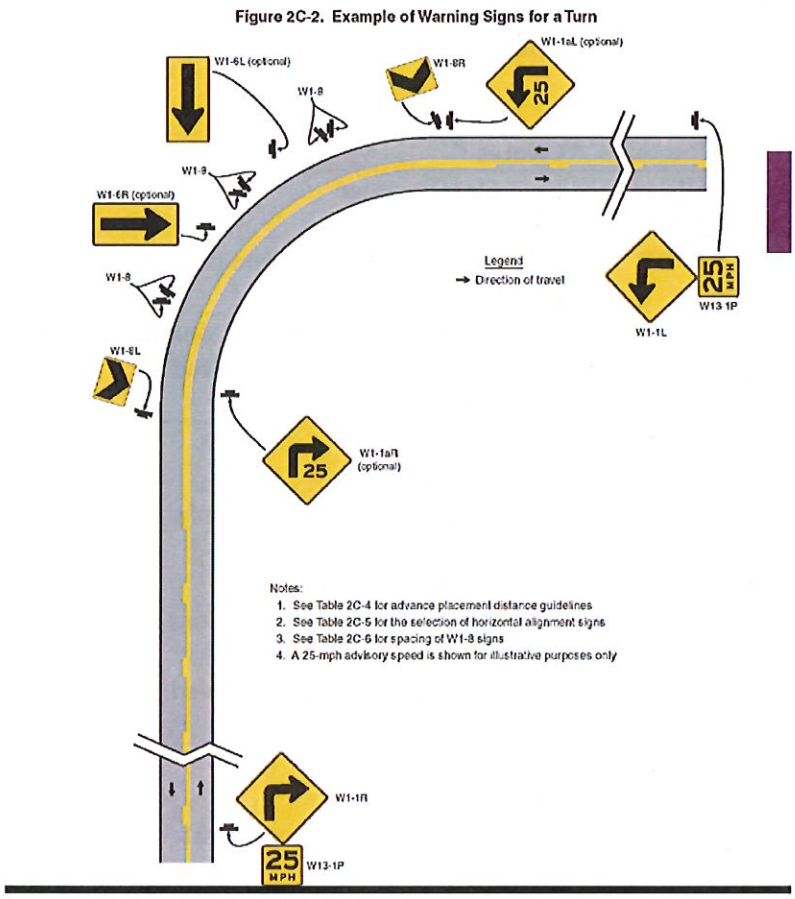


Figure 2: Horizontal Curve Signage Guidelines by AASHTO

Raised Pavement Markers

Raised pavement markers (RPMs) have been proven to improve delineation and increase preview time, particularly under wet conditions, and have been shown to decrease crash rates on highways. All three of the roadway departure crashes on this segment of Mt. Washington Drive occurred during night or darkness conditions, thus raised pavement markers may be beneficial.

Figure 3: Example of Raised Pavement Markers from FHWA

There are several types of RPMs available and used, including new technology that includes the use of LED lights. For Mt. Washington Drive, it is recommended to use the reflective abrasive resistant recessed marker per ODOT standard. These markers are installed by cutting a groove into the existing asphalt and installing the marker into the groove. When installed properly the RPM is unaffected by snow plow clearing. The current cost in Oregon is approximately $30 per installed marker. Markers are typically spaced at 40-foot intervals, per ODOT standards. For RPMs to be effective, the alignment needs to be defined well in advance of the horizontal curve. For this segment of Mt. Washington Drive, approximately 2,500-feet would require improvement. This segment includes the horizontal curve west of Archie Briggs Road detailed below in Location 2. Assuming both the yellow and white lines are installed with RPMs, approximately 250 markers would be needed for this segment at an approximate cost of $7,500.

The City of Bend streets department has reviewed the use of RPMs on City streets and has rejected them due to future replacement costs that will be incurred during re-surfacing projects. The streets departments ideally resurfaces major streets every 7-10 years, thus the need to completely replace all RPMs will each resurfacing. For this reason, RPMs have been removed from consideration in this analysis.

Delineators

Delineators are particularly beneficial at locations where the alignment might be confusing or unexpected, such as at lane reduction transitions and curves. Delineators are effective guidance devices at night and during adverse weather. An important advantage of delineators in certain locations is that they remain visible when the roadway is wet or snow covered.

The MUTCD (table 3F-1) provides guidelines for spacing on delineators on horizontal curves based on the radius of the curve. For the 300-foot horizontal curve on Mt. Washington Drive, delineators should be spaced every 50 feet along the curve. Delineators should be placed 2 to 8 feet outside the outer edge of the shoulder. The delineators should extend ahead and beyond the curve on the tangent section at an increasing spacing width up to 300 feet. This curve is 320 feet in length. Approximately 20 delineators would be required for proper installation along this horizontal curve. ODOT Standard Drawing TM570 details plastic and steel post delineators. Plastic delineators have an approximate cost of $35 each installed. The approximate cost for installing delineators is $700 for this horizontal curve on Mt. Washington Drive. The delineators can be installed in combination with the advanced warning signs and the raised pavement markers.

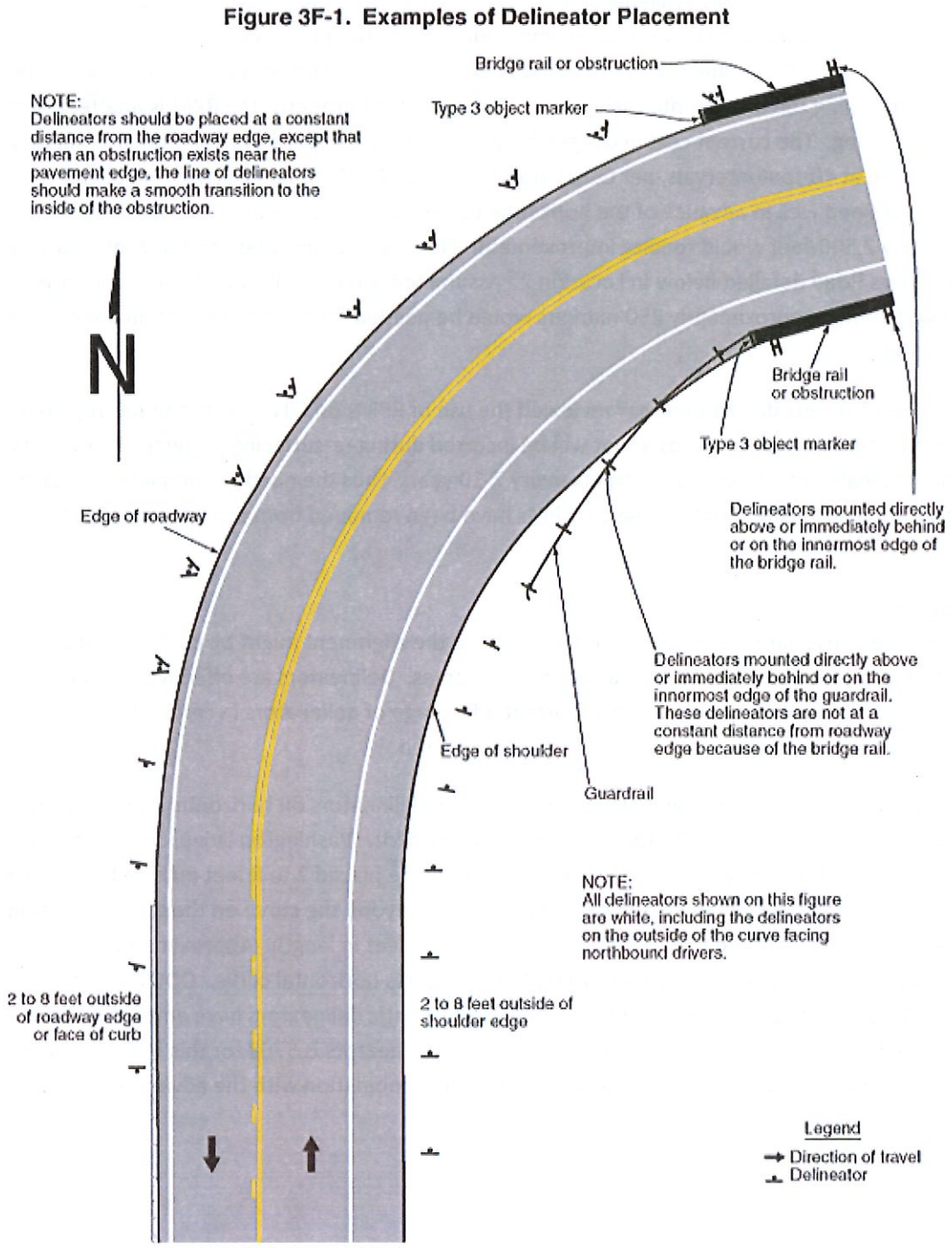


Figure 4: Examples of Delineator Placement from the MUTCD

Figure 5: Tire marks from a recent roadway departure

For this location on Mt. Washington Drive, the north side of the roadway may warrant guardrails due to the steep side slopes that exist a few feet beyond the curb. Approximately 300-feet of guardrail would be required to cover the length of the horizontal curve. Average prices for ODOT standard guardrail are currently $125 per foot plus $100 each for the end caps. Therefore, the approximate price of installing a new guardrail in this location is $37,700.

Countermeasure Suggestions

Based on our review of the countermeasures identified in the previous section, the City should consider the following lower-cost countermeasures for the horizontal curve on Mt. Washington Drive east of Archie Briggs Road:

- Installing improved signage including advanced curve warning signs at a cost of $500. → DONE
- Installing delineators a few feet outside of the curbs at an approximate cost of $700. → NOT DONE

These countermeasures are shown in the concept plan in Appendix C. To date, there have not been any serious crashes in this location that would have been prevented by a guardrail and the crash history does not warrant a guardrail according to AASHTO. Furthermore, guardrails can sometimes cause more harm than good in roadside departures, and should only be installed when absolutely necessary. However, the City should monitor this location and could consider higher-cost countermeasures, including guardrail, if severe crashes are reported in the future.

Rumble Strips

Rumble Strips are an effective countermeasure for preventing roadway departure crashes. The noise and vibration produced by rumble strips alert drivers when they leave the traveled way.

There are two main applications of rumble strips:

- Centerline Rumble Strips – an effective countermeasure to prevent head-on collisions and opposite-direction sideswipes, often referred to as cross-over or cross-centerline crashes. Primarily used to warn drivers whose vehicles are crossing centerlines of two-lane, two-way roadways.
- Shoulder Rumble Strips – an effective means of preventing run-off-the-road crashes. They are primarily used to warn drivers they have drifted from their lane toward the shoulder.

The main cause of roadway departure crashes is driver drowsiness and inattention, which are sometimes compounded by driving too fast. Alcohol and drugs can contribute to both fatigue and speed. Driver fatigue also is induced by highway hypnosis, which occurs when the lines and stripes on long, monotonous stretches of highway reduce the driver's concentration. When drivers stray from the travel lane, rumble strips rouse their attention to allow a safe recovery. Rumble strips also are helpful in alerting drivers to the lane limits where conditions such as rain, fog, snow or dust reduce driver visibility.

Currently in Oregon rumble strips are installed at approximately $1 per foot. For this curve, approximately 500 feet of roadway could have shoulder rumble strips installed at a total cost of approximately $1,000. Centerline rumble strips are not needed as there is a raised center median.

Rumble strips also have their drawbacks, including complaints about noise levels, bicyclists' concerns about safety, and maintenance issues faced by road crews. ODOT does not currently install rumble strips within 600 feet of houses. Due to the surrounding residential areas and the high bicycle traffic on Mt. Washington Drive and within the City of Bend in general, rumble strips are not recommended for this location.

Guardrails

Guardrails are used to protect motorists from potentially serious hazards located near the roadway. Bridge piers, utility poles, and severe embankments are hazards that, if encountered, may be deadly.

Existing guidelines for guardrail application allow for a great deal of inconsistency. Two virtually identical sites can be treated much differently, depending upon the discretion of the individual designers. Objective criteria are needed to help reduce or eliminate inconsistencies and provide optimal safety for all motorists and minimize the number of serious crashes along the roadways.

Location 2: Mt. Washington Drive West of Archie Briggs Road

Mt. Washington Drive has a sharp horizontal curve to the west of Archie Briggs Road. This curve is approximately 1,500 feet west of the curve discussed in location 1 above. They share many of the same characteristics.

Figure 6: Horizontal curve west of Archie Briggs Road

Existing Conditions

Similar to the conditions mentioned above at Location 1, Mt. Washington drive is a minor arterial with a posted speed of 35 MPH. The cross section is similar to above, however, there is no raised center median at this location.

The surrounding area is primarily native landscaping with steep side slopes. The Archie Briggs canyon trail crosses Mt. Washington Drive at this curve. This trail crossing is not marked in either direction for vehicle awareness. The roadway crosses a natural drainage course along this curve. There is a large culvert installed under the roadway. At the location of this culvert, the side slopes of the road are approximately 1:1 with a 15-foot drop. There is native landscaping along both sides of the road that limits sight distances.

The as-built drawings for this horizontal curve (Appendix A) show a 270-foot radius with a 3% max super elevation. This does not meet current AASHTO standards, as the minimum design curve for these conditions is 388-feet.

Crash History

There were two roadway departure crashes between the years 2007 and 2012 in the vicinity of this horizontal curve:

Date and Time	Type	Notes
Wednesday, August 15, 2012 Daylight	Non-fatal roadway departure 565 feet west of Archie Briggs Road.	• Dry conditions • Clear weather • No control • Speed too fast for conditions (limit not exceeded). • No alcohol or drugs involved • ID# 1073
Thursday, January 11, 2007 Daylight	Non-fatal injury crash involving 2 cars on the curve.	• Rain • Ice • Sideswipe-meeting • Cars coming from opposite directions, both going straight • Speed too fast for conditions (not exceeding limit) • No alcohol or drugs involved • ID# 19

Potential Countermeasures

Similar to Location 1 discussed above, there are several low cost countermeasures that may reduce the occurrences of roadway departures in this location.

Improved Signage

Currently there is no signage or chevrons indicating that a sharp horizontal curve is approaching in either direction. Installing advanced warning signs including a speed advisory sign indicating a speed of 25 MPH would be an improvement. In addition, adding chevrons to the south side of the roadway, pointing in both directions, would help motorists negotiate the curve. Lastly, installing trail crossing signs would help reduce conflicts with pedestrians. The approximate total cost for installing these signs is $1,500.

NOTHING HAS BEEN DONE HERE

Figure 7: Examples of Trail Crossing signage - MUTCD W11-15 fluorescent with W11-15P

Installing a Raised Median and Cross Walk

Unlike the horizontal curve east of Archie Briggs road, this curve does not have a raised center median. The existing roadway is currently 36-foot wide from curb to curb, with 12-foot wide travel lanes and 6-foot wide bike lanes in both directions. FHWA guidelines consider raised center medians where there a mixture of a significant number of pedestrians, high volumes of traffic (more than 12,000 ADT), and intermediate or high travel speeds. Although the existing Archie Briggs trail has light foot traffic currently, the development of the nearby Riley Ranch by the Bend Parks and Recreation Department will most likely increase the usage of this trail. Using the existing street geometry, a small raised center median could be installed. The roadway would have to be re-striped to have 11-foot wide travel lanes and 5-foot wide bike lanes. This reconfiguration leaves a 4-foot center median. Installing a raised center median would allow for a pedestrian refuge for the trail crossing and would create separation between the travel lanes improving the safety of head on crashes.

With the addition of reconfiguring the lane widths and adding a raised center median, a cross walk with fully compliant ADA curb ramps should also be installed at the Archie Briggs Trail crossing. Although the trail itself is not ADA compliant due to the steep terrain, the United States Access Board recommends all street crossings to be ADA compliant. A continental style cross walk should also be painted onto the stripe to clearly mark the crossing. Continental style (large white hash marks in the direction of the travel) cross walks are preferred due to their high visibility. The City of Bend recently retrofitted Metolius Drive with a similar treatment as shown in the photo below.

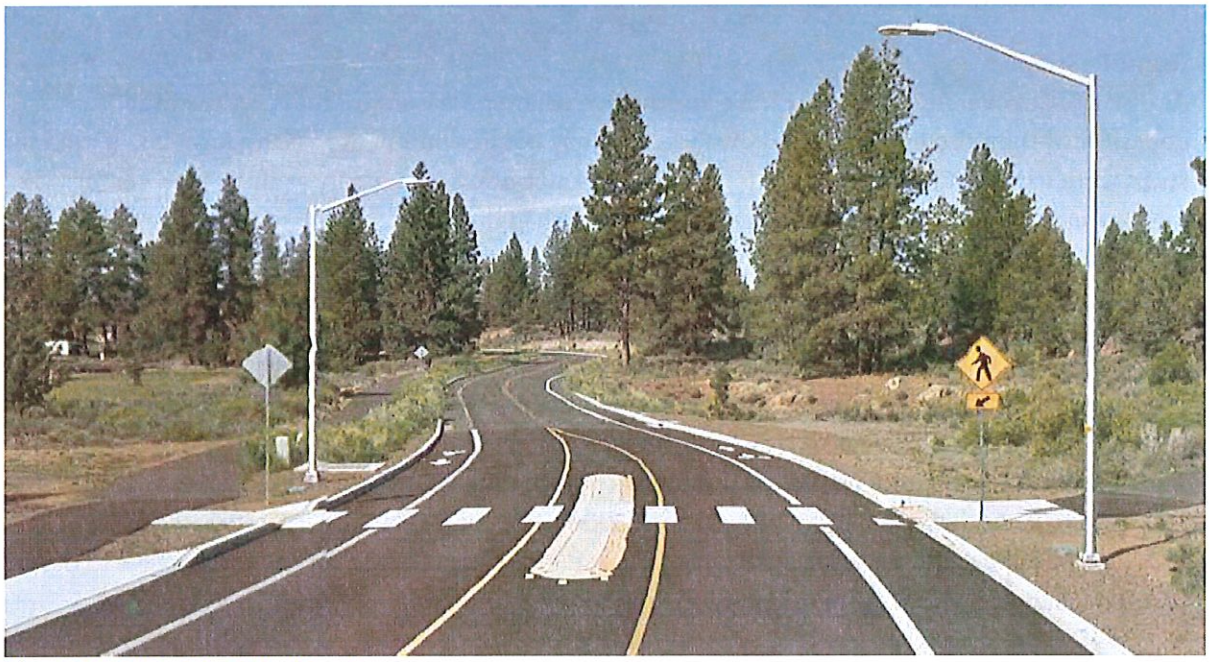


Figure 8: Metolius Drive Raised Crossing

Delineators

As discussed above, delineators are particularly beneficial at locations where the alignment might be confusing or unexpected, such as at lane reduction transitions and curves. Delineators are effective

guidance devices at night and during adverse weather. An important advantage of delineators in certain locations is that they remain visible when the roadway is wet or snow covered. For these reasons, delineators would be a beneficial low-cost safety measure for the horizontal curve west of Archie Briggs Road.

The MUTCD (table 3F-1) provides guidelines for spacing on delineators on horizontal curves based on the radius of the curve. For the 270-foot horizontal curve on Mt. Washington Drive, delineators should be spaced every 50 feet along the curve. This curve is 375 feet in length. Approximately 24 delineators would be required for proper installation along this horizontal curve. ODOT Standard Drawing TM570 details plastic and steel post delineators. Plastic delineators have an approximate cost of $35 each installed. The approximate cost for installing delineators is $840 for this horizontal curve on Mt. Washington Drive. The delineators can be installed in combination with the advanced warning signs and the raised pavement markers.

Raised Pavement Markers

As discussed above, raised pavement markers can help drivers align with the curvature of the roadway. A counter measure that improves both this location as well as Location 1 is discussed above. The total cost of the RPM is approximately $7,500, with $3,750 applied to this location.

As discussed above, the City of Bend streets department has reviewed the use of RPMs on City streets and has rejected them due to future replacement costs that will be incurred during re-surfacing projects. For this reason, RPMs have been removed from consideration in this analysis.

Rumble Strips

As discussed above, rumble strips can be an effective counter measure for reducing roadway departures. They also have several drawbacks and may not be appropriate for this location. If rumble strips were to be installed here, a center rumble strip may also be necessary as there is no center median and there has been at least one side-swipe crash in the past seven years. Installing both shoulder and center line rumble strips would cost approximately $1,500.

Guardrails

Installing a guardrail on the south side of this curve may be warranted due to the steep side slopes and drop in elevation from the roadway to the bottom of the drainage channel. If a guardrail were to be installed, one limitation would be creating a break in the guardrail for the Archie Briggs Canyon Trail. Adding a break to a guardrail is not ideal, and thus the trail would likely have to be re-routed around the new guardrail. As discussed above, the cost of a 300-foot section of guardrail is estimated to be $37,700. Including either a break in the guardrail or the re-routing of the trail would increase to the cost to approximately $40,000.

Vegetation Removal

One low-cost counter measure that would improve vehicle and pedestrian safety along this curve is the trimming or removal of vegetation along the northern edge of the curve. This land is a combination of City of Bend Right-of-Way and Bend Parks and Recreation Property. Much of the smaller vegetation - grasses, sage, rabbit brush - should be removed or mowed down. There are some larger juniper trees

that could be removed completely that would improve sight distances. A few of the large ponderosa and lodgepole pine trees are mixed in between the junipers. Limbing these trees would also help improve sight distance.

Countermeasure Suggestions

The following countermeasures were examined for the horizontal curve on Mt. Washington Drive east of Archie Briggs Road and would provide the City with low cost safety improvements:

- Installing improved signage including advanced curve warning signs, chevrons, and trail crossing signs at a cost of $1,500.
- Installing delineators on both sides of the roadway a few feet outside of the curb line at an approximate cost of $840.
- Reconfigure existing lane widths and add a raised center median with cross walk and ADA compliant ramps.
- Removing vegetation on the north side of the curve to improve sight distances.

These countermeasures are shown on the concept plan in Appendix C. To date, there have not been any serious crashes in this location that would have been prevented by a guardrail and the crash history does not warrant a guardrail according to AASHTO. Furthermore, guardrails can sometimes cause more harm than good in roadside departures, and should only be installed when absolutely necessary. However, the City should monitor this location and could consider higher-cost countermeasures, including guardrail, if severe crashes are reported in the future.

Location 3: Brookswood Boulevard South of Reed Market Road

Brookswood Boulevard between Reed Market Road and Powers Road in Southwestern Bend has seen numerous traffic crashes in the last few years including several roadway departures. Location 3 examines this segment of Brookswood Boulevard.

Figure 9: Brookswood Boulevard and McClellan Drive

Existing Conditions

Brookswood Boulevard is classified as a minor arterial in the City's TSP. The roadway was reconstructed in 2003 to current City standards with two 12-foot travel lanes, 6-foot bike lanes in each direction, curbs, and sidewalks. The sidewalks vary from being curb tight to property tight and meander around several obstacles including trees and power poles. A review of the as-built drawings (Appendix B) reveals that the design meets current AASHTO standards. No substandard elements were noted.

A bridge crosses a COID canal towards the southern end of the study section. The roadway basically drops from the canal bridge to the roundabout at Reed Market Road. The surrounding area is primarily residential with a busy park at McClellan Drive.

The southern end of Brookswood Boulevard has a signed speed of 35 mph. This speed is dropped to 25 mph to the south of McClellan Road. From McClellan Road to Reed Market Road, Brookswood Boulevard is 25 mph. This speed zone change is properly signed per MUTCD standards and there is an advanced zone change warning sign in place.

Crash History

There were several crashes on Brookswood Boulevard between 2007 and 2012, however, only 2 were classified as roadway departures:

Date and Time	Type	Notes
Sunday, December 19, 2010 Daylight	Non-fatal roadway departure	• **Snowy weather; Icy conditions** • Speed too fast for conditions (limit not exceeded). • No alcohol or drugs involved • ID# 1772
Monday, February 27, 2012 Daylight	Non-fatal roadway departure	• **Snow weather; Icy conditions** • No control • Sliding or swerving due to wet, icy, slippery, or loose surface • Fence or building damage only • Speed too fast for conditions (not exceeding limit) • No alcohol or drugs involved • ID# 297

One item of note is that both crashes occurred during icy conditions. The scope of this study did not look at crash trends city-wide, so it cannot be said if these ice-caused crashes are on par with the rest of the city. However, the roadway slopes continuously down towards the Deschutes River perhaps creating a type of canyon effect that causes Brookswood Boulevard to ice over earlier than other streets in Bend.

