Oregon Department of Transportation

BARBUR BOULEVARD ROAD SAFETY AUDIT

SW Capitol Highway to SW Naito Parkway

October 2015

Prepared for:

ODOT Region 1 Traffic
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Portland, OR 97209
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Prepared by:

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TRANSPORTATION ENGINEERING/PLANNING

MOVING**FORWARD**THINKING™

Road Safety Audit Report

Barbur Boulevard Road Safety Audit (RSA): SW Capitol Highway to SW Naito Parkway

Mile Point (MP) 6.30 to MP 1.95

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Project Engineer: Kelly M. Laustsen
Project Principal: Brian L. Ray, P.E.

KAI Project Number: 19026.0

October 2015

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Title 23 U.S.C. §409

Discovery and admission as evidence of certain reports and surveys

Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 148 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

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Technical Summary

PROJECT TITLE:

Barbur Boulevard Road Safety Audit (RSA): SW Capitol Highway to SW Naito Parkway, Mile Point (MP) 6.30 to MP 1.95

DATE:

July 20-24, 2015

RSA TEAM AND PARTICIPANTS:

- Hermanus Steyn, Pr. Eng., PE, Principal Engineer, Kittelson & Associates, Inc. (KAI)
- Joel McCarroll, PE, PTOE, Oregon Department of Transportation (ODOT) Region 4 Traffic Manager
- Dan Nabors, PE, Vanasse Hangen Brustlin, Inc. (VHB)
- Adrian Witte, PE, Senior Engineer, Toole Design Group
- Carol Cartwright, PE, ODOT Region 2 Roadway Manager
- Stacy Shetler, PE, County Traffic Engineer, Washington County
- Wendy Cawley, PE, Traffic Safety Engineer, Portland Bureau of Transportation (PBOT)
- Matthew Joerin, PE, Program Manager, Federal Highway Administration (FHWA)
- Kelly Laustsen, Senior Engineering Associate, KAI

Exhibit 1. RSA Team bicycle ride

Project Characteristics

Description	Project Characteristic
Audit Type:	Post-construction – Existing Road
Land Use Development Proposal:	No
Units of Measure:	U.S.
Adjacent Land Uses:	Commercial, some residential on north end
Posted Speed (US in miles-per-hour [mph]):	35-45 mph
Opposite Flow Separation:	Two-way left-turn (TWLT) lane on portions of corridor, median on portion of corridor
Service Function: • Highway Number • Route Number • Functional Classification • Oregon Highway Plan (OHP) Designation	 • 091 • OR 99W • Urban Principal Arterial • District Highway
Terrain:	Hilly (higher at south end)
Climatic Conditions - Temperature:	Mild Winter (rain with some freezing, icing possible), Warm Summer (sporadic hot days)
Climatic Conditions - Precipitation:	Rain with Occasional Snow in Winter

Background

The RSA Team studied Pacific Highway West (OR 99W, Highway No. 091, Barbur Boulevard) from approximately SW Capitol Highway (Mile Post [MP] 6.30) to approximately SW Naito Parkway (MP 1.95). Exhibit 2 illustrates the location and approximate extents of the study corridor.

Barbur Boulevard is a four- to five-lane highway designated as a District Highway in the Oregon Highway Plan that runs mostly north-south between the southwest suburban cities and downtown Portland. It is a major commute route for vehicles, transit, and bicycles. **For the purpose of orientation through this report, Barbur Boulevard will be described as oriented north-south and all side streets oriented as east-west.** Within the study corridor there are ten signalized intersections and five enhanced pedestrian crossings. There are four bridges on Barbur Boulevard.

An RSA is a formal safety performance examination of an existing or future road or intersection conducted by an independent audit team. The emphasis of an RSA is to identify opportunities to improve safety rather than critique work previously completed. The process includes a pre-audit data and drawings review, a field review, an analysis of safety issues and associated potential mitigations, and a presentation of findings to the owner of the roadway or project being reviewed. The RSA identifies near-, intermediate-, and long-term projects, and informs and provides guidance in defining future projects.

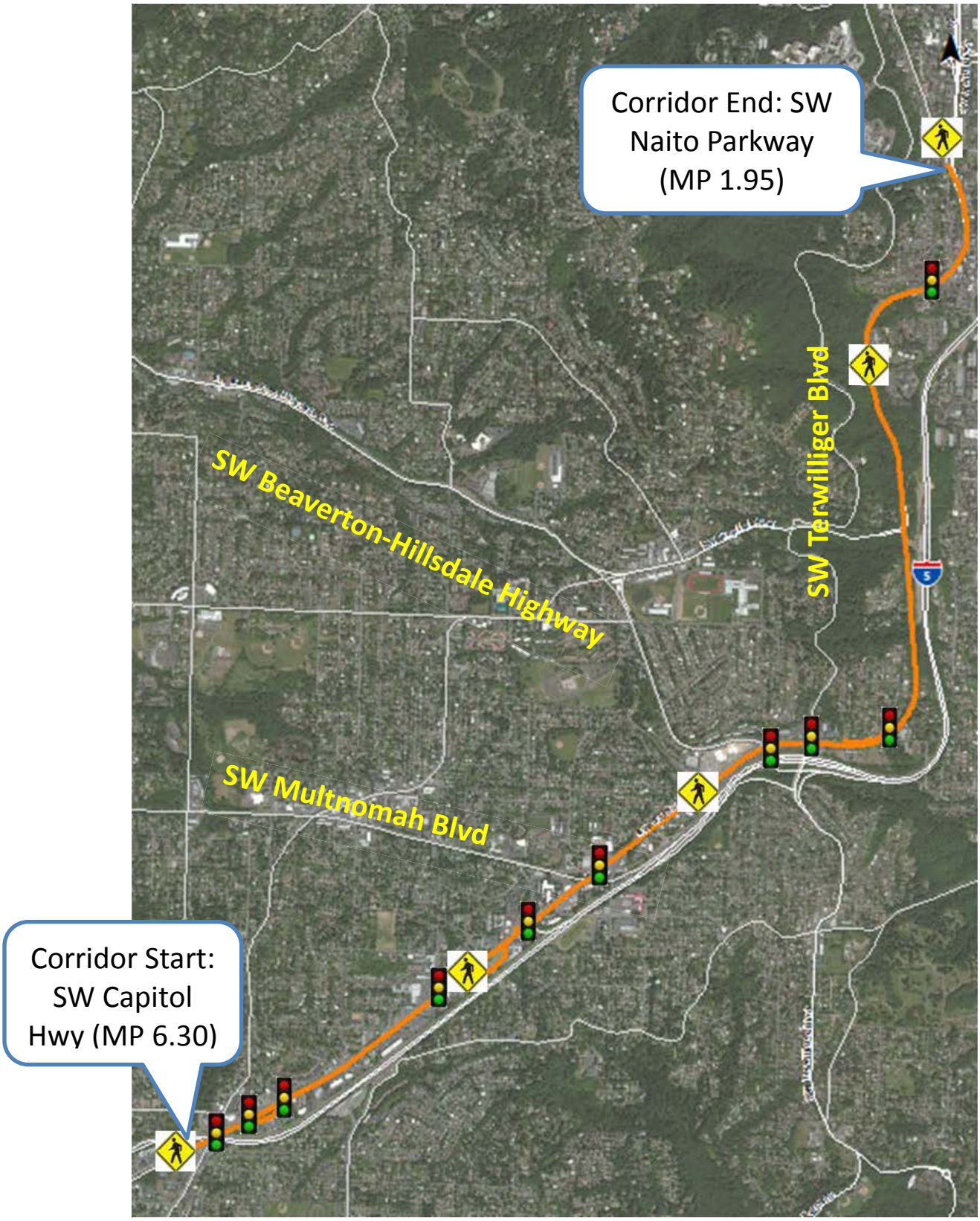

Exhibit 2. Barbur Boulevard study corridor

ODOT's 2014 Safety Priority Index System (SPIS) identifies the following locations in the top ten percent of intersections statewide. The SPIS program includes screening the state highway network to identify and prioritize sites that have potential for safety improvements. SPIS scores reflect the frequency, rate, and severity of crashes. The top ten percent list includes sites within the top ten percentile of SPIS scores.

- SW Barbur Boulevard /SW Capitol Highway (top 5% SPIS site)
- SW Barbur Boulevard /SW 30th Avenue
- SW Barbur Boulevard /SW Spring Garden Street
- SW Barbur Boulevard /SW Terwilliger Boulevard
- SW Barbur Boulevard /SW Miles Street
- SW Barbur Boulevard /SW Hamilton Street
- SW Barbur Boulevard /SW Naito Parkway

The ODOT Region 1 All Roads Transportation Safety (ARTS) Systemic Project Prioritization effort developed a data-driven list of frequent and severe crash locations where systemic countermeasures could be applied. ARTS identified a 300% list which includes locations where projects could be funded assuming 300% of the State Transportation Improvement Program (STIP) funding is available. Based on the 300% list within the study corridor:

- Barbur Boulevard between SW Capitol Highway and SW Terwilliger Boulevard was identified based on frequency and severity (Fatal & Injury A) of roadway departure crashes.
- The SW Terwilliger Boulevard, SW Bertha Boulevard, SW Capitol Hill Road, SW Taylors Ferry Road, and SW Capitol Highway intersections with Barbur Boulevard were identified based on frequency and severity (Fatal & Injury A) of crashes.

The ODOT Region 1 Active Transportation Needs Inventory (ATNI) identifies and evaluates pedestrian and bicycle facility gaps in the existing system. It also provides an evaluation tool to identify future projects that provide the greatest benefits to users considering a variety of factors, including:

- Crash History
- Crash Risk
- Access to Transit
- Access to Essential Destinations
- Serves Transportation Disadvantaged Population
- Enhances System Completeness
- In a Local Plan
- Existing Pedestrian or Bicycle Facility

The ATNI includes the Barbur Blvd study corridor and provides data on existing facilities and evaluation scores per the factors listed above.

Several studies have been completed in the past five years for the Barbur Boulevard corridor, including:

- **Barbur Concept Plan**: provides a long-term vision for a more "walkable, vibrant Barbur," including potential transportation investments, stormwater solutions, and changes to City policy and zoning. The Plan is intended to inform regional decisions for future high capacity transit in the southwest corridor.
- **High Crash Corridor Safety Plan**: assesses crash history and opportunities for corridor-wide and intersection specific improvements, such as pedestrian countdown signals and Americans with Disability Act (ADA) upgrades.
- **Barbur/OR-99W Corridor Safety and Access to Transit**: is a 2016-18 STIP project to design and construct modifications to improve safety, access to transit, and active transportation. Potential projects include: sidewalk infill, enhanced pedestrian crossing along Barbur Boulevard at Lane/Naito Parkway, enhanced existing bus stops, modifications to retaining walls and drainage, and bus-activated extended green time at up to 16 signals.
- **Southwest Corridor Plan**: lists packages of transit, roadway, bicycle, and pedestrian solutions targeted at reducing congestion, improving circulation, and improving quality of life in the corridor.

Corridor Crash Data Trends

KAI obtained crash data for a period from January 1, 2004 through September 30, 2014 from ODOT. Crashes include those coded for city streets, county roads, and state highways. The crash database maintained by the ODOT Crash Analysis & Reporting Unit provides motor vehicle crash data based on Police Reports and citizen completed forms submitted to the Department of Motor Vehicles.

Over the ten-year study period, 919 crashes were reported on Barbur Boulevard[1], including 873 vehicle related, 34 bicycle related, and 12 pedestrians. Ten fatalities were reported, eight of which involved alcohol. Eight of the crashes occurred during dark conditions with lighting, while the other two occurred during daylight. Four of these crashes occurred in the curve north of SW Miles Street. *Appendix A* includes a copy of the Barbur Boulevard RSA Pre-Audit Presentation, which includes a summary of crash history, speed study data, and historic volumes.

The following graphs highlight key trends for the study corridor, while additional crash data is provided in the Preliminary Findings section that captures the specific safety issues. Key observations from the ten-year crash data are:

- Exhibit 4 shows the number of crashes by location along the corridor:
  - SW Capitol Highway intersection has the highest concentration of crashes (109 in the vicinity of the intersection).
  - The signalized SW Bertha Boulevard (58 in the vicinity of the intersection) and SW Terwilliger Boulevard intersections (55 in the vicinity of the intersection) also have high crash concentrations.
  - The closely offset signalized SW Hamilton Street intersections (87 in the vicinity of the intersections) combined also had a concentration of crashes.
- Exhibit 5 only shows the fatal and Injury A crash locations along the corridor:
  - There were four fatalities in the vicinity of the horizontal curve north of SW Miles Street.
  - Other locations and adjacent segments with two or more are: SW Capitol Highway, SW 30th Avenue, SW Terwilliger Boulevard, and Barbur Boulevard/SW Naito Parkway diverge.
- Exhibit 6 only shows the pedestrian and bicycle related crash locations along the corridor:
  - Pedestrian related crash locations with at least two pedestrian crashes are: vicinity of Barbur Boulevard/SW Naito Parkway diverge, SW Terwilliger Boulevard intersection, and SW Capitol Highway intersection.
  - Bicycle related crash locations with at least two bicycle crashes are: segment from Barbur Boulevard/SW Naito Parkway diverge to SW Hamilton Street intersection, vicinity of SW Miles Street, SW 13th Avenue, vicinity of SW 26th Avenue and SW Barbur Court, and SW 30th Avenue.

[1] Data did not include crashes on intersection side streets

The frequency of crashes by user and severity is shown in Exhibit 3.

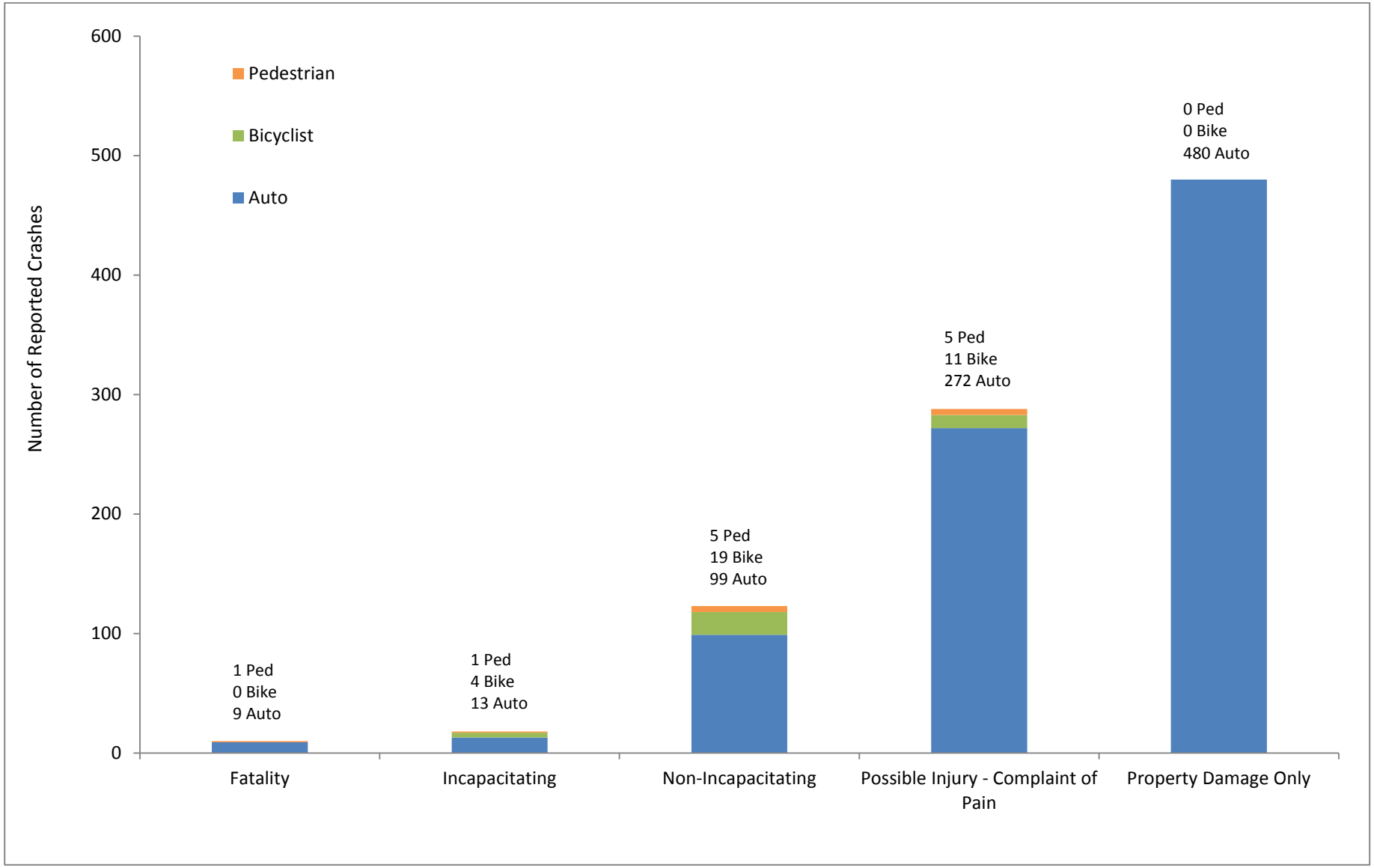

Exhibit 3. Reported crash frequency by user and severity (Jan 2004 – Sept 2014)

The frequency of crashes by location and severity is shown in Exhibit 4.

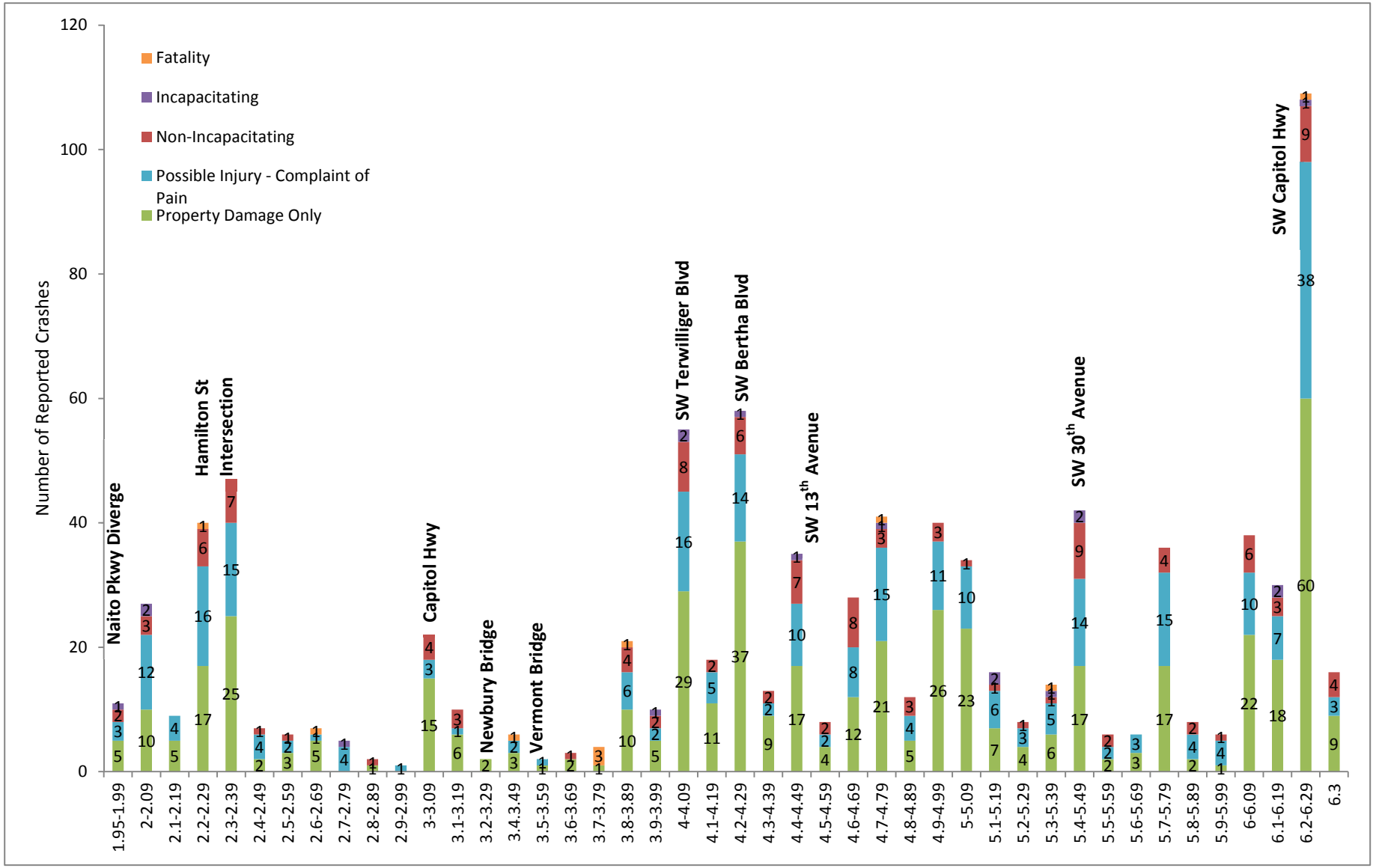

Exhibit 4. Reported crash frequency by location and severity (Jan 2004 – Sept 2014)

Exhibit 5 shows only the fatal and Injury A crashes by location.

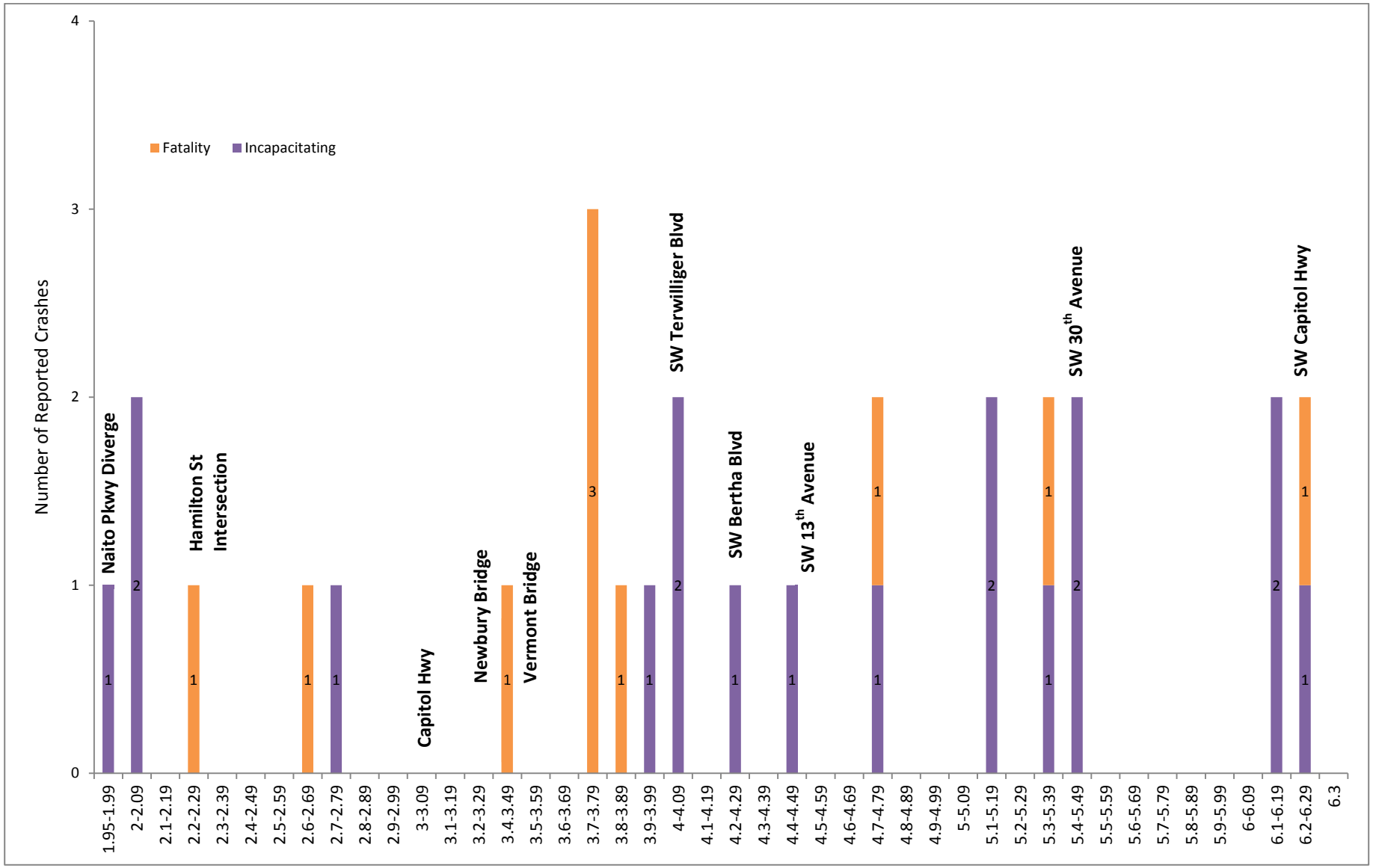

Exhibit 5. Fatal and incapacitating injury crashes by location (Jan 2004 – Sept 2014)

Exhibit 6 summarizes only the pedestrian and bicycle crashes by location.

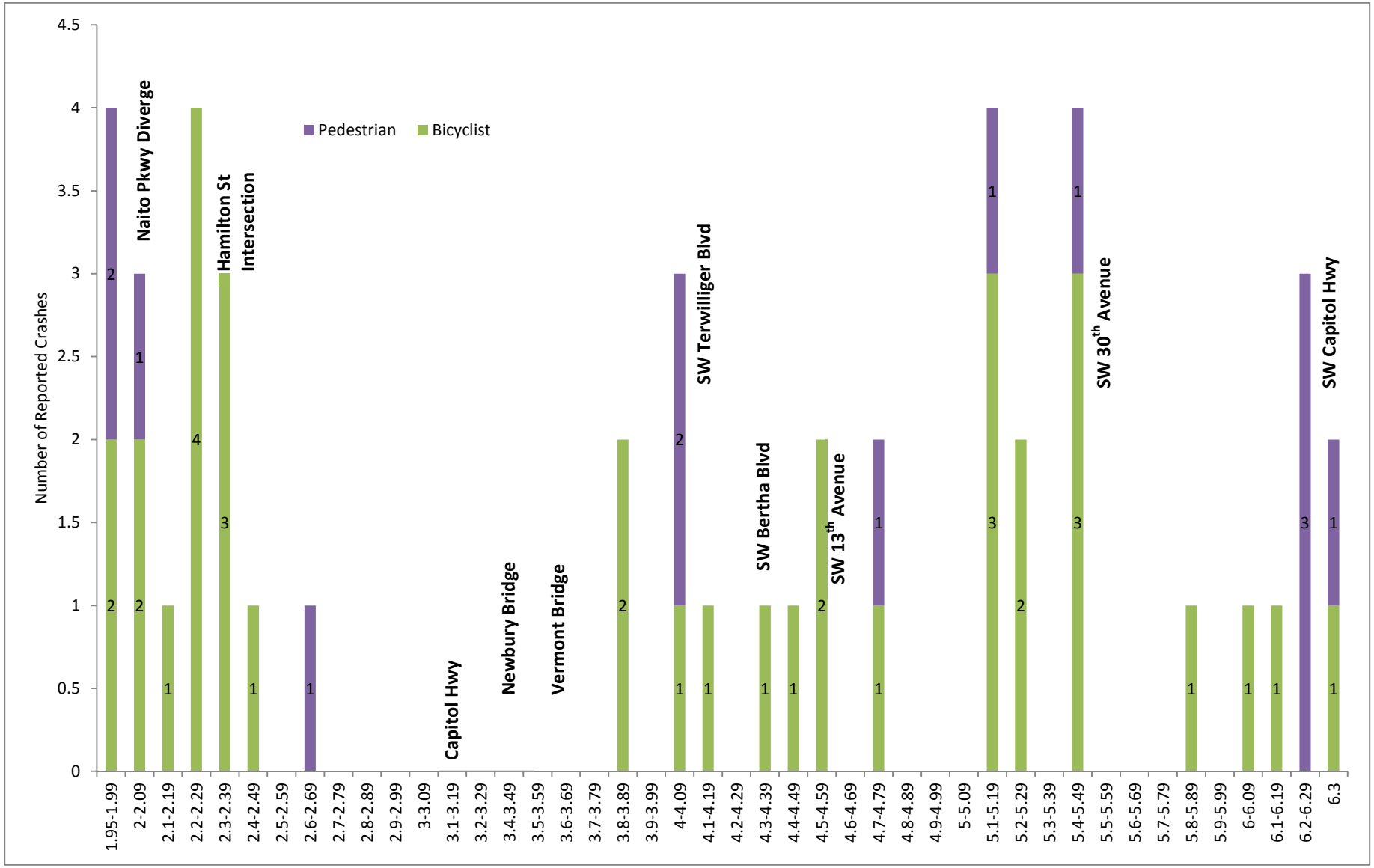

Exhibit 6. Pedestrian and bicycle crashes by location (Jan 2004 – Sept 2014)

The frequency of crashes by type and severity is shown in Exhibit 7.

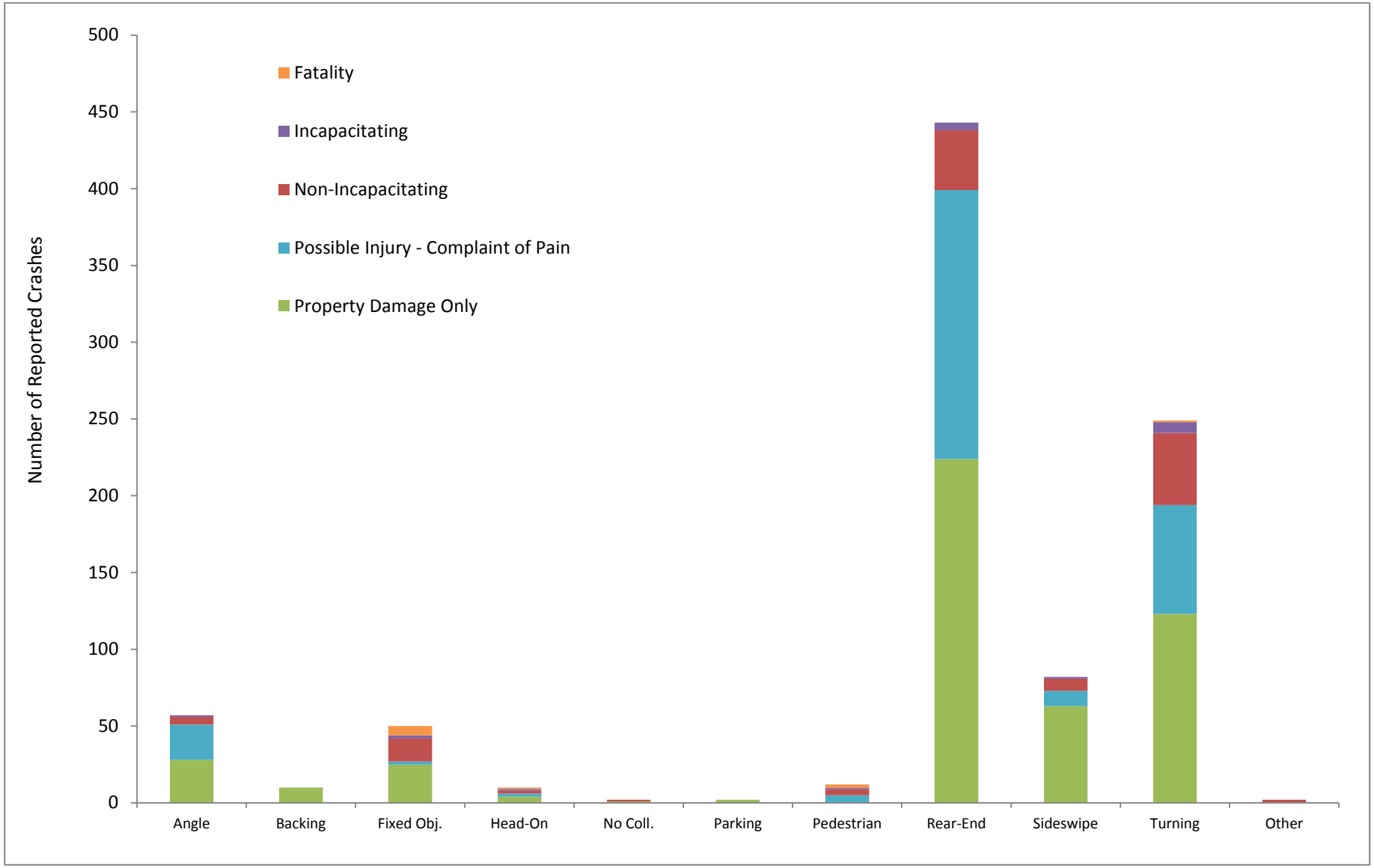

Exhibit 7. Reported crash frequency by type and severity (Jan 2004 – Sept 2014)

The frequency of turning movement and angle crashes by location is shown in Exhibit 8.

