

Appendix
CBOS Preliminary Modeling Results

The regional travel demand model is a four-step trip based travel behavior model that is consistent with the RTP and is utilized to project traffic volumes and travel times on the transportation network. The model offers an understanding of travel behavior and improvement project impacts. Travelers generally divert to alternative routes to avoid congestion and bottlenecks that will delay their trips. The travel demand model is sensitive to the capacity constraints and will reallocate trip based on capacity and travel time to reach the travelers destination. When the freeway is congested, the model will reroute trips to the local system. Vice versa, if a bottleneck is removed on the freeway, trips that would have taken the freeway will be rerouted back to the freeway.

The CBOS improvement projects were coded into the 2010 and 2035 AM and PM travel demand models and compared to No-Build conditions to determine the travel impacts and to answer the question of induced demand. The majority of the projects are auxiliary lane extensions with the purpose of improving safety through breaking up recurring bottlenecks and better facilitating freeway entering/exiting traffic.

Base No-Build Model

The first task conducted was reviewing the base model roadway network and making edits to capacity to reflect No-Build conditions, as summarized in Table 1 below. A procedure assignment was run to reflect the edited roadway network.

Table 1

Freeway Link(s)	Changed 2-Hr Capacity to:
I-5N: Wilsonville - Hubbard Hwy entrance – Wilsonville Rd entrance	12,600
I-5N: Elligsen Rd EB loop entrance – I-205 exit *	14,400
I-5N: Nyberg St exit - Nyberg St EB entrance	12,600
I-5N: Lower Boones Ferry exit – Lower Boones Ferry entrance	12,600
I-5N: Lower Boones Ferry entrance – Carman Dr entrance	14,400
I-5N: Kruse Way exit – Kruse Way entrance	12,600
I-5N: Kruse Way entrance – Haines St exit	14,400
I-5S: Carman Dr exit – Carman Dr entrance *	14,400
I-5S: Lower Boones Ferry exit – Lower Boones Ferry entrance	12,600
I-205N: Division St entrance – Washington/Stark exit	14,400
I-205N: Glisan St entrance – I-84W entrance	12,600
I-205S: Washington St entrance – Division/Powell exit	14,400
I-84E: Halsey St exit – I-205N exit	8,800

*recently constructed projects

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Build Model

From the No-Build model, a Build model was developed by coding in new capacities for the following C-BOS projects, as summarized in Table 2.

Table 2

Project ID	Location	Type of Improvement	Changed 2-Hr Capacity to:
I-5			
B	<i>I-5 NB: Phase 1 - Lower Boones Ferry Road Exit Ramp Reconfiguration</i>	<i>2-Lane Exit at LBF Road</i>	Ramp 4800
C	<i>I-5 NB: Phase 2 - Nyberg Rd. Interchange to Lower Boones Ferry Rd. Interchange</i>	<i>Auxiliary Lane Extension</i>	14,400 – 16,400
D	<i>I-5 NB: Phase 3 - Lower Boones Ferry Rd. Interchange to Carman Dr. Interchange</i>	<i>Auxiliary Lane Extension</i>	16,400
F*	<i>I-5 SB: Phase 1 - Carman Dr Entrance Ramp to Lower Boones Ferry Exit Ramp Auxiliary Lane</i>	<i>Auxiliary Lane</i>	14,400
G	<i>I-5 SB: Phase 2 - Lower Boones Ferry Rd. Exit to Lower Boones Ferry Rd. Entrance</i>	<i>Auxiliary Lane</i>	14,400
H	<i>I-5 SB: Phase 3 - Lower Boones Ferry Rd. to I-205</i>	<i>Auxiliary Lane Extension</i>	14,400 – 16,400
I-205			
I	<i>I-205 NB: Phase 1 - I-84 WB Entrance Ramp to Sandy Blvd. Exit Ramp</i>	<i>Auxiliary Lane</i>	14,400
J	<i>I-205 NB: Phase 2 - Sandy Blvd. Exit Ramp to Columbia Blvd. Exit Ramp</i>	<i>Auxiliary Lane Extension</i>	14,400
L	<i>I-205 NB: Phase 1 - Powell Blvd Entrance Lane to Washington St. Exit Ramp</i>	<i>Auxiliary Lane Extension</i>	14,400
P	<i>I-205 NB: Division St. Entrance Ramp to I-84 WB Exit Ramp</i>	<i>Auxiliary Lane Extension w/2-Lane Exit at Washington St.</i>	14,400 – 16,400 Washington Exit Ramp 3600
Q	<i>I-205 SB: I-84 EB Entrance Ramp to Stark St./Washington St. Exit Ramp</i>	<i>Auxiliary Lane</i>	14,400
I-84			
S	<i>I-84 EB: Halsey St. Exit Ramp to I-205 NB Entrance Ramp</i>	<i>Auxiliary Lane</i>	10,400
T	<i>I-84 WB: I-5 NB and I-5 SB Diverge</i>	<i>Re-striping</i>	4200

*This recently constructed project was included in both No-Build and Build models.