Potential Countermeasures

There were few roadway departure crashes on this segment of Brookswood Boulevard and the locations were not in common to indicate a unique problem location. Also, there does not appear to be a substandard section of roadway in this segment. The one common occurrence was the presence of snow and icy conditions that led to the roadway departures. A few countermeasures were examined that may improve safety on this segment of road.

Improved Signage

This segment of Brookswood Boulevard is well signed currently. The speed change is adequate and pedestrian crossing locations are called out. However, due to the horizontal and vertical geometry of the roadway, the addition of slippery roadway and ice warning signs, like shown below, may be warranted. Winter weather impacts roads throughout the City. The City should consider if this section of road warrants these signs more than other sections. These signs could be installed at a cost of approximately $500.

Figure 10: Ice and Slippery Road Warning signs

Rumble Strips

Rumble strips, discussed in detail above, can also help drivers locate the edge of the travel lane in snowy conditions when paint stripes may be concealed. This segment of Brookswood Boulevard is 3,000 feet long. Adding shoulder line rumble strips would cost approximately $6,000.

Guardrails

Guardrails are not likely warranted for any portion of this segment of Brookswood Boulevard due to curvature, side slopes, or crash history. There are existing guardrails in place at the approaches to the canal bridge. There are a few roadside obstacles including a large ponderosa tree and several power poles that are close to the edge of the roadway. A vehicle leaving the roadway may strike these obstacles causing more damage. Installing guardrail sections around these obstacles was examined but found to not meet warrants. The obstacles in question are located behind a 7-inch curb and are at least 5-feet from the back of curb.

Suggested Countermeasures

The following countermeasures were examined for the segment of Brookswood Boulevard between Reed Market Road and Powers Road:

NOT DONE

- Installing improved signage including slippery roadway and ice warnings a cost of $500.

The City of Bend should further monitor the crash history along this segment of Brookswood Boulevard. At this time, there is not a large enough sample size of crashes that leads to preferred countermeasure solution.

Location 4: Railroad Underpass on Brosterhous Road

Brosterhous Road crosses under the BNSF Railroad just north of Knott Road on the south end of Bend. The railroad crosses over the road on a single track bridge.

Figure 11: Railroad crossing on Brosterhous Road

Existing Conditions

Brosterhous Road is classified as a major collector in the City of Bend TSP and has a posted speed of 45 mph. The curve near the railroad bridge has an advisory warning speed sign posted of 35 mph. Brosterhous Road on both the north and south sides of the rail road bridge is a 2-lane road with approximately 12-wide travel lanes and 3-foot shoulders (dimensions vary). There are no curbs or sidewalks. Under the bridge, the travel lanes narrow to 11-feet wide and the shoulders drop to 1.5-feet. There is a large horizontal curve on Brosterhous Road at the bridge crossing. The northbound approach is located along this curve and the bridge is not visible to motorists until they are within a hundred feet of the bridge.

The clearance from the bottom of the bridge to the roadway is 12-feet 10-inches. There are advance warning signs on Brosterhous Road for the bridge clearance to the north near Murphy Road and to the south near Knott Road. These advanced warning signs are located on Brosterhous Road. A large truck will have already committed to approaching the low bridge when it passes these signs and there is little, if any, opportunity to turn around prior to the bridge. There is a clearance sign on the bridge itself on both approaches with a down-pointing arrow. However, these signs do not meet MUTCD standards. The arrow is over to the side of the bridge and is aligned directly with the bridge column. This could potentially confuse drivers into thinking this is a lane arrow.

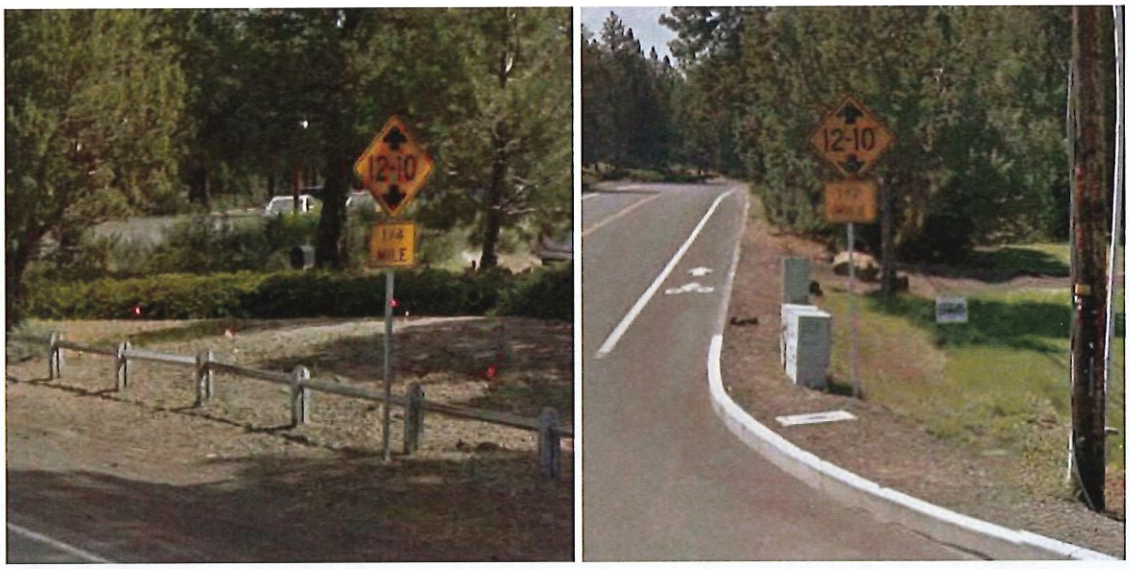


Figure 12: Advanced warning signs on Brosterhous Road at Knott Road (left) Murphy Road (right)

There are no signs indicating a narrowing of the roadway. There are no object warning markers indicating the bridge abutments. There are old and antiquated guardrails on the approaches to the bridge in each direction, however there are no guardrails on the exit side.

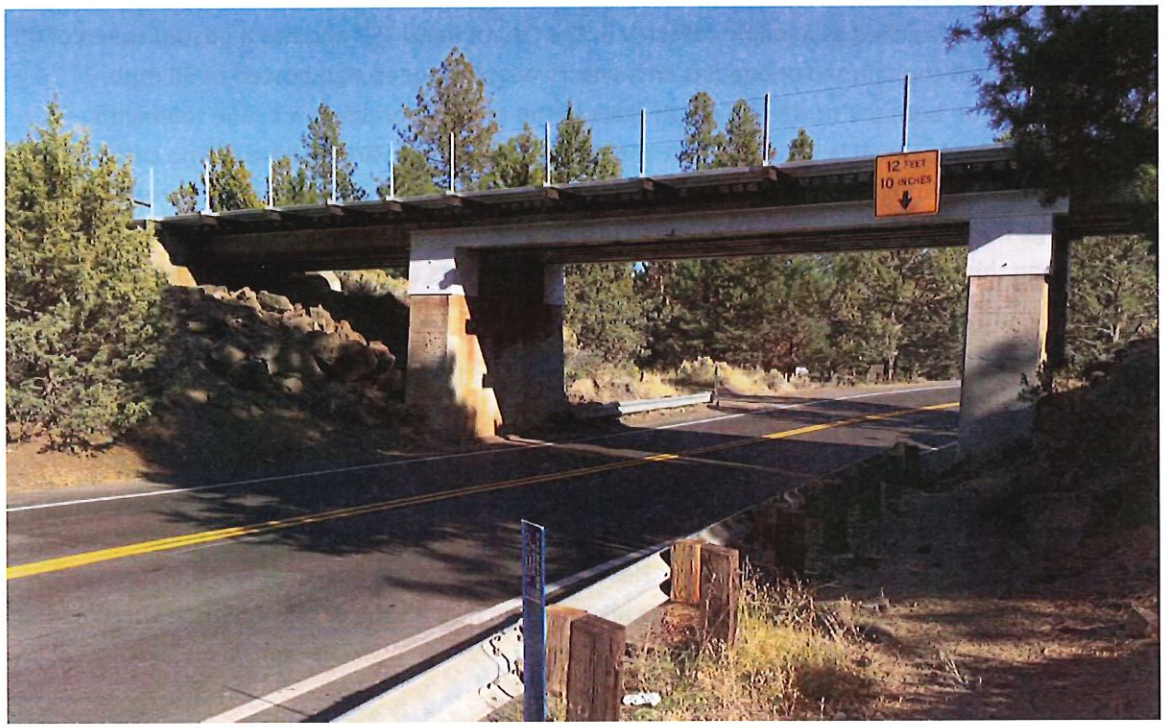


Figure 13: The existing guardrail and signage at the railroad bridge

Exhibit C

SAFETY IMPLEMENTATION PLAN
BROSTERHOUS ROAD

alta PLANNING + DESIGN
KITTELSON & ASSOCIATES, INC.
CENTURY WEST ENGINEERING CORPORATION

Exhibit C

SAFETY IMPLEMENTATION PLAN
MT. WASHINGTON DRIVE

SUMMARY
Citywide Safety Improvements Project
Phase 3: Downtown Bend

Growth Management Department
April 2017

Summary

The following is a summary of work completed to date for possible downtown walking and biking safety projects. At this time there are no design or construction funds programmed in the Transportation CIP for the downtown specific projects, however, the City continues to work on the for the Franklin and 3rd Street design and demonstration project and on the Greenwood corridor a possible demonstration project.

Background

Downtown Bend and the adjacent Central Area are important regional economic centers. Downtown hosts 400 companies with over 3,000 employees and is a main attraction for the thousands of tourists that visit Bend. The total annual payroll from downtown Bend is over $153 million dollars while the average salary for downtown employees exceeds $44,000. Transportation projects that focus on safe and accessible walking and biking projects and programs strengthens the downtown economy and corridors leading to the central area.

This summary identifies key investments in the downtown area which strategically enhance walking safety and comfort, attract and retain talented workers, and ensure visitors' experiences are positive and memorable. This summary:

- Mitigates the root causes of injury crashes identified in the 2012 Safety Study
- Implements the 2016 Parking Study recommendations

- Capitalizes on Central Area Plan, Central Westside Plan, and UGB/ILUTP policies
- Strengthens multimodal routes serving downtown:
    - Franklin Avenue,
    - Greenwood Avenue and
    - Colorado Avenue.

A Downtown Action Plan

The downtown action plan is part of the Citywide Safety Project.

It is organized into four focus areas:

Intersections

There are 16 intersections in downtown that have needs for curb extensions, safety islands, or illumination. These are:

1	Bond Street @ Louisiana	9	Oregon @ Irving
2	Bond @ Franklin Avenue	10	Oregon @ Lava
3	Bond @ Wall-Vermont	11	Oregon @ Harriman
4	Wall Street @ Newport	12	Greenwood @ Hill
5	Wall Street @ Franklin	13	Greenwood @ Harriman
6	Wall Street @ Idaho	14	Newport Avenue @ Brooks Alley
7	Harriman @ Kearney	15	Newport Avenue @ Deschutes River Trail Crossing
8	Harriman @ Irving	16	Newport Avenue @ Drake Road

Curb extensions shorten the street crossing so that they are more comfortable for, and accessible to, people of all ages and abilities.

Safety Islands are raised concrete islands located in the middle of a crosswalk. Similar to curb extensions, safety islands improve visibility and shorten roadway crossings. There are opportunities to add safety islands where painted islands now exist.

Illumination improves visibility during low light or dark conditions. Many downtown activities extend past daylight hours.

Many intersections throughout downtown do not yet have these simple, yet highly effective, street crossing safety facilities.

Figure 1 Curb Extensions provide public space and shorten crossings increasing visibility for everyone

Signal Equipment and Operations

There are four intersections in downtown that have traffic signal needs such as obsolete controllers, antiquated signal poles, and crushed conduit. These each need a complete signal reconstruction effort. These four signals are:

- Oregon at Bond
- Oregon at Wall
- Franklin at Bond
- Franklin at Wall.

The design effort will identify what is needed for each traffic signal in terms of equipment, control, detection, phasing and timing. The Oregon traffic signals will be evaluated for the potential to remove rather than upgrade. This evaluation will include network flow and operations evaluations as well as safety evaluations.

Right Turn Lanes

There are four intersections downtown that have right turn lanes which increase the length of the crossing, create conflicts for crosswalk safety, and increase the width of the intersection. The space allocated to right turn lanes could be considered for additional on-street parking, public open space, bike parking, and bus stops. The evaluation will include impacts to signal timing and safety benefits.

Corridors serving downtown

There are three main corridors considered for safety and operations enhancements that serve the downtown area. These include Greenwood Avenue, Franklin Avenue and Colorado Avenue. Various deficiencies currently exist at each one including left turn lanes, wide street crossings, bike facilities, transit stops and safety islands. The idea is to develop complete streets design concepts that consider moving traffic efficiently and safely for everyone in addition to evaluating measures that remove crossing barriers to improve connectivity.

Greenwood Avenue

Figure 2 Example of adding a left turn lane into a four lane roadway

Greenwood Avenue downtown has four travel lanes. The two inside lanes are both handling left turns when only a single left turn lane is needed.

Additionally, with both left turns and through traffic using the same lane, rear end crashes are common; as are sudden lane changes due to the left turn vehicle stopped in the through lane. Both crash types result in injury crashes.

It is difficult to cross Greenwood Avenue safely for all modes of travel as evidenced by angle crashes at all intersections.

Parking abuts moving traffic lanes without a door opening buffer, which does not provide a comfortable or safe experience for shoppers. Sideswipe crashes occur.

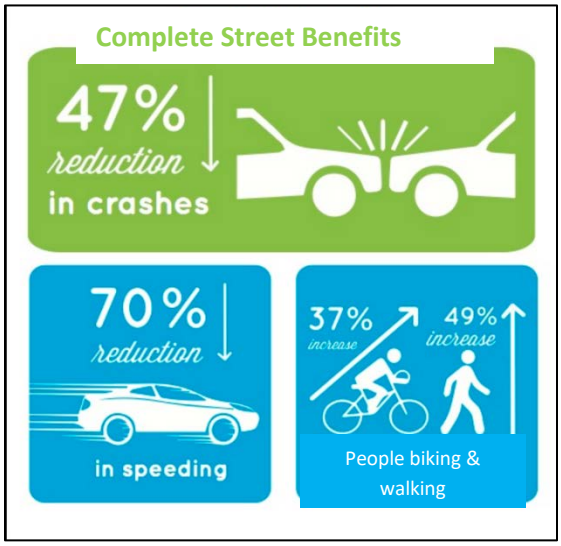
There are no bike lanes leading to wrong way riding on the sidewalk and their resultant crash pattern.

Safety benefits of adding a left turn lane to the corridor include:

- Reduces rear end crashes
- Allows for the addition of safety islands to reduce complexity of crossing
- Curb extensions with on-street parking increases visibility and shortens crossing
- Bike lanes reduce wrong way riding and provide a much needed east-west route
- reduces all corridor crashes up to 47%

Additional benefits:

- on-street parking comfort
- enhanced ability for customers to get around
- stitches north and south of downtown together
- facilitates successful businesses while enhancing the safety and efficiency of all traffic (including ‘through’ traffic)



Downtown north of Greenwood has great potential to grow. Better integrating potential high value land uses with the core of the downtown area is a key strategic investment.

Franklin Avenue

Figure 3 Example of a floating bus stop

Franklin Avenue is constrained to two traffic lanes at the rail underpass and at 5th Street. In the middle it widens to five traffic lanes, preventing safe crossings and is a barrier to north-south movements which would support local businesses. The existing traffic signal at 3rd Street runs inefficiently due to obsolete equipment and detection difficulties. There are injury crashes at 3rd Street due to a high number of conflicts and the built in conflict between right turns and bike lanes.

There is no on-street parking and small businesses along Franklin Avenue could benefit from convenience parking.

Each private lot allows storm water to flow directly into the street. Removing the outside traffic lane can aid in stormwater management. The space could be reassigned for many uses, including floating bus stops (as shown in the figure), on-street parking, landscaping, trees and bike lane buffering.

Safety benefits:

- safety islands reduce complexity of crossing
- curb extensions with on-street parking increases visibility and shortens crossings
- reducing traffic lanes from 5 to 3 facilitates safe north-south traffic movements for everyone

Additional benefits:

- on-street parking can aid small businesses
- Stitches north and south sides of Franklin Avenue together to facilitate a stronger business identify and cohesive business district.

Both north and south of Franklin Avenue has great potential to grow. Better integrating potential high value land uses is a key strategic investment.

Colorado & Arizona Avenues

Rapid growth defines these corridors. And more growth is anticipated. In 2016, the State acknowledged an Urban Growth Boundary plan that identifies 47 acres of the aging industrial district just south of Arizona as a key Opportunity Area for higher density mixed use development. The UGB plan focuses on creating a downtown-like urban development that is pedestrian focused and well-connected to the surrounding area. An existing trail segment and planned neighborhood greenways, along with the modernization of Colorado and Arizona Avenues will play an important role in the success of the emerging mixed use district.

Traffic speeds are high and crashes are indicated due to the speeds, the number of lanes, and growth in the number of people enjoying the new mixed use district.

Benefits:

- Safer crossings for a strong connection between downtown and old mill district
- Connectivity for trails and Neighborhood Greenways
- Increase on-street parking
- Facilitate an urban downtown-like setting that is walkable
- Create a strong, cohesive business district

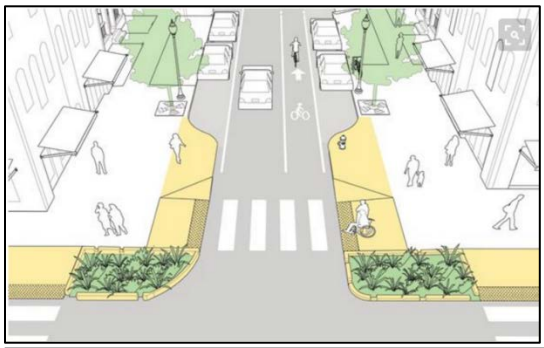
Program Deployment Methodology and Costs

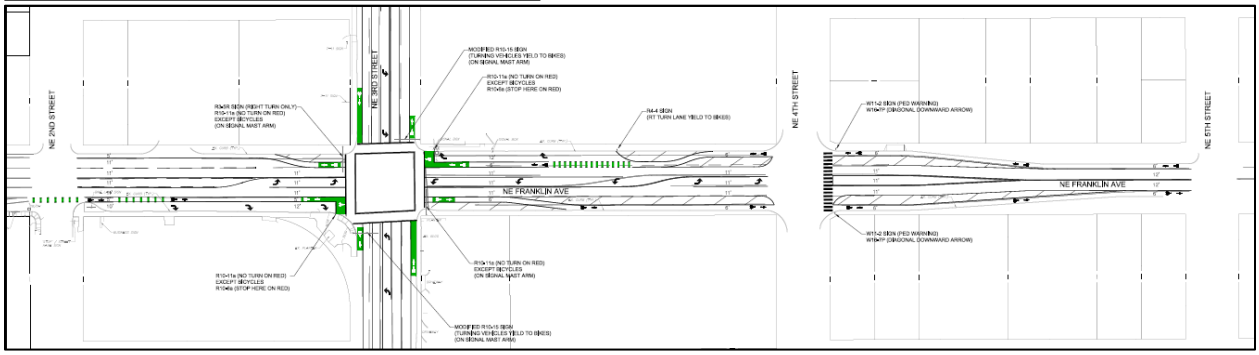
This project can utilize a collaborative process with the Downtown Bend Business Association and other stakeholders to develop and refine concept plans for safety projects throughout downtown. Concept sketches, field demonstrations, and qualitative and quantitative evaluations will be used to finalize concepts.

Concept Development & Operations Evaluation $250,000

Development of concept plans, photo simulations, and other graphics to support the field review of the demonstrations is estimated to cost $100,000 for the concepts associated with the first three focus areas, while concept plans for each additional corridor are estimated to cost $50,000 each.

Each concept would consider a complete street including walking, biking, illumination, transit stops, parking, and bike parking.





Public Outreach & Demonstrations - $350,000

The public outreach support is anticipated to cover consultant help to integrate reviews by a broad set of stakeholders such as the Downtown Bend Business Association, the TAC from the 2016 Parking Study, and the Sounding Board and Project Management Team from the Citywide Safety Program.

Figure 1 A reviewer can feel the difference in a field trial mock-up

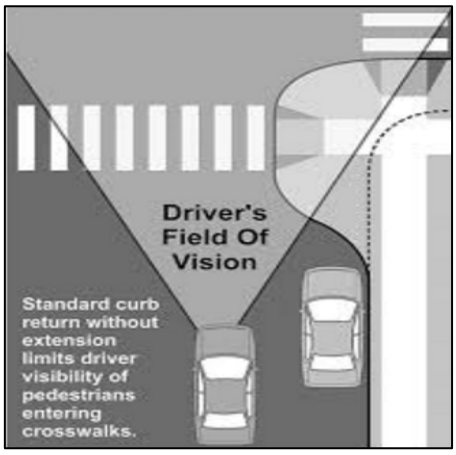


Figure 2 A reviewer can only contemplate the difference from a graphic.

To provide a dynamic hand's-on review process for stakeholders and users the project could utilize pop-up demonstrations, interim installation demonstrations and evaluations. Field demonstrations provide a visual and physical mock-up to increase participation by key stakeholders and allow them to experience the change for themselves. Recommended modifications can be made in real time so that beneficial public input can immediately be incorporated and results identified.

Setting these demonstrations in the field and performing the evaluations and review is anticipated to cost $350,000 in materials and consulting fees.

	Pop Up Demo	Long Term Demo	Tally	Cost Per Location	Level 5 Estimate
DEMONSTRATION PROJECTS					
Multi-lane Threat Countermeasure					
Greenwood Complete Streets	$15,000	$135,000			$150,000
Franklin Complete Streets	$15,000	$64,000			$79,000
Colorado Complete Streets	$15,000	$64,000			$79,000
Downtown Implementation Strategy Demos	$3,000	$10,000	9	$13,000	$117,000
Signalized Crossing Safety					
Remove Oregon Signal - Demonstration		$10,000	2	$10,000	$20,000
Remove Right Turn Lane - Demonstration	$3,000	$10,000	4	$13,000	$52,000
Subtotal Demonstration Projects					**$347,000**

Complete Design and Develop Construction Bid Documents – $700,000

It is estimated to cost $700,000 in consulting fees to develop full design documents including development of the document set for construction bidding purposes.

Construction

Downtown Implementation Strategy					
	Pop Up Demo	Long Term Demo	Tally	Cost Per Location	Level 5 Estimate
CONSTRUCTION PROJECTS					
Multi-lane Threat Countermeasure					
Install curb extensions			11	$26,000	$286,000
Install Safety Islands			6	$30,000	$180,000
Install Stop For Pedestrians in Crosswalk Signs			6	$1,000	$6,000
Bike Parking					
Group Bike Parking			2	$15,000	$30,000
Bike Corrals			3	$5,000	$15,000
Bike Share			2	$20,000	$40,000
Signalized Crossing Safety					
Remove Oregon Signal			2	$30,000	$60,000
Remove Right Turn Lane			4	$30,000	$120,000
Landscaping/On-Street Parking (currently unused roadway space)					
City Hall x 2			2	$5,000	$10,000
Subtotal Construction Projects					**$747,000**
Franklin Complete Street					
Curb Extensions			11	$26,000	$286,000
Safety Islands			3	$30,000	$90,000
Bus Stop			1	$40,000	$40,000
Grind & Inlay, Pavement Marking		**sy**	14000	$50	$700,000
Signal Modernizations			1	$150,000	$150,000
Subtotal Franklin Complete Street					**$1,266,000**
Greenwood Complete Street					
Curb Extensions			24	$26,000	$624,000
Safety Islands			7	$30,000	$210,000
Restriping (incl. chip seal)			1	$100,000	$100,000
Signal Modernizations			2	$150,000	$300,000
Subtotal Greenwood Complete Street					**$1,234,000**
Colorado Complete Street					
Curb Extensions			8	$26,000	$208,000
Pavement Marking			1	$50,000	$50,000
Subtotal Colorado Complete Street					**$258,000**
Budgeting Totals					**$3,852,000**

Timing and Funding Opportunities

This Action Plan is dependent on council prioritization and identification of a funding source. Opportunities might include transportation construction funds, transient room taxes, and parking fees. The work is easily divisible into many smaller stand-alone projects, so construction work can be phased to accommodate funding strategies.