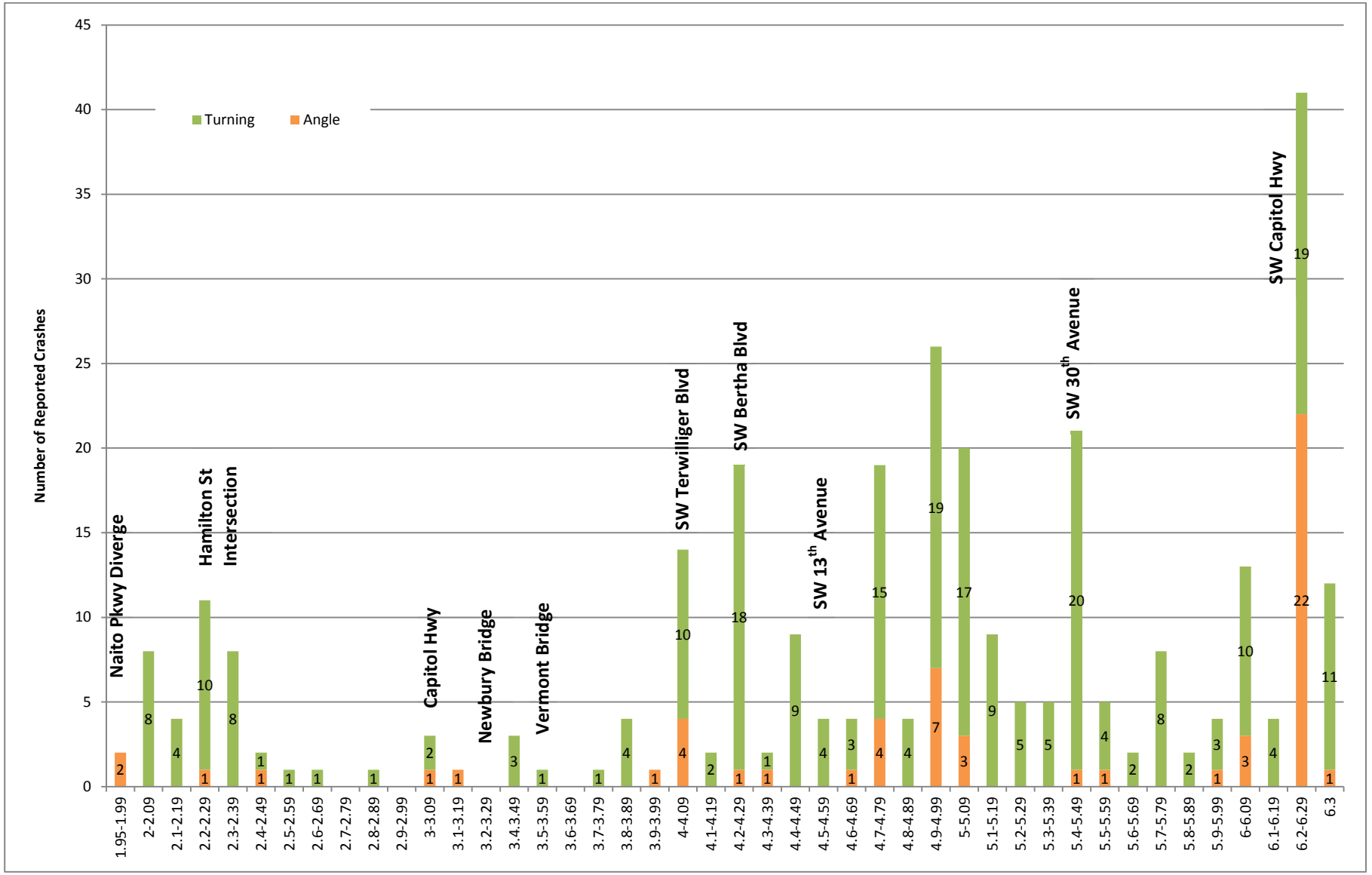

Exhibit 8. Turning and angle crashes by location (Jan 2004 – Sept 2014)

Exhibit 9 summarizes the driveway related crashes by location.

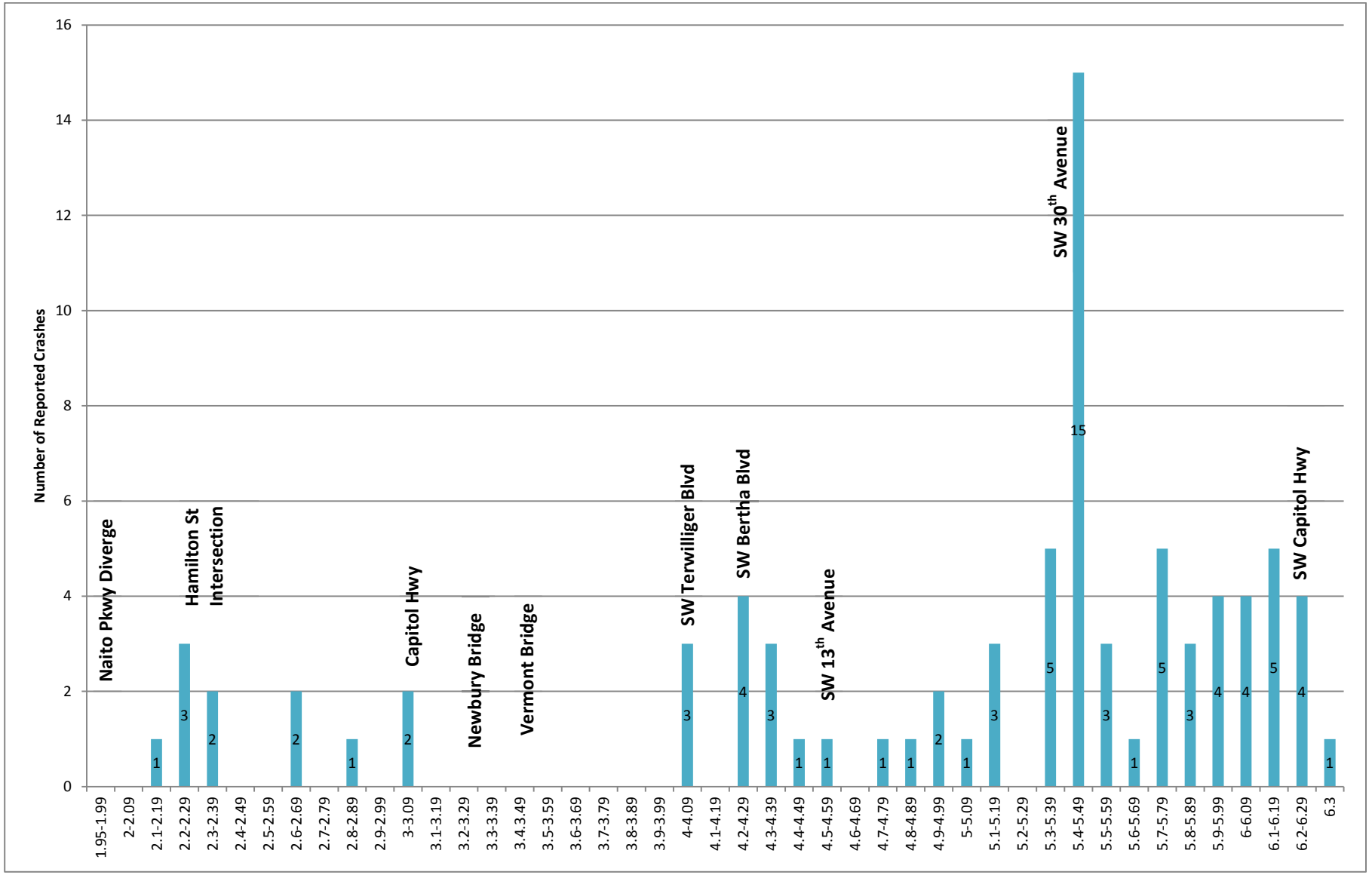

Exhibit 9. Driveway crashes by location (Jan 2004 – Sept 2014)

RSA Process

The purpose of the RSA is to identify issues that contribute to crashes or potentially create a risk for future crashes and suggest treatments for addressing those issues. The suggestions for countermeasures include engineering treatments, as well as potential educational and enforcement actions.

The RSA followed the general RSA process identified by the FHWA, as shown in Exhibit 10.

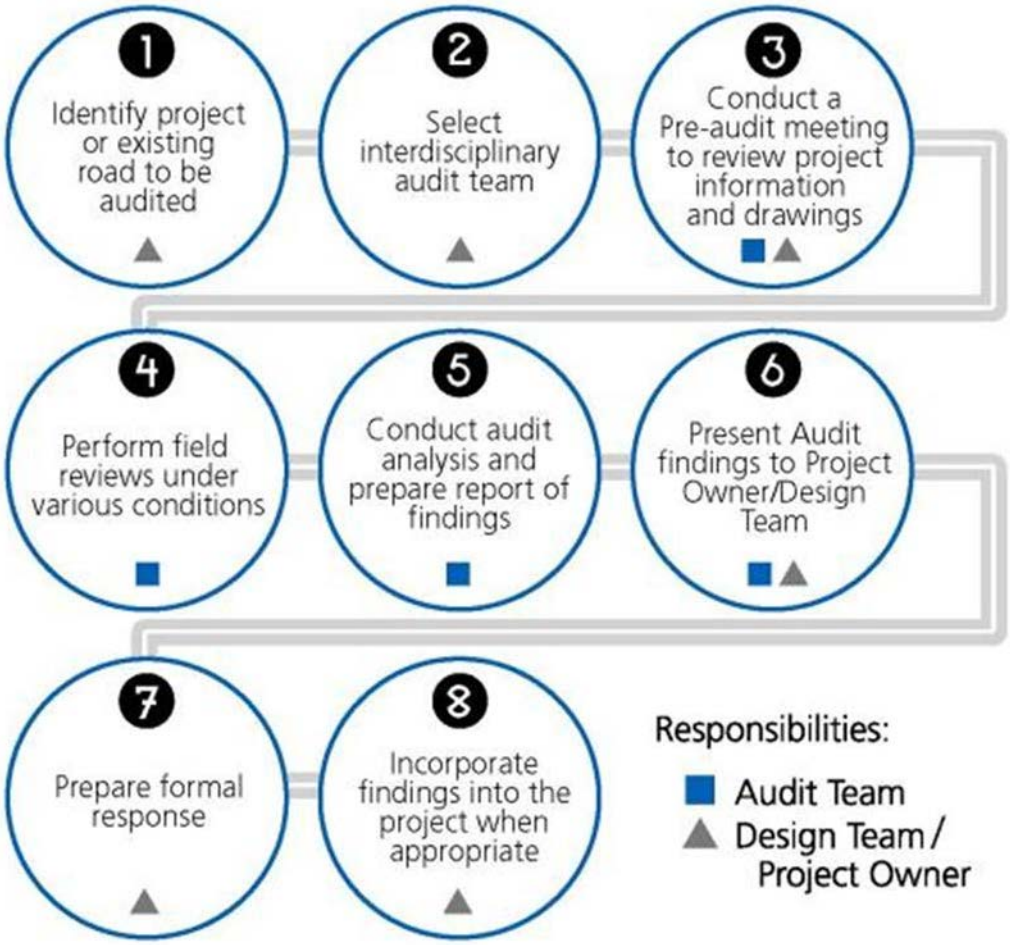

Exhibit 10. FHWA RSA Process

The RSA Team initiated work on Monday, July 20, 2015 with a kick-off/pre-audit meeting at ODOT Region 1 offices in Portland, Oregon and closed out with the preliminary findings meeting on Friday, July 24, 2015. The meetings were attended by:

Kick-off/pre-audit meeting (Monday, July 20):

- The RSA Audit Team
- Grant Riedel, Katie Bell, Dennis Mitchell, Sue D'Agnese, Shelli Romero, Mark Johnson, Kelly Brooks, Kate Freitag, Rian Windsheimer – ODOT
- Roger Averbeck – SW Neighborhood, Inc.
- Ryan Malzahn, Brett Dodson – Oregon Health & Science University (OHSU)

- Brian Rager – City of Tigard
- David Abrahamson – Portland Police
- Gerik Kransky – Bicycle Transportation Alliance
- Young Park, David Aulwes – TriMet

Preliminary findings meeting (Friday, July 24):

- The RSA Audit Team
- Grant Riedel, Katie Bell, Dennis Mitchell, Sue D'Agnese, Shelli Romero, Mark Johnson, Kelly Brooks, Kate Freitag, Katherine Burns, Cory Hamilton, Alan Snook, Susan Hanson, Andrew Plambeck – ODOT
- Roger Averbeck – SW Neighborhood, Inc.
- Gerik Kransky – Bicycle Transportation Alliance
- Grant O'Connell, Ben Baldwin – TriMet

Sign-in sheets from both meetings are provided in *Appendix B.*

Discussions at the kick-off meeting included the following topics:

- Study corridor context:
  - Address all modes.
  - Look at substandard facilities and the perception of safety, not just the crash data.
  - Improvements like delineators and signs appear to be helping.
  - The corridor is challenging to maintain, especially while keeping the maintenance crews safe.
  - The corridor is viewed as being challenging for bicyclists, especially the bridges, grade changes, and traffic.
  - Concerns about both observed speeds and posted speeds on corridor.
  - Barbur Boulevard is a major corridor for TriMet, with concerns including "unofficial Park & Ride parking" and crossings for pedestrians.
  - Safety discussion should be multimodal and focus on education.
  - Issues with distracted and impaired driving.
  - Skewed intersections and lack of controlled access is challenging.
  - Barbur Boulevard serves as an alternate route for I-5 during incidents.
- Location specific:
  - Southbound U-turns made at the Barbur Boulevard/SW Naito Parkway split.
  - Pedestrian/bicycle crossing at the Barbur Boulevard/SW Naito Parkway split should be enhanced.
  - Northbound vehicles on Barbur Boulevard waiting to turn right onto SW Hamilton Street pull forward and block the bicycle lane.
  - Some of the interchange connections are obsolete and past their useful life for functionality.
  - Barbur Court is an issue for bicycle/vehicle interactions. Vehicles from SW Barbur Court take a right onto Barbur Boulevard as bicycles are coming quickly down the hill, creating a potential conflict.
  - Rectangular rapid-flashing beacon (RRFB) at Rasmussen apartments works well and has been well received.
  - The section between SW 17th and SW 19th Avenues is challenging for bicyclists and pedestrians as there are no bicycle or pedestrian facilities and there is guardrail with large drop-offs.

The team conducted field reviews and met on the corridor to review data, discuss observations, summarize observed issues, and identify suggested improvements. The RSA Team schedule is summarized below:

MONDAY, JULY 20, 2015 (DAY 1)

- Kick-off meeting, ODOT Region 1
- Project Pre-Audit/Start-up Meeting with RSA Team
- Afternoon field work to observe road user characteristics in daylight conditions
- Night field work to observe road user characteristics after dark

TUESDAY, JULY 21, 2015 (DAY 2)

- Review supporting data (crash data, volumes, etc.)
- Discuss observations and issues
- Afternoon bicycle ride

WEDNESDAY, JULY 22, 2015 (DAY 3)

- Morning field work during morning commute
- Identify issues

Exhibit 11. Team brainstorming session

THURSDAY, JULY 23, 2015 (DAY 4)

- Prioritize issues observed
- Brainstorm mitigations
- Document findings and preliminary suggestions

FRIDAY, JULY 24, 2015 (DAY 5)

- Final work session and presentation preparation
- Present preliminary findings

Summary of Safety Issues

The RSA Team identified and categorized system-wide and location-specific safety issues based on a qualitative risk scale. For the purposes of this RSA, risk is defined as a function of exposure, probability, and consequence. *Exposure* reflects the number of users potentially influenced by the design feature. *Probability* reflects the likelihood of a crash influenced by the identified design feature. The *consequence* reflects the severity of a crash, if one occurs.

The RSA Team assigned the qualitative risk rating of safety issues relative to all other issues observed. ***Category III*** issues have potentially the greatest risk compared to the other observed issues; they are associated with higher exposure, probability, and/or consequence than other issues. ***Category II*** issues indicate higher risk than some issues and lower risk relative to other observed safety issues. ***Category I*** issues indicate the least risk compared to the other observed issues; they are associated with lower exposure, probability, and/or consequence.

Category III issues and locations identified by the RSA Team:

- Corridor speeds and cross-section inconsistency
- Access management
- Bicycle facilities
- Barbur Boulevard/SW Capitol Highway Intersection
- Barbur Boulevard Segment: SW 24th Avenue to Multnomah Boulevard Overpass
- Barbur Boulevard Segment: SW Bertha Boulevard to SW Terwilliger Boulevard
- Barbur Boulevard/SW Terwilliger Boulevard Intersection
- Barbur Boulevard Segment: Wooded Section between curve north of SW Miles Street and SW Hamilton Street
- Barbur Boulevard/SW Hamilton Street Intersection
- Barbur Boulevard Segment: SW Hamilton Street to SW Naito Parkway
- Barbur Boulevard/SW Naito Parkway Diverge

Category II issues and locations identified by the RSA Team:

- Skewed intersections/driveways
- Pedestrian facilities
- Lighting needs
- Barbur Boulevard/SW 30th Avenue Intersection
- Barbur Boulevard Segment: SW 30th Avenue to SW 24th Avenue
- Barbur Boulevard/SW 24th Avenue Intersection
- Barbur Boulevard/SW Capitol Hill Road/19th Avenue Intersection
- Barbur Boulevard Segment: SW Capitol Hill Road to SW 13th Street
- Barbur Boulevard Segment: SW 13th Street to SW Bertha Boulevard
- Barbur Boulevard/SW Bertha Boulevard Intersection
- Barbur Boulevard Segment: Horizontal curve north of SW Miles Street

Category I issues and locations identified by the RSA Team:

- Inconsistent signage and striping
- Pavement quality in bicycle lanes
- Barbur Boulevard Segment: SW Taylors Ferry Road Area
- Barbur Boulevard Segment: SW Taylors Ferry Road to SW 30th Avenue
- Barbur Boulevard/SW Miles Boulevard Intersection

The qualitative rating of risk given to each observed safety issue and location is documented in further sections.

RSA Findings

This section of the report identifies corridor-wide and intersection/segment-specific safety issues and provides suggestions to address these issues. *Appendix C* includes a copy of the Barbur Boulevard RSA Findings Presentation. The team reviewed ten years of crash data from the corridor and crash diagrams with the most recent five years of data. Graphs and references to the data are provided throughout the report where needed and a full copy of the intersection crash diagrams are available in *Appendix D*. Traffic counts reviewed by the team are provided in *Appendix E.*

Corridor-Wide Issues

ISSUE: SPEED AND CROSS-SECTION INCONSISTENCY

The RSA Team initially discussed potential issues related to speed and the corridor cross-section independently. However, the team concluded that the inconsistent cross-section along the corridor contributes to the higher than desired traveling speeds on some segments. As the team explored opportunities to address the identified issues, the suggestions identified addressed both speed and the cross-section. Therefore, the two topics are jointly discussed below.

Based on field observations and data illustrated in the Barbur Concept Plan, as shown in Exhibit 12, the observed speeds exceed posted speeds. In the Wooded Section of the corridor (between Miles Street and Hamilton Street), access is relatively limited and together with the roadway character, the facility resulted in the highest speeds. Exhibit 13 shows a portion of this limited access section.

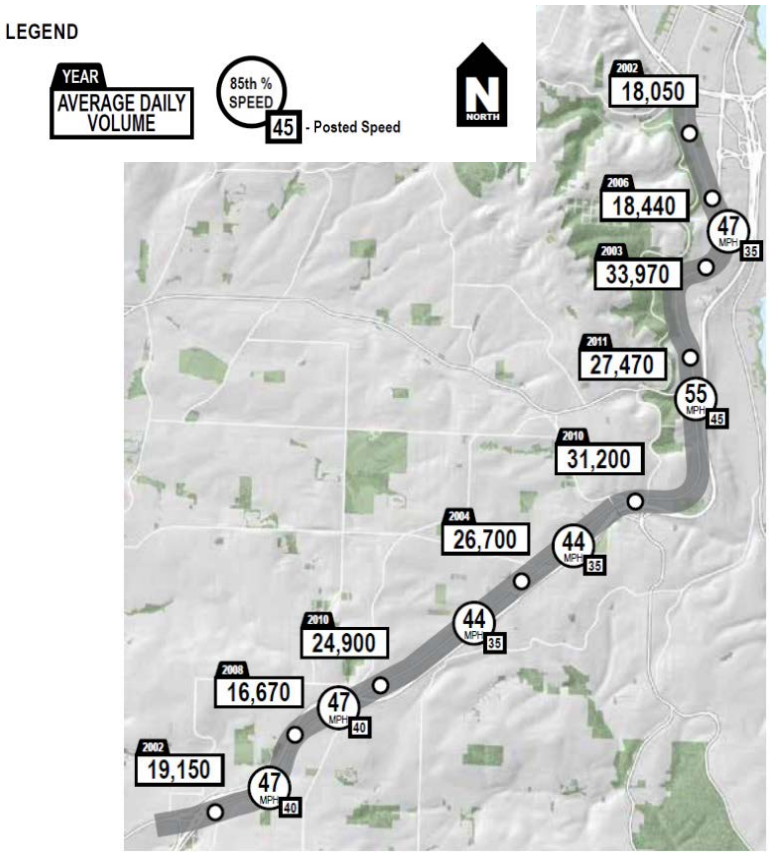

Exhibit 12. Traffic and speed on Barbur (Graphic from Barbur Concept Plan)

Exhibit 13. Barbur Boulevard looking southbound at Vermont Bridge

Based on reported crash data, 71 (8 percent) of the 919 crashes reported in the last ten years were flagged to indicate speed was involved. Due to Oregon being mostly a self-reporting state, this number is likely much higher. Speed was involved in eight of the ten fatal crashes, where speed was indicated in a Police Reports.

The cross-section varies along the corridor:

- The majority of the corridor is a five-lane cross-section with a two-way left-turn (TWLT) lane, with the exception of landscaped medians in the vicinity of SW Bertha Boulevard.
- The roadway has a four-lane undivided cross-section through the wooded section (between SW Miles Street and SW Hamilton Street).
- Where bridges or embankments restrict the width of the roadway, they often do not have sidewalks and/or bicycle lanes facilities.
- On-street parking is provided on parts of the southern corridor where accesses are more frequent.

Exhibit 14 shows the cross-section of two different segments. The image on the left is from SW 30th Avenue where the cross-section includes bicycle lanes, sidewalks, a two-way center left-turn lane, and multiple accesses. The image on the right is from the Wooded Section near Rasmussen apartments where access is limited with shoulder bicycle lanes and no sidewalks

Exhibit 14. Barbur Boulevard cross-sections near SW 30th Avenue (left) and curves near Rasmussen (right)

Table 1. Qualitative Risk Rating of Corridor Speeds and Cross-section Inconsistency

Function	Classification	Reasoning
Exposure	Category III	High speed differential between modes. Inconsistency in roadway character may lead to increase of speed differential between vehicles.
Probability	Category III	8 of 10 fatal crashes speed and alcohol related.
Consequence	Category III	Higher severity crashes due to speeds
Overall	*Category III*	-

Near-term suggestions to address corridor speeds and cross-section inconsistency:

- Consider enforcement strategies such as photo radar, as well as education strategies that may include speed feedback signs.

Intermediate suggestions to address corridor speeds and cross-section inconsistency:

- Narrow travel lanes (12 feet to 11 feet) to provide the opportunity for buffered bicycle lanes where feasible, per suggested cross-section in Exhibit 15. It is understood that this cross-section may not be able to be implemented throughout the entire study corridor in the near- to intermediate-term due to physical constraints such as the Newbury, Vermont, and Multnomah (at Safeway) Bridges, as well as the embankment section just north of the SW Capitol Hill Road-SW 19th Avenue intersection.

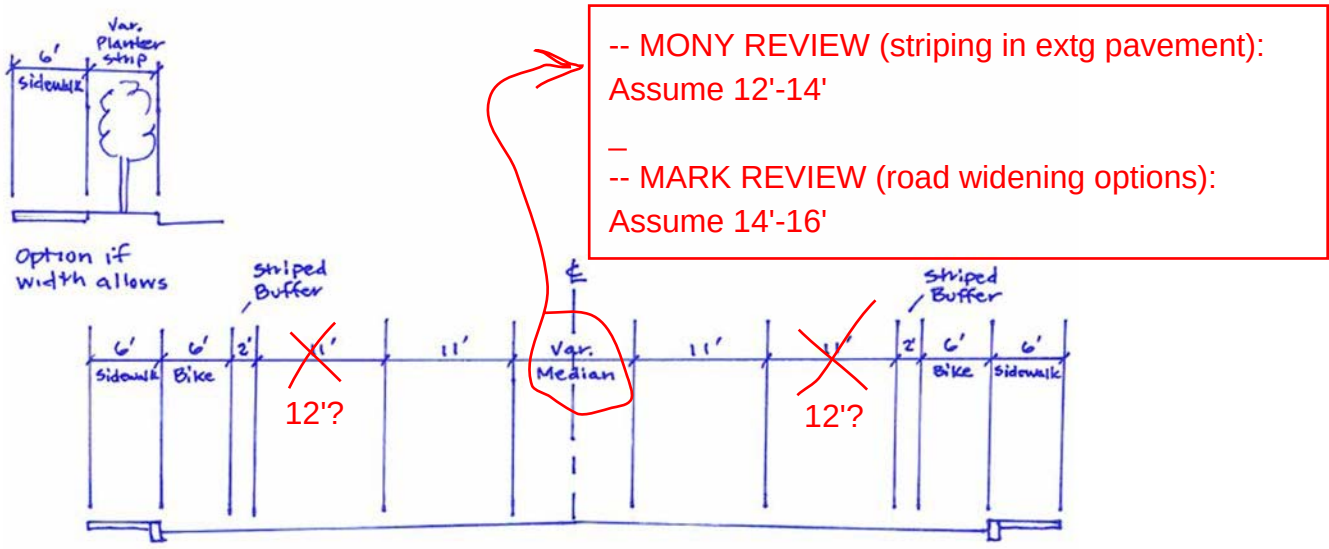

Exhibit 15. Suggested Cross-section

- Repurpose on-street parking to provide continuous pedestrian and bicycle facilities along the corridor's length, per the suggested cross-section in Exhibit 15.
- Explore opportunities to provide medians for access and speed management (see Exhibit 16).

Exhibit 16. Existing median on Barbur Boulevard near Fred Meyer

Long-term suggestions to address corridor speeds and cross-section inconsistency:

- Identify and establish an appropriate target speed based on the surrounding context and for the desired outcome. Follow-up studies may consider the following tools:
  - Utilize guidance in National Cooperative Highway Research Program (NCHRP) Report 785: *Performance Based Analysis of Geometric Design of Highways and Streets*. For example, some European countries have the design philosophy to create "self-explaining, self-enforcing" roadways, meaning they design for the speed they want people to drive, not a higher speed. This means roadway geometric design elements are based on the desired speed consistently. It results in an operating condition that is consistent with the speed environment, regardless of the horizontal or vertical alignment the driver is navigating.
  - FHWA also provides a tool called "USLIMITS2" which could be helpful in determining the appropriate speeds on Barbur Boulevard. The tool was developed initially by the Australian Road Research Board for FHWA and was refined through research as part of NCHRP Project 3-67. The web-based tool is designed to help practitioners set reasonable, safe, and consistent speed limits that are creditable and enforceable. USLIMITS2 is applicable to a wide range of roadways and responds to the need for better methods to identify appropriate speed limits.

ISSUE: ACCESS MANAGEMENT

Barbur Boulevard is classified by ODOT as a district highway, it is a major transit corridor, and is a bicycle commuting route between downtown Portland and the southwest. It provides access to numerous commercial developments, particularly along the southern end. The variation in access along the corridor results in high-volume, high-speed traffic conflicts, with low-speed crossing traffic, and conflicts with bicyclists and pedestrians. Based on the reported crash data and shown in Exhibit 17, there is a crash trend (e.g., associated with turning movements), particularly in the vicinity of SW 30th Avenue (MP 5.42).

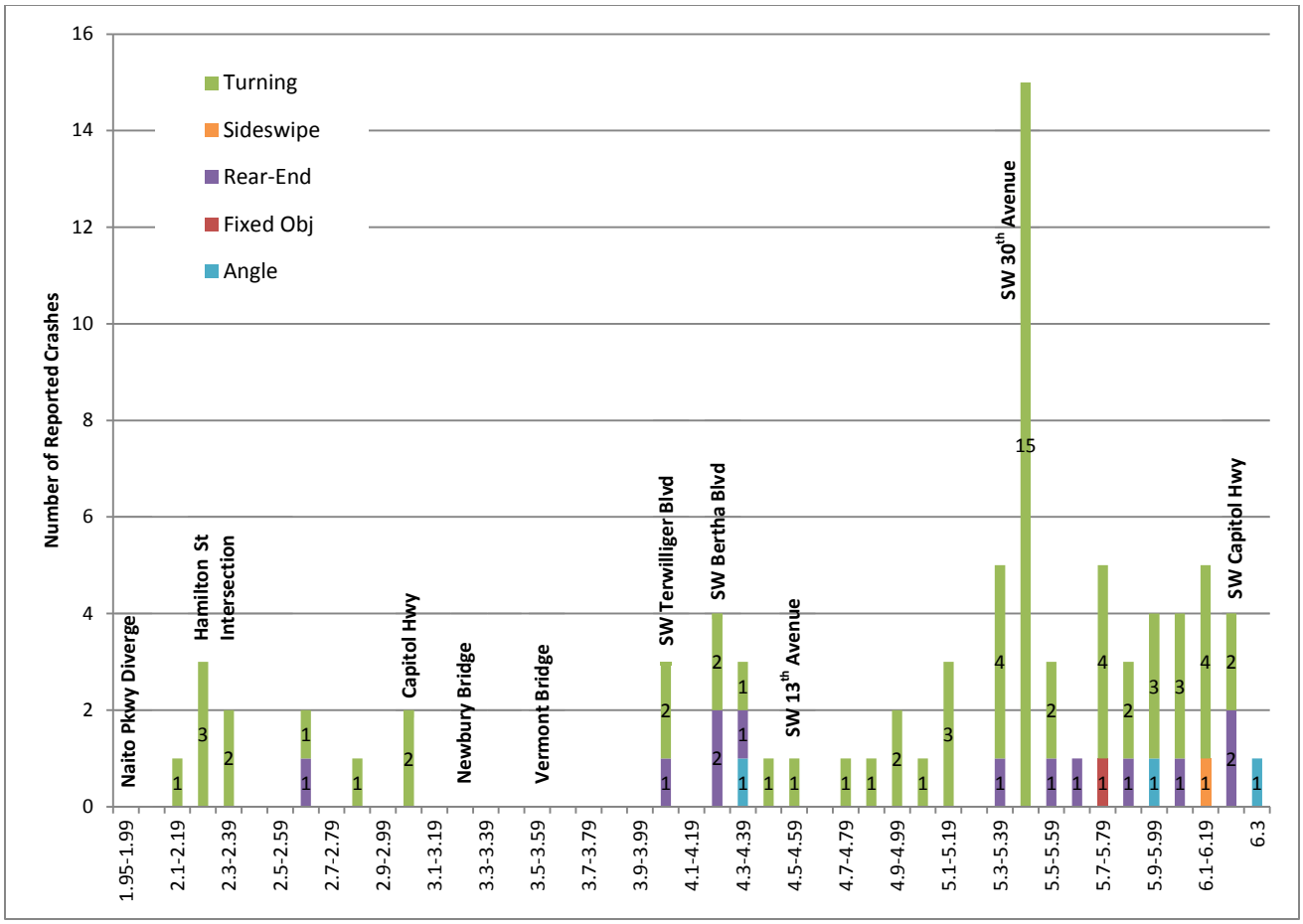

Exhibit 17. Driveway crashes by type and location (Jan 2004 – Sept 2014)

A total of 81 of the 919 reported crashes (10 years) were classified as at a driveway, four of which resulted in incapacitating injuries. Thirteen of the 81 driveway related crashes involved a bicyclist, three of which resulted in incapacitating injuries. The 13 bicycle related crashes represent 38 percent of 34 bicycle related crashes (see "Bicycle Facilities" section).

Multiple wide and often undefined accesses create inconsistencies and conflict zones with bicycle lanes and sidewalks, as shown in Exhibit 18. In many locations driveways are closely spaced or located along right-turn lanes. Lack of access management is also an issue on the side streets, with accesses in close proximity to intersections, particularly signalized intersections.

The fall 2011 *High Crash Corridor Safety Plan for SW Barbur Boulevard* identified Barbur Boulevard as a street with a "high incidence of traffic crashes, injuries, and fatalities" based on data from 2000-2009. The report noted that driveway crashes on Barbur Boulevard are about 50% higher than the citywide average. According to the report, driveway crashes are generally turning or angle crashes.

Exhibit 18. Parking adjacent to roadway at businesses near SW 35th Avenue interrupts sidewalk

Table 2. Qualitative Risk Rating of Access Management

Function	Classification	Reasoning
Exposure	Category III	High number of access locations
Probability	Category III	High number of driveway crashes, especially compared to other similar corridors
Consequence	Category III	Turning crashes: high severity for bicyclists and pedestrians
Overall	*Category III*	-

Near-term suggestions to address access management:

- At select locations, add edge line on outside of bicycle lane next to wide accesses where there is no curb.

Intermediate suggestions to address access management:

- Modify bicycle lane striping and use green paint at high volume driveways.

Long-term suggestions to address access management:

- Consolidate driveways and explore opportunities to address access management through redevelopment.
- Better define driveways (e.g., with extruded curbs or as part of redevelopment constructing a narrower driveway) and provide consistent bicycle lane striping and sidewalks through driveways.

ISSUE: SKEWED INTERSECTIONS/DRIVEWAYS

A number of intersections and driveways along the corridor are skewed, as shown in Exhibit 19. In some cases, this contributes to limited sight distance; wide, fast right-turns; and steep approaches.

Exhibit 19. Skewed intersection of Taylors Ferry Road (left) and at SW View Point Terrace (right)

Table 3. Qualitative Risk Rating of Skewed Intersections/Driveways

Function	Classification	Reasoning
Exposure	Category II	High number of skewed intersections
Probability	Category II	Turning crashes high at skewed
Consequence	Category III	Turning crashes tend to have higher severity
Overall	*Category II*	-

Near-term suggestions to address skewed intersections/driveways:

- Explore opportunities to improve sight distance at intersections/driveways (e.g., maintain vegetation and/or consider removing on-street parking).

Intermediate suggestions to address skewed intersections/driveways:

- Revisit whether right-turn lanes are needed.
- Look for opportunities to slow higher speed right-turners by reducing turning radii.

Long-term suggestions to address skewed intersections/driveways:

- Explore opportunities to realign driveways/side streets to intersect Barbur Boulevard at a desirable perpendicular angle, as well as providing adequate sight distance at unsignalized driveways/intersections.

ISSUE: BICYCLE FACILITIES

While bicycle lanes are provided on the majority of the corridor, there are several segments with no marked bicycle lanes. This condition negatively impacts safety for both drivers and bicyclists. The left image in Exhibit 20 shows no bicycle lanes on the Vermont Bridge and the right image shows a segment with no bicycle facility north of 24th Avenue. Bicyclists conflict with cars in long right-turn lanes and tapers, narrow/pinch points (such as at SW Capitol Highway and SW 19th Avenue), and locations with parking on-street or adjacent to the roadway.

