FINAL

Traffic Analysis Technical Report

I-5 Rose Quarter Improvement Project

Oregon Department of Transportation

January 8, 2019

Contents

Tables

Figures[1]

[1] Appendix D includes written descriptions of all figures referenced in this Technical Report. If needed, additional figure interpretation is available from the ODOT Senior Environmental Project Manager at (503) 731-4804.

Appendices

Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
API	Area of Potential Impact
APM	*Analysis Procedures Manual*
EB	eastbound
FHWA	Federal Highway Administration
HCM	*Highway Capacity Manual*
HCS	Highway Capacity Software
HDM	*Highway Design Manual*
I-405	Interstate 405
I-5	Interstate 5
I-84	Interstate 84
LOS	Level of Service
MMA	Multimodal Mix-Use Area
mph	miles per hour
mvmt	million vehicle miles travelled
NB	northbound
NEPA	National Environmental Policy Act
OD	Origin-Destination
ODOT	Oregon Department of Transportation
OHP	Oregon Highway Plan
ORS	Oregon Revised Statute
OTP	Oregon Transportation Plan
RTP	*Regional Transportation Plan*
SAC	Stakeholder Advisory Committee
SB	southbound
SPIS	Safety Priority Index System
TMA	Transportation Management Association
TMOS	transportation management and operation strategies
TMP	Traffic Management Plan

TOAS	*Traffic Operations Analysis Summary*
TSP	transportation system plan
v/c	volume-to-capacity ratio
WB	westbound

Executive Summary

The I-5 Rose Quarter Improvement Project (Project) is located in Portland, Oregon, along the 1.7-mile segment of Interstate 5 (I-5) between Interstate 405 (I-405) to the north (milepost 303.2) and Interstate 84 (I-84) to the south (milepost 301.5). The Project also includes the interchange of I-5 and N Broadway and NE Weidler Street (the Broadway/Weidler interchange) and the surrounding transportation network, from approximately N/NE Hancock Street to the north, N Benton Avenue to the west, N/NE Multnomah Street to the south, and NE 2nd Avenue to the east.

The purpose of the Project is to improve safety and operations on I-5 between I-405 and I-84, the Broadway/Weidler interchange, and adjacent surface streets in the vicinity of the Broadway/Weidler interchange. The existing short weaving distances and lack of shoulders for crash/incident recovery in this segment of I-5 are physical factors that contribute to the high number of crashes and safety problems. In achieving the purpose, the Project also would support improved local connectivity and multimodal access in the vicinity of the Broadway/Weidler interchange.

This report evaluates existing conditions and anticipated future year 2045 no-action (No-Build) conditions, and future year 2045 proposed action (Build) conditions for highway operations and local street operations. It also discusses long-term effects of the No-Build Alternative and the long-term, short-term (construction), and cumulative effects of the Build Alternative.

Traffic conditions were analyzed for AM peak hours (7:00 AM to 9:00 AM) and PM peak hours (4:00 PM to 6:00 PM). The second peak hours, 8:00 AM to 9:00 AM and 5:00 PM to 6:00 PM, are the most congested periods.

Existing Conditions

Focusing on highway operations, under existing conditions (2016), three of four weaving segments operate near or over capacity during the AM peak hours:

- I-5 northbound (NB) between the I-84 on-ramp and NE Weidler off-ramp
- I-5 NB between the N Broadway on-ramp and I-405 off-ramp
- I-5 southbound (SB) between the N Wheeler/N Williams/N Ramsay Way on-ramp and I-84 off-ramp

During the PM peak hours, the I-5 SB weave section between the N Wheeler/ N Ramsay on-ramp and the I-84 off-ramp are substantially congested, with traffic queues spilling back from I-84, creating slowdown on SB I-5.

Regarding analysis of existing conditions for local streets, 12 intersections were evaluated. Under existing conditions, they all operate at acceptable levels. Considering the full impact of downstream congestion, the N Wheeler, N Williams (formerly NE Wheeler), and N Ramsay intersection has queues spilling back from I-5 onto the SB ramp through N Ramsay at times during the peak periods.

Future Year 2045 Conditions

Future year 2045 conditions were analyzed for both the No-Build and Build Alternatives. The No-Build Alternative assumes planned projects would be constructed, and the Build Alternative includes proposed I-5 mainline and Broadway/Weidler interchange area improvements. The same AM and PM peak hours were used in the analysis of both alternatives.

Regarding highway operations, the proposed Build Alternative would improve traffic operations in both the AM and PM analysis periods. Three of four weaving segment operations improve under the Build Alternative:

- I-5 NB between the I-84 on-ramp and NE Weidler off-ramp
- I-5 NB between the N Broadway on-ramp and I-405 off ramp
- I-5 SB between the NE Weidler/Williams on-ramp and I-84 off-ramp

The other weaving segment, I-5 SB between the I-405 on-ramp and N Broadway off-ramp, would operate similarly to the No-Build Alternative. Travel time analysis demonstrates travel times under the Build Alternative would all be improved compared to the No-Build Alternative within the API.

Between the No-Build and Build Alternatives, intersection analysis of local streets shows that, during the dominant AM peak hour, intersection performance is acceptable, with most intersections operating with similar performances under both the No-Build and Build Alternatives. During the PM period, local intersections in the Build Alternative are generally operating better compared to the No-Build Alternative, with all intersections operating at acceptable standards.

Active transportation through the local intersections was also evaluated. Streetcar travel times along N/NE Broadway and N/NE Weidler would be improved slightly in the Build Alternative in the 4-hour analysis period. During the dominant AM and PM peak hours, the eastbound and westbound streetcar travel times would be reduced by up to 21 seconds. Bicycle movements in the local streets under the Build Alternative are expected to operate at Level of Service D or better. Bus travel times under the Build Alternative are generally comparable with the No-Build Alternative, resulting from fluctuation of vehicular volumes and reconfigurations.

1 Introduction

1.1 Project Location

The I-5 Rose Quarter Improvement Project (Project) is located in Portland, Oregon, along the 1.7-mile segment of Interstate 5 (I-5) between Interstate 405 (I-405) to the north (milepost 303.2) and Interstate 84 (I-84) to the south (milepost 301.5). The Project also includes the interchange of I-5 and N Broadway and NE Weidler Street (Broadway/Weidler interchange) and the surrounding transportation network, from approximately N/NE Hancock Street to the north, N Benton Avenue to the west, N/NE Multnomah Street to the south, and NE 2nd Avenue to the east.

Figure 1 illustrates the Project Area in which the proposed improvements are located. The Project Area represents the estimated area within which improvements are proposed, including where permanent modifications to adjacent parcels may occur and where potential temporary impacts from construction activities could result.

1.2 Project Purpose

The purpose of the Project is to improve the safety and operations on I-5 between I-405 and I-84, of the Broadway/Weidler interchange, and on adjacent surface streets in the vicinity of the Broadway/Weidler interchange and to enhance multimodal facilities in the Project Area.

In achieving the purpose, the Project would also support improved local connectivity and multimodal access in the vicinity of the Broadway/Weidler interchange and improve multimodal connections between neighborhoods located east and west of I-5.

1.3 Project Need

The Project would address the following primary needs:

- **I-5 Safety:** I-5 between I-405 and I-84 has the highest crash rate on urban interstates in Oregon. Crash data from 2011 to 2015 indicate that I-5 between I-84 and the merge point from the N Broadway ramp on to I-5 had a crash rate (for all types of crashes[2]) that was approximately 3.5 times higher than the statewide average for comparable urban interstate facilities (ODOT 2015a).

[2] Motor vehicle crashes are reported and classified by whether they involve property damage, injury, or death.

Figure 1. Project Area

    - Seventy-five percent of crashes occurred on southbound (SB) I-5, and 79 percent of all the crashes were rear-end collisions. Crashes during this 5-year period included one fatality, which was a pedestrian fatality. A total of seven crashes resulted in serious injury.
    - The Safety Priority Index System (SPIS) is the systematic scoring method used by the Oregon Department of Transportation (ODOT) for identifying potential safety problems on state highways based on the frequency, rate, and severity of crashes (ODOT 2015b). The 2015 SPIS shows two SB sites in the top 5 percent and two northbound (NB) sites in the top 10 percent of the SPIS list.
    - The 2015 crash rate on the I-5 segment between I-84 and the Broadway ramp on to I-5 is 2.70 crashes per million vehicle miles. The statewide average for comparable urban highway facilities is 0.77 crashes per million vehicle miles travelled (mvmt).
    - The existing short weaving distances and lack of shoulders for accident/incident recovery in this segment of I-5 are physical factors that may contribute to the high number of crashes and safety problems.

- **I-5 Operations:** The Project Area is at the crossroads of three regionally significant freight and commuter routes: I-5, I-84, and I-405. As a result, I-5 in the vicinity of the Broadway/Weidler interchange experiences some of the highest traffic volumes in the State of Oregon, carrying approximately 121,400 vehicles each day (ODOT 2017), and experiences 12 hours of congestion each day (ODOT 2012a). The following factors affect I-5 operations:
    - Close spacing of multiple interchange ramps results in short weaving segments where traffic merging on and off I-5 has limited space to complete movements, thus becoming congested. There are five on-ramps (two NB and three SB) and six off-ramps (three NB and three SB) in this short stretch of highway. Weaving segments on I-5 NB between the I-84 westbound (WB) on-ramp and the NE Weidler off-ramp, and on I-5 SB between the N Wheeler Avenue on-ramp and I-84 eastbound (EB) off-ramp, currently perform at a failing level-of-service during the morning and afternoon peak periods.
    - The high crash rate within the Project Area can periodically contribute to congestion on this segment of the highway. As noted with respect to safety, the absence of shoulders on I-5 contributes to congestion because vehicles involved in crashes cannot get out of the travel lanes.
    - Future (2045) traffic estimates indicate that the I-5 SB section between the N Wheeler on-ramp and EB I-84 off-ramp is projected to have the most critical congestion in the Project Area, with capacity and geometric constraints that result in severe queuing.

- **Broadway/Weidler Interchange Operations:** The complexity and congestion at the I-5 Broadway/Weidler interchange configuration is difficult to navigate for vehicles (including transit vehicles), bicyclists, and pedestrians, which impacts access to and from I-5 as well as to and from local streets. The high volumes of traffic on I-5 and Broadway/Weidler in this area contribute to congestion and safety issues (for all modes) at the interchange ramps, the Broadway and Weidler overcrossings of I-5, and on local streets in the vicinity of the interchange.

- The Broadway/Weidler couplet provides east-west connectivity for multiple modes throughout the Project Area, including automobiles, freight, people walking and biking, and Portland Streetcar and TriMet buses. The highest volumes of vehicle traffic on the local street network in the Project Area occur on NE Broadway and NE Weidler in the vicinity of I-5. The N Vancouver Avenue/N Williams couplet, which forms a critical north-south link and is a Major City Bikeway within the Project Area with over 5,000 bicycle users during the peak season, crosses Broadway/Weidler in the immediate vicinity of the I-5 interchange.
- The entire length of N/NE Broadway is included in the Portland High Crash Network—streets designated by the City of Portland for the high number of deadly crashes involving pedestrians, bicyclists, and vehicles.[3]
- The SB on-ramp from N Wheeler and SB off-ramp to N Broadway experienced a relatively high number of crashes per mile (50-70 crashes per mile) compared to other ramps in the Project Area during years 2011-2015. Most collisions on these ramps were rear-end collisions.
- Of all I-5 highway segments in the corridor, those that included weaving maneuvers to/from the Broadway/Weidler ramps tend to experience the highest crash rates:
  - SB I-5 between the on-ramp from N Wheeler and the off-ramp to I-84 (SB-S5) has the highest crash rate (15.71 crashes/mvmt).
  - NB I-5 between the I-84 on-ramp and off-ramp to NE Weidler (NB-S5) has the second highest crash rate (5.66 crashes/mvmt).
  - SB I-5 between the on-ramp from I-405 and the off-ramp to NE Broadway (SB-S3) has the third highest crash rate (4.94 crashes/mvmt).

- **Travel Reliability on the Transportation Network:** Travel reliability on the transportation network decreases as congestion increases and safety issues expand. The most unreliable travel times tend to occur at the end of congested areas and on the shoulders of the peak periods. Due to these problems, reliability has decreased on I-5 between I-84 and I-405 for most of the day. Periods of congested conditions on I-5 in the Project Area have grown over time from morning and afternoon peak periods to longer periods throughout the day.

[3] Information on the City of Portland's High Crash Network is available at https://www.portlandoregon.gov/transportation/54892.

1.4 Project Goals and Objectives

In addition to the purpose and need, which focus on the state's transportation system, the Project includes related goals and objectives developed through the joint ODOT and City of Portland N/NE Quadrant and I-5 Broadway/Weidler Interchange Plan process, which included extensive coordination with other public agencies and citizen outreach. The following goals and objectives may be carried forward beyond the National Environmental Policy Act (NEPA) process to help guide final design and construction of the Project:

- Enhance pedestrian and bicycle safety and mobility in the vicinity of the Broadway/Weidler interchange.
- Address congestion and improve safety for all modes on the transportation network connected to the Broadway/Weidler interchange and I-5 crossings.
- Support and integrate the land use and urban design elements of the Adopted N/NE Quadrant Plan (City of Portland et al. 2012) related to I-5 and the Broadway/Weidler interchange, which include the following:
  - Diverse mix of commercial, cultural, entertainment, industrial, recreational, and residential uses, including affordable housing
  - Infrastructure that supports economic development
  - Infrastructure for healthy, safe, and vibrant communities that respects and complements adjacent neighborhoods
  - A multimodal transportation system that addresses present and future needs, both locally and on the highway system
  - An improved local circulation system for safe access for all modes
  - Equitable access to community amenities and economic opportunities
  - Protected and enhanced cultural heritage of the area
  - Improved urban design conditions
- Improve freight reliability.
- Provide multimodal transportation facilities to support planned development in the Rose Quarter, Lower Albina, and Lloyd.
- Improve connectivity across I-5 for all modes.

2 Project Alternatives

This technical report describes the potential effects of no action (No-Build Alternative) and the proposed action (Build Alternative).

2.1 No-Build Alternative

NEPA regulations require an evaluation of the No-Build Alternative to provide a baseline for comparison with the potential impacts of the proposed action. The No-Build Alternative consists of existing conditions and any planned actions with committed funding in the Project Area.

I-5 is the primary north-south highway serving the West Coast of the United States from Mexico to Canada. At the northern portion of the Project Area, I-5 connects with I-405 and the Fremont Bridge; I-405 provides the downtown highway loop on the western edge of downtown Portland. At the southern end of the Project Area, I-5 connects with the western terminus of I-84, which is the east-west highway for the State of Oregon. Because the Project Area includes the crossroads of three regionally significant freight and commuter routes, the highway interchanges within the Project Area experience some of the highest traffic volumes found in the state (approximately 121,400 average annual daily trips). The existing lane configurations consist primarily of two through lanes (NB and SB), with one auxiliary lane between interchanges. I-5 SB between I-405 and Broadway includes two auxiliary lanes.

I-5 is part of the National Truck Network, which designates highways (including most of the Interstate Highway System) for use by large trucks. In the Portland-Vancouver area, I-5 is the most critical component of this national network because it provides access to the transcontinental rail system, deep-water shipping and barge traffic on the Columbia River, and connections to the ports of Vancouver and Portland, as well as to most of the area's freight consolidation facilities and distribution terminals. Congestion on I-5 throughout the Project Area delays the movement of freight both within the Portland metropolitan area and on the I-5 corridor. I-5 through the Rose Quarter is ranked as one of the 50 worst freight bottlenecks in the United States (ATRI 2017).

Within the approximately 1.5 miles that I-5 runs through the Project Area, I-5 NB connects with five on- and off-ramps, and I-5 SB connects with six on- and off-ramps. Drivers entering and exiting I-5 at these closely spaced intervals, coupled with high traffic volumes, slow traffic and increase the potential for crashes. Table 1 presents the I-5 on- and off-ramps in the Project Area. Table 2 shows distances of the weaving areas between the on- and off-ramps on I-5 in the Project Area. Each of the distances noted for these weave transitions is less than adequate per current highway design standards (ODOT 2012b). In the shortest weave section, only 1,075 feet is available for drivers to merge onto I-5 from NE Broadway NB in the same area where drivers are exiting from I-5 onto I-405 and the Fremont Bridge.

Table 1. I-5 Ramps in the Project Area

I-5 Travel Direction	On-Ramps From	Off-Ramps To
Northbound	• I-84 • N Broadway/N Williams Avenue	• NE Weidler Street/NE Victoria Avenue • I-405 • N Greeley Avenue
Southbound	• N Greeley Avenue • I-405 • N Wheeler Avenue/N Ramsay Way	• N Broadway/N Vancouver Avenue • I-84 • Morrison Bridge/Highway 99E

Notes: I = Interstate

Table 2. Weave Distances within the Project Area

I-5 Travel Direction	Weave Section	Weave Distance
Northbound	I-84 to NE Weidler Street/NE Victoria Avenue	1,360 feet
Northbound	N Broadway/N Williams Avenue to I-405	1,075 feet
Southbound	I-405 to N Broadway	2,060 feet
Southbound	N Wheeler Avenue/N Ramsay Way to I-84	1,300 feet

Notes: I = Interstate

As described in Section 1.3, the high volumes, closely spaced interchanges, and weaving movements result in operational and safety issues, which are compounded by the lack of standard highway shoulders on I-5 throughout much of the Project Area.

Under the No-Build Alternative, I-5 and the Broadway/Weidler interchange and most of the local transportation network in the Project Area would remain in its current configuration, with the exception of those actions included in the Metro 2014 *Regional Transportation Plan* (RTP) financially constrained project list (Metro 2014).[4] One of these actions includes improvements to the local street network on the Broadway/Weidler corridor within the Project Area. The proposed improvements include changes to N/NE Broadway and N/NE Weidler from the Broadway Bridge to NE 7th Avenue. The current design concept would remove and reallocate one travel lane on both N/NE Broadway and N/NE Weidler to establish protected bike lanes

[4] Metro Regional Transportation Plan ID 11646. Available at: https://www.oregonmetro.gov/sites/default/files/Appendix%201.1%20Final%202014%20RTP%20%20Project%20List%208.5x11%20for%20webpage_1.xls

and reduce pedestrian crossing distances. Proposed improvements also include changes to turn lanes and transitions to minimize pedestrian exposure and improve safety. The improvements are expected to enhance safety for people walking, bicycling, and driving through the Project Area. Implementation is expected in 2018-2027.

The City's Broadway/Weidler corridor project does not include Americans with Disabilities (ADA) ramp upgrades or transit boarding islands. To preserve the operations of the interchange ramp terminals and prevent queuing onto the highway mainline, the following local roadway segments are precluded from the travel lane reduction:

- NE Broadway between 2nd and Williams
- NE Weidler between N Benton and 2nd

As for event access, motor vehicles egressing the Rose Quarter parking facilities after events would access I-5 SB by traveling east on N Ramsay through the signalized intersection and directly onto the highway on-ramp. Bicycle and pedestrian trips egressing events in the Rose Quarter would disperse in several directions, with strong movement south to the Rose Quarter Transit Center and north and east to off-site parking and local neighborhoods.

2.2 Build Alternative

The Project alternatives development process was completed during the ODOT and City of Portland 2010-2012 N/NE Quadrant and I-5 Broadway/Weidler Interchange planning process. A series of concept alternatives were considered following the definition of Project purpose and need and consideration of a range of transportation-related problems and issues that the Project is intended to address.

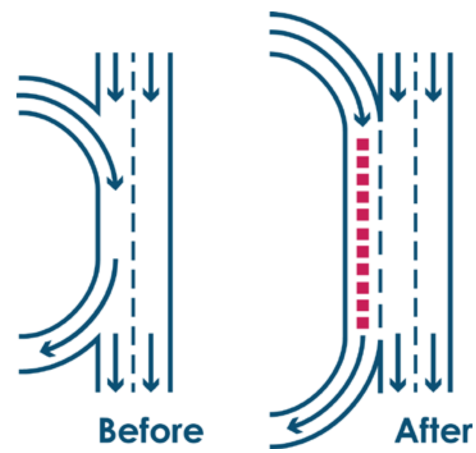
In conjunction with the Stakeholder Advisory Committee (SAC) and the public during this multi-year process, ODOT and the City of Portland studied more than 70 design concepts, including the Build Alternative, via public design workshops and extensive agency and stakeholder input. Existing conditions, issues, opportunities, and constraints were reviewed for the highway and the local transportation network. A total of 19 full SAC meetings and 13 subcommittee meetings were held; each was open to the public and provided opportunity for public comment. Another 10 public events were held, with over 100 attendees at the Project open houses providing input on the design process. Of the 70 design concepts, 13 concepts advanced for further study based on SAC, agency, and public input, with six concepts passing into final consideration.

One recommended design concept, the Build Alternative, was selected for development as a result of the final screening and evaluation process. The final I-5 Broadway/Weidler Facility Plan (ODOT 2012a) and recommended design concept, herein referred to as the Build Alternative, were supported by the SAC and unanimously adopted in 2012 by the Oregon Transportation Commission and the Portland City Council.[5] The features of the Build Alternative are described below.

The Build Alternative includes I-5 mainline improvements and multimodal improvements to the surface street network in the vicinity of the Broadway/Weidler interchange. The proposed I-5 mainline improvements include the construction of auxiliary lanes (also referred to as ramp-to-ramp lanes) and full shoulders between I-84 to the south and I-405 to the north, in both the NB and SB directions. See Section 2.2.1 for more detail.

Construction of the I-5 mainline improvements would require the rebuilding of the N/NE Weidler, N/NE Broadway, N Williams, and N Vancouver structures over I-5.

With the Build Alternative, the existing N/NE Weidler, N/NE Broadway, and N Williams overcrossings would be removed and rebuilt as a single highway cover structure over I-5 (see Section 2.2.2). The existing N Vancouver structure would be removed and rebuilt as a second highway cover, including a new roadway crossing connecting N/NE Hancock and N Dixon Streets. The existing N Flint Avenue structure over I-5 would be removed. The I-5 SB on-ramp at N Wheeler would also be relocated to N/NE Weidler at N Williams, via the new Weidler/Broadway/Williams highway cover. A new bicycle and pedestrian bridge over I-5 would be constructed at NE Clackamas Street, connecting Lloyd with the Rose Quarter (see Section 2.2.4.3).



What are Ramp-to-Ramp or Auxiliary Lanes?

Ramp-to-Ramp lanes provide a direct connection from one ramp to the next. They separate on-and off-ramp merging from through traffic, and create better balance and smoother maneuverability, which improves safety and reduces congestion.

Surface street improvements are also proposed, including upgrades to existing bicycle and pedestrian facilities and a new center-median bicycle and pedestrian path on N Williams between N/NE Weidler and N/NE Broadway (see Section 2.2.4.4).

2.2.1 I-5 Mainline Improvements

The Build Alternative would modify I-5 between I-84 and I-405 by adding safety and operational improvements. The Build Alternative would extend the existing auxiliary lanes approximately 4,300 feet in both NB and SB directions and add 12-foot

[5] Resolution No. 36972, adopted by City Council October 25, 2012. Available at: https://www.portlandoregon.gov/citycode/article/422365

shoulders (both inside and outside) in both directions in the areas where the auxiliary lane would be extended. Figure 2 illustrates the location of the proposed auxiliary lanes. Figure 3 illustrates the auxiliary lane configuration, showing the proposed improvements in relation to the existing conditions. Figure 4 provides a cross section comparison of existing and proposed conditions, including the location of through lanes, auxiliary lanes, and highway shoulders.

A new NB auxiliary lane would be added to connect the I-84 WB on-ramp to the N Greeley off-ramp. The existing auxiliary lane on I-5 NB from the I-84 WB on-ramp to the NE Weidler off-ramp and from the N Broadway on-ramp to the I-405 off-ramp would remain.

The new SB auxiliary lane would extend the existing auxiliary lane that enters I-5 SB from the N Greeley on-ramp. The existing SB auxiliary lane currently ends just south of the N Broadway off-ramp, in the vicinity of the Broadway overcrossing structure.

Under the Build Alternative, the SB auxiliary lane would be extended as a continuous auxiliary lane from N Greeley to the Morrison Bridge and the SE Portland/Oregon Museum of Science and Industry off-ramp. Figure 4 presents a representative cross section of I-5 (south of the N/NE Weidler overcrossing within the Broadway/Weidler interchange area), with the proposed auxiliary lanes and shoulder, to provide a comparison with the existing cross section.

The addition of 12-foot shoulders (both inside and outside) in both directions in the areas where the auxiliary lanes would be extended would provide more space to allow vehicles that are stalled or involved in a crash to move out of the travel lanes. New shoulders would also provide space for emergency response vehicles to use to access an incident within or beyond the Project Area.

