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MEMORANDUM

DATE: January 11, 2017

TO: Project Management Team

FROM: DKS Associates: Scott Mansur, P.E., PTOE and Lacy Brown, Ph.D., P.E.
Toole Design Group: Jessica Zdeb, AICP

SUBJECT: **Winter-Maple Bikeway: Existing Conditions Transportation Analysis** P14180-017

Introduction

The City of Salem's Transportation System Plan (TSP) Bicycle Element (adopted in 2014) identifies the Winter-Maple Family Friendly Bikeway (WMFFB) as a Tier 1–High Priority project for implementation. The approved alignment, shown on Figure 1 on the following page, follows Winter Street north from the Capitol Mall. After approximately one mile, the route shifts one block west to Cottage Street, then shifts west again to Maple Avenue. Near the northern end of alignment, Maple Avenue becomes Auto Group Avenue. The route follows Auto Group Avenue to the east, and then continues north on Cherry Avenue to Salem Parkway, where it connects with the existing multi-use path that parallels the north side of Salem Parkway. The approved alignment is approximately 2.5 miles long.

While the general alignment has been identified, specific physical, operational, and signage improvements are necessary to create an attractive, safe and convenient route for bicycling and walking while providing local access at appropriate speeds. The primary objective of this Project is to develop a streetscape to better accommodate multimodal circulation, improve safety for all modes, encourage a healthy lifestyle and support uses adjacent to the WMFFB.

This memorandum outlines the existing transportation conditions in the study area, including safety and operational performance for vehicles, pedestrians, and bicyclists.

LEGEND

- Study Intersection
- Proposed Bikeway Alignment

DKS

No Scale

Figure 1

Proposed Bikeway Alignment, Study Intersections, and Cross Section Photos

Project Motivation

The WMFFB, once constructed, will provide a real choice for bicyclists and pedestrians of all ages and abilities and serve as the first complete family-friendly bikeway in the City. Family friendly bikeways are intended to prioritize bicycle circulation while discouraging non-local cut-through vehicle traffic. They are located on low-volume and low-speed streets that have been optimized for bicycle travel by using traffic calming and traffic reduction devices, signage and pavement markings, and specialized intersection crossing treatments. Family-friendly bikeways are an important component of providing a balanced, interconnected, and safe transportation system in Salem that supports a variety of transportation options. WMFFB will support safe and convenient biking and walking to employment, schools, parking, shopping and parks.

Many people, typically assumed to be between 55 and 60 percent of the population, are interested in bicycling but are dissuaded by stressful interactions with motor vehicles. Cyclists were categorized by their level of comfort with automobile traffic first by the City of Portland in 2005, with categorization based on professional judgement and familiarity with the bicycling public.[1] These initial numbers have been vetted over time and are widely agreed upon in the bicycle planning community. More recently, Dr. Jennifer Dill of Portland State University conducted a larger regional phone survey to validate the percentages of the population that associate with each comfort category.[2] The "Regional" results below are likely similar to rider characteristics in Salem.

Table 1. Cycling Comfort Level of Portland and Portland Region Respondents

Cyclist Comfort Level	Description	City of Portland	Regional	All
Strong and Fearless	Very comfortable without bike lanes	6%	2%	4%
Enthused and Confident	Very comfortable with bike lanes	9%	9%	9%
Interested but Concerned	• Not very comfortable, interested in biking more • Not very comfortable, currently cycling for transportation but not interested in cycling more	60%	53%	56%
No Way, No How	• Physically unable • Very uncomfortable on paths • Not very comfortable, not interested, not currently cycling for transportation	25%	37%	31%
Total Number of Respondents (Weighted)		436	479	915

[1] https://www.portlandoregon.gov/transportation/article/264746
[2] http://web.pdx.edu/~jdill/Types_of_Cyclists_PSUWorkingPaper.pdf

This “Interested but Concerned” slice of the population would consider riding a bicycle if more facilities within their comfort range existed. For example, these potential riders are more comfortable riding on a low-volume, low-speed street like Maple Avenue as opposed to a higher-volume, higher-speed street with bike lanes such as Cherry Avenue. Crossing improvements that serve to connect existing comfortable streets may attract this new group of bicyclists to riding in Salem.

In addition to attracting different types of cyclists, the proposed WMFFB would also provide safe mobility choices for underserved communities. The Salem-Keizer Area Transportation Study 2012 Geographic Profile of Transportation Disadvantaged Populations indicates that the census tracts surrounding WMFFB have a higher than average concentration of persons living in poverty and persons without access to a motor vehicle. Additionally, two of the three census tracts surrounding the route have higher than average rates of non-white and Hispanic populations. The treatments envisioned will support neighborhood livability and increase active transportation options for people of all ages.

Background Information

This section presents the key findings of a review of previously conducted studies and plans that should be considered as part of the WMFFB evaluation and design process.

Previously Considered Bikeway Alternatives

A bicycle and pedestrian connection between Keizer and downtown Salem has been a discussion point for nearly 40 years. The 1980 Salem Bike Plan[3] included three alignment alternatives for a bikeway connecting downtown Salem with the residential neighborhoods north of Salem Parkway. One alignment followed Front Street, another followed 4th Street, and a third followed Winter Street, Laurel Avenue, the railroad tracks, and Cherry Avenue. Over the years, the desire for a bicycle and pedestrian connection has not waivered but the potential alignments have shifted.

In 2009, ODOT and the Mid-Willamette Valley Council of Governments (MWVCOG) developed a bike shed map and a map of potential bikeway alignments.[4] The documentation included a proposed alignment connecting downtown to Salem Parkway that follows Winter Street, Myrtle Avenue, and Cherry Street.

In 2008, the City of Salem applied for an ODOT grant for the proposed North Salem Bicycle Boulevard project which included bike lane striping, pedestrian crossing improvements, railroad crossing improvements, and traffic calming following the Winter Street, Myrtle Avenue, and Cherry Street alignment described in the preceding paragraph. The city was not awarded the grant, however in 2010, an element of the original application was considered for funding through the Streets and

[3] Salem Area Bicycle Plan, Adopted SATS Coordinating Committee, et al., March 28, 1980
[4] Map Created by ODOT, May 2009

Bridges General Obligation Bond, pedestrian crossing safety project (City Council, April 12, 2010, Agenda Item 8(c)). This potential project would have constructed a median island at Fairgrounds Road NE at Winter Street NE. Feedback from the Grant Neighborhood Association resulted in this project not receiving funding and shifting the alignment of the route to avoid this complicated, six-leg, intersection.

The 1980 and 2009 maps described above are included in the Appendix.

Planned Future Projects

There are several planned future transportation projects within the study area that are identified in the City of Salem Transportation System Plan (TSP) or Capital Improvement Project (CIP) list but are not funded at this time. Table 2 includes all planned future projects within the study area for the WMFFB.

Table 2. City of Salem Planned Future Projects in Study Area

Location	Planned Project	Source Document
Cherry Avenue, BNRR to Salem Parkway	Widen to 5 lanes with 4 travel lanes, a center turn lane, curbs, gutters, sidewalks, and bike lanes.	Salem TSP Street System Element, High Priority Projects List
Union Street, Commercial Street to Winter Street	Design and construct enhanced bicycle facilities	Salem Adopted CIP (FY 2016/17-2020/21), Project 255
Winter Street, Court Street to Norway Street	Family Friendly Bikeway	Salem TSP Bicycle System Element, Tier 1 Recommended Project List
Norway Street, Winter Street to 5th Street	Family Friendly Bikeway	Salem TSP Bicycle System Element, Tier 1 Recommended Project List
Cottage Street /Maple Avenue	Family Friendly Bikeway	Salem TSP Bicycle System Element, Tier 1 Recommended Project List
Cherry Avenue at Salem Parkway	Intersection Improvements (scope TBD)	Salem TSP Pedestrian System Element, Tier 1 Recommended Project List
Maple Avenue, Hickory Street to Bliler Avenue	New Sidewalks or Sidewalk Infill	Salem TSP Pedestrian System Element, Tier 3 Recommended Project List
Capitol Auto Group Avenue	New Sidewalks or Sidewalk Infill	Salem TSP Pedestrian System Element, Tier 3 Recommended Project List

Existing Transportation Conditions

The WMFFB includes 32 intersections (4 Major Arterials, 3 Minor Arterials, 6 Collectors and 19 local streets). Several high volume intersections provide challenging crossings for people walking and biking. The following sections provide detailed descriptions of the existing infrastructure as well as operational and safety performance for all road users.

Existing Infrastructure

Along the proposed WMFFB alignment, Winter Street, Norway Street, Cottage Street, Maple Avenue, and Auto Group Avenue are all two-way, two-lane local roadways. The study section of Cherry Avenue, classified as a major arterial in the Salem TSP, transitions from a three-lane roadway to a four-lane roadway between Auto Group Avenue and Salem Parkway. Table 3 summarizes the number of lanes, posted speed, and classification for each of the study roadway segments.

Table 3. Study Roadway Characteristics

Roadway (Segment)	Number of Lanes	Posted Speed (mph)	Salem TSP Classification
Winter Street (Court Street to Norway Street)	2	25	Local Roadway
Norway Street (Winter Street to Cottage Street)	2	25	Local Roadway
Cottage Street (Norway Street to South Street)	2	25	Local Roadway
Maple Avenue (South Street to Bliler Avenue)	2	25	Local Roadway
Auto Group Avenue (Culdesac to Cherry Avenue)	2	25	Local Roadway
Cherry Avenue (Auto Group Avenue to Salem Parkway)	3-4	35	Major Arterial

Bicycle and Pedestrian Facilities

The existing bicycle and pedestrian facilities along the proposed WMFFB alignment are shown on

Figure 2. Sidewalks are currently provided on at least one side of the street along the majority of the proposed WMFFB alignment, except for the segment of Maple Street north of Locust Street. Within the study area, Cherry Avenue is the only roadway segment with dedicated bicycle lanes. More detailed information regarding the existing bicycle and pedestrian infrastructure is presented later in this memorandum as part of the Bicycle and Pedestrian Level of Stress evaluation. Figure 2b shows how the proposed WMFFB would tie in to other existing and proposed bicycle facilities in the area.

Parking Facilities

On-street angled parking is provided on Winter Street between Court Street and D Street. On-street parallel parking is permitted on the remainder of the study alignment, with the exception of Cherry Avenue and a small portion of Auto Group Avenue.

LEGEND

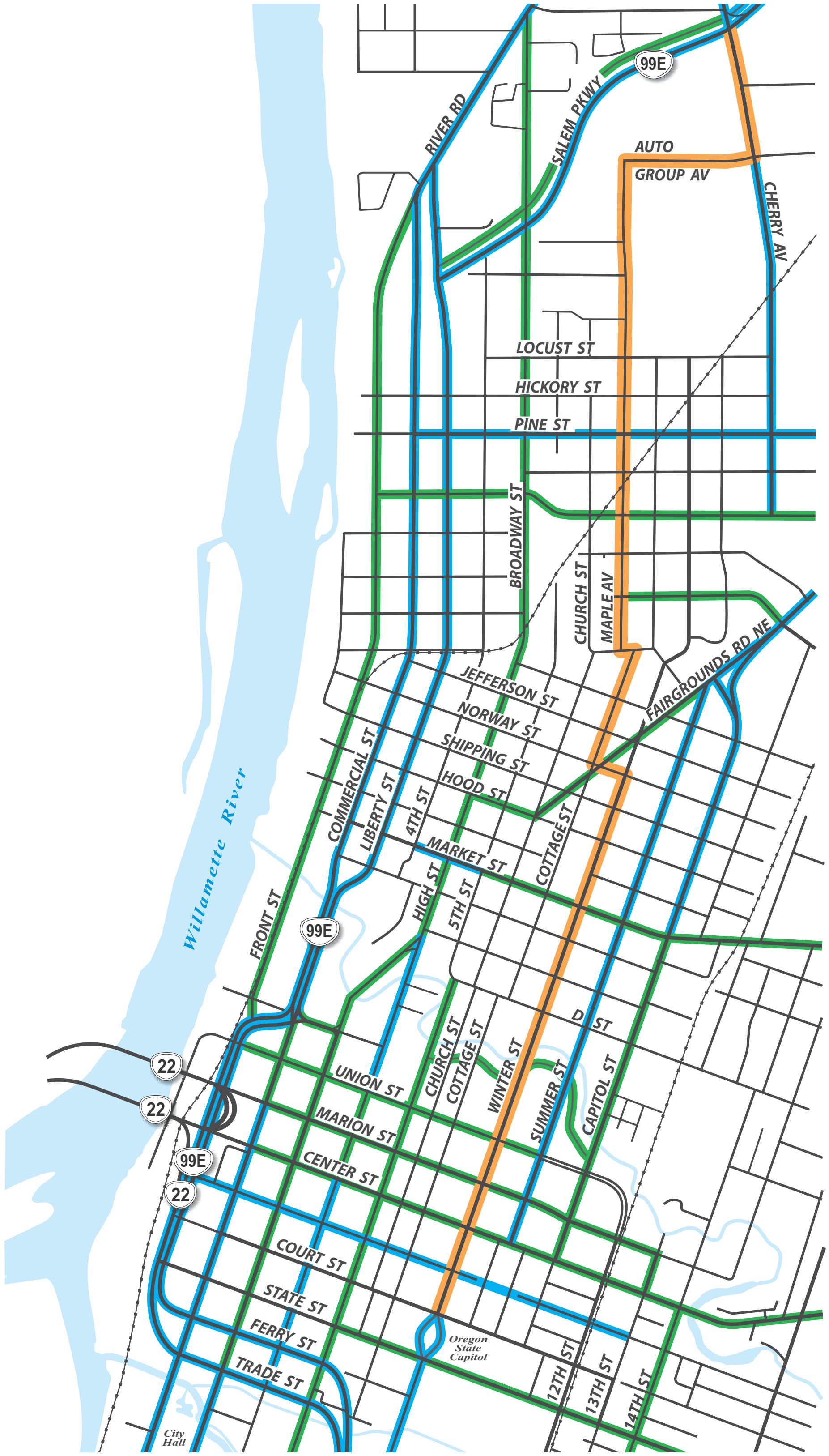
- Existing Sidewalks
- Existing Bicycle Lanes
- Existing Multi-use Path