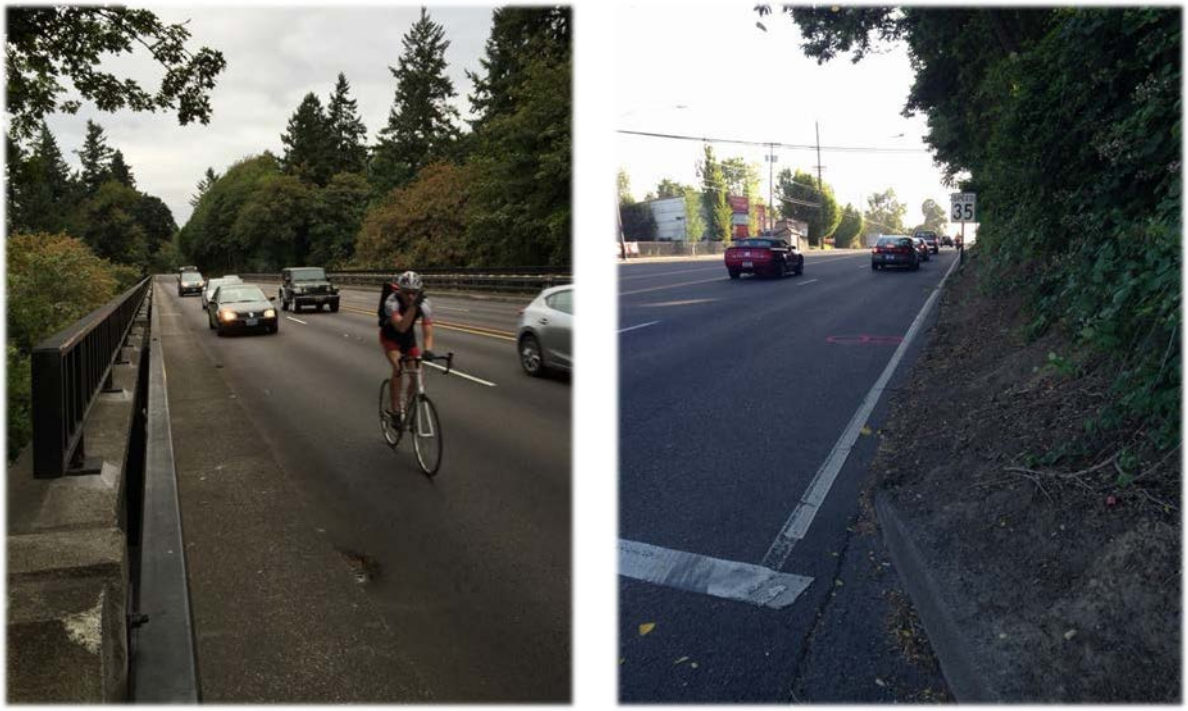

Exhibit 20. Lack of bicycle lane on Newbury and Vermont Bridges (left) and north of SW 24th Avenue (right)

The RSA Team also conducted a risk-based assessment and identified the following locations to address potential safety issues based on risk:

- There are no bicycle lanes on the Newbury, Vermont, and Multnomah, or the segments in the vicinity of SW 24th Avenue intersection.
- As discussed in the "Location Specific" sections, there are segments where bicyclists and right-turning vehicles share the space (no defined bicycle lane).
- Parked cars obscure sight lines, and cars entering/exiting the on-street parking conflict with bicyclists and may result in bicyclists entering the outside travel lane to avoid the conflict.
- There are numerous accesses and the turning movements in/out of these accesses conflict with bicyclists.

There were a total of 34 crashes involving bicyclists reported on the corridor over the last ten years. The majority of the crashes (26 of the 34) cited not yielding the right of way as a contributing cause. Exhibit 21 shows the bicycle related crashes by location. The data indicates two or more reported bicycle crashes at the following locations:

- From Hamilton Street to Naito Parkway diverge (13 crashes – angle and turning movements);
- Near SW Miles Street (two crashes – turning movements);
- SW 26th Avenue (two crashes – turning movement);

- Near SW Barbur Court (three crashes - – turning movements); and
- Vicinity of SW 30th Avenue (three crashes – turning and sideswipe).

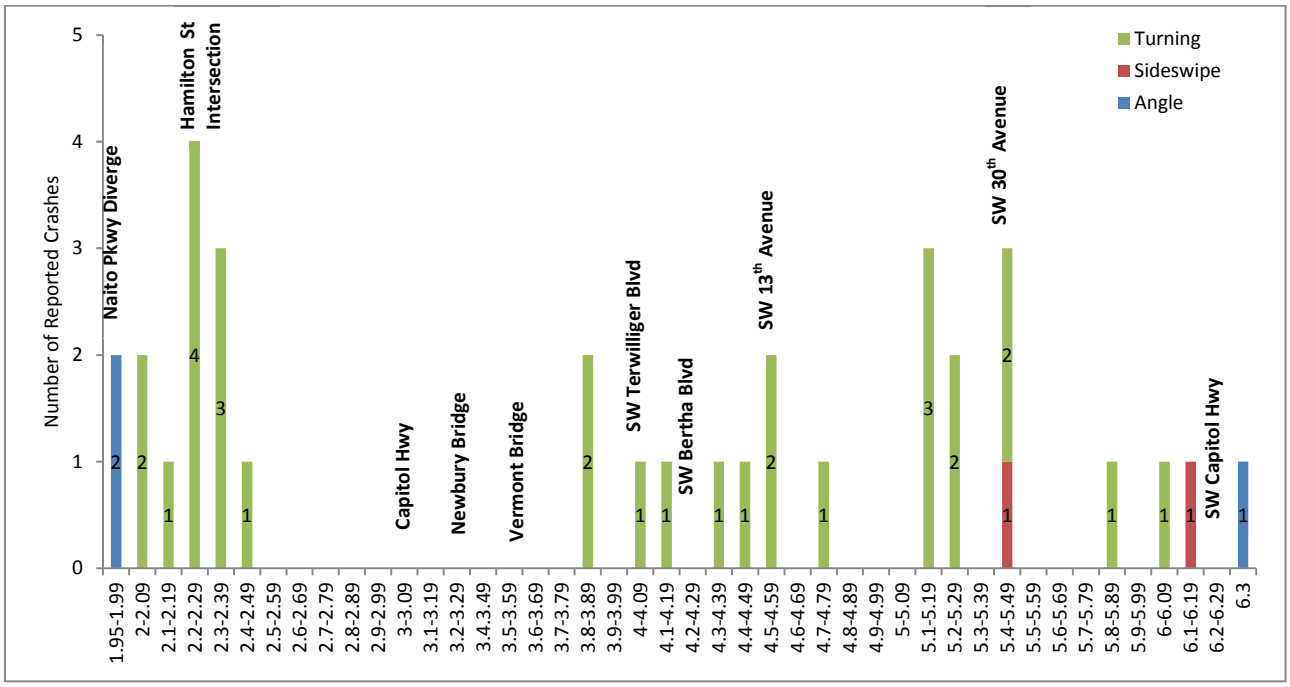

Exhibit 21. Reported crash data for bicyclists by location and type (Jan 2004 – Sept 2014)

Exhibit 22 graphs these crashes by severity and collision type.

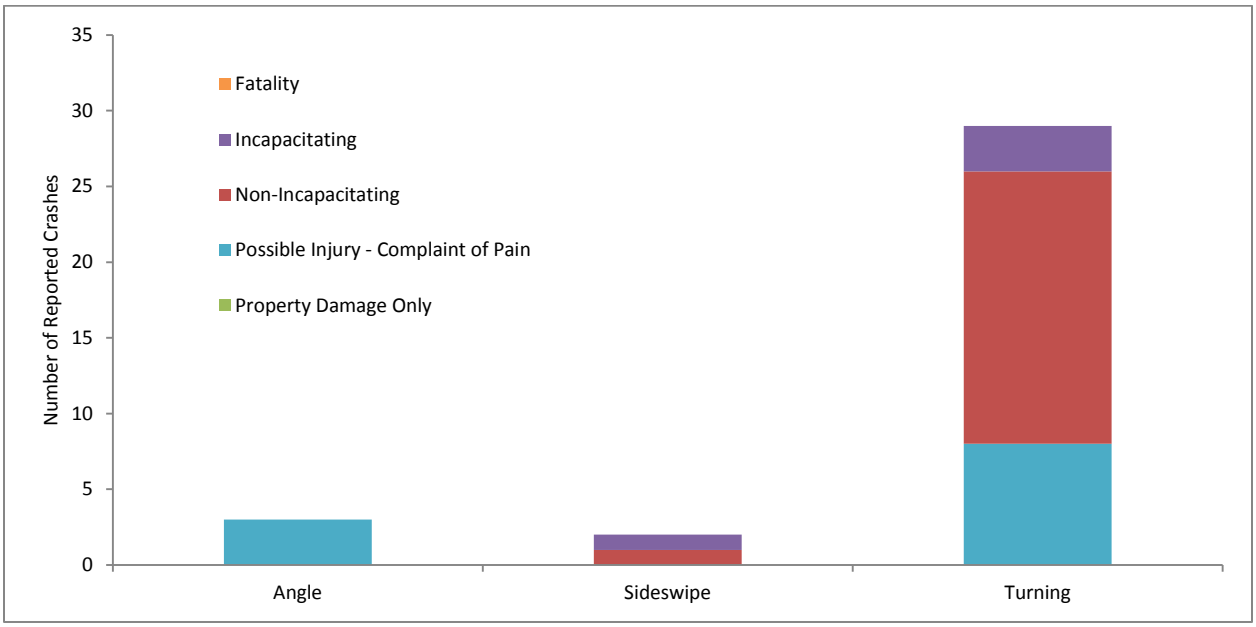

Exhibit 22 . Reported crash data for bicyclists by severity and type (Jan 2004 – Sept 2014)

Table 4. Qualitative Risk Rating of Bicycle Facility Gaps and Deficiencies

Function	Classification	Reasoning
Exposure	Category III	Higher where there are no facilities, parked cars and numerous accesses
Probability	Category III	Crash data reflects 34 bicycle related crashes
Consequence	Category III	Potential for high severity crashes
Overall	*Category III*	-

Near-term suggestions to address bicycle facilities:

- Provide clear direction for drivers and bicyclists through pavement markings at conflict areas, including:
  - At select locations, carrying bicycle lane markings through accesses/driveway areas.
  - Shortening skipped bicycle striping at transition/conflict areas to minimize weaving-section across bicycle lane.

Intermediate suggestions to address bicycle facilities:

- Provide clear direction for drivers and bicyclists through pavement markings at conflict areas, including:
  - Using green pavement marking at intersections and driveways with high volumes of right-turns.
  - Eliminating on-street parking where possible.
  - Extending skipped bicycle striping through wide intersections to guide bicyclists and bring attention to bicycles on the roadway (as seen in Exhibit 23).

Exhibit 23. Non-corridor example green paint through a turn lane and through an intersection (Portland, OR)

- Provide consistent bicycle facilities by:
  - Restriping the roadway to narrow travel lanes where possible (consistent with suggested corridor cross-section, see previous “Speed and Cross-section Inconsistency” section), including buffered bike lane.

Long-term suggestions to address bicycle facilities:

- Create shared pedestrian and bicycle space where width is limited.
- Where there is insufficient roadway width, either widen the highway cross-section or provide alternative location to provide bicycle facilities.

ISSUE: PEDESTRIAN FACILITIES

Sidewalk facilities are relatively limited on the corridor, although several enhanced crossings have been installed. There is a lack of sidewalk connectivity in some areas of high pedestrian demand, such as at the transit center, between shopping centers, and at bus stops. A limited portion of the sidewalk facilities are ADA compliant; some facilities have obstructions in the sidewalk and others lack compliant curb ramps, as shown in Exhibit 24.

Exhibit 24. Lack of pedestrian facilities at Barbur Boulevard and SW 24th Avenue

A RRFB at Alice Street is planned and funded. This will provide another enhanced crossing opportunity. Other planned and funded projects (i.e., 2016 – 2018 STIP and Metropolitan Transportation Improvement Program [MTIP] funding) include pedestrian and bicycle facilities between SW 24th Avenue and SW 19th Avenue, shown in Exhibit 25.

The skewed intersections along Barbur Boulevard lengthen crossing distances at some intersections, such as SW Capitol Highway. In addition, there are relatively long longitudinal distances between enhanced crossings on portions of the corridor, such as:

- 0.37 miles between Transit Center and planned SW Alice Street crossing,
- 0.36 miles between SW 30th Avenue and SW 24th Avenue,
- 0.34 miles between SW Capitol Hill Road and RRFB at SW 13th Avenue, and
- 0.34 miles between SW Hamilton Street and marked crossing on SW Naito Parkway ramp.

TriMet typically suggests bus stops should be spaced be less than a quarter mile. Pedestrian facilities should be provided to connect bus stop locations to surrounding uses, which may require the need for enhanced crossings.

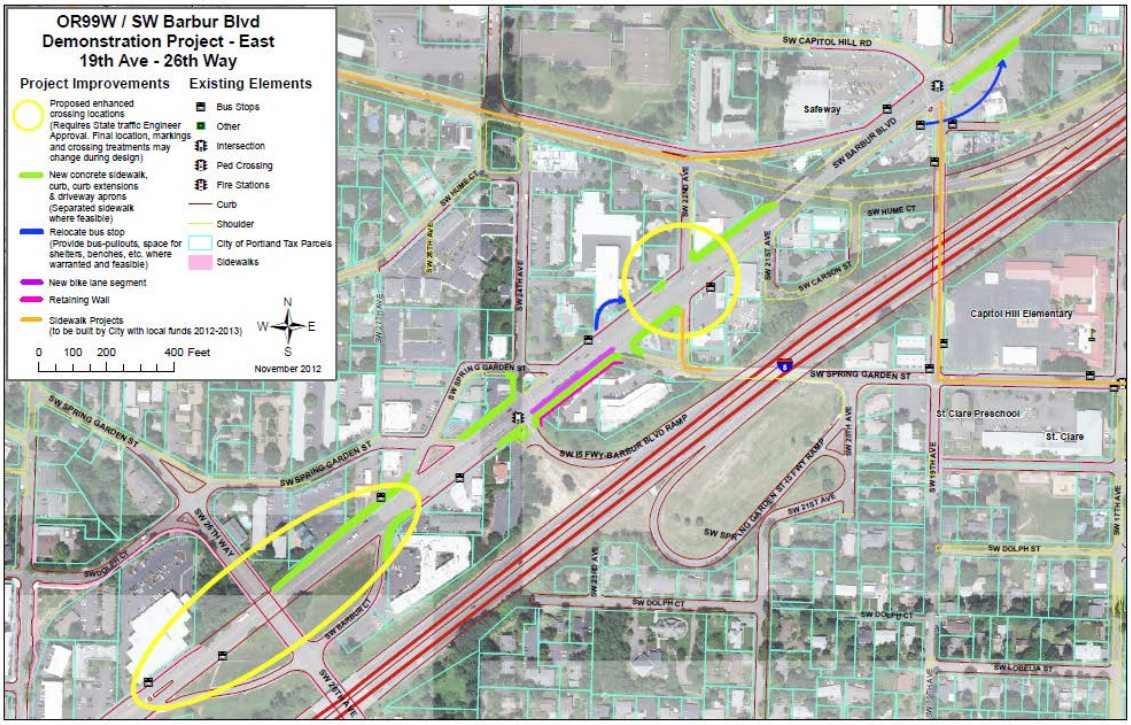

Exhibit 25. OR 99W/SW Barbur Boulevard demonstration project

Twelve pedestrian crashes were reported on the corridor in the ten years of crash data reviewed. One resulted in a fatality, one in an incapacitating injury, five in non-incapacitating injuries, and five in possible injuries. The crashes occurred at or near:

- SW Naito Parkway (three crashes – motorist failed to yield right-of-way),
- SW Hamilton Street (one crash crossing midblock and vehicle speeding),
- SW Terwilliger Boulevard (two crashes – pedestrian ignore traffic signal and motorist failed to yield right-of-way),
- SW 19th Avenue (one crash – pedestrian ignore traffic signal),
- SW 26th Avenue (one crash – crossing midblock),
- SW 30th Avenue (one crash – pedestrian ignore traffic signal), and
- SW Capitol Highway (three crashes – including one fatal; pedestrians ignore traffic signal).

Table 5. Qualitative Risk Rating of Pedestrian Facilities

Function	Classification	Reasoning
Exposure	Category II	High transit/pedestrian use, however several new enhanced crossings
Probability	Category I	Crash data reflects relatively low number of related crashes
Consequence	Category III	Potential for high severity crashes
Overall	*Category II*	-

Near-term suggestions to address pedestrian facilities:

- Look for opportunities for frontage improvements with development, including bicycle lanes and sidewalks.
- Upgrade striping at crossings with double-white no passing markings (in place of dashed lane line striping) leading up to midblock crossings.

Intermediate suggestions to address pedestrian facilities:

- Consider additional opportunities for enhanced crossings to provide crossings at regular intervals along the corridor.
- Provide concrete sidewalks across driveways.
- Narrow travel lanes to provide room for pedestrian facilities where topography is limiting (e.g. south of Alice Street, see later "Barbur Boulevard Segment: SW Taylors Ferry Road to SW 30th Avenue" section).

Long-term suggestions to address pedestrian facilities:

- Prioritize the sections of sidewalk that are needed to fill critical gaps.
- Include updating sidewalks and curb ramps to ADA standards with programmed projects.

ISSUE: LIGHTING NEEDS

While overall lighting on the corridor is consistent (uniform) and updated [from High Pressure Sodium (HPS) to Light Emitting Diodes (LED)], lighting is not updated on some portions of the corridor. There are some intersections that appear dark, such as Barbur Boulevard/SW Capitol Highway, Barbur Boulevard/SW Bertha Boulevard approach, and the curve near SW Hamilton Street. Exhibit 26 shows tree canopies obstructing roadway lighting along the inside of the curve immediately south of the Hamilton Street intersection. The RSA Team also noticed existing street lights that were not functional, which the team communicated to maintenance staff. The bridges appear dark as there is no lighting or edge striping. Exhibit 27 graphs the crashes by severity and lighting conditions. As seen in the graph, eight of the ten fatalities occurred during dark with light conditions, as did five of the 18 incapacitating injury crashes. Three of the bicycle crashes and six of the pedestrian crashes occurred during dark with light conditions.

Exhibit 26. View from corridor at night south of Hamilton Street

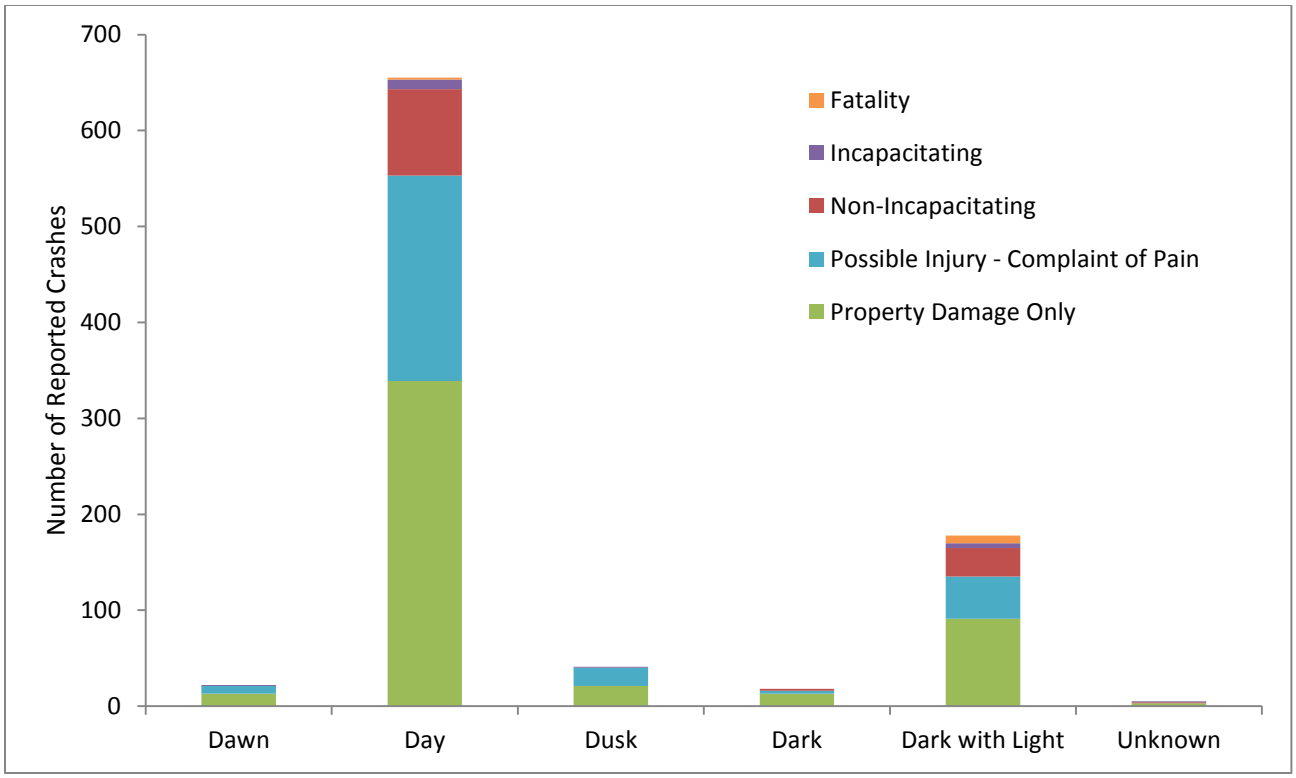

Exhibit 27. Reported crash data by severity and lighting conditions (Jan 2004 – Sept 2014)

Table 6. Qualitative Risk Rating of Lighting

Function	Classification	Reasoning
Exposure	Category I	Lower volume of vehicles at night
Probability	Category II	High number of fatal crashes at night
Consequence	Category III	Nighttime crashes had higher severity crashes; these also had speed and alcohol indicated
Overall	*Category II*	-

Near-term suggestions to improve lighting:

- Maintain tree canopies in the vicinity of street light poles to provide desired light levels.

Intermediate suggestions to improve lighting:

- Continue installing consistent LED lighting along the corridor where old HPS lighting still exists, consistent with ongoing efforts by PBOT.
- Evaluate lighting at intersections and enhanced crossings along the corridor and provide improved lighting where needed. The intent is to light crossing locations from the front to illuminate pedestrians for approaching vehicles.

ISSUE: INCONSISTENT SIGNAGE AND STRIPING

The RSA Team observed some signs blocked by vegetation and noted street name signs are difficult to see, particularly in the dark. The team also noted that wayfinding signage along the corridor is confusing in places, particularly to I-5. For example, the wayfinding signs for southbound vehicles on Barbur Boulevard are also visible from the Capitol Highway approach, as shown in Exhibit 28. Delineation to define spaces and conflict areas is missing, particularly in sections with numerous wide accesses.

Exhibit 28. Signage at Barbur Boulevard/Capitol Highway

Table 7. Qualitative Risk Rating of Inconsistent Signage and Striping

Function	Classification	Reasoning
Exposure	Category I	Primarily applies to those unfamiliar with the corridor
Probability	Category II	Not historically reported as a crash cause, but may contribute to crashes
Consequence	Category I	Typically lower severity side-swipe and rear-end crashes due to last minute lane changes
Overall	*Category I*	-

Near-term suggestions to address inconsistent signage and striping:

- Clear and maintain vegetation along the corridor.
- Reevaluate wayfinding signage and find opportunities to clarify signage.
- Relocate and replace signage as appropriate.
- Consider advance intersection signage ("Next Signal" signs) for better wayfinding.

Intermediate suggestions to address inconsistent signage and striping:

- Use consistent pavement markings along the corridor, especially through driveways and conflict areas (green paint, bike lane extensions and shortening dashed bike lanes in transition areas).

Intermediate to long-term suggestions to address inconsistent signage and striping:

- Considering overhead signage to increase visibility.

ISSUE: PAVEMENT QUALITY IN BICYCLE LANES

The RSA Team noted locations where the pavement quality is poor or the pavement seam is in the bicycle lane. This creates an uncomfortable ride for bicyclists and may increase the risk of bicyclists being redirected unexpectedly. In addition, some grate inlets in the bicycle lane are uneven as a result of past overlay projects.

Exhibit 29. Grate in bicycle lane and pavement quality

Table 8. Qualitative Risk Rating of Pavement Quality in Bicycle Lanes

Function	Classification	Reasoning
Exposure	Category I	Few locations along corridor
Probability	Category I	Not historically reported as a crash cause
Consequence	Category I	Relatively low risk
Overall	*Category I*	-

Near-term suggestions to address pavement quality in bicycle lanes:

- Provide and maintain clear, smooth bicycle facilities.
- Level-grate inlets by removing any abrupt vertical elevation between pavement and inlet, as appropriate.

Intermediate to long-term suggestions to address pavement quality in bicycle lanes:

- Consider bicycle lane conditions and opportunities for improvement during overlay and construction.
    - The RSA Team is aware that any pavement preservation project up to the curb may trigger ADA improvements. The team suggests that when there is any improvement, the project should consider addressing uneven bicycle lane conditions without changing the scope of the specific project.

Long-term suggestions to address pavement quality in bicycle lanes:

- Relocate pavement seam and align with bicycle lane or auto lane lines to avoid seam in bicycle lane.

Intersection and Roadway Segment Specific Issues

Each intersection and segment of the corridor has unique characteristics and issues that the team developed specific suggestions for in addition to the system-wide suggestions. The corridor is broken in to the following intersections and segments:

- Barbur Boulevard/SW Capitol Highway Intersection Configuration
- Barbur Boulevard/SW Taylors Ferry Road Area
- Barbur Boulevard segment: SW Taylors Ferry Road to SW 30th Avenue
- Barbur Boulevard/SW 30th Avenue Intersection
- Barbur Boulevard segment: SW 30th Avenue to SW 24th Avenue
- Barbur Boulevard/SW 24th Avenue Intersection
- Barbur Boulevard segment: SW 24th Avenue to Multnomah Crossing
- Barbur Boulevard/SW Capitol Hill Road Intersection
- Barbur Boulevard segment: SW Capitol Hill Rd to SW 13th Street
- Barbur Boulevard segment: SW 13th Street to SW Bertha Boulevard
- Barbur Boulevard/SW Bertha Boulevard Intersection
- Barbur Boulevard segment: SW Bertha Boulevard to SW Terwilliger Boulevard
- Barbur Boulevard/SW Terwilliger Boulevard Intersection
- Barbur Boulevard/SW Miles Street Intersection
- Barbur Boulevard segment: Horizontal Curve North of SW Miles Street
- Barbur Boulevard segment: Wooded Section to SW Hamilton Street (Bridges)
- Barbur Boulevard/SW Hamilton Street Intersection
- Barbur Boulevard segment: SW Hamilton Street to SW Naito Parkway
- Barbur Boulevard/SW Naito Parkway Diverge

BARBUR BOULEVARD/SW CAPITOL HIGHWAY INTERSECTION

The Barbur Boulevard/SW Capitol Highway intersection is a five-legged, skewed intersection on the southern end of the corridor. Exhibit 30 highlights key characteristics of this intersection configuration that are summarized below:

- Skewed intersection angle between Barbur Boulevard and SW Capitol Highway.
- SW Huber Street and SW Taylors Ferry Road jughandles accommodate left-turns from Barbur Boulevard and SW Capitol Highway. The existing signage does not clearly define the desired travel paths for these left-turns through the jughandle configurations.
- Southbound I-5 off-ramp is located on a lower road hierarchy (SW Taylors Ferry Road) compared to Barbur Boulevard and SW Capitol Highway.
- Northbound I-5 on-ramp is located on a lower road hierarchy (SW Huber Street) compared to Barbur Boulevard and SW Capitol Highway.
- The intersection is complex due to the skewed alignment and the I-5 southbound on-ramp, as seen in Exhibit 31.

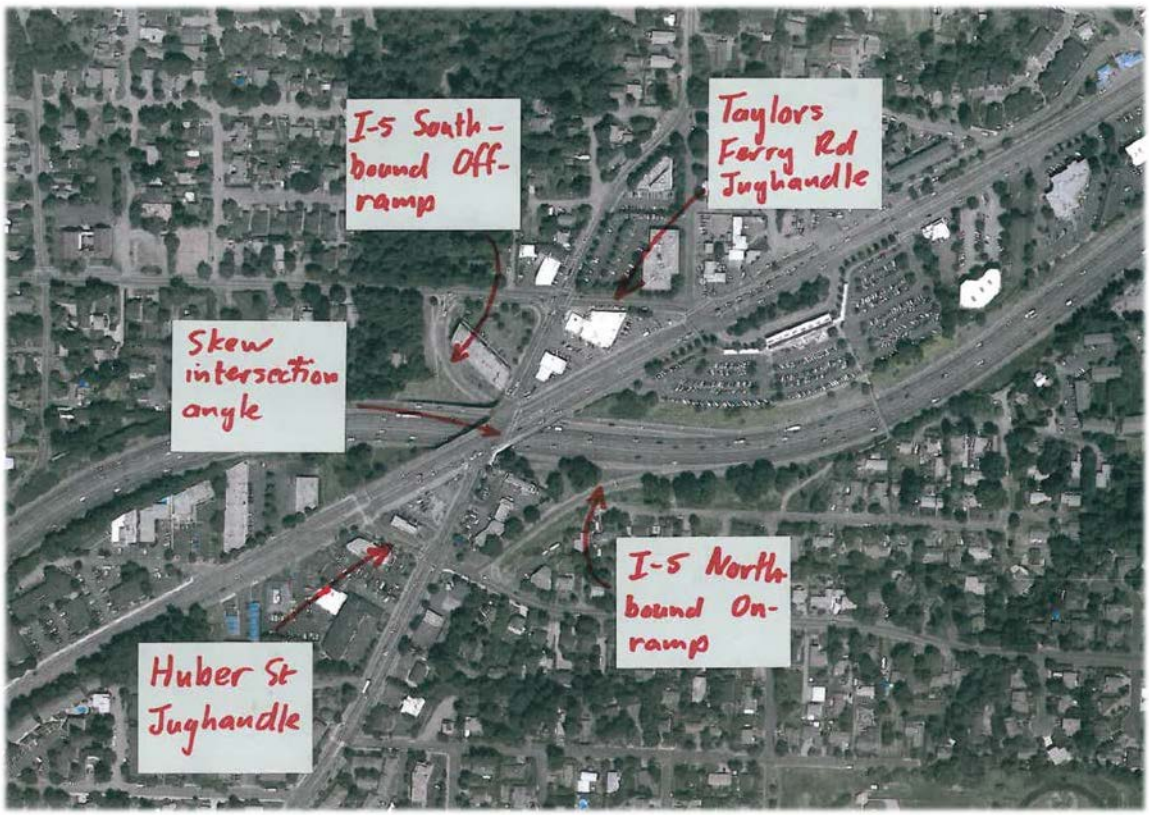

Exhibit 30. Existing intersection configuration and key characteristics of Barbur Boulevard/SW Capitol Highway

Exhibit 31. Northbound left-turning vehicles waiting for a gap at Barbur Boulevard/SW Capitol Highway

Issues observed by the RSA Team at the intersection include:

- High volume of vehicles on all approaches at this intersection.
- Northbound left-turners to I-5 south observed making their turn on red due to a lack of gaps during their permissive green.
- Bus-only left-turn on southbound approach not highly utilized by buses (2 counted during the weekday PM peak hour). Other vehicles were observed entering the lane and either moving back over in to the through lane or turning left with the bus.
- Access/driveway points on the southbound approach are wide and not well defined.
- There is a lack of guide signage to direct users to jughandles and the required out of direction travel.
- The pedestrian crossing across the north leg of Barbur Boulevard is long (approximately 120 feet), which impacts signal timing.
- The southbound bicycle lane is 4.5 feet wide and sandwiched between the through and right-turn lanes, as shown in Exhibit 32. The southbound right-turn lane to SW Capitol Highway/I-5 Southbound on-ramp is long and transitions across the bicycle lane. Vehicles regularly merge across the bicycle lane at multiple locations along its length.

Exhibit 32. Southbound approach at Barbur Boulevard/SW Capitol Highway

Crash data from the last five years is mapped in the crash diagram provided in Exhibit 33. ***For orientation, Barbur Boulevard is oriented north-south and SW Capitol Highway as east-west.*** Ninety three crashes were reported during this time period. The crashes (MP 6.19 to MP 6.23) were grouped as follow:

- Primarily rear-end crashes along all approaches, with the majority along the southbound approach of Barbur Boulevard.
- 16 angle crashes, including:
    - Six northbound Barbur Boulevard with westbound Capitol Highway (acute angle),
    - Four northbound Barbur Boulevard with eastbound Capitol Highway (flat angle),
    - Three southbound Barbur Boulevard with eastbound Capitol Highway (acute angle), and
    - Three southbound Barbur Boulevard with westbound Capitol Highway (flat angle).
- Nine turning crashes, mostly westbound and eastbound right-turn from Capitol Highway (flat angle).
- 12 sideswipe crashes, with the majority in the southbound direction along Barbur Boulevard.
- Other collision types including backing, three pedestrian, and eight fixed object. Five driveway related crashes were reported along southbound approach.
- 23 of the crashes disregarded the traffic signal that mostly resulted in angle crashes. 10 of these resulted in injury crashes which included two illegal left-turns.
- 31 total injury crashes were reported.