GROWTH MANAGEMENT

Executive Summary
Strategic Implementation Plan for Pedestrian and Bike Infrastructure

This is a summary of the Strategic Implementation Plan for Pedestrian and Biking Infrastructure as well as the public process that was followed in development of this plan. The strategy summarized here achieves a unified pedestrian and biking transportation system through the incremental but systematic deployment of safe and accessible facilities and places high importance on the use of state of the art design techniques to increase user comfort and perception of safety in order to support and encourage increased levels of walking and biking in targeted areas of the community. The approach provides a priority assessment for capital projects and uses multiple deployment mechanisms including the use of alternative funding sources and maximizing implementation during maintenance activities.

Public Outreach

A citizens' advisory committee was created to guide the development of this implementation plan. Named the Bicycling and Walking Improvement Priorities (BWIP) Committee, members represented appointed committees of both the Deschutes County Commission and the Bend City Council, as well as bicycling and accessibility advocacy groups in the community. The committee met frequently throughout 2013 and 2014. The group completed a chartering process to document their goals, objectives and roles in the development of the strategic implementation plan. The committee hosted a forum open to the public to begin creating the strategy and then presented draft and final strategies to the following committees:

- City of Bend Accessibility Advisory Committee
- Central Oregon Coalition for Access
- Deschutes County Bike and Pedestrian Advisory Committee
- Bend Metropolitan Planning Organization Citizens Advisory Committee
- Bend Metropolitan Planning Organization Policy Board
- Neighborhood Association Roundtable
- City of Bend Traffic Safety Advisory Committee
- City of Bend Planning Commission.

Strategic Implementation Plans

Biking Facilities

The recommended bicycling system deployment strategy includes the following delivery techniques:

- Focus on central core where densities and land use intensity are greatest (Century Drive to Purcell; Butler Market to Reed Market);
- Capitalize on private development provided infrastructure;
- Capitalize on maintenance projects (e.g. overlays);
- Provide the next level of bike facility (not just a bike lane) (e.g. buffered, cycle track, separated, bike box, etc.) to serve the broadest range of community members; and
- Create complete street to accommodate multimodal trips along & across the street.

A new system element, Bike Boulevards, has been incorporated to broaden the reach of the existing bike lane system. Whereas bike lanes are provided on arterial and collector roadways which carry heavier traffic loads and freight traffic, Bike Boulevards are located on local streets to provide a less stressful and more

comfortable route for a broader range of community members. Bike Boulevards are important to achieve increased mode split and safety.

Next Steps for implementing the City of Bend's Bicycle Facilities:

1. Develop and issue design RFP which will provide concept designs for the projects identified in Table 1.
2. Create a revolving fund and budget system that creates concept plans, provides project designs and constructs projects.
3. Identify funding for on-going bicycle system maintenance.

The MPO Policy Board has provided a separate budgetary line item within Bend's Surface Transportation Program funding for bike facility maintenance which would include on-going sign and pavement marking maintenance.

Pedestrian Facilities

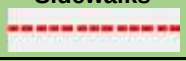
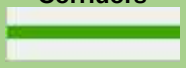
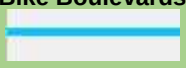
The recommended deployment strategy for pedestrian facilities includes three delivery techniques:

- Focus on Pedestrian Zones: Complete Neighborhoods that already have many of the elements that make them attractive to pedestrians;
- Continue to require Complete Streets: streets serving all modes, all abilities, along and across the street;
- Provide less stressful and more comfortable, safe & secure pedestrian facilities (not only technically ADA compliant but also attractive, safe and inviting by including street crossings, buffered sidewalks, street trees, illumination, etc.).

Next Steps for the Pedestrian System Deployment

1. Develop and issue design RFP which will provide concept designs for many of the projects identified in this deployment strategy.
2. Create a revolving funding and budgeting system that creates concept plans, designs projects, and constructs projects.
3. Develop a program and identify funding for on-going pedestrian system maintenance.

Table 1 Project List

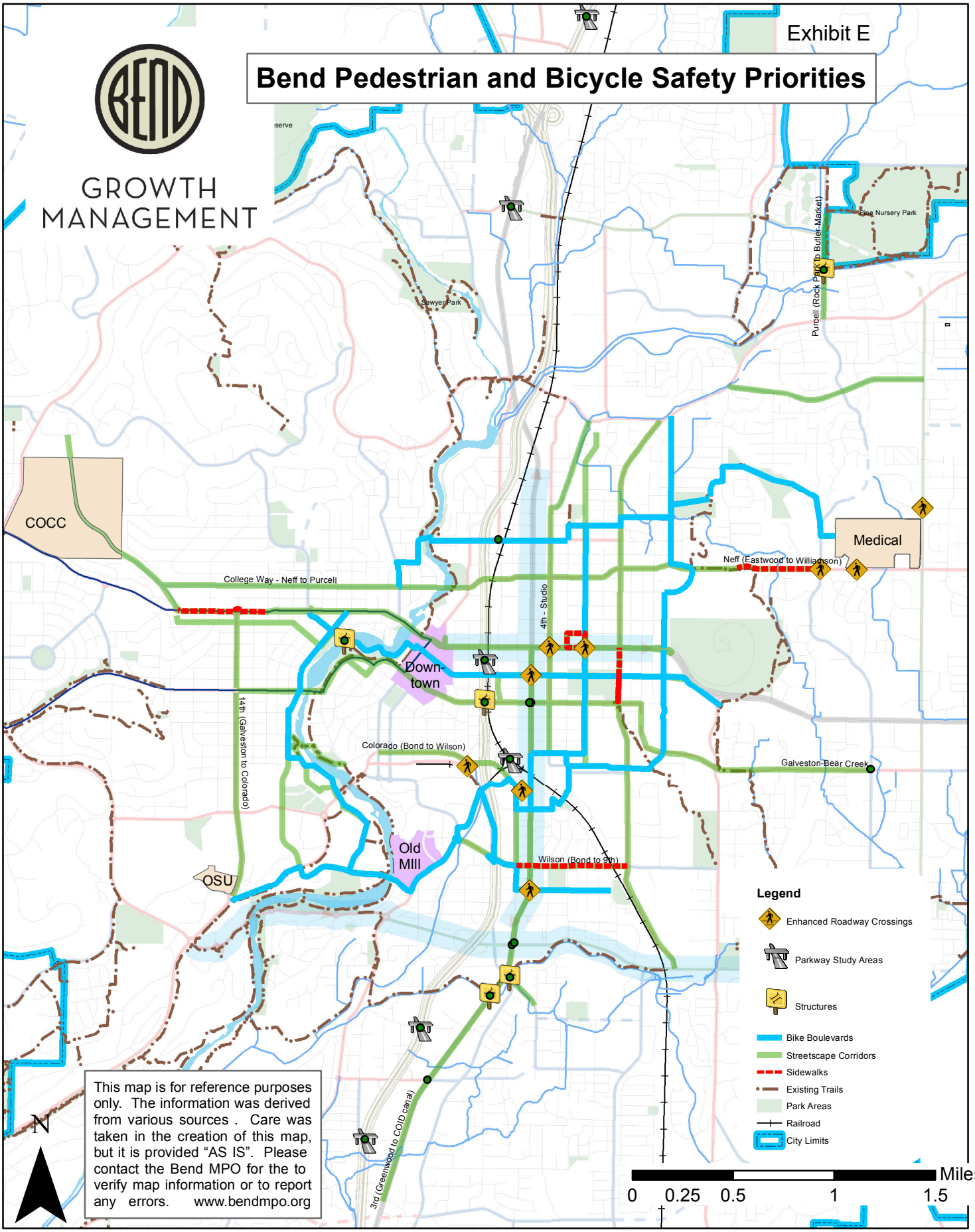
2014 Pedestrian and Bicycle Safety Project Priorities		
Prioritized System Element	**Location**	**Project Description & Class 5* Cost Estimate**
Structures 	Drake Park Footbridge 3rd Street canal (south of Brosterhous) Brosterhous canal (east of 3rd) Purcell Blvd canal (north of Empire) Franklin Undercrossing of RR & Parkway	Add or enhance pedestrian and biking facilities at these locations. **$2 to $10 million** (estimate includes Corridor Study below)
Corridor Study 	Parkway over/under crossings (corridor concept)	US97 Study for safety crossings with ODOT, city of Bend and Bend MPO to determine mitigation to congestion and strategies for multimodal comfort/performance & connectivity
Sidewalks 	Bend Community Center (perimeter streets 5th, 6th, Greenwood, Kearney) CIP Sidewalks: Newport, 8th, Wilson, Neff/Purcell.	Add sidewalks. **$3 to $5 million**
Streetscape Corridors 	College Way-Portland-Olney-Neff (COCC to St. Charles) Newport-Greenwood (College Way to NE 12th Street) Galveston-Riverside-Franklin-Bear Creek (14th to Purcell) Colorado-2nd Street (Bond to Wilson) Wilson (Bond to 9th) 14th (Colorado to Newport) 3rd Street (Greenwood to COID canal) 4th/Studio (Alden to Butler Market) 8th-9th (Reed Market to Butler Market)	Prioritized for both pedestrian and biking upgrade-create integrated streetscape projects (e.g. landscaping, illumination, enhanced roadway crossing & bike lanes, missing sidewalk). **$10 - $15 million**
Overlays (not mapped)	**Up to 8 overlays**	Take advantage of 'clean slate' afforded with fresh pavement surface to facilitate complete biking corridors (e.g. enhanced connectivity, use of state of the art bike lanes such as buffered bike lanes, green conflict zones, bike boxes, and protected bike lanes). **$1 to $2 million**
Stormwater Grate Inlet Elevation Changes (not mapped)	Wilson Avenue Bond Street 8th/9th Street Franklin Avenue 3 additional corridors	Smooth pavement transitions for stormwater grate inlets located in bike lanes. **$50,000 to $100,000 per year**
Trip Facilities (not mapped)	Way Finding Signage	Add way finding signage along key routes to provide travel times and directions to community destinations **$500,000 implementation and $25,000 per year**
Bike Boulevards 	COCC to St. Charles Hosp (4 mi) via 1st Street Rapids COCC to Larkspur Trail (3.2 mi) via Hawthorne OSU-OMD-Coyner Trail via Aune (4 miles) Juniper Swim-Bend High-Marshall High via 6th St (2.3 miles) Harmon-Columbia route (2 miles) Kenwood to OMD 12th Street (2 miles) Bend High to Butler Mkt	Deploy 6 initial neighborhood bikeways on local streets and providing enhanced crossings of busy streets. **$2 to $3 million**
Downtown	Bike Parking Pedestrian Facility Enhancements Bike Facility Enhancements	Add group bike parking downtown to optimize safety of all users. Upgrade traffic signal equipment and phasing/timing to enhance safety of all users. Add pedestrian safety features such as enhanced crossings, curb extensions, illumination. Add bikeway facilities throughout downtown. **$2 to $3 million**
Enhanced Roadway Crossings 	3rd at Hawthorne 3rd at Roosevelt Greenwood at 6th Greenwood at 4th Neff at Williamson Neff at Purcell 27th at Conners	Enhanced crossings include median refuge, high visibility signing and pavement marking and can include activated flashing lights. **$1 to $5 million**

**Class 5: Conceptual, predesign or preliminary estimate with accuracy range of -50% - +100%*

Exhibit E

Bend Pedestrian and Bicycle Safety Priorities

GROWTH MANAGEMENT



This map is for reference purposes only. The information was derived from various sources . Care was taken in the creation of this map, but it is provided "AS IS". Please contact the Bend MPO for the to verify map information or to report any errors. www.bendmpo.org

N

Date: 9/30/2015

Planning Projects Synthesis

There are several large planning projects which have been initiated, but are not yet completed.

- Urban Growth Boundary Remand (UGB) Project
- Central Westside Plan
- Bend Central District Multimodal Mixed Use Area (BCD MMA) Plan
- OSU Cascades Master Planning (future)

Each of these planning efforts will have their own set of construction projects and priorities identified. It is anticipated that there will be some overlap of projects, as well as new projects. Once these projects are completed, there will need to be an integration and synthesis of these project lists and priorities. It is anticipated that this will be performed as part of the city's 5-Year CIP Update.

Standards and Specifications

Staff shall pursue amendments to the city's standards and specifications that enable incorporation of the elements of the Toolbox into new construction or reconstruction of older facilities. A link to the Toolbox can be found here: http://bendoregon.gov/modules/showdocument.aspx?documentid=17952 or you can review bendoregon.gov/growth under Transportation Planning Program with the Multimodal Safety Program for more information.

Figure 1 - Toolbox example improvements

FINAL MEMORANDUM

DATE: March 20, 2017

TO: Robin Lewis, City of Bend

FROM: Steve Boice, P.E., PTOE
Chris Maciejewski, P.E, PTOE
Randy Johnson, P.E., PTOE
Sina Vadaei, EI

SUBJECT: **City of Bend Roundabout Assessment**
Task 4 Data Evaluation P16172-001

Introduction

The purpose of this memorandum is to present the evaluation results of the field data collected at the study roundabout of 15th Street/Reed Market Road in Bend, Oregon. This roundabout was constructed as a multi-lane hybrid to meet immediate travel demand needs while allowing for phasing of additional lanes if needed in the future. It is also one of five newer roundabouts that have been constructed with the City's updated roundabout design standards. The analysis aims to address citizen concerns of driver confusion, higher travel speeds, and potentially higher crash rates compared to other single lane roundabouts within the City. It also considers the impacts these factors may have on roundabout operations and capacity.

Evaluation Criteria and Results

To evaluate the operation and safety of the roundabout, six criteria were analyzed as presented previously as part of the methodology memorandum. A summary of the results of each of the criteria is given below.

Crash Data

Table 1 shows the total reported collisions at the intersection of 15th Street/Reed Market Road as well as the calculated observed crash rates for both before and after the construction of the roundabout[1]. Typically observed crash rates approaching or exceeding 1.0/million entering vehicles (MEV) are flagged for further review. As shown in the table the crash rate per MEV at the intersection prior to the roundabout, under traffic signal control, exceeded 1.0, which indicates there was a need for investigation into potential safety improvements. A roundabout was constructed at this intersection largely due to operational and safety benefits. After the

[1] City of Bend crash records, 2010-2015, provided by Jovi Anderson, City of Bend

construction of the roundabout, the average number of crashes per year and crash rate per MEV was reduced. The average number of total crashes per year was reduced from 18.2 to 2, which is an 84-percent decrease in reported crashes per year.

Table 1: Reported Crashes and Observed Crash Rates

Year	Reported Crashes				Average Crashes/ Year	Observed Crash Rate/Million Entering Vehicle (MEV)	% Total Reduction
	Fatal	Injury	PDO[2]	Total			
Before (2010 to 2014)[1]	0	26	65	91	18.2	1.9	84
After (2015)[1]	0	2	1	2	3	0.3	

Notes:
1. Before refers to the time before the roundabout was built. After refers to the time after the roundabout was built. The roundabout was opened November 21, 2014 and the "After" crash data is available only for the year 2015. The 2015 data is preliminary and subject to change.
2. PDO = Property Damage Only crashes

This is a significant reduction in crashes, therefore the comparison of crash rates for other single lane and multi-lane roundabouts were conducted. Table 2 shows the average annual crash rates at 11 U.S intersections that were converted to roundabouts[2]. The average crash rate of the study roundabout is much less than other U.S large sized roundabouts, however the available crash data is limited to one year.

Table 2: Average Annual Crash Rates at 11 U.S. Intersections Converted to Roundabouts

Size	Sites	Before Roundabout			Roundabout			% Total Reduction
		Injury	PDO	Total	Injury	PDO	Total	
Small/Moderate[1]	8	2.0	2.4	4.8	0.5	1.6	2.4	50
Large[2]	3	5.8	15.7	21.5	4.0	11.3	15.3	29

Notes:
1. Mostly single-lane roundabouts with an inscribed circle diameter of 30 to 35 m (100 to 115 ft).
2. Multilane roundabouts with an inscribed circle diameter greater than 50 m (165 ft).

Additionally, the crash rate reduction from this study was compared to the crash reduction factor (CRF) from Crash Modification Factors Clearing House[3]. A crash reduction factor (CRF) is the percentage crash reduction that might be expected after implementing a given countermeasure at a specific site.

[2] Roundabouts: An Informational Guide. Washington, D.C.: U.S. Dept. of Transportation, Federal Highway Administration, 2000. June 2000. Web.
[3] "Crash Modification Factors Clearinghouse." Crash Modification Factors Clearinghouse. N.p., n.d. Web. 24 Feb. 2017.

Table 3 shows the CRF for converting a signalized intersection into a roundabout. As listed, the CRF for the study roundabout is also greater than other studies and is comparable with that used by the Oregon Department of Transportation (ODOT).

Table 3: Crash Reduction Factors for Converting a Signalized Intersection into Single or Multi-Lane Roundabout

	Crash Reduction Factor (%)
Single-Lane[4]	26
Multi-Lane[3]	19
ODOT Roundabout[5]	48-78*
Study Roundabout (Hybrid)	89

*Note: This CRF does not include PDO's

Count Data

Existing volumes were collected for three different days at the study roundabout using a combination of video and road tubes. Figure 1 through Figure 3 show the peak hour turn movement counts for each respective day of count data. The volumes were found to be relatively consistent over the study period. Table 4 shows the peak hour times and total entering volume. The highest p.m. peak hour volume occurred on September 21, 2016 (Wednesday) beginning at 4:30 p.m. The current peak hour volumes are consistent with the previously forecasted peak hour volumes for the intersection (current 2016 p.m. peak 2,594 versus projected 2020 p.m. peak 2,585, current 2016 a.m. peak 2,166 versus projected 2020 a.m. peak 2,079)[6].

Figure 4 shows the trend of existing average daily eastbound traffic volumes given the three days of count data over the 24-hour period. As illustrated the volumes peak in the morning from 7 a.m. to 9 a.m. and in the afternoon from 4 p.m. to 6 p.m. The right lane of the west leg approach has lower volumes than the left lane since the right lane is a right turn only lane. This makes the left lane of the west leg approach the critical lane, a concept that is important when modifying the capacity model later in this memorandum.

[4] Gross, Frank, Craig Lyon, Bhagwant Persaud, and Raghavan Srinivasan. "Safety Effectiveness of Converting Signalized Intersections to Roundabouts." Accident Analysis & Prevention 50 (2012): n. pag. Web.
[5] ODOT HSIP Countermeasures and Crash Reduction Factors, January 2015.
[6] G.O. Bond Reed Market Intersection Evaluation Report, DKS Associates, October 2012.

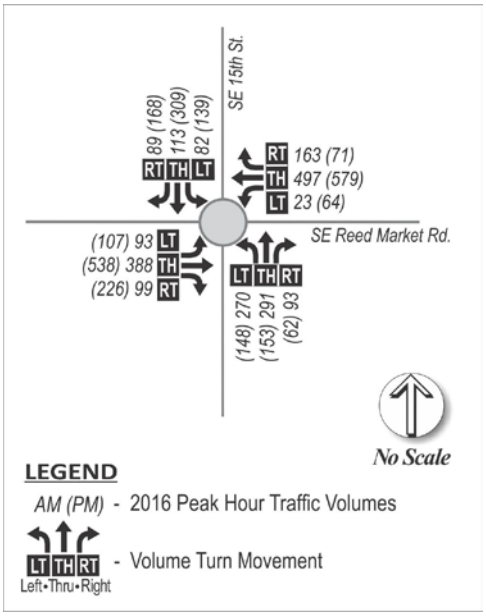


Figure 1: Peak Hour Volumes for 9/20/2016

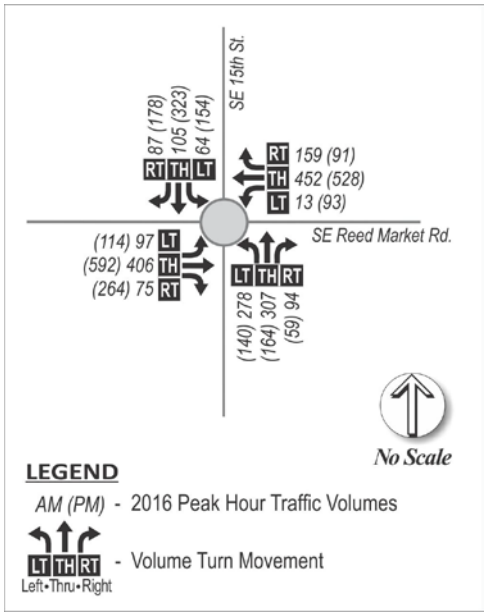


Figure 2: Peak Hour Volumes for 9/21/2016

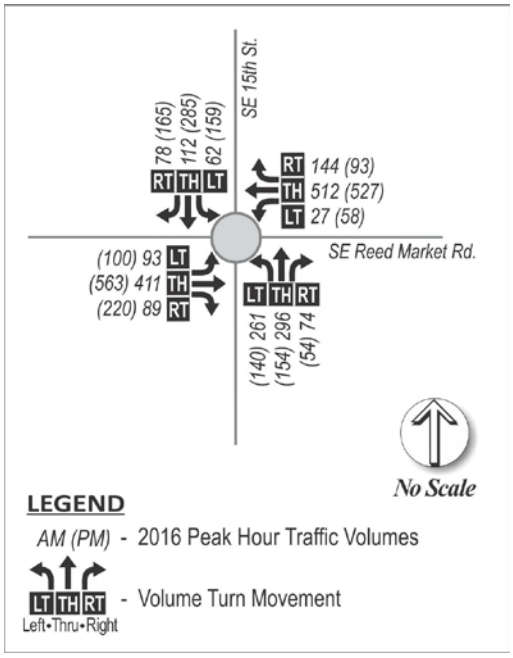


Figure 3: Peak Hour Volumes for 9/22/2016

Table 4: Peak Hour Times and Total Volumes for Collected Data

Date	a.m. Peak Hour (p.m. Peak Hour)	Total a.m. Volume (Total p.m. Volume)
September 20, 2016	7:10 to 8:10 (4:50 to 5:50)	2,201 (2,564)
September 21, 2016	7:10 to 8:10 (4:30 to 5:30)	2,137 (2,700)
September 22, 2016	7:05 to 8:05 (4:40 to 5:40)	2,159 (2,518)

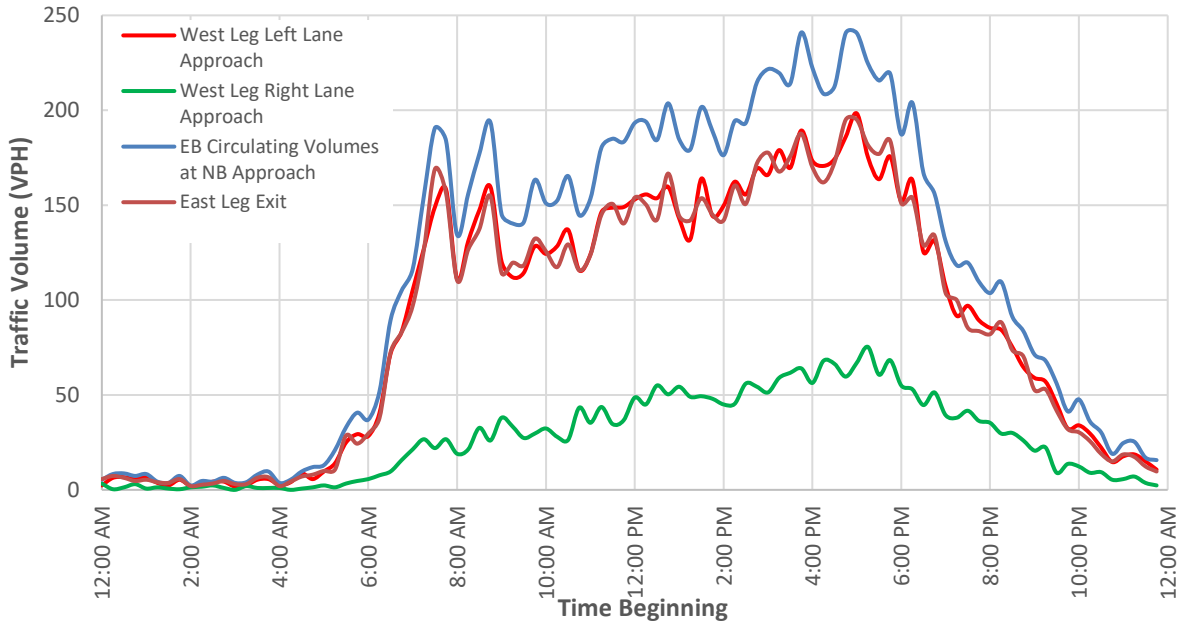


Figure 4: Average Daily Volumes at 15th Street/Reed Market Road

Pedestrian Yielding Compliance

Table 5 shows the yielding compliance rate of all vehicles during a pedestrian or bicyclist crossing event at the marked crosswalk on the east leg of the study roundabout.