No new through lanes would be added to I-5 as part of the Build Alternative; I-5 would maintain the existing two through lanes in both the NB and SB directions.

2.2.2 Highway Covers

2.2.2.1 Broadway/Weidler/Williams Highway Cover

To complete the proposed I-5 mainline improvements, the existing structures crossing over I-5 must be removed, including the roads and the columns that support the structures. The Build Alternative would remove the existing N/NE Broadway, N/NE Weidler, and N Williams structures over I-5 to accommodate the auxiliary lane extension and new shoulders described in Section 2.2.1.

The structure replacement would be in the form of the Broadway/Weidler/Williams highway cover (Figure 5). The highway cover would be a wide bridge that spans east-west across I-5, extending from immediately south of N/NE Weidler to immediately north of N/NE Broadway to accommodate passage of the Broadway/Weidler couplet. The highway cover would include design upgrades to make the structure more resilient in the event of an earthquake.

Figure 2. Auxiliary Lane/Shoulder Improvements

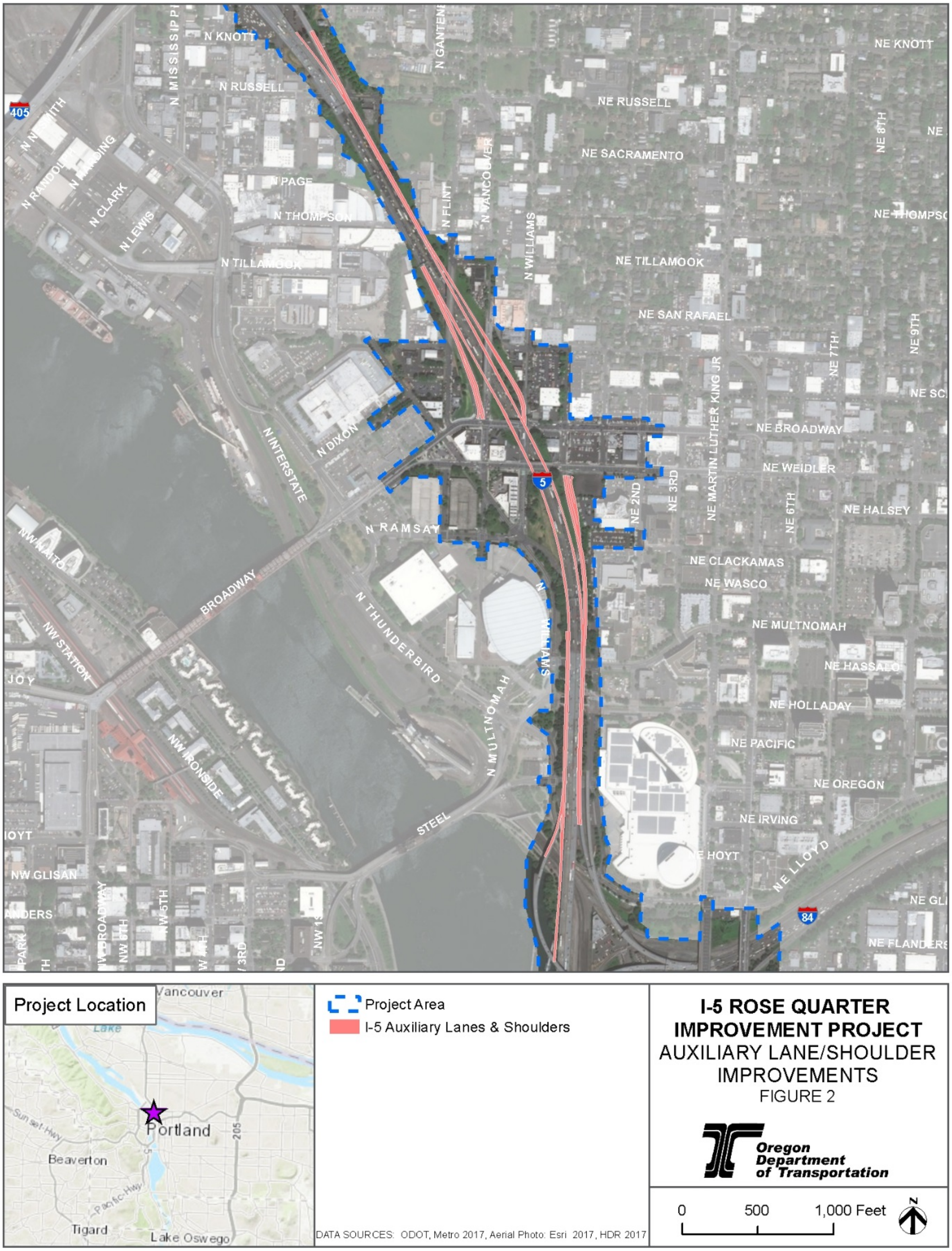


Figure 3. I-5 Auxiliary (Ramp-to-Ramp) Lanes – Existing Conditions and Proposed Improvements

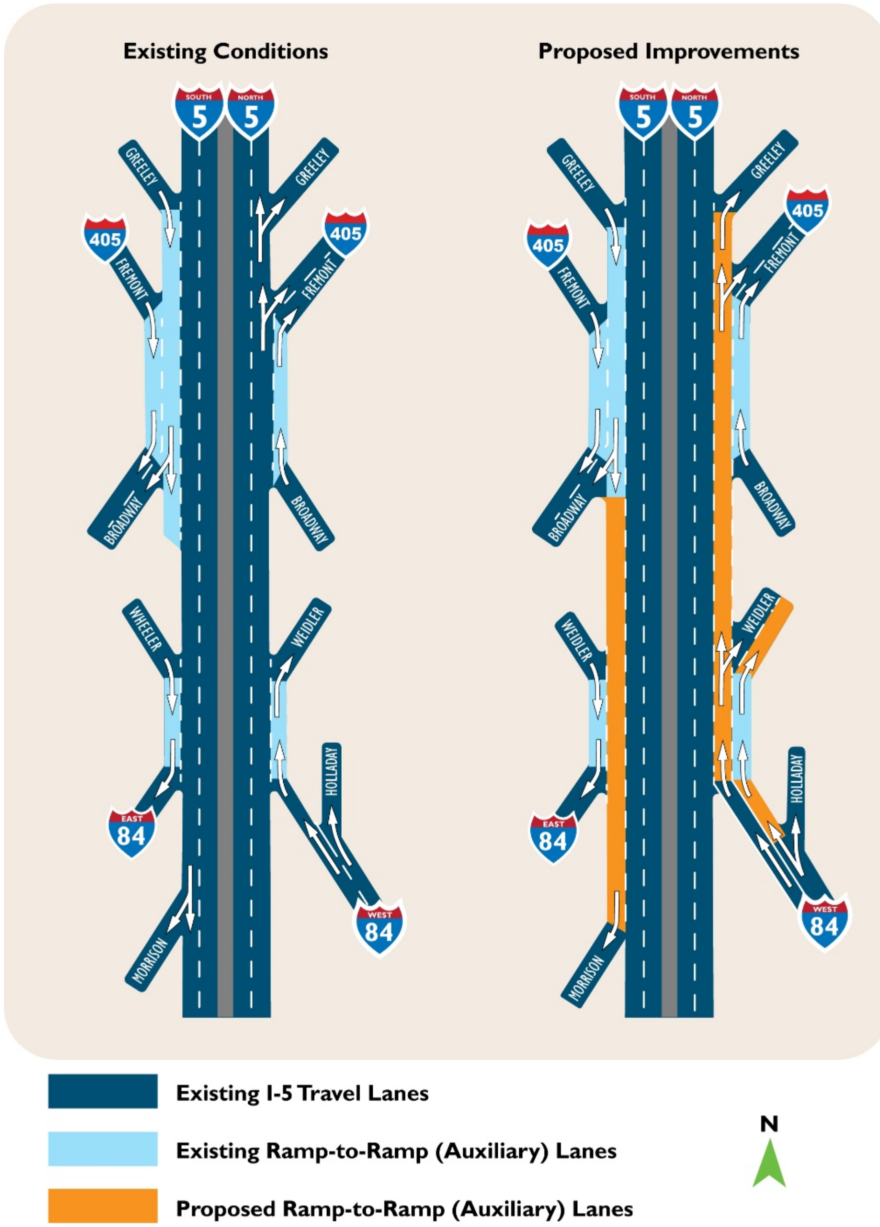
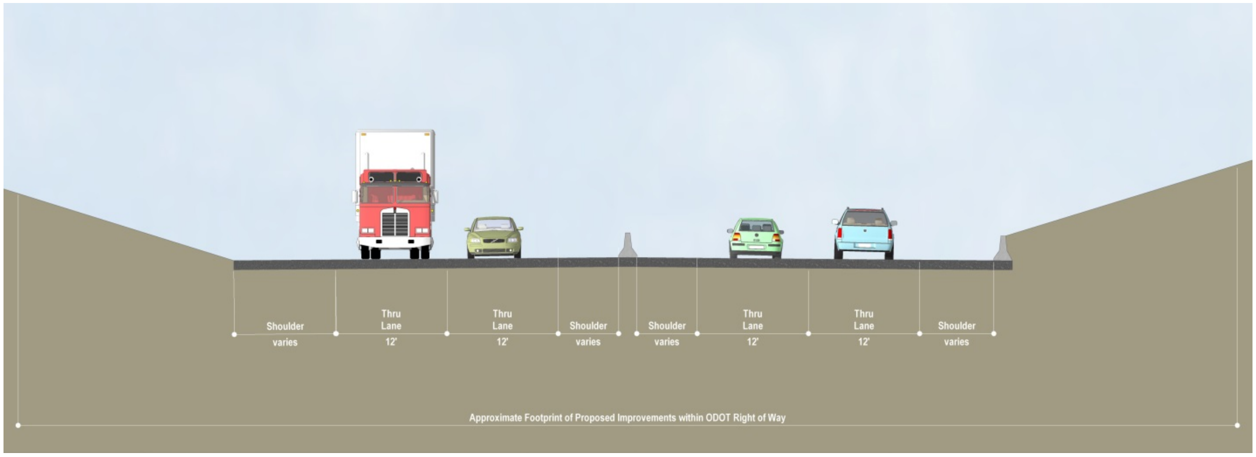
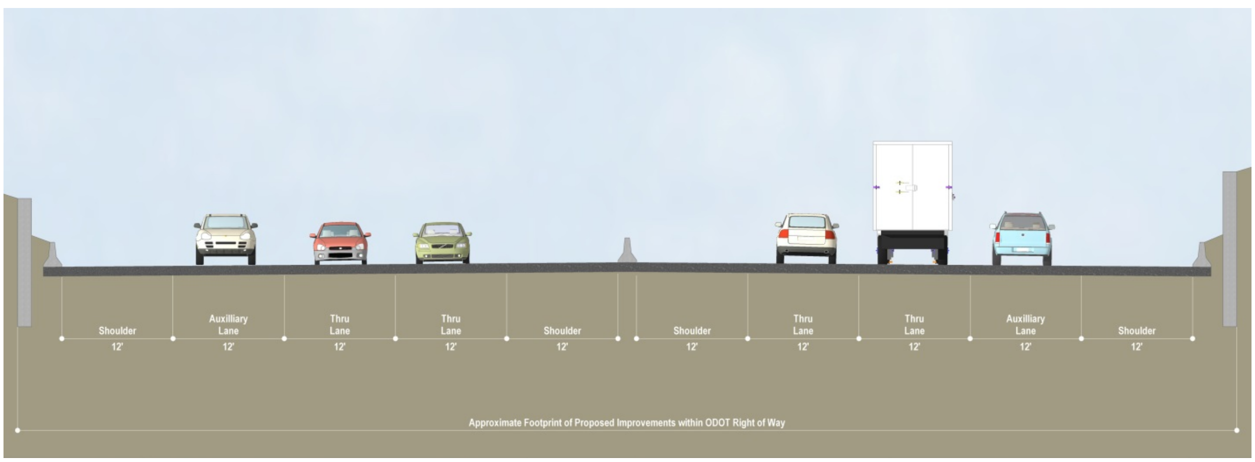


Figure 4. I-5 Cross Section (N/NE Weidler Overcrossing) – Existing Conditions and Proposed Improvements



Existing Lane Configuration



Proposed Lane Configuration

Figure 5. Broadway/Weidler/Williams and Vancouver/Hancock Highway Covers

The highway cover would connect both sides of I-5, reducing the physical barrier of I-5 between neighborhoods to the east and west of the highway while providing additional surface area above I-5. The added surface space would provide an opportunity for new and modern bicycle and pedestrian facilities and public spaces when construction is complete, making the area more connected, walkable, and bike friendly.

2.2.2.2 N Vancouver/N Hancock Highway Cover

The Build Alternative would remove and rebuild the existing N Vancouver structure over I-5 as a highway cover (Figure 5). The Vancouver/Hancock highway cover would be a concrete or steel platform that spans east-west across I-5 and to the north and south of N/NE Hancock. Like the Broadway/Weidler/Williams highway cover, this highway cover would provide additional surface area above I-5. The highway cover would provide an opportunity for public space and a new connection across I-5 for all modes of travel. A new roadway connecting neighborhoods to the east with the Lower Albina area and connecting N/NE Hancock to N Dixon would be added to the Vancouver/Hancock highway cover (see element "A" in Figure 6).

2.2.3 Broadway/Weidler Interchange Improvements

Improvements to the Broadway/Weidler interchange to address connections between I-5, the interchange, and the local street network are described in the following subsections and illustrated in Figure 6.

Figure 6. Broadway/Weidler Interchange Area Improvements

2.2.3.1 Relocate I-5 Southbound On-Ramp

The I-5 SB on-ramp is currently one block south of N Weidler near where N Wheeler, N Williams, and N Ramsay come together at the north end of the Moda Center. The Build Alternative would remove the N Wheeler on-ramp and relocate the I-5 SB on-ramp north to N Weidler. Figure 6 element “B” illustrates the on-ramp relocation.

2.2.3.2 Modify N Williams between Ramsay and Weidler

The Build Alternative would modify the travel circulation on N Williams between N Ramsay and N Weidler. This one-block segment of N Williams would be closed to through-travel for private motor vehicles and would only be permitted for pedestrians, bicycles, and public transit (buses) (Figures 6 and 7). Private motor vehicle and loading access to the facilities at Madrona Studios would be maintained.

2.2.3.3 Revise Traffic Flow on N Williams between Weidler and Broadway

The Build Alternative would revise the traffic flow on N Williams between N/NE Weidler and N/NE Broadway. For this one-block segment, N Williams would be converted from its current configuration as a two-lane, one-way street in the NB direction with a center NB bike lane to a reverse traffic flow two-way street with a 36-foot-wide median multi-use path for bicycles and pedestrians. These improvements are illustrated in Figures 6 and 7.

The revised N Williams configuration would be designed as follows:

- Two NB travel lanes along the western side of N Williams to provide access to the I-5 NB on-ramp, through movements NB on N Williams, and left-turn movements onto N Broadway.
- A 36-foot-wide center median with a multi-use path permitted only for bicycles and pedestrians. The median multi-use path would also include landscaping on both the east and west sides of the path.
- Two SB lanes along the eastern side of N Williams to provide access to the I-5 SB on-ramp or left-turn movements onto NE Weidler.

2.2.4 Related Local System Multimodal Improvements

2.2.4.1 New Hancock-Dixon Crossing

A new roadway crossing would be constructed to extend N/NE Hancock west across and over I-5, connecting it to N Dixon (see Figure 6, element “E”). The new crossing would be constructed on the Vancouver/Hancock highway cover and would provide a new east-west crossing over I-5. Traffic calming measures would be incorporated east of the intersection of N/NE Hancock and N Williams to discourage use of NE Hancock by through motor vehicle traffic. Bicycle and pedestrian through travel would be permitted (see Figure 6, element “F”).

Figure 7. Conceptual Illustration of Proposed N Williams Multi-Use Path and Revised Traffic Flow

2.2.4.2 Removal of N Flint South of N Tillamook and Addition of New Multi-Use Path

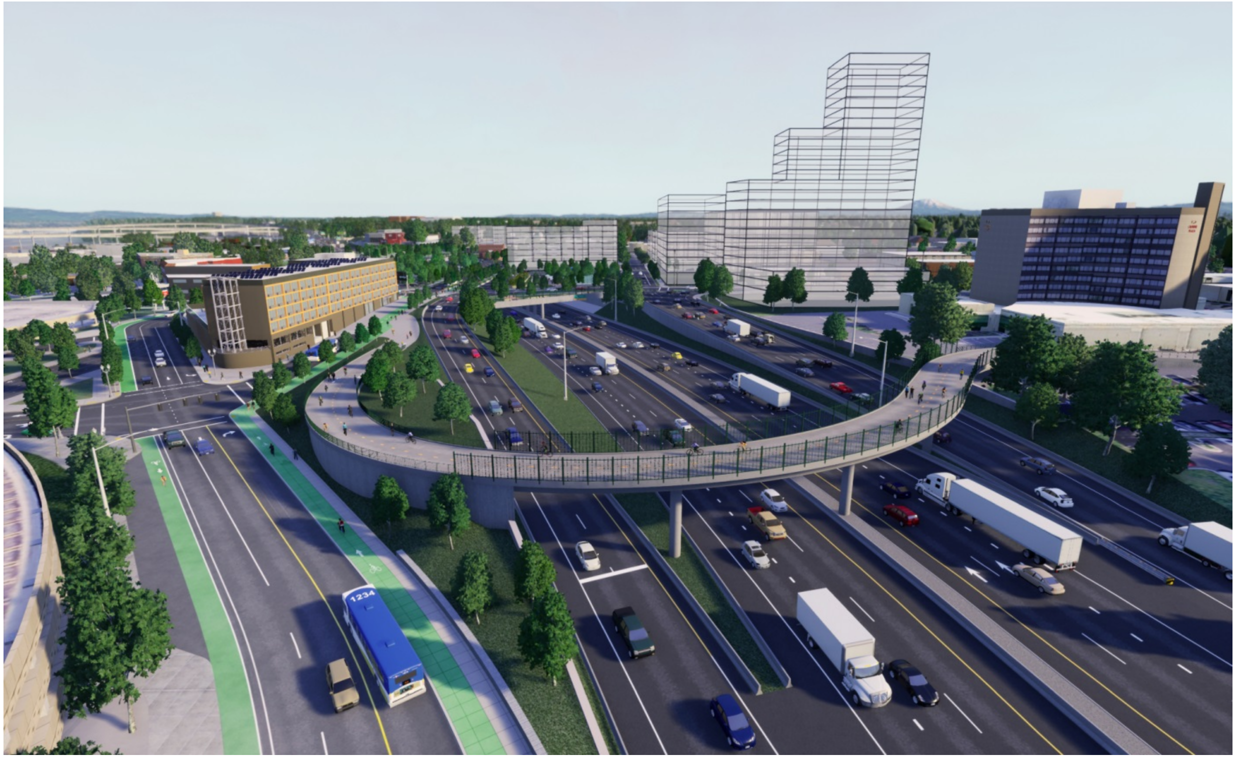
The existing N Flint structure over I-5 would be removed, and N Flint south of N Russell Street would terminate at and connect directly to N Tillamook (see Figure 6, element "G"). The portion of Flint between the existing I-5 overcrossing and Broadway would be closed as a through street for motor vehicles. Driveway access would be maintained on this portion of N Flint to maintain local access.

A new multi-use path would be added between the new Hancock-Dixon crossing and Broadway at a grade of 5 percent or less to provide an additional travel route option for people walking and biking. The new multi-use path would follow existing N Flint alignment between N Hancock and N Broadway (see Figure 6, element "G").

2.2.4.3 Clackamas Bicycle and Pedestrian Bridge

South of N/NE Weidler, a new pedestrian- and bicycle-only bridge over I-5 would be constructed to connect NE Clackamas Street near NE 2nd Avenue to the N Williams/ N Ramsay area (see Figure 6, element "H," and Figure 8). The Clackamas bicycle and pedestrian bridge would offer a new connection over I-5 and would provide an alternative route for people walking or riding a bike through the Broadway/Weidler interchange.

Figure 8. Clackamas Bicycle and Pedestrian Crossing



2.2.4.4 Other Local Street, Bicycle, and Pedestrian Improvements

The Build Alternative would include new widened and well-lit sidewalks, ADA-accessible ramps, high visibility and marked crosswalks, widened and improved bicycle facilities, and stormwater management on the streets connected to the Broadway/Weidler interchange.[6]

A new two-way cycle track would be implemented on N Williams between N/NE Hancock and N/NE Broadway. A two-way cycle track would allow bicycle movement in both directions and would be physically separated from motor vehicle travel lanes and sidewalks. This two-way cycle track would connect to the median multi-use path on N Williams between N/NE Broadway and N/NE Weidler.

The bicycle lane on N Vancouver would also be upgraded between N Hancock and N Broadway, including a new bicycle jug-handle at the N Vancouver and N Broadway intersection to facilitate right-turn movements for bicycles from N Vancouver to N Broadway.

Existing bicycle facilities on N/NE Broadway and N/NE Weidler within the Project Area would also be upgraded, including replacing the existing bike lanes with wider, separated bicycle lanes. New bicycle and pedestrian connections would also be

[6] Additional details on which streets are included are available at http://i5rosequarter.org/local-street-bicycle-and-pedestrian-facilities/

made between the N Flint/N Tillamook intersection and the new Hancock-Dixon connection.

These improvements would be in addition to the new Clackamas bicycle and pedestrian bridge, upgrades to bicycle and pedestrian facilities on the new Broadway/Weidler/Williams and Vancouver/Hancock highway covers, and new median multi-use path on N Williams between N/NE Broadway and N/NE Weidler described above and illustrated in Figure 6.

3 Regulatory Framework

Federal, state, regional, and local plans and policies have been established that guide the development of transportation projects. Some of these plans and policies relate to the design and operation of the Project. The *Land Use Technical Report* (ODOT 2019a) includes detailed descriptions of the most applicable regulatory documents (i.e., Oregon Statewide Planning Program, Transportation Planning Rule, Metro's RTP, and City of Portland Comprehensive Plan). Additional planning and policy documents that are directly related to implementing a transportation project in this location are described below.

3.1 Federal Plans and Policies

3.1.1 ADA Guide

The ADA Guidelines contains scoping and technical requirements for accessibility to buildings and facilities by individuals with disabilities under the ADA of 1990. These scoping and technical requirements are to be applied during the design, construction, and alteration of buildings and facilities to ensure accessibility and usability to individuals with disabilities. The 2010 ADA Standards for Accessible Design, dated September 15, are the most recent guidelines (U.S. Department of Justice 2010).

3.1.2 Federal Highway Administration (FHWA) Bicycle and Pedestrian Guides

The purpose of FHWA guidance is to describe federal legislative and policy direction related to safety and accommodation for bicycling and walking. The Intermodal Surface Transportation Efficiency Act of 1991 enacted significant changes to federal transportation policy and programs that expanded consideration of and eligibility for funding bicycle and pedestrian improvements. The Transportation Equity Act for the 21st Century (TEA-21) in 1998 and the Safe Accountable, Flexible, Efficient Transportation Equity Act: a Legacy for Users (SAFETEA-LU) in 2005 continued these provisions. The Moving Ahead for Progress in the 21st Century Act (MAP-21) of 2012 enacted some program and funding changes but continued broad consideration and eligibility for bicycling and walking. Bicycle and pedestrian design standards are included in the American Association of State Highway and Transportation Officials (AASHTO) guidance document *A Policy on Geometric Design of Highways and Streets – 2011* (AASHTO 2011) and in the ODOT 2012 *Highway Design Manual* (HDM; ODOT 2012b).

3.2 State Laws, Plans, and Policies

3.2.1 Oregon Transportation Plan

The 2006 Oregon Transportation Plan (OTP) is the state's long-range multimodal transportation plan (ODOT 2007). The OTP is the overarching policy document among a series of plans that together form the state transportation system plan (TSP). The OTP considers all modes of Oregon's transportation system as a single system and addresses the future needs of Oregon's airports, bicycle and pedestrian facilities, highways and roadways, pipelines, ports and waterway facilities, public transportation, and railroads. It assesses state, regional, and local public and private transportation facilities. The OTP establishes goals, policies, strategies, and initiatives that address the core challenges and opportunities facing Oregon. The OTP provides the framework for prioritizing transportation improvements based on varied future revenue conditions, but it does not identify specific projects for development.