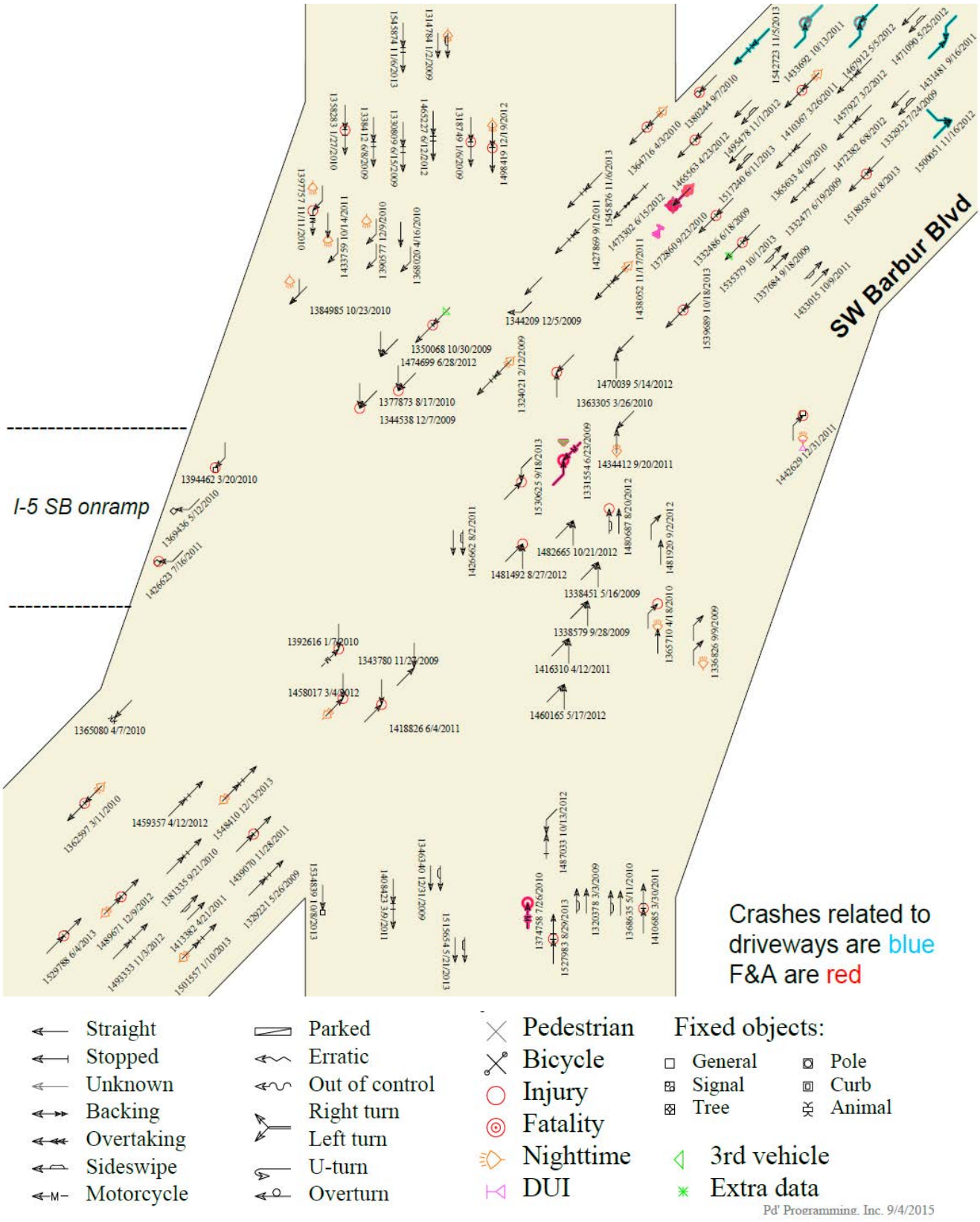

Exhibit 33. Crash diagram for Barbur Boulevard/SW Capitol Highway (2009-2013)

Table 9. Qualitative Risk Rating of Barbur Boulevard/SW Capital Highway Intersection

Function	Classification	Reasoning
Exposure	Category III	Jug handle configurations reduce conflicts at main intersection, but increase conflicts at multiple other intersections
Probability	Category III	Intersection with the highest number of reported crashes in the study corridor
Consequence	Category II	Long crossing distances, long bicycle lanes between through and right-turn lanes. 31 injury crashes reported in last five years of crash data available.
Overall	*Category III*	-

Near-term suggestions to improve Barbur Boulevard/SW Capitol Highway:

- Install retro-reflective backplates and supplemental signal heads to address "disregarded traffic signal" related crashes.
- Revisit signal head orientation and/or installing programmable signal heads to address acute angle related crashes.
- Provide clear directional signage for SW Huber Street and SW Taylors Ferry Road jughandles, directing vehicles to continue through the intersection and make a downstream left (since left-turns are not allowed at the intersection) (See Exhibit 34). This suggestion needs to be analyzed to understand the potential impacts on the key intersections within the jughandle configurations.

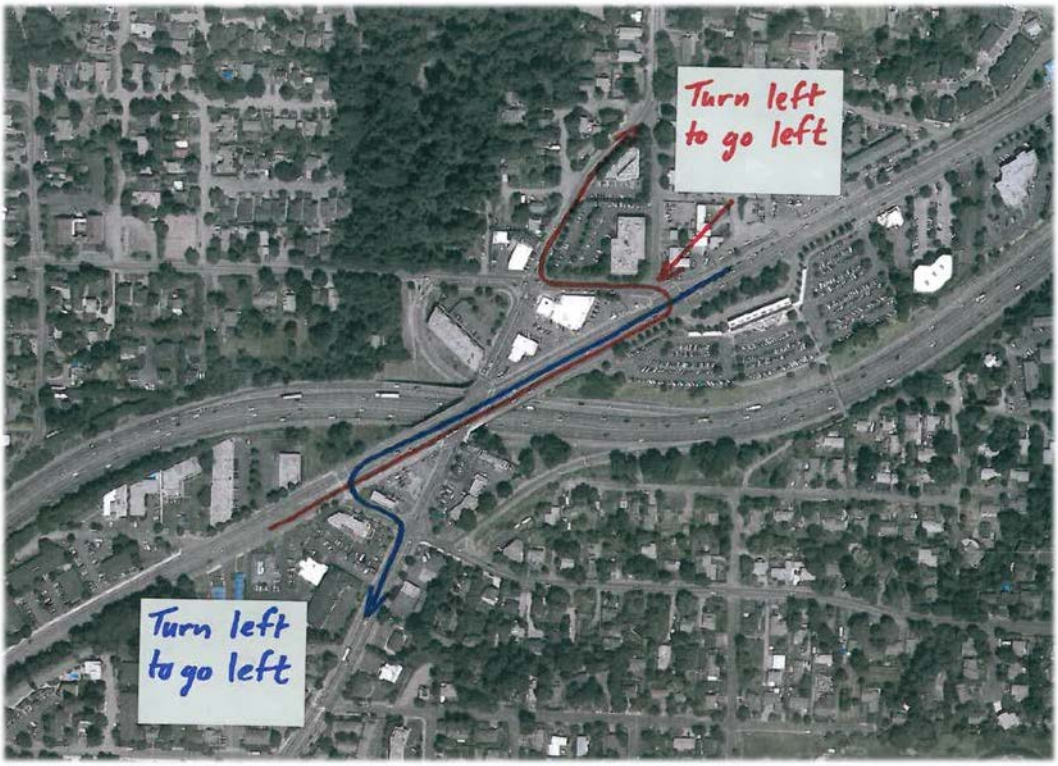

Exhibit 34. Suggested paths for left-turns off Barbur Boulevard through jughandles

Intermediate suggestions to improve Barbur Boulevard/SW Capitol Highway:

- Better define accesses (e.g., narrowing driveways) in the southbound Barbur Boulevard right-turn lane to minimize conflict areas with bicyclists and vehicles.
- Narrow the travel lanes and provide a wider bicycle lane with buffer (4.5 feet currently between through and right turn lanes over a length of approximately 540 feet) – consistent with suggested corridor cross-section.
- Add green pavement markings at bicycle/vehicle conflict points, such as the southbound bicycle lane at Barbur Foods.
- Explore removing the southbound bus-only left-turn lane to minimize driver confusion and provide additional width for bicycle and pedestrian facilities.
- Remove northbound right-turn lane at Huber (Exhibit 35 left image) and provide bicycle lane, as well as better define shared northbound bus/bicycle lane at SW Capitol Highway intersection (Exhibit 35 right image).

Exhibit 35. Right-turn to SW Huber St (left), shared northbound bus and bicycle lane (left)

- Consider restriping opportunities along Capitol Highway to potentially add bicycle lanes:
    - Eastbound approach (Capitol Highway – south leg on exhibit) towards Barbur Boulevard:
        - Right: serving rights to I-5 southbound on-ramp, as well as onto Barbur Boulevard
        - Through: continuing through on SW Capitol Highway
    - Westbound approach (Capitol Highway – north leg on exhibit) towards Barbur Boulevard:
        - Right: serving rights onto Barbur Boulevard
        - Through: continuing through on SW Capitol Highway

Long-term suggestions to improve Barbur Boulevard/SW Capitol Highway:

- Remove all left-turns at main intersection, as shown in Exhibit 36.

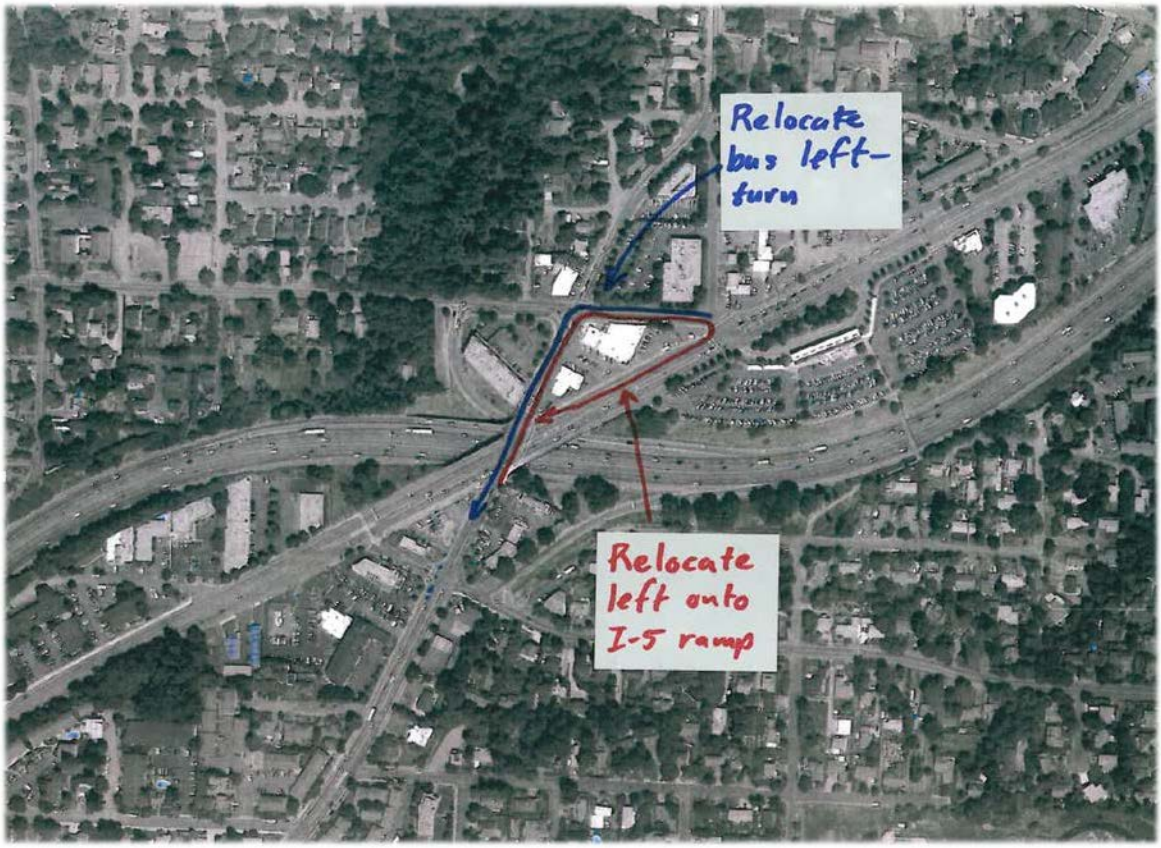

Exhibit 36. Relocate existing lefts

- Improve the existing SW Taylors Ferry Road/SW Capitol Highway intersection with a signal or single-lane roundabout, maintaining a channelized eastbound right-turn.
- Consider options for better traffic control and improve the jughandles to provide separation of turning movements, such as:
    - Relocate I-5 southbound on-ramp to the existing I-5 southbound off-ramp/Taylors Ferry Road intersection (see Exhibit 37),
    - Develop two offset T-intersections of Capitol Highway with Barbur Boulevard (see Exhibit 38), or
    - Develop two offset T-intersections of Capitol Highway (east) and Taylors Ferry Road (west) with Barbur Boulevard (see Exhibit 39).
- Consider an intersection/interchange preliminary design study to identify future needs at this location and identify property impacts.

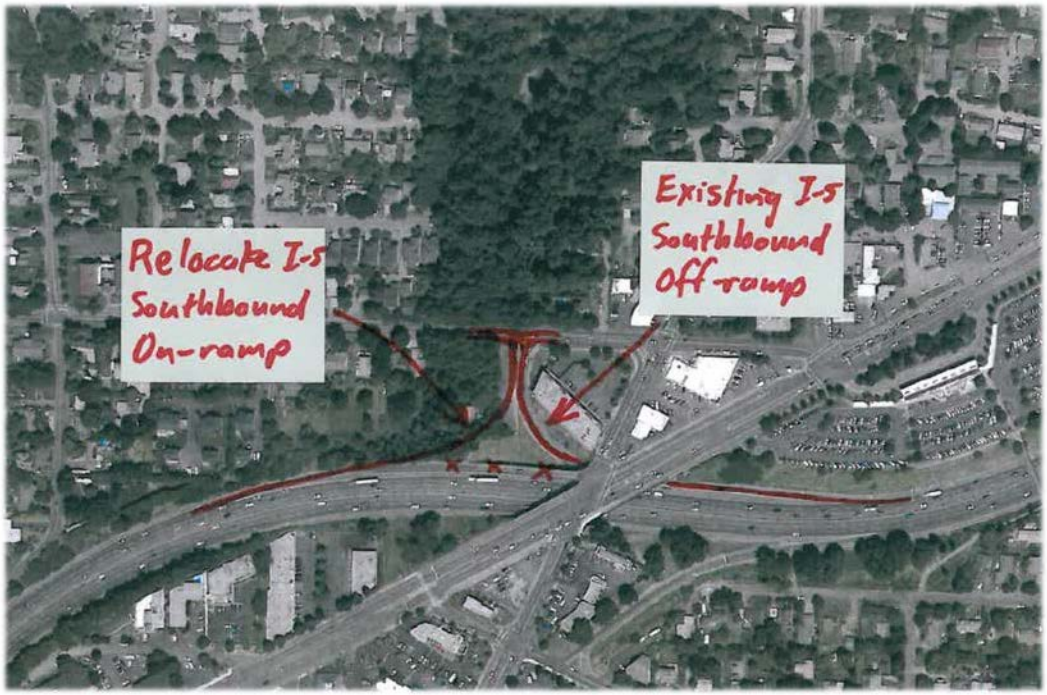

Exhibit 37. Relocate I-5 Southbound On-Ramp

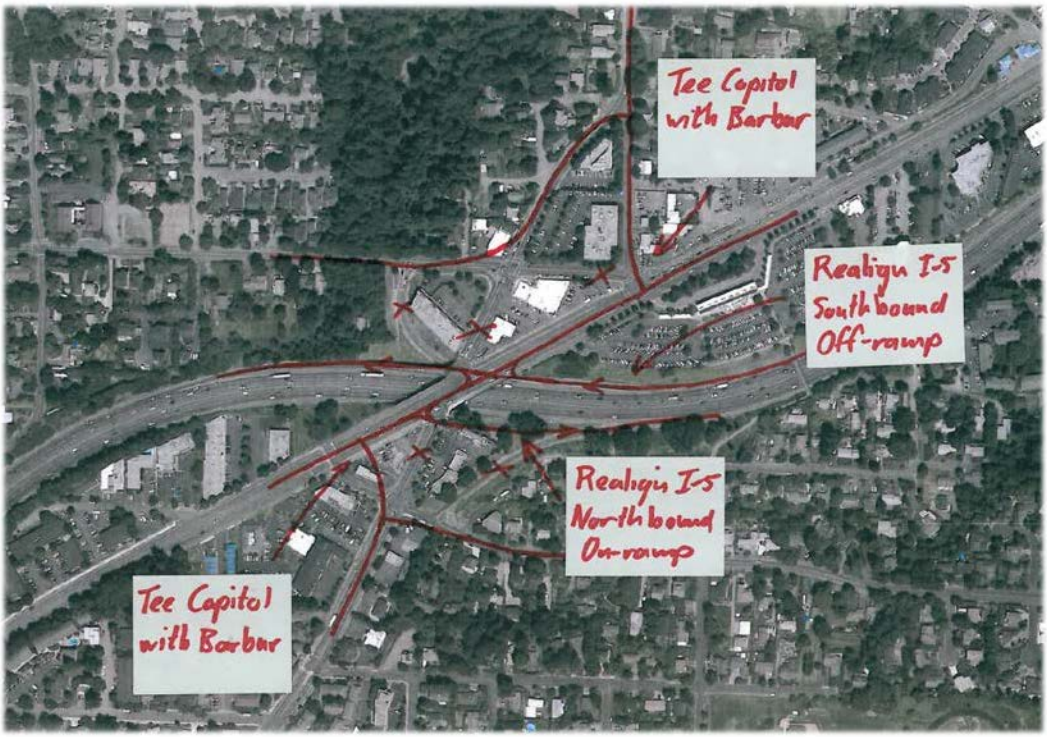

Exhibit 38. Offset T-intersections of Capitol Hwy with Barbur Boulevard

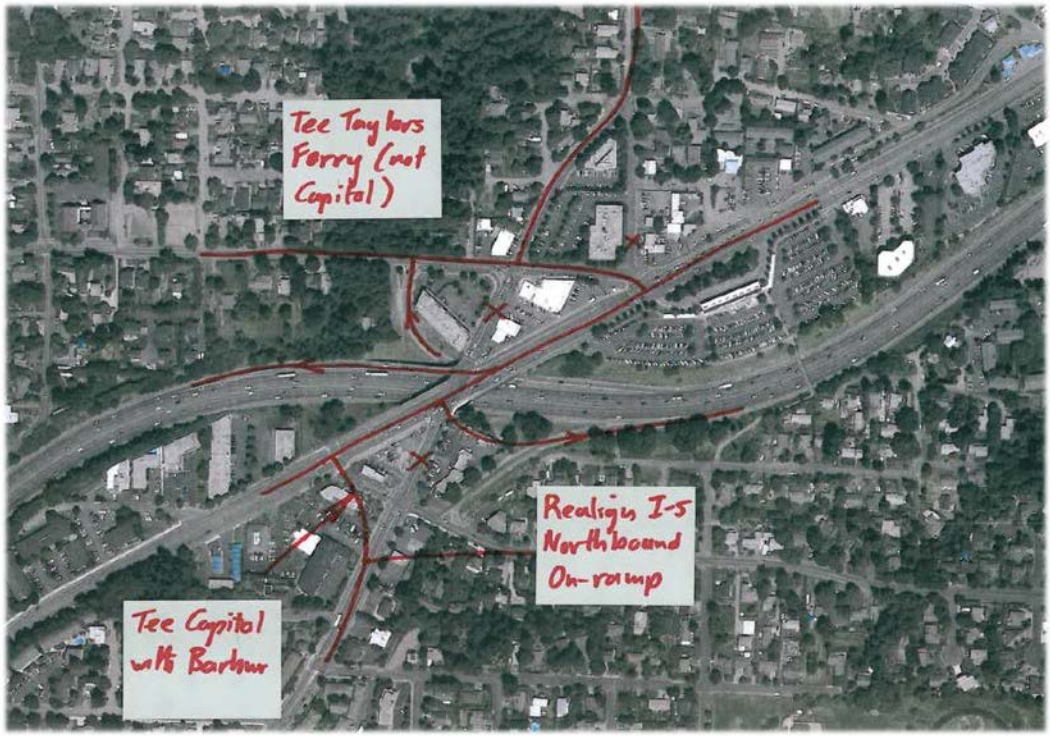

Exhibit 39. Offset T-intersections of Capitol Hwy (east) and Taylors Ferry Rd (west) with Barbur Boulevard

BARBUR BOULEVARD SEGMENT: SW TAYLORS FERRY ROAD AREA

SW Taylors Ferry Road intersects SW Barbur Boulevard at a traffic signal shared with SW 41st Avenue and farther north at a two-way stop-controlled intersection near SW Baird Street. The signalized intersection was recently improved with a curb extension (Exhibit 40), providing enhanced pedestrian facilities and tightening the radius for northbound right-turns.

Exhibit 40. Recent curb extension at SW 41st Avenue/SW Taylors Ferry Road

Issues observed by the RSA Team at and between the SW Taylors Ferry Road intersections include:

- ADA issues along the sidewalks and at crossings, such as the crossing of the southern transit center access.
- Poor pedestrian connectivity.
- Skewed angle of both SW Taylors Ferry Road intersections.
- On-street parking on the east side of Barbur Boulevard and parking on the west side of Barbur Boulevard that backs out into the roadway.

Exhibit 41. Southern entrance to transit center lacks a pedestrian crossing (left), end of sidewalk on west side of Barbur Boulevard across from northern entrance to transit center (center), and pole in middle of sidewalk on east side of Barbur Boulevard (right)

Crash data (MP 5.78 to 6.20) from the last ten years from this segment, including SW Taylors Ferry Road (SW 41st Avenue) and SW Taylors Ferry Road (at Baird Street), is summarized below:

- 86 crashes along this road segment including four angle, 22 turning, 53 rear-end related, five sideswipe overtaking, one fixed object, and one head-on collision types.
- About a third of the crashes occurred at the traffic signal (SW Taylors Ferry Road [SW 41st Avenue]).
- Of the 22 turning crashes, nine disregarded the traffic signal and the rest failed to yield right-of-way. The majority of the crashes were related to left-turns, especially from the side-streets.
- The majority of the rear-end crashes were associated with following too closely and inattention.
- 42 of the 86 crashes resulted in injuries.
- Three crashes involved bicyclists; two were classified as turning crashes and one as a sideswipe overtaking collision type.

Table 10. Qualitative Risk Rating of Area between Barbur Boulevard/SW Taylors Ferry Road Intersections

Function	Classification	Reasoning
Exposure	Category I	High number of multimodal users (transit center)
Probability	Category I	Mostly rear-end crashes
Consequence	Category III	High number of pedestrian and bicycles accessing transit center
Overall	*Category I*	-

Near-term suggestions to improve segment of Barbur Boulevard between two intersections of SW Taylors Ferry Road:

- Install wayfinding signage to direct pedestrians through the transit center.
- Add a defined pedestrian crossing across the southern entrance to the transit center.

Intermediate to long-term suggestions to improve segment of Barbur Boulevard between two intersections of SW Taylors Ferry Road:

- Where there are gaps, infill sidewalk and perform ADA upgrades.
- Remove on-street parking to provide space for sidewalks and/or buffered bicycle lanes to enhance route continuity for pedestrians and bicyclists.

BARBUR BOULEVARD SEGMENT: SW TAYLORS FERRY ROAD TO SW 30TH AVENUE

A RRFB is designed for the SW Alice Street intersection to provide an enhanced pedestrian crossing. Plans for the RRFB are illustrated in Exhibit 42.

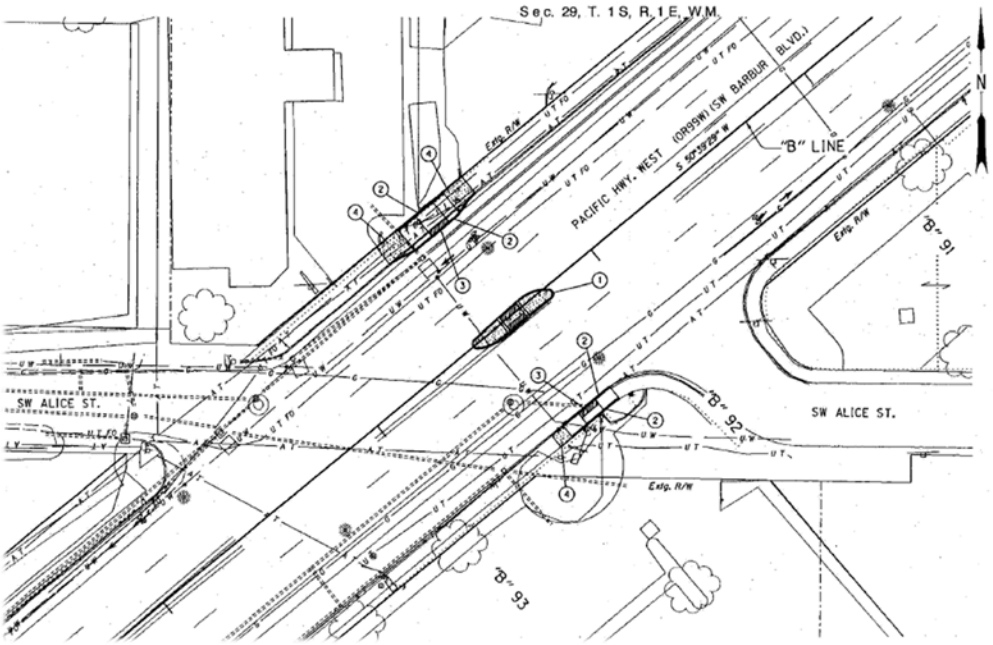

Exhibit 42. Plans for RRFB at intersection of SW Alice Street

Crash data (MP 5.42 to 5.78) from the last ten years between the intersections of SW Taylors Ferry Road (at Baird Street) and SW 30th Avenue is summarized below:

- 24 crashes along this road segment (less than three per year) including two angle, nine turning, and 13 rear-end related collision types.
- Seven driveway related crashes.
- 13 of the report crashes involved injuries.
- No reported bicycle or pedestrian crashes.

Issues observed by the RSA Team at and between the SW Taylors Ferry Road and SW 30th Avenue intersections include:

- Pedestrian connectivity, especially along the west side between SW Taylors Ferry Road (near SW Baird Street) and SW Alice Street.
- On-street parking limits sight distance from accesses and side-streets.
- Limited sight distance at SW Alice Street due to skewed angle of the roadway and topography.
- ADA issues, particularly with sidewalk obstruction, and a lack of pedestrian connectivity.

Exhibit 43. No sidewalk on southbound Barbur Boulevard approaching SW 35th Avenue (left) and no sidewalk through accesses on east side of Barbur (right)

Table 11. Qualitative Risk Rating of Barbur Boulevard Segment: SW Taylors Ferry Road to SW 30th Avenue

Function	Classification	Reasoning
Exposure	Category II	Lack of sidewalk connectivity
Probability	Category I	Relatively few crashes
Consequence	Category II	Pedestrians need to cross Barbur Boulevard or walk along roadway
Overall	*Category I*	-

Intermediate to long-term suggestions to improve Barbur Boulevard between SW Taylors Ferry Road and SW 30th Avenue:

- Shift alignment to the east by removing parking and add sidewalk and a buffered bicycle lane on the west side of the roadway – consistent with suggested corridor cross-section. This also provides better sight distance for drivers on SW Alice Street. A conceptual sketch for this improvement is provided in Exhibit 44.

Exhibit 44. Sketch for alignment change concept with parking removal

BARBUR BOULEVARD/SW 30TH AVENUE INTERSECTION

All four corners of the Barbur Boulevard/SW 30th Avenue intersection are developed, with multiple access points near the intersection. The accesses interrupt sidewalks, which introduce additional potential conflict points between pedestrians and vehicles (see Exhibit 45 and Exhibit 46). On-street parking on SW Barbur Boulevard limits sight-distance for vehicles exiting accesses in the vicinity of the intersection. Crash data from the last five years at the SW 30th Avenue intersection is shown in the crash diagram in Exhibit 47 and summarized below.

- Total of 27 crashes at this intersection, including 11 driveway related crashes (away from the intersection).
- 10 of the 27 crashes resulted in injury crashes, including one bicycle.

Exhibit 45. Northbound approach to Barbur Boulevard/SW 30th Avenue

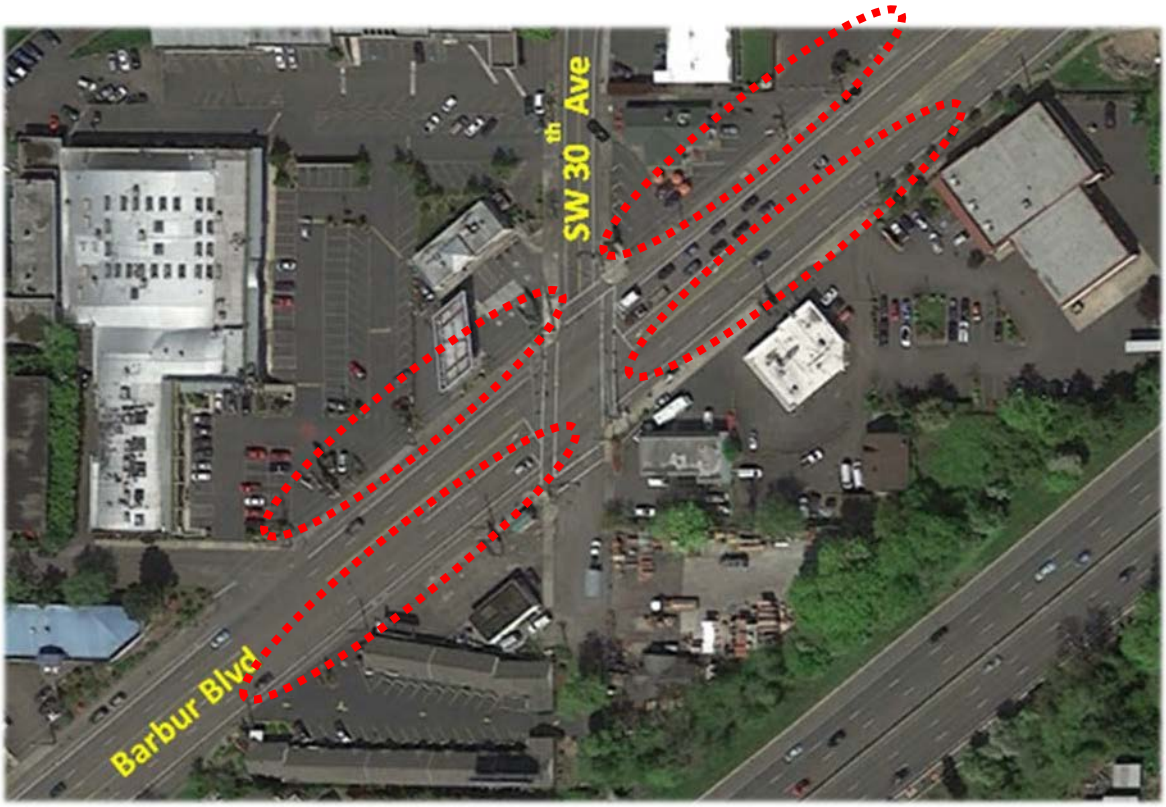

Exhibit 46. Driveways near the Barbur Boulevard/SW 30th Avenue intersection (Google Earth)

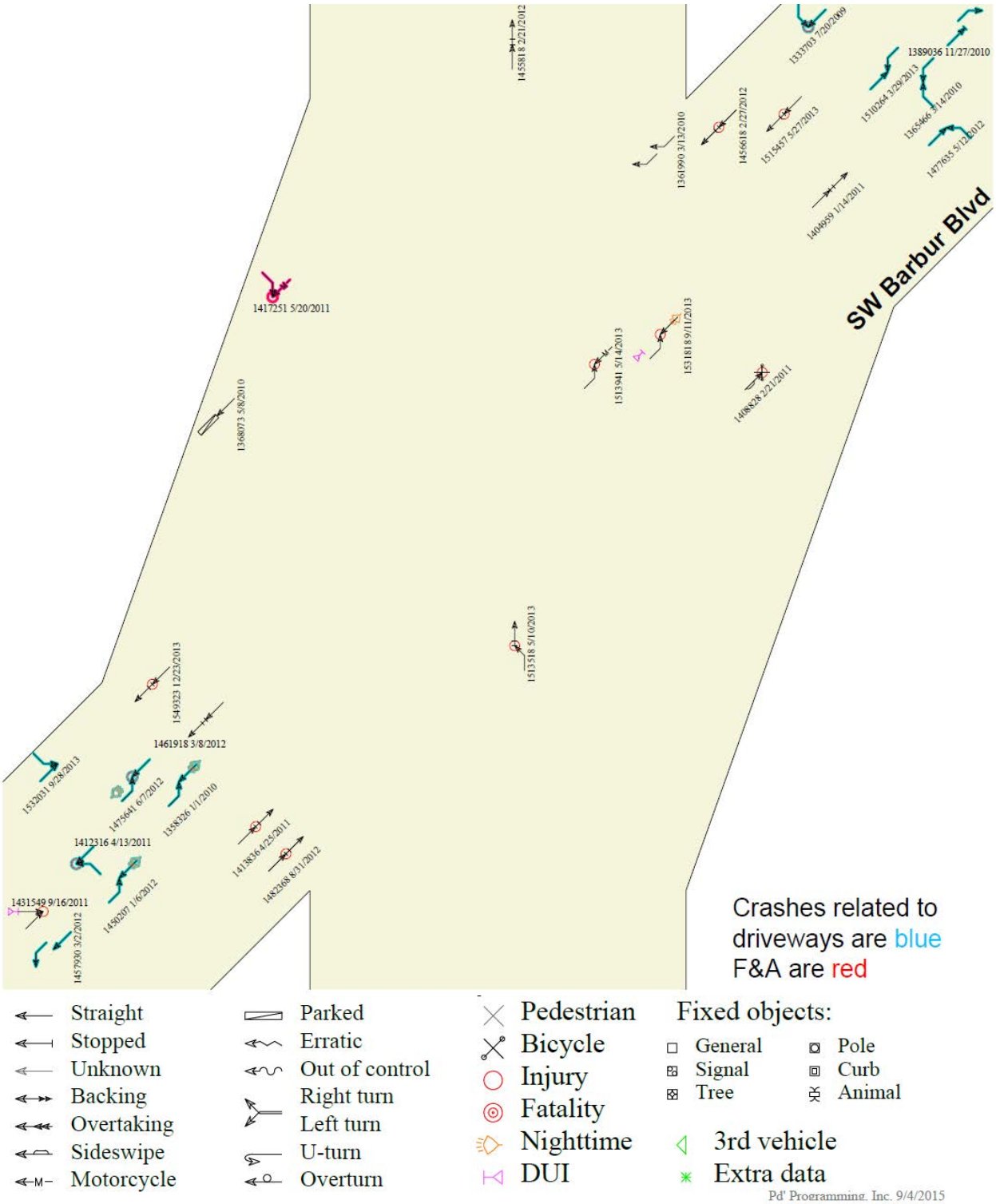

Exhibit 47. Crash diagram for Barbur Boulevard/SW 30th Avenue (2009-2013)

Table 12. Qualitative Risk Rating of Barbur Boulevard/SW 30th Avenue Intersection

Function	Classification	Reasoning
Exposure	Category II	High number of driveways
Probability	Category II	High number of driveway related crashes
Consequence	Category III	Driveway vehicle crashes have higher severity potential conflict with bicycles and pedestrians at driveways
Overall	*Category II*	-

Intermediate-term suggestions to improve intersection of Barbur Boulevard/SW 30th Avenue:

- Remove on-street parking and provide appropriate bicycle lane striping (see previous "Bicycle Lane Gaps and Deficiencies" section.