No Scale

DKS

Figure **2a**

Existing Bicycle & Pedestrian Facilities along WMFFB Alignment



LEGEND

- Proposed Bikeway Alignment
- Existing Bicycle Facilities
- Proposed Bicycle Facilities

No Scale

Figure **2b**

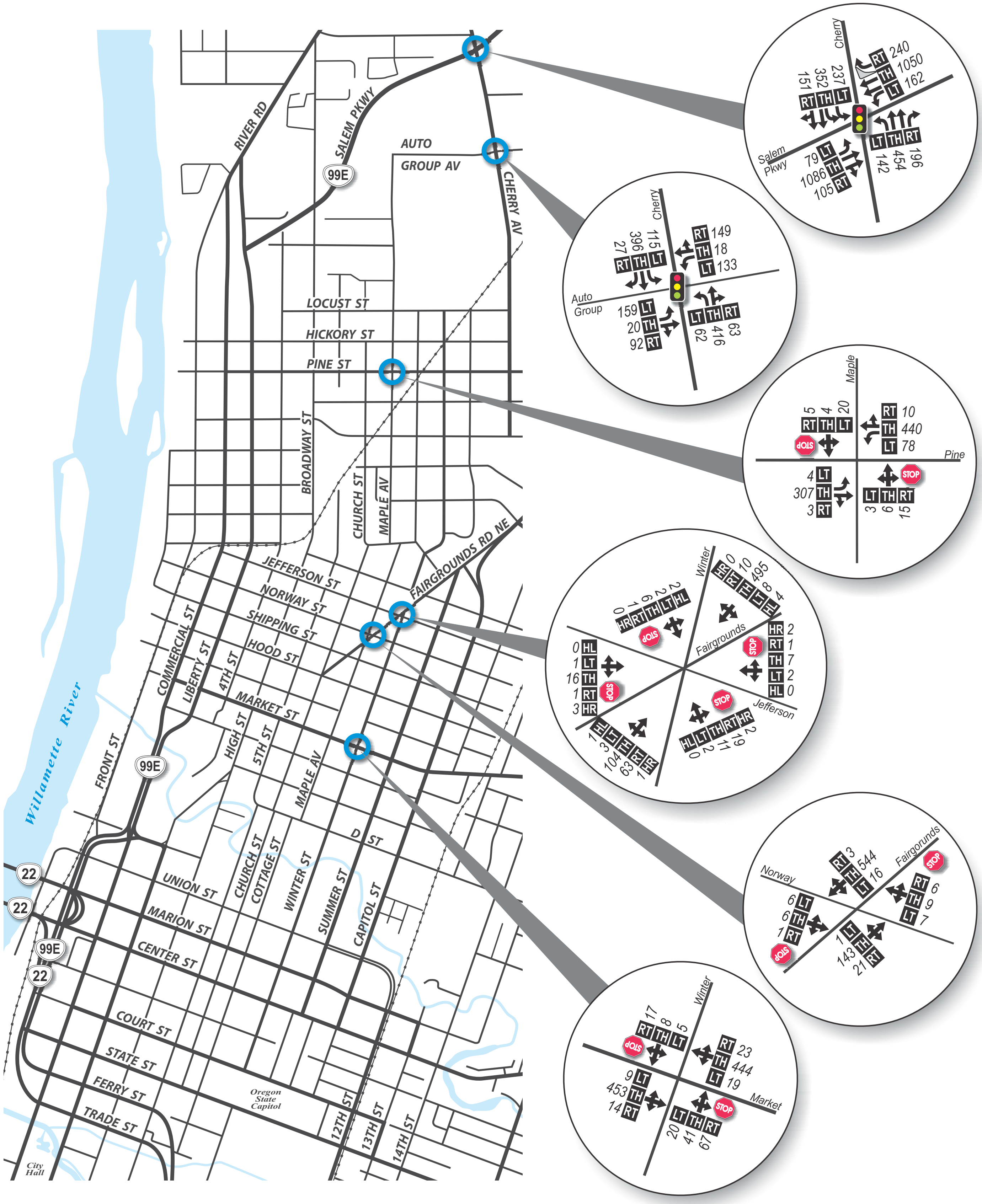
Proposed WMFFB Alignment with Connecting Bicycle Facilities

Transit Facilities

The local transit service, Cherriots, operates one bus route within the proposed WMFFB alignment. Route 2 runs on Winter Street NE between Chemeketa Street and Market Street with stops near Belmont Street, D Street, Union Street, and Chemeketa Street. Route 2 is a frequent route with service every 15 minutes during peak periods.

Traffic Volumes and Intersection Operations

Evening (4:00-6:00 p.m.) peak hour intersection turning movement counts (including bicycle and pedestrian counts) and daily roadway segment vehicle counts were collected at key locations along the proposed WMFFB alignment. All traffic counts were collected by ODOT on typical weekdays in June 2016 prior to the end of the school year. The p.m. peak hour intersection turning movement volumes are shown on Figure 3, the average daily traffic (ADT) volumes are shown on Figure 4, and the p.m. peak hour pedestrian and bicycle volumes are shown on Figure 5.



LEGEND

- Study Intersection
- Traffic Signal
- Stop Sign
- Lane Configuration
- 000 - PM Peak Hour Traffic Volumes
- HL (Hard Left), LT TH RT (Left•Thru•Right), HR (Hard Right) - Volume Turn Movement

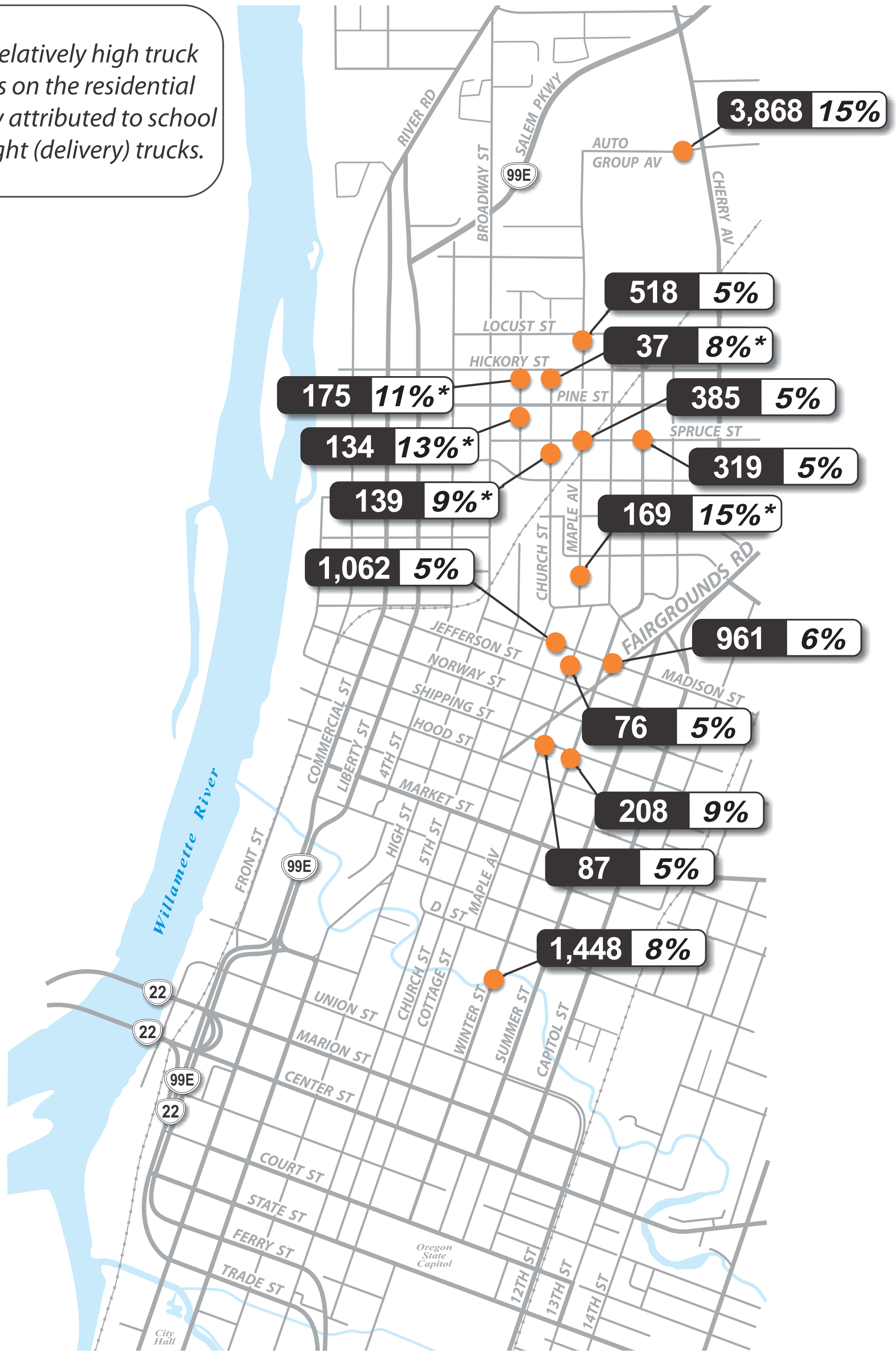
DKS

No Scale

Figure 3

2016 Existing Conditions 30th Highest Hour Traffic Volumes

**Note: The relatively high truck percentages on the residential streets is likely attributed to school buses and light (delivery) trucks.*