3.2.2 Oregon Highway Plan

The 1999 Oregon Highway Plan (OHP; ODOT 1999) defines policies and investment strategies for Oregon's state highway system for the next 20 years. It further refines the goals and policies of the OTP and is part of Oregon's TSP. The OHP has three main elements:

- The Vision presents a vision for the future of the state highway system, describes economic and demographic trends in Oregon and future transportation technologies, summarizes the policy and legal context of the OHP, and contains information on the current highway system.
- The Policy Element contains goals, policies, and actions in five policy areas: system definition, system management, access management, travel alternatives, and environmental and scenic resources.
- The System Element contains an analysis of state highway needs, revenue forecasts, descriptions of investment policies and strategies, an implementation strategy, and performance measures.

3.2.3 ODOT Highway Design Manual

The ODOT HDM (ODOT 2012b) provides uniform highway design standards and procedures for ODOT. It is intended to provide guidance for the design of new construction; major reconstruction (4R); resurfacing, restoration, and rehabilitation (3R); or resurfacing (1R) projects. The manual is used for all projects that are located on the state highways and by all ODOT personnel for planning studies and project development. The flexibility contained in the manual supports the use of Practical Design concepts and Context Sensitive Design practices.

The manual is in agreement with the AASHTO document *A Policy on Geometric Design of Highways and Streets - 2011* (AASHTO 2011). National Highway System or federal-aid projects on roadways that are under the jurisdiction of cities or counties will typically use the AASHTO design standards or ODOT 3R design standards. State and local planners will also use the manual in determining design requirements as they relate to the state highways in TSPs, Corridor Plans, and Refinement Plans.

3.2.4 Division 51: Access Management Rules

Division 51 establishes procedures, standards, and approval criteria used by ODOT to govern highway approach permitting and access management consistent with Oregon Revised Statutes (ORS), Oregon Administrative Rules, statewide planning goals, acknowledged comprehensive plans, and the OHP. The intent of Division 51 is to provide a highway access management system based on objective standards that balance the economic development objectives of properties abutting state highways with the transportation safety and access management objectives in a manner consistent with local TSPs and the land uses permitted in local comprehensive plan(s) acknowledged under ORS Chapter 197.

3.3 Regional and Local Plans

3.3.1 TriMet Plans

TriMet has adopted service enhancement plans for various portions of the metropolitan area. The North/Central Service Enhancement Plan encompasses the Area of Potential Impact (API) for this Project. Service enhancements included in the plan for this area include extended service hours for the Line 4 Division/Fessenden and a new bus route connecting the Parkrose/Sumner Transit Center to downtown via NE Prescott Street, NE Alberta Street, and NE Martin Luther King Jr Boulevard to the Rose Quarter Transit Center and the Steel Bridge.

TriMet is currently considering long-term plans for the Steel Bridge, including consideration of a new transit-only crossing as well as the long-term layout and function of the Rose Quarter Transit Center. No final documents or policy decisions have been made regarding these opportunities.

3.3.2 City of Portland Transportation System Plan and Mixed-Used Multi-Modal Plan

The City of Portland TSP, which is necessary to meet state and regional planning requirements, was updated in 2018 (City of Portland 2018). The TSP is an element of the City's Comprehensive Plan, and it contains several modal plans including bicycle, pedestrian, and freight, as well as neighborhood area plans and street plans. Transportation projects included in the TSP that are in or adjacent to the Project Area include streetcar turnarounds at NE Grand Avenue and NE Weidler and at NE Grand and NE Oregon Street, new traffic signals along NE Grand and NE Martin Luther King Jr. Boulevard, a new bicycle and pedestrian bridge across I-84 in the vicinity of NE 7th, redesign of the Rose Quarter Transit Center, and a multi-use pathway along the east bank of the Willamette River north of the Steel Bridge.

Portland's Central City gained Multimodal Mix-Use Area (MMA) designation as part of the adoption of the Central City 2035 Plan (City of Portland et al. 2018). With the MMA designation, the City would not need to consider ODOT mobility standards when approving Comprehensive Plan or Zoning Map Amendments with the Central City's MMA boundary and have flexibility of lifting congestion standards and accepting a higher level of congestion on Central City streets for all modes of travel. The local intersections within the API are all within the designated Central City's MMA Boundary, thereby subject to follow the City's MMA attributes as illustrated in the MMA plan (City or Portland et al. 2018) as follows:

- High-quality connectivity to and within the area by modes of transportation other than the automobile
- A denser level of development of a variety of commercial and residential uses than in surrounding areas
- A desire to encourage these characteristics through development standards
- An understanding that increased automobile congestion within and around the MMA is accepted as a potential trade-off

3.3.3 Go Lloyd

Go Lloyd was founded in 1994 as the Lloyd District Transportation Management Association (TMA). TMAs are public/private partnerships formed so that employers, developers, building owners, and government entities can work collectively to establish policies, programs, and services to address local transportation issues and foster economic development. Go Lloyd is managed by a board of directors and works closely with local government agencies, non-profits, and business to promote transportation and economic development improvements for Lloyd.

Go Lloyd tracks transportation activities and plans in the district and prepares an annual report that includes results of the Employee Commute Choice Survey. Survey results are used to report on transportation mode split to the district and help to measure the effectiveness of various programs. Go Lloyd does not adopt specific plans and policies but has worked closely with the City of Portland on the N/NE Quadrant Plan as part of the Central City Plan and Comprehensive Plan updates.

3.4 Other Relevant Guidance

3.4.1 American Association of State Highway and Transportation Officials (AASHTO)

AASHTO is a standards-setting body that publishes specifications, test protocols, and guidelines, which are used in highway design and construction throughout the United States. AASHTO sets transportation standards and policy for the United States but is not an agency of the federal government; rather, it is an organization of the states themselves. Policies of AASHTO are not federal laws or policies, but rather are ways to coordinate state laws, policies, and design standards in the field of transportation. The association represents not only highways but includes air, rail, water, and public transportation.

The voting membership of AASHTO consists of the Department of Transportation of each state in the United States, as well as those of Puerto Rico and the District of

Columbia. The United States Department of Transportation; some U.S. cities, counties, and toll-road operators; most Canadian provinces; the Hong Kong Highways Department; the Ministry of Public Works and Settlement; and the Nigerian Association of Public Highway and Transportation Officials have non-voting associate memberships.

3.4.2 National Association of City Transportation Officials Urban Street Design Guide

The National Association of City Transportation Officials is an association of 62 American cities and 10 transit agencies. The Urban Street Design Guide provides guidance on the design and operation of urban streets (NACTO 2018). The guide is not prescriptive but provides recommendations and description of best practices for implementing urban streets that function safely for all modes of travel.

4 Methodology and Data Sources

This section presents the methodology used to develop traffic volumes and analyze highway and local street operations. Potential cumulative impacts were assessed based on the Metro RTP-based regional travel demand model, in which traffic numbers consider identified reasonably foreseeable future actions.

4.1 Project Area and Area of Potential Impact

The API for the traffic analysis generally corresponds to the Project Area shown in Figure 1, except along N Broadway, where the API extends west to N Larrabee (see Figure 9).

4.2 Resource Identification and Evaluation

4.2.1 Study Intersections

The existing and future (2045) No-Build and Build traffic operations analysis focused on the following intersections (see Figure 10):

1. I-5 SB exit-ramp at N Broadway and N Vancouver
2. N/NE Broadway and N Williams
3. NE Broadway and NE Victoria
4. NE Broadway and NE 2nd
5. NE Weidler and NE 2nd
6. I-5 NB off-ramp at NE Weidler and NE Victoria
7. N/NE Weidler and N Williams
8. N Weidler and N Vancouver
9. N Broadway and N Benton
10. N Broadway and N Larrabee
11. N Wheeler/N Williams (formerly NE Wheeler)/N Ramsay
12. N Williams and N/NE Hancock
13. N Vancouver and N Hancock (Build Alternative Only)

These focused intersections are within the API and would be most impacted by the Project. As multimodal higher functional classification roadways, they serve greater volumes of traffic, have the potential for downstream effects, and are representative of traffic conditions within the Project Area.

Figure 9. Transportation Area of Potential Impact

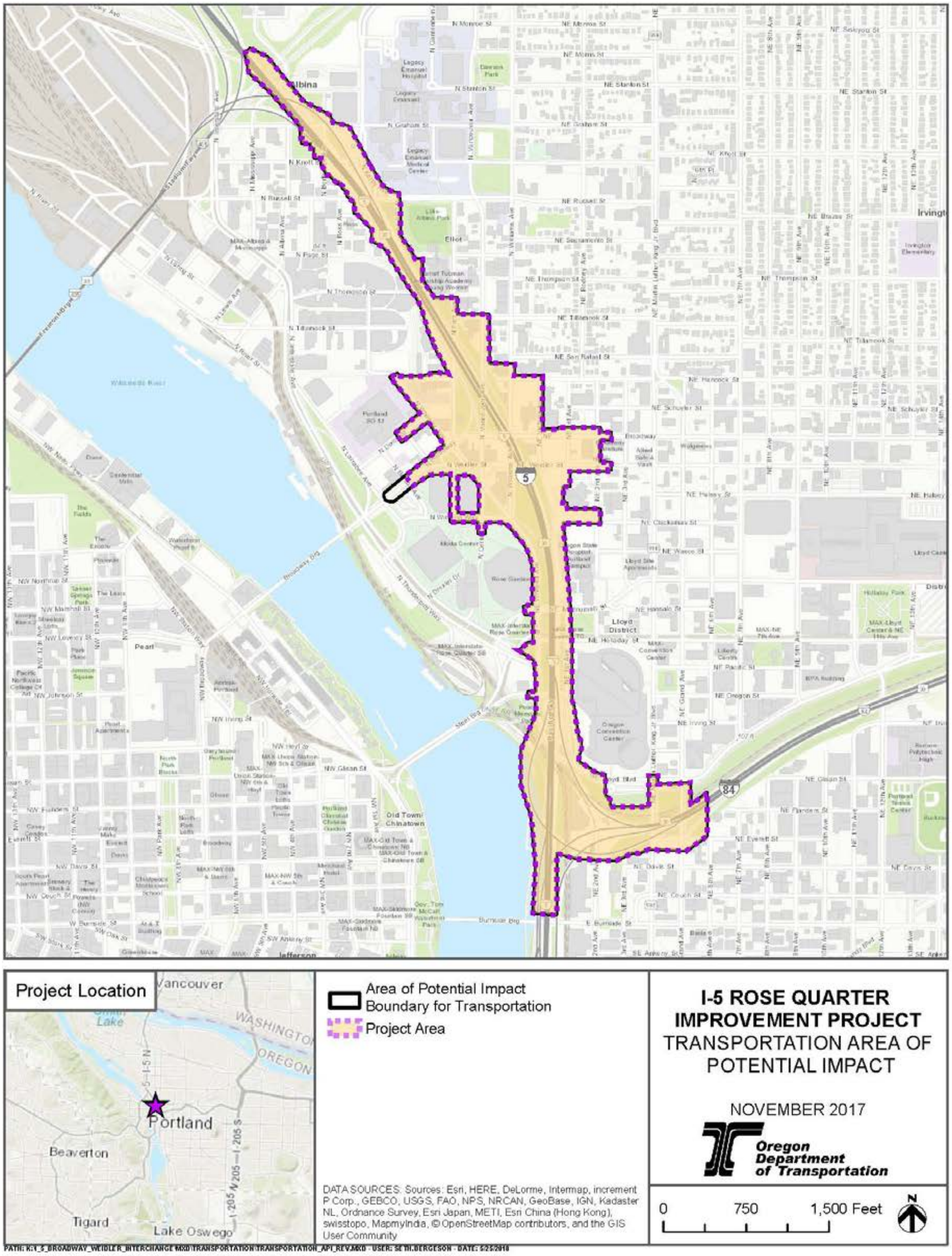
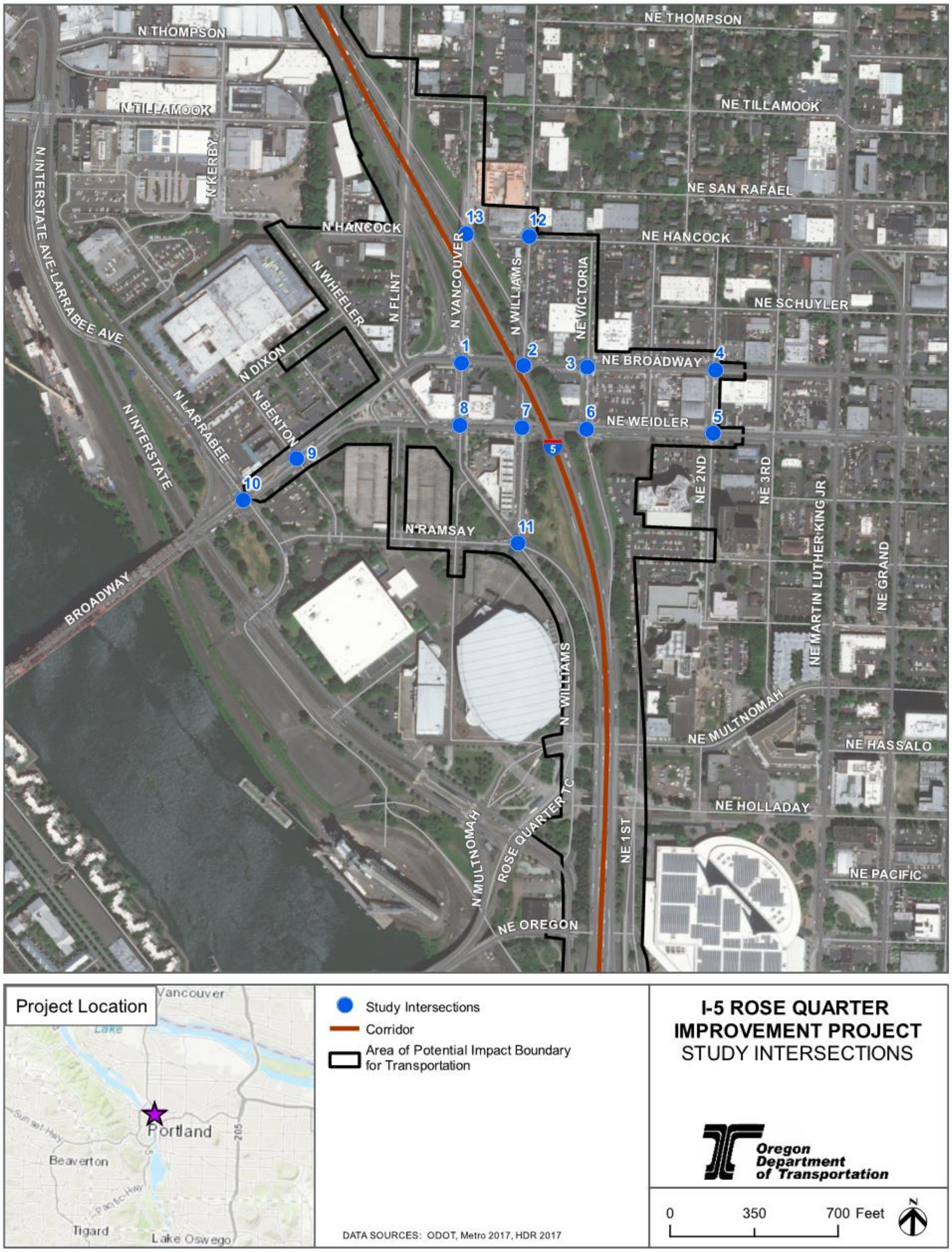


Figure 10. Study Intersections



4.2.2 Traffic Volumes

Traffic volumes were developed for existing conditions and future (2045) No-Build and Build conditions. Each condition includes an AM and a PM first peak hour and second peak hour volume set.

4.2.2.1 Existing Traffic Volume

ODOT collected existing intersection turning movement counts in October 2016 during the morning (7:00 AM to 9:00 AM) and evening (4:00 PM to 6:00 PM) peak periods for mid-week weekdays (Tuesday-Thursday) as consistent with ODOT's *Analysis Procedures Manual* (APM) guidelines (ODOT 2016). For the Portland region, traffic data collected during Tuesday through Thursday are most representative of the typical traffic conditions by avoiding the flex- and alternative work schedules. The turning movement counts included cars and trucks as well as bicycles and pedestrians. Turning movement counts were collected at the following intersections:

- N Broadway and N Benton
- N Broadway and N Larrabee
- I-5 SB off-ramp at N Vancouver and N Broadway
- N Vancouver and N Weidler
- N Williams and N/NE Broadway
- N Williams and N/NE Weidler
- N/NE Hancock and N Williams
- N Hancock and N Vancouver
- NE 2nd and NE Broadway
- NE 2nd and NE Weidler
- NE Victoria and NE Broadway
- I-5 NB off-ramp at NE Victoria and NE Weidler
- N Wheeler and N Ramsay
- NE Martin Luther King Boulevard and NE Broadway
- NE Martin Luther King Boulevard and NE Weidler
- NE Grand and NE Broadway
- NE Grand and NE Weidler
- N Russell and N Vancouver
- N/NE Russell and N Williams
- N Larrabee and N Interstate (two locations)

- N/NE Multnomah and N Williams (formerly NE Wheeler)

Traffic volumes for I-5 were obtained from the Portland area transportation data archive (PORTAL) in 2016. The 2016 PORTAL data were compared to the highway volumes used in the *Traffic Operations Analysis Summary* (TOAS) report for the I-5 Broadway/Weidler Interchange Improvements project completed by HDR in January 2015 (see Appendix A). Traffic volumes in the 2016 data were found to be lower than in the 2013 PORTAL data that were used previously. To be consistent with the previous analysis work, traffic volumes from the TOAS report were used for the highway and ramps in the API and supplemented with new ramp volumes at the Broadway/Weidler interchange from the more recent intersection turning movement counts.

Based on the intersection and highway counts, the AM highest peak hour for the network was determined to occur between 8:00 AM and 9:00 AM, and the PM highest peak hour was between 5:00 PM and 6:00 PM. The first morning and afternoon peak hours are less congested and occur between 7:00 AM and 8:00 AM and between 4:00 PM and 5:00 PM, respectively.

4.2.2.2 Future Traffic Volumes

Per ODOT's APM, the Metro travel demand model (assigned to the detailed City of Portland network) was used to forecast future demand (horizon year 2045, based on a 20-year design life from the expected start of construction in 2023) (ODOT 2016). Metro maintains travel demand models for existing (year 2015) and future conditions (year 2040 consistent with the RTP). Metro provided the City of Portland with the 2015 and 2040 trip tables. The City's network was then used to run the 2015 and 2040 travel demand models, as it provides a finer street detail for analysis. The volume growth from the 2015 base year and 2040 future financially constrained regional travel demand models was used to identify an annual growth rate using a straight-line growth method. This growth rate was applied to the 5-year increment between 2040 and 2045 to define the demand model for the Project's horizon year.

The modeled volume growth between 2015 base year and 2045 future year was added to the existing traffic counts to establish the 2045 volumes used for the operations analysis. This procedure is consistent with the National Cooperative Highway Research Program Report 765 methodology.

The travel demand model also accounts for peak spreading, which is when traffic demand exceeds capacity, and the resulting traffic volumes are served over a longer peak duration (temporal spreading). Peak spreading is likely to occur by the forecast year of 2045, and Metro's travel demand model includes temporal adjustments that account for peak spreading and are then reflected in the forecast volume sets.

4.2.2.3 Volume Balancing

Volume balancing is a technique applied to traffic volumes to obtain a cohesive set of network volumes. Volume balancing is based on engineering judgment, weighing the importance of the count date, the traffic patterns, the surrounding land uses, and physical constraints, including the topography of the land. The practice attempts to balance volumes exiting and entering each intersection. Volume balancing was performed for all existing and future volume sets. Exact volume balancing was only conducted in areas where no intermediate access was available or where the volumes appeared to be above the expected variance.

4.3 Assessment of Impacts

The operational criteria, standards, and software used for the analysis of highway and local street operations are presented below.

4.3.1 Operational Criteria

Transportation engineers have established various targets for measuring traffic capacity and motor vehicle operations at intersections. Bicycle and pedestrian operations at these intersections are discussed in the *Active Transportation Technical Report* (ODOT 2019b). Three typical motor vehicle operations measures analyzed for this Project are described in the following subsections.

4.3.1.1 Volume-to-Capacity Ratio

A comparison of intersection demand to capacity is one method of evaluating how an intersection is operating or expected to operate for motor vehicles. This comparison is presented as a volume-to-capacity (v/c) ratio. A v/c ratio of less than 1.00 indicates that the motor vehicle volume is less than the available capacity. As the v/c approaches 0.00, traffic conditions are better, with little congestion and low delays for most intersection movements. As the v/c ratio approaches 1.00, traffic becomes more congested and unstable with longer delays. A v/c over 1.00 means that the motor vehicle demand exceeds the available capacity of the intersection.

4.3.1.2 Level of Service

Level of Service (LOS) is another measure for evaluating motor vehicle traffic capacity and quality of service of roadways. LOS results supplement the v/c ratio to gain a better understanding of how motor vehicles operate at the intersections. LOS is a function of control delay, which includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. Six service levels have been established, ranging from LOS A, where there is insignificant or no motor vehicle delay, to LOS F, where the delay is more than 50 seconds at unsignalized intersections or more than 80 seconds at signalized intersections.

The intersections not associated with the highway ramp terminals are subject to City of Portland standards of LOS D for signalized intersection and LOS E for unsignalized intersections (City of Portland n.d.). It should be noted that at signalized intersections, some motor vehicle movements, particularly side street approaches or left turns onto side streets, might experience longer delays because they receive only a small portion of the effective green time during a signal cycle, but their v/c ratio may be relatively low. For this reason, it is worthwhile to examine both v/c ratio and LOS when evaluating overall intersection motor vehicle operations. Although LOS is not a mobility target, both it and v/c were evaluated.

4.3.1.3 95th Percentile Queuing

Queuing estimates help provide a more complete assessment of how an intersection is operating for motor vehicles in congested conditions, but they cannot capture the potential additional delays at other intersections within the analysis. To be consistent with ODOT procedures, 95th percentile queue lengths were used for this analysis.

4.3.2 Mobility Standards

For the existing conditions and future No-Build analysis, the mobility targets in the updated OHP (ODOT 1999) apply to the highway and ramp terminal intersections. This version of the OHP defines mobility targets in terms of v/c ratios, which, within a metro area, are dependent upon the roadway classification and area type. According to OHP Table 7, the mobility target for this portion of I-5, which is located within central Portland, is a v/c of 1.1 for the highest hour of the peak period and 0.99 or less for the second highest hour. The mobility target for highway ramp terminal intersections is a v/c of 0.85 for both the peak hours.

The intersections not associated with the highway ramp terminals are subject to City of Portland's LOS standards as described in Section 4.3.1.2.

The analysis results of the Build scenario use the standards in the 2012 ODOT HDM, which is more restrictive than OHP targets. The HDM defines mobility targets in terms of v/c ratios, which are also dependent on roadway classification and area type (ODOT 2012b: Table 10-2). The HDM-defined target for I-5 and highway ramp terminal intersections is a v/c of 0.75, which would be used for approvals in the design phase of the Project. The Build mobility target for the local street intersections is a v/c of 1.1 or less for the highest hour of the peak period and 0.99 or less for the second highest hour.

4.3.3 Traffic Operations Software

Traffic operations for intersections and roadways were evaluated and compared using a combination of deterministic and microsimulation processes. The local street network was analyzed using Synchro 9, which uses the general characteristics of an intersection to evaluate how it will operate based on the *Highway Capacity Manual* (HCM) (TRB 2010).[7] The deterministic process produces v/c ratio and delay and LOS as measurements of performance.

Highway operations were analyzed using VISSIM 10, a widely used, behavior-based multi-purpose traffic microsimulation program. VISSIM tracks individual vehicle movements and interactions more realistically than typical HCM methods and quantifies the performance of individual movements and overall delays and queue

[7] HCM 2010 analysis currently does not provide all output needed using Synchro.

lengths for highways, ramps, and intersections. The local street network was also modeled in VISSIM to analyze the operations of motor vehicles, transit, and bicycles, and to evaluate queuing between closely spaced intersections. This software produces highway speed and travel time as well as intersection delay and queuing to measure vehicle performance. Analysis results from VISSIM are based on the average of 10 simulation runs. Ten runs will generate a large enough sample size to produce true statistical average Measures of Effectiveness.

Highway Capacity Software (HCS) was used for the deterministic analysis of the highway to evaluate merge, diverge, and weaving operations. HCS produces v/c ratio, density, and LOS to measure vehicle performance based on the HCM. VISSIM does not provide v/c ratio as an output.

VISSIM and Synchro models were developed for existing year (2016) and future year (2045) Build and No-Build conditions. AM and PM peak periods were analyzed for all analysis scenarios.