Long-term suggestions to improve intersection of Barbur Boulevard/SW 30th Avenue:

- Consolidate and define driveways.

BARBUR BOULEVARD SEGMENT: SW 30TH AVENUE TO SW 24TH AVENUE

The segment of Barbur Boulevard between SW 30th Avenue and SW 24th Avenue includes northbound access to SW 26th Way via Barbur Court. There are narrow bicycle lanes (3-5 feet) and sidewalks (5 feet) on the bridge over SW 26th Way; there are no sidewalks immediately off the bridge. The right-turn on to Barbur Court is skewed, resulting in higher speeds for right-turning traffic. There are no defined bicycle lanes through either intersection with Barbur Court, as shown in Exhibit 48.

Exhibit 48. No pedestrian and bicycle facilities at bridge (left), gap in bicycle lane markings with right-turn from SW Barbur Court to Barbur Boulevard

Crash data (MP 5.08 to 5.42) from the last ten years between the SW 30th Avenue and SW 24th Avenue is summarized below:

- 31 reported crashes along this road segment (about three per year), including 16 turning, nine rear-end related crashes, three fixed objects, one sideswipe, one head-on, and one pedestrian collision types.
- Five crashes involving bicyclists, all associated with turning movements.
- One pedestrian crash related to a pedestrian crossing mid-block.
- 16 of the 31 crashes resulted in injuries (including the bicycle and pedestrian crashes).
- One fatal crash was reported, which was classified as a fixed object crash, occurred in the vicinity of SW Barbur Court during dark with light conditions, and was flagged as involving alcohol.

Table 13. Qualitative Risk Rating of Barbur Boulevard Segment: SW 30th Avenue to SW 24th Avenue

Function	Classification	Reasoning
Exposure	Category II	High number of accesses and driveways
Probability	Category I	Relatively few total crashes
Consequence	Category II	High percentage of injury crashes
Overall	*Category II*	-

Intermediate suggestions to improve Barbur Boulevard between SW 30th Avenue and SW 24th Avenue:

- Remove the southbound right-turn lane onto SW 26th Way.
- Consider consolidating bus stops with improved pedestrian access (i.e., once gaps in the sidewalk network are filled) within this segment by improving the transit stops at SW 30th Avenue and SW 24th Avenue.
- Implement the typical suggested corridor cross-section to provide more space for sidewalks and/or buffered bicycle lanes.

Long-term suggestions to improve Barbur Boulevard between SW 30th Avenue and SW 24th Avenue:

- Tighten the right-turns from Barbur Boulevard to SW Barbur Court and from SW Barbur Court to Barbur Boulevard.

BARBUR BOULEVARD/SW 24TH AVENUE INTERSECTION

Several improvements are planned for the Barbur Boulevard/SW 24th Avenue intersection as part of a demonstration project, including new sidewalk on three corners of the intersection. The improvements are illustrated in Exhibit 49.

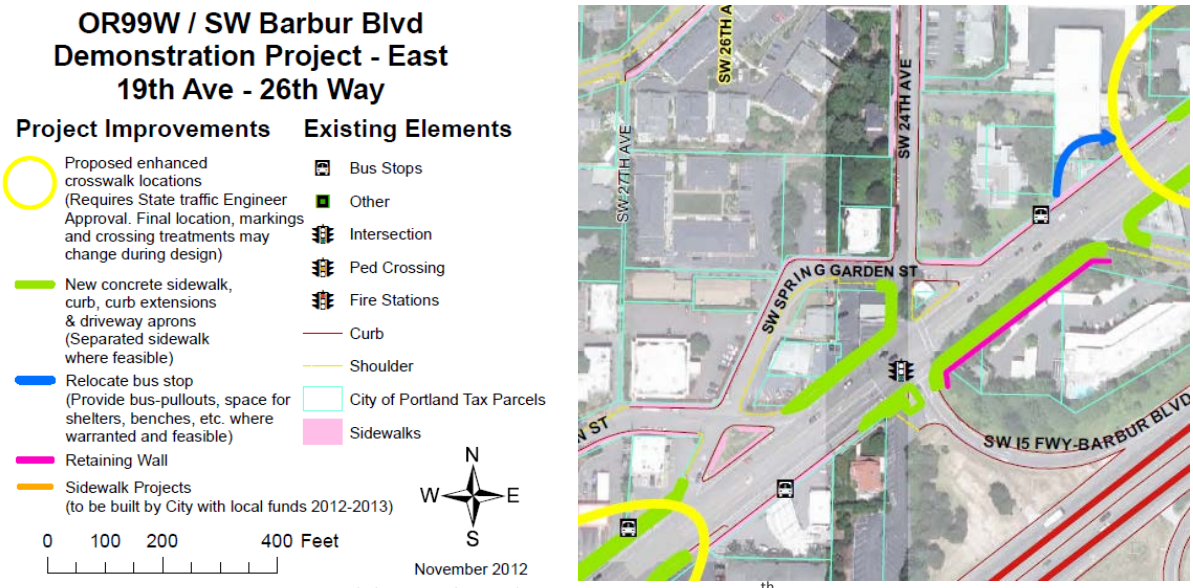

Exhibit 49. Planned improvements at SW 24th Avenue

The improvements will address several of the issues observed by the RSA Team, such as the lack of pedestrian facilities on the northeast corner and lack of bicycle lanes through the intersection (as shown in Exhibit 50 left image). The RSA Team noted issues with access management at the intersection, particularly with the Pancake House and its access to the I-5 southbound off-ramp. The alignment of SW Spring Garden Street also results in closely spaced intersections and driveways in the vicinity of SW 24th Avenue.

Exhibit 50. Northeast corner lacking pedestrian facilities at Barbur Boulevard/SW 24th Avenue (left) and aerial view from Google Earth

Traffic data indicates high side-street left-turns during the morning peak period (both SW 24th Avenue and Southbound I-5 off-ramp/Pancake House), as well as a high side-street left-turn (Southbound I-5 off-ramp) during the afternoon peak period. The crash data (5 years) shows a high proportion (12 of 21 crashes) of turning/angled movement crashes, as seen in the crash diagram in Exhibit 51, which are mostly related to the acute angle of the intersection. Turning movement crashes are typically side-street left-turns with through traffic on Barbur Boulevard.

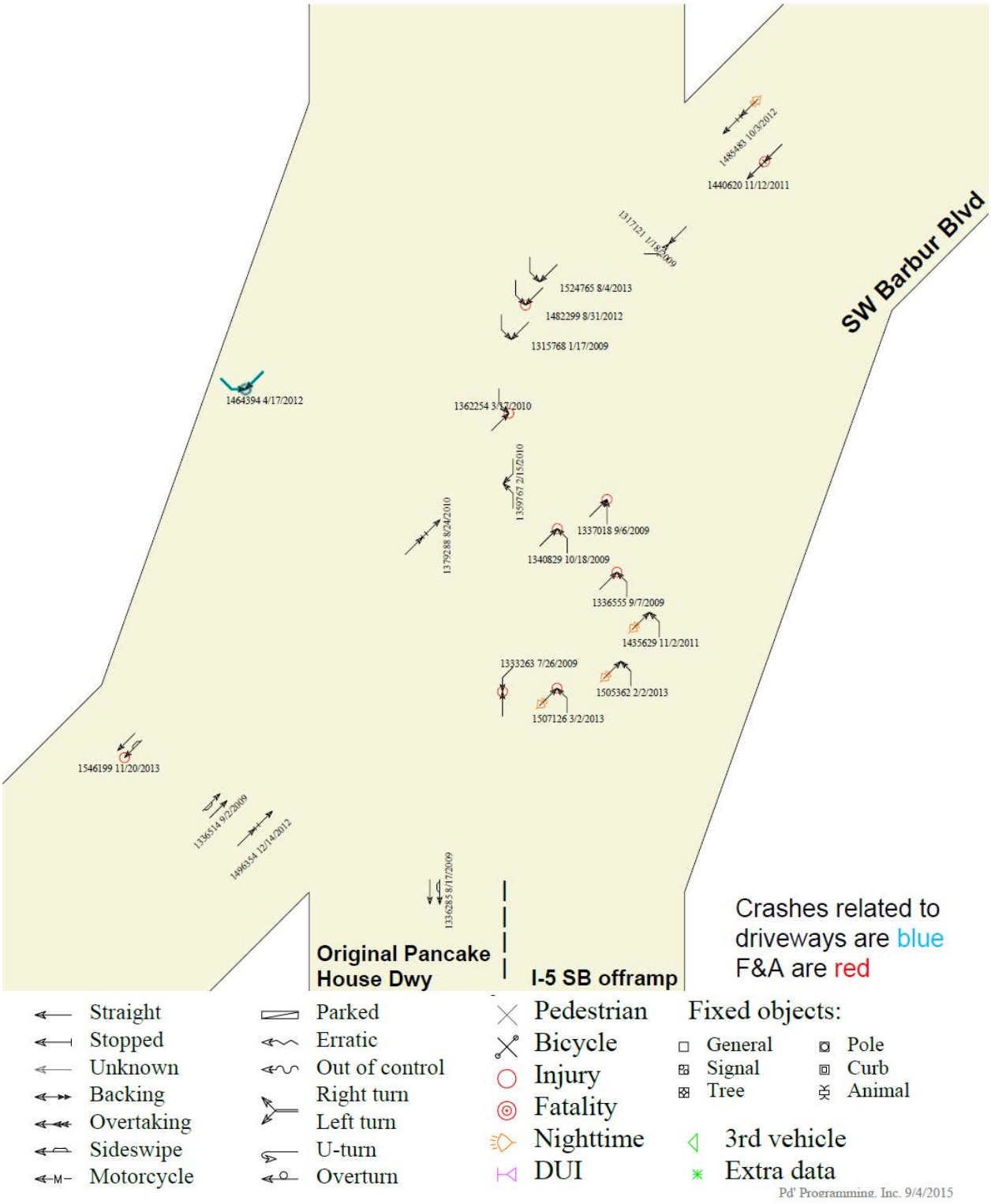

Exhibit 51. Crash diagram for Barbur Boulevard/SW 24th Avenue (2009-2013)

The RSA Team observed additional issues, such as obscured freeway signage for northbound I-5 on-ramp (Exhibit 52) and the lack of clarity for desired routes to freeway.

Exhibit 52. Obscured I-5 signage from northbound Barbur Boulevard just past SW 24th Avenue

Table 14. Qualitative Risk Rating of Barbur Boulevard/SW 24th Avenue Intersection

Function	Classification	Reasoning
Exposure	Category II	High volume of turning movements
Probability	Category II	High proportion of turning/angled crashes
Consequence	Category II	Typical crash types may result in higher severity
Overall	*Category II*	-

Near-term suggestions to improve intersection of Barbur Boulevard/SW 24th Avenue

- Improve signage to I-5 north of SW 24th Avenue, which is obscured by vegetation (Exhibit 52).
- Consider updating traffic signal phasing and timing to address turning movement crashes, as well as revisit the all red interval.

Intermediate suggestions to improve intersection of Barbur Boulevard/SW 24th Avenue

- Remove right turn /deceleration lane southwest of 24th Avenue to allow for continuous bicycle lane.

Long-term suggestions to improve intersection of Barbur Boulevard/SW 24th Avenue:

- Implement access management strategies, especially access to Pancake House. The RSA Team understands that the Pancake House may have a historic designation and that any modifications to its access may be challenging.
- Assess the potential to remove or relocate the I-5 southbound off-ramp at this intersection, given other I-5 southbound off-ramps within the study corridor. While the team reviewed connections to and from I-5 along the corridor, a more extensive study is needed to evaluate the feasibility of potentially removing an off-ramp.

BARBUR BOULEVARD SEGMENT: SW 24TH AVENUE TO MULTNOMAH BOULEVARD OVERPASS

The RSA Team observed the following issues on Barbur Boulevard between SW 24th Avenue and the Multnomah Boulevard overpass:

- The long southbound deceleration right-turn lane from Barbur Boulevard to SW Spring Garden Street, which also serves as a jughandle for making a left into the Pancake House, creates an extended area of potential conflicts between bicyclists and vehicles moving in to the right-turn lane (Exhibit 53 left image).
- The wide angle of the northbound right-turn onto Spring Garden St (towards the I-5 on-ramp) encourages higher speeds (Exhibit 53 right image).

Exhibit 53. Southbound right-turn deceleration lane to Spring Garden St (left), northbound right-turn to Spring Garden St (right)

- Inconsistent sidewalks and bicycle lanes, including over the Multnomah Boulevard overpass. The bridge is 48 feet wide with no bicycle lanes and narrow sidewalks, as shown in Exhibit 54.

Exhibit 54. Bridge over SW Multnomah Boulevard

Crash data (MP 4.79 to 5.07) from the last ten years between the SW 24th Avenue and SW Capitol Hill Road is summarized below:

- 51 crashes along this road segment (approximately five per year), including seven angle, 22 turning, 16 rear-end related crashes, four sideswipe overtaking, one fixed object, and one head-on collision types.
- For the 29 angle/turning crashes, 11 proceeded after stopping, 25 did not yield right-of-way (including 18 that were side-street left-turn and the majority were associated with the acute angle of the turn).
- 19 of the 51 crashes resulted in injuries.
- No pedestrian or bicycle crashes were reported.

Table 15. Qualitative Risk Rating of Barbur Boulevard Segment: SW 24th Avenue to Multnomah Crossing

Function	Classification	Reasoning
Exposure	Category II	Inconsistent bicycle and pedestrian facilities and many access/conflict points
Probability	Category II	High percentage side-street turning/angle crashes
Consequence	Category III	19 of 51 crashes are vehicle injury crashes
Overall	*Category III*	-

Intermediate suggestions to improve Barbur Boulevard between SW 24th Avenue and Multnomah Crossing:

- Modify the angle of the northbound right-turn lane to Spring Garden Street to encourage slower speeds.
- Explore shortening or removing the southbound right-turn lane to Spring Garden Street to reduce the conflict area between bicyclists and vehicles.

Long-term suggestions to improve Barbur Boulevard between SW 24th Avenue and Multnomah Crossing:

- Combine SW 22nd Avenue and SW Spring Garden Street on the east side of the intersection by T-ing them into a single intersection (this would entail right-of-way impacts).
- Explore opportunities to realign sidestreet to intersect with Barbur Boulevard more perpendicular.
- Consider options for the bridge that narrow the travel lanes to provide improved shared bicycle and pedestrian facilities, as shown in Exhibit 55. These options need to be evaluated to determine how the cross-section on the bridge would transition to/from the adjacent approaching road segments.

RSA Teamcross-section

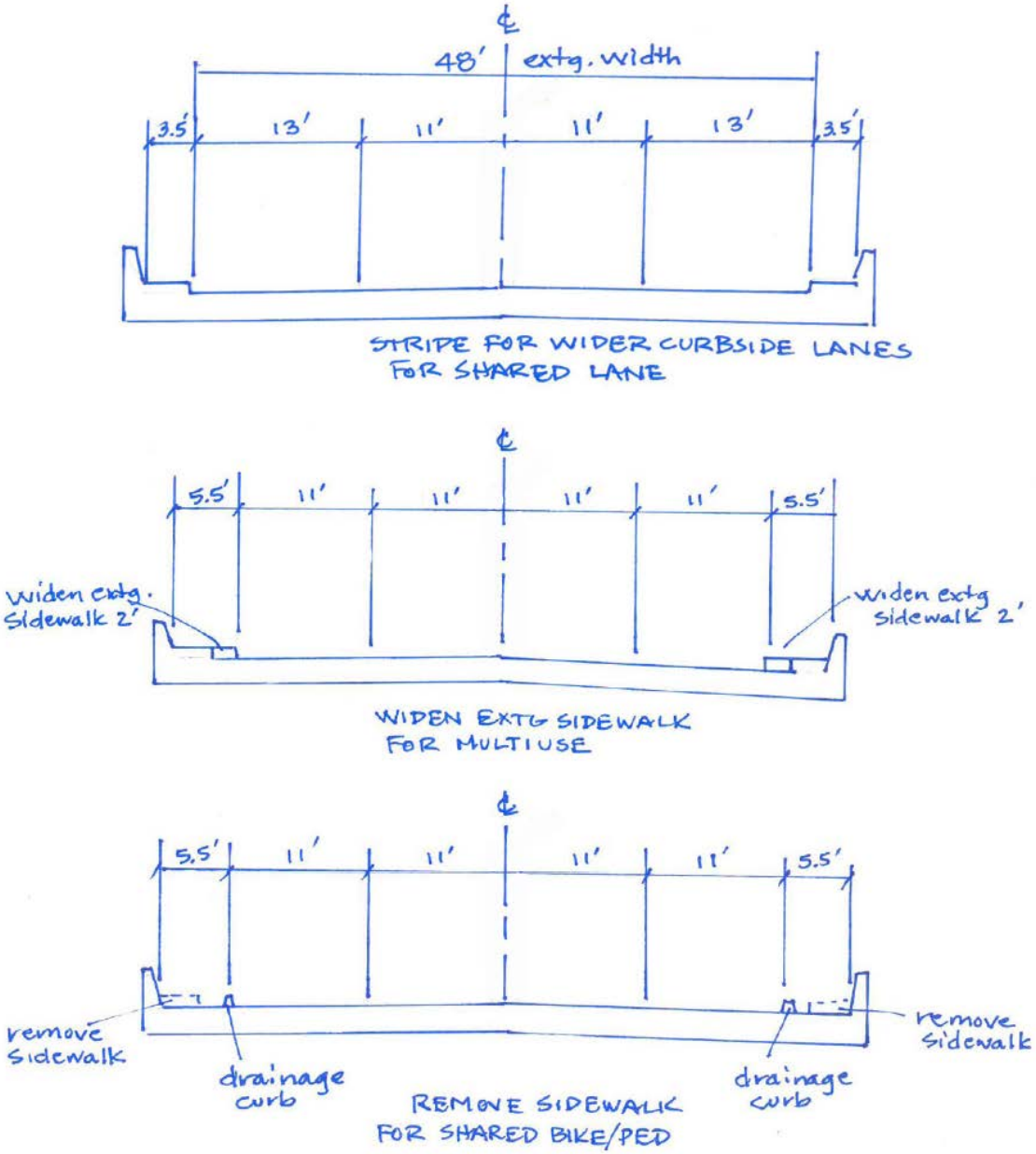

Exhibit 55. Cross-section options for Bridge over SW Multnomah Boulevard

- Explore a bicycle-only connection via SW Carson Street and/or SW Hume Court to Multnomah Boulevard (which would require a steep ramp down) to provide an option for bicyclists to bypass Barbur Boulevard (between Multnomah Bridge and the SW Terwilliger Boulevard intersection) via SW Multnomah Boulevard.
- Replace the Multnomah Bridge to provide the desired cross-sectional dimensions based on the corridor vision and the adjacent road segments approaching the bridge.

BARBUR BOULEVARD/SW CAPITOL HILL RD/19TH AVE INTERSECTION

Observations show high left and right turning volumes at morning and afternoon peak periods. Traffic data show higher pedestrian volumes (e.g., 18 and 42 crossing Barbur Boulevard during the AM and PM peak hours, respectively) at this intersection due to the grocery store (Safeway) in the southwest corner of the intersection. There are also a high number of bicyclists (i.e., 20 and 33 during the AM and PM peak hours, respectively) going through this intersection, especially in the southbound direction, due to the influx of bicycles from SW Multnomah Boulevard (out of town) and SW Barbur Boulevard (into town).

The RSA Team observed the following key issues at the Barbur Boulevard/SW Capitol Hill Road intersection:

- The bicycle lane in the southbound direction continues for bicyclists turning right onto Multnomah. For through bicyclists, the bicycle lane ends at the slip ramp to SW Multnomah Boulevard so bicyclists have to merge into the travel lane, with no signing or striping provided for direction (Exhibit 56, left image).
- There is back out parking at the restaurant on the southwest corner of the intersection with no sidewalk bicycle lane markings or roadway edge line (Exhibit 56, right image).
- Bicycle and pedestrian facilities end northeast of the intersection with fill embankment on both sides (Exhibit 57, left image).
- Queues on SW 19th Avenue were observed to block SW Multnomah Way, so vehicles were observed weaving through the queue to access SW Multnomah Way (frontage road).
- The northbound bus stop is nearside in the right-turn lane, providing challenges for through cyclists, right-turning vehicles, and buses merging back in to the through lane (Exhibit 57, right image).

Exhibit 56. Southbound bicycle lane approaching SW Multnomah Boulevard (left), parking on southeast corner of intersection (right)

Exhibit 57. Embankment north of SW Capitol Hill Road (left), northbound bus stop (right)

Crash data (MP 4.74 to 4.80) from the last five years at the SW 19th Avenue/SW Capitol Hill Road intersection is shown in the crash diagram in Exhibit 58 and summarized below:

- Total of 23 crashes at this intersection, including ten rear-end related crashes.
- 12 of 23 crashes resulted in injuries, including four angle/turning crashes potentially associated with acute skew angle
- One crash involving a pedestrian on northbound Barbur Boulevard and one crash involving a bicyclist on westbound SW 19th Avenue.

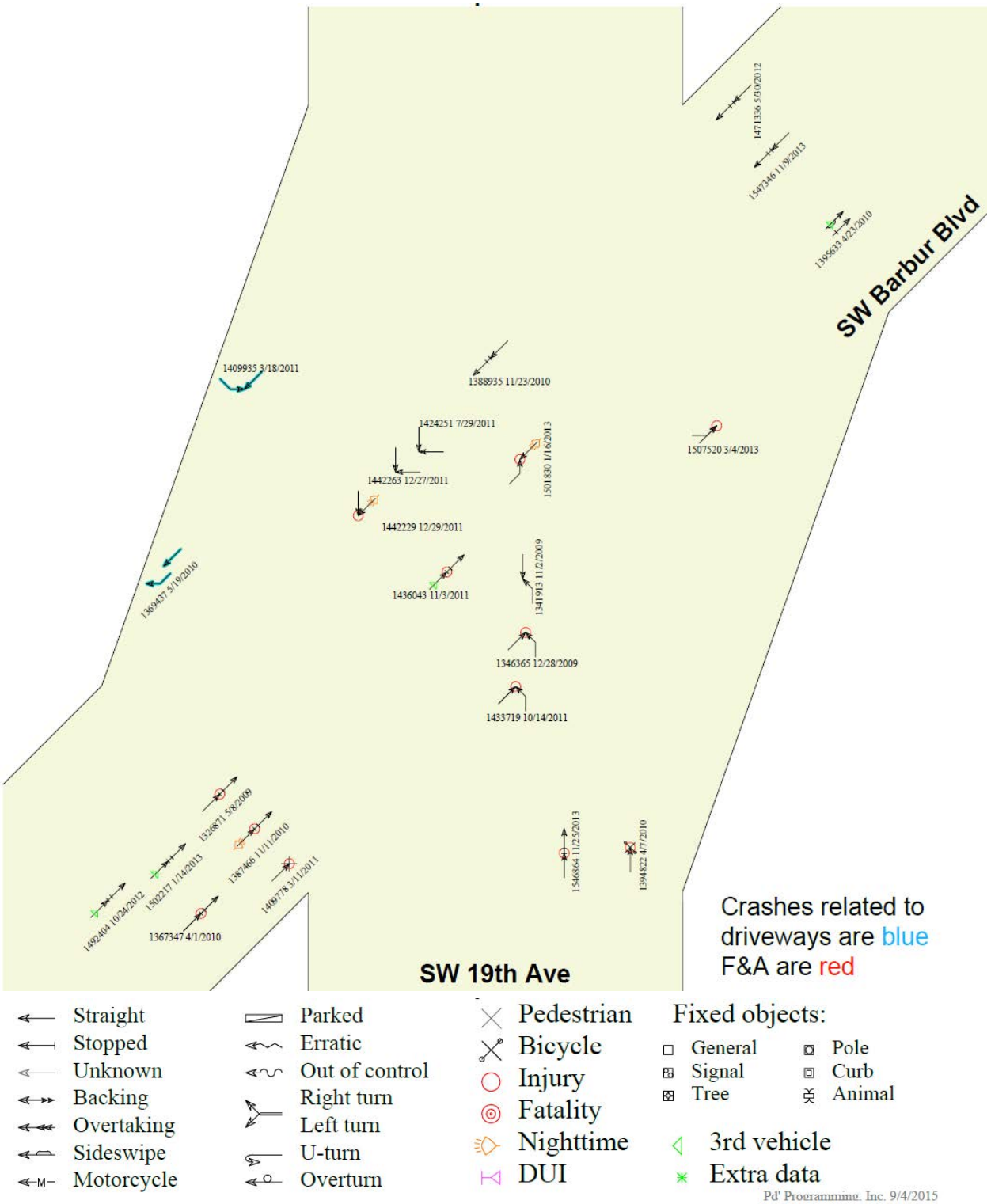

Exhibit 58. Crash diagram for Barbur Boulevard/SW Capitol Hill Road/19th Avenue (2009-2013)

Table 16. Qualitative Risk Rating of Barbur Boulevard/SW Capitol Hill Road/19th Avenue Intersection

Function	Classification	Reasoning
Exposure	Category I	Relatively lower volumes vehicles
Probability	Category I	Relatively lower opportunities for conflicts
Consequence	Category III	12 of 23 crashes are injury crashes with some higher severity with turning crashes. Relative high number of pedestrian and bicycles at this intersection.
Overall	*Category II*	-

Intermediate-term suggestions to improve intersection of Barbur Boulevard/SW Capitol Hill Road/19th Avenue:

- Consider relocating the northbound bus stop from the nearside to the far-side of the intersection.
- Restripe the parking stalls on the southeast corner of the intersection (at Humdinger) to further separate the parking stalls from the roadway and bicycle and pedestrian facilities. Utilize striping to define bicycle and pedestrian space along this parking.

Long-term suggestions to improve intersection of Barbur Boulevard/SW Capitol Hill Road/19th Avenue:

- Consider removing the northbound right-turn lane to provide bicycle and pedestrian facilities through the intersection, which will likely require modifications to the existing pedestrian island.
- If no widening is planned, then consider changing the intersection configuration by reducing lanes to 10.5 feet and providing 4-foot minimum bicycle lanes through the intersection (Exhibit 59 shows a conceptual intersection layout). There is approximately 60 feet of width available immediately north of the intersection.

Exhibit 59. Sketch of conceptual options for SW Capitol Hill Road

BARBUR BOULEVARD SEGMENT: SW CAPITOL HILL RD TO SW 13TH STREET

As shown in Exhibit 60, there is an embankment with no bicycle or pedestrian facilities just northeast of the SW Capitol Hill Road intersection. There is a guardrail adjacent to the travel lanes. There is a 3-foot shoulder on the west side of the roadway and a pedestrian demand path behind the guardrail that pedestrians were observed using. At its narrowest point the roadway is approximately 56 feet wide in this segment.

Exhibit 60. Embankment north of SW Capitol Hill Road lacking pedestrian or bicycle facilities

There is backing out parking on the east side of the roadway with no pedestrian facilities, as shown in Exhibit 61. On-street parking near 13th Avenue impedes sight distance from side streets and driveways.

Exhibit 61. Parking off east side of roadway

Crash data (MP 4.46 to 4.78) from the last ten years from SW Capitol Hill Road to SW 13th Street is summarized below:

- 36 crashes along this road segment (less than four per year), including one angle, seven turning, 25 rear-end related crashes, one fixed object, one angle, and one head-on collision types.

- For the 25 rear-end crashes, the majority cited following too closely as a crash cause. The crashes occurred in both directions with no clear trend.
- 20 of the 36 crashes resulted in injuries.
- Two bicycle crashes were reported, both of which were classified as turning crashes.

Table 17. Qualitative Risk Rating of Barbur Boulevard Segment: SW Capitol Hill Road to SW 13th Street

Function	Classification	Reasoning
Exposure	Category II	Potential for conflicts where there bicycle facilities are absent, but relatively low total crashes
Probability	Category II	Numerous access points and inconsistent bicycle/pedestrian facilities
Consequence	Category III	20 of 36 injury crashes. There is a potential risk for high severity bicycle crashes on the embankment.
Overall	*Category II*	-

Intermediate-term suggestions to improve Barbur Boulevard between SW Capitol Hill Road and SW 13th Avenue:

- Remove parking to improve sight distance and potentially provide wider or buffered bicycle lanes for the segment north of the embankment.

Long-term suggestions to improve Barbur Boulevard between SW Capitol Hill Road and SW 13th Avenue:

- Infill sidewalk gaps on the east side of the roadway and address ADA issues.
- Implement access management strategies as part of redevelopment.
- Consider modifying the cross-section over the embankment to either restripe within the existing guardrails or widen onto the existing road prism with a barrier, as shown in Exhibit 62.

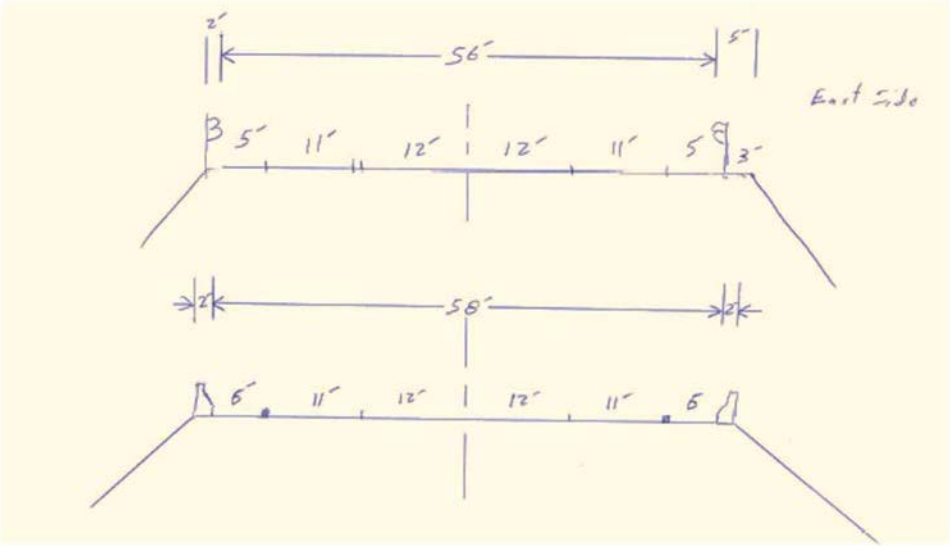

Exhibit 62. Options for Roadway Cross-section on Embankment

BARBUR BOULEVARD SEGMENT: SW 13TH STREET TO SW BERTHA BOULEVARD

Observed issues include:

- The two entrances to Fred Meyer along the site's frontage create conflicts with bicyclists, particularly at the northern entrance which is located in close proximity to the signal at SW Bertha Boulevard (shown in Exhibit 63). Queues from this entrance were observed to spill back in the bicycle lane and through auto lane. There is also a shared bus pullout in front of the Fred Meyer, which can cause confusion between bicyclists and buses about whom has the right-of-way.

Exhibit 63. Southbound on Barbur at northern Fred Meyer entrance

- Northbound left-turning vehicles from Barbur Boulevard to SW 13th Street were observed using the active RRFB cycle as an opportunity to turn left, as shown in Exhibit 64. Some confusion was observed between southbound through vehicles and bicyclists about who has the right-of-way to proceed after the RRFB was activated.
- The skewed approach of SW Multnomah Way contributes to inadequate sight distance for right-turning vehicles onto Barbur Boulevard.
- The transition across the bike lane to the right-turn lane at Custer is long and undefined.

Crash data (MP 4.23 to 4.45) from the last ten years between SW 13th Avenue and SW Bertha Boulevard is summarized below:

- 34 crashes along this road segment (less than four per year), including four turning, 21 rear-end related crashes, four sideswipe overtaking, four fixed object, and one angle collision types.
- For the 21 rear-end crashes, the majority cited following too closely as a contributing cause. More rear-end crashes were reported southbound on Barbur Boulevard compared to northbound.
- 11 of the 34 crashes resulted in injuries.
- Seven crashes were reported as occurring at a driveway.
- One bicycle crash was reported, which was classified as a turning crash.

Exhibit 64. Vehicles using activated RRFB cycle to turn on to and from SW 13th Avenue

Table 18. Qualitative Risk Rating of Barbur Boulevard Segment: SW 13th Street to SW Bertha Boulevard

Function	Classification	Reasoning
Exposure	Category II	Relatively low number of crashes with a number of high-volume driveways
Probability	Category II	High number of rear end crashes
Consequence	Category III	High potential for conflicts at driveways and higher severity potential with bicycle and pedestrians
Overall	*Category II*	-

Intermediate suggestions to improve Barbur Boulevard between SW 13th Avenue and SW Bertha Boulevard:

- Shorten the skipped bicycle striping portion of the right-turn lane transition on the southbound approach to SW Custer Street to minimize the conflict area with bicyclists.
- Add green pavement markings to the bicycle lane to indicate key conflict areas at major driveways, bus pullouts, and at SW 13th Avenue.

Long-term suggestions to improve Barbur Boulevard between SW 13th Avenue and SW Bertha Boulevard:

- Consider working with Fred Meyer to develop parking management strategies and informational signage or systems at Fred Meyer's driveways, particularly the northern driveway, to discourage drivers from entering lots that are full and minimize queues that back onto the highway.
- Consider shortening the right turn lane for SW Custer Street so that the southernmost Fred Meyer driveway is not in the right-turn lane for SW Custer Street.