LEGEND

- Traffic Count Location

ADT / Truck Percentage

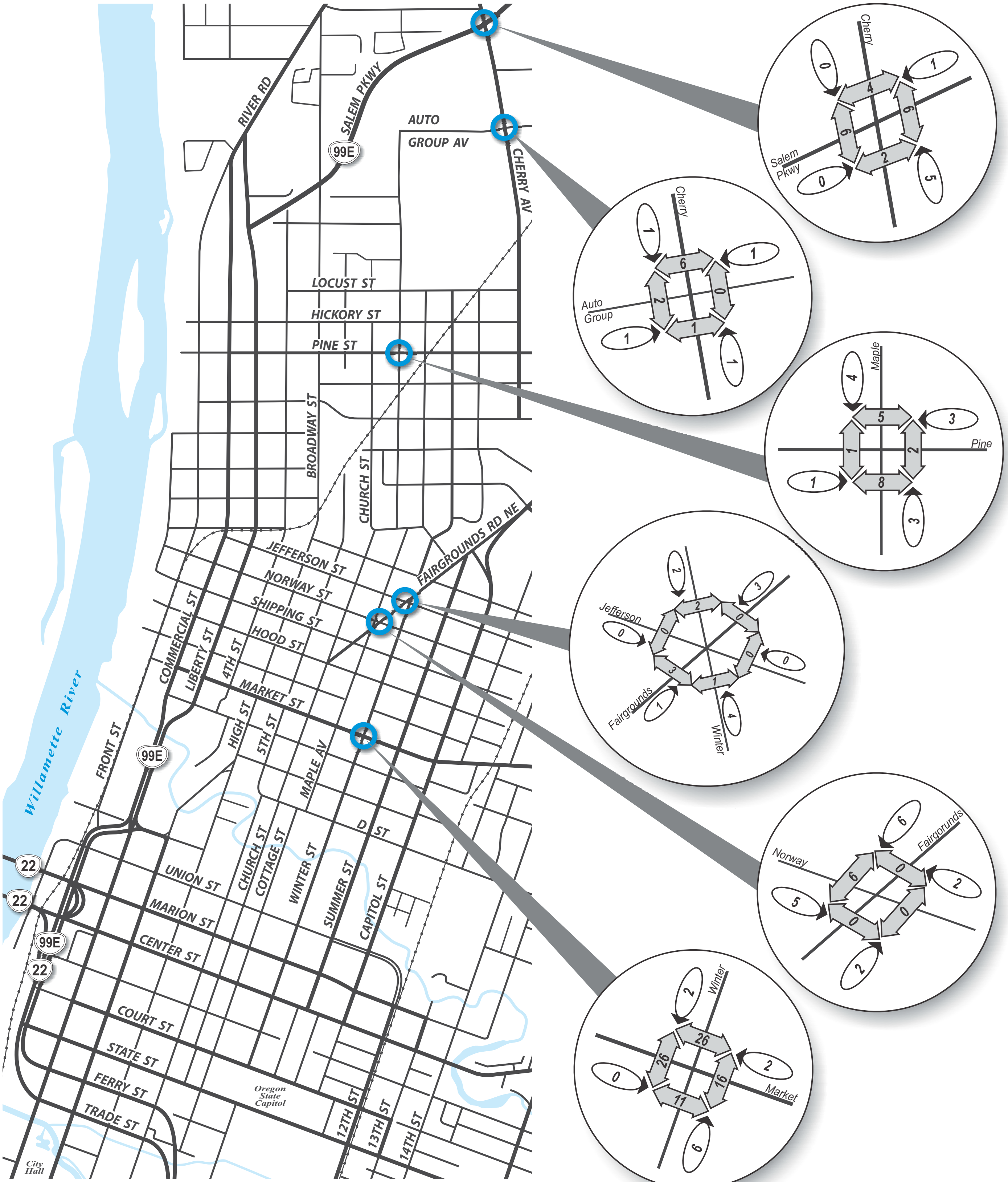
0,000 00%

DKS

No Scale

Figure 4

Existing 2016 Average Daily Traffic Volumes



LEGEND

- Study Intersection

00 - Pedestrian Volume

00 - Bicycle Volume

DKS

No Scale

Figure 5

2016 Existing Conditions PM Peak Hour Pedestrian & Bicycle Volumes

Mobility Standards

Agency mobility standards often require intersections to meet level of service (LOS) or volume-to-capacity (V/C) intersection operation thresholds.

- The **intersection LOS** is similar to a "report card" rating based upon average vehicle delay. Level of service A, B, and C indicate conditions where traffic moves without significant delays over periods of peak hour travel demand. Level of service D and E are progressively worse operating conditions. Level of service F represents conditions where average vehicle delay has become excessive and demand has exceeded capacity. This condition is typically evident in long queues and delays.
- The **volume-to-capacity (V/C)** ratio represents the level of saturation of the intersection or individual movement. It is determined by dividing the peak hour traffic volume by the maximum hourly capacity of an intersection or turn movement. When the V/C ratio approaches 0.95, operations become unstable and small disruptions can cause the traffic flow to break down, as seen by the formation of excessive queues.

According to the City of Salem Level of Service Standards, mobility standards are given as LOS, delay, and V/C ratios and are based on intersection traffic control devices.[5] The mobility standards for signalized and unsignalized intersections are shown in Table 4.

Table 4. City of Salem Mobility Standards

Jurisdiction	Traffic Control	Mobility Standard		
		LOS	*Delay*	*V/C Ratio*
City of Salem	Signalized	E	< 80 seconds	0.90
	Unsignalized	E	< 50 seconds	-

Existing Intersection Operations

The existing traffic operations at the study intersections were determined for the PM peak hours using 2000 Highway Capacity Manual methodology[6] for signalized intersections and 2010 Highway Capacity Manual methodology[7] for unsignalized intersections. The estimated operating conditions of each study intersection are shown in Table 5 on the following page.

[5] Division 6 of the City of Salem Department Public Works Design Standards Administrative Rules.
[6] *2000 Highway Capacity Manual*, Transportation Research Board, Washington DC, 2000.
[7] *2010 Highway Capacity Manual*, Transportation Research Board, Washington DC, 2010.

Table 5. Existing PM Peak Hour Intersection Operations

Intersection	Operating Standard			Existing PM Peak Hour		
	LOS	***Delay (s)***	***v/c***	***LOS***	***Delay (s)***	***v/c***
Unsignalized Intersections						
Winter Street/ Market Street	E	< 50	-	A/E	35.2	0.56
Fairgrounds Road/Norway Street	E	< 50	-	A/C	17.2	0.06
Fairgrounds Road /Jefferson Street/Winter Street[1]	E	< 50	-	A/C	15.4	0.06
Maple Avenue/Pine Street	E	< 50	-	A/D	32.9	0.86
Signalized Intersections						
Auto Group Avenue/Cherry Avenue	E	< 80	0.90	B	14.1	0.57
Salem Parkway/Cherry Avenue	E	< 80	0.90	D	43.8	0.80

[1]Although the proposed WMFFB alignment does not include the intersection of Fairgrounds Road/Jefferson Street/Winter Street, the alignment is still preliminary. This additional analysis was included for informational purposes that can be used during any future refinement of the bikeway alignment.

As shown in Table 5, all study intersections meet the City of Salem's operating standards during the existing PM peak period. The Salem Parkway/Cherry Avenue intersection is approaching capacity which limits future opportunities for special bicycle signal phases.

Roadway and Intersection Safety Performance

The safety performance of the roadway segments and intersections that comprise the proposed bikeway alignment was evaluated using the most recent five years of crash data available in the ODOT crash database (2011-2015). During that time period, there were a total of 118 crashes within the study area. Of those, three were bicycle-related and two were pedestrian-related. The following sections provide detailed descriptions of the observed crash patterns and safety concerns along the WMFFB proposed alignment.

Bicycle and Pedestrian Crashes

During the study period (2011-2015), there were two fatal crashes in the vicinity of the WMFFB proposed alignment, both of which were pedestrian crashes. There were also three crashes involving bicyclists, all resulting in injuries. The locations of the bicycle and pedestrian crashes are shown on Figure 6.

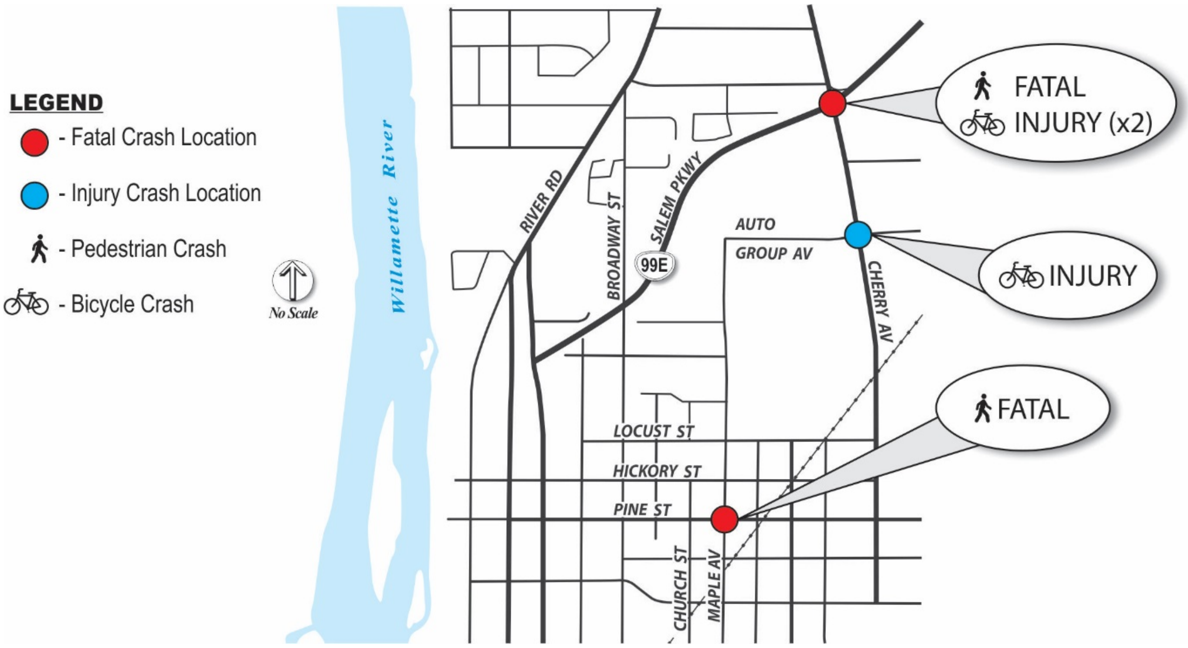


Figure 6. Bicycle and Pedestrian Crash Locations and Severities

Both pedestrian crashes occurred at night, and the reported causes were both attributed to the driver (reckless driving in one case, failure to yield to a pedestrian in the other). Weather was not considered a factor in either case.

All three bicycle crashes occurred during daylight conditions on clear, dry days. In one case, the bicyclist was reported to be in the roadway illegally, while another cyclist disregarded a traffic signal and struck a motor vehicle. In the third crash, officers were unable to determine the cause of the crash.

Overall Crash Trends

Table 6 presents the number of crashes that occurred along the proposed WMFFB alignment by crash type and crash severity. The majority of crashes are intersection-related, as evidenced by the large proportion of rear-end (37%) and angle or turning (32%) crashes. At non-intersection locations, the most prevalent recorded crash types were sideswipe (10%), parking-related (7%), and fixed-object (5%). As shown in Table 6, nearly half of the reported crashes were property damage only (PDO). The majority of the remaining crashes resulted in injuries or possible injuries. There were two crashes that resulted in fatalities.

Table 6. WMFFB Alignment Crashes by Type and Severity, 2011-2015

Crash Type	Fatal	Serious Injury	Injury	Possible Injury	Property Damage Only	Total
Rear End	0	0	4	20	20	44 (37%)
Angle/Turning	0	0	6	16	15	37 (31%)
Sideswipe	0	0	0	2	10	12 (10%)
Parking Related	0	0	0	3	5	8 (7%)
Fixed Object	0	0	1	2	3	6 (5%)
Bicycle	0	0	3	0	0	3 (3%)
Pedestrian	2	0	0	0	0	2 (2%)
Other [a]	0	0	1	0	5	6 (5%)
Total	2 (2%)	0 (0%)	15 (13%)	43 (36%)	58 (49%)	118 (100%)

[a] "Other" category includes backing, non-collision, and unknown crash types.

Weather Conditions

Approximately 20% of the reported crashes occurred during rainy or wet conditions. The remaining 80% of crashes occurred during clear or cloudy conditions. On average, Salem experiences 140 rainy days per year (39% of the year), which suggests that there is not an overrepresentation of weather-related crashes along the WMFFB alignment.

Time of Day

Figure 7 presents of a breakdown of reported crashes by time of day. The highest frequency of crashes occurred during peak travel times for businesses and schools: 9:00 a.m., noon, 3:00 p.m., and 5:00 p.m., as shown below.

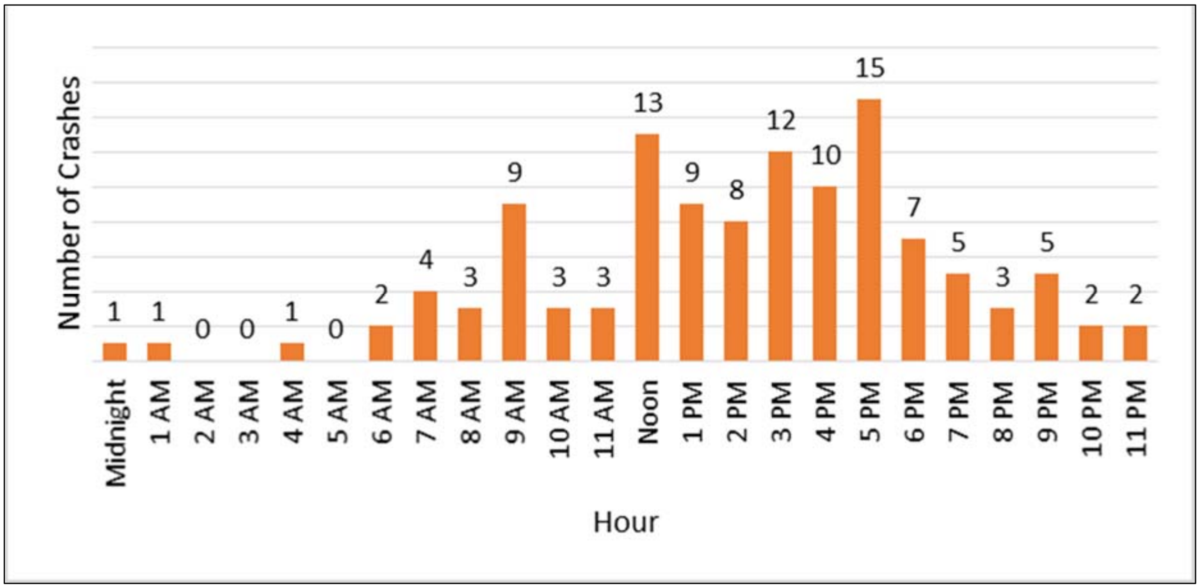


Figure 7. Crash Trends: Time of Day (2011-2015)

Lighting Conditions

The majority of crashes reported on the WMFFB alignment occurred during daylight conditions (77%). Of the nighttime crashes reported, approximately 24% occurred at locations with street lighting, while approximately 76% occurred at locations with no (or non-working) street lighting.