4.3.3.1 Existing Model Development

The base VISSIM model for the Project was developed using the previous VISSIM model from the 2015 TOAS. The TOAS model included the same API on I-5 as well as the ramp terminal intersections on the local street network. Detailed information on the development of the original model can be found in Appendix A. The Project VISSIM model retained much of the previous network and expanded the network to include the local street intersections identified in Section 4.2.1. Model assumptions, parameters, and network coding techniques for developing the base VISSIM model are discussed in the following subsections.

Model Geometrics

Scaled aerial photography was used to expand the base VISSIM network and establish intersection lane configurations, stop bar locations, and turn pocket lengths. The high-resolution aerials were also used to review the merge, weave, diverge, and lane drop sections on I-5 from the previous TOAS model. Several locations on the local street network have recently been reconfigured and were not shown on the aerial imagery that was provided. These locations include the SB off-ramp to N Broadway and N Vancouver. These areas were reviewed for accuracy based on field observations and updated accordingly.

Vehicle Inputs

Balanced motor vehicle traffic volumes were summarized in 15-minute intervals using a 0.95 peak hour factor to represent the traffic fluctuations during simulated peak periods, which allowed the VISSIM models to more closely represent traffic arrival patterns and queuing on the highway and at study intersections. The VISSIM models are 2-hour-long peak periods plus a seeding period. The seeding period is a 30-minute-long period prior to the start of peak period. The seeding period applies first peak hour volume inputs and allows for vehicles to be loaded into the network before recording simulation results.

The first peak hours were developed by factoring the second peak hour volumes based on the raw count data provided by ODOT. Based on existing count data, the first peak hours on the local street network and the highway represent the following percent of second peak hour traffic volumes:

- AM First Peak Hour (7:00-8:00 AM)
  - Arterial – 83 percent
  - Highway – 100 percent
- PM First Peak Hour (4:00-5:00 PM)
  - Arterial – 96 percent
  - Highway – 96 percent

In addition to motor vehicle inputs, bicycle and pedestrian volumes were included at all API intersections.

Vehicle Routing

Traffic patterns in VISSIM were modeled using static routes and routing decisions. Vehicle routing through the API was achieved through the development of Origin-Destination (OD) matrices. Separate OD matrices were developed for the highway/ramps and local street network. The highway OD matrices used the Bluetooth OD data provided by ODOT for the TOAS model. The local street OD matrices were estimated by evaluating permitted/prohibited movements and calculating the ratios of individual turn movements at each intersection.

All OD matrices were developed using VISSIM's OD matrix estimation feature, TFlowFuzzy.[8] The OD matrices were developed based on the peak hour volume counts and applied throughout the peak period. The same traffic patterns were assumed for both cars and trucks, resulting in routing decisions that were applied to all vehicle types.

Signal Timing and Ramp Meters

Signal timing data and phasing were provided by Portland Bureau of Transportation and coded in VISSIM using the Ring-Barrier Controller. Detector locations were provided for some of the intersections via as-builts. In other cases, timing, sequences, and phasing were interpolated based on signal timing sheets supplemented by field observations. ODOT provided ramp meter data as saturation flow rates in 15-minute increments. A programming script was developed to mimic ramp metering operations using the metering rates. Signal heads for the ramp meters were positioned in the current locations, and vehicle detectors were added to detect arriving vehicles at ramp meters. The script was developed such that during every simulation time step, the modeled ramp meters would check if a vehicle has

[8] TFlowFuzzy is a matrix estimation method in VISUM used to adjust an OD matrix so that the result of the assignment more closely matches the observed volumes within the network.

approached the ramp meter, define the appropriate green time to mimic the metering rate, and allow the approaching vehicle to pass.

Transit

Transit data for bus and streetcar operations were obtained from TriMet's website. Within the API, there are three bus lines (4, 17, and 44) and a streetcar (Central Loop) that travel on N/NE Broadway and N/NE Weidler. Lines 4 and 44 run exclusively on N Williams and the Vancouver/Williams couplet. TriMet actual bus schedule times were used as the basis for coding bus headways in the peak period model. The VISSIM models used 15-minute headways for existing conditions, except for Line 4, which has 10-minute headways. Average dwell times were based on data provided by TriMet, which equated to 25 seconds per stop.

4.3.3.2 Existing Model Calibration

Calibration is an iterative process that involves adjusting model parameters until the simulation reasonably replicates driver behavior, traffic flow patterns, and field-measured data. The calibration process used for the VISSIM models followed ODOT and FHWA guidelines for determining the acceptability of model results as compared to existing operations.

The 2015 TOAS model was extensively calibrated on I-5 using speed data from INRIX and field observations. Since the current VISSIM model is using very similar traffic volumes on the highway, no additional calibration was performed on I-5. Detailed information on the calibration of the highway can be found in the TOAS report in Appendix A. With the expansion of the previous VISSIM model to include the API intersections, calibration was required on the local street network. A synopsis of the calibration process is described below.

Visual Checking and Error Correction

The visual checking and error correction process focused on addressing coding errors before the calibration process began. This process involved reviewing data inputs, VISSIM error reports, and model animations. Although primarily performed during model development, visual checking and error correction is still an important process that should be performed during calibration. When making changes to driver behavior or other model parameters, this step helps ensure that unintended consequences are identified and corrected in the model.

Data inputs included network geometry, traffic volumes, signal timing, and route choices and were reviewed by the model developer as well as a quality control reviewer. VISSIM produces an error file after each simulation run. Errors can include vehicle removal, signal issues, end of link errors, and various others. Critical errors in the model were accounted for and corrected during this step. Visual checking of the animation was performed to check for abnormal driving behavior or irregular queuing within the network and to identify coding parameters subject to additional refinement.

Calibration Targets

The team calibrated the Project VISSIM model for the local street network using both traffic volumes and visual audits in accordance with ODOT's Protocol for VISSIM Simulation. The following targets were set for calibration:

- Volumes to be within a GEH Statistic[9] value of 5.0 for all entry and exit locations, all entrance and exit ramps, and all intersection turn movements greater than 100 vehicles per hour. GEH values higher than 5.0 are acceptable but should warrant investigation, and values over 10.0 indicate there may be an error with the model.
- Visual audits to check consistency with field conditions of the following: on- and off-ramp queuing, patterns and extent of queues at intersections and congested links, lane utilization/choice, location of bottlenecks, etc.

As part of the calibration process, adjustments included changes to the driver behavior parameters and lane change distances. These changes were based on engineering judgment and field-observed vehicular operations.

Traffic Volume Calibration

A comparison of the existing condition modeled traffic volumes and balanced field-collected volumes at each intersection in the AM and PM highest peak hours (8:00-9:00 AM) and (5:00-6:00 PM) are provided in Tables 3 and 4, respectively. The traffic volume summaries are based on total volume (sum of all turning movements). Individual movement results for each intersection are provided in Appendix B.

As shown below, the AM and PM peak hour traffic volumes, as measured in the VISSIM simulation models, correlate well with the balanced field-collected volumes, with a calculated GEH of 5.0 or less for all intersections. N Broadway and N Vancouver/I-5 SB Ramp in the PM peak hour has a GEH value of 5.0, which is still considered acceptable. The primary reason for this result is congestion and queuing on I-5 during the peak period that limits the amount of traffic that can reach the SB off-ramp.

[9] The GEH formula is used in traffic engineering, forecasting, and modeling to compare two sets of traffic volumes.

Table 3. Traffic Volume Summary – Existing Condition 8:00-9:00 AM

Intersection	Measured Volume	Simulated Volume	GEH
N Williams & N/ NE Hancock	465	451	0.7
N/NE Broadway & N Williams	2455	2392	1.3
N Broadway & N Vancouver/ I-5 SB Ramp	2580	2411	3.4
N Broadway & N Larrabee	1965	1903	1.4
N Interstate & N Larrabee	1070	1067	0.1
N Weidler & N Vancouver	2050	1946	2.3
N Vancouver & N Russell	1105	1100	0.2
N/NE Multnomah & N Williams (formerly NE Wheeler)	605	604	0.0
N Wheeler/N Williams (formerly NE Wheeler) & N Ramsay/I-5 SB Ramp	1160	1146	0.4
N/NE Weidler & N Williams	1030	953	2.4
N Williams & N/NE Russell	1010	997	0.4
N Broadway & N Benton	1880	1807	1.7
N Larrabee & N Interstate	570	559	0.5
NE Broadway & NE Victoria	2305	2253	1.1
NE Grand & NE Weidler	2090	2021	1.5
NE Grand & NE Broadway	2700	2686	0.3
NE Martin Luther King Jr & NE Weidler	2975	2878	1.8
NE Martin Luther King Jr & NE Broadway	3320	3284	0.6
NE Weidler & NE Victoria/I-5 NB Ramp	2030	1905	2.8
NE Weidler & NE 2nd	1640	1537	2.6
NE Broadway & NE 2nd	1925	1895	0.7

Notes: NB = northbound; SB = southbound

Table 4. Traffic Volume Summary – Existing Condition 5:00-6:00 PM

Intersection	Measured Volume	Simulated Volume	GEH
N Williams & N/NE Hancock	650	636	0.6
N/NE Broadway & N Williams	2315	2256	1.2
N Broadway & N Vancouver/I-5 SB Ramp	2475	2232	5.0
N Broadway & N Larrabee	2740	2679	1.2
N Interstate & N Larrabee	1715	1708	0.2
N Weidler & N Vancouver	2800	2654	2.8
N Vancouver & N Russell	1330	1325	0.1
N/NE Multnomah & N Williams (formerly NE Wheeler)	940	922	0.6
N Wheeler/N Williams (formerly NE Wheeler) & N Ramsay/I-5 SB Ramp	1355	1312	1.2
N/NE Weidler & N Williams	1845	1747	2.3
N Williams & N/NE Russell	1325	1309	0.4
N Broadway & N Benton	2650	2564	1.7
N Larrabee & N Interstate	775	765	0.4
NE Broadway & NE Victoria	2030	1984	1.0
NE Grand & NE Weidler	3310	3244	1.2
NE Grand & NE Broadway	3045	3024	0.4
NE Martin Luther King Jr & NE Weidler	3265	3175	1.6
NE Martin Luther King Jr & NE Broadway	2895	2876	0.4
NE Weidler & NE Victoria/I-5 NB Ramp	2530	2397	2.7
NE Weidler & NE 2nd	2045	1939	2.4
NE Broadway & NE 2nd	1545	1530	0.4

Notes: NB = northbound; SB = southbound

Visual Audits

Visual audits were performed on the VISSIM models to match field conditions, with attention focused on the extent of congestion and queuing on the local street network. Visual observations of the VISSIM models were compared to field observations and observed “congestion” using Google Traffic, a feature on Google Maps that displays “typical” and real-time traffic conditions on major roads and highways. Visual observations showed congestion levels on the local street network that were consistent with field conditions, which included the following:

- Extensive queuing and congestion on N Vancouver, N Wheeler, and N/NE Broadway during the PM peak period. Queuing starts at the SB on-ramp at N Wheeler/N Ramsay and extends, at times, as far east as NE Grand. This queuing is primarily caused by congestion on I-5 and I-84, which impacts the SB on-ramp from N Wheeler/N Ramsay.
- Moderate congestion and queuing on EB N Broadway at N Larrabee during the PM peak period. Queuing extends over the Broadway Bridge.
- Minor congestion and queuing on WB NE Broadway during the AM peak period.
- Queuing on the SB and NB off-ramps that extend to the I-5 mainline during the PM peak period. During the AM peak period, queue spillback was observed, at times, on the NB off-ramp.

Overall, the calibration of the existing conditions VISSIM models for the local street network produced simulation output that replicated existing traffic operations and field observed driver behavior for both the AM and PM peak periods.

4.3.3.3 Future No-Build Model Development

The future No-Build VISSIM model for the Project was developed using the calibrated existing conditions model. The changes made between the existing and future No-Build models included the following:

- The No-Build condition assumed no changes to network geometry except the Broadway/Weidler roadway reconfiguration as described in Section 2.1.
- Vehicle routing (OD) and inputs were updated using the 2045 No-Build volumes refined by the Project team. The routes and inputs are consistent with the growth assumptions in the Central City 2035 Plan (City of Portland et al. 2012).
- Future bicycle and pedestrian volumes were derived from Metro’s bike model, refined by the Project team, and incorporated into the No-Build model.
- Streetcar headways were reduced from 15 minutes to 10 minutes based on Portland Streetcar’s planned service improvements.
- Minor signal timing adjustments were made to the free-running signals on N Broadway at N Larrabee and N Benton.
- The No-Build condition assumes that the existing bottlenecks and congestion on NB I-5 north of the API would be improved due to other planned future I-5 projects identified on Metro’s financially constrained project list in the adopted 2014 Metro RTP.

4.3.3.4 Future Build Model Development

The future Build VISSIM model for the Project was developed using the future No-Build model. The changes made between the No-Build and Build models included the following:

- Network geometry for the highway and local streets was modified to match the recommended Build Alternative using the latest design files.
- Vehicle routing (OD) and inputs were updated using the 2045 Build volumes developed by the Project team. The proposed modifications to the local street network in the Build Alternative associated primarily with the relocation of the SB on-ramp to I-5 resulted in changes to volumes and trip patterns feeding into the SB on-ramp that are fundamentally different from the No-Build condition.
- The No-Build future bicycle and pedestrian volumes were refined by the Project team based on the proposed modifications to the local street network, specifically with the removal of the Flint structure and the addition of bicycle improvements to the Vancouver and Broadway intersection, and were incorporated into the Build model. The proposed modifications to the local street network in the Build Alternative shifts all the SB traveling bikes from N Vancouver to N Williams Avenue.
- Transit headways for the streetcar were reduced from 15 minutes to 10 minutes based on a proposed increase in service by year 2045.
- Signal timing adjustments were made to the coordinated signals along NE Broadway and NE Weidler to account for the relocation of the I-5 SB on-ramp and the resulting redistribution of traffic. Different cycle lengths were evaluated along the corridor, but it was determined that the existing 70-second cycle length would provide the best operations.
- Minor signal timing adjustments were made to the free-running signals on N Broadway at N Larrabee and N Benton.

4.4 Cumulative Impacts

The cumulative impacts analysis considered the Project's impacts combined with other past, present, and reasonably foreseeable future actions that would result in environmental impacts in the Project Area. Because transportation impacts typically occur on a broader, system-wide scale, the Project team considered actions within and immediately beyond the Project Area. The cumulative impact assessment qualitatively assessed the magnitude of impacts associated with projects listed in the financially constrained element of Metro's RTP (Metro 2014) and other shorter-term projects and service improvements identified by the City of Portland and TriMet (summarized in Appendix A), in combination with anticipated Project impacts. This assessment also identified the contribution of the Project to overall cumulative impacts.

5 Affected Environment

This section describes existing traffic operations in the API. This analysis of existing highway and local street traffic conditions provides a point of comparison for the future No-Build scenario and supports the purpose and need statement for this Project.

5.1 Existing Highway Traffic Operations

This section describes existing highway traffic operations using v/c ratio and LOS results from HCS, lane-by-lane vehicle speeds, and travel times for select routes from VISSIM.

5.1.1 HCS Results

HCS was used for the analysis of the highway to evaluate mainline, merge, diverge, and weaving operations to supplement the VISSIM analysis. The HCS analysis results are presented in Tables 5 and 6 and include v/c ratios that are compared to OHP mobility standards. As shown below, three of the four weaving segments are operating near or over capacity in both AM peak hours: I-5 NB between I-84 on-ramp and NE Weidler off-ramp, I-5 NB between N Broadway on-ramp and I-405 off-ramp, and I-5 SB between N Wheeler on-ramp and I-84 off-ramp.

The I-5 NB weave between the N Broadway on-ramp and the I-405 off-ramp well exceeds the OHP mobility target (v/c = 0.99) in both AM peak hours. It should be noted that the HCS analysis does not consider downstream congestion, and the results indicate acceptable operations in locations where the VISSIM speed results show substantial congestion (i.e., the I-5 SB weave between the N Wheeler on-ramp and the I-84 off-ramp during the PM peak period). Queue spillback from congestion on I-84 in existing conditions creates slowdown on SB I-5 that extends north of the weave area. This observed queuing and other field collected data were all considered in VISSIM model calibration.

Table 5. HCS Analysis Results: Existing First Peak Hour AM (PM)

Direction	Location	Analysis Type	V/C	Volume Density (pc/mi/ln)	LOS
I-5 Northbound	I-84 On-Ramp to Weidler Off-Ramp	Weaving	0.97 (0.82)	* (35.9)	F (E)
	Weidler Off-Ramp to Broadway On-Ramp	Basic Section	0.81 (0.70)	37.8 (32.5)	E (D)
	Broadway On-Ramp to I-405 Off-Ramp	Weaving	1.31 (0.72)	* (28.5)	F (D)
	Greeley Off-Ramp	Diverge	0.63 (0.66)	26.7 (28.0)	C (C)
I-5 Southbound	I-405 On-Ramp to Broadway Off-Ramp	Weaving	0.63 (0.56)	27.2 (22.6)	C (C)
	Broadway Off-Ramp to Wheeler On-Ramp	Basic Section	0.87 (0.67)	40.9 (31.2)	E (D)
	Wheeler On-Ramp to I-84 Off-Ramp	Weaving	0.94 (0.78)	* (33.1)	F (D)
	Morrison Off-Ramp	Diverge	0.81 (0.57)	33.2 (23.1)	D (C)

Notes: HCS = Highway Capacity Software; LOS = Level of Service; v/c = volume-to-capacity ratio
LOS is based on the calculated volume density and not based on v/c ratio shown.
Red = v/c ratio exceeds Oregon Highway Plan mobility target of 0.99 for first peak hour.
* = Volume density not reported (demand exceeds capacity).
xx (xx): results without parenthesis are for AM; with parenthesis are for PM.

Table 6. HCS Analysis Results: Existing Second Peak Hour AM (PM)

Direction	Location	Analysis Type	V/C	Volume Density (pc/mi/ln)	LOS
I-5 Northbound	I-84 On-Ramp to Weidler Off-Ramp	Weaving	0.97 (0.85)	* (38.0)	F (E)
	Weidler Off-Ramp to Broadway On-Ramp	Basic Section	0.81 (0.73)	37.8 (33.9)	E (D)
	Broadway On-Ramp to I-405 Off-Ramp	Weaving	1.31 (0.74)	* (29.9)	F (D)
	Greeley Off-Ramp	Diverge	0.63 (0.69)	26.7 (29.2)	C (C)
I-5 Southbound	I-405 On-Ramp to Broadway Off-Ramp	Weaving	0.63 (0.58)	27.2 (23.8)	C (C)
	Broadway Off-Ramp to Wheeler On-Ramp	Basic Section	0.87 (0.69)	40.9 (32.5)	E (D)
	Wheeler On-Ramp to I-84 Off-Ramp	Weaving	0.94 (0.81)	* (34.9)	F (D)
	Morrison Off-Ramp	Diverge	0.81 (0.59)	33.2 (24.1)	D (C)

Notes: HCS = Highway Capacity Software; LOS = Level of Service; v/c = volume-to-capacity ratio
LOS is based on the calculated volume density and not based on v/c ratio shown.
Red = v/c ratio exceeds Oregon Highway Plan mobility target of 1.1 for second peak hour.
* = Volume density not reported (demand exceeds capacity).
xx (xx): results without parenthesis are for AM; with parenthesis are for PM.

5.1.2 Lane-by-Lane Speed

Lane-by-lane vehicle speeds from VISSIM are presented in Figures 11 and 12 for the existing AM and PM peak periods. During the onset of AM peak period, speeds break down (less than 30 miles per hour [mph]) on I-5 SB north of the I-405 off-ramp. Speeds less than 20 mph occur at the existing three-to-two lane reduction south of the N Broadway off-ramp. This lane reduction, coupled with the heavy weaving volumes between I-405 and N Broadway, results in slow speeds as far north as the Greeley on-ramp. During the highest morning peak (8:00-9:00 AM), this same pattern of sluggish traffic movement and congestion worsens, causing speeds to drop below 20 mph in all lanes between the existing lane reduction and the I-405 on-ramp. In the NB direction, speeds less than 30 mph were observed between the I-84 on-ramp and the NE Weidler off-ramp in both peak hours. Speeds also break down during the 8:00-9:00 AM hour between the N Broadway on-ramp and the I-405 off-ramp.

During 4:00-5:00 PM, substantial congestion and slow speeds (less than 20 mph) occur in multiple lanes on I-5 SB between the I-405 on-ramp and the existing lane reduction. Speeds below 40 mph extend north to the Greeley on-ramp. This same pattern of slow speeds and congestion worsens during 5:00-6:00 PM, with I-5 SB operating below 20 mph in all lanes from I-405 on-ramp south to the Broadway/Weidler interchange lane drop.

In the NB direction during 4:00-5:00 PM, congestion outside of the API due to limited highway capacity causes slow operating speeds north of the Greeley off-ramp. Speeds below 20 mph from the north end of I-5 NB extend south to the I-405 on-ramp, and speeds below 30 mph extend to the Greeley off-ramp. During 5:00-6:00 PM, the NB weave between I-84 and NE Weidler also breaks down more in the second PM peak hour, with speeds below 40 mph. The congestion north of I-405 continues to build, propagating speeds below 30 mph as far south as the N Broadway on-ramp.