BARBUR BOULEVARD/SW BERTHA BOULEVARD INTERSECTION

Traffic data indicates high side-street turning movements during both morning and afternoon peak periods at the intersection of Barbur Boulevard/SW Bertha Boulevard. In addition, pedestrian volumes are relatively high due to the bus stop in the southeast corner of the intersection. The major SW Multnomah Boulevard-SW Barbur Boulevard bicycle route results in a high number of bicyclists going through this intersection. Crash data (5 years) shown in the crash diagram (see Exhibit 65) is summarized below.

- A total of 35 crashes at this intersection with 22 rear-end crashes, with other crash types including angle, turning, driveway and sideswipe crashes.
- Of the 22 rear-end crashes, nine were along eastbound Bertha Boulevard and eight along southbound Barbur Boulevard.
- 14 of the 35 crashes resulted in injuries.

Based on observations by the RSA Team and past assessment of the Barbur Boulevard/SW Bertha Boulevard intersection, the intersection is near or at capacity. The SW Bertha Boulevard approaches are split phased, which constrains the signal timing at the intersection resulting in the intersection operation at capacity. The team observed vegetation limiting intersection visibility, particularly at the northeast corner where the geometry of the pedestrian facilities also hinders the view of turning vehicles (Exhibit 66). The large turning radii at the intersection allow relatively high speed turns.

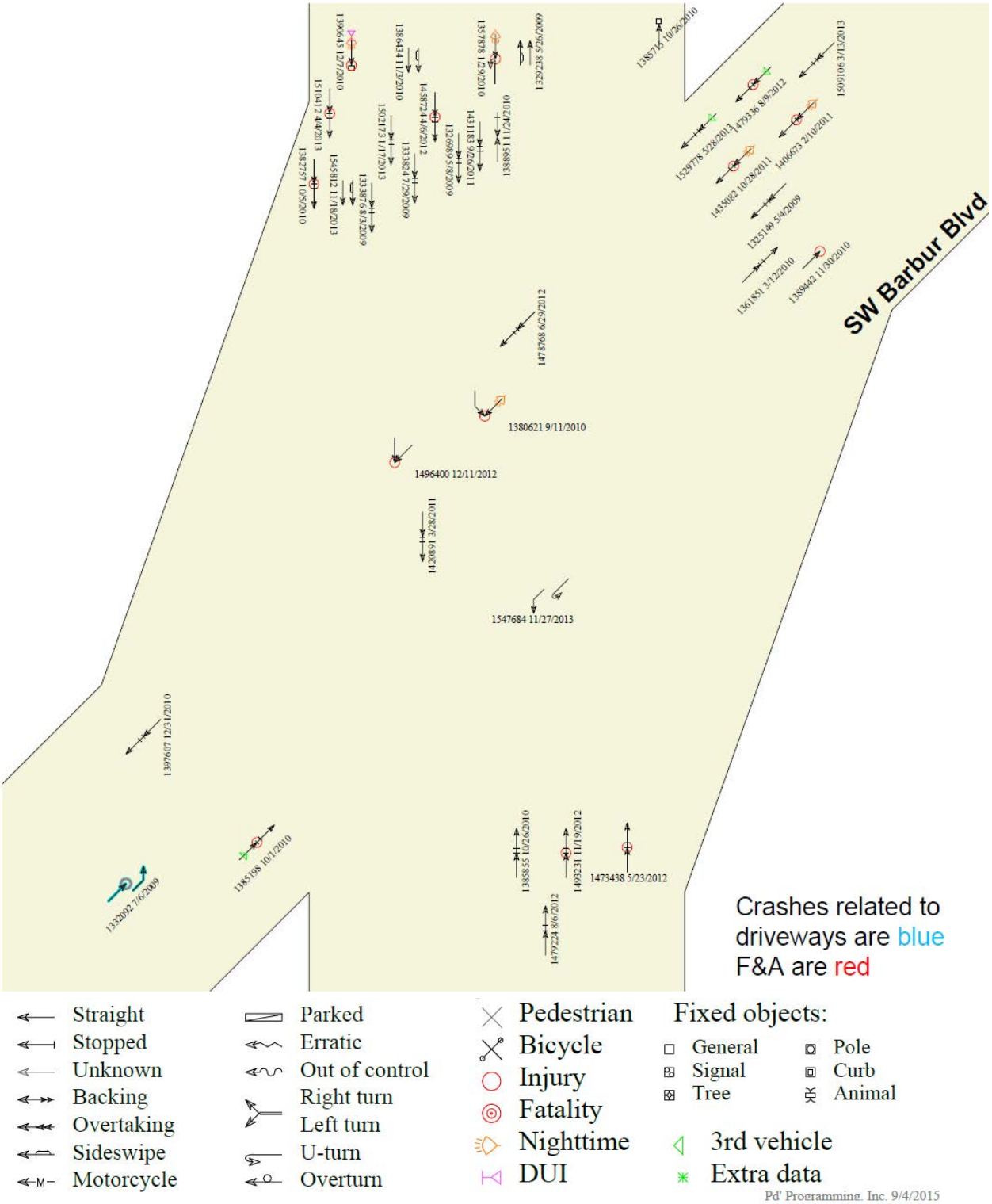

Exhibit 65. Crash Diagram for Barbur Boulevard/SW Bertha Boulevard (2009-2013)

Exhibit 66. View of northeast corner of Barbur Boulevard/SW Bertha Boulevard

Table 19. Qualitative Risk Rating of Barbur Boulevard/SW Bertha Boulevard Intersection

Function	Classification	Reasoning
Exposure	Category II	Busy intersection for all modes, conflicts associated with Fred Meyer driveways
Probability	Category II	Relative low crash history compared to other study intersections and volumes
Consequence	Category III	Vehicle crashes (potential severity due to turning patterns), but potential conflict with bicycles and pedestrians (high severity)
Overall	*Category II*	-

Near-term suggestions to improve intersection of Barbur Boulevard/SW Bertha Boulevard:

- Maintain vegetation at the intersection to improve visibility of pedestrians on the northeast corner.

Intermediate suggestions to improve intersection of Barbur Boulevard/SW Bertha Boulevard:

- Use a smaller curb radius on the northeast corner to orient pedestrians towards traffic. Such a modification should accommodate the appropriate design vehicle, since this intersection is part of a ramp terminal.
- Modify the sidewalk on the northeast corner to create a curb tight sidewalk at the intersection to provide better visibility between motorists and pedestrians.

Long-term suggestions to improve intersection of Barbur Boulevard/SW Bertha Boulevard:

- Improve intersection geometry to remove the split phasing and allow more efficient signal timing operations.

BARBUR BOULEVARD SEGMENT: SW BERTHA BOULEVARD TO SW TERWILLIGER BOULEVARD

There is a long weaving section between SW Bertha Boulevard and SW Terwilliger Boulevard involving right-turning vehicles from the I-5 southbound off-ramp and vehicles from SW Barbur Boulevard turning right at SW Terwilliger Boulevard, as shown in Exhibit 67. This creates a long conflict zone with the bike lane that is positioned between the through and right-turn lanes. In addition, there is no sidewalk between SW Bertha Boulevard and SW Terwilliger Boulevard on the freeway side of Barbur Boulevard – there is an unofficial, unpaved walking path.

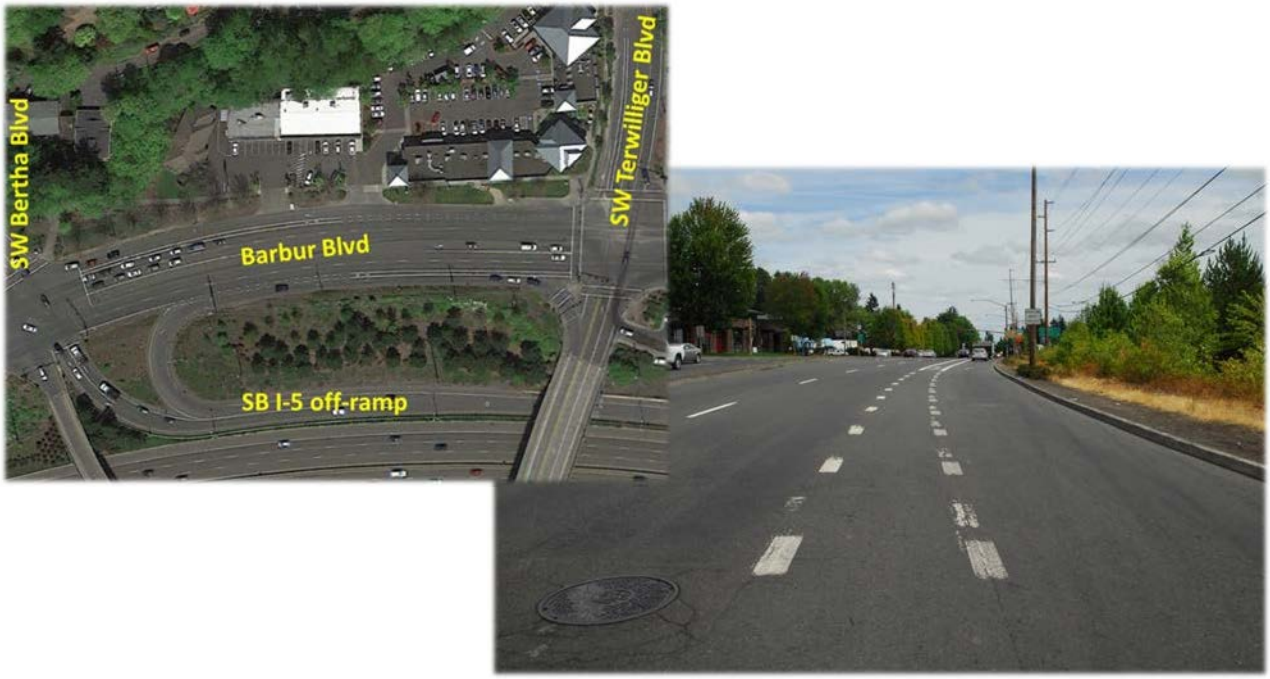

Exhibit 67. Weaving section between SW Bertha Boulevard and SW Terwilliger Boulevard (Google Earth, left)

There is a long transition across the bike lane into the southbound right-turn lane that includes the bus zone, as shown in Exhibit 68.

Exhibit 68. Transition to southbound right-turn lane with bus zone

Crash data (MP 4.09 to 4.21) from the last ten years between the intersections of SW Bertha Boulevard and SW Terwilliger Boulevard was reviewed, with key findings summarized below:

- Six sideswipe overtaking crashes were reported, three in the northbound direction and three in the southbound direction.
- The majority of crashes on this segment are associated with the intersections of SW Bertha Boulevard or SW Terwilliger Boulevard. Rear-end related crashes are the most common crash type, followed by sideswipe and turning collision types.
- One bicycle crash was reported associated with a vehicle movement from southbound I-5 to northbound Barbur Boulevard.

Table 20. Qualitative Risk Rating of Barbur Boulevard Segment: SW Bertha Boulevard to SW Terwilliger Boulevard

Function	Classification	Reasoning
Exposure	Category III	Congested with high number vehicles weaving
Probability	Category II	Congested but fewer conflict opportunities
Consequence	Category III	High potential risk for vehicle/bicycle crash in weave section
Overall	*Category III*	-

Near-term suggestions to improve Barbur Boulevard between SW Bertha Boulevard and SW Terwilliger Boulevard:

- Emphasize the conflict area for the eastbound weave across the bicycle lane with green paint (see bottom half of sketch, Exhibit 69).

Intermediate suggestions to improve Barbur Boulevard between SW Bertha Boulevard and SW Terwilliger Boulevard:

- Shorten the transition into the westbound right-turn lane and define the bus stop location, for better channelization (see top half of sketch, Exhibit 69).

Exhibit 69. Shorten transition into westbound right-turn lane by striping and/or potential curbing

Long-term suggestions to improve Barbur Boulevard between SW Bertha Boulevard and SW Terwilliger Boulevard:

- Add sidewalk on the south side of Barbur Boulevard.

BARBUR BOULEVARD/SW TERWILLIGER BOULEVARD INTERSECTION

Traffic data indicates high side-street traffic volumes during both morning and afternoon peak periods. In addition, the pedestrian counts are relatively high due to the bus stops at this intersection. There are also a high number of bicyclists going through this intersection, due to the major SW Multnomah Boulevard-SW Barbur Boulevard bicycle route; i.e., making a right (westbound) in the morning from SW Terwilliger Boulevard to Barbur Boulevard, and going through (southbound) in the afternoon on Barbur Boulevard. Crash data shown in the crash diagram (see Exhibit 70) is summarized below.

- 48 total crashes at this intersection, 34 were rear-end crashes, and other crashes were angle, turning, driveway and side-swipe.
- For the 34 rear-end crashes, 10 were along northbound Barbur Boulevard, and nine along westbound SW Terwilliger Boulevard.
- 26 of the 48 crashes resulted in injuries.
- Five driveway related crashes.
- Two pedestrian crashes and two bicycle crashes, one of which occurred at a driveway.

The RSA Team observed operational issues at Barbur Boulevard/SW Terwilliger Boulevard intersection, including:

- Westbound left-turning vehicles (from SW Terwilliger Boulevard) running the red-light to make it through the intersection.
- Southbound left turn queue (on Barbur Boulevard) spilling back into the through lane.
- Northbound right-turning vehicles (from Barbur Boulevard) filling the available space on Terwilliger Boulevard over the bridge so there is limited space for receiving through and left-turning vehicles (Exhibit 71 left image). Vehicles waiting to make a right-turn onto the Terwilliger Bridge regularly block the bicycle lane.

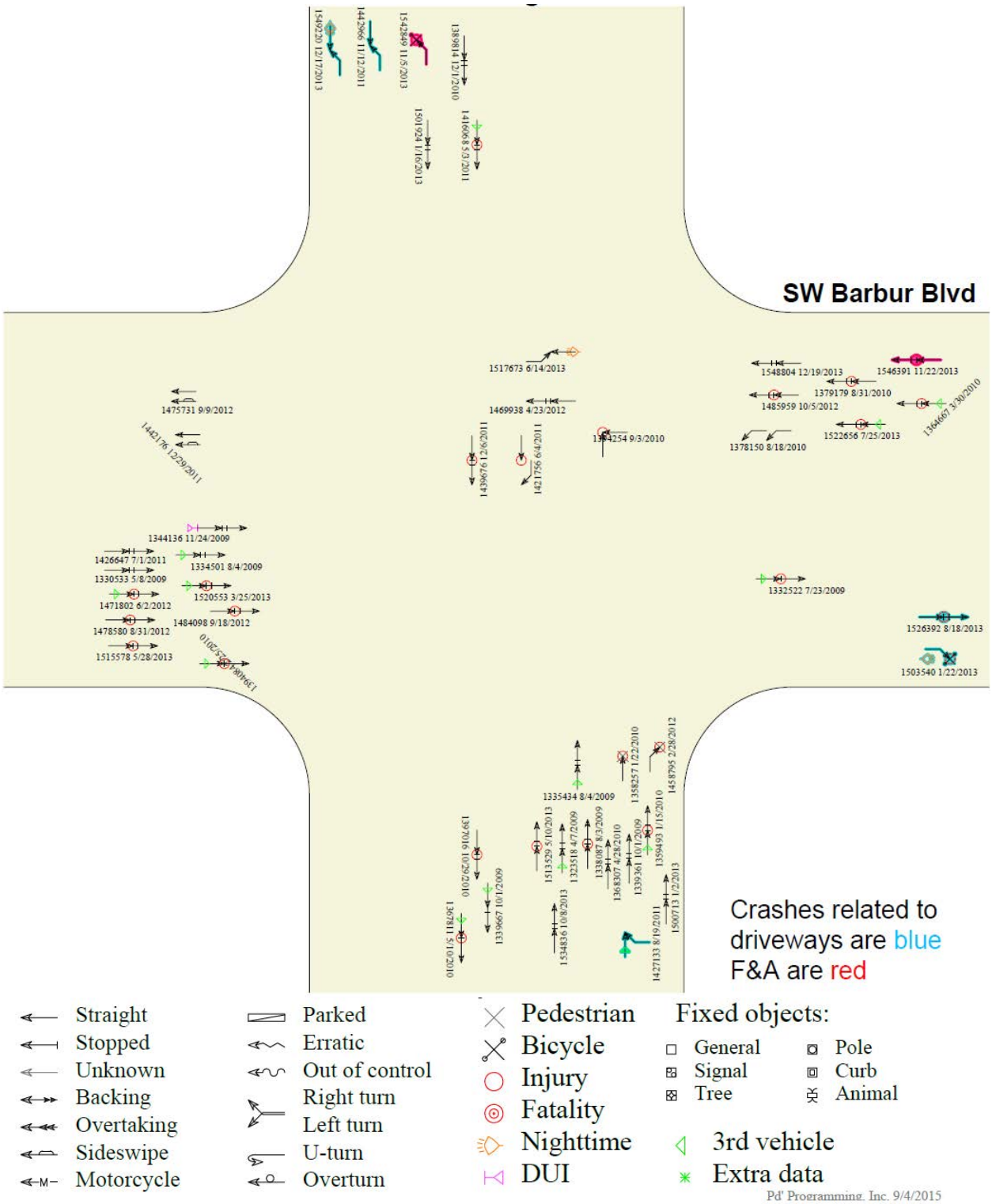

Exhibit 70. Crash Diagram for Barbur Boulevard/SW Terwilliger Boulevard (2009-2013)

- Multiple bicycles made northbound and southbound left-turns (from Barbur Boulevard) either by moving across the travel lanes into the left-turn lane or performing a two-part turn by staying on the right side of the street and using the cross-street green phase (Exhibit 71 right image).

Exhibit 71. Space limited to turn on Terwilliger Boulevard (left), left-turning bicyclists on Barbur Boulevard (right)

- There are a high number of bicyclists in the morning making a right-turn from the SW Terwilliger Boulevard onto northbound Barbur Boulevard and in the afternoon a left-turn from Barbur Boulevard onto SE Terwilliger Boulevard.
- The RSA Team observed some southbound buses not using the right-turn only bus bypass lane, resulting in the need to transition across the bicycle lane through the intersection to access the stop on the far-side of SW Terwilliger Boulevard (Exhibit 72).

Exhibit 72. Southbound bus crossing the bicycle lane

Table 21. Qualitative Risk Rating of Barbur Boulevard/SW Terwilliger Boulevard Intersection

Function	Classification	Reasoning
Exposure	Category III	High volume intersection for all modes
Probability	Category III	Crash history reflects relatively high numbers of reported crashes
Consequence	Category III	High potential for conflicts between modes 2 pedestrian and 2 bicycle crashes
Overall	*Category III*	-

Near-term suggestions to improve intersection of Barbur Boulevard/SW Terwilliger Boulevard:

- Evaluate and optimize signal timing at the intersection and coordination with the I-5 off-ramp, particularly for SW Terwilliger Boulevard.

Intermediate suggestions to improve intersection of Barbur Boulevard/SW Terwilliger Boulevard:

- Coordinate with TriMet (bus drivers) to determine a consistent approach for buses traveling southbound on Barbur Boulevard through this intersection. Considerations include:
    - For consistency, all buses use upstream right-turn lane to enter downstream bus stop to eliminate buses transitioning from the through lane to the bus stop through the intersection and across the bicycle lane.
    - Move bus stop to near-side to create queue jump lane.
- Consider red light running enforcement; however no crashes were reported, but red light running was observed.
- Consider bicycle box/storage for left-turns from SW Barbur Boulevard and general wayfinding for bicyclists.
- Investigate lengthening the southbound left-turn pocket.
- Add green pavement markings in the northbound bicycle lane to address right turn queuing across the bicycle lane.

Long-term suggestions to improve intersection of Barbur Boulevard/SW Terwilliger Boulevard:

- Improve intersection geometry by potentially providing dual left-turn lanes to accommodate the high left-turn movements.

BARBUR BOULEVARD/SW MILES STREET INTERSECTION

The Barbur Boulevard/SW Miles Street intersection is skewed with offset approaches of SW Miles Street with low side-street traffic volumes. The bicycle lane on the west side of Barbur Boulevard is narrow (5 feet next to the retaining wall), as seen in Exhibit 73 (right image). Vegetation impedes visibility on the side streets. The southbound bus stop is not ADA compliant, because of the narrow sidewalk and lacks curb ramps. The northbound bus stop at SW Miles Street is close to the bus stop at SW Brier Place (approximately one-tenth of a mile apart). The skewed angle of Miles encourages high speed right turns and creates a long bicycle crossing along Barbur Boulevard.


Exhibit 73. Barbur Boulevard and SW Miles Street intersection (looking south) and bicycle lane abutting retaining wall

Table 22. Qualitative Risk Rating of Barbur Boulevard/SW Miles Boulevard Intersection

Function	Classification	Reasoning
Exposure	Category I	Lower side-street volumes
Probability	Category I	Relatively low number of crashes
Consequence	Category I	Crash history shows primarily PDOs
Overall	*Category I*	-

Near-term suggestions to improve Barbur Boulevard/SW Miles Street:

- Trim and maintain vegetation to provide better sight distance from the side streets.
- Consider improved delineation of the island on the westbound Miles Street approach (Exhibit 74).

Intermediate suggestions to improve Barbur Boulevard/SW Miles Street:

- Better define the intersection radius (potential curb extension to differentiate on-street parking on Miles Street) on the east leg of SW Miles Street and use green paint to define the bicycle lane through the intersection.
- Consider consolidating the northbound bus stops at SW Miles Street and SW Brier Place.

Exhibit 74. View from northbound approach to SW Miles Street

Long-term suggestions to improve Barbur Boulevard/SW Miles Street:

- Conduct a feasibility study to potentially remove one of the side-street legs of the intersection to address the offset approaches of the intersection.

BARBUR BOULEVARD SEGMENT: HORIZONTAL CURVE NORTH OF SW MILES STREET

There were four fatal crashes reported on the roadway curve just north of SW Miles Street over the last ten years, as shown in Exhibit 75. Three of these crashes were fixed object crashes that occurred at nighttime and involved alcohol; the other crash was a head-on collision during the day and not alcohol related. Three of the crashes occurred in the southbound direction while one of the fixed object crashes occurred in the northbound direction.

In 2014, ODOT installed tubular markers, reflectors and reflectorized yellow paint on the raised median, as well as added a speed feedback sign for southbound traffic approaching the curve. Since these improvements, no crashes have occurred in this curve.

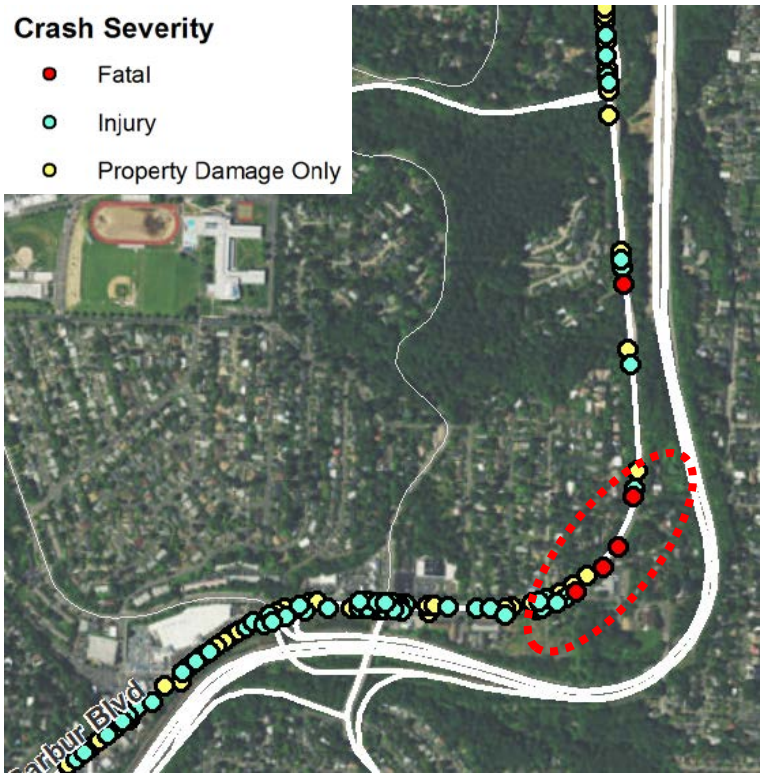

Exhibit 75. Reported crashes between SW Miles St and SW Capitol Highway (January 2004-September 2014)

Table 23. Qualitative Risk Rating of Barbur Boulevard Segment: Horizontal Curve North of SW Miles Street

Function	Classification	Reasoning
Exposure	Category II	High traffic volumes at high-speeds
Probability	Category I	No reported crashes since 2014 improvements
Consequence	Category III	Run-off the road type of crashes in urban setting (crashes prior to 2014 improvements involved four fatalities)
Overall	*Category II*	-

Near-term suggestions to improve Barbur Boulevard from SW Miles Street through curve:

- Add delineation to the curve in the northbound direction.

BARBUR BOULEVARD SEGMENT: WOODED SECTION TO SW HAMILTON STREET

Further north, the Wooded Section includes the Newbury and Vermont Bridges and the intersection with Capitol Highway (eastbound to northbound fly-over). The RSA Team reviewed and observed the following:

- 66 reported crashes within the 10-year period from MP 2.5 to 3.69
    - Two fatalities; i.e., horizontal curve south of Hamilton Street (pedestrian) and Parkhill Drive intersection at Vermont Bridge, both involved speed and alcohol.
    - Majority of crash types are rear-end (34 of 66) that occur more or less equally in both directions, as well as sideswipe overtaking (14 of 66) with typical causes such as; followed too closely, improper driving, improper change of traffic lane, improper overtaking, and speed too fast for conditions.
    - The crash data shows a history of rear-end and sideswipe crashes north of the Capitol Highway flyover in both the northbound and southbound directions.
- Although there are low pedestrian (1)/bicycle (none) related crashes along this segment, ODOT's Active Transportation Needs Inventory (ATNI) study scored this segment very high due to crash risk and potential for high severity.
- Pedestrian access to the bus stops at SW Parkhill Drive and at the Capitol Highway structure is challenging (shown in Exhibit 76). The stops on the west side of the roadway are behind the guardrail right next to the bridge. There are no pedestrian facilities on either side of the roadway and the ridership indicates an average of less than 5 people a day at each stop.

Exhibit 76. Northbound bus stop at SW Parkhill Dr. (left), southbound bus stop at SW Parkhill Dr. (right)

- Based on the team's nighttime visit, there is no lighting or edge line on the bridge structures, creating a gap in lighting and visibility in defining the edges of the roadway.

- In the northbound direction, a route for bicyclists around the flyover and merge is provided. In the southbound direction, green paint is used to highlight the conflict between the bicycle lane and high-volume right-turn to Capitol Highway.

Exhibit 77. Northbound turn to Capitol Highway with green paint to highlight conflict area (left), southbound route for bicyclists to avoid Capitol Highway merge to Barbur Boulevard (right)

- Data in the Barbur Concept Plan shows that speeds on the corridor are highest (85th percentile speed of 55 mph compared to 45-mph posted speed) through the wooded section. This is likely due to the lack of traffic signals, accesses, and roadside development. These characteristics result in undesirable speed differential between motor vehicles and bicyclists, especially over the bridges where bicyclists are sharing the outside lanes across the bridges.
- There is a gap in the bicycle network with no bicycle lanes over the bridges. There are signs activated by bicyclists that flash to indicate the presence of bicyclists on the bridges. Key issues for bicyclists include vehicle speeds, lack of dedicated space, and relying on the motorized vehicles to recognize and yield to a slower non-motorized user that must share the lane.


Exhibit 78. Southbound approach to Newbury Bridge (left), warning sign at northbound approach to Vermont Bridge (right)

At the north end of this segment, there is an existing RRFB installation at the Rasmussen apartments. The RRFB was installed in February 2012 and there has only been one crash (i.e., rear-end) since the installation.

Table 24. Qualitative Risk Rating of Barbur Boulevard Segment: Wooded Section to SW Hamilton Street

Function	Classification	Reasoning
Exposure	Category III	High traffic volumes at high-speeds
Probability	Category II	Currently low-to-medium bicycle usage
Consequence	Category III	Potential for high severity crash
Overall	*Category III*	-

The RSA Team reached consensus on the following suggestions for this segment.

Near-term suggestions to improve Barbur Boulevard between Wooded Section to SW Hamilton Street:

- Install 4-inch edge line on the bridges to improve visibility, particularly at night.
- Add pavement symbols indicating the loops that actuate the warning lights on the bridges so bicyclists are aware of where they need to ride.
- Consider signage or striping to encourage bicyclists to take the outside travel lane across the bridges.

Intermediate suggestions to improve the Wooded Section to SW Hamilton Street:

- Add additional detection upstream of the existing northbound loops (in the downhill direction) so bicyclists who choose to merge into the travel lane earlier still activate the warning lights. Consider different detectors than inductive loops to detect non-metallic bicycles.
- Consider speed management techniques, such as:
    - Install a speed feedback sign in the northbound direction prior to the bridges.
    - Increase enforcement, such as fixed photo radar along this segment.

- Consider installing transverse rumble strips in advance of the bicycle warning signs to increase driver awareness - applicability of this treatment to be evaluated for noise impact on adjacent neighborhoods.
- Consider techniques to improve delineation, such as using recessed raised pavement markers (RRPM) to narrow the travel lanes to help decrease vehicle speeds.
  - Install yellow RRPM inside the 'A' lane (double yellow)
  - Install white RRPM along the lane line pavement marking

Long-term suggestions to improve the Wooded Section to SW Hamilton Street

- Replace the Vermont and Newbury bridges to provide the desired cross-sectional dimensions based on the corridor vision and the adjacent road segments approaching the bridges.

Further suggestions without consensus to improve the Wooded Section to SW Hamilton Street:

The RSA Team explored a wide range of options for reallocating the space on the existing bridges due to it being structurally infeasible to widen these bridges to address the speed differential between different modes. The team did not conduct new operational analyses. There is not a preferred option within the available existing cross section. The team suggests further evaluation of the trade-offs associated with these options and how they compare to the evolving vision for this corridor.

The RSA Team did not assume any desired vision for the corridor and only developed these explorations to highlight the pros and cons of various options to present the range of possibilities for addressing the safety issues. The team wanted to present a range of options that were discussed and each option begins with an introduction that notes the purpose for considering the option. The team focused on the intent of the RSA, which is to consider safety for all user groups based on both crash data and risk factors. The team concluded that further operational assessment is needed to evaluate the options. The options developed by the team are presented on the following pages for consideration.

Explored Option #1: Maintain the existing bridge structure and cross-section

Purpose of this option: Assess the pros and cons of the current configuration and provide a baseline for comparison against any proposed changes.

This option maintains the existing cross-section on the bridge, as shown in Exhibit 79. (See near-term suggestions to accommodate bicyclists on bridges.) The evaluation of this option highlights the challenges and opportunities with the existing condition.

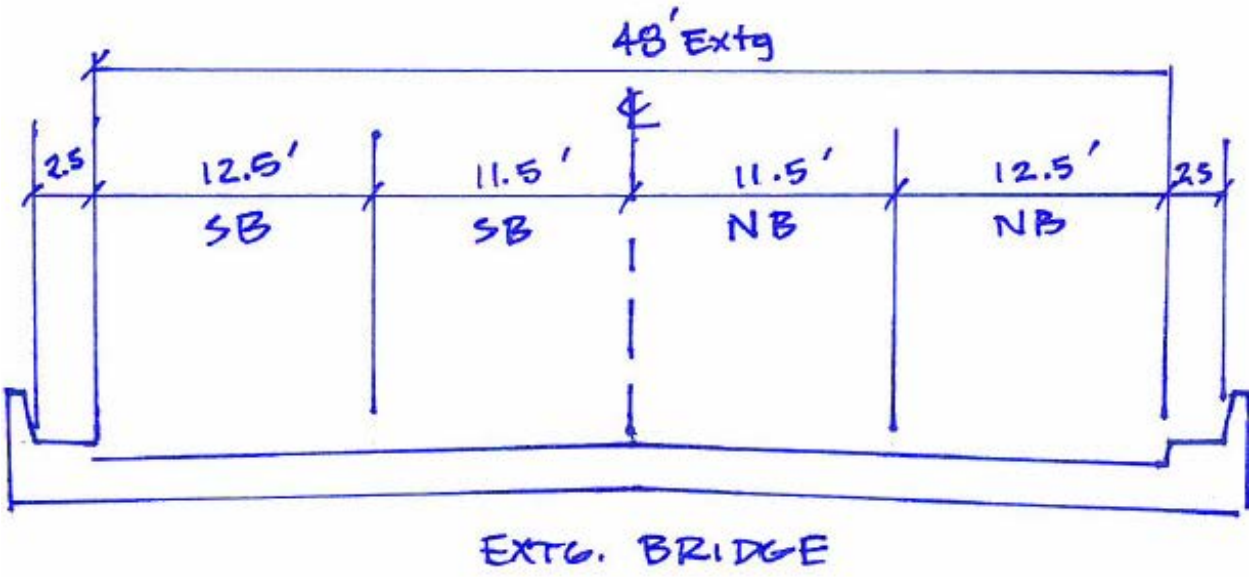

Exhibit 79. Existing bridge cross-section

Pros:

- Existing vehicular capacity of the roadway maintained through this segment with the existing lane configuration on the bridge.

Cons:

- High risk to bicyclist in the event of a crash, because there is no separation between different modes.
- Continued differential between posted speeds and operating speeds anticipated, as well as motor vehicle and bicyclists.
- Latent demand (bicyclists deterred from riding due to the bridges) continues to not be realized.

Additional Considerations/Needed Assessment:

- Evaluate speed management methods to reduce vehicular speeds approaching the bridges as discussed in the previous "Speed and Cross-section Inconsistency" section (corridor-wide issue).
- Consider alternative route for potential multi-use path off the roadway as suggested in the Southwest Corridor study.

Explored Option #2: Narrow the travel lanes to provide bicycle lanes

Purpose of this option: Provides minimal bicycle facilities (4-foot bicycle lanes) and four 10-foot travel lanes.