Critical Crash Rate Analysis

In addition to general crash trend investigations, an analysis of critical crash rates can aid in identifying locations with higher than expected crash frequencies. The total number of crashes experienced at a specific location is related to the volume of traffic present. A crash rate, which represents the observed annual crash frequency per unit of traffic volume (one million entering vehicles for intersections, or 100 million vehicles for roadway segments), allows for relative safety comparisons between locations with differing levels of traffic volume. Furthermore, the Oregon Department of Transportation publishes critical crash rates, which present the expected crash rate (90^{th} percentile) for intersections and roadway segments across the state. An observed crash rate that is higher than the corresponding critical crash rate indicates a potential safety issue and warrants further investigation. The intersection and roadway segment crash rates (observed and critical) are presented in Table 7 and Table 8, respectively.

Table 7. Intersection Crash Rate Analysis Results

Intersection	Entering ADT	Observed Crash Frequency (2011-2015)			Observed Crash Rate [a, c]	Critical Crash Rate [a]
		Fatal	Injury	PDO		
Winter Street/ Market Street	10,720	0	3	1	0.204	0.408
Fairgrounds Road/Norway Street	7,320	0	2	2	0.299	0.408
Fairgrounds Road / Jefferson Street/Winter Street	7,380	0	3	2	0.371	n/a [b]
Maple Avenue/Pine Street	8,580	1	0	0	0.064	0.408
Auto Group Avenue/Cherry Avenue	15,780	0	2	4	0.208	0.860
Salem Parkway/Cherry Avenue	38,500	1	23	24	0.692	0.860

[a] Intersection Crash Rate = Average Annual Crashes/Million Entering Vehicles
[b] Unique intersection configuration; no comparable critical crash rate available.
[c] Bold/shaded text indicates the observed crash rate exceeds the critical crash rate.

Table 8. Roadway Segment Crash Rate Analysis Results

Roadway Segment	ADT	Length (mi)	Observed Crash Frequency (2011-2015)			Observed Crash Rate [a, b]	Critical Crash Rate [a, c]
			Fatal	Injury	PDO		
Winter Street: Court St. to Union St.	4,000	0.321	0	6	7	178.1	325.6
Winter Street: Union St. to Market St.	1,450	0.441	0	7	1	302.3	325.6
Winter Street: Market St. to Norway St.	350	0.253	0	0	3	**469.7**	325.6
Norway Street: Winter St. to Cottage St.	2,000	0.066	0	0	0	0.0	325.6
Cottage Street: Norway St. to South St.	160	0.219	0	1	1	**684.9**	325.6
Maple Avenue: South St. to Pine St.	390	0.394	0	0	2	281.0	325.6
Maple Avenue: Pine St. to Bliler St.	520	0.348	0	1	2	316.1	325.6
Auto Group Avenue: Bliler St. to Cherry Ave.	3,870	0.327	0	0	0	0.0	325.6
Cherry Avenue: Auto Group Ave. to Salem Pkwy.	10,430	0.241	0	1	2	15.8	331.2

[a] Segment Crash Rate = Average Annual Crashes/100 Million Vehicle Miles Traveled, normalized to 1.0 mi segment length. Segment crash rates exclude any intersection-related crashes included in Table 4.
[b] Bold text indicates the observed crash rate exceeds the critical crash rate.
[c] Critical crash rate is the average critical rate for minor arterials and collectors in urban cities.

As shown in Table 7 and Table 8, there are two roadway segments that exceed the critical crash rate, while all of the intersections have a typical safety performance. The two roadway segments that exceed the critical crash rate (Winter Street between Market Street and Norway Street, and Cottage Street between Norway Street and South Street) have a very low volume of traffic and short segment lengths, both of which can contribute to over-inflated crash rates. Although the crash frequency appears to be relatively low for both segments, both observed crash rates are significantly higher than the critical crash rate. There is no apparent pattern in crash type, crash location, or crash cause on either segment.

Bicycle and Pedestrian Level of Traffic Stress (LTS)

The proposed WMFFB alignment was evaluated for level of bicyclist and pedestrian comfort under existing conditions. The Bicycle Level of Traffic Stress (LTS) and Pedestrian Level of Traffic Stress (PLTS) from the ODOT Analysis Performance Manual methodologies were applied in scoring segments and intersections along the corridor.[8] This type of evaluation provides planners and engineers an understanding where infrastructure changes are needed to improve the comfort of bicyclists and pedestrians traveling along a roadway and through intersections. For the WMFFB, this analysis will help guide the types of treatments and their priority for implementation.

The level of traffic stress methodologies and inputs are briefly described below, followed by evaluation results and analysis.

Level of Traffic Stress Analysis Methodology

Bicycle Level of Traffic Stress

ODOT's Bicycle Level of Traffic Stress is based on a methodology developed by researchers at the Mineta Transportation Institute at San Jose State University and first published in a 2012 report.[9] The stated methodology assesses street segments, intersections, and intersection approaches for the level of stress incurred by bicyclists riding there. LTS is scored on a scale of 1 to 4 with 4 being the most stressful. The segment assessment is based on roadway and traffic characteristics including:

- number of lanes,
- traffic speed,
- presence and width of on-street parking, and
- presence and width of bike lanes.

[8] Level of Traffic Stress methodologies and application examples appear on pages 14-8 through 14-50 of the Analysis Procedures Manual. The APM is available online at https://www.oregon.gov/ODOT/TD/TP/pages/apm.aspx.
[9] Maaza C. Mekuria, Ph.D., P.E., PTOE, Peter G. Furth, Ph.D. and Hilary Nixon, Ph.D. Low-Stress Bicycling and Network Connectivity. 2012. Available at: http://transweb.sjsu.edu/project/1005.html

Segments with separated bike lanes[10] are automatically assigned the lowest stress score, LTS 1.

The intersection assessment is based on:

- signalization,
- number of lanes on the cross street, and
- presence of median on the cross street.[11]

The intersection approach assessment is based on:

- presence of turn lanes,
- number of lanes crossed by left-turning bicyclist,
- speed limit, and
- interaction of the right turn lane and bike lane.[12]

The core idea of this methodology is that one factor (speed, number of lanes, type of bicycle facility, etc.) can sway the way in which a bicyclist experiences the roadway. For instance, a street with a bike lane may rate more stressful than one without if the bike lane street has higher speed traffic.

The methodology also relies upon the concept that a bicyclist's choice of route (or decision whether to ride for a given trip) is influenced by the most stressful condition experienced. In practice, this means that a low-stress street ceases to be a comfortable route for most bicyclists if there is an unsignalized crossing of a wide, high-speed street. This concept is particularly pertinent for family-friendly bikeways whose alignment is often chosen to take advantage of existing low-volume, low-speed streets that may cross arterials at unsignalized locations.

Generally, LTS 1 and 2 segments and intersections are considered "low-stress." These facilities are comfortable to a large segment of bicyclists. Table 9 presents a summary of the bicycle LTS scoring criteria described in the ODOT APM.

[10] Separated bike lanes refer to a space for bicyclists within or adjacent to the roadway that is separated from automobile traffic by some type of vertical barrier and is not shared with pedestrians.

[11] The original methodology essentially uses number of lanes as a proxy for traffic volume. This often works well in practice, but LTS scores tend to skew higher than actual bicyclist experience in locations where streets are overbuilt.

[12] Consideration of left turn movements and interaction with automobile left turn lanes is an addition to the Mineta Institute methodology by ODOT.

Table 9. Description of Bicycle LTS Scoring Criteria (from the ODOT APM)

LTS Score	Description
1	Suitable for all bicyclists, including children who are trained to safely cross intersections. Low traffic speeds, no more than one lane in either direction.
2	Suitable for teen and adult bicyclists. Speeds slightly higher, but still with low differential between bicycles and automobiles. Streets can be up to three lanes. Intersections are not difficult to cross.
3	Moderately stressful and suitable for some adult bicyclists comfortable with moderate speeds, up to 35 mph where bike lanes are present or 30 mph in shared lane situations. Streets may be up to five lanes wide.
4	Highly stressful conditions for most riders and suitable only for experienced bicyclists comfortable with proximity to/sharing road with high-speed automobile traffic. Streets may be two to five lanes wide, but with higher speeds. Intersections are wide or high-speed and are likely difficult to cross.

Pedestrian Level of Traffic Stress

ODOT developed the Pedestrian Level of Traffic Stress measure as a complement to the bicycle measure. It operates on a similar principle whereby a single characteristic of the pedestrian realm can sway the way in which a pedestrian experiences the roadway segment or intersection. Ratings reflect the experience both of able-bodied pedestrians and those using wheeled mobility devices.

Segments are evaluated with the following criteria:

- sidewalk condition and width
- buffer type and width
- bike lane width
- parking width
- number of lanes and posted speed
- illumination presence
- general land use

The factor pairs of total buffer width and number of lanes, and posted speed and buffer type are interacted in a matrix to come up with a PLTS score. For example, a segment with a buffer width of 12 feet on a four-lane street is PLTS 2, but is PLTS 3 on a six-lane street. Similarly, a more robust buffer type—landscaped with trees versus paved—mitigates the impact of higher speeds on PLTS.

Intersection crossings are evaluated with the following criteria:

- functional class
- number of lanes and posted speeds
- roadway average daily traffic (ADT) [optional]
- sidewalk ramps
- median refuge and illumination presence
- signalized general intersection features

Table 10 presents a summary of the ODOT APM characterizations of each PLTS rating.[13]

Table 10. Description of Pedestrian LTS Scoring Criteria (from the ODOT APM)

PLTS Score	Description
1	Little to no traffic stress on a sidewalk or shared-use path with a buffer between the facility and automobile traffic. Suitable for all users including children under 10 and those using wheeled mobility devices.
2	Little traffic stress but requires more attention to traffic than may be expected of younger children. Some factors may limit use for those in wheeled mobility devices. Adjacent roadway may have higher speed/volume, but facility is buffered.
3	Moderate stress. Able-bodied adults feel uncomfortable, but safe using facility. Can be higher speed roadway with small buffers. Wheeled mobility device users may find parts impassable.
4	High traffic stress. Route unsuitable and only used by able-bodied adults with no other routing choices. No/narrow buffer for facility on higher speed street, or lack of sidewalk.

Level of Traffic Stress Analysis Results

Bicycle Level of Traffic Stress

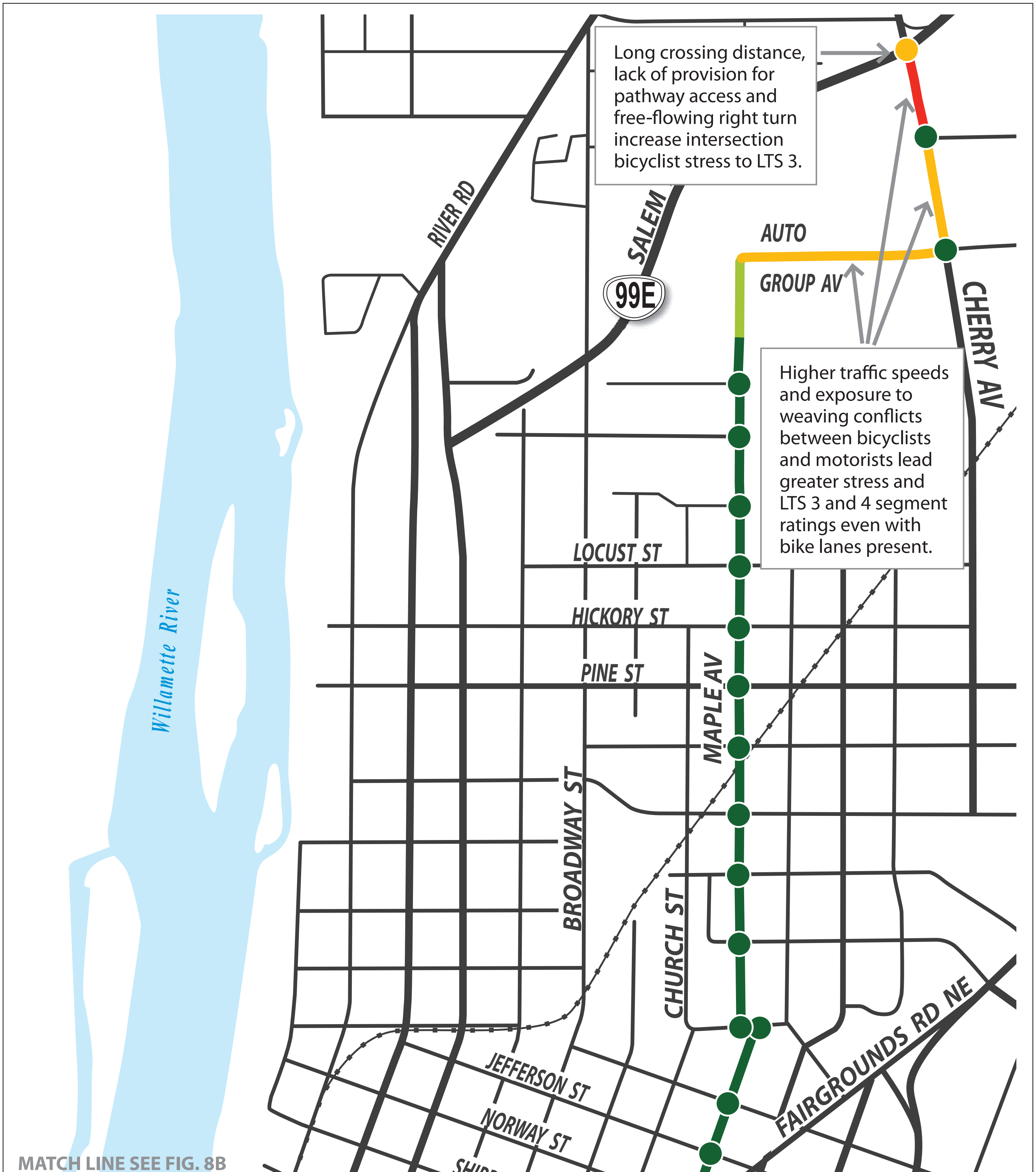
Generally, segment conditions along the WMFFB proposed alignment are comfortable for biking today. The bicycle LTS scoring results are shown on Figure 8 and Figure 9 on the following pages. Nearly all segments rate LTS 1 or 2 with the exception of northern end of the alignment where higher traffic speeds and bike lane/right turn lane conflicts create more stressful conditions.