The pedestrian/bicyclist yielding rates of eastbound entering vehicles is high (95-percent to 100-percent), however the exiting vehicles along the west leg have a much lower pedestrian yielding compliance rate (65-percent). In comparison, roundabouts across the country showed an average yield rate of 76 to 79-percent on the entry side and 54 to 69-percent on the exit side[7]. Therefore, the yielding rate for entering vehicles at this roundabout is higher than average, and within average for exiting vehicles.

[7] Rodegerts, Lee, et al. (2007), Roundabouts in the Unites States. NCHRP Report 572. National Cooperative Highway Research Program. Transportation Research Board. Washington, DC. 2007Rouphail et al., 2005

It is important to note that pedestrian volumes at this roundabout were low during the traffic count periods and almost half of the crossing events were bicyclists using the crosswalk. All the bicyclists using the crosswalk biked across rather than getting off their bikes prior to the crossing[8]. Drivers could be more likely to yield to pedestrians than bicyclists because drivers could interpret bicyclists as vehicles.

Table 5: Pedestrian/Bicyclist Yielding Compliance Rate on the East Leg of the Study Roundabout

Date	Time	# of Crossing Events	Sample Size (# of Vehicles)	Yielding Compliance[1]		
				Exiting Vehicles	Entering Vehicles (Left Lane)	Entering Vehicles (Right Lane)
September 20, 2016	6 a.m. – 8 p.m.	8	23	60%	85%	100%
September 21, 2016	6 a.m. – 8 p.m.	12	24	63%	100%	100%
September 22, 2016	6 a.m. – 8 p.m.	10	13	100%	100%	100%
Total Yielding Compliance[2]		**30**	**60**	**65%**	**95%**	**100%**
Nationwide Comparison				**54% – 69%**	**76% to 78%**	

Notes:
1. Yielding compliance is calculated by dividing the number of vehicles that yielded by the total number of vehicles that had the opportunity to yield or not yield during the crossing events on a given day. A motorist is in compliance when they slowed or stopped/remained stopped for a crossing pedestrian/bicyclist waiting on the curb or splitter island to cross.
2. Total yielding compliance is calculated by dividing number of vehicles that did not yield by the total number of vehicles that had the opportunity to yield or not yield during the crossing events over the three days of the study.

To further understand the nature of yielding compliance Table 6 summarizes the pedestrian/bicyclist yielding compliance rate of pedestrians/bicyclists that walked/biked from the curb towards the island. As indicated, the percentage drops slightly. In comparison, roundabouts across the country showed an average yield rate of 76-percent on the entry side and 54-percent on the exit side[9].

[8] ORS 814.410 states that a bicycle may operate on sidewalk or entering crosswalk if operating at a speed that is similar to an ordinary walk.
[9] Rodegerts, Lee, et al. (2007), Roundabouts in the Unites States. NCHRP Report 572. National Cooperative Highway Research Program. Transportation Research Board. Washington, DC. 2007Rouphail et al., 2005

Table 6: Pedestrian/Bicyclist Yielding Compliance Rate on the East Leg of the Study Roundabout for pedestrians/bicyclists walking/biking towards the island

Date	Time	# of Crossing Events	Sample Size (# of Vehicles)	Yielding Compliance		
				Exiting Vehicles	Entering Vehicles (Left Lane)	Entering Vehicles (Right Lane)
September 20, 2016	6 a.m. – 8 p.m.	5	14	43%	50%	N/A
September 21, 2016	6 a.m. – 8 p.m.	9	15	56%	100%	N/A
September 22, 2016	6 a.m. – 8 p.m.	6	3	N/A	100%	100%
Total Yielding Compliance		**20**	**32**	50%	83%	100%
Nationwide Comparison				**54%**	**76%**	

Table 7 summarizes the yielding compliance rate for pedestrians and bicyclists separately. The yielding compliance rate increases for exiting vehicles when there is a pedestrian present compared to bicyclist.

Table 7: Pedestrian Versus Bicyclists Yielding Compliance Rate on the East Leg of the Study Roundabout

Date	Time	# of Crossing Events	Sample Size (# of Vehicles)	Yielding Compliance		
				Exiting Vehicles	Entering Vehicles (Left Lane)	Entering Vehicles (Right Lane)
Total Bicyclist Yielding Compliance		14	30	55%	100%	100%
Total Pedestrian Yielding Compliance		16	30	75%	90%	100%
Nationwide Comparison				54% – 69%	76% to 78%	

Table 8 summarizes the yielding compliance rate for pedestrians and bicyclists that traveled from the curb towards the island separately. Again, the yielding compliance rate increases for exiting vehicles when there is a pedestrian present compared to a bicyclist.

Table 8: Pedestrian Versus Bicyclists Yielding Compliance Rate on the East Leg of the Study Roundabout for pedestrians/bicyclists walking/biking towards the island

Date	Time	# of Crossing Events	Sample Size (# of Vehicles)	Yielding Compliance		
				Exiting Vehicles	Entering Vehicles (Left Lane)	Entering Vehicles (Right Lane)
Total Bicyclist Yielding Compliance		11	14	38%	100%	N/A
Total Pedestrian Yielding Compliance		9	18	63%	80%	100%
Nationwide Comparison				54% – 69%	76% to 78%	

Based on the given data, the entry pedestrian compliance rate exceeds the national average. The high compliance rate on entry may be attributed to adequate sight distance, crosswalk marking visibility and driver expectancy to yield at entry to the roundabout. Exiting vehicles tend to increase their speed in the roundabout and increase their speed even more as they exit the roundabout. While the exiting pedestrian yielding compliance rate is lower, adequate sight distance is available, operating speeds are below the design speed, and the rate is comparable to national averages. One possible factor to lower rates at the exit could be driver expectancy to not yield after entering an intersection.

Based on the low number of observed natural pedestrian crossings further analysis with a larger sample size is recommended (staged crossings) to assess yielding compliance for both pedestrians and bicyclists.

Lane Assignment Compliance

Table 9 shows the lane assignment compliance rate of all vehicles along the west and south leg approaches while Figure 5 shows a graphical representation of the total correct lane assignment compliance rate by approach leg. To measure compliance, each vehicle was observed through video to see whether they used the correct lanes from the point of entry to where they exit.

Table 9: Lane Assignment Compliance Rate by Leg Approach

West Leg Approach					
Date	**Time**	**Volume**		**Lane Compliance Rate**	
		Left Lane	**Right Lane**	**Left Lane**	**Right Lane**
September 20, 2016	4 p.m. – 6 p.m.	1,412	590	100%	98%
September 21, 2016	4 p.m. – 6 p.m.	1,487	521	100%	97%
September 22, 2016	4 p.m. – 6 p.m.	1,353	454	100%	95%
Total		**4,252**	**1,565**	**100%**	**97%**
South Leg Approach					
Date	**Time**	**Volume**		**Lane Compliance Rate**	
		Left Lane	**Right Lane**	**Left Lane**	**Right Lane**
September 20, 2016	4 p.m. – 6 p.m.	295	113	93%	96%
September 21, 2016	4 p.m. – 6 p.m.	293	103	92%	91%
September 22, 2016	4 p.m. – 6 p.m.	264	108	97%	98%
Total		**852**	**324**	**94%**	**95%**

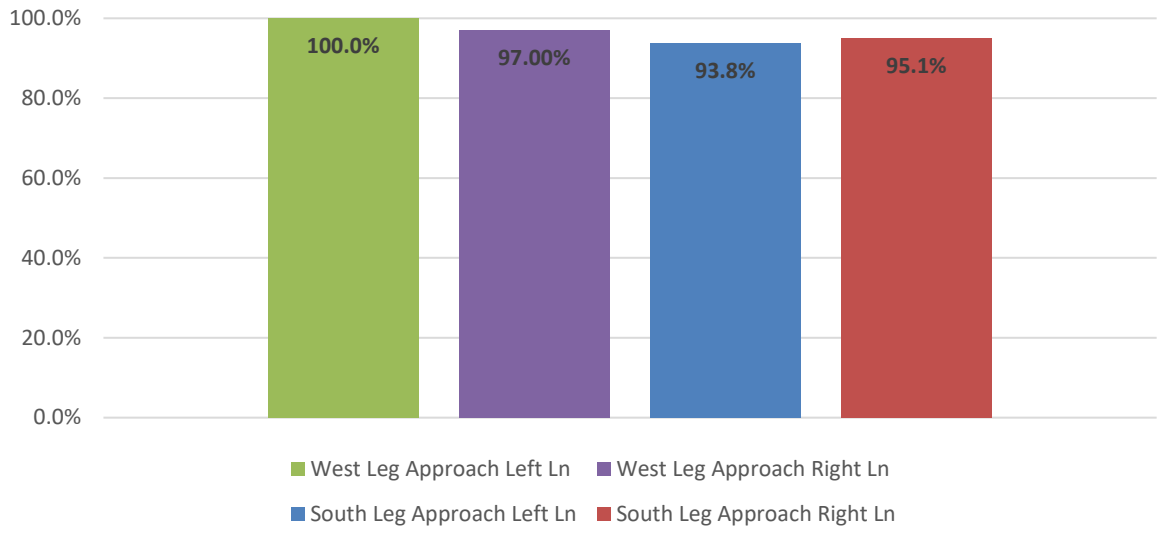


Figure 5: Total Lane Assignment Compliance Rate by Leg Approach

Overall, the lane assignment compliance rate at this roundabout is high. The south leg approach has a slightly lower compliance rate than the west leg, but was still observed to have a lane assignment compliance of over 90-percent. The slightly lower compliance for the south leg could be because the lane-use configuration at this approach is different than the other three legs. The eastbound, westbound, and southbound approach have a thru-left turn lane as well as a dedicated right turn only lane, while the northbound approach has a thru-right turn lane and a left turn only lane. Table 10 which shows the origin to destination rates for both the west and south leg confirms that almost all the vehicles that incorrectly used the left lane (left turn only) coming from the south leg approach proceeded to go straight (north leg). For the west leg approach, most vehicles that were non-compliant were the vehicles using the right lane (right turn only) as they proceeded straight (east leg).

Table 10: Origin to Destination Rates of Vehicles using the Roundabout during P.M. Peak Hours

	Origin	Destination			
		South Leg	North Leg	West Leg	East Leg
West Leg	Left Lane	(0.02%)	17.17%	0.00%	82.81%
	Right Lane	97.06%	(0.06%)	(0.00%)	(2.88%)
South Leg	Left Lane	0.00%	(6.10%)	93.78%	(0.12%)
	Right Lane	(0.00%)	69.85%	(4.94%)	25.21%

Notes:
1. (X.XX%) Represents percent of vehicles that have a destination that is non-compliant with the assigned lane utilization
2. X.XX% Represents percent of vehicles that have a destination that is compliant with the assigned lane utilization

Vehicle Speed

Table 11 shows the measured 85th percentile speeds at the west leg entrance, middle of circulating roadway at the south leg, and the east leg exit of the roundabout. Figure 6 indicates the locations at which speeds were measured. The measured 85th percentile speeds at each location were all below the design speed.

Table 11: 85th Percentile Speed by Vehicle's Location at the Roundabout

Location	Sample Size (Vehicles)	85th % Speed (MPH)	Design Speed (MPH)
Entrance (Left Lane)	22,845	15	27.6
Entrance (Right Lane)	7,218	14	27.6
Mid-Circulating	43,291	17	18.8
Exit	25,661	22	34.8

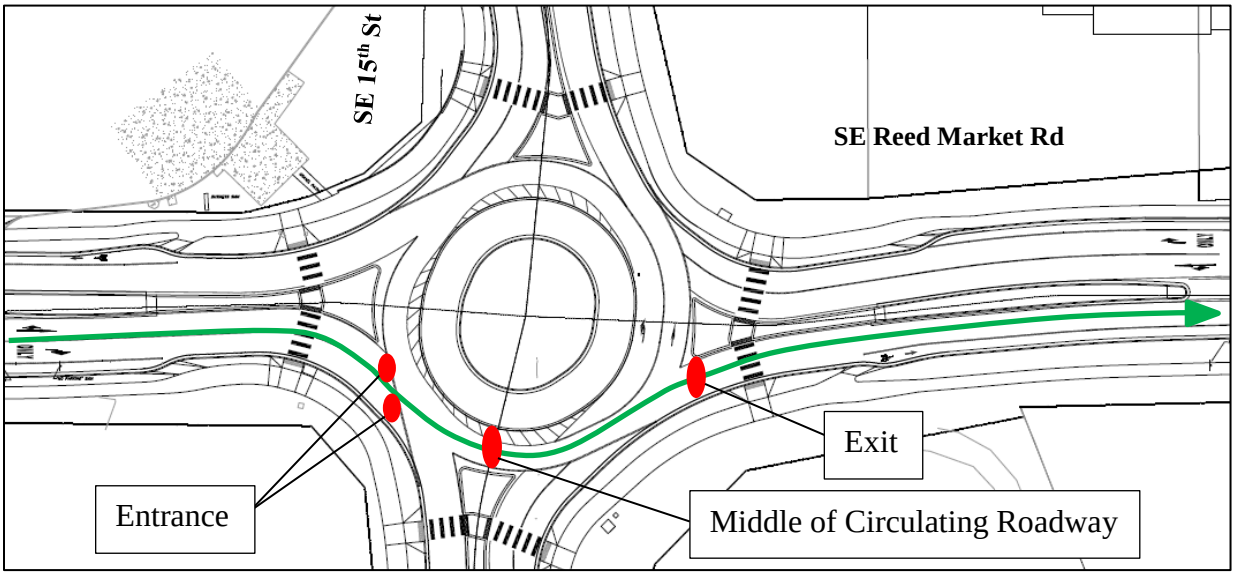


Figure 6: Speed Measuring Locations

Figure 7 illustrates the percent distribution of speeds at the three different points of the roundabout. There is a small percentage of vehicles that drive above the design speed as listed in Table 12.

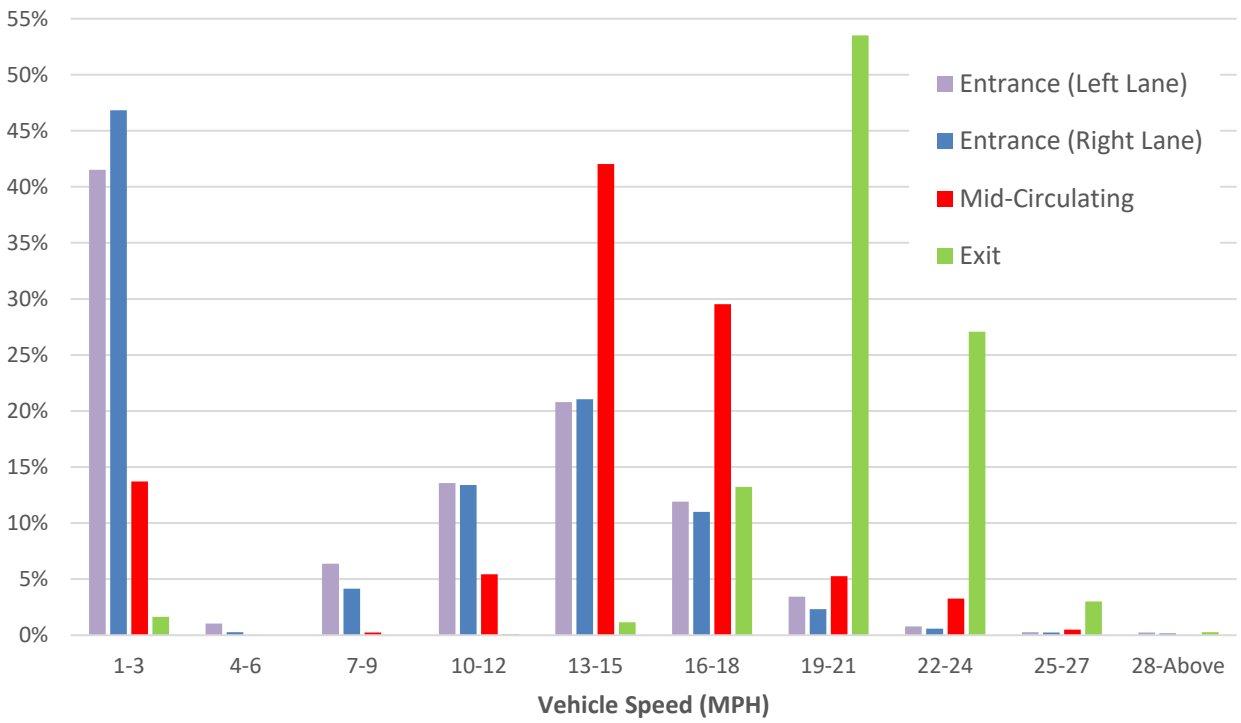


Figure 7: Percent Distribution of Speed by Vehicle's Location at the Roundabout

Table 12: Percent of Vehicles Driving Above the Design Speed

Location	Percent of Vehicles Driving Above the Design Speed
Entrance (Left Lane)	0.5%
Entrance (Right Lane)	0.3%
Mid-Circulating	9.1%
Exit	0.0%

As provided in the figures and tables above, vehicles tend to enter the roundabout with lower speeds and speed up continuously as they exit the roundabout. The 85th percentile speeds at all locations of the roundabout are below the design speed.

Gap Acceptance Analysis

This section presents the estimates of critical gap and follow up headway. These values are then used to develop a new specific capacity model for the multi-lane hybrid study roundabout.

Critical Headway (Gap)

As discussed in the methodology memorandum, the critical gap is the minimum gap an entering driver would find acceptable. The critical gap was evaluated using the maximum likelihood

technique[10], a method that estimates the average critical gap of all drivers by assuming that a single driver's critical gap ranges between their largest rejected gap (or lag) and the accepted gap. Two different methodologies were used for estimating critical gap as follows:

- **Method 1:** Does not include observations that contains accepted gaps larger than 10 seconds.
- **Method 2:** Includes observations that contains accepted gaps larger than 10 seconds.

Both methods do not include observations that do not have a rejected gap/lag or had an accepted gap that was smaller than the largest rejected gap. Exiting vehicles were also not included in this study.

Table 13 shows the results of the critical gap for the west approach (eastbound) of the roundabout during the p.m. peak hour. As listed, Method 2 has a higher mean critical gap since all accepted gaps were included. Method 2 also shows a higher standard deviation because of that reason. Since NCHRP 572 recommends multi-lane capacity analysis to be conducted on a lane by lane basis and reported for the most critical lane (lane with the highest volume) on each approach, this study separated out mean critical gap by lane. The critical lane for the eastbound approach of the study roundabout is the left lane. Therefore, the mean critical gap for this study is between 3.80 to 4.10 seconds. It is recommended that Method 1 be used for this study due to the lower standard deviation.

Table 14 shows a reference of critical gaps found in other studies. The critical gap found in this study is lower than the national average. However, the critical gap is similar to the City of Bend's current standard (4.1 seconds) for a single lane roundabout. It is important to note that the City of Bend's standard for critical gap is based on a single lane roundabout and not for a hybrid roundabout, as is the case with this roundabout.

Table 13: Critical Gap Results for the West Approach of Study Roundabout

West Leg Approach	Method 1			Method 2		
	Sample Size	Mean Critical Gap (s)	Standard Deviation (s)	Sample Size	Mean Critical Gap (s)	Standard Deviation (s)
Left Lane	217	3.80	0.63	350	4.10	0.81
Right Lane	87	3.32	0.83	127	3.49	0.86
Total	304	3.62	0.77	477	3.91	0.90

[10] Rodegerts, Lee, et al. (2007), Roundabouts in the Unites States. NCHRP Report 572. National Cooperative Highway Research Program. Transportation Research Board. Washington, DC. 2007Rouphail et al., 2005

Table 14: Mean Critical Gap Comparison

Reference	Mean Critical Gap (s)		
	Single	Left	Right
HCM 2010[11]	5.19	4.29	4.11
NCHRP 572[12]	5.10	4.50	4.20
2010 Bend Study[13]	4.10	N/A	

Follow-Up Headway

As discussed in the methodology, the follow-up headway is defined as the headway maintained by two consecutive entering vehicles using the same gap in the conflicting stream. The follow-up headway was observed for the west leg (eastbound approach) of the study roundabout during the p.m. peak hour. Figure 8 illustrates the frequency of the follow-up headway for the left and right lane. For the left lane, very few follow-up headways exceed six seconds. Approximately 2-percent of the data exceed a follow-up headway of six seconds. Therefore, a follow-up headway threshold of six seconds was established for the left lane, assuming that it would indicate a queued condition. Similarly, a follow-up headway threshold of eight seconds was established for the right lane. Approximately 6-percent of the data exceed a follow-up headway of eight seconds. Using these thresholds, the mean follow-up headways for each lane of the west leg approach were calculated and are shown in Table 15.

The mean follow-up headway is approximately 2.86 seconds for the left lane (critical lane) of the study approach while the right lane is slightly higher at 3.27 seconds. Table 16 shows a reference of follow-up headways found in other studies. It can be seen that the follow-up headway found in this study is similar to the national average. However, the follow-up headway is slightly higher than the City of Bend's current standard (2.7 seconds) for a single lane roundabout. Again values are expected to be different from the City of Bend's current standard as this study analyzes a multi-lane hybrid roundabout and not a single lane roundabout.