This option modifies the existing cross-section on the bridge by restriping within the existing pavement width to introduce 4-foot bicycle lanes or shoulder in addition to the existing four narrower travel lanes, as shown in Exhibit 80. The evaluation of this option illustrates the challenges with reallocating space on the bridges to provide bicycle lanes within the existing cross-section. The RSA Team discussed the challenges with this exploration, if the character of the road does not change to encourage slower speeds through this segment, and noted that other options for providing bicycle facilities are more desirable for both vehicle and bicycle comfort and safety, such as providing a three-lane cross-section (see Options #4, #5, and #6), as well as wider sidewalks (Option #3).

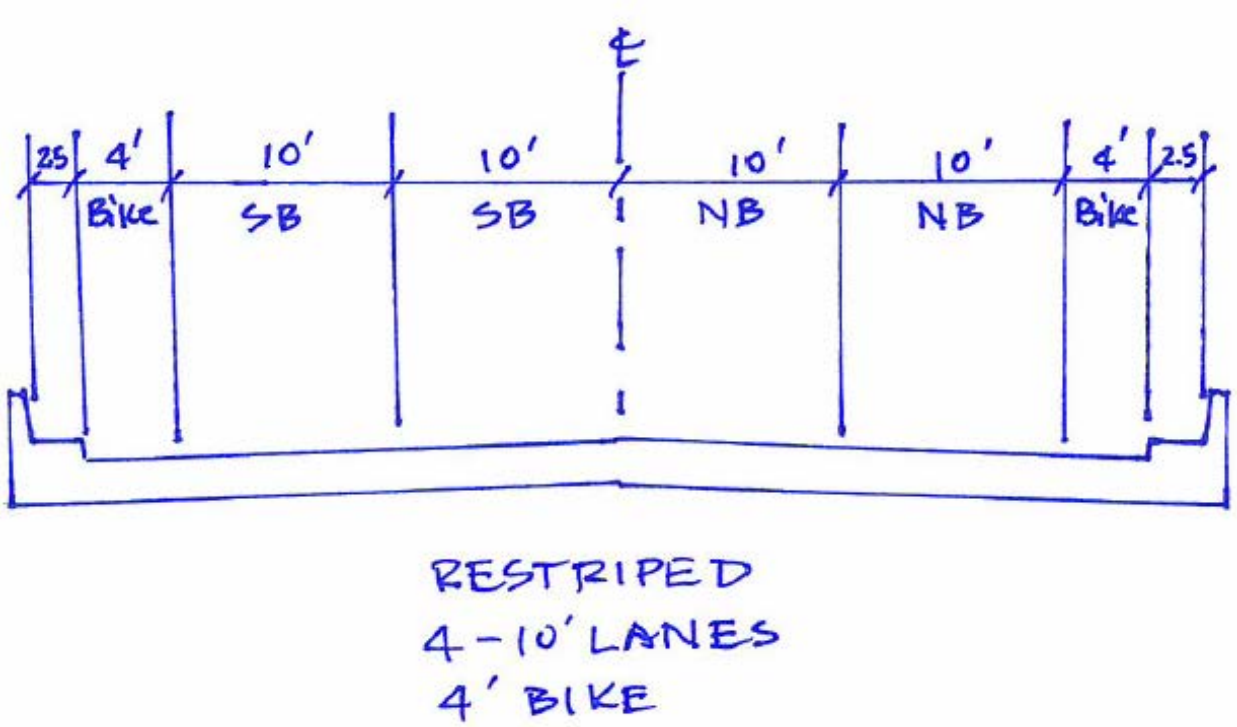

Exhibit 80. Option #2 cross-section with 10-foot travel lanes and bicycle lanes

Pros:

- Four narrow vehicle lanes maintained through this segment.
- Minimal 4-foot bicycle lanes provided over bridges (separate space of bicyclists).
- Slower speeds for motor vehicles encouraged through narrower travel lanes.

Cons:

- High risk to all users in the event of a crash.
- Increased risk of sideswipe (both meeting and overtaking) crashes (vehicle/vehicle and vehicle/bicycle) with narrower travel lanes, particularly for trucks and buses.
- The narrow travel lanes are challenging for buses, which are 10.5 feet-wide including the mirrors.
- Possible encroachment on the bicycle lane by vehicles/buses in the outer travel lane, as well as encroachment into adjacent travel lanes.
- Lack of comfort for all users due to the minimal facilities provided.

Additional Considerations/Needed Assessment:

- If 10-foot lanes are considered, evaluate speed management methods to reduce vehicular speeds below 30 mph approaching the bridges.

Explored Option #3: Narrow the travel lanes to provide wider multi/use sidewalks

Purpose of this option: The intent of this option is to maintain existing vehicular operations while providing an option for bicyclists that do not feel comfortable sharing the outside lane with vehicles.

This option keep existing beacons and widens the existing sidewalks to 4.5 feet while maintaining four 11-foot travel lanes on the bridge, as shown in Exhibit 81. The 4.5-foot raised sidewalk serves both pedestrians and bicycles. The evaluation of this option illustrates the challenges and opportunities with creating shared space to accommodate bicycles and pedestrians within the existing cross-section.

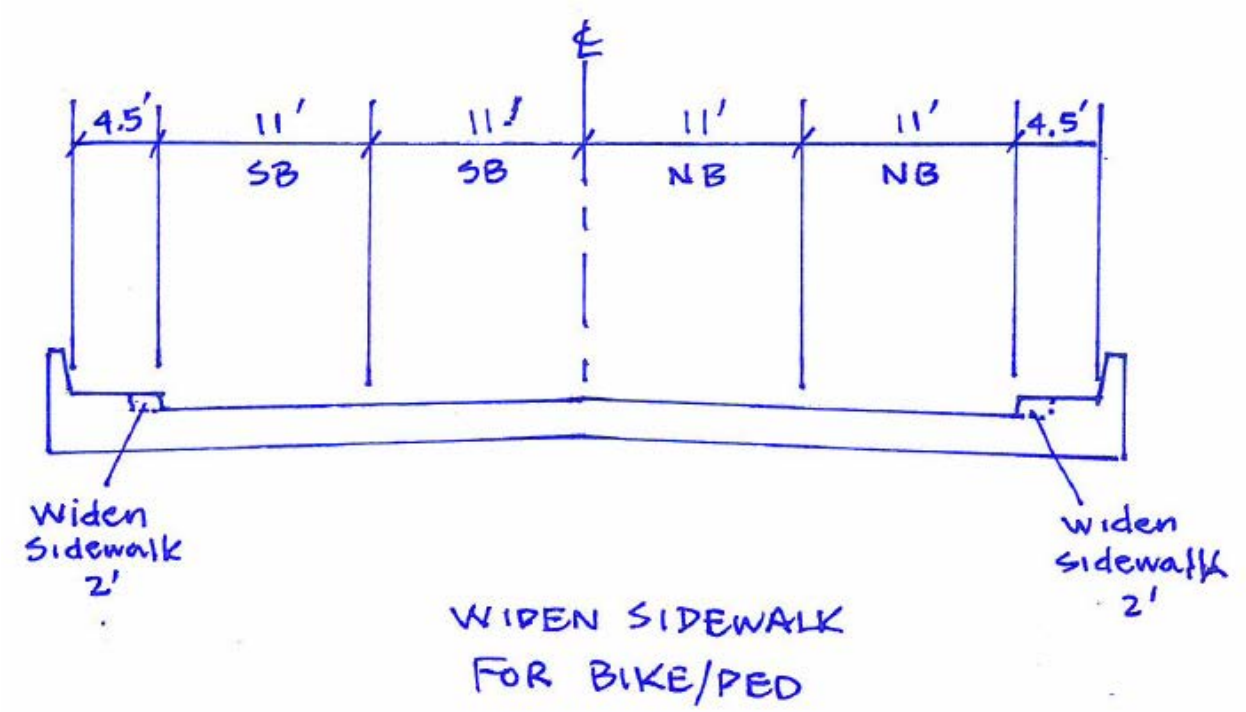

Exhibit 81. Option #3 cross-section with 11-foot travel lanes and wider sidewalks

Pros

- Four vehicle lanes maintained through this segment.
- Consistency with the suggested typical cross-section provided (e.g., 11-foot travel lanes).
- Narrower lanes may reduce vehicular speeds.
- A vertical separation between bicycles and auto traffic provided.
- An option for bicyclists who do not feel comfortable taking the lane is provided. Bicyclists can take the wider sidewalk and walk their bicycles over the bridge, if desired.
- Improved facility for pedestrians provided with wider sidewalk.

Cons

- The widened sidewalk is narrow and high for bicyclists, so may be uncomfortable for some riders (who feel it is too close to edge of the bridge with only a railing for protection). The 4.5 feet space for bicyclists between a vertical curb on the one side and the bridge railing on the other side may still result in bicyclists taking the outside travel lane.
- No shy distance is provided between the travel lanes and the face of the curb and may increase risk of sideswipe crashes.
- Given its narrow width, the shared bicycle/pedestrian space is not ideal for either mode.

Additional Considerations/Needed Assessment:

- Evaluate speed management methods to reduce vehicular speeds approaching the bridges as discussed in the previous "Speed and Cross-section Inconsistency" section (corridor-wide issue).

Explored Option #4: Northbound merge before bridges

Purpose of this option: The intent of this option is to provide enhanced bicycle facilities (i.e., buffered bicycle lanes), while maintaining 11-foot travel lanes.

This option modifies the existing cross-section by restriping within the existing pavement width to introduce buffered bicycle lanes and to reduce the number of lanes on the bridges to three travel lanes, as shown in Exhibit 82. Removing the fourth lane is accomplished by merging one of the northbound through lanes prior to the most southern bridge.

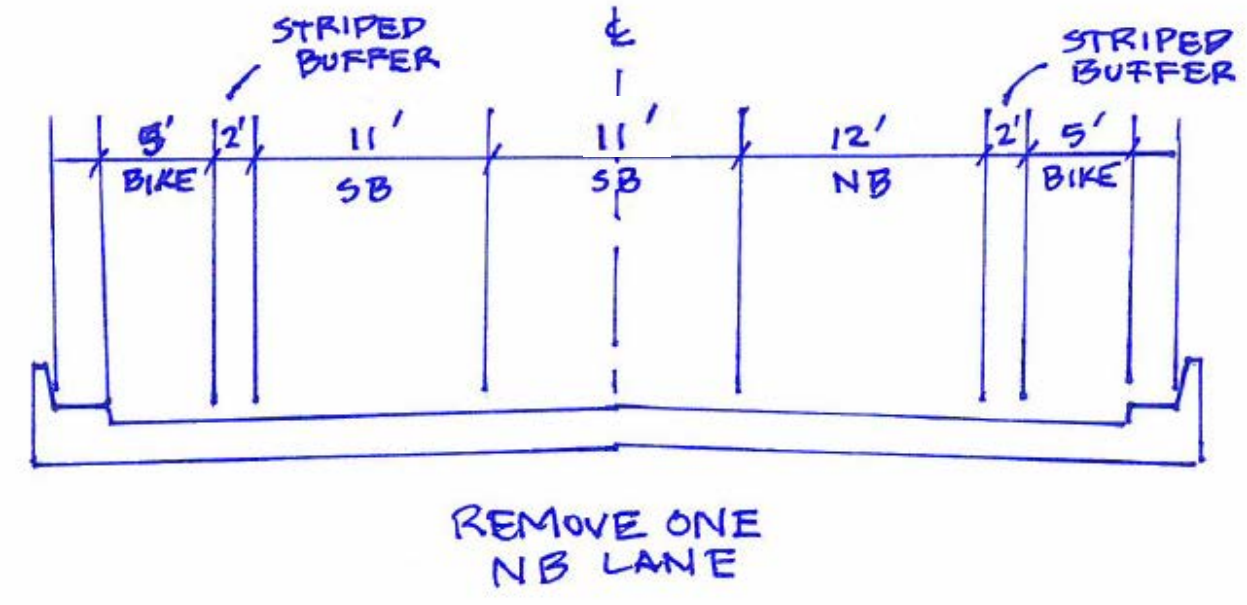

Exhibit 82. Option #4 cross-section with three-travel lanes and buffered bicycle lanes

Pros

- Buffered bicycle lanes provide additional protection and have demonstrated safety improvements over a typical bicycle lane.
- Speed management in the northbound direction created through the required merge before the bridges and single travel lane.
- Horizontal separation between bicycles and auto traffic provided.

Cons

- The ability to implement incident management (ICM) is limited with a single northbound travel lane, because northbound I-5 traffic may be redirected to the I-5 Terwilliger exit to bypass an incident to the north on I-5.
- Potential safety implications associated with the transition area at the two-to-one lane merge and the potential impact it may have on upstream signals.
- Increased congestion for northbound traffic anticipated, with impacts to upstream signals (SW Miles Street, SW Terwilliger Boulevard, SW Bertha Boulevard), which may result in increased rear-end crashes.
- Although Barbur Boulevard serves directional peak traffic (AM northbound into town and PM southbound out of town), there is a northbound PM peak in addition to the AM peak because of congestion on I-5 – motorists use Barbur Boulevard as an alternate to access the Ross Island Bridge). Therefore, this option has impacts during both the AM and PM peak periods.

Additional Considerations/Needed Assessment:

- The NCHRP Report 707: *Guidelines on the Use of Auxiliary through Lines at Signalized Intersections* provides guidance to analyze upstream signals (e.g., SW Miles St, SW Terwilliger Boulevard, SW Bertha

Boulevard) and well as developing the lane merge. Consider signal timing techniques and design strategies to encourage higher lane utilization for northbound traffic at the Barbur Boulevard/Terwilliger Boulevard intersection.

  - Reduce the green time on the approach to encourage the use of the outside auxiliary lane. Research indicates that providing less time for that approach results in higher utilization.
  - Provide overhead signage communicating the continuation of the outside lane through the intersection.

- Analyze impacts of design on route choice, travel time, delay, reliability, etc.

Explored Option #5: Southbound drop lane at SW Capitol Highway

Purpose of this option: As with Option #4, the intent of this option is to provide enhanced bicycle facilities (i.e., buffered bicycle lanes), while maintaining 11-foot travel lanes.

This option modifies the existing cross-section by restriping within the existing pavement width to introduce buffered bicycle lanes and to reduce the number of lanes on the bridge to three travel lanes, as shown in Exhibit 83. Removal of the fourth lane is accomplished by dropping the southbound outside lane into a right-turn only lane onto Capitol Highway. Based on recent 2-hour peak period traffic counts (April 2014), it appears the split between southbound Barbur/Capitol traffic is approximately between 50/50 and 60/40:

- AM Peak Period: southbound on Barbur Boulevard (773) and westbound on Capitol Highway (831)
- PM Peak Period: southbound on Barbur Boulevard (2,596) and westbound on Capitol Highway (1,795)

This traffic volume split supports the suggested right-turn lane channelization. This option will likely need overhead signage to clearly show the outside southbound drop lane.

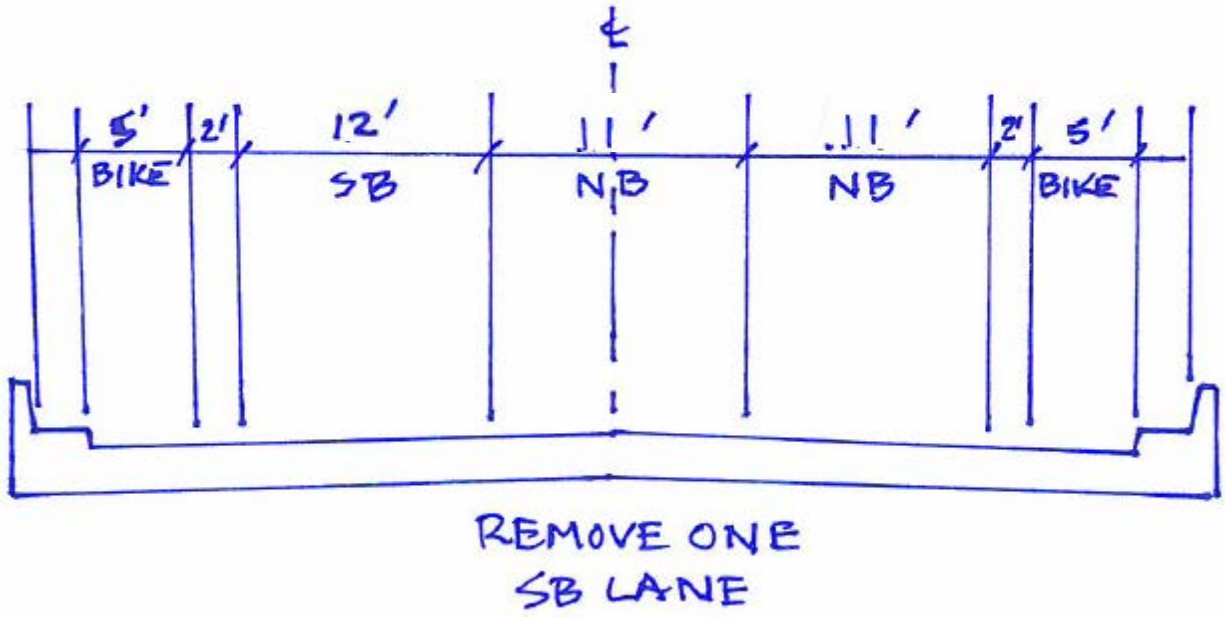

Exhibit 83. Option #5 cross-section with three-travel lanes and buffered bicycle lanes

Pros

- Buffered bicycle lanes consistent with the suggested typical cross-section provided.
- Speed management in the southbound direction created through the lane drop before the bridges and single travel lane.
- The suggested drop lane at SW Capitol Highway may also serve as speed management in the southbound direction beyond the bridges leading into the curve at Miles Street (where three fatalities have occurred in the last five years in the southbound direction).
- Horizontal separation between bicycles and auto traffic provided.
- Consistent with split of traffic volumes between Southbound Barbur Boulevard and Southbound SW Capitol Highway. During the afternoon peak period, the majority of vehicles using the outside lane currently turn onto SW Capitol Highway.

Cons

- The ability to implement incident management (ICM) is limited with a single southbound travel lane. However, accessing Barbur Boulevard from I-5 southbound is challenging and may only attract motorists already in downtown Portland.
- Increased congestion anticipated for southbound traffic with single travel lane through this segment.
- Safety implications associated with the transition area of the southbound bicycle lane across the southbound right-turn drop lane onto SW Capitol Highway.
- Potential last-minute southbound lane changes and the associated upstream effects on traffic at SW Hamilton Street signals.

Additional Considerations/Needed Assessment:

- Southbound buses stopping at the Parkhill Dr. bus stop (although limited) will block the bicycle lane and sidewalk and may encroach into the single travel lane. The RSA Team also discussed the removal of these bus stops with TriMet, which would need additional investigation.
- The bicycle lane will need to transition across the drop lane to SW Capitol Highway, potentially requiring a different treatment than currently used. More study is needed to assess the safety implications associated with the modified treatment.
- The single southbound through lane will need to transition on the Newbury Bridge.
- Need to analyze impacts of design on route choice, travel time, delay, reliability, etc.

Explored Option #6: Reversible travel lane

Purpose of this option: To provide enhanced bicycle facilities (i.e., buffered bicycle lanes) and more flexibility for vehicle operations than the three-lane cross-sections associated with Option #4 or Option #5.

This option modifies the existing cross-section by restriping within the existing pavement width to introduce buffered bicycle lanes and to reduce the number of lanes on the bridge to three travel lanes, as shown in Exhibit 84. This option creates a reversible lane to serve the peak direction when needed. Overhead variable signage consistent with the MUTCD will be required.

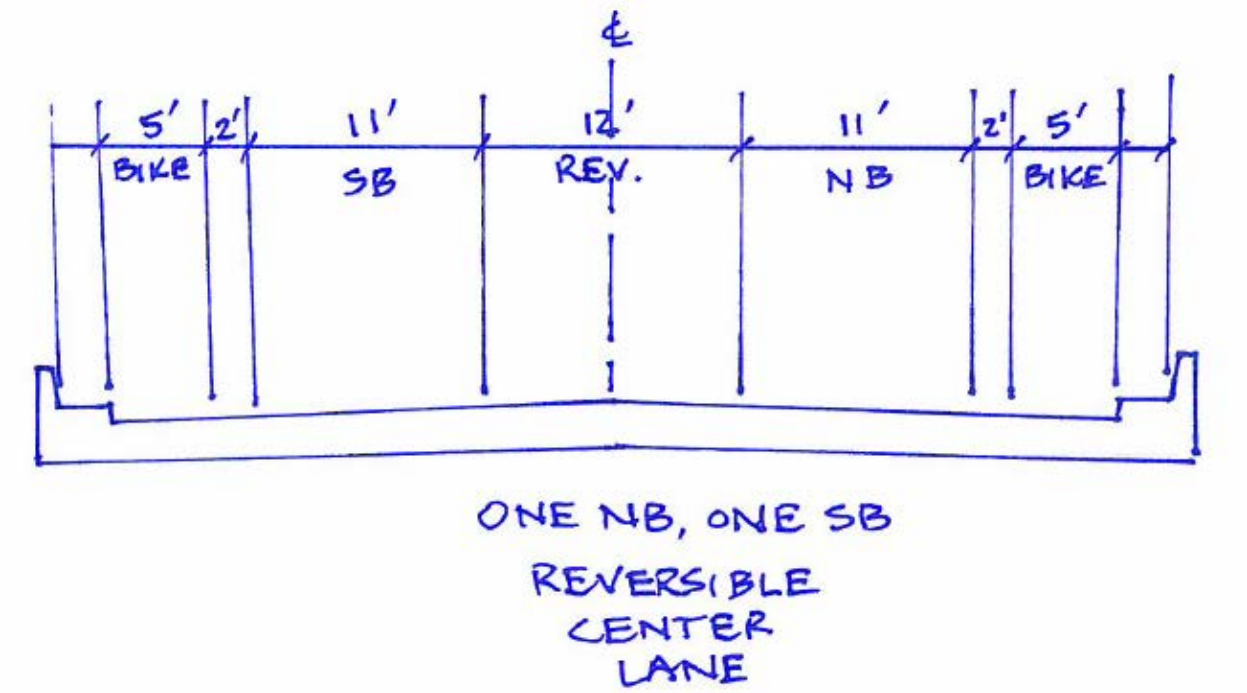

Exhibit 84. Option #6 cross-section with reversible center travel lane

Pros

- Buffered bicycle lanes consistent with the suggested typical cross-section provided.
- Speed management provided with the single travel lane based on the off-peak flow (e.g., when two northbound lanes are needed for the morning peak period, then the single lane southbound lane may result in slower speeds).
- Horizontal separation between bicycles and auto traffic provided.
- Additional directional capacity in the peak periods available with the reversible center travel lane.
- Ability to implement incident management (ICM) in either direction maintained based on the need (e.g., when the incident impacts northbound traffic, then the reversible lane will be implemented in the northbound direction.

Cons

- Driver confusion may be created with the reversible lane, especially when the lanes are flipped. This may increase the risk of potential rear-end, head-on and/or sideswipe crashes.
- The additional signage for the reversible configuration may detract from other conditions, such as the merges/diverges.
- Relatively high cost of implementation as well as on-going operation and maintenance costs, which may make this option infeasible as an intermediate option until the bridge structures can be replaced.
- Northbound volumes are nearly as high as southbound volumes in the PM peak, so the benefit of being able to use the reversible lane to serve dominant traffic volumes may not apply.

Additional Considerations/Needed Assessment:

- Driver education will be needed for drivers to learn the reversible travel lane operations.
- Transition points will be required at the beginning/end of the reversible lane.
- Need to analyze impacts of design on route choice, travel time, delay, reliability, etc.

Explored Option #7: One vehicle lane in each direction with protected bicycle lanes

Purpose of this option: Provide maximum space for bicyclists on both sides of the roadway.

This option modifies the existing cross-section by restriping within the existing pavement width to introduce protected bicycle lanes and to reduce the number of lanes on the bridge to two travel lanes, as shown in Exhibit 85. This option assumes one of the northbound lanes is merged and the southbound outside lane is dropped prior to the bridges, which influences traffic operations in both directions on Barbur Boulevard. This option provides the greatest degree of separation for bicyclists, but it may create unacceptable diversions and operational issues from a wider transportation system perspective. Also, while this option provides enhanced bicycle facilities across the bridges, these conditions are not provided on the remainder of the corridor.

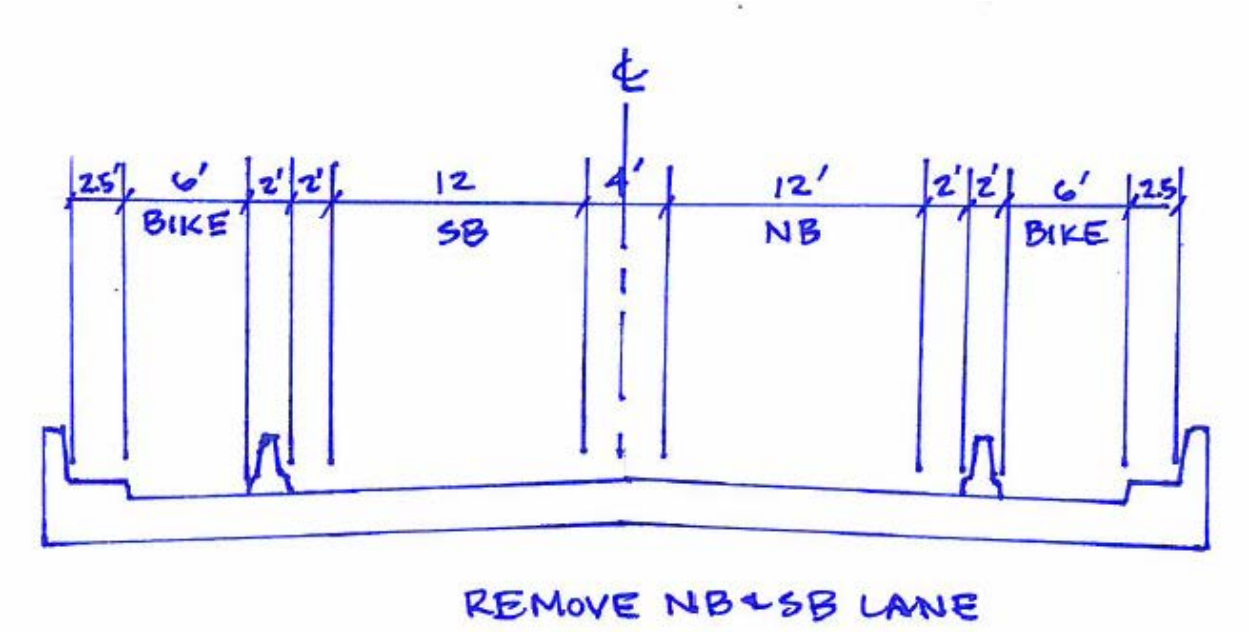

Exhibit 85. Option #7 cross-section with single travel lane in each direction and protected bicycle lanes

Pros

- Buffered or protected bicycle lanes consistent with the suggested cross-section provided (maximum protection for bicyclists of options presented).
- Speed management created in both directions through the single travel lane.
- Horizontal and physical separation between bicycles and auto traffic provided.

Cons

- Increased congestion for southbound and northbound traffic anticipated, with impacts to upstream signals (SW Miles St, SW Terwilliger Boulevard, SW Bertha Boulevard, SW Hamilton Street) , which may result in increased rear-end crashes.
- Incidents in this section could completely shut down the roadway.
- Limited ability to implement incident management (ICM) with single northbound and southbound travel lanes.
- Safety implications associated with the transition areas to/from the three-lane cross-section and anticipated congestion.

Additional Considerations/Needed Assessments:

- If a barrier is provided, it will produce additional dead load on the bridge.
- Need to analyze impacts of design on route choice, travel time, delay, reliability, etc.

BARBUR BOULEVARD/SW HAMILTON STREET INTERSECTION

Based on the reported crash data, the Barbur Boulevard/SW Hamilton Street intersection has the highest number of bicycle crashes along the corridor. The intersection includes two offset T-intersections. The RSA Team observed the following issues:

- Northbound bicycles going through the first intersection, which acts like a queue jump to give bicyclists a lead at the second intersection.
- There is a "No Turn on Red Sign" on the northbound approach, but it is unclear to what this sign refers.
- There is a northbound right-turn arrow provided at the five-section signal head, although there is no right-turn lane that serves the protected phase (Exhibit 86 left image).
- There is a high volume of northbound right-turning vehicles at the second intersection, presenting a potential conflict with through bicyclists (Exhibit 86 right image).
- The pedestrian phase on the west leg begins midway into the green phase and ends before the end of the green phase, creating a very short north-south pedestrian cycle.

Exhibit 86. Northbound approach to Barbur Boulevard/SW Hamilton Street

Crash data from the last five years at the offset T-intersections of SW Hamilton Street is shown in the crash diagrams in Exhibit 87 and summarized below:

- A total of 49 crashes at this combined offset T-intersections. Nine crashes were reported at the western leg of SW Hamilton Street and 40 crashes at the eastern leg of SW Hamilton Street.
- 27 of the total crashes were rear-end related crashes and six sideswipe crashes.
- 26 of the 49 crashes resulted in injuries, including one fatality.
- Three bicycle crashes were reported involving right-turning vehicles on the northbound approach to the eastern leg of SW Hamilton Street, all injury crashes.
- Three bicycle crashes were reported just north of the eastern leg of SW Hamilton Street, all driveway related.
- In addition, to the reported bicycle crashes, there is a high potential risk due to the vehicle/bicycle conflict. There are 65 and 51 bicycles going through these intersections during the weekday AM and PM peak hours, respectively.

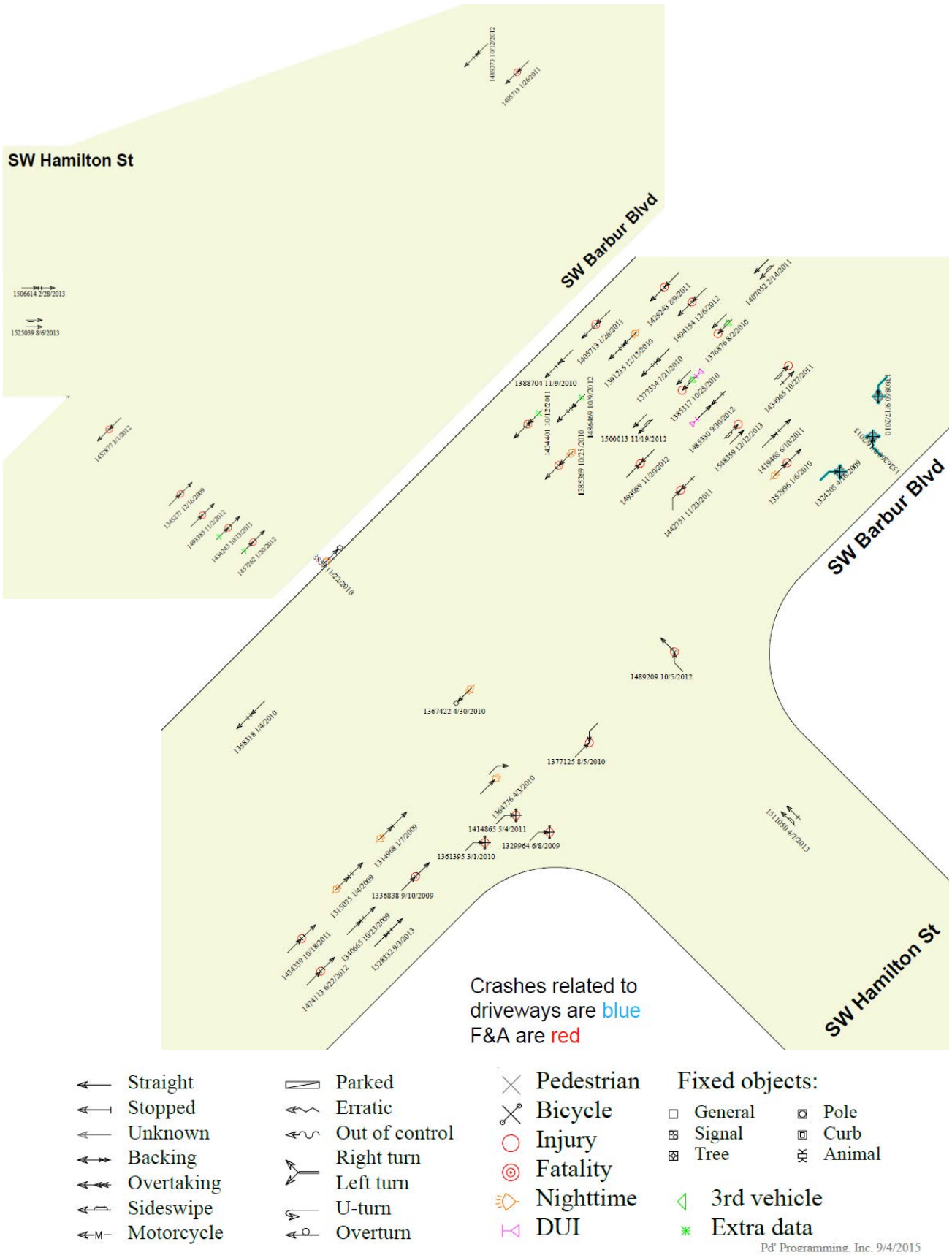

Exhibit 87. Crash Diagram for Barbur Boulevard/SW Hamilton Street (2009-2013)

Table 25. Qualitative Risk Rating of Barbur Boulevard/SW Hamilton Street Intersection

Function	Classification	Reasoning
Exposure	Category III	High volumes for all modes
Probability	Category III	Highest number of bicycle crashes
Consequence	Category III	High potential for high severity crashes
Overall	*Category III*	-

Near-term suggestions to improve the intersection of Barbur Boulevard/SW Hamilton Street:

- Increase the pedestrian timing and/or clearance interval in accordance with best practices (e.g., leading pedestrian interval), particularly on the west leg.
- Investigate whether the five-section head for the northbound right-turn should be removed or modified.
- Add a sign for northbound right-turning vehicles to yield to bicyclists and pedestrians and green paint in the bicycle lane through the intersection and bus stop to highlight the conflict area (Exhibit 88 left image). Provide warning pavement marking for bicyclists to watch for right-turning vehicles (Exhibit 88 right image).