Figure 11. Lane-by-Lane Speed – Existing AM Peak Period

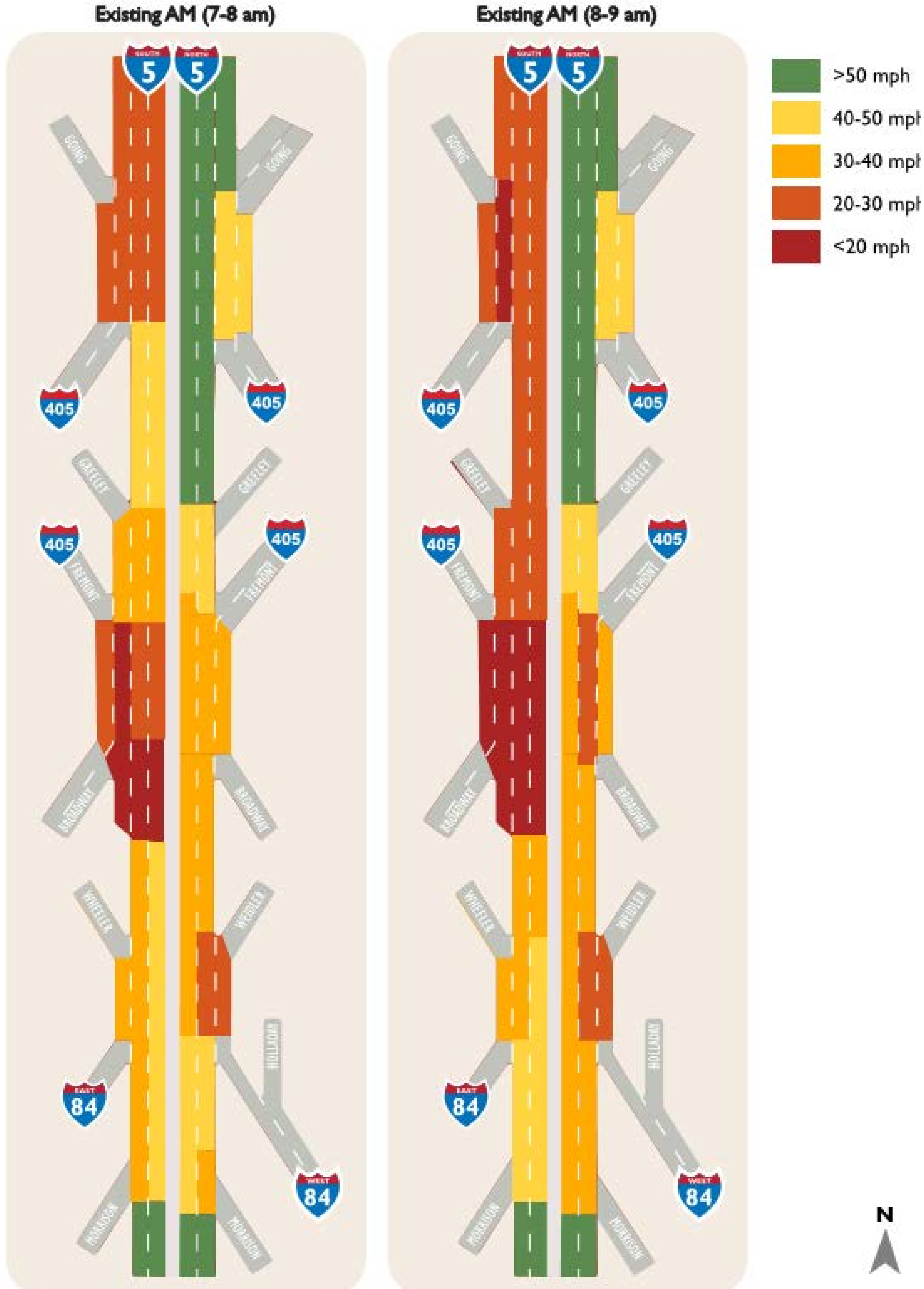
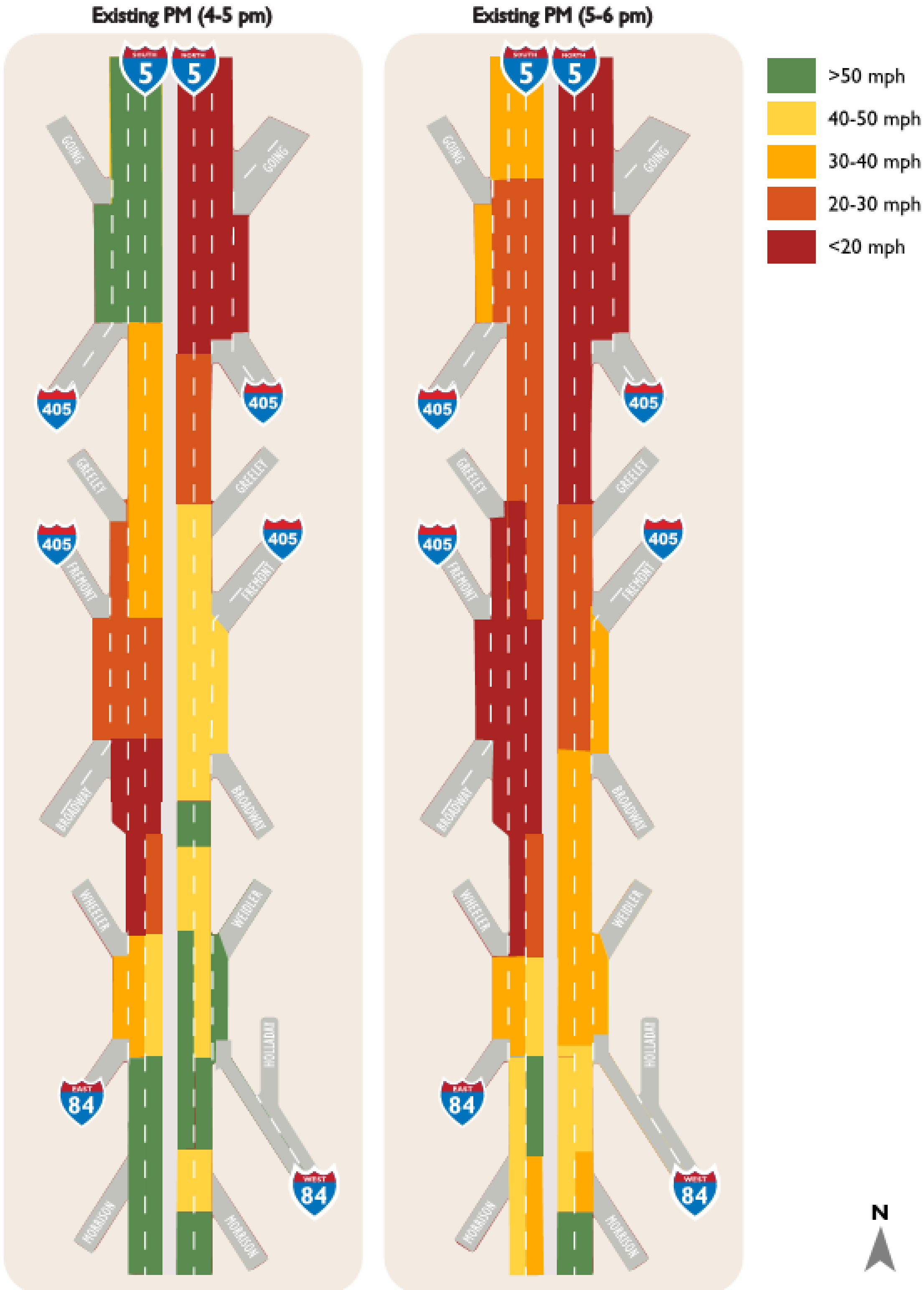


Figure 12. Lane-by-Lane Speed – Existing PM Peak Period



5.1.3 Highway Travel Time

Travel time routes were modeled in VISSIM to provide a comparison of travel times of vehicles along I-5. The travel time routes on I-5 spanned between N Going Street to the north and SE Morrison Street to the south as shown in Figure 13. The routes that were used in the highway analysis represent the following six common travel routes for commuter and freight traffic within the API:

- Route A – I-5 SB, north of N Going on-ramp to N Broadway off-ramp (Rose Quarter)
- Route B – I-5 SB, north of N Going on-ramp to south of Morrison Bridge off-ramp (end to end)
- Route C – I-5 SB, north of N Going on-ramp to I-84 EB off-ramp
- Route D – I-5 NB, south of Morrison on-ramp to NE Weidler off-ramp (Rose Quarter)
- Route E – I-5 NB, south of Morrison on-ramp to north of N Going off-ramp (end to end)
- Route F – I-5 SB, N Wheeler on-ramp to south of Morrison off-ramp

The travel times for the existing AM and PM peak periods are presented in Table 7. As shown below, the first peak hour travel times are generally shorter than the second peak hour travel times, and the PM peak period travel times are greater than those in the AM peak period. The I-5 SB travel times are particularly long during 5:00-6:00 PM, with trips taking up to 17 minutes between N Going and the I-84 off-ramp.

Table 7. Existing Conditions - Travel Time (minutes)

Route	AM Period		PM Period	
	7-8 AM	8-9 AM	4-5 PM	5-6 PM
Route A	4.4	7.1	6.1	10.8
Route B	6.2	9.1	9.2	14.4
Route C	6.9	9.9	12.2	17.3
Route D	1.5	1.8	1.0	1.6
Route E	4.0	4.6	8.0	10.8
Route F	1.1	1.1	1.4	1.4

Figure 13. Travel Time Routes

5.2 Existing Local Street Traffic Operations

This section describes existing traffic operations for the local street intersections using Synchro and VISSIM. Synchro was used to obtain intersection v/c ratio and LOS results due to the limitations of providing v/c ratios from microsimulation. VISSIM was used to analyze the operations of motor vehicles, transit, and bicycles and to evaluate queuing between closely spaced intersections.

5.2.1 Synchro Analysis Results

Synchro software was used for the analysis of the local street intersection operations to supplement the VISSIM analysis. The Synchro analysis results are presented in Tables 8 and 9 and include v/c ratios and LOS that respectively compare to OHP mobility standards and the City's operational targets. As shown below, the v/c ratio for the I-5 SB off-ramp intersection at N Broadway and N Vancouver exceeds the OHP mobility target during 8:00 to 9:00 AM. The I-5 NB off-ramp at NE Weidler and NE Victoria intersection LOS E exceeds the City's operational target LOS D for signalized intersection. The Synchro analysis also indicates that all API intersections are currently operating at LOS D or better under existing PM conditions.

It should be noted that Synchro does not consider downstream congestion or the full impacts of queue spillback between intersections. For example, at the N Wheeler and N Ramsay intersection during the PM peak period, the Synchro results show that the intersection is operating at LOS B, but the VISSIM analysis indicates that the intersection is operating at LOS C or worse. This is due to downstream congestion on I-5 that causes occasionally queue spillback onto the SB on-ramp that extends north to N Broadway.

Table 8. Synchro Analysis Results: Existing AM Peak Period

ID	Intersection	7-8 AM			8-9 AM		
		V/C	Delay (sec/veh)	LOS	V/C	Delay (sec/veh)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	0.78	23.9	C	0.94	37.7	D
2	N/NE Broadway & N Williams Ave	0.48	7.0	A	0.59	8.7	A
3	NE Broadway & NE Victoria Ave	0.46	10.1	B	0.56	11.7	B
4	NE Broadway & NE 2nd Ave	0.34	4.2	A	0.41	4.5	A
5	NE Weidler St & NE 2nd Ave	0.28	4.6	A	0.34	4.8	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	0.41	22.4	C	0.56	55.3	E
7	N/NE Weidler St & N Williams Ave	0.20	6.9	A	0.25	7.2	A
8	N Weidler St & N Vancouver Ave	0.43	12.0	B	0.52	12.8	B
9	N Broadway & N Benton Ave	0.26	7.2	A	0.31	7.7	A
10	N Broadway & N Larrabee Ave	0.74	20.6	C	0.87	26.4	C
11	N Wheeler Ave/ N Williams (formerly NE Wheeler) & N Ramsay Way	0.33	6.4	A	0.41	7.0	A
12	N Williams Ave & N/NE Hancock St	0.10	9.6	A	0.13	10.0	A

Notes: LOS = Level of Service; OHP = Oregon Highway Plan; sec/veh = seconds per vehicle; v/c = volume-to-capacity ratio
Red = Second peak hour v/c ratio exceeds OHP mobility target of 0.85 for ramp terminals or the City's operational targets for local streets.

Table 9. Synchro Analysis Results: Existing PM Peak Period

ID	Intersection	4-5 PM			5-6 PM		
		V/C	Delay (sec/veh)	LOS	V/C	Delay (sec/veh)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	0.81	32.2	C	0.84	35.2	D
2	N/NE Broadway & N Williams Ave	0.51	8.5	A	0.54	8.7	A
3	NE Broadway & NE Victoria Ave	0.48	9.3	A	0.51	9.5	A
4	NE Broadway & NE 2nd Ave	0.33	6.1	A	0.35	6.2	A
5	NE Weidler St & NE 2nd Ave	0.41	5.4	A	0.42	5.5	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	0.52	15.1	B	0.54	15.9	B
7	N/NE Weidler St & N Williams Ave	0.42	9.9	A	0.44	10.2	B
8	N Weidler St & N Vancouver Ave	0.67	16.8	B	0.70	17.4	B
9	N Broadway & N Benton Ave	0.45	18.4	B	0.47	18.7	B
10	N Broadway & N Larrabee Ave	0.86	32.2	C	0.89	33.3	C
11	N Wheeler Ave/ N Williams (formerly NE Wheeler) & N Ramsay Way	0.47	11.6	B	0.49	11.9	B
12	N Williams Ave & N/NE Hancock St	0.18	10.9	B	0.19	11.1	B

Notes: LOS = Level of Service; OHP = Oregon Highway Plan; sec/veh = seconds per vehicle; v/c = volume-to-capacity ratio

5.2.2 VISSIM Analysis Results

The VISSIM models developed for the Project include both the highway and local street network, which allows for an evaluation of intersection operations that account for the impacts of downstream congestion and queue spillback. The VISSIM analysis was used to analyze overall intersection operations as well as individual movements. The VISSIM analysis results including overall intersection delay and LOS are presented in Tables 10 and 11. Detailed output showing volume, delay, and queue length for all movements at API intersections are included in Appendix B.

Table 10. VISSIM Intersection Results: Existing AM Peak Period

ID	Intersection	7-8 AM		8-9 AM	
		Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	18.5	B	21.8	C
2	N/NE Broadway & N Williams Ave	10.6	B	11.0	B
3	NE Broadway & NE Victoria Ave	14.5	B	19.0	B
4	NE Broadway & NE 2nd Ave	4.4	A	4.3	A
5	NE Weidler St & NE 2nd Ave	5.7	A	6.4	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	13.5	B	13.1	B
7	N/NE Weidler St & N Williams Ave	2.7	A	2.8	A
8	N Weidler St & N Vancouver Ave	11.3	B	12.3	B
9	N Broadway & N Benton Ave	9.3	A	10.5	B
10	N Broadway & N Larrabee Ave	7.9	A	8.5	A
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	9.7	A	15.6	B
12	N Williams Ave & N/NE Hancock St	3.6	A	3.8	A

Notes: LOS = Level of Service; sec/veh = seconds per vehicle

Table 11. VISSIM Intersection Results: Existing PM Peak Period

ID	Intersection	4-5 PM		5-6 PM	
		Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	20.2	C	23.0	C
2	N/NE Broadway & N Williams Ave	11.0	B	12.2	B
3	NE Broadway & NE Victoria Ave	13.9	B	16.0	B
4	NE Broadway & NE 2nd Ave	7.5	A	7.8	A
5	NE Weidler St & NE 2nd Ave	14.0	B	14.5	B
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	11.3	B	12.5	B
7	N/NE Weidler St & N Williams Ave	8.2	A	9.0	A
8	N Weidler St & N Vancouver Ave	19.1	B	21.2	C
9	N Broadway & N Benton Ave	15.7	B	15.7	B
10	N Broadway & N Larrabee Ave	16.6	B	16.8	B
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	23.6	C	33.1	C
12	N Williams Ave & N/NE Hancock St	4.9	A	5.0	A

Notes: LOS = Level of Service; sec/veh = seconds per vehicle

In VISSIM, the intersection LOS is computed from a microsimulation analysis and is therefore reported as an "estimated LOS." VISSIM tracks individual vehicle movements and interactions and quantifies overall intersection delays more realistically than typical HCM methods. The estimated LOS is based on HCM criteria for signalized intersections. For queuing, VISSIM reports queue length from the stop bar along any path until it reaches an upstream study intersection. Per the ODOT VISSIM Protocol, the 95th percentile queue length is manually calculated as the average of maximum queues plus 1.65 times the standard deviation. This methodology tends to report 95th percentile queue lengths that are greater than the average maximum queue measured in VISSIM.

The results of the VISSIM analysis indicate that all intersections are operating at LOS C or better during the AM and PM peak periods. The VISSIM simulation shows queue spillback from the NB off-ramp to the Broadway/Weidler interchange at times during the PM peak period. It should be noted that when the highway is congested and the off-ramp queue spills back onto the mainline, VISSIM will report longer queue lengths that capture exiting vehicles that are upstream of the actual ramp queue. The standard deviations for the off-ramp queues are also high, indicating that the ramp queues varied substantially between simulation runs.

5.2.3 Streetcar Travel Time

Travel time routes were modeled in VISSIM to provide a comparison in the travel times of the Portland Streetcar along N/NE Broadway and N/NE Weidler. The travel time routes for both the WB and EB streetcar were measured between NE Grand and the east side of Broadway Bridge.

The travel time results for the existing AM and PM peak hours are presented in Table 12. As shown below, the first peak hour travel times are generally shorter than those in the second peak hour, and the travel times are greater in the PM peak period than in the AM peak period. EB and WB streetcar travel times are slightly longer in the PM peak period, with trips taking over 4 minutes due to congestion on NE Weidler and NE Broadway.

Table 12. Existing Conditions – Streetcar Travel Time (minutes)

Route	AM Period		PM Period	
	7-8 AM	8-9 AM	4-5 PM	5-6 PM
Westbound Streetcar	3.9	4.2	4.2	4.5
Eastbound Streetcar	3.5	3.5	4.1	4.4

5.2.4 Bicycle Delay

Peak hour bicycle delay through the signalized API intersections was analyzed in VISSIM for all dedicated bike lanes. On N Vancouver between N Broadway and N Weidler, the bicycle delay was reported on the shared SB bus/bike lane. In this analysis, the bicycle LOS is computed from a microsimulation analysis and is therefore reported as an "estimated LOS" based on HCM criteria for vehicle delay at signalized intersections. As shown in Table 13, all bicycle movements are operating at LOS C or better in both the AM and PM peak hours.

Table 13. Existing Highest Peak Hour Bicycle Delay and Level of Service

ID	Intersection	Movement	8-9 AM			(5-6PM)		
			Volume	Delay (sec)	LOS	Volume	Delay (sec)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	WB Bike	64	13.3	B	20	12.8	B
		SB Bike	212	27.9	C	26	27.7	C
2	N/NE Broadway & N Williams Ave	WB Bike	73	29.9	C	16	33.0	C
		NB Bike	32	20.8	C	495	22.9	C
3	NE Broadway & NE Victoria Ave	WB Bike	60	6.1	A	28	6.5	A
4	NE Broadway & NE 2nd Ave	WB Bike	60	3.1	A	24	4.7	A
5	NE Weidler St & NE 2nd Ave	EB Bike	4	1.8	A	52	4.4	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	EB Bike	4	5.3	A	60	6.9	A
7	N/NE Weidler St & N Williams Ave	EB Bike	4	3.6	A	40	4.6	A
		NB Bike	24	20.7	C	311	25.9	C
8	N Weidler St & N Vancouver Ave	EB Bike	20	19.5	B	323	16.1	B
		SB Bike	210	19.2	B	24	17.5	B
9	N Broadway & N Benton Ave	WB Bike	462	6.3	A	49	12.3	B
		EB Bike	24	3.8	A	335	12.6	B
10	N Broadway & N Larrabee Ave	WB Bike	422	7.0	A	57	6.9	A
		EB Bike	28	8.8	A	325	10.2	B
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	NB Bike	20	24.8	C	304	24.0	C
		SB Bike	216	7.2	A	32	14.3	B

Notes: LOS = Level of Service; sec = seconds

6 Environmental Consequences

This section discusses the anticipated beneficial and adverse impacts of the Project with regard to traffic operations under the No-Build and Build Alternatives.

6.1 No-Build Alternative

As described in Section 2.1, the No-Build Alternative consists of existing conditions and other planned and funded transportation improvement projects that would be completed in and around the Project Area by 2045.

6.1.1 Direct Impacts

Under the No-Build Alternative, the proposed I-5 mainline and Broadway/Weidler interchange area improvements would not be constructed, and the current road system would remain in place.

Generally, future traffic conditions under the No-Build alternative are forecast to deteriorate by the analysis year 2045, the ending year for traffic modeling, resulting in increased congestion. LOS and travel delay per vehicle and v/c ratios are expected to worsen at most key intersections and locations analyzed for traffic conditions. Worsening conditions are expected to occur during both the morning and afternoon peak periods.

At some local road intersections, changes in travel conditions between the No-Build and Build Alternatives would not be noticeable or would be slightly worse. In order to directly compare No-Build condition to the Build Alternative, detailed traffic analysis results are presented in Section 6.2.

6.1.2 Indirect Impacts

Under the No-Build Alternative, the growing traffic demand creates more severely congested travel condition, heavier weaving density, and potentially worse peak spreading—a greater duration of congested conditions--beyond the API and the analysis period. Other indirect impacts related to worsening traffic congestion would be less overall travel time reliability, longer travel times, traffic diversion to other routes, and potential travel demand shifts to other modes. Impacts related to greater congestion and longer periods of congestion are captured in other technical reports, such as the *Transportation Safety Technical Report* (ODOT 2019c) and *Socioeconomics Technical Report* (ODOT 2019d).

6.2 Build Alternative

Under the Build Alternative, the Project's proposed roadway, bicycle, and pedestrian improvements would be constructed, as described in Section 2.2.

6.2.1 Short-Term Construction Impacts

Construction of the Project would have short-term impacts to highway traffic, local street motor vehicle traffic, bicyclists, pedestrians, transit, and event access. A detailed transportation management plan would be prepared during the Project design phase that would describe the construction sequence and strategies for maintaining through travel and local access for all modes of transportation. Overall Project construction and transportation disruption could occur in phases for up to 4 years.

Highway lane closures are likely on I-5 during removal and construction of the overcrossing structures, including potential closure of all directional lanes. Lane closures would be concentrated during late nights and weekends.

All transportation modes (pedestrian, bicycle, motor vehicle, streetcar, and bus) would experience disruption during construction and would require a sequence of temporary accommodations. TriMet has indicated that it may consider temporarily rerouting affected bus lines in the area for the duration of construction to avoid a series of temporary route changes that would be confusing for riders. Future discussions and negotiations would determine specific details regarding accommodations needed to maintain streetcar service and comparable transit connections during construction.

Streetcar operations during construction could be accommodated by including streetcar tracks in temporary structures that would be constructed to carry the east/west bicycle, pedestrian, and motor vehicle trips through the Broadway/Weidler corridor. To maintain streetcar connectivity, there would be a temporary “bus bridge” established during the construction of the temporary structure.

Temporary local street closures or turn restrictions would be implemented as necessary to limit traffic diversion onto local streets. Street closures would be limited to 1-week periods and managed through extensive outreach and traffic management strategies. Temporary pedestrian accommodations would be ADA-compliant.

Event access would be maintained during construction and could require an increased level of active traffic management before and after events. The Project would coordinate closely with the Moda Center, City of Portland, and Oregon Convention Center to avoid traffic disruptions to major events to the extent practicable.

6.2.2 Long-Term and Operational Direct Impacts

6.2.2.1 Future Highway Traffic Operations

This section describes future No-Build and Build highway traffic operations using v/c ratio and LOS results from HCS, and lane-by-lane vehicle speeds and travel times for select routes from VISSIM.

HCS Results

HCS is a deterministic analysis tool and uses equations outlined in the HCM 2010 to identify operationally deficient locations and provide v/c ratios as an output. VISSIM is a finer-level, micro-simulation traffic modeling tool that simulates downstream congestion and lane-by-lane interactions and provides high resolution of traffic output data, but this tool does not provide v/c ratios. HCS was used for the analysis of the highway to evaluate mainline, merge, diverge, and weaving operations to supplement the VISSIM analysis. The HCS analysis results comparing the No-Build and Build Alternatives are presented in Tables 14 and 15.

In the No-Build Alternative, two weave segments exceed the OHP mobility target of a v/c ratio of 0.99 in the AM peak period: the I-5 NB weave between the I-84 on-ramp and the NE Weidler off-ramp and the I-5 SB weave between the N Wheeler on-ramp and I-84 off -ramp.

In the Build Alternative, all four weaving segments would operate over the HDM design standard of a v/c ratio of 0.75 during the 7:00-9:00 AM peak hours. The HDM design standard is more restricted than the No-Build mobility target of a v/c ratio of 0.99. During the 4:00-6:00 PM peak hours, two weaving segments would operate over the design standard: the I-5 NB weave between the I-84 on-ramp and NE Weidler off-ramp and the I-5 SB weave between the NE Weidler on-ramp and I-84 off-ramp. The HCS analysis results comparing the No-Build and Build Alternatives are presented in Tables 14 and 15. The v/c ratios that exceed OHP and HDM mobility standards are highlighted.

As shown below, although the proposed Build Alternative v/c ratios exceed HDM design standards, it is expected to substantially improve highway operations compared to the No-Build Alternative. One exception is at the I-5 SB weave segment between I-405 and the NE Broadway exit ramp. The Build Alternative would operate slightly worse than the No-Build Alternative, but the segment would carry more volumes through the area under the Build Alternative than the No-Build Alternative.

It should be noted that the HCS analysis does not consider downstream congestion, and the results indicate acceptable operations in location where the VISSIM speed results show substantial congestion (i.e., the I-5 SB weave between the NE Weidler on-ramp and the I-84 off-ramp during the PM peak period). Queue spillback from congestion on I-84 creates slowdown on SB I-5 that extends north of the weave area in both the No-Build and Build Alternatives. The downstream slowdown impact to the SB segment between NE Broadway off-ramp and NE Weidler on-ramp is not considered in the HCS analysis.

Table 14. HCS Analysis Results: 2045 No-Build and Build First AM (PM) Peak Hour

Direction	Location	Analysis Type	2045 No-Build			2045 Build		
			V/C	Volume Density (pc/mi/ln)	LOS	V/C	Volume Density (pc/mi/ln)	LOS
I-5 Northbound	I-84 On-Ramp to Weidler Off-Ramp	Weaving	1.16 (1.02)	* (*)	F (F)	0.98 (0.82)	40.4 (33.5)	E (D)
	Weidler Off-Ramp to Broadway On-Ramp	Basic Section	0.91 (0.79)	42.5 (36.6)	E (E)	0.72 (0.64)	33.5 (29.6)	D (D)
	Broadway On-Ramp to I-405 Off-Ramp	Weaving	0.92 (0.78)	36.9 (31.6)	E (D)	0.78 (0.68)	30.8 (27.0)	D (C)
	Greeley Off-Ramp	Diverge	0.75 (0.72)	32.4 (30.6)	D (D)	0.65 (0.59)	23.5 (22.0)	C (C)
I-5 Southbound	I-405 On-Ramp to Broadway Off-Ramp	Weaving	0.73 (0.64)	32.1 (25.5)	D (C)	0.76 (0.65)	34.9 (28.5)	D (D)
	Broadway Off-Ramp to Weidler On-Ramp	Basic Section	0.94 (0.70)	44.1 (32.8)	E (D)	0.70 (0.56)	33.0 (26.3)	D (D)
	Weidler On-Ramp to I-84 Off-Ramp	Weaving	1.03 (0.81)	* (34.7)	F (D)	0.99 (0.80)	41.3 (30.2)	E (D)
	Morrison Off-Ramp	Diverge	0.81 (0.61)	33.3 (24.9)	D (C)	0.69 (0.58)	24.4 (19.6)	C (C)

Notes: HCS = Highway Capacity Software; HDM = *Highway Design Manual*; LOS = Level of Service; OHP = Oregon Highway Plan; pc/mi/ln = passenger car per mile per lane; v/c = volume-to-capacity ratio
LOS is based on the calculated volume density and not based on v/c ratio shown.
Orange = v/c ratio exceeds OHP mobility target of 0.99 for the No-Build peak hour.
Red = v/c ratio exceeds HDM mobility target of 0.75 for the Build peak hour.
* = Volume density not reported (demand exceeds capacity).