[11] TRB, Highway Capacity Manual, Chpt. 21 and supplemental 33, N.R.C., Washington DC, 2010.
[12] Rodegerdts, L., M. Blogg, E. Wemple, E. Myers, M. Kyte, M. Dixon, G. List, A. Flannery, R. J. Troutbeck, W. Brilon, and Others. *National Cooperative Highway Research Program Report 572: Roundabouts in the United States*, Transportation Research Board of the National Academic, Washington, D.C, 2007.
[13] Roundabout Evaluation and Design Guidelines, Kittleson & Associates, Inc., April 2010

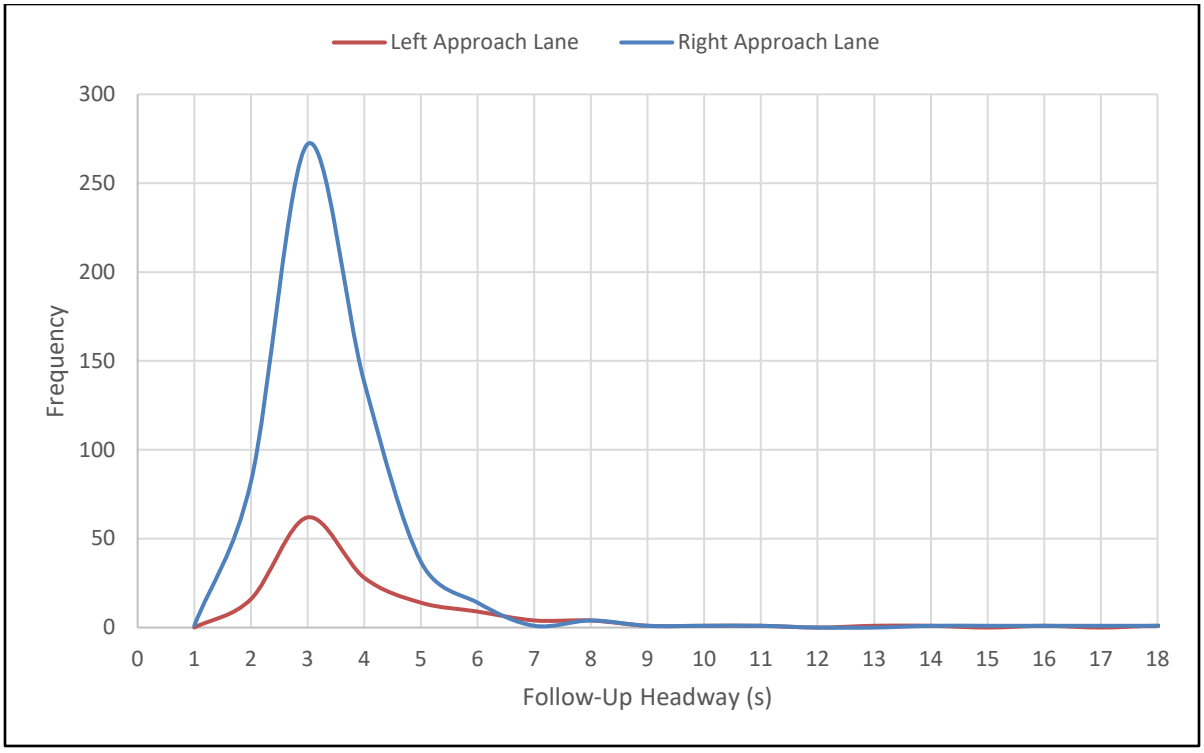


Figure 8: Follow-Up Headway Frequency for the West Leg Left and Right Approach Lane

Table 15: Follow-Up Headway Estimates for the West Leg Approach of Study Roundabout

Left Lane			Right Lane		
Sample Size	**Mean Follow-Up Headway <6 s (s)**	**Standard Deviation (s)**	**Sample Size**	**Mean Follow-Up Headway < 8 s (s)**	**Standard Deviation (s)**
544	2.86	0.85	137	3.27	1.38

Table 16: Mean Follow-Up Headway Comparison

Reference	Mean Follow-Up Headway (s)		
	Single	Left	Right
HCM 2010[14]	3.19	3.19	3.19
NCHRP 572[15]	3.20	3.40	3.10
2010 Bend Study[16]	2.7	N/A	

[14] TRB, Highway Capacity Manual, Chpt. 21 and supplemental 33, N.R.C., Washington DC, 2010.
[15] Rodegerdts, L., M. Blogg, E. Wemple, E. Myers, M. Kyte, M. Dixon, G. List, A. Flannery, R. J. Troutbeck, W. Brilon, and Others. *National Cooperative Highway Research Program Report 572: Roundabouts in the United States*, Transportation Research Board of the National Academic, Washington, D.C, 2007.
[16] Roundabout Evaluation and Design Guidelines, Kittleson & Associates, Inc., April 2010

Capacity

The parameters in the capacity model (Equation 1[17]) can be calibrated to account for the driver's behavior found in this study.

$$c_{pce} = A * \exp(-B * v_{c,pce})$$ Equation 1

Where

$c_{pce} = lane\ capacity\ \left(\frac{pc}{h}\right)$

$A = \frac{3600}{t_f}$

$B = \frac{t_c - t_f/2}{3600}$

$v_c = conflicting\ circulating\ flow\ rate, adjusted\ for\ heavy\ vehicles\ \left(\frac{pc}{h}\right)$

$t_f = follow - up\ headway\ (s)$

$t_c = critical\ headway\ (s)$

The values that will be evaluated for this study are the A and B variables. The calibrated capacity model for the study roundabout as well as the existing HCM 2010 and City of Bend standard capacity models are shown in

Table 17.

Table 17: Calibrated Capacity Model for the Study Roundabout vs Existing Capacity Models

	t_f (s)	t_c (s)	A	B	c_{pce} (pc/h)
Study Roundabout					
West Leg Left Lane (Critical Lane)	2.86	3.80	1259	0.0007	$1259 * \exp(-0.0007 * v_{c,pce})$
West Leg Right Lane	3.27	3.32	1101	0.00047	$1101 * \exp(-0.00047 * v_{c,pce})$
National Average (HCM 2010 & NCHRP 572)					
Single Lane	3.2	5.1	1125	0.001	$1130 * \exp(-0.0010 * v_{c,pce})$
Multi-Lane (Critical Lane)	3.2	4.2	1125	0.0007	$1130 * \exp(-0.0007 * v_{c,pce})$
City of Bend Existing Standards					
Single Lane	2.7	4.1	1333	0.0008	$1333 * \exp(-0.0008 * v_{c,pce})$
[18]Multi-Lane (Critical Lane)	3.2	4.2	1125	0.0007	$1130 * \exp(-0.0007 * v_{c,pce})$

[17] Roundabout Evaluation and Design Guidelines, Kittleson & Associates, Inc., April 2010

[18] There no calibrated City of Bend model for multi-lane roundabouts therefore NCHRP 572 values are reported.

Table 17 compares the study roundabout's west leg lane capacity using the different capacity models based on the p.m. peak hour traffic volumes at the study intersection. When comparing the study roundabout's capacity model for the left or right lane to the existing capacity models, the study roundabout's calibrated capacity model provides a similar lane capacity to the City's existing single lane roundabout model. The measured capacity is approximately 29-percent higher than national averages.

The results indicate that although there are two approaching lanes for both the study approach and adjacent approach (right turn lane and through/left lane) the lane capacity is similar to a single lane due to the single circulating lane. Note that a multi-lane roundabout refers to when entry lanes are conflicted by two circulating lanes. The right turn lane along the adjacent approach (north leg) does not appear to affect the left lane capacity. It is recommended that additional legs of the study roundabout be evaluated in addition to other roundabouts for further comparison to better understand the distribution of critical gap and follow-up headway for a larger sample size.

Table 18: Study Roundabout West Leg Lane Capacity Comparison

Reference	Conflicting Flow	c_{pce} (pc/h)	% Difference from Study Roundabout's c_{pce}
Study Roundabout			
Left Lane (Critical Lane)	607	824	N/A
Right Lane	607	828	N/A
Single Lane			
NCHRP 572/HCM 2010	607	616	-29%
Existing City of Bend Standard	607	820	-1%
Multi-Lane			
NCHRP 572/HCM 2010/ Existing City of Bend Standard	607	740	-11%

Findings

Based on the findings presented above, the safety and operations of the study roundabout is within or above national averages. Data collected at the roundabout indicate that drivers are generally complying with lane assignments, yielding to pedestrians, and operating within expected operating speeds. While enhancements could be considered in some areas, such as yielding at the roundabout exit, results indicate a high level of overall compliance. The following sections describe key findings and recommendations where appropriate by performance measure.

Crash Data

Comparing crash data from before and after the roundabout was constructed, it is evident that crash rates have improved compared to traffic signal operations. The crash rate is lower when compared to other roundabouts within the U.S., however the after data is limited to one year. While crash records should continue to be evaluated, there is no apparent safety issue at this time.

Pedestrian Yielding Compliance

The observed yielding compliance rate to pedestrians and bicyclists at the study hybrid multi-lane roundabout is higher than the national average, but may be lower than expected compared to other locations in Bend (e.g., single lane roundabouts and mid-block crossings of 2 to 3 lane facilities). For example, the yielding compliance rate for exiting vehicles was found to be lower than the rate for entering vehicles, although still comparable to national averages. From this study, there are no immediate concerns that likely necessitate an active pedestrian crossing treatments such as a rectangular rapid flashing beacon (RRFB) at the roundabout approaches. Per NCHRP Report 562, the need for an active pedestrian crossing treatment is a function of pedestrian volumes (minimum of 20 pedestrians per hour is needed for any sort of treatment recommendation), speeds, surrounding area's population, major road volumes, pedestrian crossing distance, and expected motorist compliance at pedestrian crossings. Results from this study show that pedestrian counts are low (1 pedestrian/hr), speeds at the roundabout are below the design speeds, pedestrian crossing distance is short due to the splitter island, and the pedestrian yielding compliance rates are comparable to national averages (if not higher).

However, there was an observed reduction in yielding compliance for bicycle movements utilizing the pedestrian crossing areas. Low cost improvements to improve yielding compliance rates at the study roundabout exits for this condition can include additional signing, enforcement, and driver education. Additional signing can include a "DISMOUNT BIKES" sign for bicyclists using the crosswalk. This allows the bicyclist to behave like a pedestrian so that motorists may be more likely to observe the desired crossing movement (i.e., the bicycle would then approach the roundabout at a lower speed, increasing the time for a driver to see them) and comply with the crosswalk laws. Another option to further promote yielding behavior could be a sign for exiting vehicles. This sign could say EXITING VEHICLES stop FOR bike and pedestrians (See Figure 9). However, this sign is not currently approved in the Manual on Uniform Traffic Control Devices[19] (MUTCD) and would need further research and approval from FHWA for implementation. Furthermore, oversized pedestrian crossing signs could be installed at the roundabout exits.

[19] "Manual on Uniform Traffic Control Devices for Streets and Highways - 2009 Edition." (n.d.): n. pag. FHWA. U.S Department of Transportation, Federal Highway Administration, Dec. 2009. Web.

Figure 9: Potential Sign for Exiting Vehicles at the Roundabout

Due to a small sample size of natural pedestrian crossings (the majority of observed crossings were bicycles), it is recommended further data to be gathered to capture a larger sample size of pedestrian crossings before implementing enhancements other than the "DISMOUNT BIKES" signage. A larger sample size can be can be accomplished through staged crossing events.

Lane Assignment Compliance

The observed lane assignment compliance rate is also high (above 90%) and no major improvements appear to be needed. The only recommendations at this time are to maintain the existing pavement markings as some of the existing pavement legends and striping are fading away. Figure 10 shows the existing lane-use arrow in the left lane fading away, making it look like the left lane is a left turn only lane. To maintain the effectiveness of the paint currently used, restriping of the roundabout on a yearly basis could be part of the City maintenance program. This maybe most useful after the winter season when snow and ice have cleared. For longer lasting durable striping, thermoplastic and methyl methacrylate inlayed could be installed; however, this should be reviewed with the City's maintenance practices including snowplowing and street sweeping. Continued driver education could also improve lane assignment compliance rate over time as drivers become more accustomed to navigating roundabouts of various types and aware of visual cues such as signing/striping.

Furthermore, if additional enhancement is desired at a later time to improve the south leg lane assignment compliance, installing lane-use arrows in advance and at the approach of the roundabout (downstream of crosswalk) is optional per the MUTCD[20]. This can provide additional direction for drivers. Larger lane use signs could also help or installing them on both sides of the roadway (in median and along curb).

[20] "2009 Edition Chapter 3C. Roundabout Markings." Chapter 3C - MUTCD 2009 Edition - FHWA. U.S Department of Transportation, Federal Highway Administration, 8 July 2015. Web.

Figure 10: Existing Lane-Use Arrows Fading Away

Vehicle Speed

Vehicle speed at the study roundabout was not found to be a significant issue. Vehicles enter the roundabout at approximately 14-15 mph, circulate at 17 mph, and exit at 22 mph. While there are no advisory speed signs along the roundabout approaches, these speeds are consistent with the design speeds.

Critical Gap and Follow-Up Headway

Results of the critical and follow-up headway for the west leg show a similar lane capacity for a hybrid multi-lane approach with a single conflicting yielding lane and the City's current model for a single lane roundabout. The measured capacity is approximately 29-percent higher than national averages. The right turn lane along the adjacent approach (north leg) does not appear to affect the left lane capacity along the west leg approach. Due to the limited sample size, it is recommended that further data be gathered to provide a larger sample size before calibrating the capacity model (as shown in
Table 17) for a multi-lane hybrid roundabout. Additional legs of the study roundabout in addition to other legs of roundabouts with similar hybrid lane configuration should be assessed to better understand the distribution of critical gap and follow-up headway.
.

Exhibit G

Capital Improvement Program 2019-2023

Accessibility Construction
Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2018-19	2019-20	2020-21	2021-22	2022-23	5 Year Total
1ACAI Citywide Accessibility Improvements Includes Barrier Removal	1	$ 57,000	$ -	$ -	$ -	$ -	$ 57,000
1ADSC Dean Swift Road Corridor	5	150,000	-	-	-	-	150,000
1ADIV NE Division Street Corridor	5	500,000	-	-	-	-	500,000
1ALPD Lodge Pole Drive Corridor	5	-	315,000	-	-	-	315,000
1APSC Poplar Street Corridor	5	-	250,000	-	-	-	250,000
1ATHT SW Truman Hill Taft Silver Lake Corridor	5	-	-	440,000	-	-	440,000
1ACAC SW Cleveland Avenue Corridor	5	-	-	190,000	-	-	190,000
1ADAC NW Delaware Avenue Corridor	5	-	-	-	500,000	-	500,000
1AHSC NW Hill Street Corridor	5	-	-	-	250,000	-	250,000
1ASSC NW Seismore Street Corridor	5	-	-	-	125,000	-	125,000
1SRWN Riverwest Neighborhood	5	-	-	-	-	350,000	350,000
1ARIV Riverside Neighborhood	5	-	-	-	-	350,000	350,000
Total Accessibility Construction CIP		**$ 707,000**	**$ 565,000**	**$ 630,000**	**$ 875,000**	**$ 700,000**	**$ 3,477,000**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Exhibit G

Capital Improvement Program 2019-2023

General Obligation Bond Construction
Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2018-19	2019-20	2020-21	2021-22	2022-23	5 Year Total
1T14R 14th St. Reconstruction	1	$ 1,002,028	$ -	$ -	$ -	$ -	$ 1,002,028
1T14B 14th St. Reconstruction Phase II	3	181,246	-	-	-	-	181,246
1TR3N Reed Mkt: 3rd to Newberry	1	160,000	-	-	-	-	160,000
Total GO Bond CIP		**$ 1,343,274**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 1,343,274**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Exhibit G

Capital Improvement Program 2019-2023

Transportation Construction
Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2018-19	2019-20	2020-21	2021-22	2022-23	5 Year Total
1T14R 14th St. Reconstruction	1	$ 500,000	$ -	$ -	$ -	$ -	$ 500,000
1T14B 14th St. Reconstruct Phase II	3	3,884,314	-	-	-	-	3,884,314
1TCSI Citywide Safety Improvements	5	1,590,600	1,000,000	-	-	-	2,590,600
1TGCI Galveston Corridor Improvements	5	265,000	-	-	-	-	265,000
1TNPS Neff & Purcell Intersection Design	5	200,000	600,000	-	-	-	800,000
1TBKE Bicycle Greenways	5	440,000	225,000	225,000	-	-	890,000
1XECI Empire Corridor Improvement Projects:	4	5,800,000	11,000,000	2,400,000	3,800,000	400,000	23,400,000
1XMCI Murphy Corridor Improvement Projects:	5	2,021,700	10,361,200	5,349,100	3,936,700	4,621,900	26,290,600
Total Transportation Construction CIP		**$ 14,701,614**	**$ 23,186,200**	**$ 7,974,100**	**$ 7,736,700**	**$ 5,021,900**	**$ 58,620,514**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Exhibit G

Capital Improvement Program 2019-2023

Water
Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2018-19	2019-20	2020-21	2021-22	2022-23	5 Year Total
1WEWL Egypt Waterline	1	$ 400,000	$ -	$ -	$ -	$ -	$ 400,000
1WMP1 Water Master Plan Update	N/A	750,000	-	-	-	-	750,000
1WAWP Awbrey Well Supply Expansion	5	-	2,021,760	-	-	-	2,021,760
1WCPS College Parallel Pipe Study	N/A	-	1,215,760	-	-	-	1,215,760
1WLPE Lafayette Pipe Enlargement	5	-	250,640	-	-	-	250,640
1WVSS Valves Operational System Study	N/A	-	78,000	78,000	78,000	-	234,000
1WSPP Parallel Piping Brookswood to Brosterhous	5	-	-	1,596,400	-	-	1,596,400
1WSSC New Water Well – Near NE Shirley Court	5	-	-	2,830,464	-	-	2,830,464
1WRBO Parallel Piping Rock Bluff to Brookswood	5	-	-	-	2,940,000	-	2,940,000
1WSWO New Water Well Shiloh Site	5	-	-	-	2,721,600	-	2,721,600
1WRBRM Parallel Mains Brosterhous/Reed Mkt	5	-	-	-	-	1,742,000	1,742,000
Total Water CIP		**$ 1,150,000**	**$ 3,566,160**	**$ 4,504,864**	**$ 5,739,600**	**$ 1,742,000**	**$ 16,702,624**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Exhibit G

Capital Improvement Program 2019-2023

Water Reclamation
Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2018-19	2019-20	2020-21	2021-22	2022-23	5 Year Total
1SNAF North Area Force Main	1	$ 100,000	$ -	$ -	$ -	$ -	$ 100,000
1SNAS North Area Gravity Main	1	100,000	-	-	-	-	100,000
1SP1X SEI Phase 1 Extension	1	100,000	-	-	-	-	100,000
1S2S3 SEI Schedule 2S&3	1	100,000	-	-	-	-	100,000
1SWRF Secondary Expansion	1	3,100,000	-	-	-	-	3,100,000
1SCAP Capacity Improvements	5	6,000,000	-	-	-	-	6,000,000
1SPIR Plant Interceptor Rehabilitation	5	10,000,000	-	-	-	-	10,000,000
1S036 Drake Lift Station Condition Upgrade	5	1,000,000	2,000,000	-	-	-	3,000,000
1SNIP North Interceptor Phase I	5	11,000,000	12,000,000	-	-	-	23,000,000
1SPSD Pump Station Decommissions Program Projects:	4	1,465,000	3,000,000	-	-	-	4,465,000
1SSHI Solids Handling Improvement Project	5	1,450,000	2,500,000	1,500,000	-	-	5,450,000
1SAMM Amethyst Mahogany Street Sewer	5	500,000	2,900,000	1,470,000	1,470,000	-	6,340,000
1SFPU Facilities Plan Update	N/A	-	500,000	-	-	-	500,000
1SMP1 Collection System Master Plan (Years 6-10)	N/A	-	750,000	-	-	-	750,000
1SPSO Parallel Sewer on Olney Avenue	5	-	600,000	-	-	-	600,000
1SGPA Gravity Pipe Condition Assessment	5	-	-	200,000	200,000	200,000	600,000
1SHWK Headworks	5	-	-	-	1,000,000	-	1,000,000
1SOC1 Odor Control Master Plan	N/A	-	-	-	1,155,000	-	1,155,000
1SSLA Sewer Storage - Land Acquisition	N/A	-	-	-	730,000	-	730,000
1SNI2 North Interceptor Phase II & III	5	-	-	-	6,700,000	6,700,000	13,400,000
1SSFU Support Facilities Upgrade	N/A	-	-	-	1,250,000	1,250,000	2,500,000
Total Water Reclamation CIP		**$ 34,915,000**	**$ 24,250,000**	**$ 3,170,000**	**$ 12,505,000**	**$ 8,150,000**	**$ 82,990,000**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Exhibit G

Capital Improvement Program 2019-2023

Stormwater

Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2018-19	2019-20	2020-21	2021-22	2022-23	5 Year Total
1RNPR Newport Pipe Replacement Design	5	$ 442,000	$ -	$ -	$ -	$ -	$ 442,000
1RMP1 Stormwater Master Plan Update	N/A	-	500,000	-	-	-	500,000
1RRMC Roosevelt & McKinley	5	-	-	104,000	475,000	-	579,000
1RFGU Franklin & Greenwood Underpass	5	-	-	1,200,000	600,000	1,500,000	3,300,000
1RMNW Minnesota & Wall Stormwater	5	-	-	-	-	250,000	250,000
Total Stormwater CIP		**$ 442,000**	**$ 500,000**	**$ 1,304,000**	**$ 1,075,000**	**$ 1,750,000**	**$ 5,071,000**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Exhibit G

Capital Improvement Program 2019-2023

Airport
Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2018-19	2019-20	2020-21	2021-22	2022-23	5 Year Total
AP18A Helicopter Operations Area Phase II	1	$ 692,400	$ -	$ -	$ -	$ -	$ 692,400
AP16A West Apron	1	726,300	-	-	-	-	726,300
AP19A Master Plan Update	NA	311,100	242,500	-	-	-	553,600
**AP20A South Hangar Taxilane Rehab	5	-	-	166,000	334,000	-	500,000
**AP21A Runway Ext. EA Phase I Environmental	NA	-	250,000	-	-	-	250,000
**AP22A Runway Ext. EA Phase II Environmental	NA	-	-	250,000	-	-	250,000
**AP23A Runway Ext. Design/Property Acquisition	5	-	-	10,000,000	-	-	10,000,000
**AP24A Runway Construction	5	-	-	-	10,000,000	-	10,000,000
Total Airport CIP		**$ 1,729,800**	**$ 492,500**	**$ 10,416,000**	**$ 10,334,000**	**$ -**	**$ 22,972,300**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**
** Project numbers may change

Note: Airport capital improvement projects are pending approval of 90% FAA funding and funding for City match.

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Exhibit G

Capital Improvement Program 2019-2023

Facilities Management
Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2018-19	2019-20	2020-21	2021-22	2022-23	5 Year Total
FA19CX Boyd Acres Building C - Replace Roof	3	$ 45,000	$ -	$ -	$ -	$ -	$ 45,000
FA19EX 639 NW Brooks Re-Roof	3	20,000	-	-	-	-	20,000
FA19AX Boyd Acres Building D - Replace Roof	3	106,000	-	-	-	-	106,000
FA20AX Site Development/Fuel Island - Boyd Acres**	5	-	3,704,530	-	-	-	3,704,530
FA20AX Site Paving/Grading - Pilot Butte Campus**	5	-	6,375,600	-	-	-	6,375,600
FA21AX Vehicle Storage/Parking - Pilot Butte Campus**	5	-	-	8,528,400	-	-	8,528,400
FA22AX Fleet Building/Truck Wash - Pilot Butte Campus**	5	-	-	-	13,549,882	-	13,549,882
FA22BX Operations Building B Remodel - Boyd Acres**	5	-	-	-	1,097,712	-	1,097,712
FA23AX Relocate Sand Pile - Pilot Butte Campus**	5	-	-	-	-	908,928	908,928
FA23BX New Utilities Admin Building - Boyd Acres**	5	-	-	-	-	4,468,896	4,468,896
Total Facilities Management CIP		**$ 171,000**	**$ 10,080,130**	**$ 8,528,400**	**$ 14,647,594**	**$ 5,377,824**	**$ 38,804,948**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Notes:
** These projects were generated as a result of the 20 year facilities plan created in February 2015.