Intersections also rate mostly in the LTS 1 and 2 range. Signalized intersections are given a default rating of LTS 1, but some latitude is afforded the evaluator in these situations. Stop-controlled and uncontrolled intersections along the corridor all rated LTS 1 or 2 owing to relatively low speeds and fewer number of lanes on the cross streets.

[13] Summarized from page 14-30 of the Analysis Procedures Manual.

The results of LTS analysis are largely reflective of bicyclists' experience along the proposed WMFFB alignment today with two exceptions: the crossings at Fairgrounds Road and Pine Street. Both of these intersections rate LTS 1 using the ODOT methodology because of the lower speed limit (30 mph) on the cross street and number of lanes (two and three lanes, respectively). At the intersection of Fairgrounds Road/Norway Street, the rating does not consider the highly skewed approaches, the actual width of the street (approx. 46 feet consisting of two 23-foot lanes), or unmarked crosswalks and parking lanes. All of these factors contribute to making this a higher stress crossing.

At Pine Street, automobile volumes, the width of the street and lack of crosswalks, signage and lighting contribute to a higher level of stress for bicyclists. Both of these intersections are likely candidates for treatments to improve the safety and comfort of crossing bicyclists.



LEGEND

Intersection Level of Traffic Stress	Street Segment Level of Traffic Stress
● - 1	▬ - 1
● - 2	▬ - 2
● - 3	▬ - 3
● - 4	▬ - 4

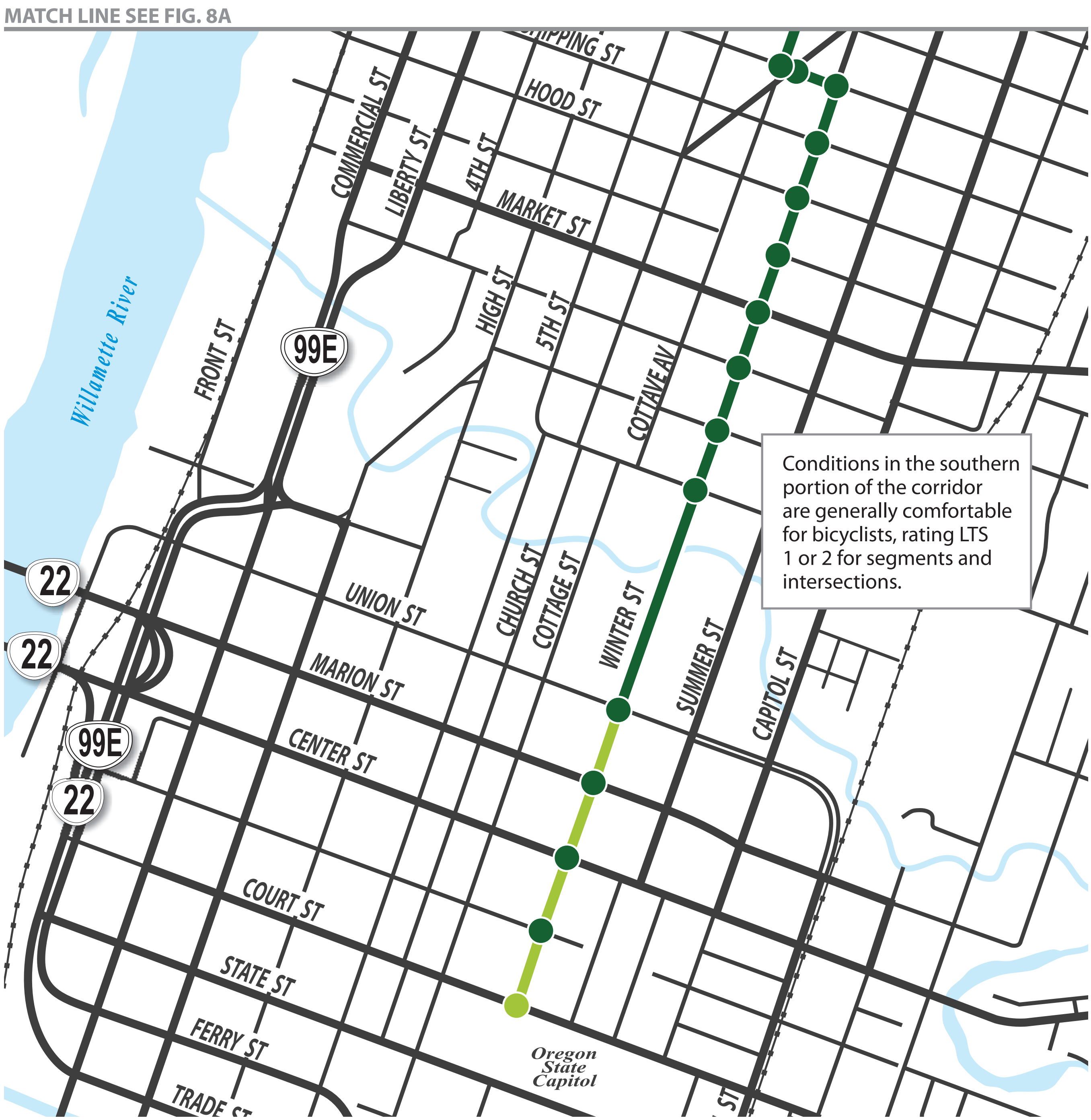
DKS

Toole Design Group

No Scale

Figure 8A

Bicycle Level of Traffic Stress, North Alignment



LEGEND

Intersection Level of Traffic Stress	Street Segment Level of Traffic Stress
- 1	- 1
- 2	- 2
- 3	- 3
- 4	- 4

DKS

Toole Design Group

No Scale

Figure 8B

Bicycle Level of Traffic Stress, South Alignment

Pedestrian Level of Traffic Stress

The PLTS methodology scores each side of the street independently, so data were gathered pertaining to the sidewalk, or lack thereof, for both sides of the street along the WMFFB alignment. Intersections are scored as a single entity, so one score appears for each. Additionally, ODOT's guidance instructs the reviewer to consider one major fault along an otherwise fair condition sidewalk as grounds for scoring that block very poor (PLTS 4).[14] Thus, the resulting PLTS is more reflective of sidewalk condition and the impact it has on wheeled mobility device users than the overall pedestrian environment as experienced by an able-bodied pedestrian. The PLTS analysis was completed with and without consideration of sidewalk condition, as shown on Figure 10 through Figure 13 on the following pages.

Under the ODOT methodology, the majority of the corridor scores PLTS 3 or 4 for segment ratings and PLTS 1 or 2 for crossings. Though land uses create a comfortable pedestrian environment, automobile speeds and volumes are relatively slow along the corridor and most segments have sidewalks with large, landscaped buffers, these factors are overridden by the relatively poor quality of sidewalks. Most block faces were rated in the poor or very poor categories because of the presence of cracking, faulting and rough conditions.

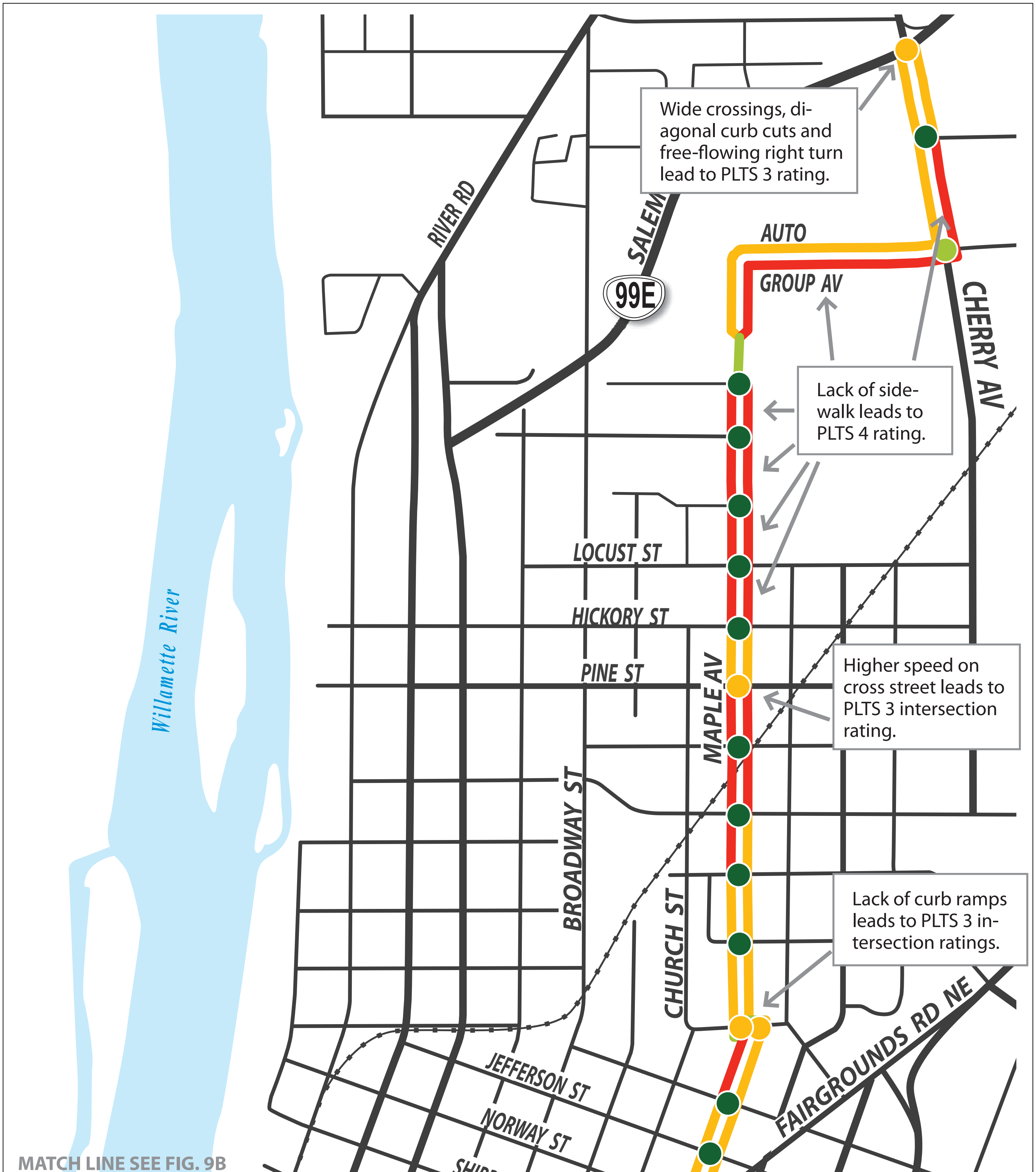
Most intersections along the corridor rate PLTS 1 or 2. These ratings can be attributed to the low speed and number of lanes on cross streets, presence of signals at larger streets, and the provision of adequate curb ramps and lighting. Unsignalized collector and local street intersections are evaluated on those criteria alone, while unsignalized arterial crossings also consider the ADT of the cross street.[15]

Four intersections rate as PLTS 3:

- Cherry Avenue at Salem Parkway
- Maple Avenue at Pine Street
- Maple/Cottage at South Street
- Norway Street at Fairgrounds Road

These intersections are generally made more stressful because of the speed, width and traffic volume of cross streets.