Table 15. HCS Analysis Results: 2045 No-Build and Build Second Peak Hour AM (PM)

Direction	Location	Analysis Type	2045 No-Build			2045 Build		
			V/C	Volume Density (pc/mi/ln)	LOS	V/C	Volume Density (pc/mi/ln)	LOS
I-5 Northbound	I-84 On-Ramp to Weidler Off-Ramp	Weaving	1.16 (1.02)	* (*)	F (F)	0.98 (0.85)	40.4 (35.3)	E (E)
	Weidler Off-Ramp to Broadway On-Ramp	Basic Section	0.91 (0.82)	42.5 (38.1)	E (E)	0.72 (0.66)	33.5 (30.8)	D (D)
	Broadway On-Ramp to I-405 Off-Ramp	Weaving	0.92 (0.82)	36.9 (33.3)	E (D)	0.78 (0.72)	30.8 (28.3)	D (D)
	Greeley Off-Ramp	Diverge	0.75 (0.75)	32.4 (31.9)	D (D)	0.65 (0.62)	23.5 (22.9)	C (C)
I-5 Southbound	I-405 On-Ramp to Broadway Off-Ramp	Weaving	0.73 (0.67)	32.1 (26.8)	D (C)	0.76 (0.68)	34.9 (29.9)	D (D)
	Broadway Off-Ramp to Weidler On-Ramp	Basic Section	0.94 (0.73)	44.1 (34.1)	E (D)	0.70 (0.58)	33.0 (27.4)	D (D)
	Weidler On-Ramp to I-84 Off-Ramp	Weaving	1.03 (0.84)	* (36.7)	F (E)	0.99 (0.83)	41.3 (32.0)	E (D)
	Morrison Off-Ramp	Diverge	0.81 (0.64)	33.3 (26.0)	D (C)	0.69 (0.60)	24.4 (20.4)	C (C)

Notes: HCS = Highway Capacity Software; HDM = *Highway Design Manual*; LOS = Level of Service; OHP = Oregon Highway Plan; pc/mi/ln = passenger car per mile per lane; v/c = volume-to-capacity ratio
LOS is based on the calculated volume density and not based on v/c ratio shown.
Orange = v/c ratio exceeds OHP mobility target of 1.1 for the No-Build peak hour.
Red = v/c ratio exceeds HDM mobility target of 0.75 for the Build peak hour.
* = Volume density not reported (demand exceeds capacity).

Lane-by-Lane Speed

Lane-by-lane vehicle speeds from VISSIM are presented in Figures 14 through Figure 17 for the future AM and PM peak hours.[10]

During the onset of the AM peak period, speed would improve substantially on I-5 SB and NB within the API under the Build Alternative (Figure 14). In the No-Build Alternative, speeds less than 20 mph occur at the three-to-two lane drop south of the N Broadway off-ramp and extend north to the I-405 on-ramp. In the Build Alternative, speeds in this segment would exceed 40 mph between the existing lane drop to the N Broadway off-ramp; speed in the left lane between the N Broadway off-ramp to Greeley on-ramp would be over 20 mph. Speed on I-5 NB would improve considerably as well, particularly in the weaving segment between the I-84 on-ramp and the NE Weidler off-ramp. Speeds less than 50 mph still occur in the weaving segment between the N Broadway on-ramp and I-405, but speed in the left lane would approach 50 mph.

A similar improvement in speed would result during 8:00-9:00 AM (Figure 15). In the No-Build Alternative, the same pattern of slow speeds and congestion at the existing three-to-two lane drop south of the N Broadway off-ramp worsens, with speeds less than 20 mph extending further upstream to the I-405 off-ramp. This segment would be improved under the Build Alternative: speed at the N Broadway/Weidler Interchange would exceed 40 mph; speed in the left lane between the N Broadway off-ramp to Greeley on-ramp would be over 20 mph. The I-5 NB speed would also improve, particularly in the weaving segment between the I-84 on-ramp and the Greeley off-ramp.

[10] In both No-Build and Build scenarios, the existing bottlenecks north of the API were removed in the VISSIM model due to other future planned improvements in the I-5 corridor identified on the financially constrained project list in the 2014 Metro RTP, as noted in Section 4.3.3.3. This removal would result in higher speeds on I-5 NB compared to existing conditions.

Figure 14. Lane-by-Lane Speed – Future AM Peak Hour 7-8 AM

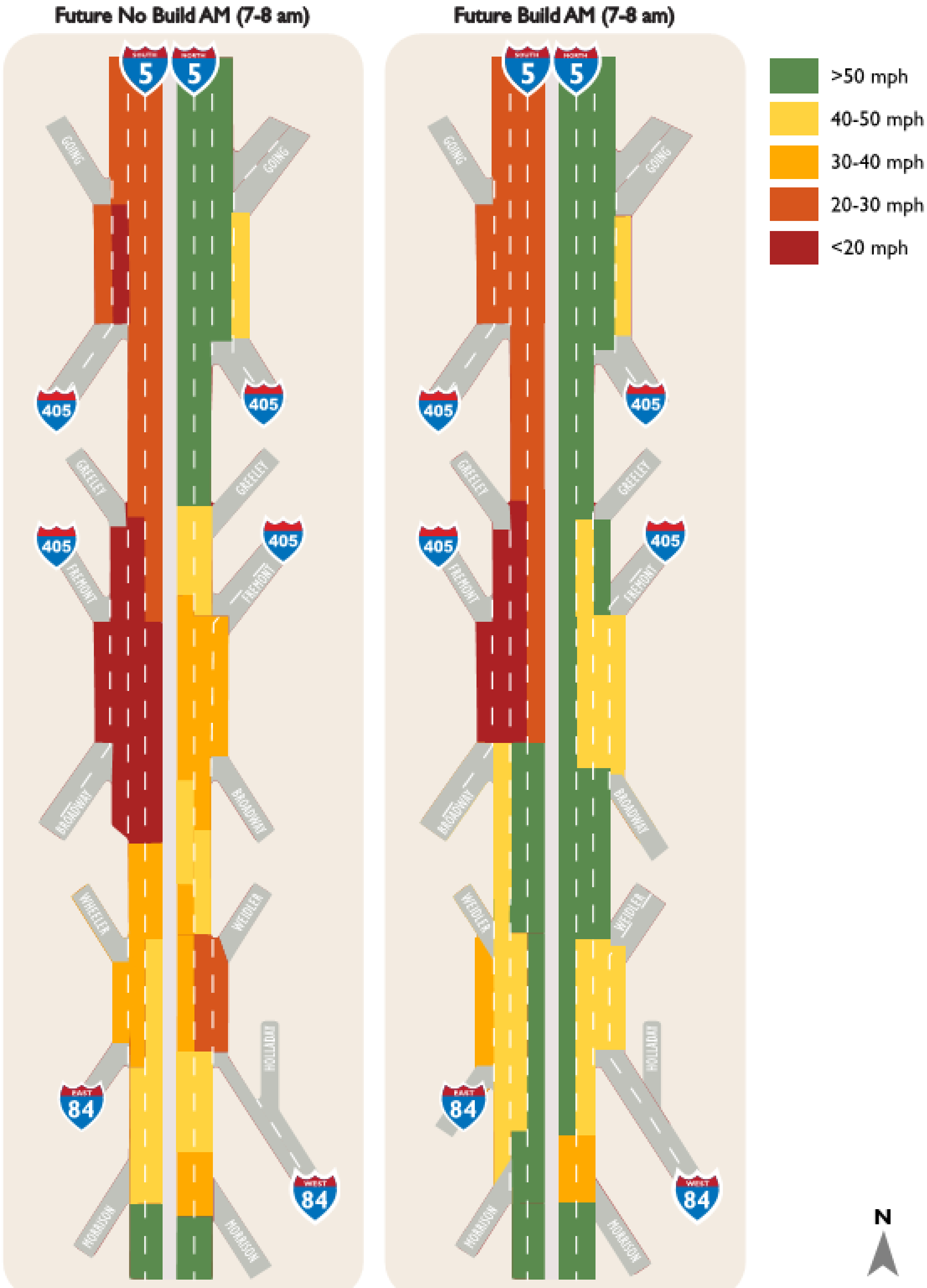
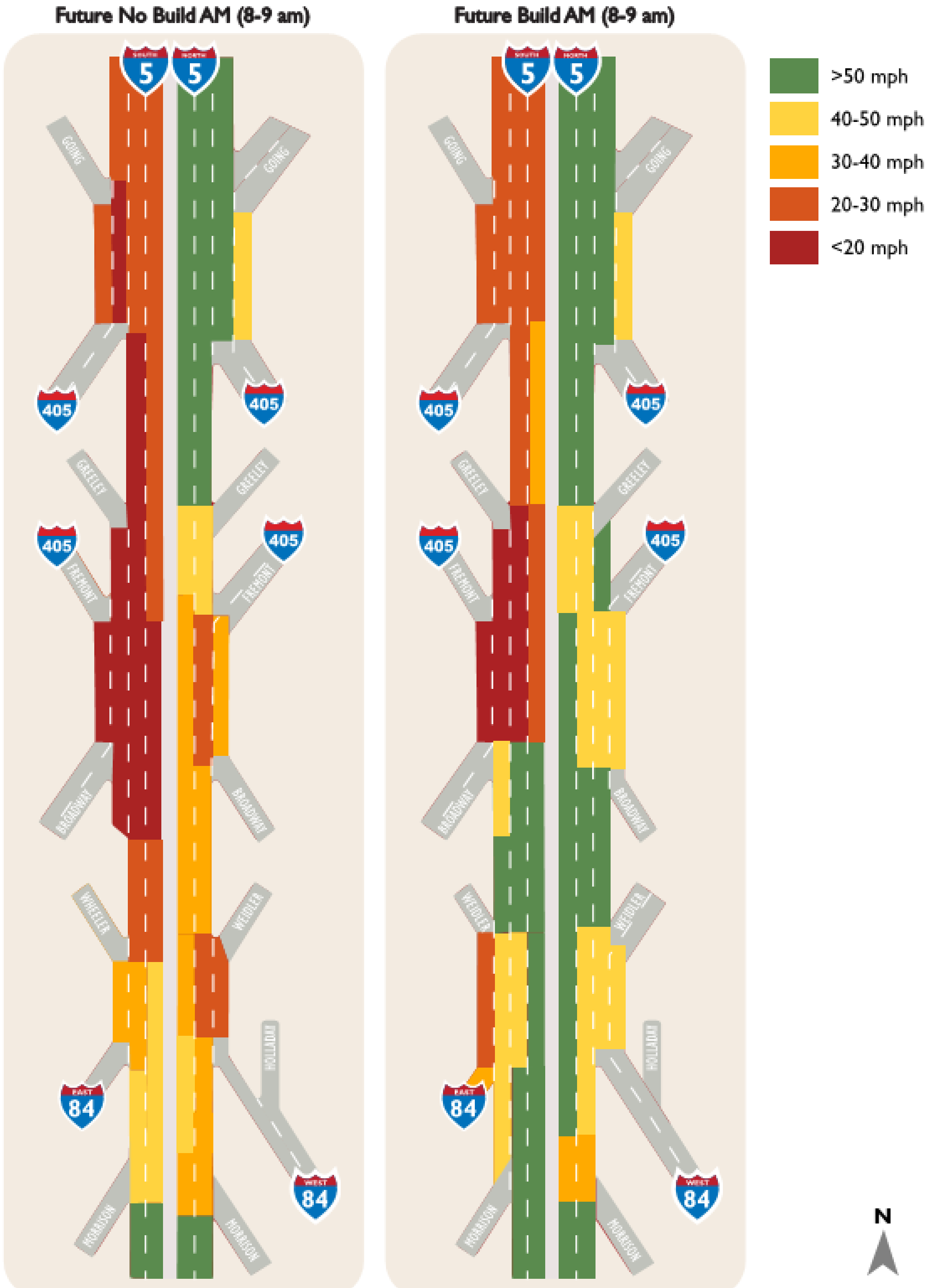


Figure 15. Lane-by-Lane Speed – Future AM Peak Hour 8-9 AM



During 4:00-5:00 PM in the No-Build Alternative, severe congestion and slow speed (less than 20 mph) occur across all SB lanes near the existing lane reduction as far north as I-405 (Figure 16). The SB right lane speeds below 20 mph extend north to the Greeley on-ramp. Under the Build Alternative, speed would improve on I-5 SB but weaving congestion would result in slow speed (20-40 mph) between the Greeley on-ramp and the N Broadway off-ramp. Slow speed (less than 20 mph) would occur on in the right lane of the I-5 SB weaving segment between the NE Weidler on-ramp and the I-84 off-ramp, but speed in the middle lanes in this area would improve. Speed on I-5 NB would increase substantially throughout the API, with most lanes approaching 50 mph or higher between I-84 and I-405.

During 5:00-6:00 PM, the same pattern of slow speeds and congestion worsen (Figure 17) compared to the last hour under both Alternatives. In the No-Build Alternative, I-5 SB congestion extends further upstream to I-405 off-ramp with slow speeds (20-40 mph) between the I-405 off-ramp and N Wheeler on-ramp. Under the Build Alternative, speeds on I-5 SB would be considerably improved; at the Broadway/Weidler interchange, speeds in the left and middle lanes would exceed 50 mph; from the I-5 SB entry to the I-405 on-ramp, and speeds in most lanes would increase by at least 10 mph. I-5 NB would also substantially improve under the Build Alternative, with most lane speeds at or above 40 mph.

Highway Travel Time

Comparisons of the AM and PM peak period travel time results along the six study routes between the future No-Build and Build Alternatives are presented in Tables 16 and 17, respectively. These routes were used for the existing conditions highway analysis and are common travel routes for commuter and freight traffic within the API. The travel routes are described in Section 5.1.3 and illustrated on Figure 13.

As shown below, travel times in all six routes would improve between the No-Build and Build Alternatives in the AM peak period, with SB Routes A, B, and C showing a significant travel time reduction.

During the PM peak period, all travel times would be shorter. For vehicles traveling south of the Rose Quarter area (Routes B and C), the proposed improvements provide a substantial decrease in travel time. While the travel time for Route F is slightly better than No-Build in the PM peak period, the difference is less than 12 seconds and can be attributed to the geometric differences associated with the realignment of the Wheeler on-ramp.

Figure 16. Lane-by-Lane Speed – Future PM Peak Hour 4-5 PM

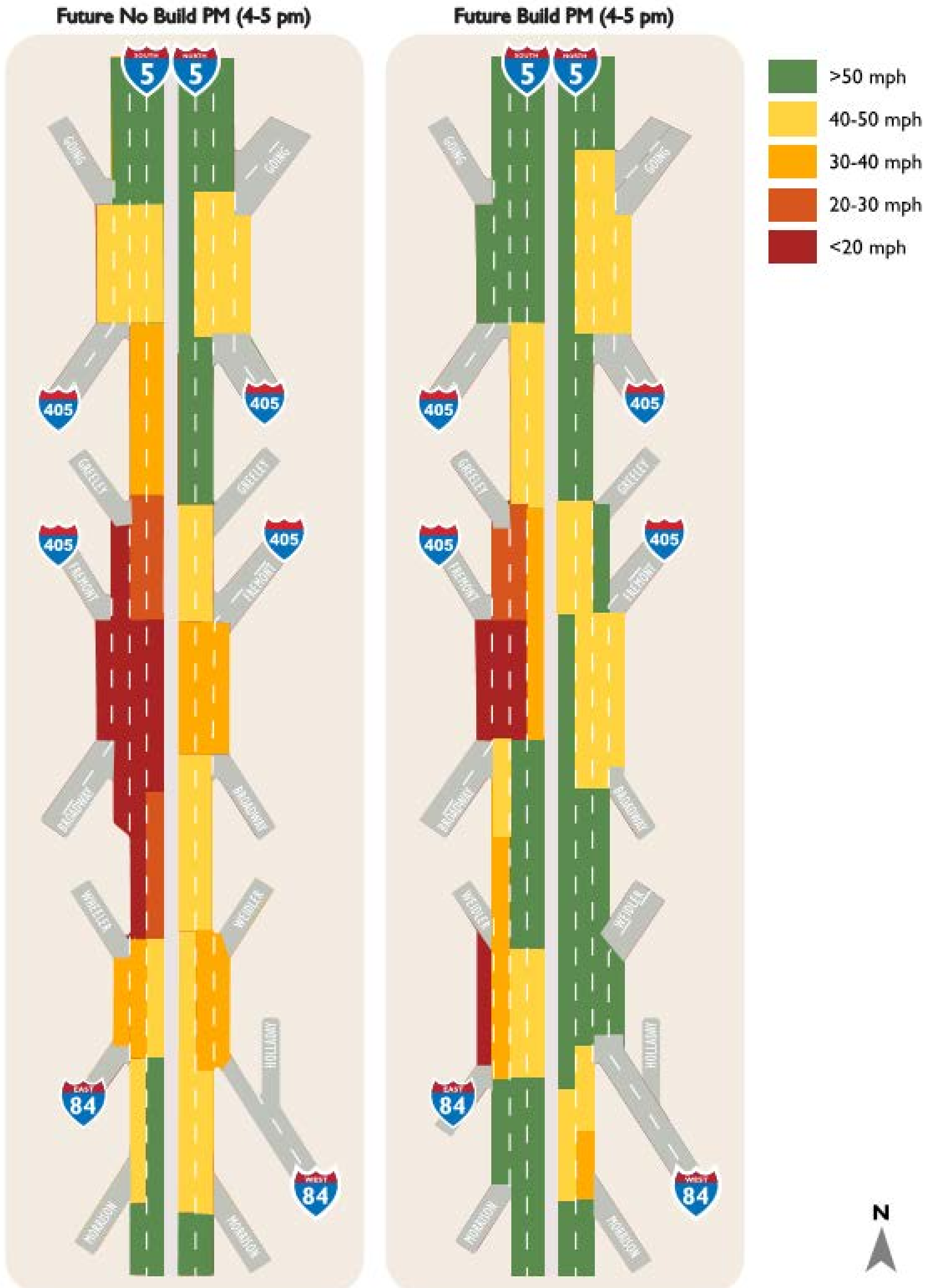


Figure 17. Lane-by-Lane Speed – Future PM Peak Hour 5-6 PM

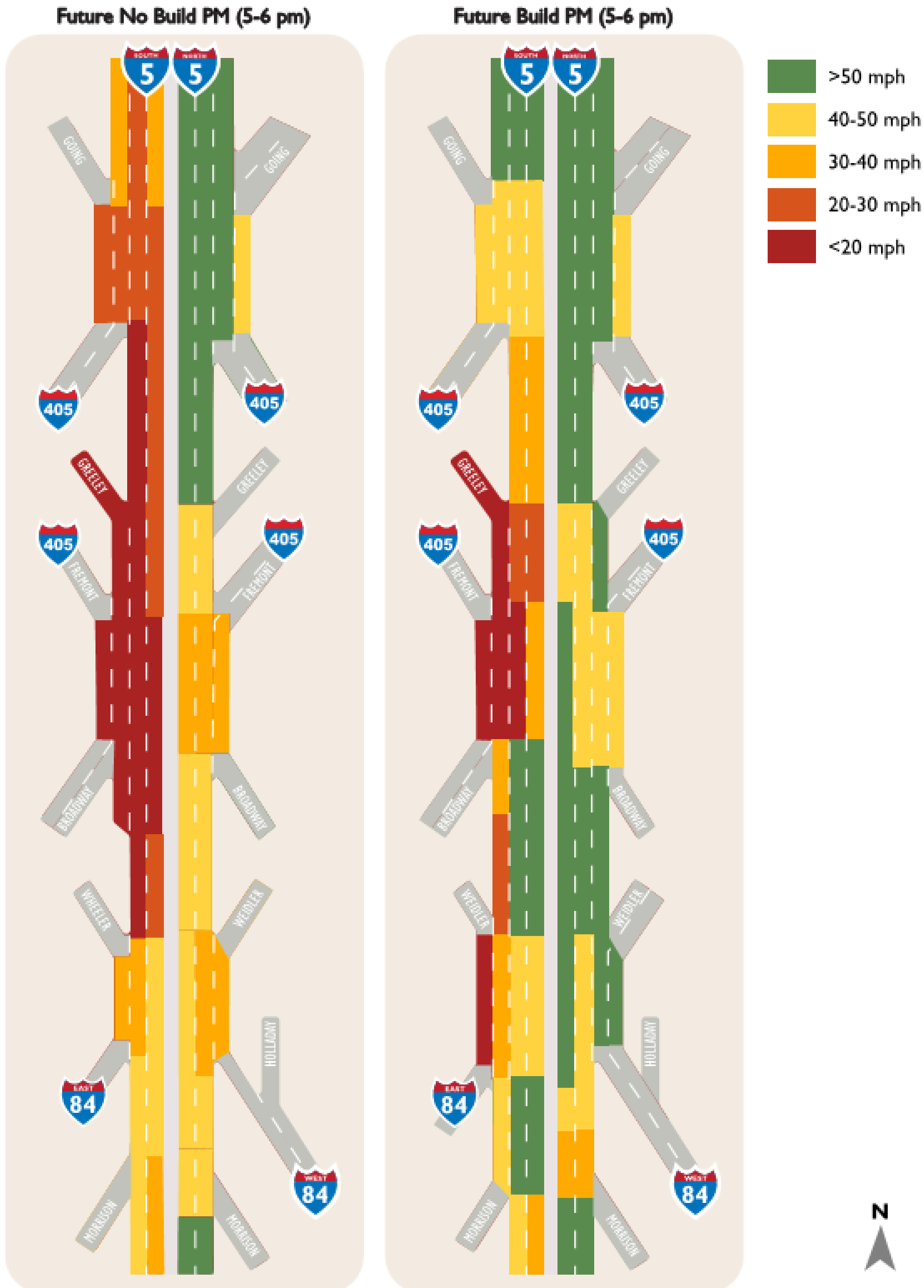


Table 16. Future No-Build and Build – AM Travel Time (minutes)

Route	7-8 AM		8-9 AM	
	No-Build	Build	No-Build	Build
Route A	7.3	5.4	9.0	5.2
Route B	9.2	5.3	11.5	5.2
Route C	10.2	8.7	12.5	8.7
Route D	1.5	1.0	1.7	1.0
Route E	3.9	2.9	4.3	2.9
Route F	1.1	0.7	1.2	0.7

Table 17. Future No-Build and Build – PM Travel Time (minutes)

Route	4-5 PM		5-6 PM	
	No-Build	Build	No-Build	Build
Route A	6.9	3.7	10.6	4.6
Route B	10.1	3.6	13.9	4.5
Route C	13.0	10.1	16.9	12.1
Route D	1.3	1.0	1.3	1.0
Route E	3.4	3.0	3.4	3.0
Route F	1.4	1.1	1.4	1.2

6.2.2.2 Future Local Street Traffic Operations

This section describes the future No-Build and Build traffic operations for the local street intersections using Synchro and VISSIM. Synchro was used to obtain intersection v/c ratio and LOS results due to the limitations of providing v/c ratios from microsimulation. VISSIM was used to analyze the operations of motor vehicles, transit, and bicycles, and evaluate queuing between closely spaced intersections.