Exhibit G

Capital Improvement Program 2018-2022

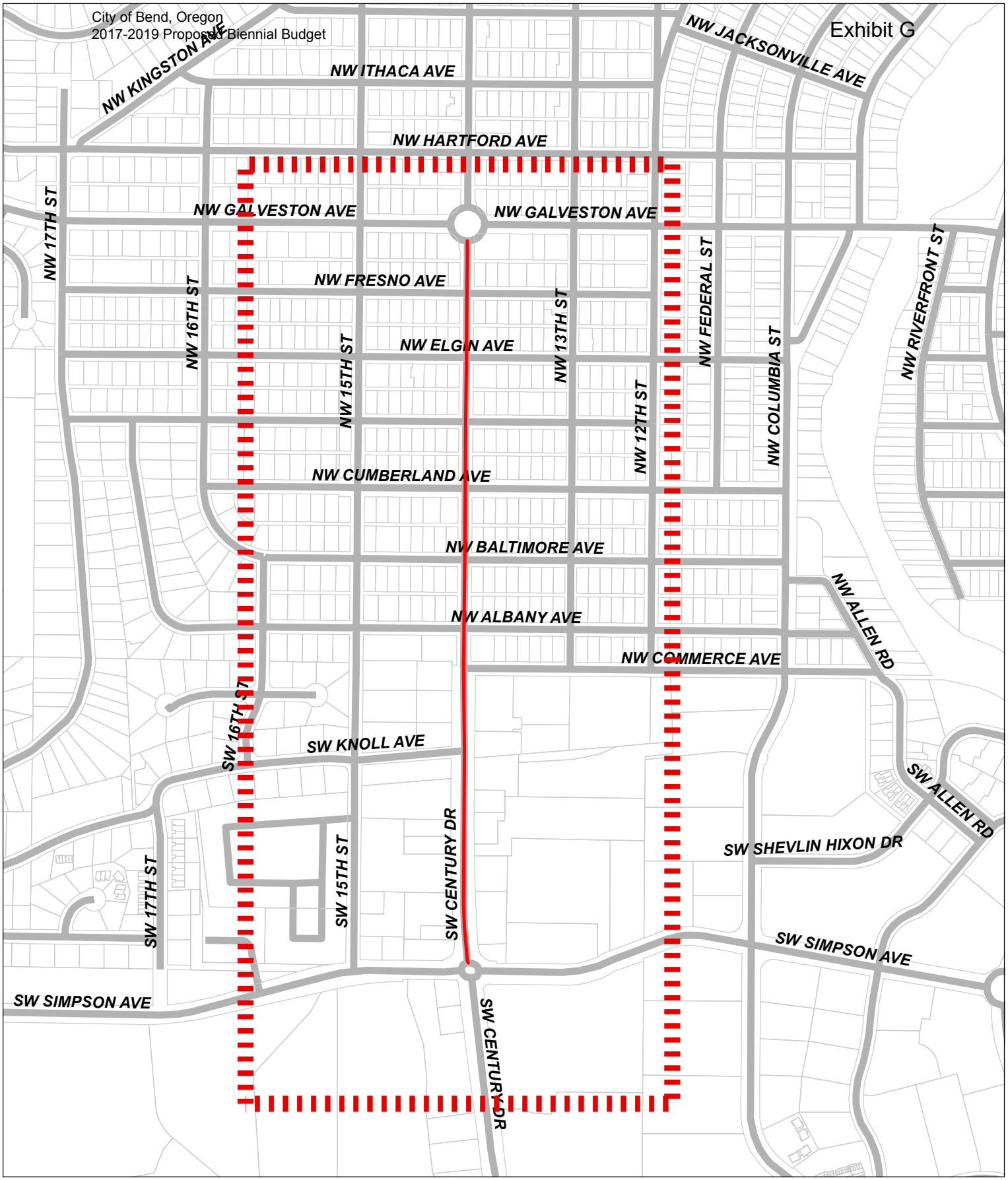
Transportation Construction
Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2017-18	2018-19	2019-20	2020-21	2021-22	5 Year Total
1T14R 14th St. Reconstruction	5	$ 901,330	$ 150,000	$ -	$ -	$ -	$ 1,051,330
1TCSI Citywide Safety Improvements	4	1,969,000	775,000	-	-	-	2,744,000
1TGCI Galveston Corridor Improvements	5	520,000	2,630,000	1,300,000	-	-	4,450,000
1TBKE Bicycle Greenways	5	225,000	225,000	225,000	225,000	-	900,000
1TNPS Neff and Purcell Intersection	5	50,000	350,000	300,000	3,300,000	-	4,000,000
1TSDP Complete Street Corridors	5	140,000	380,000	830,000	1,150,000	-	2,500,000
1TEMP Empire Corridor Improvements	5	500,000	1,500,000	2,000,000	3,000,000	3,000,000	10,000,000
1TMPY Murphy Corridor Improvements	5	500,000	1,500,000	2,000,000	3,000,000	3,000,000	10,000,000
1T14B 14th St. Reconstruct Schedule B Newport to Galveston	5	-	1,300,000	1,300,000	-	-	2,600,000
Total Transportation Construction CIP		**$ 4,805,330**	**$ 8,810,000**	**$ 7,955,000**	**$ 10,675,000**	**$ 6,000,000**	**$ 38,245,330**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Exhibit G



1T14R 14th St Reconstruction

Capital Improvement Projects
2018 - 2022

NOT TO SCALE

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018 – 2022

SUMMARY

Project Title: 14th St. Reconstruction

Project Type: Transportation

Project Fund: GO Bond / Transportation Construction

Project #: 1T14R

Project Manager: Sabourin, Garrett

Cost Estimate Classification: 5

Status: Open

Stage: Design

Budget Period: 2017 – 2019

Total Project Est: $6,193,242

Target Start Date: 2016

Target Completion: Oct 2019

METHOD OF FINANCING

TYPE	PERCENTAGE
GO Bond	83%
Transportation SDC's	17%

DESCRIPTION

14th Street is the 8th and final project to be completed under the 2011 voter approved General Obligation Fund Measure. Project limits extend from the intersection of Colorado Avenue to Newport Avenue. This project is intended to address sub-par infrastructure, multi-modal transportation, pedestrian safety, accessibility, stormwater, lighting, and align with objectives as established in the Central Westside Plan and Urban Growth Boundary Remand.

NEED/JUSTIFICATION

Voters approved this project as the eighth (8th) and final project to be completed under the GO Bond measure. The project was presented as a "bonus" project, only to be completed if substantial cost savings experienced on previous seven (7) projects. As of project initiation the estimated cost savings were approximately $4 million, to be budgeted for design and construction. Costs in excess of GO Bond funding will be paid out of Transportation Const. Fund.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: This project will decrease maintenance costs in street and operations budget.

Consequences of Delaying or Eliminating this Project: Project is part of the voter approved General Obligation Bond.

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$1,836,872	$4,206,370	$150,000	$ -	$ -	$ -	$ 6,193,242

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title:	Citywide Safety Improvements	Budget Period:	2017-2019
		Total Project Est:	$3,534,289
Project Type:	Transportation	Target Start Date:	2016
Project Fund:	Transportation Construction Fund	Target Completion:	Sep 2018
Project #:	1TCSI		
Project Manager:	Rowan, Rory		
Cost Estimate Classification:	4		
Status:	Open		
Stage:	Design		

METHOD OF FINANCING

TYPE	PERCENTAGE
Transportation SDC's	100%

DESCRIPTION

With the help of the community and a prior safety study, the city has identified multiple locations across the city where there have been a high number of crashes. Several treatments are proposed to make these locations safer for people walking, riding bicycles, and driving. This project will further develop the design of these treatments and construct them with additional community input.

NEED/JUSTIFICATION

This project focuses on providing a safe, accessible, and cost effective transportation system. The high benefit, low cost safety improvements proposed as part of this project have been specifically selected by the consultant team, through community input, the Oregon Department of Transporttaion (OODOT) and Bend Police Dept. to target high risk streets and intersections.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: Some new pavement markings, signs, beacons, and lighting added will require minimal ongoing routine replacement and power costs.

Consequence of Delaying or Eliminating this Project: There is a high likelihood of continued crashes resulting in serious injuries and in some cases deaths.

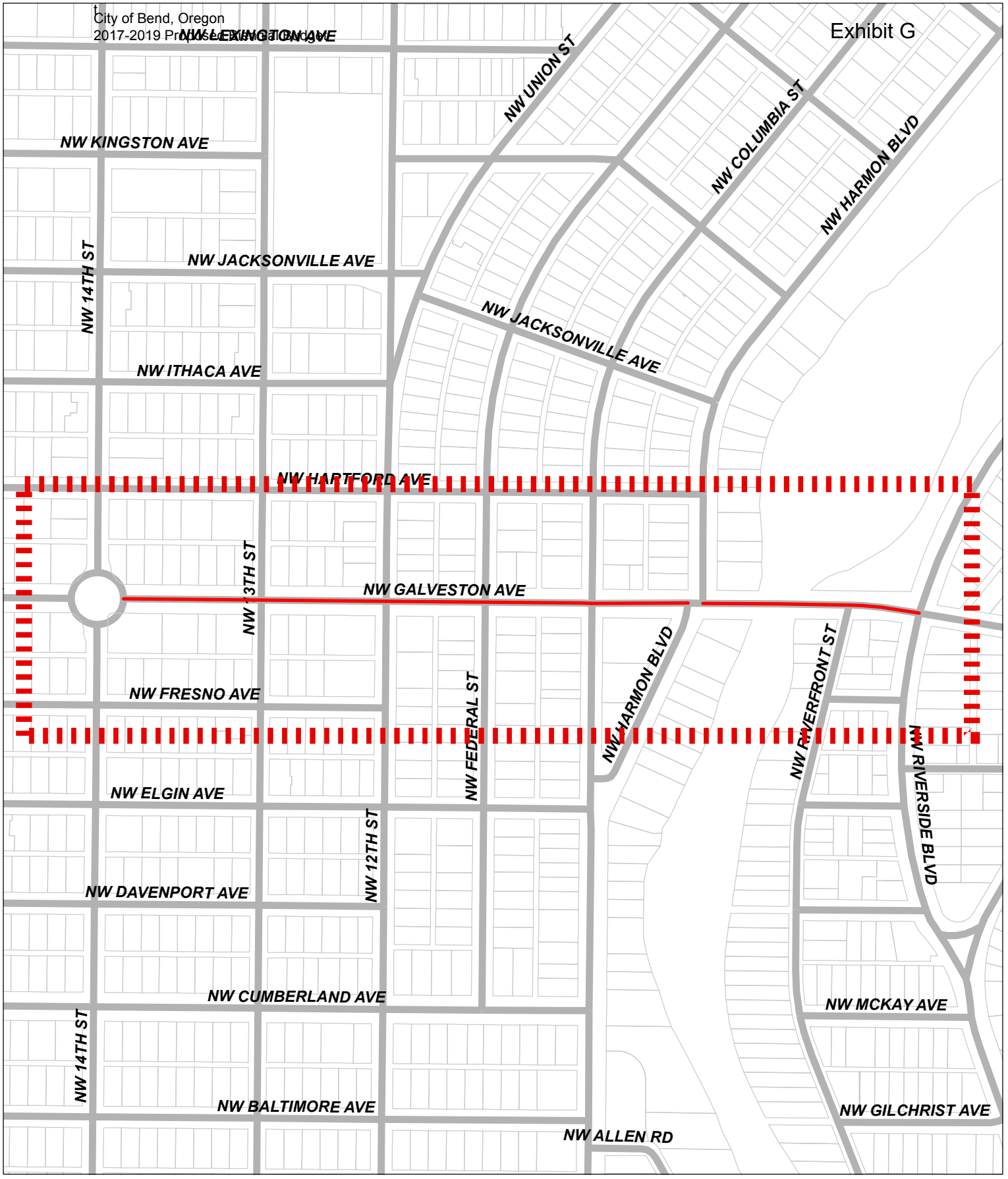
Project Related To: N/A

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$790,289	$1,969,000	$775,000	$ -	$ -	$ -	$3,534,289

City of Bend, Oregon
2017-2019 Proposed Capital Budget

Exhibit G



1TGCI Galveston Corridor Improvements

Capital Improvement Projects
2018 - 2022

NOT TO SCALE

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018 – 2022

SUMMARY

Project Title: Galveston Corridor Improvements

Project Type: Transportation

Project Fund: Transportation Construction - CIP

Project #: 1TGCI

Project Manager: Sabourin, Garrett

Cost Estimate Classification: 5

Status: Open

Stage: Design

Budget Period: 2017 – 2019

Total Project Est: $4,830,329

Target Start Date: 2011

Target Completion: Oct 2017

METHOD OF FINANCING

TYPE	PERCENTAGE
Transportation SDC's	100%

DESCRIPTION

In July 2015 City Council approved the recommended 3-lane hybrid concept, with minimal median treatment and authorized the project to proceed to 30% design. The 3-lane hybrid includes the reconstruction of the Galveston Ave right of way, 14th Street to Deschutes River. Improvements include full-depth reconstruction, stormwater mgmt, distribuition system line upgrades, buffered bike lanes, accessible crossings, sidewalks, transit facilities, on-street parking, and several aesthetic improvements. Improvements are reflective of a typical complete street transportation project with add'l utility upgrades for economy of scale and maintenance purposes.

NEED/JUSTIFICATION

Galveston Avenue, from 14th Street to the Deschutes River, has long been a priority arterial for improvement as identified by the Traffic Safety Advisory Committee (TSAC) during the evaluation of arterial and collector street safety projects. The safety criteria rated projects based on crashes, pedestrian and bicycle use estimates, speeds, volumes and missing sidewalks. The sidewalks, storm drainage and general street infrastructure are currently substandard.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: Additional maintenance for striping and pavement preservation.

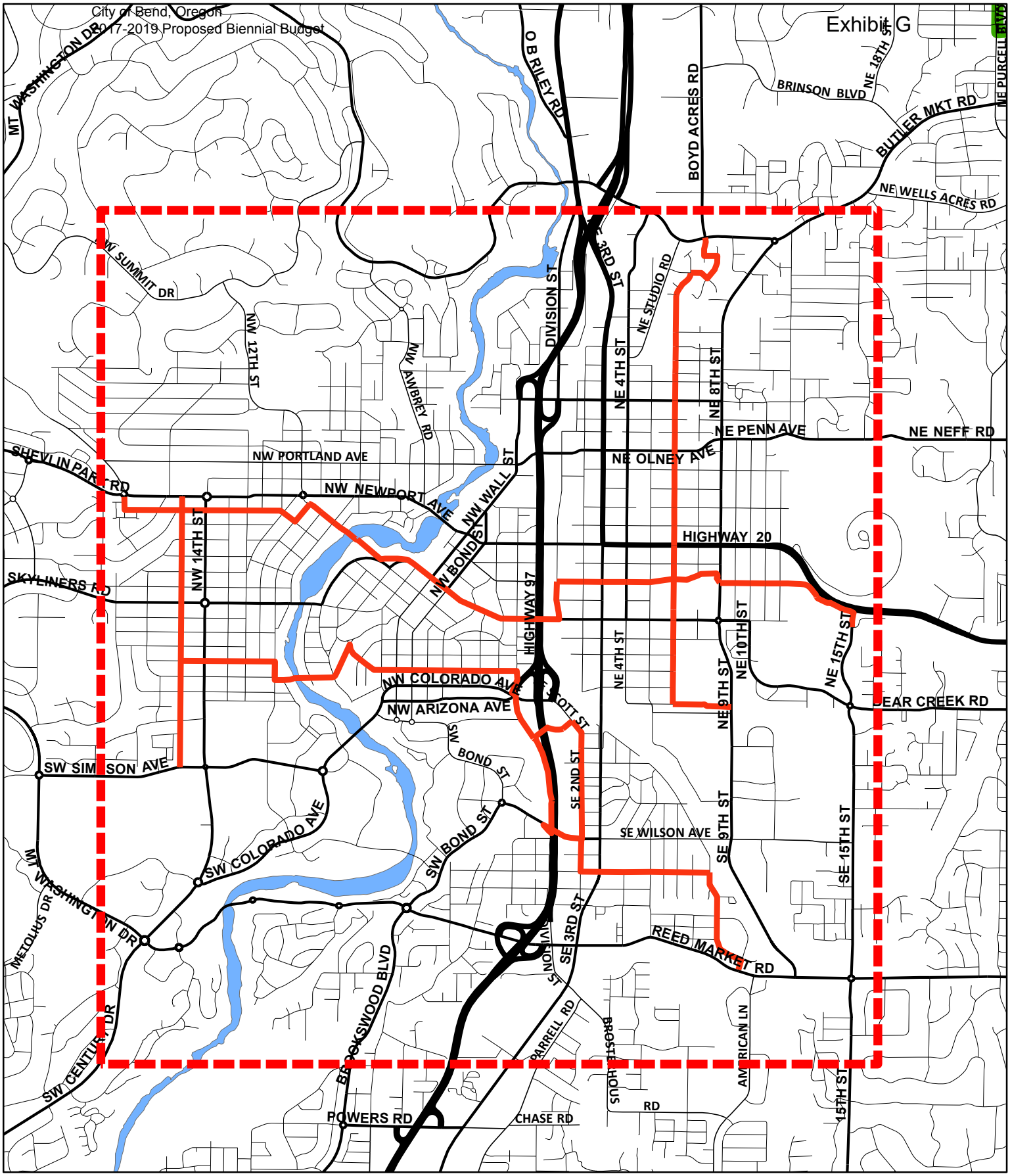
Consequence of Delaying or Eliminating this Project: The project is currently being coordinated with a business and citizen task-force that is motivated to initiate a project. Delaying the design funding for the project may cause the task-force to cease their efforts.

Project Related To: Project related to TSAC and the Galveston Improvement Taskforce.

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$380,329	$520,000	$2,630,000	$1,300,000	$ -	$ -	$4,830,329

Exhibit G



1TBKE Bicycle Greenways

Capital Improvement Projects
2018 - 2022

CITY OF BEND

0 0.25 0.5 Miles

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title: Bicycle Greenways

Project Type: Transportation
Project Fund: Transportation
Project # 1TBKE
Project Manager: N/A
Cost Estimate Classification: 5
Status: Pending
Stage: Pending

Budget Period: 2017-2019
Total Project Est: $900,000
Target Start Date: 2018
Target Completion: Oct 2021

METHOD OF FINANCING

TYPE	PERCENTAGE
Transportation SDC's	100%

DESCRIPTION

Design and construct four bike greenway projects.

NEED/JUSTIFICATION

The projects were identified as a priority in the 2014 Bike and Walking Priority Process. Council gave direction to staff to include projects in the CIP at the March 22, 2017 Council Financial Strategy session.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: Growth Management Department requested a transportation planner to assist with possible evaluation of bike greenway concepts; EIPD has requested two project managers.

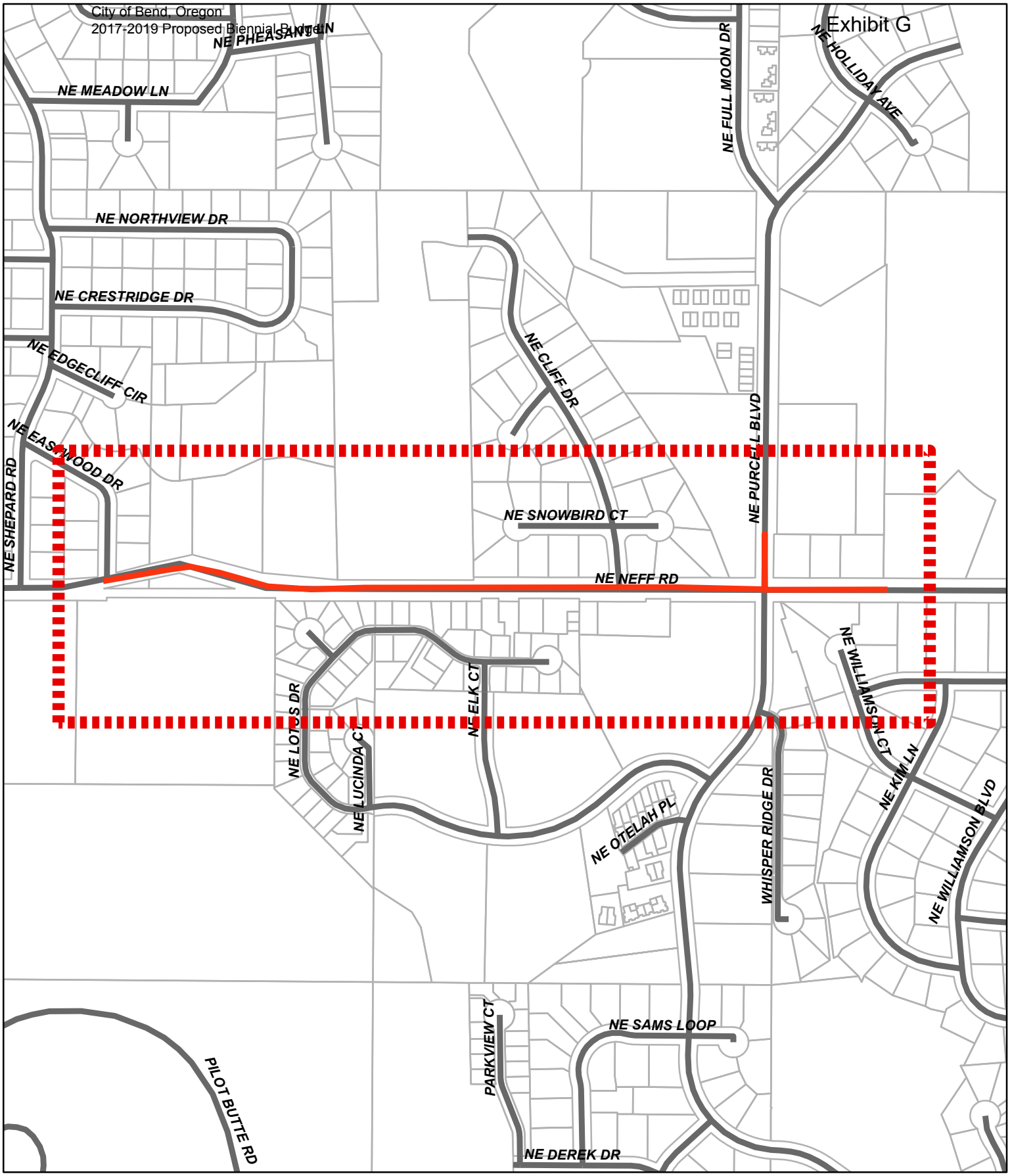
Consequence of Delaying or Eliminating the Project: There is no imminent safety or regulatory issue to delay the project; eliminating the project may cause issue with the state Department of Land Conservation and Development as the Bike Greenways was listed as a project in the City adopted Integrated Land Use and Transportation Plan to reduce vehicle miles travelled and supports the infill
/opportunity areas development

Project Related to: Implementation of the Urban Growth Boundary assessment relating to infill/opportunity areas

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$ -	$225,000	$225,000	$225,000	$225,000	$ -	$900,000

Exhibit G



1TNPS Neff & Purcell Intersection

Capital Improvement Projects
2018 - 2022

CITY OF BEND

0 250 500 Feet

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title:	Neff and Purcell Intersection (Formerly Neff & Purcell Sidewalk)
Project Type:	Transportation
Project Fund:	Transportation Construction Fund
Project #:	1TNPS
Project Manager:	Rowan, Rory
Cost Estimate Classification:	5
Status:	Pending
Stage:	Pending

Budget Period:	2017-2019
Total Project Est:	$4,000,000
Target Start Date:	2017
Target Completion:	May 2021

METHOD OF FINANCING

TYPE	PERCENTAGE
Transportation SDC's and Water/Sewer Franchise Fees	100%

DESCRIPTION

Public engagement, survey, design, and construction of missing sidewalks and a safer intersection for all users serving the surrounding medical, residential, and school properties. This intersection and corridor has been highly prioritized by members of the community serving on the City of Bend Accessibility Advisory Committee and a previous safety study.

NEED/JUSTIFICATION

This intersection and surrounding streets have been previously identified by the community and a safety study as one of the highest priority parts of the city needing safety improvements. The aging traffic signal at this intersection is in need of routine replacement and this coupled with the improved community connectivity will benefit users of all ages and abilities and the surrounding neighborhoods.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: Could reduce operating costs if aging traffic signal is replaced and stormwater issues are addressed.