[14] See page 14-32 through 14-34 of the Analysis Procedures Manual for sidewalk condition guidance.
[15] The method also considers the presence of a refuge median, but there are none along this corridor.



LEGEND

Intersection Level of Traffic Stress
- 1
- 2
- 3
- 4

Street Segment Level of Traffic Stress
- 1
- 2
- 3
- 4

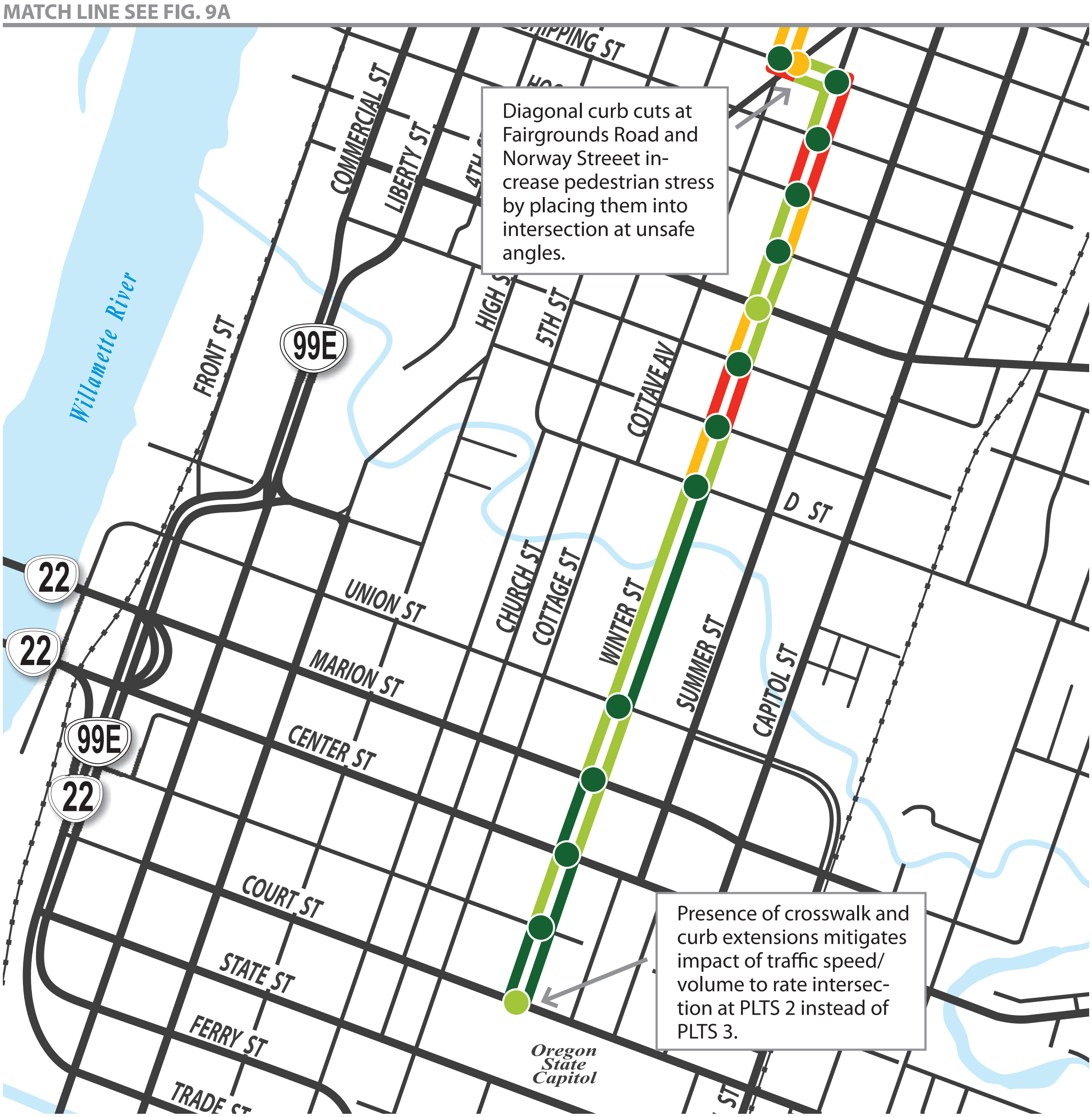
DKS

Toole Design Group

No Scale

Figure 9A

Pedestrian Level of Traffic Stress, North Alignment



LEGEND

Intersection Level of Traffic Stress
- 1
- 2
- 3
- 4

Street Segment Level of Traffic Stress
- 1
- 2
- 3
- 4

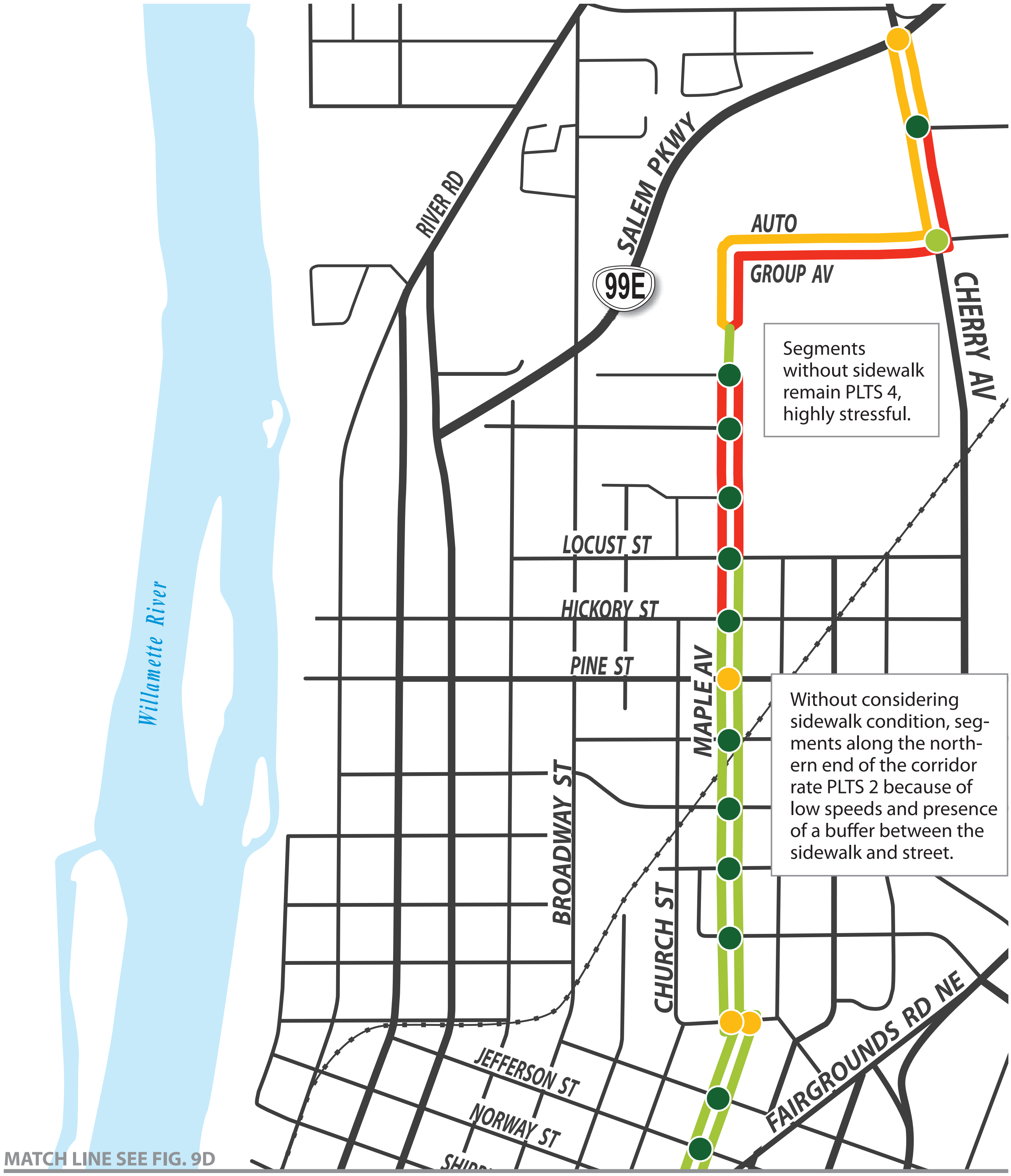
DKS

Toole Design Group

No Scale

Figure 9B

Pedestrian Level of Traffic Stress, South Alignment



LEGEND

Intersection Level of Traffic Stress	Street Segment Level of Traffic Stress
- 1	- 1
- 2	- 2
- 3	- 3
- 4	- 4

DKS

Toole Design Group

No Scale

Figure 9C

Pedestrian Level of Traffic Stress - Excluding Sidewalk Condition, North Alignment

MATCH LINE SEE FIG. 9C

LEGEND

Intersection Level of Traffic Stress	Street Segment Level of Traffic Stress
● - 1	— - 1
● - 2	— - 2
● - 3	— - 3
● - 4	— - 4

DKS

Toole Design Group

No Scale

Figure **9D**

Pedestrian Level of Traffic Stress - Excluding Sidewalk Condition, South Alignment

Summary of Existing Transportation Analysis

The proposed alignment for the WMFFB was evaluated based on intersection operations, intersection and roadway segment safety performance, and bicycle and pedestrian level of stress. The following list summarizes the key findings of the existing transportation analysis:

- All study intersections currently operate at acceptable levels and meet the City of Salem's operating standards. The Salem Parkway/Cherry Avenue intersection is approaching capacity which limits future opportunities for special bicycle signal phases.
- In terms of safety performance, there are two roadway segments that have an observed crash rate greater than what is expected for similar facility types: the segment of Winter Street between Market Street and Norway Street, and the segment of Cottage Street between Norway Street and South Street. These segments have a very low volume of traffic and short segment lengths, both of which contribute to over-inflated crash rates.
- An evaluation of the level of traffic stress currently experienced by bicyclists and pedestrians along the proposed WMFFB alignment indicated the highest stress locations are at the northern end of the alignment (Auto Group Avenue, Cherry Avenue, and Salem Parkway). Additionally, intersections along Fairgrounds Road and Pine Street present higher stress conditions for both modes and will likely need to be addressed through design treatments.
- The high stress locations for bicyclists are a result of higher traffic speeds, turning movement conflicts between bicycles and automobiles, lack of provision for movements onto/off of the multiuse path at the Salem Parkway/Cherry Avenue intersection, narrow streets and lack of crosswalks, and poor signage and lighting along bicycle routes.
- The high stress locations for pedestrians are a result of higher traffic speeds, width of the roadways, traffic volumes on the minor streets, lack of curb ramps, and diagonal curb cuts.