With the implementation of the City of Portland's Broadway/Weidler Corridor Plan update as described under Section 2.1, a travel lane is reduced in each direction between the Broadway Bridge and NE 7th Avenue, except for the segments in and adjacent to the highway ramp terminals (Figures 18–21). Traffic demand for Broadway and Weidler is reduced, and the projected volumes are not as high as if there were no lane reductions. A portion of the trips that normally would take Broadway/Weidler are expected to find alternative parallel travel routes with faster

Figure 18. Broadway EB Lanes West of N Benton – Existing Conditions

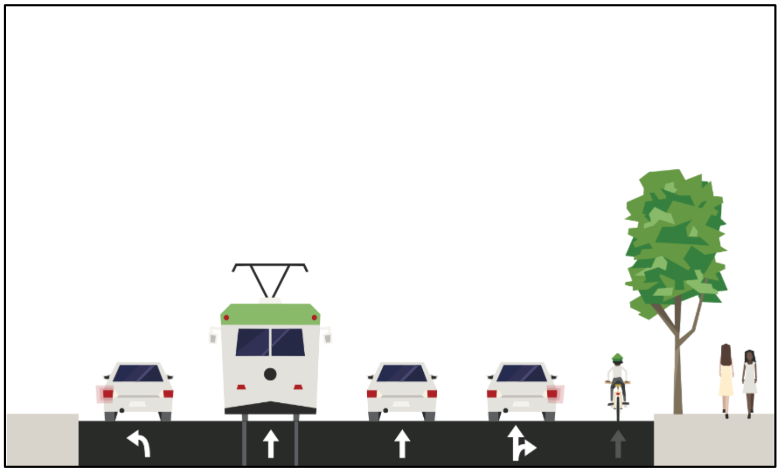


Figure 19. Broadway EB Lanes West of N Benton – No-Build

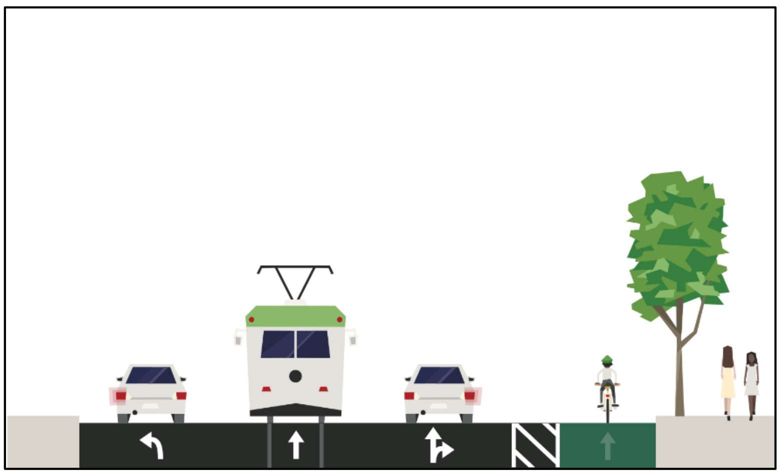


Figure 20. Broadway WB Lanes East of NE 2nd – Existing Conditions

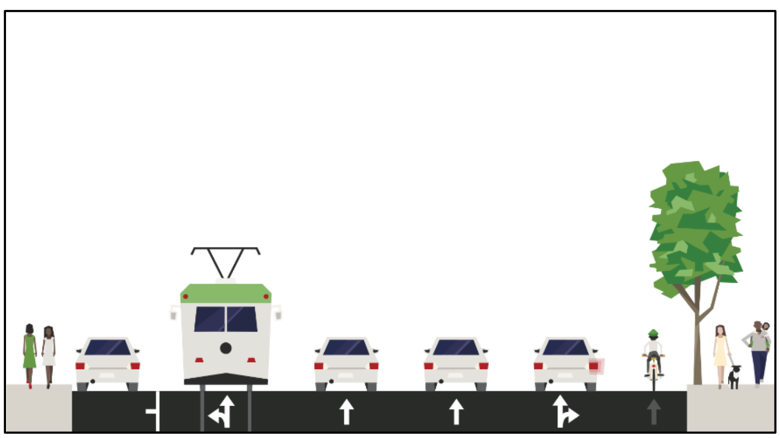
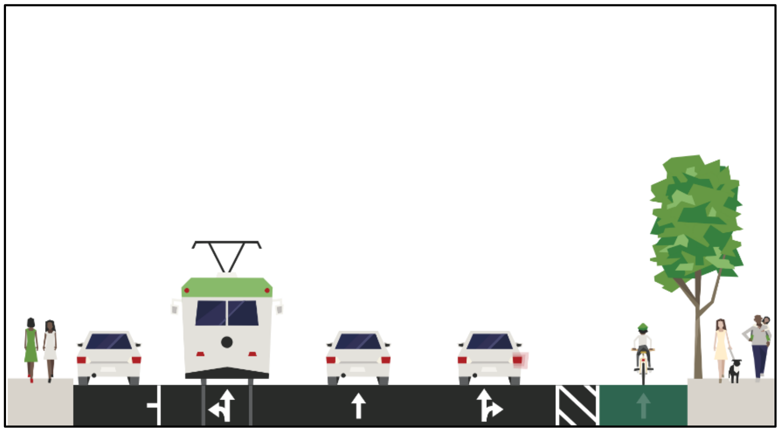


Figure 21. Broadway WB Lanes East of NE 2nd – No-Build



travel times. The combination of the lowered travel demand for Broadway/Weidler and the roadway sections at the ramp terminal intersections being precluded from lane reductions allowed the ramp terminal intersections to operate adequately under future No-Build and Build scenarios for the vast majority of the intersections.

Synchro Analysis Results

Synchro software was used for the analysis of the local street intersection operations to supplement the VISSIM analysis. The Synchro analysis results are presented in Tables 18 through 21 for the No-Build and Build Alternatives, with v/c ratios identified that exceed v/c mobility standards for ramp terminal intersections and LOS operational target for local streets. As shown below, the I-5 SB ramp terminal intersection at N Broadway and N Vancouver would exceed the OHP mobility target in the No-Build Alternative and the HDM mobility target in the Build Alternative during the 8:00-9:00 AM and 4:00-6:00 PM peak hours. None of the local street intersections are predicted to exceed the City's LOS operational targets (LOS D for signalized intersection and LOS E for unsignalized intersection).

The overall Build Alternative is predicted to operate better than the No-Build Alternative during the two peak periods, with lower v/c ratios and delays per vehicle. At some locations, however, the Build Alternative would operate with slightly longer delay than the No-Build Alternative. That is attributed to higher volume served under the Build Alternative. For example, at the NE Broadway and NE Victoria intersection during 7:00-8:00 AM, the Build Alternative would serve 336 more vehicles traveling WB through and 284 more vehicle turning NB left; during 8:00-9:00 AM, the Build Alternative serves 80 more vehicles traveling WB through and 165 more vehicles turning NB left. At the N/NE Weidler and N Williams intersection, the Build Alternative would operate consistently worse across the analysis periods than the No-Build Alternative because the build geometry shifts SB on-ramp volumes to this intersection to provide more storage than the No-Build Alternative. During the

Table 18. Synchro Analysis Results: Future Conditions 7:00-8:00 AM

ID	Intersection	No-Build			Build		
		V/C	Delay (sec/veh)	LOS	V/C	Delay (sec/veh)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	0.91	42.7	D	0.73	25.5	C
2	N/NE Broadway & N Williams Ave	0.56	11.6	B	0.56	21.3	C
3	NE Broadway & NE Victoria Ave	0.52	11.3	B	0.56	13.4	B
4	NE Broadway & NE 2nd Ave	0.42	9.5	A	0.41	8.8	A
5	NE Weidler St & NE 2nd Ave	0.33	6.7	A	0.37	4.7	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	0.47	22.0	C	0.43	15.1	B
7	N/NE Weidler St & N Williams Ave	0.26	3.7	A	0.47	8.3	A
8	N Weidler St & N Vancouver Ave	0.40	8.8	A	0.34	14.0	B
9	N Broadway & N Benton Ave	0.34	10.6	B	0.40	10.0	A
10	N Broadway & N Larrabee Ave	0.46	17.7	B	0.49	13.3	B
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	0.36	9.4	A	0.12	6.8	A
12	N Williams Ave & N/NE Hancock St	0.13	10.3	B	0.52	7.5	A
13	N Vancouver Ave & NE Hancock St	-	-	-	0.26	6.5	A

Notes: HDM = *Highway Design Manual*; LOS = Level of Service; OHP = Oregon Highway Plan; sec/veh = seconds per vehicle; v/c = volume-to-capacity ratio
Orange = v/c ratio exceeds OHP mobility target of 0.85 for ramp terminals.
Red = v/c ratio exceeds HDM mobility target of 0.75 for ramp terminals, or LOS below D for signalized local intersections and E for unsignalized local intersections.

Table 19. Synchro Analysis Results: Future Conditions 8:00-9:00 AM

ID	Intersection	No-Build			Build		
		V/C	Delay (sec/veh)	LOS	V/C	Delay (sec/veh)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	1.10	95.3	F	0.87	49.2	D
2	N/NE Broadway & N Williams Ave	0.68	13.1	B	0.67	26.5	C
3	NE Broadway & NE Victoria Ave	0.63	11.6	B	0.68	15.4	B
4	NE Broadway & NE 2nd Ave	0.51	10.6	B	0.51	10.0	A
5	NE Weidler St & NE 2nd Ave	0.40	8.7	A	0.45	5.0	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	0.62	56.1	E	0.51	17.9	B
7	N/NE Weidler St & N Williams Ave	0.32	4.5	A	0.56	9.1	A
8	N Weidler St & N Vancouver Ave	0.51	8.9	A	0.45	13.3	B
9	N Broadway & N Benton Ave	0.41	11.4	B	0.48	10.4	B
10	N Broadway & N Larrabee Ave	0.55	18.9	B	0.57	16.5	B
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	0.44	10.5	B	0.56	9.1	A
12	N Williams Ave & N/NE Hancock St	0.33	14.2	B	0.60	9.5	A
13	N Vancouver Ave & NE Hancock St	-	-	-	0.32	6.4	A

Notes: HDM = *Highway Design Manual*; LOS = Level of Service; OHP = Oregon Highway Plan; sec/veh = seconds per vehicle; v/c = volume-to-capacity ratio
Orange = v/c ratio exceeds OHP mobility target of 0.85 for ramp terminals.
Red = v/c ratio exceeds HDM mobility target of 0.75 for ramp terminals, or LOS below D for signalized local intersections and E for unsignalized local intersections.

Table 20. Synchro Analysis Results: Future Conditions 4:00-5:00 PM

ID	Intersection	No-Build			Build		
		V/C	Delay (sec/veh)	LOS	V/C	Delay (sec/veh)	LOS
1	I-205 SB off-ramp at N Broadway & N Vancouver Ave	0.94	53.9	D	0.88	41.3	D
2	N/NE Broadway & N Williams Ave	0.56	13.4	B	0.53	14.5	B
3	NE Broadway & NE Victoria Ave	0.51	9.5	A	0.56	11.9	B
4	NE Broadway & NE 2nd Ave	0.39	9.7	A	0.40	9.9	A
5	NE Weidler St & NE 2nd Ave	0.39	11.7	B	0.50	10.2	B
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	0.59	16.5	B	0.64	23.3	C
7	N/NE Weidler St & N Williams Ave	0.45	4.5	A	0.72	12.5	B
8	N Weidler St & N Vancouver Ave	0.61	12.6	B	0.62	20.0	B
9	N Broadway & N Benton Ave	0.53	20.5	C	0.47	18.7	B
10	N Broadway & N Larrabee Ave	0.65	27.2	C	0.69	31.6	C
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	0.37	11.9	B	0.10	13.2	B
12	N Williams Ave & N/NE Hancock St	0.21	11.2	B	0.59	8.3	A
13	N Vancouver Ave & NE Hancock St	-	-	-	0.33	6.8	A

Notes: HDM = *Highway Design Manual*; LOS = Level of Service; OHP = Oregon Highway Plan; sec/veh = seconds per vehicle; v/c = volume-to-capacity ratio

Orange = v/c ratio exceeds OHP mobility target of 0.85 for ramp terminals.

Red = v/c ratio exceeds HDM mobility target of 0.75 for ramp terminals, or LOS below D for signalized local intersections and E for unsignalized local intersections.

Table 21. Synchro Analysis Results: Future Conditions 5:00-6:00 PM

ID	Intersection	No-Build			Build		
		V/C	Delay (sec/veh)	LOS	V/C	Delay (sec/veh)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	0.98	63.1	E	0.91	49.2	D
2	N/NE Broadway & N Williams Ave	0.58	13.7	B	0.56	15.2	B
3	NE Broadway & NE Victoria Ave	0.53	9.4	A	0.59	12.2	B
4	NE Broadway & NE 2nd Ave	0.40	9.9	A	0.42	10.2	B
5	NE Weidler St & NE 2nd Ave	0.41	12.0	B	0.52	10.6	B
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	0.61	17.6	B	0.67	24.0	C
7	N/NE Weidler St & N Williams Ave	0.47	4.7	A	0.74	13.0	B
8	N Weidler St & N Vancouver Ave	0.64	12.8	B	0.66	20.4	C
9	N Broadway & N Benton Ave	0.55	21.1	C	0.50	19.4	B
10	N Broadway & N Larrabee Ave	0.68	28.1	C	0.71	32.9	C
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	0.38	12.1	B	0.22	9.8	A
12	N Williams Ave & N/NE Hancock St	0.21	14.8	B	0.60	8.7	A
13	N Vancouver Ave & NE Hancock St	-	-	-	0.35	6.9	A

Notes: HDM = *Highway Design Manual*; LOS = Level of Service; OHP = Oregon Highway Plan; sec/veh = seconds per vehicle; v/c = volume-to-capacity ratio
Orange = v/c ratio exceeds OHP mobility target of 0.85 for ramp terminals.
Red = v/c ratio exceeds HDM mobility target of 0.75 for ramp terminals, or LOS below D for signalized local intersections and E for unsignalized local intersections.

5:00-6:00 PM peak hour at the I-5 NB off-ramp at NE Weidler and NE Victoria, the Build Alternative would be slightly worse than the No-Build Alternative because 220 more vehicles from the off-ramp would be served. During the 5:00-6:00 PM peak hour at the N Weidler and N Vancouver intersection, more EB through traffic would be served in the Build Alternative; therefore, this intersection would operate slightly worse than the No-Build Alternative.

The Synchro analyses also indicate that under the Build conditions, all API intersections would operate at LOS D or better and with v/c ratios well within the City's mobility targets. It should be noted that Synchro does not consider surrounding congestion or the full impacts of queue spillback between intersections. For example, at the I-5 SB off-ramp at N Broadway and N Vancouver, Synchro delays are consistently less than VISSIM delays across the analysis periods. That is attributed to traffic flow constrained by upstream and downstream intersections during the highest peak hour.

VISSIM Analysis Results

The VISSIM models developed for the Project include both the highway and local street network, which allows for an evaluation of intersection operations accounting for the impacts of downstream congestion and queue spillback. The VISSIM analysis was used to analyze overall intersection operations as well as individual movements. The VISSIM analysis results are presented in Tables 22-25 and include overall intersection delay and LOS. Detailed output showing volume, delay, and queue length for the API intersections for all movements are included in Appendix B.

The results of the VISSIM analysis indicate that during the AM peak hours, the intersection operations are expected to operate at LOS C or better for both alternatives. During the PM peak hours, the NE Broadway N and Larrabee intersection is expected to exceed the City's operation target of LOS D.

Intersection operations between the No-Build and Build Alternatives are generally comparable with some intersections operating with less delay while some with slightly more delay. This is primarily due to the higher volume of served vehicles in the Build condition, and re-routing of certain vehicular and bicycle movements under the Build Alternative. Some intersections in the Build conditions incorporate a separate dedicated signal phase for bicycles and pedestrians, thus increasing the overall intersection delay. Discussions regarding critical intersections and the intersections with higher delay in the Build Alternatives are as follows:

- Although the intersection of NE Broadway and N Larrabee would operate with an additional delay of 5 seconds in the Build Alternative than in the No-Build Alternative during the morning peak period, it would operate at LOS B. The Build Alternative would accommodate more throughput by serving 88 more vehicles during 7:00-8:00 AM and 121 more vehicles during 8:00-9:00 AM than the No-Build Alternative would.

Table 22. VISSIM Analysis Results: Future Condition 7:00-8:00 AM

ID	Intersection	No-Build		Build	
		Delay (sec)	LOS	Delay (sec)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	20.4	C	20.0	B
2	N/NE Broadway & N Williams Ave	13.6	B	14.2	B
3	NE Broadway & NE Victoria Ave	19.1	B	18.5	B
4	NE Broadway & NE 2nd Ave	8.8	A	9.8	A
5	NE Weidler St & NE 2nd Ave	8.1	A	4.9	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	14.4	B	16.6	B
7	N/NE Weidler St & N Williams Ave	3.3	A	9.8	A
8	N Weidler St & N Vancouver Ave	9.7	A	10.1	B
9	N Broadway & N Benton Ave	12.0	B	10.2	B
10	NE Broadway & N Larrabee Ave	9.5	A	14.5	B
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	13.6	B	11.5	B
12	N Williams Ave & NE Hancock	4.4	A	9.8	A
13	N Vancouver Ave & NE Hancock St	—	—	4.4	A

Notes: LOS = Level of Service; sec = seconds

Table 23. VISSIM Analysis Results: Future Condition 8:00-9:00 AM

ID	Intersection	No-Build		Build	
		Delay (sec)	LOS	Delay (sec)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	23.6	C	24.9	C
2	N/NE Broadway & N Williams Ave	15.0	B	14.7	B
3	NE Broadway & NE Victoria Ave	26.0	C	22.7	C
4	NE Broadway & NE 2nd Ave	9.7	A	12.0	B
5	NE Weidler St & NE 2nd Ave	8.7	A	5.5	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	14.4	B	16.0	B
7	N/NE Weidler St & N Williams Ave	3.7	A	12.1	B
8	N Weidler St & N Vancouver Ave	12.2	B	11.9	B
9	N Broadway & N Benton Ave	13.3	B	11.0	B
10	NE Broadway & N Larrabee Ave	12.1	B	17.1	B
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	33.8	C	4.0	A
12	N Williams Ave & NE Hancock	5.2	A	11.6	B
13	N Vancouver Ave & NE Hancock St	—	—	4.8	A

Notes: LOS = Level of Service; sec = seconds

Table 24. VISSIM Analysis Results: Future Condition 4:00-5:00 PM

ID	Intersection	No-Build		Build	
		Delay (sec)	LOS	Delay (sec)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	52.5	D	34.0	C
2	N/NE Broadway & N Williams Ave	14.1	B	15.8	B
3	NE Broadway & NE Victoria Ave	16.8	B	22.9	C
4	NE Broadway & NE 2nd Ave	11.5	B	13.9	B
5	NE Weidler St & NE 2nd Ave	17.4	B	14.4	B
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	18.8	B	18.3	B
7	N/NE Weidler St & N Williams Ave	10.6	B	9.5	A
8	N Weidler St & N Vancouver Ave	18.3	B	16.9	B
9	N Broadway & N Benton Ave	20.9	C	15.6	B
10	NE Broadway & N Larrabee Ave	62.0	E	53.3	D
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	24.3	C	11.5	B
12	N Williams Ave & NE Hancock	4.4	A	9.9	A
13	N Vancouver Ave & NE Hancock St	—	—	8.2	A

Notes: LOS = Level of Service; sec = seconds

Table 25. VISSIM Analysis Results: Future Condition 5:00-6:00 PM

ID	Intersection	No-Build		Build	
		Delay (sec)	LOS	Delay (sec)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	67.3	E	37.3	D
2	N/NE Broadway & N Williams Ave	14.9	B	15.8	B
3	NE Broadway & NE Victoria Ave	18.7	B	24.3	C
4	NE Broadway & NE 2nd Ave	12.0	B	15.2	B
5	NE Weidler St & NE 2nd Ave	17.6	B	14.0	B
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	19.7	B	16.7	B
7	N/NE Weidler St & N Williams Ave	10.9	B	10.0	A
8	N Weidler St & N Vancouver Ave	18.9	B	18.3	B
9	N Broadway & N Benton Ave	21.5	C	16.0	B
10	NE Broadway & N Larrabee Ave	67.7	E	63.6	E
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	23.5	C	10.9	B
12	N Williams Ave & NE Hancock	4.3	A	10.1	B
13	N Vancouver Ave & NE Hancock St	—	—	9.3	A

Notes: LOS = Level of Service; sec = seconds

- The Build Alternative relocated the SB on-ramp to the NE Weidler/N Williams intersection and added contraflow on N Williams between NE Broadway and NE Weidler, which together changed traffic patterns and shifted all the traffic destined for I-5 SB and I-84 EB to N/NE Weidler to access the SB on-ramp. In contrast, in the No-Build Alternative this portion of on-ramp traffic was more distributed and metered through multiple intersections. Therefore, the Build Alternative served more volumes at the NE Weidler/N Williams intersection: 682 more vehicles during 7:00-8:00 AM and 928 more vehicles during 8:00-9:00 AM. In addition to the increased volume throughput in the Build Alternative, separate protected EB bike signal phase and pedestrian phase were added for the purpose of enhanced safety and mode separation but resulted in additional overall intersection delay. !!
- The N Wheeler/N Ramsey Way/I-5 SB Ramp intersection would not serve on-ramp traffic in the Build condition; therefore, the intersection overall delay would decrease.
- The NE Weidler/NE Victoria/I-5 NB exit ramp intersection would operate at LOS B with 2 seconds of longer delay during the morning peak period in the Build condition. The longer delay is due to the higher volume of served vehicles. The upgraded dual NB right-turn lane would carry 59 more vehicles during 7:00-8:00 AM and 123 more vehicles during 8:00-9:00 AM on the exit ramp.
- At the NE Broadway/NE 2nd intersection, the Build condition would also operate with slightly longer delay than the No-Build Alternative because it would serve 86 more vehicles during 7:00-8:00 AM, 87 more vehicles during 8:00-9:00 AM, 81 more vehicles during 4:00-5:00 PM, and 62 more vehicles during 5:00-6:00 PM.
- The NE Broadway/NE Victoria intersection respectively served 206 and 169 more vehicles in the Build Alternative during 4:00-5:00 PM and 5:00-6:00 PM, thus increasing overall intersection delay.
- At the NE Broadway/N Vancouver/I-5 SB Ramp intersection, the No-Build Alternative would accommodate the SB on-ramp vehicles from NE Broadway. In the Build condition, this portion of on-ramp traffic would be rerouted to the proposed contraflow link on N Williams. During the afternoon peak, this NE Broadway/N Vancouver/I-5 SB Ramp intersection would operate substantially better in the Build condition and slightly better during the morning peak.
- The N Williams/NE Hancock intersection is signalized in the Build condition but is two-way stop controlled in the No-Build condition. Signal control provides more safety benefits and slightly increases intersection delay.

The 95th percentile of maximum queue lengths at local intersections are shown in Table 26. The I-5 SB off-ramp to N/NE Broadway simulated queue lengths are consistently below the storage length in both of the future conditions. On the I-5 NB off-ramp, the right turn movement to N/NE Weidler is predicted to have much longer queue in the No-Build, substantially exceeding the available storage during 4:00-6:00 PM. In the Build condition, the NB through movement queue at the NB off-ramp was long with a high standard deviation during 4:00-5:00 PM, indicating queues of that movement varied considerably among ten simulation runs. In the No-Build condition, the NB through vehicles would be blocked by the long NB right-turn queue.

Table 26. VISSIM Analysis Results: Future Conditions 95th Percentile Queue Length, feet

Intersection Movement	Storage Length	7-8 AM		8-9 AM		4-5 PM		5-6 PM	
		No-Build	Build	No-Build	Build	No-Build	Build	No-Build	Build
I-5 SB exit-ramp at N Broadway & N Vancouver Ave, Southeast Bound Through	994	421	328	491	375	754	517	888	588
I-5 SB exit-ramp at N Broadway & N Vancouver Ave, Southeast Bound Right	460	336	253	290	251	251	166	296	166
I-5 NB exit-ramp at NE Weidler St & NE Victoria Ave, Northbound Through	1,028	342	358	594	306	614	1,177	1,087	831
I-5 NB exit-ramp at NE Weidler St & NE Victoria Ave, Northbound Right	430	567	425	405	316	1,893	312	1,157	355

The Build Alternative network would provide a more direct access to I-5 SB by relocating the SB on-ramp to immediately east of the N/NE Weidler and N Williams intersection. With the more direct access to I-5 SB, a three-lane on-ramp would be constructed to allow for more storage during ramp meter operations and prevent queue spillback from the highway. A longer left-turn lane is provided on N Broadway WB at N Williams to further ensure that vehicle queues associated with the more direct I-5 SB destined traffic movement would not impact streetcar operations in the adjacent through lane.

Streetcar Travel Time

Travel time routes were modeled in VISSIM to provide a comparison in the travel times of the Portland Streetcar along N/NE Broadway and N/NE Weidler. The travel time routes for both the WB and EB Streetcar were between NE Grand Avenue and the east side of Broadway Bridge.

The travel time results for the future No-Build and Build conditions are presented in Table 27. As shown below, the streetcar travel times are similar between the two alternatives, with a slight improved travel time for the Build Alternative due to the changes in traffic volumes and lane configurations between alternatives. The EB streetcar travel times during the afternoon peak period are generally greater than the morning peak.