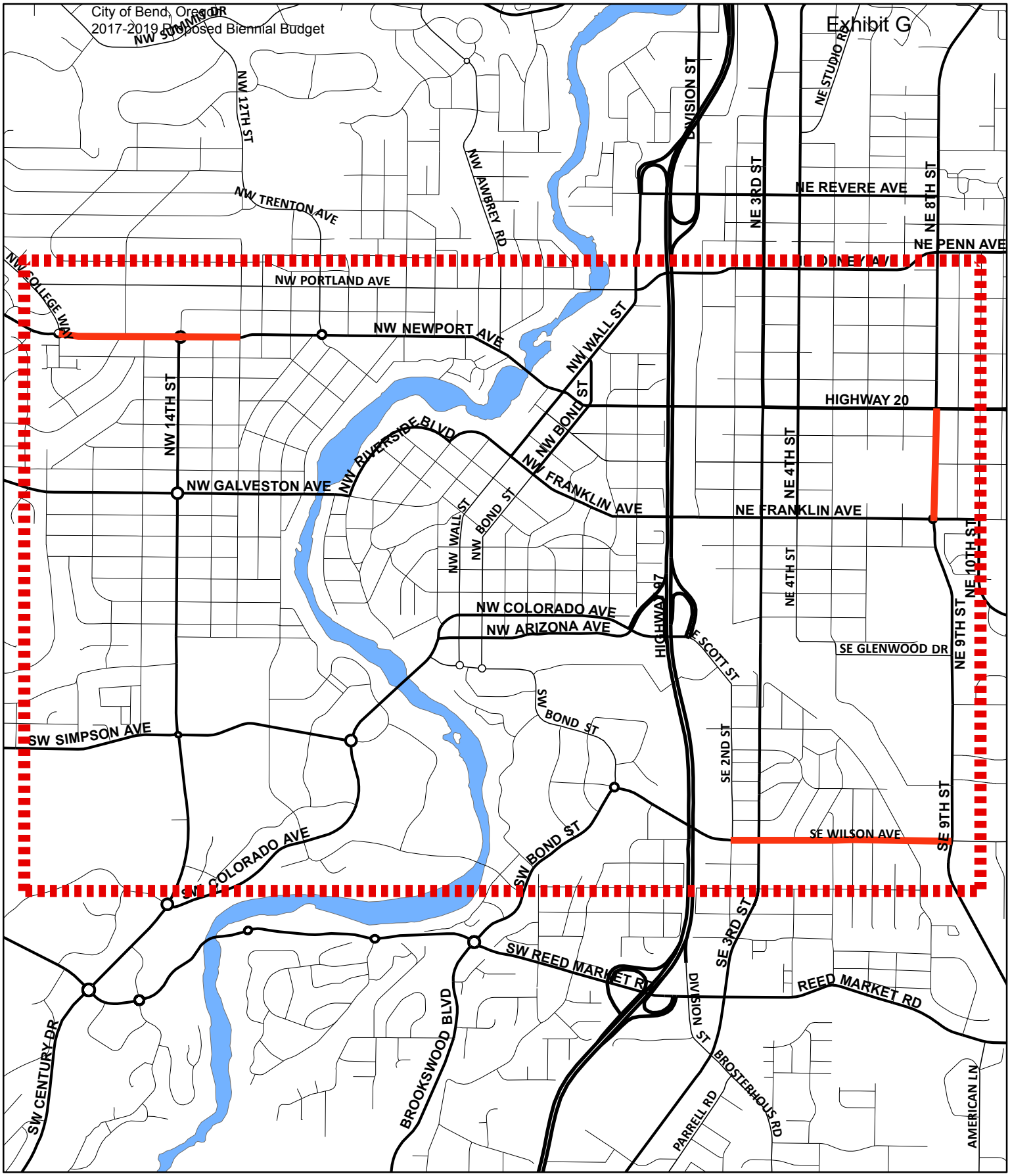
Consequence of Delaying or Eliminating this Project: One of the highest crash and most congested intersections in the community would remain.

Project Related To: N/A

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$ -	$50,000	$350,000	$300,000	$3,300,000	$ -	$4,000,000

Exhibit G



1TSDP Complete Street Corridors

Capital Improvement Projects
2018 - 2022

CITY OF BEND

0 1,000 2,000 Feet

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018 – 2022

SUMMARY

Project Title: Complete Street Corridors (formerly Sidewalk Design & Projects)
Project Type: Transportation
Project Fund: Transportation Construction - CIP
Project #: 1TSDP
Project Manager: Rowan, Rory
Cost Estimate Classification: 5
Status: Open
Stage: Pending

Budget Period: 2017-2019
Total Project Est: $2,501,000
Target Start Date: 2017
Target Completion: Oct 2020

METHOD OF FINANCING

TYPE	PERCENTAGE
Transportation SDC's	100%

DESCRIPTION

Improve existing, if needed, and install key missing sidewalk links on primary collectors and arterials as recommended by City of Bend Accessibility Advisory Committee (COBAAC). Scope the following corridors: 8th Street, 27th Street, Newport Avenue and Wilson Avenue. There are also three pedestrian crossing locations from COBAAC: Neff/Williamson; 27th/Conners; 8th/Hawthorne.

NEED/JUSTIFICATION

Sidewalks are an integral part of the transportation system. The sidewalks recommended by COBAAC are missing sections that when built will complete the sidewalk corridor. The sidewalk projects are consistent with the Transportation Options Sidewalk Program reviewed and approved by COBAAC (2012). These sidewalk projects will increase pedestrian access, mobility, and safety.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: Concrete sidewalks will last about 30 years.

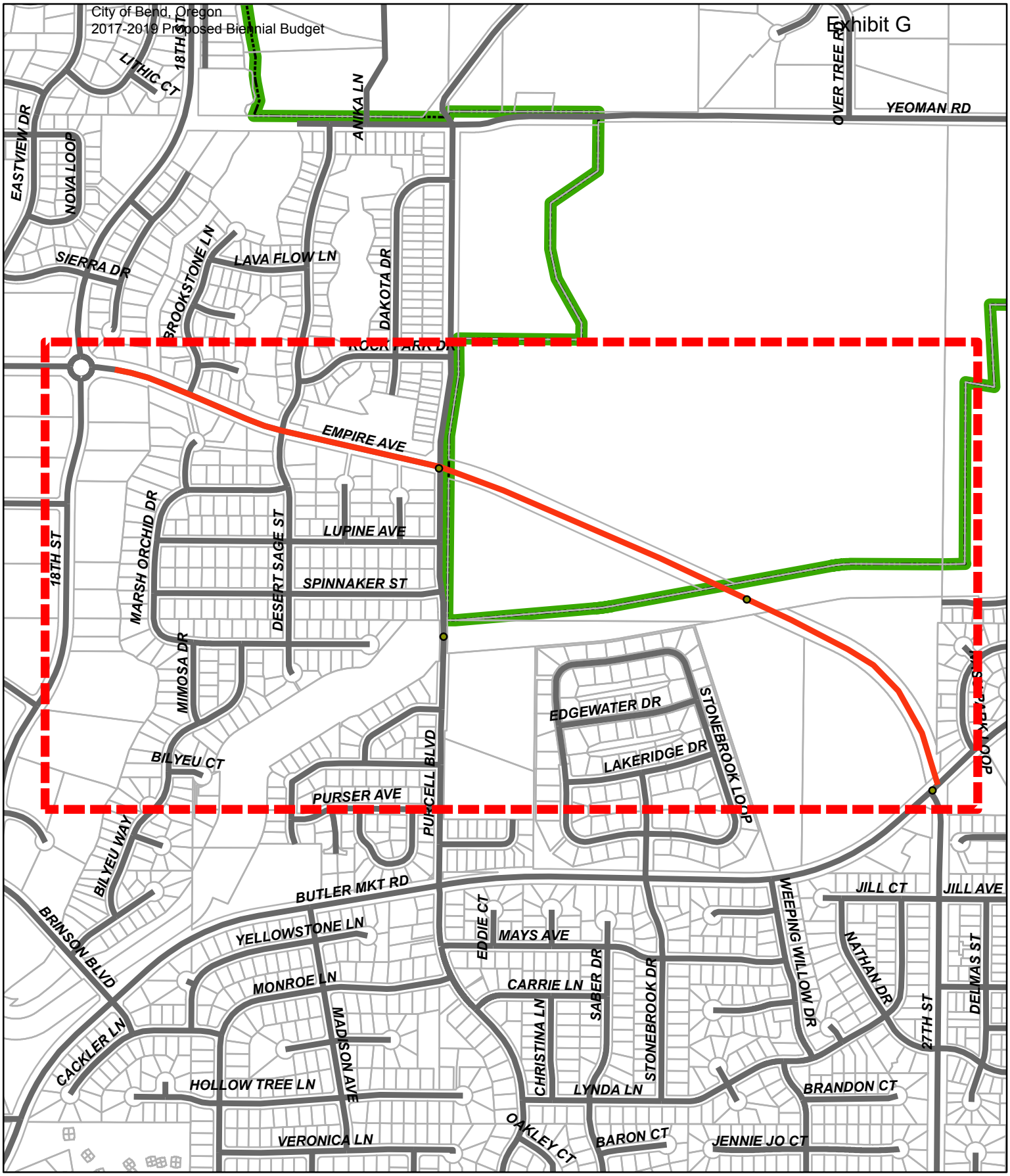
Consequences of Delaying or Eliminating this Project: Without these projects the City's risk and liability increases.

Project Related To: COBAAC reviewed and recommended the current sidewalk and pedestrian crossing improvements based on the Transportation Options program and sidewalk focus completed in 2012.

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$1,000	$140,000	$380,000	$830,000	$1,150,000	$ -	$2,501,000

Exhibit G



1TECI Empire Corridor Improvements

Capital Improvement Projects
2018 - 2022

CITY OF BEND

0 450 900 Feet

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title: Empire Corridor Improvements

Project Type: Transportation

Project Fund: Transportation

Project :# 1TECI

Project Manager: N/A

Cost Estimate Classification: 5

Status: Pending

Stage: Pending

Budget Period: 2017-2019

Total Project Est: $10,000,000*

Target Start Date: 2018

Target Completion: Dec 2022

METHOD OF FINANCING

TYPE	PERCENTAGE
Transportation SDC's and Water/Sewer Franchise Fees	100%

DESCRIPTION

Complete design and construction for the Empire Corridor (18th to 27th/Butler Market) that includes the Purcell Canal crossing south of the Empire/Purcell intersection.

NEED/JUSTIFICATION

Empire Corridor is a high priority project for the last ten years; a 30% design was completed in 2009 however funds were not available; the City Council at the March 22, 2017 financial retreat recommended staff conduct a 100% design.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: EIPD has requested two project engineers to assist with the design.

Consequence of Delaying or Eliminating the Project: There are no known legal or regulatory issues about delaying the project. Eliminating the project will prolong connectivity and access issues in NE Bend. The project is also listed on the Integrated Land Use and Transportation Plan to reduce vehicle miles traveled which was approved by the state as part of the UGB.

Project Related to: Implementation of the Urban Growth Boundary assessment relating to the NE Expansion area and the recently completed Murphy Road corridor (Parrell to Brookswood)

PROJECT COST BY FISCAL YEAR

Paid to Date ** + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$ -	$500,000	$1,500,000	$2,000,000	$3,000,000	$3,000,000	$10,000,000

*Project extends past current 5-Year CIP with $20,000,000 estimated in 2022-23 and beyond.

** Does not include prior planning expenditures.

Exhibit G

1TMCI Murphy Corridor Improvements

Capital Improvement Projects
2018 - 2022

CITY OF BEND

0 750 1,500 Feet

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title: Murphy Corridor Improvements

Project Type: Transportation

Project Fund: Transportation

Project #: 1TMCI

Project Manager: N/A

Cost Estimate Classification: 5

Status: Pending

Stage: Pending

Budget Period: 2017-2019

Total Project Est: $10,000,000*

Target Start Date: 2018

Target Completion: Dec 2022

METHOD OF FINANCING

TYPE	PERCENTAGE
Transportation SDC's and Water/Sewer Franchise Fees	100%

DESCRIPTION

Complete design and construction for the Murphy Corridor from Parrell to 15th.

NEED/JUSTIFICATION

The Murphy Corridor is a high priority for the last ten years; a preliminary design and corridor study was completed in 2010 however funds were not available; the City Council at the March 22, 2017 financial retreat recommended staff conducted a 100% design.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: EIPD has requested two project engineers to assist with the design.

Consequence of Delaying or Eliminating the Project: There are no known legal or regulatory issues about delaying the project. Eliminating the project will prolong connectivity and access issues in SE Bend that includes emergency services. The project is also listed on the Integrated Land Use and Transportation Plan to reduce vehicle miles traveled which was approved by the state as part of the UGB.

Project Related to: Implementation of the Urban Growth Boundary assessment relating to the SE Expansion and Opportunity areas.

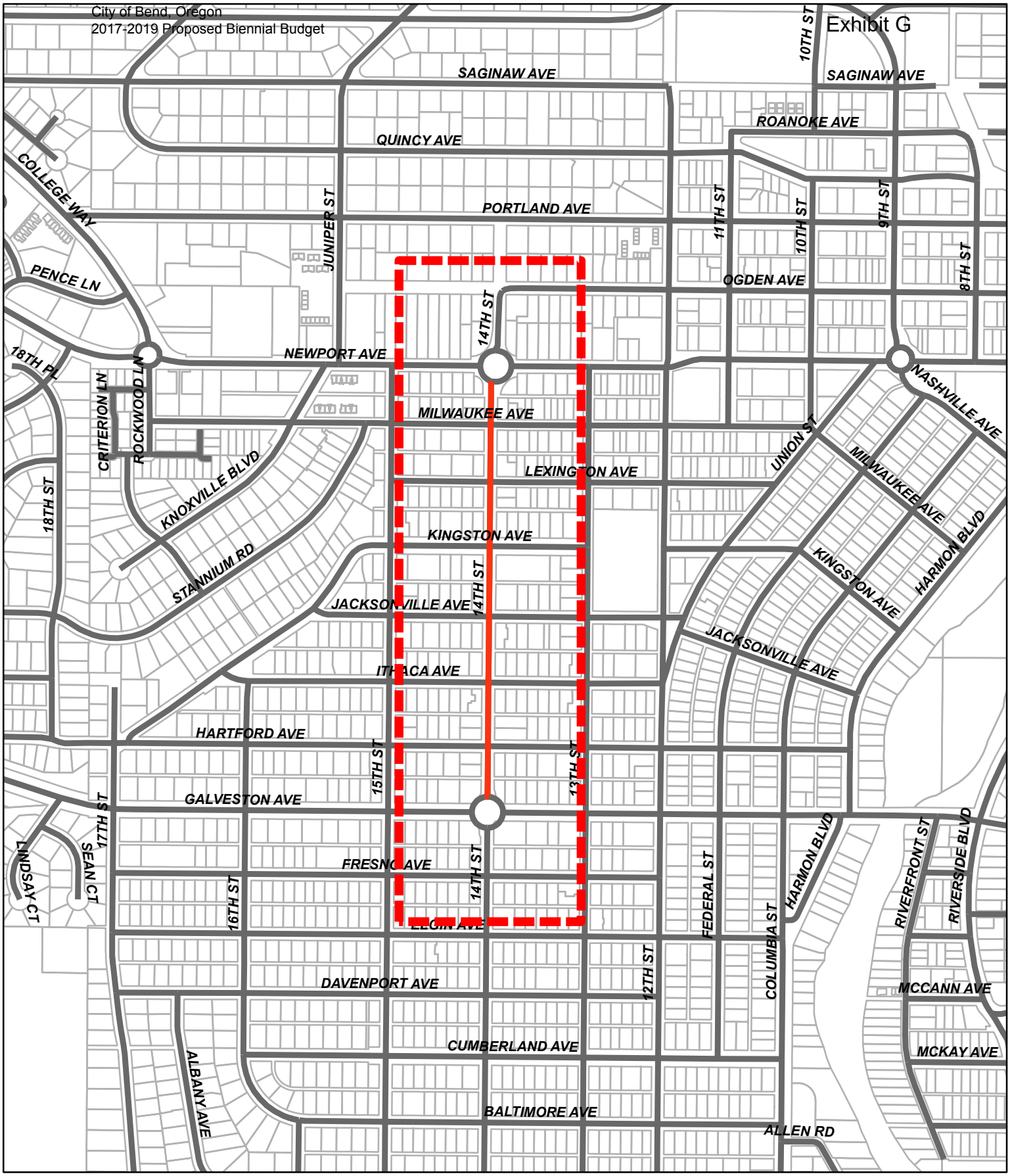
PROJECT COST BY FISCAL YEAR

Paid to Date** + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$ -	$500,00	$1,500,000	$2,000,000	$3,000,000	$3,000,000	$10,000,000

*Project extends past current 5-Year CIP with $20,000,000 estimated in 2022-23 and beyond

** Does not include prior planning expenditures.

Exhibit G



1T14B 14th St. Reconstruction - Sched B Newport to Galveston

Capital Improvement Projects
2018 - 2022

CITY OF BEND

0 400 800 Feet

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title: 14th St. Reconstruction – Schedule B Newport to Galveston

Project Type: Transportation

Project Fund: Transportation

Project #: 1T14B

Project Manager: Garrett Sabourin

Cost Estimate Classification: 5

Status: Pending

Stage: Pending

Budget Period: 2017-2019

Total Project Est: $2,600,000

Target Start Date: 2018

Target Completion: Apr 2020

METHOD OF FINANCING

TYPE	PERCENTAGE
Transportation SDC's	100%

DESCRIPTION

The design of 14th Street, Newport to Galveston, was initiated in conjunctions with the GO Bond 14th Street Reconstruction project. The GO Bond initially identified the segment from Galveston to Simpson. The project limits were extended north to Newport and south to Colorado under council approval. Newport to Galveston's segment of roadway will continue to be designed simultaneously and funded through a separate source. This project is intended to address subpar infrastructure, multi-modal transportation, pedestrian safety, accessibility, stormwater, lighting, and align with objectives as established in the Central Westside Plan and Urban Growth Boundary Remand.

NEED/JUSTIFICATION

This project closely aligns with project 1T14R outlined above. In addition, the extended limits, included with this project were given consideration and ultimately added due to sub-par existing infrastructure, recent development, future development, and planning priorities as outlined in the UGB remand and 2016 Central Westside Plan.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: This project will decrease maintenance costs in street and operations budget.

Consequence of Delaying or Eliminating the project: Once construction funding is identified for this segment the project team will begin coordinating with a large group of stakeholders to address Right of Way acquisition, encroaching private features, conflicting franchise utilities of concern, transportation detours, etc. If the project was delayed or eliminated the impact would be wide spread, and may include additional cost, schedule adjustments, contract amendments, etc. Some of the additional consequences, not as easily quantified, may include a reduced level of confidence and trust with external stakeholders which has the potential to affect future construction efforts and coordination.

Project Related to: 1T14R (14th Street Reconstruction – GO Bond). This segment will be construction with Transportation Construction Funding and will not be part of the GO Bond. The GO Bond segment currently includes Simpson RAB.

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$ -	$ -	$1,300,000	$1,300,000	$ -	$ -	$2,600,000

(This page intentionally left blank)

Exhibit G

Capital Improvement Program 2018-2022

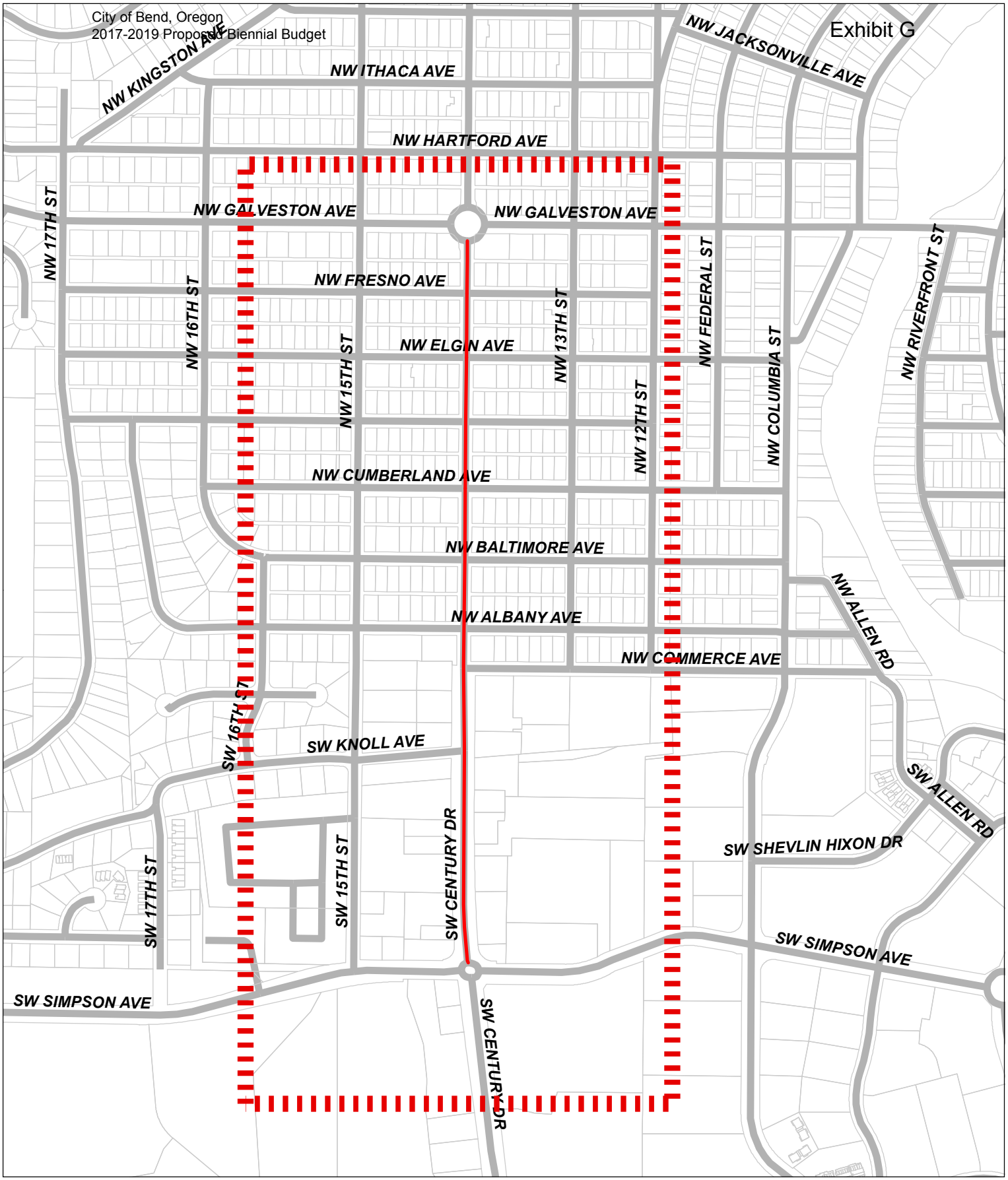
General Obligation Bond Construction
Five Year Capital Improvement Program (CIP) Schedule

	Cost Estimate Classification *	2017-18	2018-19	2019-20	2020-21	2021-22	5 Year Total
1T14R 14th St. Reconstruction	4	$ 3,305,039	$ -	$ -	$ -	$ -	$ 3,305,039
1TPWP Powers & Brookswood Roundabout Phase II	2	50,000	-	-	-	-	50,000
1TR3N Reed Mkt: 3rd to Newberry	1	160,000	16,000	-	-	-	176,000
Total GO Bond CIP		**$ 3,515,039**	**$ 16,000**	**$ -**	**$ -**	**$ -**	**$ 3,531,039**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

Exhibit G



1T14R 14th St Reconstruction

Capital Improvement Projects
2018 - 2022

NOT TO SCALE

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018 – 2022

SUMMARY

Project Title: 14th St. Reconstruction

Project Type: Transportation

Project Fund: GO Bond / Trans Construction

Project #: 1T14R

Project Manager: Sabourin, Garrett

Cost Estimate Classification: 5

Status: Open

Stage: Design

Budget Period: 2017 – 2019

Total Project Est: $6,193,242

Target Start Date: 2016

Target Completion: Oct 2019

METHOD OF FINANCING

TYPE	PERCENTAGE
GO Bond	83%
Transportation SDC's	17%

DESCRIPTION

14th Street is the 8th and final project to be completed under the 2011 voter approved General Obligation Fund Measure. Project limits extend from the intersection of Colorado Avenue to Newport Avenue. This project is intended to address sub-par infrastructure, multi-modal transportation, pedestrian safety, accessibility, stormwater, lighting, and align with objectives as established in the Central Westside Plan and Urban Growth Boundary Remand.

NEED/JUSTIFICATION

Voters approved this project as the eighth (8th) and final project to be completed under the GO Bond measure. The project was presented as a "bonus" project, only to be completed if substantial cost savings experienced on previous seven (7) projects. As of project initiation the estimated cost savings were approximately $4 million, to be budgeted for design and construction. Costs in excess of GO Bond funding will be paid out of Transportation Const. Fund.