Appendix A – Previously Considered Bikeway Alternative Maps

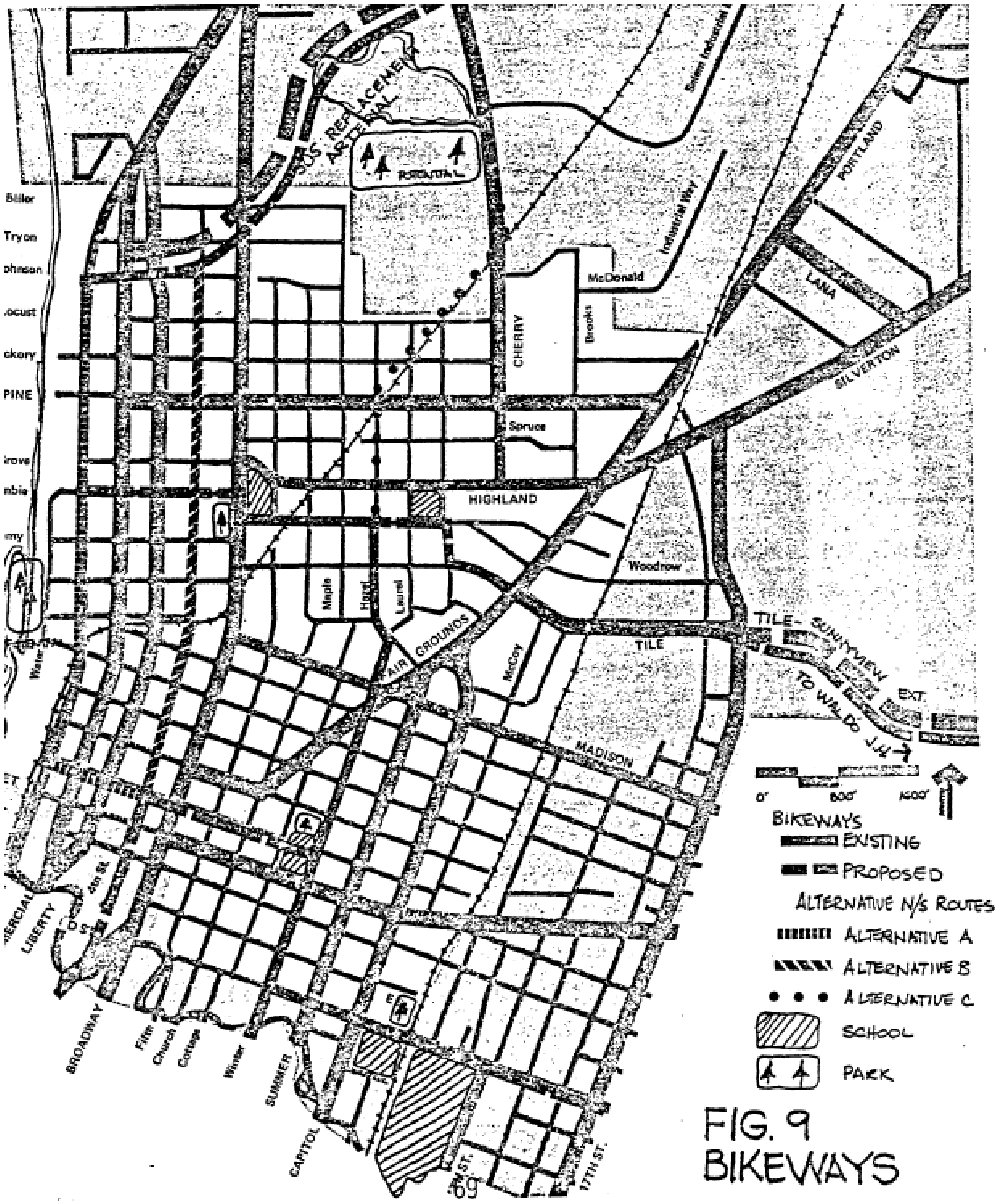
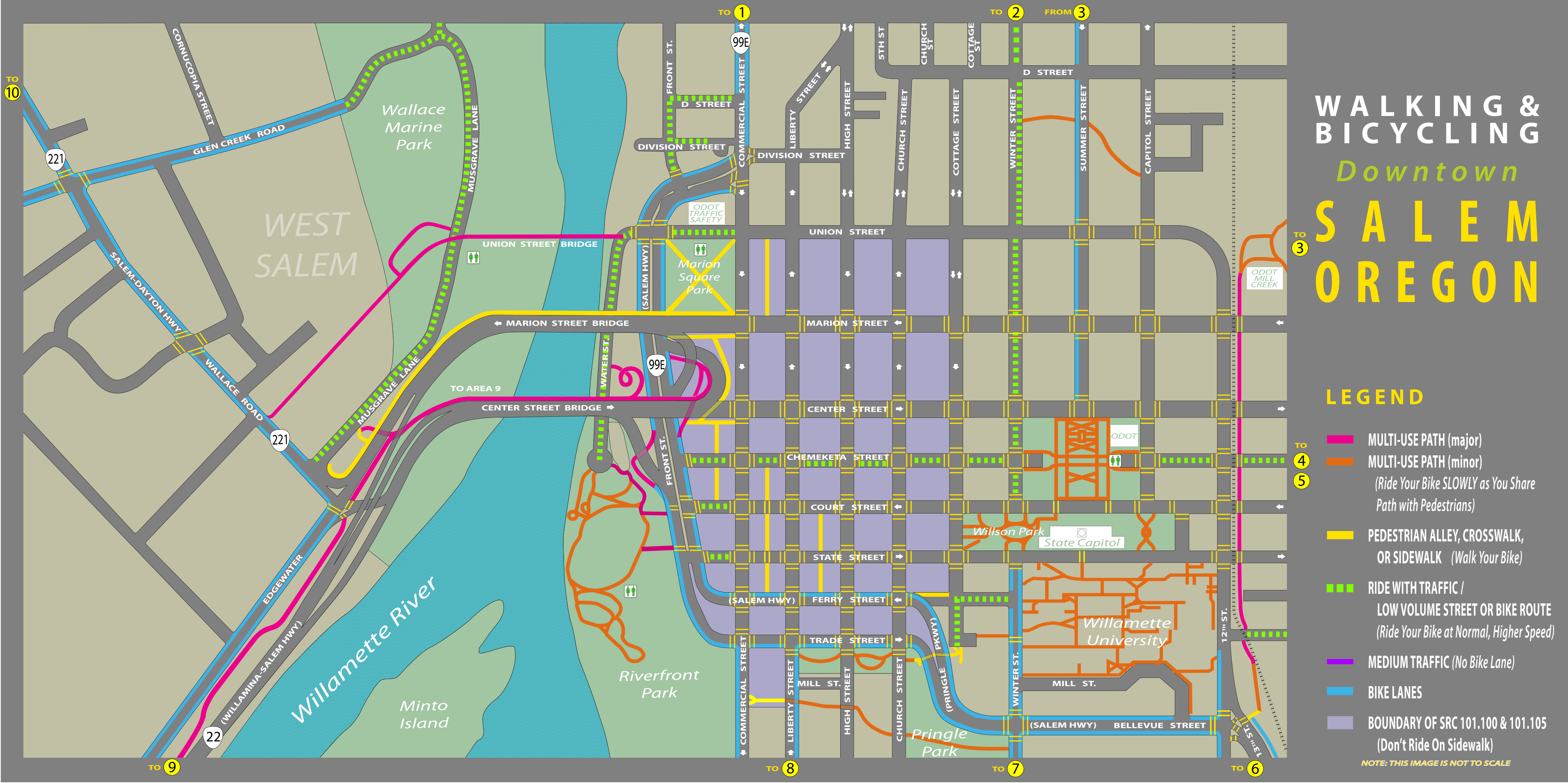
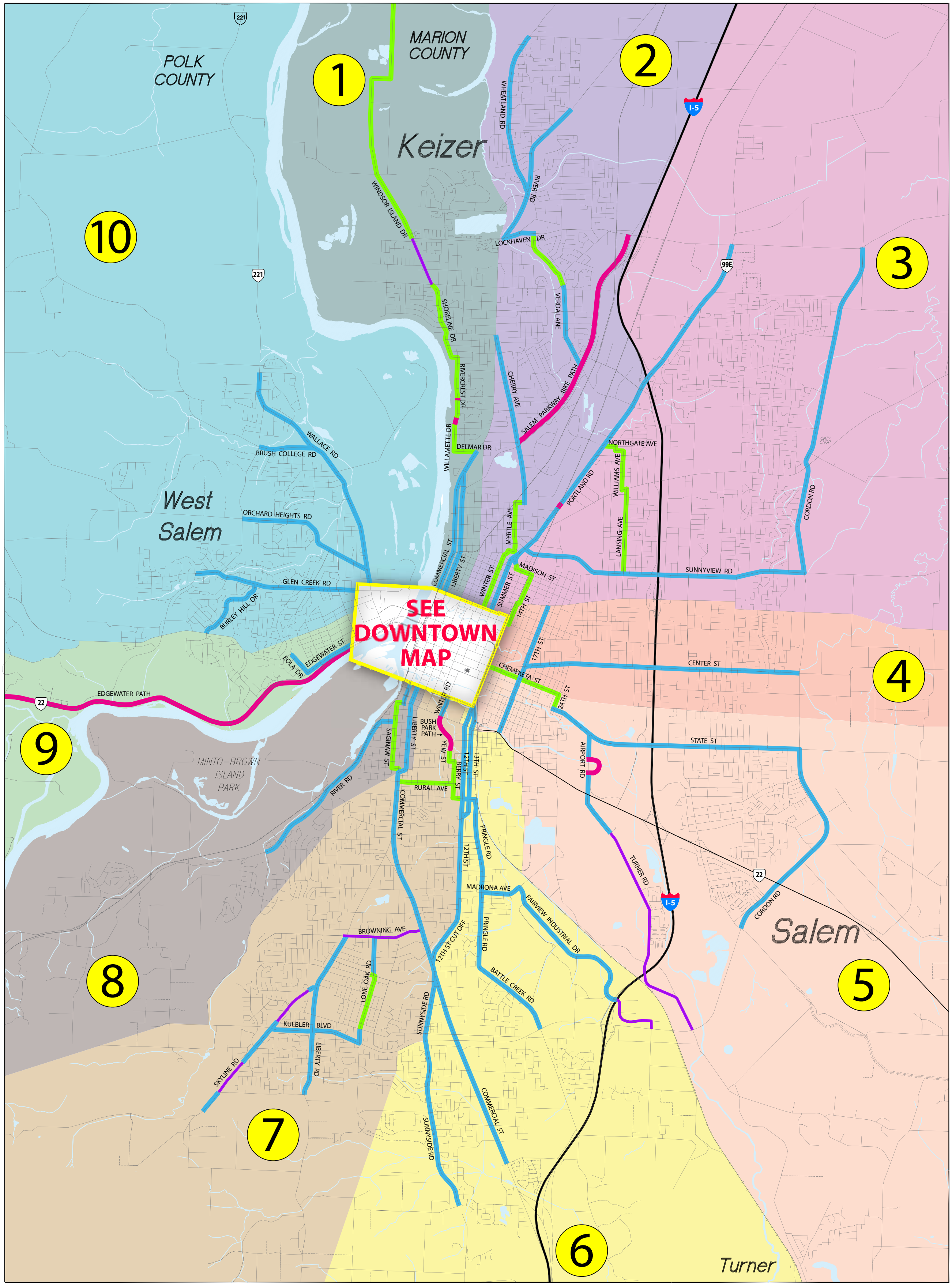


FIG. 9
BIKEWAYS



WALKING & BICYCLING
Downtown
SALEM OREGON
LEGEND
MULTI-USE PATH (major)
MULTI-USE PATH (minor)
(Ride Your Bike SLOWLY as You Share Path with Pedestrians)
PEDESTRIAN ALLEY, CROSSWALK, OR SIDEWALK (Walk Your Bike)
RIDE WITH TRAFFIC / LOW VOLUME STREET OR BIKE ROUTE
(Ride Your Bike at Normal, Higher Speed)
MEDIUM TRAFFIC (No Bike Lane)
BIKE LANES
BOUNDARY OF SRC 101.100 & 101.105
(Don't Ride On Sidewalk)
NOTE: THIS IMAGE IS NOT TO SCALE
WEST SALEM
Wallace Marine Park
Marion Square Park
Willamette River
Minto Island
Riverfront Park
Pringle Park
Willson Park
State Capitol
Willamette University
ODOT
ODOT TRAFFIC SAFETY
ODOT MILL CREEK
GLEN CREEK ROAD
CORNUCOPIA STREET
MUSGRAVE LANE
SALEM-DAYTON HWY
WALLACE ROAD
EDGEWATER
(WILLAMINA-SALEM HWY)
UNION STREET BRIDGE
MARION STREET BRIDGE
CENTER STREET BRIDGE
TO AREA 9
FRONT ST.
D STREET
DIVISION STREET
COMMERCIAL STREET
LIBERTY STREET
HIGH STREET
5TH ST
CHURCH ST
COTTAGE ST
WINTER STREET
SUMMER STREET
CAPITOL STREET
UNION STREET
MARION STREET
CENTER STREET
CHEMEKETA STREET
COURT STREET
STATE STREET
(SALEM HWY) FERRY STREET
TRADE STREET
MILL ST.
(PRINGLE PKWY)
WINTER ST.
12TH ST.
13TH ST.
(SALEM HWY) BELLEVUE STREET
WATER ST.
(SALEM HWY)
99E
221
22
TO 1
TO 2
FROM 3
TO 3
TO 4
5
TO 6
TO 7
TO 8
TO 9
TO 10

"Bike sheds" and suggested routes to downtown - DRAFT



Map created by ODOT, maintained by MWVCOG.
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May 2009

Appendix B – Intersection Operation Output Files

Intersection	
Intersection Delay, s/veh	4.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	9	453	14	19	444	23	20	41	67	5	8	17
Conflicting Peds, #/hr	26	0	11	11	0	26	26	0	16	16	0	26
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	89	89	89	89	89	89	89	89	89	89	89	89
Heavy Vehicles, %	0	1	0	22	0	0	0	0	6	0	0	0
Mvmt Flow	10	509	16	21	499	26	22	46	75	6	9	19

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	551	0	0	551	0	0	1158	1156	569	1204	1151	564
Stage 1	-	-	-	-	-	-	563	563	-	580	580	-
Stage 2	-	-	-	-	-	-	595	593	-	624	571	-
Follow-up Headway	2	-	-	2	-	-	4	4	3	4	4	3
Pot Capacity-1 Maneuver	1029	-	-	926	-	-	175	198	514	162	200	529
Stage 1	-	-	-	-	-	-	514	512	-	504	503	-
Stage 2	-	-	-	-	-	-	494	497	-	477	508	-
Time blocked-Platoon, %		-	-		-	-						
Mov Capacity-1 Maneuver	1007	-	-	906	-	-	150	181	492	102	183	506
Mov Capacity-2 Maneuver	-	-	-	-	-	-	150	181	-	102	183	-
Stage 1	-	-	-	-	-	-	496	494	-	486	476	-
Stage 2	-	-	-	-	-	-	441	470	-	353	490	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	0	35	23