Table 27. Future Conditions – Streetcar Travel Time (minutes)

Route	Alternative	AM Period		PM Period	
		7-8 AM	8-9 AM	4-5 PM	5-6 PM
Westbound Streetcar	No-Build	4.1	4.3	4.5	4.7
	Build	3.9	4.0	4.3	4.5
Eastbound Streetcar	No-Build	3.5	3.6	4.7	4.9
	Build	3.6	3.6	4.4	4.8

Bicycle Analysis

Bicycle delay and travel times through the signalized intersections were analyzed in VISSIM for all dedicated bike lanes. On N Vancouver, between N Broadway and N Weidler, the bicycle delay was reported on the shared SB bus/bike lane. In this analysis, the bicycle LOS is computed from the microsimulation analysis and is therefore reported as an "estimated LOS" and is based on HCM criteria for vehicle delay at signalized intersections.

As shown in Tables 28 and 29, the delay and LOS for most bicycle movements are similar between the No-Build and Build Alternatives. Most movements are operating at LOS C or better in both the AM and PM peak hours except for the EB and WB movements at the N Broadway and N Larrabee Avenue intersection. The reconfiguration of the intersection between the two alternatives adds a new bike signal and the additional protected phase results in increased delay. This analysis focuses on signalized intersections only.

Table 28. Future Bicycle Delay and Level of Service – 8:00-9:00 AM

ID	Intersection	Movement	No-Build			Build		
			Volume	Delay (sec)	LOS	Volume	Delay (sec)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	WB Bike	125	13.3	B	401	14.1	B
		SB Bike	178	27.7	C	0	0.0*	A
2	N/NE Broadway & N Williams Ave	WB Bike	137	27.0	C	129	27.0	C
		NB Bike	28	20.4	C	28	20.3	C
		SB Bike	-	-	-	553	2.5	A
3	NE Broadway & NE Victoria Ave	WB Bike	96	7.6	A	88	6.8	A
4	NE Broadway & NE 2nd Ave	WB Bike	107	5.2	A	107	6.0	A
5	NE Weidler St & NE 2nd Ave	EB Bike	4	3.2	A	4	2.9	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	EB Bike	4	5.8	A	4	8.1	A
7	N/NE Weidler St & N Williams Ave	EB Bike	4	3.7	A	4	17.2	B
		NB Bike	24	20.2	C	24	16.9	B
		SB Bike	-	-	-	174	16.6	B
8	N Weidler St & N Vancouver Ave	EB Bike	20	19.5	B	20	16.7	B
		SB Bike	175	19.1	B	0	0.0	A
9	N Broadway & N Benton Ave	WB Bike	691	9.4	A	681	10.0	B
		EB Bike	28	5.7	A	28	6.1	A
10	N Broadway & N Larrabee Ave	WB Bike	622	25.9	C	616	28.1	C
		EB Bike	32	17.7	B	32	23.1	C
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	NB Bike	20	28.4	C	20	0.0	A
		SB Bike	200	8.9	A	200	2.8	A

Notes: EB = eastbound; LOS = Level of Service; NB = northbound; SB = southbound; sec = seconds; WB = westbound

I-5 SB off-ramp at N Broadway/N Vancouver SB bike volume was zero because it was assumed to shift to the proposed N Williams bike lane.

Table 29. Future Bicycle Delay and Level of Service – 5:00-6:00 PM

ID	Intersection	Movement	No-Build			Build		
			Volume	Delay (sec)	LOS	Volume	Delay (sec)	LOS
1	I-5 SB off-ramp at N Broadway & N Vancouver Ave	WB Bike	40	13.3	B	52	13.6	B
		SB Bike	22	29.1	C	0	0.0	A
2	N/NE Broadway & N Williams Ave	WB Bike	28	32.0	C	24	31.5	C
		NB Bike	414	23.0	C	413	23.1	C
		SB Bike	-	-	-	586	3.7	A
3	NE Broadway & NE Victoria Ave	WB Bike	48	7.8	A	40	7.7	A
4	NE Broadway & NE 2nd Ave	WB Bike	44	6.4	A	44	7.1	A
5	NE Weidler St & NE 2nd Ave	EB Bike	100	5.3	A	100	4.6	A
6	I-5 NB off-ramp at NE Weidler St & NE Victoria Ave	EB Bike	93	8.6	A	88	8.4	A
7	N/NE Weidler St & N Williams Ave	EB Bike	68	4.4	A	64	16.9	B
		NB Bike	304	25.7	C	299	20.9	C
		SB Bike	-	-	-	20	18.9	B
8	N Weidler St & N Vancouver Ave	EB Bike	326	16.0	B	326	16.0	B
		SB Bike	20	17.4	B	0	0.0	A
9	N Broadway & N Benton Ave	WB Bike	72	11.9	B	64	14.5	B
		EB Bike	365	12.0	B	366	10.8	B
10	N Broadway & N Larrabee Ave	WB Bike	84	40.1	D	76	47.4	D
		EB Bike	361	40.6	D	361	48.9	D
11	N Wheeler/N Williams (formerly NE Wheeler Ave) & N Ramsay Way	NB Bike	297	24.1	C	293	0.2	A
		SB Bike	28	14.1	B	28	6.7	A

Notes: EB = eastbound; LOS = Level of Service; NB = northbound; SB = southbound; sec = seconds; WB = westbound

Bike travel times going WB and EB on N/NE Broadway and N/NE Weidler between N Larrabee and NE 2nd are also evaluated by using the VISSIM simulated travel time results. The Build Alternative WB bike travel time is 2 percent and 4 percent higher than the No-Build Alterative during the AM and PM analysis periods, respectively, primarily as a result of vehicular demand volume differences, the rerouting of the SB on-ramp traffic, and reconfiguration of the N Broadway and N Vancouver intersection (Table 30). EB bike travel time in the Build Alternative is approximately 8 percent higher than the No-Build Alternative because of the addition of the protected EB bike signal phase at the NE Weidler and N Williams intersection. The *Active Transportation Technical Report* (ODOT 2018b) provides an in-depth analysis of impact on multimodal transportation system.

Table 30. Future Bike Travel Time

Bike Travel Time, Minutes								
	7-8 AM		8-9 AM		4-5 PM		5-6 PM	
	No-Build	Build	No-Build	Build	No-Build	Build	No-Build	Build
Bike Westbound	4.1	4.2	4.2	4.3	4.5	4.7	4.5	4.7
Bike Eastbound	3.2	3.4	3.3	3.6	3.8	4.2	3.8	4.2

Bus Travel Time

Bus service travel times from VISSIM-simulated results were used to assess bus operation under future conditions. Four bus lines transverse the Project local intersections area. Bus 4 and Bus 44 travel on N Williams and N Vancouver between NE Multnomah and NE Russell within the API. Bus 17 travels WB on N/NE Broadway from NE Grand to N Larrabee, and Bus 7 travels EB on N/NE Broadway between NE Grand and N Larrabee.

As shown in Table 31, Bus 4 and 44 travel times are slightly higher in the Build Alternative. These two routes along N Williams pass through the Hancock intersection that operates, which would operate under free-flow in the No-Build Alternative but would operate under signal control in the Build Alterative. However, the fact that N Williams south of N Weidler would be converted exclusively to Bus-Only in the Build Alternative favors bus travel with less delay. Bus 17 travel times between the two alternatives were generally comparable, with some intersections operating a little better and some a little worse, resulting from fluctuation of vehicular volumes.

Table 31. Future Bus Travel Time

Bus Travel Time, Minutes								
	7-8 AM		8-9 AM		4-5 PM		5-6 PM	
	No-Build	Build	No-Build	Build	No-Build	Build	No-Build	Build
Bus 4 and 44 NB	5.0	4.8	5.0	5.0	5.2	5.3	5.1	5.3
Bus 4 and 44 SB	4.4	4.3	4.6	4.5	4.9	4.9	6.0	4.6
Bus 17 WB	4.5	4.6	5.0	4.8	5.0	5.1	5.1	5.1
Bus 17 EB	4.0	4.3	4.2	4.6	5.1	4.6	5.1	4.6

Notes: EB = eastbound; WB = westbound

6.2.3 Long-Term and Operational Indirect Impacts

The Build Alternative would revise the traffic flow on N Williams between N/NE Weidler and N/NE Broadway. The proposed configuration would provide WB Broadway left-turning traffic a direct access to the realigned SB on-ramp without going through the signalized intersections on N Vancouver. Under the existing configuration, the SB on-ramp-destined traffic from N/NE Broadway must travel further on N/NE Broadway, turn left to N Vancouver, and then travel further SB through on N Vancouver across N Weidler and N Ramsay to the on-ramp to I-5 south. This current circuitous route through congested local streets would be eliminated in the reverse traffic flow configuration, substantially facilitating operation in the local intersection area. At the N Broadway and N Vancouver intersection, the proposed reverse flow releases traffic pressure of serving both the I-5 SB off-ramp traffic and on-ramp traffic, resulting in improved intersection operation.

Conflicting zones created because of the reversed flow would be resolved by signal control and yield signing. At the N/NE Broadway/N Williams intersection, the WB left-turn traffic would yield to pedestrians on the south crosswalk. Bicycles WB on N/NE Broadway crossing Williams would have their own protected signal phase. At the N/NE Weidler/N Williams intersection, the EB through and right-turn movements would not move concurrently with the SB reversed flow. Bicycles EB on N/NE Weidler crossing N Williams and NB crossing N/NE Weidler would have their own protected signal.

The Build Alternative would indirectly affect event access, and several post-event circulation options were presented to the Moda Center and City of Portland (owners of the Veterans Memorial Coliseum) as potential mitigation for post-event operations. The movement of the on-ramp would necessitate a change in post-event motor vehicle circulation patterns, with vehicles directed north on N Wheeler to N Weidler (N Wheeler would be one-way SB under typical operation). This routing could be accomplished with active traffic management using cones and traffic management personnel. The option of maintaining a full-time NB lane on N Wheeler between N Ramsay and N Weidler could be explored during Project design.

Bicycle and pedestrian post-event movements in the Build Alternative would be similar to the No-Build Alternative but with the addition of the Clackamas bicycle and pedestrian bridge available to accommodate trips crossing over I-5 toward Lloyd. The bridge would provide pedestrians and bicyclists with a route with less exposure to motor vehicles and highway ramps.

Synchro analysis of post-event Build traffic has been completed and shown to have no fatal flaws. Discussion with Moda Center and the City of Portland is continuing, working toward an updated post-event Traffic Management Plan (TMP). Additional detailed analysis would be conducted in the TMP development stage.

Positive impacts related to the Build alternative include less potential for peak spreading, compared to the No-Build Alternative, better enabling travelers to travel by their preferred mode, route, and time.

6.3 Cumulative Effects

Cumulative impacts are those environmental effects that result from the incremental effect of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes those other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 Code of Federal Regulations 1508.7).

The analysis of cumulative impacts involves a series of steps conducted in the following order:

- Identify the resource topics that could potentially experience direct or indirect impacts from construction and operation of the proposed Project.
- Define the geographic area (spatial boundary) within which cumulative impacts will be assessed, as well as the timeframe (temporal boundary) over which other past, present, and past, present, and reasonably foreseeable future actions will be considered.
- Describe the current status or condition of the resource being analyzed as well as its historical condition (prior to any notable change) and indicate whether the status or condition of the resource is improving, stable, or in decline.
- Identify other actions or projects that are reasonably likely to occur within the area of potential impact during the established time frame and assess whether they could positively or negatively affect the resource being analyzed.
- Describe the combined effect on the resource being analyzed when the direct and indirect impacts of the project are combined with the impacts of other actions

or projects assumed to occur within the same geographic area during the established time frame.

6.3.1 Spatial and Temporal Boundaries

The geographic area used for the cumulative impact analysis is the same as the API described in Section 4.1 and shown on Figure 9. The time frame for the cumulative impact analysis extends from the beginning of large-scale urban development in and around the Project Area to 2045, the horizon year for the analysis of transportation system changes.

6.3.2 Past, Present, and Reasonably Foreseeable Future Actions

The past, present, and past, present, and reasonably foreseeable future actions that were considered in assessing cumulative effects are summarized in the following subsections.

6.3.2.1 Past Actions

Past actions include the following:

- Neighborhood and community development
  - Historical development of the Portland area and accompanying changes in land use
  - Development of the local transportation system (including roads, bicycle and pedestrian facilities, and bus transit)
  - Utilities (water, sewer, electric, and telecommunications)
  - Parks, trails, bikeways
- Commercial and residential development in and around the Project Area
  - Veterans Memorial Coliseum (1960)
  - Lloyd Center (1960)
  - Legacy Emanuel Medical Center (1970)
  - Oregon Convention Center (1990)
  - Rose Garden (1995)
- Regional transportation system development
  - Marine terminal facilities on the Willamette River
    - Port of Portland (1892)
    - Commission of Public Docks (1910)
    - Port of Portland (1970; consolidation of Port of Portland and Commission of Public Docks)

- Freight rail lines (late 1800s and early 1900s)
- Highways
  - I-84 (1963)
  - I-5 (1966)
  - I-405 (1973)
- Rail transit system
  - MAX light rail (1986)
  - Portland Streetcar (2001)

6.3.2.2 Present Actions

Present actions include the ongoing operation and maintenance of existing infrastructure and land uses, including the following:

- Ongoing safety improvements for bicycles and pedestrians
- Local and regional transportation system maintenance
- Utility maintenance

6.3.2.3 Reasonably Foreseeable Future Actions

Reasonably foreseeable future actions included projects listed in the financially constrained element of Metro's RTP (Metro 2014) and other shorter-term projects and service improvements identified by the City of Portland and TriMet (Appendix C). These projects were assumed to be in place under the No-Build Alternative. It was also assumed that these projects would be designed according to applicable agency standards.

6.3.3 Results of Cumulative Impact Analysis

The evaluation of the transportation impacts of the Project is largely cumulative in nature. The forecast of the performance and operation of the transportation system is based on Metro's regional travel demand model and on analysis tools that rely on the regional model data. The travel demand model is built on population and employment growth forecasts adopted by the Metro Council and the financially constrained project list included in the RTP (Metro 2014). These growth forecasts and planned transportation projects incorporate the reasonably foreseeable future growth and major actions that would potentially impact transportation operations in the API.

6.4 Conclusions

Future conditions were analyzed for the year 2045, for both No-Build, which assumes planned projects are constructed, and the Build Alternative, which includes the proposed improvements described in Section 2. Focusing on highway conditions, the proposed Build Alternative improves operations for both the AM and PM analysis periods. Three of four weaving segment operations improve under the Build Alternative: 1) I-5 NB between I-84 on-ramp and NE Weidler off-ramp, 2) I-5 NB between the N Broadway on-ramp and I-405 off ramp, 3) I-5 SB between the NE Weidler on-ramp and I-84 off-ramp. The final weaving segment, I-5 SB between the I-405 on-ramp and N Broadway off-ramp, operates at LOS D, which is the same for the No-Build Alternative. The lane-by-lane speed diagrams (Figures 14-17) also show an overall improvement in highway operations between the No-Build and Build Alternatives.

Travel time analysis demonstrates that travel times within the API under the Build Alternative would all be improved compared to the No-Build Alternative.

Between the No-Build and Build Alternatives, intersection analysis of local streets shows that, during the AM peak hour, intersection performance is acceptable, with most intersections operating with similar performances under both the No-Build and Build Alternatives. During the PM analysis period, local intersections in the Build Alternative are generally operating better compared to the No-Build Alternative, with all intersections operating at acceptable standards.

Active transportation through the local intersections was also evaluated. Streetcar travel times along N/NE Broadway and N/NE Weidler would be slightly improved under the Build Alternative during both AM and PM analysis periods. During the highest AM and PM peak hours, the EB and WB streetcar travel times would be reduced by up to 21 seconds. Bicycle movements in the local streets under the Build Alternative are expected to operate at LOS D or better. Bus travel times under the Build Alternative are generally comparable with the No-Build Alternative, resulting from fluctuation of vehicular volumes and reconfigurations.

7 Avoidance, Minimization, and Mitigation Measures

The Project would have short-term construction impacts to highway drivers and local street road users in all the modes of travel. Appendix D includes avoidance and minimization measures, and the following traffic mitigation strategies would be implemented in an effort to maintain mobility of the transportation systems:

- Development of a comprehensive transportation management plan that documents construction staging and schedule, alternate routes during road closure, lane closure restrictions as well as transportation management and operation strategies (TMOS). Specific TMOS elements may include public information and outreach to encourage changes in travel behavior, provision of real-time information to road users using Intelligent Transportation Systems, and incident/emergency management to detect and remove incidents and restore traffic quickly.
- In the Broadway/Weidler interchange area, streetcar operations during construction could be accommodated by including streetcar tracks in temporary structures that would be constructed to carry the east/west bicycle, pedestrian, and motor vehicle trips through the Broadway/Weidler corridor. To maintain streetcar connectivity, there would be a temporary "bus bridge" established during the construction of the temporary structure. Extensive TMOS strategies would be developed to minimize traffic disruption to other streets beyond the API. In addition, TriMet has indicated that it may consider temporary bus routes around the impacted area to avoid temporary route changes. Discussion and negotiations would determine accommodations needed for streetcar service and comparable transit connections.
- Event access would be maintained with enhanced TMOS strategies before and after events. The Project would coordinate with the Moda Center, City of Portland, and Oregon Convention Center to avoid traffic disruptions during major events to the extent practicable.

For long-term mitigation, ODOT and the City of Portland would further evaluate the local intersection signal timing during the design phase.

8 Contacts and Coordination

To complete this report, the preparers coordinated with the City of Portland and Metro to obtain traffic volume assignments and bicycle trip assignments from the regional travel demand model, with TriMet to obtain route- and stop-level transit ridership data and policies and plans for future improvements, and with Portland Streetcar Inc. to obtain policies and plans for future improvements. Other contacts included various ODOT staff and other members of the consultant team.

9 Preparers

Name	Discipline	Education	Years of Experience
John Cullerton, Parametrix	Transportation Lead	B.S., Geography, University of Oregon (1977)	38
Ryan LeProwse, Parametrix	Traffic Analysis	B.S., Civil Engineering, University of Portland (1999)	19
Rory Renfro, Alta Planning and Design	Transit (bus/light rail) and active transportation	M.S., Urban & Regional Planning, Portland State University (2007) B.S., Urban & Regional Planning, Arizona State University (2001)	17
Katie Mangle, Alta Planning and Design	Active transportation	M.S., City Planning, Massachusetts Institute of Technology (1996) B.S., Growth and Structure of Cities, Bryn Mawr College (1994)	18
Mike Sellinger, Alta Planning and Design	Active transportation	M.S., Urban & Regional Planning, Portland State University (2014) B.S., Economics and Politics, Brandeis University (2010)	4
Kirk Paulson, Alta Planning and Design	Active transportation	B.S., Civil Engineering, Washington State University (2008)	5
Elizabeth Wemple, PE, HDR Inc.	Safety Planning and Engineering	Master of City Planning, University of California at Berkeley (1992) M.S., Transportation Engineering, University of California at Berkeley (1991) M.S., University of California at Berkeley (1987)	30
Andrew Johnson, HDR Inc.	Transportation Planning	Master of Regional Planning, Community and Region Planning, University of Minnesota, Twin Cities, 2002 B.S., Geography, University of Minnesota, Twin Cities (2000)	17

Name	Discipline	Education	Years of Experience
Camille Alexander, HDR Inc.	Transportation Planning	B.S., Urban Planning, University of Utah (2007)	9
Jeremy Jackson, HDR Inc.	Traffic Engineering	B.S., Civil Engineering, Washington University in St. Louis (2005)	13
Chengxin Dai, HDR Inc.	Traffic Engineering	M.S., Transportation Engineering, Portland State University (2013) B.S., Civil Engineering, Portland State University (2010)	5
Natalie Sager (Lindsoe), HDR Inc.	Safety Planning and Engineering, EIT	B.S., Civil Engineering, University of Minnesota – Twin Cities (May 2014)	4
Meekyung Lee, HDR Inc.	Safety Planning and Engineering, EIT	Bachelor of Civil Engineering, University of Minnesota (2016) B.S., Mathematics University of Winnipeg (2014)	2

10 References

AASHTO (American Association of State Highway and Transportation Officials). 2011. Policy on Geometric Design of Highways and Streets, 6th Edition, 2011. Washington D.C.

ATRI (American Transportation Research Institute). 2017. “2017 Top 100 Truck Bottleneck List.” Available: http://atri-online.org/2017/01/17/2017-top-100-truck-bottleneck-list/ (accessed April 7, 2018).

City of Portland. 2016. Amendments to the Transportation System Plan. Initial Steps to Implement the 2035 Comprehensive Plan. As Amended Draft December 5, 2016. Adopted December 21, 2016. Available: https://www.portlandoregon.gov/transportation/73296.

City of Portland. 2018. Portland 2035 Transportation System Plan. Adopted May 2018. Available: https://www.portlandoregon.gov/transportation/77358 (accessed October 2, 2018).

City of Portland. 2016. Portland 2035 Transportation System Plan Amendments. Volume 2B. Central City 2035. Available: https://www.portlandoregon.gov/bps/article/581223.

City of Portland. n.d. Portland Policy Document. TRN-10.27 - Traffic Capacity Analysis for Land Use Review Cases. Available: https://www.portlandoregon.gov/citycode/article/41049 (accessed April 7, 2018).

City of Portland, ODOT, and Portland Bureau of Planning and Sustainability. 2012a. Central City 2035: N/NE Quadrant Plan. Adopted by City Council October 25, 2012. Available: https://www.portlandoregon.gov/bps/article/422031 (accessed April 7, 2018).

City of Portland, ODOT, and Portland Bureau of Planning and Sustainability. 2018. Central City 2035: Volume 2B Transportation System Plan Amendments. Effective July 9, 2018. Available: https://www.portlandoregon.gov/bps/article/689701 (accessed December 2, 2018).

Metro. 2014. Regional Transportation Plan. Available: https://www.oregonmetro.gov/sites/default/files/2015/05/29/RTP-2014-final.PDF (accessed April 7, 2018).

NACTO (National Association of City Transportation Officials). 2018. Urban Street Design Guide.

ODOT (Oregon Department of Transportation). 1999. Oregon Highway Plan, an Element of the Oregon Transportation Plan. Originally Adopted March 18, 1999, Including Amendments through May 2015. Available: http://www.oregon.gov/ODOT/Planning/Documents/OHP.pdf.

ODOT. 2007. Oregon Transportation Plan. Adopted September 20, 2006. Available: https://digital.osl.state.or.us/islandora/object/osl:8463 (accessed October 2018).

ODOT. 2012a. Facility Plan: I-5 Broadway/Weidler Interchange Improvements. Available: https://www.portlandoregon.gov/bps/article/415777 (accessed April 7, 2018).

ODOT. 2012b. ODOT Highway Design Manual. Available: https://www.oregon.gov/ODOT/Engineering/Pages/Hwy-Design-Manual.aspx (accessed April 7, 2018).

ODOT. 2015a. "State Highway Crash Rate Table." Available: http://www.oregon.gov/ODOT/Data/Documents/Crash_Rate_Tables_2015.pdf. (accessed March 3, 2018).

ODOT. 2015b. "On-State, Top 10% Groups – By Score." Available: http://www.oregon.gov/ODOT/Engineering/DocSPIS/Top10SPISgroupsByScore_Statewide_2015.pdf. (accessed March 3, 2018.

ODOT. 2016. Analysis Procedure Manual. Version 2. Transportation Development Division Planning Section, Transportation Planning Analysis Unit, Salem, Oregon. Available: http://www.oregon.gov/ODOT/Planning/Pages/APM.aspx.

ODOT. 2019a. Land Use Technical Report. I-5 Rose Quarter Improvement Project. Prepared for the Oregon Department of Transportation. Portland, Oregon. January.

ODOT. 2019b. Active Transportation Technical Report. I-5 Rose Quarter Improvement Project. Prepared for the Oregon Department of Transportation. Portland, Oregon. January.

ODOT. 2019c. Transportation Safety Technical Report. I-5 Rose Quarter Improvement Project. Prepared for the Oregon Department of Transportation. Portland, Oregon. January.

ODOT. 2019d. Socioeconomics Technical Report. I-5 Rose Quarter Improvement Project. Prepared for the Oregon Department of Transportation. Portland, Oregon. January.

TRB (Transportation Research Board). 2010. HCM 2010: Highway Capacity Manual. Washington D.C.

U.S. Department of Justice. 2010. 2010 ADA Standards for Accessible Design. Available: https://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm (accessed May 2018).