FINANCIAL NARRATIVE

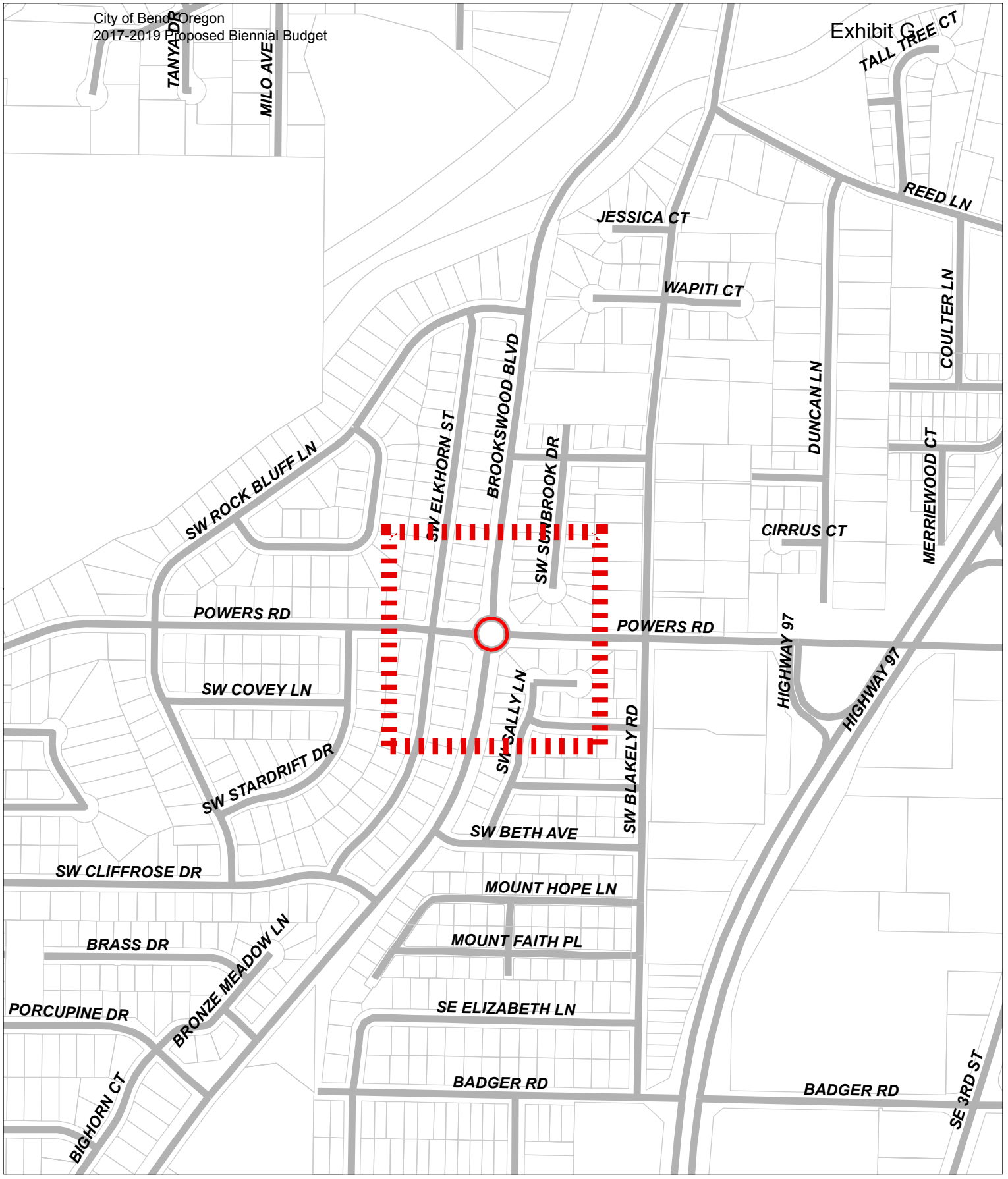
Impact on Annual Operating Budget: This project will decrease maintenance costs in street and operations budget.

Consequences of Delaying or Eliminating this Project: Project is part of the voter approved General Obligation Bond. Project Related To: General Obligation Bond

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$1,836,872	$4,206,370	$150,000	$ -	$ -	$ -	$ 6,193,242

Exhibit G



1TPWP Powers/Brookswood RAB

Capital Improvement Projects
2018 - 2022

NOT TO SCALE

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title:	Powers & Brookswood Roundabout Phase II	Budget Period:	2017-2019
		Total Project Est:	$50,000
Project Type:	Transportation	Target Start Date:	2017
Project Fund:	General Obligation Bond Fund	Target Completion:	Oct 2017
Project #:	1TPWP		
Project Manager:	Sabourin, Garrett		
Cost Estimate Classification:	2		
Status:	Open		
Stage:	Design		

METHOD OF FINANCING

TYPE	PERCENTAGE
GO Bond	100%

DESCRIPTION

Re-construct check dams to convey water at appropriate velocity and location. Check dam height will also convert swale into retention ponds for increased retention capacity and sediment collection.

NEED/JUSTIFICATION

The stormwater from the newly constructed roundabout on Brookswood and Powers is conveyed to and drains into stormwater structures through a swale to the northeast of the roundabout. The Powers & Brookswood Roundabout Phase II Project intent is to rehabilitate this swale. This will be done by cleaning out the storm structures and re-constructing the check dams to convert the swale into a series of retention ponds. This will ensure proper erosion control and sediment collection.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: No impact on operating budget.

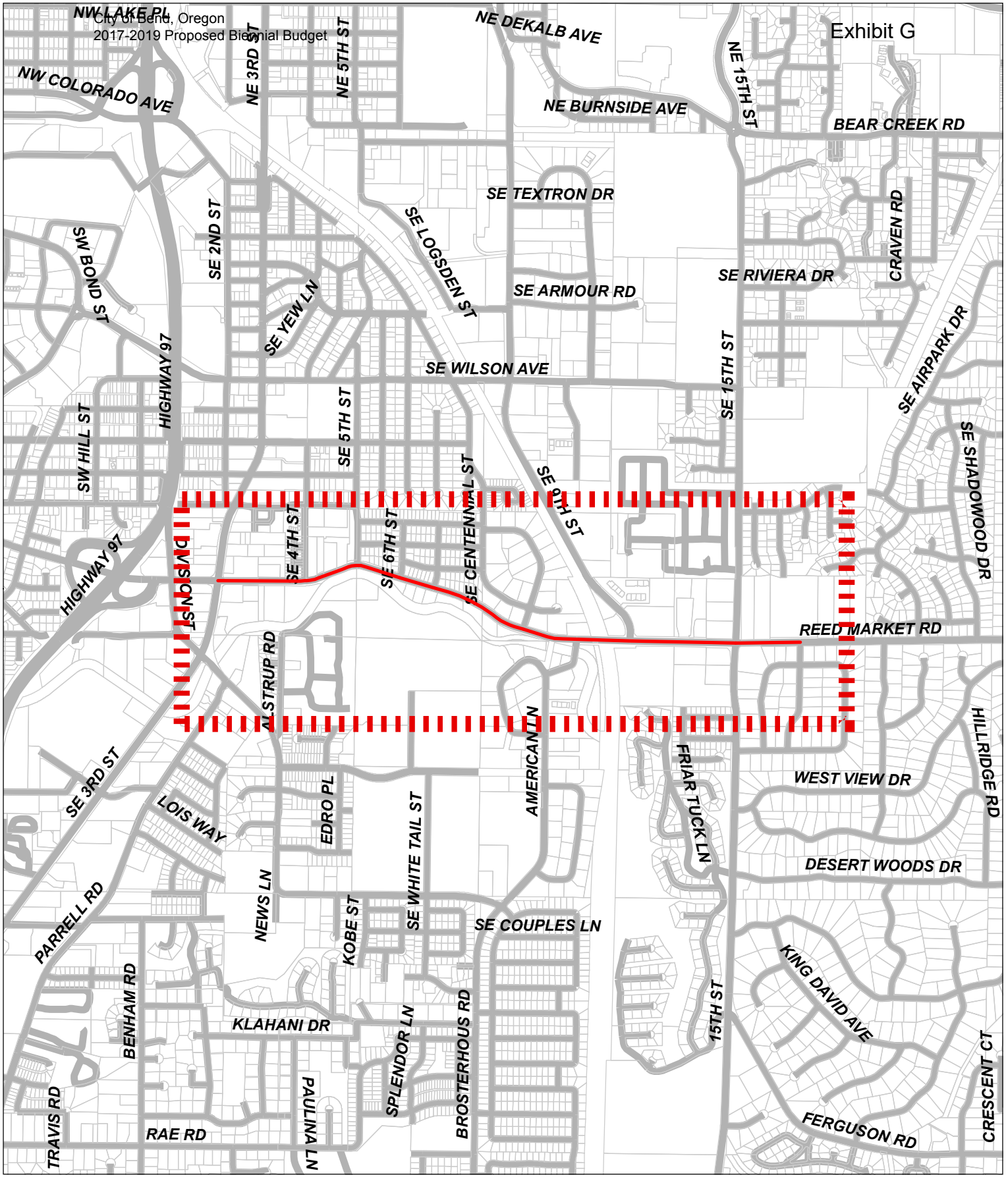
Consequences of Delaying or Eliminating this Project: Not applicable, project is substantially complete.

Project Related To: 1XGOB General Obligation Bond

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$ -	$50,000	$ -	$ -	$ -	$ -	$50,000

Exhibit G



1TR3N Reed Market: 3rd to Newberry

Capital Improvement Projects
2018 - 2022

NOT TO SCALE

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title:	Reed Market: 3rd to Newberry	Budget Period:	2017-2019
		Total Project Est:	$13,808,664
Project Type:	Transportation	Target Start Date:	2012
Project Fund:	General Obligation Bond Fund	Target Completion:	Oct 2018
Project #:	1TR3N		
Project Manager:	Sabourin, Garrett		
Cost Estimate Classification:	1		
Status:	Open		
Stage:	Construction		

METHOD OF FINANCING

TYPE	PERCENTAGE
GO Bond	100%

DESCRIPTION

Upgrade the existing roadway to current City of Bend standards to a major arterial. This includes two (2) travel lanes and a continuous center turn lane, six (6) foot shoulders and bike lanes, separated sidewalks and a landscape strip. This project also provides new stormwater facilities, signing, lighting, retaining walls and striping; upgrades the existing railroad crossing; and realigns American Lane to the west of the current location and reconstructs a bridge at the new location. At the intersection of Reed Market and 15th Street the existing signalized intersection will be upgraded to a roundabout.

NEED/JUSTIFICATION

Improved safety of the corridor for vehicular, pedestrian, and bicycle traffic. Reduced congestion in the corridor.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: This project will decrease maintenance costs in street and operations budget.

Consequences of Delaying or Eliminating this Project: Project is part of the voter approved General Obligation Bond.

Project Related To: 1XGOB General Obligation Bond

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$13,632,664	$160,000	$16,000	$ -	$ -	$ -	$13,808,664

Exhibit G

Capital Improvement Program 2018-2022

Accessibility Construction
Five Year Capital Improvement Program (CIP) Schedule

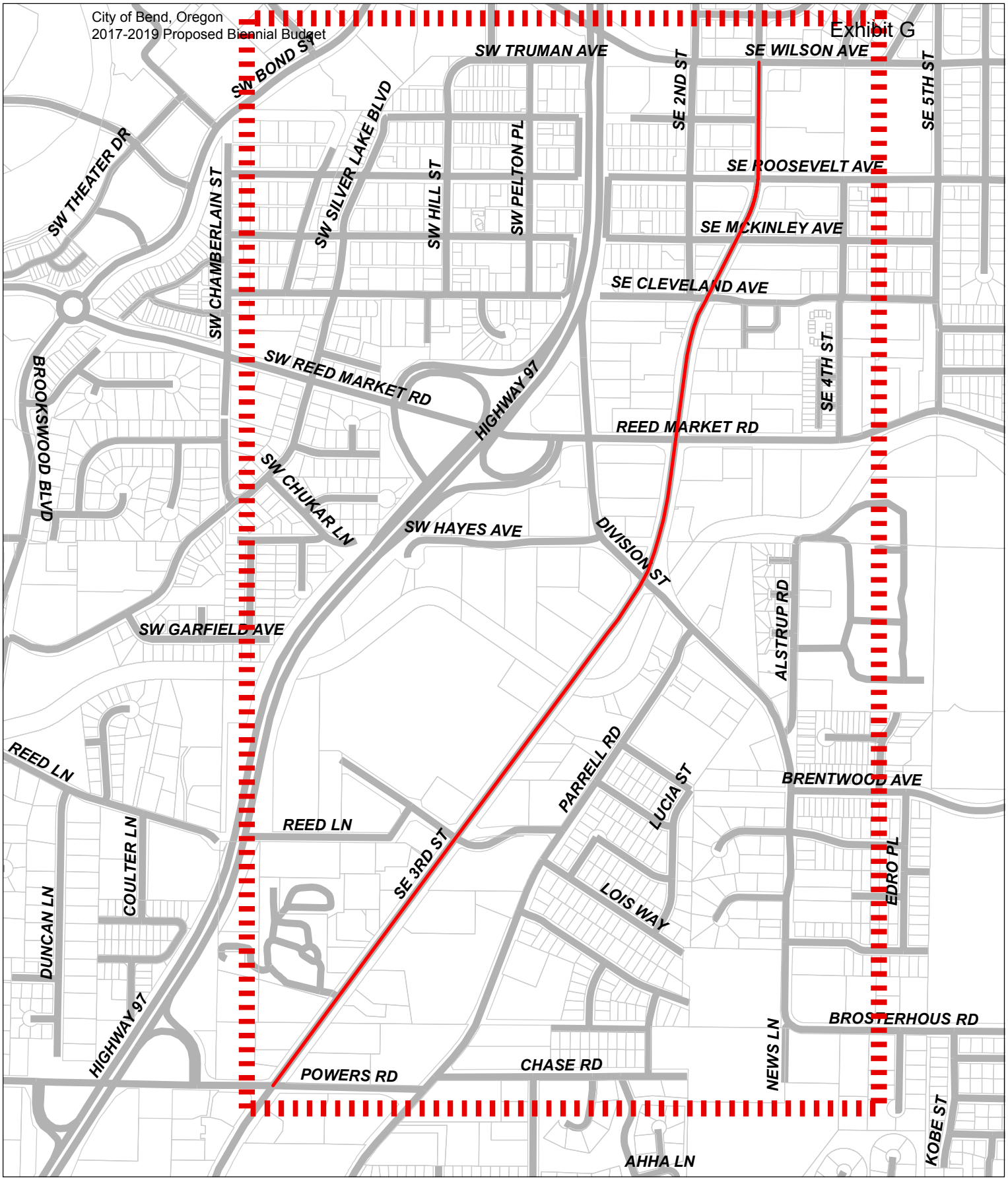
	Cost Estimate Classification *	2017-18	2018-19	2019-20	2020-21	2021-22	5 Year Total
1A3AA South 3rd Street Pedestrian Improvements	1	$ 15,000	$ -	$ -	$ -	$ -	$ 15,000
1ACAI Citywide Accessibility Improvements Includes Barrier Removal	2	850,000	-	-	-	-	850,000
Dean Swift Road Corridor	5	-	150,000	-	-	-	150,000
NE Division Street Corridor	5	-	500,000	-	-	-	500,000
Lodge Pole Drive Corridor	5	-	-	315,000	-	-	315,000
Poplar Street Corridor	5	-	-	250,000	-	-	250,000
SW Truman Hill Taft Silver Lake Corridor	5	-	-	-	440,000	-	440,000
SW Cleveland Avenue Corridor	5	-	-	-	190,000	-	190,000
NW Delaware Avenue Corridor	5	-	-	-	-	500,000	500,000
NW Hill Street Corridor	5	-	-	-	-	250,000	250,000
NW Sisemore Street Corridor	5	-	-	-	-	125,000	125,000
Total Accessibility Construction CIP		**$ 865,000**	**$ 650,000**	**$ 565,000**	**$ 630,000**	**$ 875,000**	**$ 3,585,000**

*** Cost estimate classifications are based on standards developed by the Association for the Advancement of Cost Engineering International (AACE)**

Estimate Class	Purpose	Project Definition Level	Cost Est. Range
Class 5	Concept or Feasibility	0% to 2%	+100% / -50%
Class 4	Preliminary Engineering	1% to 15%	+50% / -30%
Class 3	Semi-Detailed (30-60% Design)	10% to 40%	+30% / -20%
Class 2	Detailed (60-90% Design)	30% to 70%	+20% / -15%
Class 1	Final (100% Design)	50% to 100%	+15% / -10%
N/A	Not Applicable		

City of Bend, Oregon
2017-2019 Proposed Biennial Budget

Exhibit G



1A3AA South 3rd St Pedestrian Improvements

Capital Improvement Projects
2018 - 2022

NOT TO SCALE

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title:	South 3rd Street Pedestrian Improvements	Budget Period:	2017-2019
		Total Project Est:	$812,874
Project Type:	Transportation	Target Start Date:	2011
Project Fund:	Accessibility Construction Fund	Target Completion:	Jul 2017
Project #:	1A3AA		
Project Manager:	Suhr, Burr		
Cost Estimate Classification:	1		
Status:	Open		
Stage:	Design		

METHOD OF FINANCING

TYPE	PERCENTAGE
Water/Sewer Franchise Fees	100%

DESCRIPTION

Project is a collaboration with ODOT to provide continuous pedestrian facilities along the 3rd Street corridor between Wilson Avenue and Powers Road by repairing existing facilities that are either non-existent, out of compliance, or deteriorated.

NEED/JUSTIFICATION

Sidewalks, curb ramps and bike lanes do not exist continually on the 3rd Street arterial. Curb ramps are required per DOJ settlement and bike lanes are required on arterials per state transportation rules. Sidewalks link curb ramps and transit stops. 3rd Street has several "high crash" locations for pedestrians and bicyclists according to Crash Study (2012). Significant multi modal access, mobility, and safety improvements.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: No impact on operations budget

Consequence of Delaying or Eliminating this Project: 3rd Street would remain an incomplete and non-compliant ADA pedestrian corridor. Cascade East Transit (CET) bus stops would remain unideal for pedestrian safety

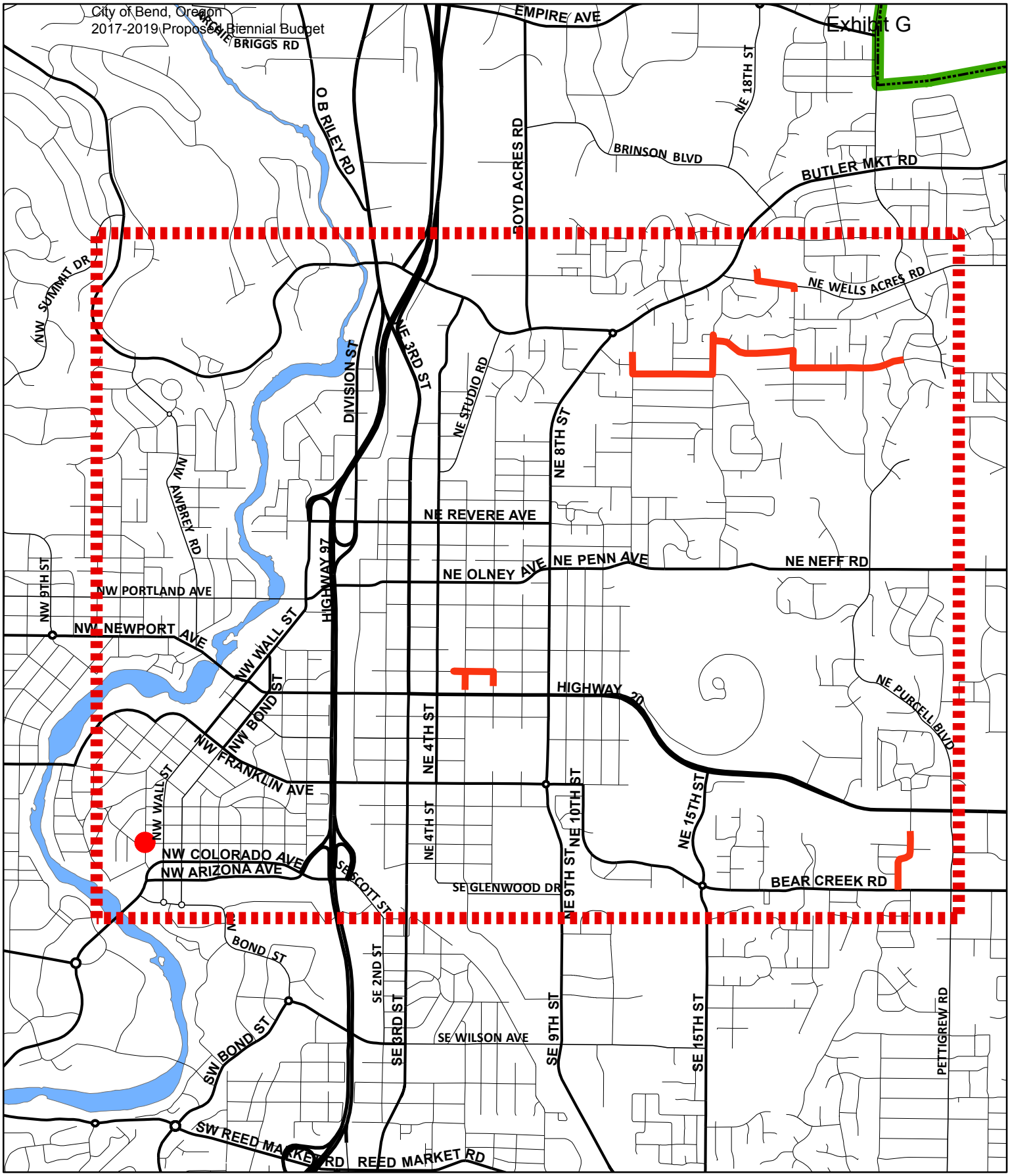
Project Related To: 1WSW3 South 3rd Street – Water portion

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$797,874	$15,000	$ -	$ -	$ -	$ -	$812,874

City of Bend, Oregon
2017-2019 Proposed Biennial Budget

Exhibit G



1ACAI Citywide Accessibility Improvements

Capital Improvement Projects
2018 - 2022

CITY OF BEND

0 1,250 2,500 Feet

Exhibit G

ENGINEERING

Engineering & Infrastructure Planning Department

Capital Improvement Program Project Summary

CIP Fiscal Years 2018– 2022

SUMMARY

Project Title:	Citywide Accessibility Improvements Includes Barrier Removal	Budget Period:	2017-2019
		Total Project Est:	$3,876,000
Project Type:	Transportation	Target Start Date:	2016
Project Fund:	Accessibility Construction Fund	Target Completion:	June 2022
Project #:	1ACAI		
Project Manager:	Rowan, Rory		
Cost Estimate Classification:	2 - 5		
Status:	Open		
Stage:	Design		

METHOD OF FINANCING

TYPE	PERCENTAGE
Water/Sewer Franchise Fees	100%

DESCRIPTION

Through the help of dedicated volunteers on the City of Bend Accessibility Advisory Committee (COBAAC) and the Central Oregon Coalition for Access (COCA), key corridors and neighborhoods across the city have been prioritized for accessibility improvements. This project will design, construct, or repair these curb ramps and sidewalks including those identified through the City's Barrier Removal Request process.

NEED/JUSTIFICATION

Under the terms of previous legal settlements, federal requirements, and the City's adopted ADA Transition Plan, barriers to accessibility in the public right of way must be addressed in a timely manner. These improvements do so by addressing specific Barrier Removal Requests previously submitted by the community as well as by reducing additional barriers to accessibility in comprehensive corridors. Refer to the 5-year Capital Improvement Program schedule for details of corridors identified for improvements.

FINANCIAL NARRATIVE

Impact on Annual Operating Budget: Reduces operating costs by repairing existing damaged or non-compliant sidewalk and curb ramps.

Consequence of Delaying or Eliminating this Project: High priority Barrier Removal Requests submitted by the accessibility community would not be addressed.

Project Related To: N/A

PROJECT COST BY FISCAL YEAR

Paid to Date + 2016-17 EST	2017-18	2018-19	2019-20	2020-21	2021-22	Total
$306,000	$850,000	$650,000	$565,000	$630,000	$875,000	$3,876,000