Minor Lane / Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	258	1007	-	-	906	-	-	237
HCM Lane V/C Ratio	0.557	0.01	-	-	0.024	-	-	0.142
HCM Control Delay (s)	35.2	8.611	0	-	9.069	0	-	22.7
HCM Lane LOS	E	A	A		A	A		C
HCM 95th %tile Q(veh)	3.104	0.03	-	-	0.072	-	-	0.488

Notes

~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection	
Intersection Delay, s/veh	0.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	6	6	1	7	9	6	1	143	21	16	544	3
Conflicting Peds, #/hr	0	0	0	0	0	0	6	0	0	0	0	6
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	0	0	0	0	1	0	0	2	0
Mvmt Flow	7	7	1	8	10	7	1	155	23	17	591	3

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	805	808	599	801	798	173	595	0	0	178	0	0
Stage 1	628	628	-	169	169	-	-	-	-	-	-	-
Stage 2	177	180	-	632	629	-	-	-	-	-	-	-
Follow-up Headway	4	4	3	4	4	3	2	-	-	2	-	-
Pot Capacity-1 Maneuver	303	317	505	305	321	876	991	-	-	1410	-	-
Stage 1	474	479	-	838	763	-	-	-	-	-	-	-
Stage 2	829	754	-	472	478	-	-	-	-	-	-	-
Time blocked-Platoon, %								-	-		-	-
Mov Capacity-1 Maneuver	288	311	502	294	315	872	986	-	-	1403	-	-
Mov Capacity-2 Maneuver	288	311	-	294	315	-	-	-	-	-	-	-
Stage 1	474	470	-	837	762	-	-	-	-	-	-	-
Stage 2	807	753	-	454	469	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	17	15	0	0

Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	986	-	-	309	371	1403	-	-
HCM Lane V/C Ratio	0.001	-	-	0.046	0.064	0.012	-	-
HCM Control Delay (s)	8.655	0	-	17.2	15.4	7.598	0	-
HCM Lane LOS	A	A		C	C	A	A	
HCM 95th %tile Q(veh)	0.003	-	-	0.143	0.206	0.038	-	-

Notes
~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection	
Intersection Delay, s/veh	0.8

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	1	16	3	2	7	2	1	104	64	4	484	10
Conflicting Peds, #/hr	2	0	1	1	0	2	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	1	17	3	2	8	2	1	113	70	4	526	11

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	699	729	534	705	700	150	539	0	0	185	0	0
Stage 1	542	542	-	152	152	-	-	-	-	-	-	-
Stage 2	157	187	-	553	548	-	-	-	-	-	-	-
Follow-up Headway	4	4	3	4	4	3	2	-	-	2	-	-
Pot Capacity-1 Maneuver	357	352	550	354	366	902	1040	-	-	1402	-	-
Stage 1	528	523	-	855	775	-	-	-	-	-	-	-
Stage 2	850	749	-	521	520	-	-	-	-	-	-	-
Time blocked-Platoon, %								-	-		-	-
Mov Capacity-1 Maneuver	349	349	549	337	363	900	1040	-	-	1402	-	-
Mov Capacity-2 Maneuver	349	349	-	337	363	-	-	-	-	-	-	-
Stage 1	527	520	-	853	773	-	-	-	-	-	-	-
Stage 2	839	747	-	499	517	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	15	14	0	0

Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1040	-	-	369	401	1402	-	-
HCM Lane V/C Ratio	0.001	-	-	0.059	0.03	0.003	-	-
HCM Control Delay (s)	8.465	0	-	15.4	14.3	7.576	0	-
HCM Lane LOS	A	A		C	B	A	A	
HCM 95th %tile Q(veh)	0.003	-	-	0.187	0.092	0.009	-	-

Notes

~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection	
Intersection Delay, s/veh	0.8

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	3	103	1	8	497	0	0	11	19	2	6	1
Conflicting Peds, #/hr	2	0	1	1	0	2	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	92	92	92	92	92	92	92	92	92	92	92	92
Heavy Vehicles, %	0	0	0	0	0	0	0	0	0	0	0	0
Mvmt Flow	3	112	1	9	540	0	0	12	21	2	7	1

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	540	0	0	113	0	0	680	677	115	693	678	542
Stage 1	-	-	-	-	-	-	119	119	-	558	558	-
Stage 2	-	-	-	-	-	-	561	558	-	135	120	-
Follow-up Headway	2	-	-	2	-	-	4	4	3	4	4	3
Pot Capacity-1 Maneuver	1039	-	-	1489	-	-	368	377	943	360	377	544
Stage 1	-	-	-	-	-	-	890	801	-	518	515	-
Stage 2	-	-	-	-	-	-	516	515	-	873	800	-
Time blocked-Platoon, %		-	-		-	-						
Mov Capacity-1 Maneuver	1037	-	-	1487	-	-	358	372	941	340	372	543
Mov Capacity-2 Maneuver	-	-	-	-	-	-	358	372	-	340	372	-
Stage 1	-	-	-	-	-	-	887	799	-	516	510	-
Stage 2	-	-	-	-	-	-	503	510	-	837	798	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0	0	11	15

Minor Lane / Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	603	1037	-	-	1487	-	-	377
HCM Lane V/C Ratio	0.054	0.003	-	-	0.006	-	-	0.026
HCM Control Delay (s)	11.3	8.483	0	-	7.435	0	-	14.8
HCM Lane LOS	B	A	A		A	A		B
HCM 95th %tile Q(veh)	0.171	0.009	-	-	0.018	-	-	0.08

Notes

~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection	
Intersection Delay, s/veh	24.5

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	4	307	3	78	440	10	3	6	15	20	4	5
Conflicting Peds, #/hr	5	0	8	8	0	5	1	0	2	2	0	1
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	89	89	89	89	89	89	89	89	89	89	89	89
Heavy Vehicles, %	25	6	33	5	3	10	0	0	7	0	0	0
Mvmt Flow	4	345	3	88	494	11	3	7	17	22	4	6

Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	343	98	17	264	93	25	18	0	0	32	0	0
Stage 1	60	60	-	30	30	-	-	-	-	-	-	-
Stage 2	283	38	-	234	63	-	-	-	-	-	-	-
Follow-up Headway	4	4	4	4	4	3	2	-	-	2	-	-
Pot Capacity-1 Maneuver	570	785	979	683	795	1029	1612	-	-	1593	-	-
Stage 1	897	837	-	979	868	-	-	-	-	-	-	-
Stage 2	677	855	-	762	840	-	-	-	-	-	-	-
Time blocked-Platoon, %								-	-		-	-
Mov Capacity-1 Maneuver	269	762	971	431	772	1020	1609	-	-	1590	-	-
Mov Capacity-2 Maneuver	269	762	-	431	772	-	-	-	-	-	-	-
Stage 1	889	820	-	971	860	-	-	-	-	-	-	-
Stage 2	284	848	-	433	823	-	-	-	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	14	33	1	5

Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR
Capacity (veh/h)	1609	-	-	746	694	1590	-	-
HCM Lane V/C Ratio	0.002	-	-	0.473	0.855	0.014	-	-
HCM Control Delay (s)	7.242	0	-	14.1	32.9	7.297	0	-
HCM Lane LOS	A	A		B	D	A	A	
HCM 95th %tile Q(veh)	0.006	-	-	2.559	9.894	0.043	-	-

Notes
~ : Volume Exceeds Capacity; $: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	159	20	92	133	18	149	62	416	63	115	396	27
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Util. Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frpb, ped/bikes	1.00	0.98		1.00	0.98		1.00	1.00		1.00	1.00	0.98
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
Frt	1.00	0.88		1.00	0.87		1.00	0.98		1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	1.00
Satd. Flow (prot)	1781	1622		1717	1579		1768	1826		1687	1863	1577
Flt Permitted	0.64	1.00		0.67	1.00		0.37	1.00		0.26	1.00	1.00
Satd. Flow (perm)	1192	1622		1218	1579		681	1826		467	1863	1577
Peak-hour factor, PHF	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Adj. Flow (vph)	185	23	107	155	21	173	72	484	73	134	460	31
RTOR Reduction (vph)	0	64	0	0	104	0	0	14	0	0	0	19
Lane Group Flow (vph)	185	66	0	155	90	0	72	543	0	134	460	12
Confl. Peds. (#/hr)	6		1	1		6	2					2
Confl. Bikes (#/hr)			1			1			1			1
Heavy Vehicles (%)	1%	0%	1%	5%	0%	3%	2%	2%	0%	7%	2%	0%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	Perm
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		6
Actuated Green, G (s)	16.0	16.0		16.0	16.0		16.0	16.0		16.0	16.0	16.0
Effective Green, g (s)	16.0	16.0		16.0	16.0		16.0	16.0		16.0	16.0	16.0
Actuated g/C Ratio	0.40	0.40		0.40	0.40		0.40	0.40		0.40	0.40	0.40
Clearance Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
Lane Grp Cap (vph)	476	648		487	631		272	730		186	745	630
v/s Ratio Prot		0.04			0.06			c0.30			0.25	
v/s Ratio Perm	c0.16			0.13			0.11			0.29		0.01
v/c Ratio	0.39	0.10		0.32	0.14		0.26	0.74		0.72	0.62	0.02
Uniform Delay, d1	8.5	7.5		8.3	7.6		8.1	10.3		10.1	9.6	7.3
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	1.00
Incremental Delay, d2	2.4	0.3		1.7	0.5		2.4	6.8		21.3	3.8	0.1
Delay (s)	10.9	7.8		10.0	8.1		10.4	17.0		31.4	13.4	7.3
Level of Service	B	A		A	A		B	B		C	B	A
Approach Delay (s)		9.6			8.9			16.3			16.9	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	14.1	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.57		
Actuated Cycle Length (s)	40.0	Sum of lost time (s)	8.0
Intersection Capacity Utilization	67.6%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↑		↰	↑↑	↱	↰	↑↑	↱	↰↰	↑↑	
Volume (vph)	79	1086	105	162	1050	240	142	454	196	237	352	151
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	0.95		1.00	0.95	1.00	1.00	0.95	1.00	0.97	0.95	
Frpb, ped/bikes	1.00	1.00		1.00	1.00	0.98	1.00	1.00	0.97	1.00	0.99	
Flpb, ped/bikes	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.95	
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1736	3385		1703	3505	1535	1752	3539	1507	3467	3318	
Flt Permitted	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (perm)	1736	3385		1703	3505	1535	1752	3539	1507	3467	3318	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	81	1120	108	167	1082	247	146	468	202	244	363	156
RTOR Reduction (vph)	0	6	0	0	0	138	0	0	152	0	40	0
Lane Group Flow (vph)	81	1222	0	167	1082	109	146	468	51	244	479	0
Confl. Peds. (#/hr)	4		2	2		4	6		6	6		6
Confl. Bikes (#/hr)						1			5			
Heavy Vehicles (%)	4%	5%	6%	6%	3%	3%	3%	2%	4%	1%	4%	1%
Turn Type	Prot	NA		Prot	NA	Perm	Prot	NA	Perm	Prot	NA	
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases						8			2			
Actuated Green, G (s)	11.0	47.0		17.0	53.0	53.0	16.0	30.0	30.0	10.0	24.0	
Effective Green, g (s)	11.0	47.0		17.0	53.0	53.0	16.0	30.0	30.0	10.0	24.0	
Actuated g/C Ratio	0.09	0.39		0.14	0.44	0.44	0.13	0.25	0.25	0.08	0.20	
Clearance Time (s)	4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Lane Grp Cap (vph)	159	1325		241	1548	677	233	884	376	288	663	
v/s Ratio Prot	0.05	c0.36		c0.10	0.31		c0.08	0.13		c0.07	c0.14	
v/s Ratio Perm						0.07			0.03			
v/c Ratio	0.51	0.92		0.69	0.70	0.16	0.63	0.53	0.13	0.85	0.72	
Uniform Delay, d1	51.9	34.8		49.0	27.1	20.1	49.2	38.9	34.9	54.2	44.9	
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	11.2	12.0		15.2	2.6	0.5	12.1	2.3	0.7	25.3	6.7	
Delay (s)	63.1	46.8		64.2	29.7	20.6	61.3	41.2	35.7	79.6	51.6	
Level of Service	E	D		E	C	C	E	D	D	E	D	
Approach Delay (s)		47.8			32.1			43.4			60.5	
Approach LOS		D			C			D			E	

Intersection Summary			
HCM 2000 Control Delay	43.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.80		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	78.3%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			