Exhibit 88. Example signage and pavement markings for northbound right-turn

Intermediate suggestions to improve the intersection of Barbur Boulevard/SW Hamilton Street:

- Consider adding a sign or bicycle signal so that northbound bicyclists can legally go through the first signal to get a jump at the second signal.

Long-term suggestions to improve the intersection of Barbur Boulevard/SW Hamilton Street:

- Conduct a feasibility study to potentially simplify operations at these offset intersections. It is understood that SW Hamilton Street to the west provides access to OHSU, while to the east it serves the neighborhood between Barbur Boulevard and I-5, but also serves as a cut-through to the Ross Island Bridge.

BARBUR BOULEVARD SEGMENT: SW HAMILTON STREET TO SW NAITO PARKWAY

The RSA Team observed the following issues:

- In the southbound direction, a multi-use path is provided for pedestrians and bicyclists around the Barbur Boulevard/Naito Parkway merge.
- The bicycle wayfinding for the path is unclear and vegetation blocks a portion of the multi-use path and visibility of signage along the path, as shown in Exhibit 89.
- There are stairs with no delineation leading up to residences that extend into the path.
- In the northbound direction, bicyclists choosing to continue on Barbur Boulevard at the Barbur Boulevard/Naito split have to either transition across two travel lanes, or use the provided jughandle and pedestrian crossing (discussed in the next section).

Exhibit 89. Bicycle lane entrance to multi-use path around Naito Parkway (left), Stairs jutting in to multi-use path without signage or marking (right)

- Northbound (inbound) Barbur Boulevard's three lanes diverge with the center lane feeding both Naito and Barbur. Some last-minute lane changes were observed due to queuing in the outside lane to Naito.

Crash data (MP 2.01 to 2.28) from the last ten years between the SW Hamilton Street and Barbur Boulevard/SW Naito Parkway split is summarized below:

- 40 crashes along this road segment, including 16 turning, 16 rear-end related crashes, four sideswipe overtaking, two fixed object, one head-on, and one parking collision types.
- For the 16 rear-end crashes, the majority cited following too closely as a contributing cause. The majority of rear-end crashes occurred in the northbound direction on Barbur Boulevard.
- For the 19 turning crashes, 3 were U-turns, 9 right-turns, and 7 left-turns.

- 22 of the 40 crashes resulted in injuries. One fatal crash was reported, which was a fixed object crash. The crash occurred during dark with light conditions, on an icy roadway surface, with alcohol involved.
- Five crashes involved bicyclists, all of which were turning crashes.

Table 26. Qualitative Risk Rating of Barbur Boulevard Segment: SW Hamilton Street to SW Naito Parkway

Function	Classification	Reasoning
Exposure	Category III	High vehicle and bicycle volumes
Probability	Category III	High frequency of bicycle merging to continue northbound on Barbur Boulevard
Consequence	Category III	Potential for high severity crashes
Overall	*Category III*	-

Near-term suggestions to improve Barbur Boulevard between SW Hamilton Street and SW Naito Parkway:

- Provide symbols for bicyclists and pedestrians on the southbound multi-use path to define the space for each mode.
- Provide guide signage leading bicyclists up onto the multi-use path around the Barbur Boulevard/SW Naito Parkway merge.
- Trim or remove the overgrown vegetation on the multi-use path that blocks signage and impedes the path.
- Add object markers to the stairs on the multi-use path to warn bicyclists and pedestrians of this obstruction.

BARBUR BOULEVARD/SW NAITO PARKWAY DIVERGE

The RSA Team observed the following issues:

- Northbound (inbound) Barbur Boulevard splits with the rightmost two lanes leading to SW Naito Parkway and the leftmost two lanes continuing on Barbur Boulevard. The center lane approaching the split is an option lane.
- There is limited visibility at the pedestrian crossing on SW Naito Parkway, which crosses two travel lanes (see Exhibit 90).
- There is a bicycle ramp provided to a jughandle that turns bicyclists to the left to cross Naito Parkway. The ramp is steep and there is a lack of bicycle wayfinding signage.
- The RSA Team observed numerous last-minute lane changes in the road segment leading up to this diverge. These lane changes are likely drivers jumping the queue and then cutting into the line to access the Ross Island Bridge.

Exhibit 90. Bicycle ramp to jughandle and pedestrian crossing (left),

Crash data (MP 1.95 to 2.01) from the last ten years in the vicinity of the Barbur Boulevard/SW Naito Parkway split is summarized below:

- 25 crashes in the vicinity of the diverge, including two angle, thirteen rear-end related crashes, two sideswipe overtaking, three fixed object, two turning, and three pedestrian collision types.
- 14 of the 25 crashes resulted in injuries.
- Three pedestrian and two bicycle crashes were reported. The three crashes involving bicyclists were reported as turning or angle crashes.

Table 27. Qualitative Risk Rating of Barbur Boulevard/SW Naito Parkway Diverge

Function	Classification	Reasoning
Exposure	Category II	High volumes for all modes
Probability	Category III	High risk of multiple threat bicycle/pedestrian crossing
Consequence	Category III	High risk of higher severity crashes
Overall	*Category III*	-

Near-term suggestions to improve Barbur Boulevard/SW Naito Parkway:

- Relocate the gore further south using striping. This provides the opportunity to also move the bicycle ramp further south and creates additional space in advance of the crossing on SW Naito Parkway, as shown in Exhibit 91.

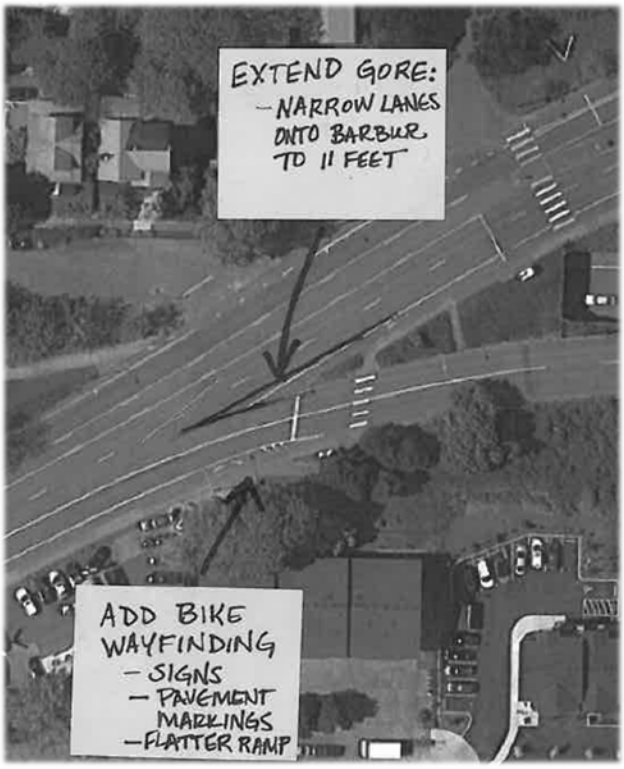

Exhibit 91. Concepts for Barbur Boulevard/SW Naito Pkwy Split

Intermediate suggestions to improve Barbur Boulevard/SW Naito Parkway:

- Modify the ramp for bicyclists to access the jughandle and provide wayfinding signage.
- Modify the crosswalk striping to include green paint to indicate it is for pedestrians and bicyclists, as shown in Exhibit 92.

Exhibit 92. Non-corridor example green paint through a crosswalk (Portland, OR)

Long-term suggestions to improve Barbur Boulevard/SW Naito Parkway:

- Provide overhead signage for vehicles indicating the lanes for Barbur Boulevard and SW Naito Parkway to provide better guidance for vehicles and minimize potential conflicts due to lane changes.
- Install a RRFB at the SW Naito Parkway crossing including overhead signage/beacon for the enhanced crossing.

Summary of Findings and Suggestions

Summary of Findings and Suggestions

Table 28 and Table 29 index all issues identified during the RSA and are formatted to allow ODOT an efficient way to provide a response to each safety issue.

Table 28. Summary of Corridor-wide Issues, Risk, and Suggestions

Issue	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Speed and Cross-section Inconsistency	III	*Near-term suggestions to address corridor speeds and cross-section inconsistency:* ▪ Consider enforcement strategies such as photo radar, as well as education strategies that may include speed feedback signs.	
		Intermediate suggestions to address corridor speeds and cross-section inconsistency: ▪ Narrow travel lanes (12 feet to 11 feet) to provide the opportunity for buffered bicycle lanes, per suggested cross-section in Exhibit 15. It is understood that this cross-section may not be able to be implemented throughout the entire study corridor in the near- to medium-term due to physical constraints such as the Newbury, Vermont, and Multnomah (at Safeway) Bridges, as well as the embankment section just north of the SW Capitol Hill Road-SW 19th Avenue intersection. ▪ Repurpose on-street parking to provide continuous pedestrian and bicycle facilities along the corridor's length, per the suggested cross-section in Exhibit 16. ▪ Explore opportunities to provide medians for access and speed management.	
		Long-term suggestions to address corridor speeds and cross-section inconsistency: ▪ Identify and establish an appropriate target speed based on the surrounding context and for the desired outcome.	
Access Management	III	*Near-term suggestions to address access management:* ▪ At select locations, add edge line on outside of bicycle lane next to wide accesses where there is no curb.	
		Intermediate suggestions to address access management: ▪ Modify bicycle lane striping and use green paint at high volume driveways.	
		Long-term suggestions to address access management: ▪ Consolidate driveways and explore opportunities to address access management through redevelopment. ▪ Better define driveways (e.g., with extruded curbs or as part of redevelopment constructing a narrower driveway) and provide consistent bicycle lane striping and sidewalks through driveways.	

Issue	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Skewed Intersections/Driveways	II	*Near-term suggestions to address skewed intersections/driveways:* ▪ Explore opportunities to improve sight distance at intersections/driveways (e.g., maintain vegetation and/or consider removing on-street parking).	
		Intermediate suggestions to address skewed intersections/driveways: ▪ Revisit whether right-turn lanes are needed. ▪ Look for opportunities to slow higher speed right-turners by reducing turning radii.	
		Long-term suggestions to address skewed intersections/driveways: ▪ Explore opportunities to realign driveways/side streets to intersect Barbur Boulevard at a desirable perpendicular angle, as well as providing adequate sight distance at unsignalized driveways/intersections.	
Bicycle Facilities	III	*Near-term suggestions to address bicycle lane gaps and deficiencies:* ▪ Provide clear direction for drivers and bicyclists through pavement markings at conflict areas, including: o At select locations, carrying bicycle lane markings through accesses/driveway areas. o Shortening skipped bicycle striping at transition/conflict areas to minimize weaving-section across bicycle lane.	
		Intermediate suggestions to address bicycle lane gaps and deficiencies: ▪ Provide clear direction for drivers and bicyclists through pavement markings at conflict areas, including: o Using green pavement marking at intersections and driveways with high volumes of right-turns. o Eliminating on-street parking where possible. o Extending skipped bicycle striping through wide intersections to guide bicyclists and bring attention to bicycles on the roadway (as seen in Exhibit 23). ▪ Provide consistent bicycle facilities by: o Restriping the roadway to narrow travel lanes where possible in order to provide bicycle accommodations (consistent with suggested corridor cross-section, see previous “Speed and Cross-section Inconsistency” section), including buffered bike lane.	
		Long-term suggestions to address bicycle lane gaps and deficiencies: ▪ Fill missing links in the bicycle facilities by: o Create shared pedestrian and bicycle space where width is limited. o Where there is insufficient roadway width, either widen the highway cross-section or provide alternative location to provide bicycle facilities.	

Issue	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Pedestrian Facilities	II	*Near-term suggestions to address pedestrian facility gaps and deficiencies:* ▪ Look for opportunities for frontage improvements with development, including bicycle lanes and sidewalks. ▪ Upgrade striping at crossings with double-white no passing markings (in place of dashed lane line striping) leading up to midblock crossings.	
		Intermediate suggestions to address pedestrian facility gaps and deficiencies: ▪ Provide concrete sidewalks across driveways. ▪ Narrow travel lanes to provide room for pedestrian facilities where topography is limiting (e.g. south of Alice Street, see later "Barbur Boulevard Segment: SW Taylors Ferry Road to SW 30th Avenue" section). ▪ Continue to explore locations to provide additional enhanced crossings in collaboration with TriMet to provide more frequent crossings along the study corridor.	
		Long-term suggestions to address pedestrian facility gaps and deficiencies: ▪ Prioritize the sections of sidewalk that are needed to fill critical gaps. ▪ Include updating sidewalks and curb ramps to ADA standards with programmed projects.	
Lighting Needs	II	*Near-term suggestions to improve limited lighting:* ▪ Maintain tree canopies in the vicinity of street light poles to provide desired light levels.	
		Intermediate suggestions to improve limited lighting: ▪ Continue installing consistent LED lighting along the corridor where old HPS lighting still exists, consistent with ongoing efforts by PBOT. ▪ Evaluate lighting at intersections and enhanced crossings along the corridor and provide improved lighting where needed. The intent is to light crossing locations from the front to illuminate pedestrians for approaching vehicles.	
Inconsistent Signage and Striping	I	*Near-term suggestions to address inconsistent signage and striping:* ▪ Clear and maintain vegetation along the corridor. ▪ Reevaluate wayfinding signage and find opportunities to clarify signage. ▪ Relocate and replace signage as appropriate. ▪ Consider advance intersection signage ("Next Signal" signs) for better wayfinding.	
		Intermediate suggestions to address inconsistent signage and striping: ▪ Use consistent pavement markings along the corridor, especially through driveways and conflict areas (green paint, bike lane extensions and shortening dashed bike lanes in transition areas).	
		Intermediate to long-term suggestions to address inconsistent signage and striping: ▪ Considering overhead signage to increase visibility.	

Issue	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Pavement Quality in Bicycle Lanes	I	*Near-term suggestions to address undesirable pavement quality:* ▪ Provide and maintain clear, smooth bicycle facilities. ▪ Level grate inlets by removing any abrupt vertical elevation between pavement and inlet, as appropriate.	
		Intermediate to long-term suggestions to address undesirable pavement quality: ▪ Consider bicycle lane conditions and opportunities for improvement during overlay and construction. o The RSA Team is aware that any pavement preservation project up to the curb may trigger ADA improvements. The team suggests that when there is any improvement, the project should consider addressing uneven bicycle lane conditions without changing the scope of the specific project.	
		Long-term suggestions to address undesirable pavement quality: ▪ Relocate pavement seam and align with bicycle lane or auto lane lines to avoid seam in bicycle lane.	

Table 29. Summary of Intersection/Location Issues, Risk, and Suggestions

Location	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Barbur Boulevard/SW Capitol Highway Intersection	III	*Near-term suggestions to improve Barbur Boulevard/SW Capitol Highway:* ▪ Install retro-reflective backplates and supplemental signal heads to address "disregarded traffic signal" related crashes. ▪ Revisit signal head orientation and/or installing programmable signal heads to address acute angle related crashes. ▪ Provide clear directional signage for SW Huber Street and SW Taylors Ferry Road jughandles, directing vehicles to continue through the intersection and make a downstream left (since left-turns are not allowed at the intersection) (See Exhibit 34). This suggestion needs to be analyzed to understand the potential impacts on the key intersections within the jughandle configurations.	
		Intermediate suggestions to improve Barbur Boulevard/SW Capitol Highway: ▪ Better define accesses (e.g., narrowing driveways) in the southbound Barbur Boulevard right-turn lane to minimize conflict areas with bicyclists and vehicles. ▪ Narrow the travel lanes and provide a wider bicycle lane with buffer (4.5 feet currently between through and right turn lanes over a length of approximately 540 feet) – consistent with suggested corridor cross-section. ▪ Add green pavement markings at bicycle/vehicle conflict points, such as the southbound bicycle lane at Barbur Foods. ▪ Explore removing the southbound bus-only left-turn lane to minimize driver confusion and provide additional width for bicycle and pedestrian facilities. ▪ Remove northbound right-turn lane at Huber (Exhibit 35 left image) and provide bicycle lane, as well as better define shared northbound bus/bicycle lane at SW Capitol Highway intersection (Exhibit 35 right image). ▪ Consider restriping opportunities along Capitol Highway to potentially add bicycle lanes: o Eastbound approach (Capitol Highway – south leg on exhibit) towards Barbur Boulevard: ▪ Right: serving rights to I-5 southbound on-ramp, as well as onto Barbur Boulevard ▪ Through: continuing through on SW Capitol Highway o Westbound approach (Capitol Highway – north leg on exhibit) towards Barbur Boulevard: ▪ Right: serving rights onto Barbur Boulevard ▪ Through: continuing through on SW Capitol Highway	

Location	Qualitative Risk Rating	Suggestions	Agency Response/Comment
		Long-term suggestions to improve Barbur Boulevard/SW Capitol Highway: ▪ Remove all left-turns at main intersection, as shown in Exhibit 36. ▪ Improve the existing SW Taylors Ferry Road/SW Capitol Highway intersection with a signal or single-lane roundabout, maintaining a channelized eastbound right-turn. ▪ Consider options for better traffic control and improve the jughandles to provide separation of turning movements, such as: o Relocate I-5 southbound on-ramp to the existing I-5 southbound off-ramp/Taylors Ferry Road intersection (see Exhibit 37), o Develop two offset T-intersections of Capitol Highway with Barbur Boulevard (see Exhibit 38), or o Develop two offset T-intersections of Capitol Highway (east) and Taylors Ferry Road (west) with Barbur Boulevard (see Exhibit 39). ▪ Consider an intersection/interchange preliminary design study to identify future needs at this location and identify property impacts.	
Barbur Boulevard Segment: SW Taylors Ferry Road Area	I	*Near-term suggestions to improve segment of Barbur Boulevard between two intersections of SW Taylors Ferry Road:* ▪ Install wayfinding signage for pedestrians through the transit center. ▪ Add a defined pedestrian crossing across the southern entrance to the transit center.	
		Intermediate to long-term suggestions to improve segment of Barbur Boulevard between two intersections of SW Taylors Ferry Road: ▪ Where there are gaps, infill sidewalk and perform ADA upgrades. ▪ Remove on-street parking to provide space for sidewalks and/or buffered bicycle lanes to enhance route continuity for pedestrians and bicyclists.	
Barbur Boulevard Segment: SW Taylors Ferry Road to SW 30th Avenue	I	*Intermediate to long-term suggestions to improve Barbur Boulevard between SW Taylors Ferry Road and SW 30th Avenue:* ▪ Shift alignment to the east by removing parking and add sidewalk and a buffered bicycle lane on the west side of the roadway – consistent with suggested corridor cross-section. This also provides better sight distance for drivers on SW Alice Street. A conceptual sketch for this improvement is provided in Exhibit 44.	
Barbur Boulevard/SW 30th Avenue Intersection	II	*Intermediate suggestions to improve intersection of Barbur Boulevard/SW 30th Avenue:* ▪ Remove on-street parking and provide appropriate bicycle lane striping (see previous "Bicycle Lane Gaps and Deficiencies" section.	
		Long-term suggestions to improve intersection of Barbur Boulevard/SW 30th Avenue: ▪ Consolidate and define driveways.	

Location	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Barbur Boulevard Segment: SW 30th Avenue to SW 24th Avenue	II	*Intermediate suggestions to improve Barbur Boulevard between SW 30th Avenue and SW 24th Avenue:* ▪ Remove the southbound right-turn lane onto SW 26th Way. ▪ Consider consolidating bus stops with improved pedestrian access (i.e., once gaps in the sidewalk network are filled) within this segment by improving the transit stops at SW 30th Avenue and SW 24th Avenue. ▪ Implement the typical suggested corridor cross-section to provide more space for sidewalks and/or buffered bicycle lanes.	
		Long-term suggestions to improve Barbur Boulevard between SW 30th Avenue and SW 24th Avenue: ▪ Tighten the right-turns from Barbur Boulevard to SW Barbur Court and from SW Barbur Court to Barbur Boulevard.	
Barbur Boulevard/SW 24th Avenue Intersection	II	*Near-term suggestions to improve intersection of Barbur Boulevard/SW 24th Avenue:* ▪ Improve signage to I-5 north of SW 24th Avenue, which is obscured by vegetation (Exhibit 52). ▪ Consider updating traffic signal phasing and timing to address turning movement crashes, as well as revisit the all red interval.	
		Intermediate suggestions to improve intersection of Barbur Boulevard/SW 24th Avenue: ▪ Remove right turn /deceleration lane southwest of 24th Avenue to allow for continuous bicycle lane.	
		Long-term suggestions to improve intersection of Barbur Boulevard/SW 24th Avenue: ▪ Implement access management strategies, especially access to Pancake House. The RSA Team understands that the Pancake House may have a historic designation and that any modifications to its access may be challenging. ▪ Assess the potential to remove or relocate the I-5 southbound off-ramp at this intersection, given other I-5 southbound off-ramps within the study corridor. While the team reviewed connections to and from I-5 along the corridor, a more extensive study is needed to evaluate the feasibility of potentially removing an off-ramp.	

Location	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Barbur Boulevard Segment: SW 24th Avenue to Multnomah Boulevard Overpass	III	*Intermediate suggestions to improve Barbur Boulevard between SW 24th Avenue and Multnomah Crossing:* ▪ Modify the angle of the northbound right-turn lane to Spring Garden Street to encourage slower speeds. ▪ Explore shortening or removing the southbound right-turn lane to Spring Garden Street to reduce the conflict area between bicyclists and vehicles.	
		Long-term suggestions to improve Barbur Boulevard between SW 24th Avenue and Multnomah Crossing: ▪ Combine SW 22nd Avenue and SW Spring Garden Street on the east side of the intersection by T-ing them into a single intersection (this would entail right-of-way impacts). ▪ Explore opportunities to realign sidestreet to intersect with Barbur Boulevard more perpendicular. ▪ Consider options for the bridge that narrow the travel lanes to provide improved shared bicycle and pedestrian facilities, as shown in Exhibit 55. These options need to be evaluated to determine how the cross-section on the bridge would transition to/from the adjacent approaching road segments. ▪ Explore a bicycle-only connection via SW Carson Street and/or SW Hume Court to Multnomah Boulevard (which would require a steep ramp down) to provide an option for bicyclists to bypass Barbur Boulevard (between Multnomah Bridge and the SW Terwilliger Boulevard intersection) via SW Multnomah Boulevard. ▪ Replace the Multnomah Bridge to provide the desired cross-sectional dimensions based on the corridor vision and the adjacent road segments approaching the bridge.	
Barbur Boulevard/SW Capitol Hill Rd/19th Ave Intersection	II	*Intermediate suggestions to improve intersection of Barbur Boulevard/SW Capitol Hill Road/19th Avenue:* ▪ Consider relocating the northbound bus stop from the nearside to the far-side of the intersection. ▪ Restripe the parking stalls on the southeast corner of the intersection (at Humdinger) to further separate the parking stalls from the roadway and bicycle and pedestrian facilities. Utilize striping to define bicycle and pedestrian space along this parking.	
		Long-term suggestions to improve intersection of Barbur Boulevard/SW Capitol Hill Road/19th Avenue: ▪ Consider removing the northbound right-turn lane to provide bicycle and pedestrian facilities through the intersection, which will likely require modifications to the existing pedestrian island. ▪ If no widening is planned, then consider changing the intersection configuration by reducing lanes to 10.5 feet and providing 4-foot minimum bicycle lanes through the intersection (Exhibit 59 shows a conceptual intersection layout). There is approximately 60 feet of width available immediately north of the intersection.	

Location	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Barbur Boulevard Segment: SW Capitol Hill Rd to SW 13th Street	II	*Intermediate suggestions to improve Barbur Boulevard between SW Capitol Hill Road and SW 13th Avenue:* ▪ Remove parking to improve sight distance and potentially provide wider or buffered bicycle lanes for the segment north of the embankment.	
		Long-term suggestions to improve Barbur Boulevard between SW Capitol Hill Road and SW 13th Avenue: ▪ Infill sidewalk gaps on the east side of the roadway and address ADA issues. ▪ Implement access management strategies as part of redevelopment. ▪ Consider modifying the cross-section over the embankment to either restripe within the existing guardrails or widen onto the existing road prism with a barrier, as shown in Exhibit 62.	
Barbur Boulevard Segment: SW 13th Street to SW Bertha Boulevard	II	*Intermediate suggestions to improve Barbur Boulevard between SW 13th Avenue and SW Bertha Boulevard:* ▪ Shorten the skipped bicycle striping portion of the right-turn lane transition on the southbound approach to SW Custer Street to minimize the conflict area with bicyclists. ▪ Add green pavement markings to the bicycle lane to indicate key conflict areas at major driveways, bus pullouts, and at SW 13th Avenue.	
		Long-term suggestions to improve Barbur Boulevard between SW 13th Avenue and SW Bertha Boulevard: ▪ Consider working with Fred Meyer to develop parking management strategies and informational signage or systems at Fred Meyer's driveways, particularly the northern driveway, to discourage drivers from entering lots that are full and minimize queues that back onto the highway. ▪ Consider shortening the right turn lane for SW Custer Street so that the southernmost Fred Meyer driveway is not in the right-turn lane for SW Custer Street.	
Barbur Boulevard/SW Bertha Boulevard Intersection	II	*Near-term suggestions to improve intersection of Barbur Boulevard/SW Bertha Boulevard:* ▪ Maintain vegetation at the intersection to improve visibility of pedestrians on the northeast corner.	
		Intermediate suggestions to improve intersection of Barbur Boulevard/SW Bertha Boulevard: ▪ Use a smaller curb radius on the northeast corner to orient pedestrians towards traffic. Such a modification should accommodate the appropriate design vehicle, since this intersection is part of a ramp terminal. ▪ Modify the sidewalk on the northeast corner to create a curb tight sidewalk at the intersection to provide better visibility between motorists and pedestrians.	
		Long-term suggestions to improve intersection of Barbur Boulevard/SW Bertha Boulevard: ▪ Improve intersection geometry to remove the split phasing and allow more efficient signal timing operations.	

Location	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Barbur Boulevard Segment: SW Bertha Boulevard to SW Terwilliger Boulevard	III	*Near-term suggestions to improve Barbur Boulevard between SW Bertha Boulevard and SW Terwilliger Boulevard:* ▪ Emphasize the conflict area for the eastbound weave across the bicycle lane with green paint (see bottom half of sketch, Exhibit 69).	
		Intermediate suggestions to improve Barbur Boulevard between SW Bertha Boulevard and SW Terwilliger Boulevard: ▪ Shorten the transition into the westbound right-turn lane and define the bus stop location, potentially with a curb extension for better channelization (see top half of sketch, Exhibit 69).	
		Long-term suggestions to improve Barbur Boulevard between SW Bertha Boulevard and SW Terwilliger Boulevard: ▪ Add sidewalk on the south side of Barbur Boulevard.	
Barbur Boulevard/SW Terwilliger Boulevard Intersection	III	*Near-term suggestions to improve intersection of Barbur Boulevard/SW Terwilliger Boulevard:* ▪ Evaluate and optimize signal timing at the intersection and coordination with the I-5 off-ramp, particularly for SW Terwilliger Boulevard.	
		Intermediate suggestions to improve intersection of Barbur Boulevard/SW Terwilliger Boulevard: ▪ Coordinate with TriMet (bus drivers) to determine a consistent approach for buses traveling southbound on Barbur Boulevard through this intersection. Considerations include: o For consistency, all buses use upstream right-turn lane to enter downstream bus stop to eliminate buses transitioning from the through lane to the bus stop through the intersection and across the bicycle lane. o Move bus stop to near-side to create queue jump lane. ▪ Consider red light running enforcement; however no crashes were reported, but red lighting was observed. ▪ Consider bicycle box/storage for left-turns from SW Barbur Boulevard and general wayfinding for bicyclists. ▪ Investigate lengthening the southbound left-turn pocket. ▪ Add green pavement markings in the northbound bicycle lane to address right turn queuing across the bicycle lane.	
		Long-term suggestions to improve intersection of Barbur Boulevard/SW Terwilliger Boulevard: ▪ Improve intersection geometry by potentially providing dual left-turn lanes to accommodate the high left-turn movements.	

Location	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Barbur Boulevard/SW Miles Street Intersection	I	*Near-term suggestions to improve Barbur Boulevard/SW Miles Street:* ▪ Trim and maintain vegetation to provide better sight distance from the side streets. ▪ Consider improved delineation of the island on the westbound Miles Street approach (Exhibit 74).	
		Intermediate suggestions to improve Barbur Boulevard/SW Miles Street: ▪ Better define the intersection radius (potential curb extension to differentiate on-street parking on Miles Street) on the east leg of SW Miles Street and use green paint to define the bicycle lane through the intersection. ▪ Consider consolidating the northbound bus stops at SW Miles Street and SW Brier Place.	
		Long-term suggestions to improve Barbur Boulevard/SW Miles Street: ▪ Conduct a feasibility study to potentially remove one of the side-street legs of the intersection to address the offset approaches of the intersection.	
Barbur Boulevard Segment: Horizontal Curve North of SW Miles Street	II	*Near-term suggestions to improve Barbur Boulevard from SW Miles Street through curve:* ▪ Add delineation to the curve in the northbound direction.	
Barbur Boulevard Segment: Wooded Section to SW Hamilton Street	III	*Near-term suggestions to improve the Vermont and Newbury bridges:* ▪ Install 4-inch edge line on the bridges to improve visibility, particularly at night. ▪ Add pavement symbols indicating the loops that actuate the warning lights on the bridges so bicyclists are aware of where they need to ride. ▪ Consider signage or striping to encourage bicyclists to take the outside travel lane across the bridges.	
		Intermediate suggestions to improve the Vermont and Newbury bridges: ▪ Add additional detection upstream of the existing northbound loops (in the downhill direction) so bicyclists who choose to merge into the travel lane earlier still activate the warning lights. Consider different detectors than inductive loops to detect non-metallic bicycles. ▪ Consider speed management techniques, such as: o Install a speed feedback sign in the northbound direction prior to the bridges. o Increase enforcement, such as fixed photo radar along this segment. o Consider installing transverse rumble strips in advance of the bicycle warning signs to increase driver awareness - applicability of this treatment to be evaluated for noise impact on adjacent neighborhoods. o Consider techniques to improve delineation, such as using recessed raised pavement markers (RRPM) to narrow the travel lanes to help decrease vehicle speeds. ▪ Install yellow RRPM inside the 'A' lane (double yellow) ▪ Install white RRPM along the lane line pavement marking	

Location	Qualitative Risk Rating	Suggestions	Agency Response/Comment
		Long-term suggestions to improve the Vermont and Newbury bridges: ▪ Replace the Vermont and Newbury bridges to provide the desired cross-sectional dimensions based on the corridor vision and the adjacent road segments approaching the bridges.	
		Further suggestions without consensus to improve the Wooded Section (Vermont and Newbury bridges) ▪ The RSA team explored a wide range of options along the two existing bridges between SW Terwilliger Boulevard and SW Hamilton Street, and there is no preferred option within the existing cross section of the structures. The team suggests studying and evaluating the trade-offs associated with these options and how they compare to the evolving vision of the corridor. o Explored Option #1: Maintain the existing bridge structure and cross-section. o Explored Option #2: Narrow the travel lanes to provide bicycle lanes o Explored Option #3: Narrow the travel lanes to provide wider sidewalks o Explored Option #4: Northbound merge before bridges o Explored Option #5: Southbound drop lane at SW Capitol Highway o Explored Option #6: Reversible travel lane o Explored Option #7: One vehicle lane in each direction with protected bicycle lanes	
Barbur Boulevard/SW Hamilton Street Intersection	III	*Near-term suggestions to improve the intersection of Barbur Boulevard/SW Hamilton Street:* ▪ Increase the pedestrian timing and/or clearance interval in accordance with best practices (e.g., leading pedestrian interval), particularly on the west leg. ▪ Investigate whether the five-section head for the northbound right-turn should be removed or modified. ▪ Add a sign for northbound right-turning vehicles to yield to bicyclists and pedestrians and green paint in the bicycle lane through the intersection and bus stop to highlight the conflict area (Exhibit 88 left image). Provide warning pavement marking for bicyclists to watch for right-turning vehicles (Exhibit 88 right image).	
		Intermediate suggestions to improve the intersection of Barbur Boulevard/SW Hamilton Street: ▪ Consider adding a sign or bicycle signal so that northbound bicyclists can legally go through the first signal to get a jump at the second signal.	
		Long-term suggestions to improve the intersection of Barbur Boulevard/SW Hamilton Street: ▪ Conduct a feasibility study to potentially simplify operations at these offset intersections. It is understood that SW Hamilton Street to the west provides access to OHSU, while to the east it serves the neighborhood between Barbur Boulevard and I-5, but also serves as a cut-through to the Ross Island Bridge.	

Location	Qualitative Risk Rating	Suggestions	Agency Response/Comment
Barbur Boulevard Segment: SW Hamilton Street to SW Naito Parkway	III	*Near-term suggestions to improve Barbur Boulevard between SW Hamilton Street and SW Naito Parkway:* ▪ Provide symbols for bicyclists and pedestrians on the southbound multi-use path to define the space for each mode. ▪ Provide guide signage leading bicyclists up onto the multi-use path around the Barbur Boulevard/SW Naito Parkway merge. ▪ Trim or remove the overgrown vegetation on the multi-use path that blocks signage and impedes the path. ▪ Add object markers to the stairs on the multi-use path to warn bicyclists and pedestrians of this obstruction.	
Barbur Boulevard/W Naito Parkway Diverge	III	*Near-term suggestions to improve Barbur Boulevard/SW Naito Parkway:* ▪ Relocate the gore further south using striping. This provides the opportunity to also move the bicycle ramp further south and creates additional space in advance of the crossing on SW Naito Parkway, as shown in Exhibit 92.	
		Intermediate suggestions to improve Barbur Boulevard/SW Naito Parkway: ▪ Modify the ramp for bicyclists to access the jughandle and provide wayfinding signage. ▪ Modify the crosswalk striping to include green paint to indicate it is for pedestrians and bicyclists, as shown in Exhibit 91.	
		Long-term suggestions to improve Barbur Boulevard/SW Naito Parkway: ▪ Provide overhead signage for vehicles indicating the lanes for Barbur Boulevard and SW Naito Parkway to provide better guidance for vehicles and minimize potential conflicts due to lane changes. ▪ Install a RRFB at the SW Naito Parkway crossing including overhead signage/beacon for the enhanced crossing.	