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For varying reasons as noted, the projects summarized in Table 3 were not modeled.

Table 3

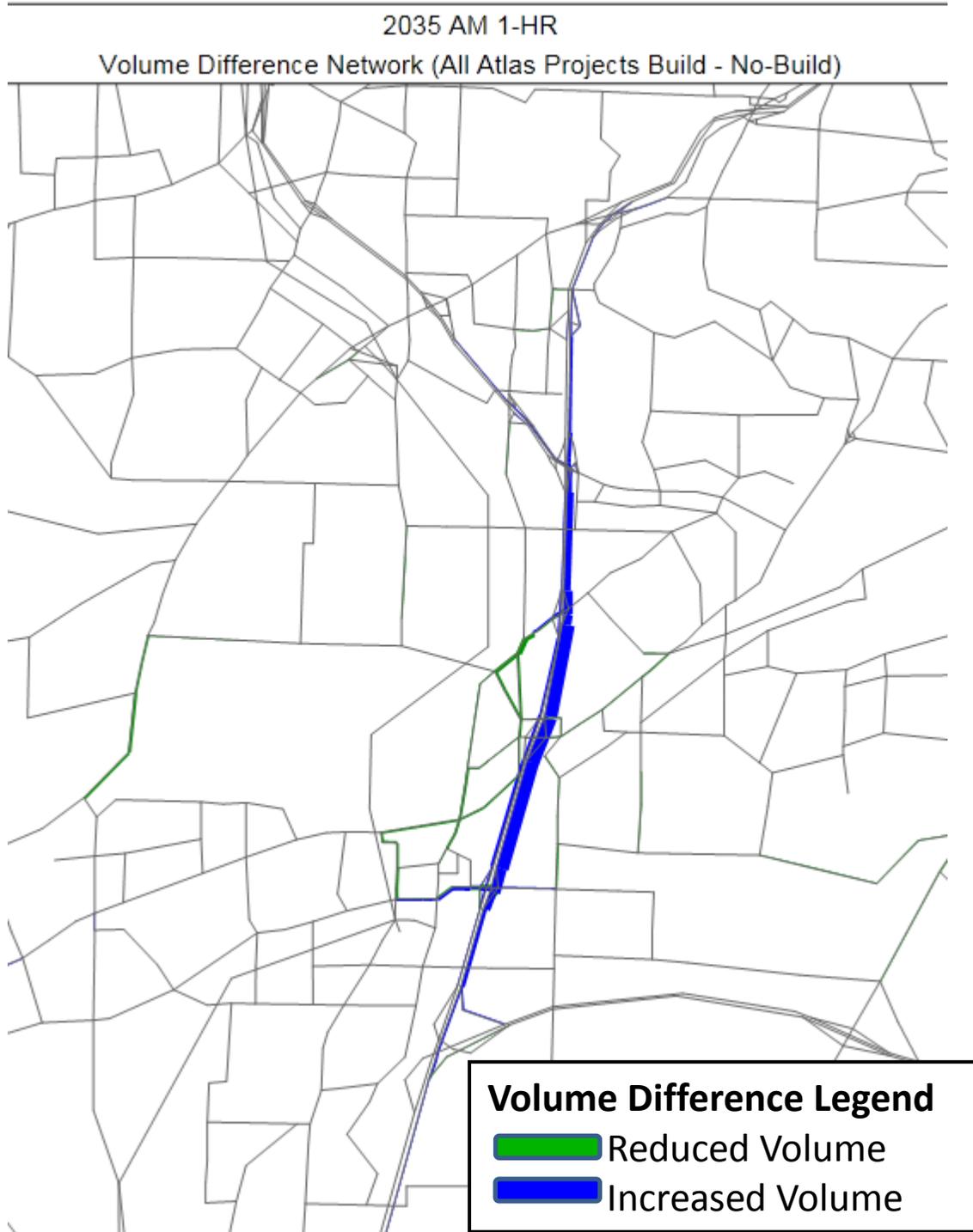
Project ID	Location	Type of Improvement
I-5		
A	I-5 NB: Terwilliger Blvd. Entrance Ramp	<i>Recommended for further analysis</i>
E	I-5 NB: Nyberg Rd. Interchange to Carman Dr. Interchange	<i>Project deleted</i>
I-205		
M, N & O	<i>I-205 NB: Division St. entrance ramp to I-84 WB Exit Ramp</i>	<i>Projects are included in Project P</i>
I-84		
R	<i>I-84 EB: Grand Ave. Entrance Ramp Extension</i>	<i>Recommended for further analysis</i>
I-405		
Project U	<i>I-405 SB/US30 EB: Entrance ramp lane re-arrangement.</i>	<i>Does not make a difference in the model</i>

After the procedure assignment was run for the Build model, a volume difference plot was created to analyze the changes in trips. 2010 and 2035 showed similar traffic trends, with volume differences being more pronounced in 2035. As such, 2035 results are being presented to show the traffic impacts of the C-BOS combined projects.

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2035 Volume Difference

Figure 1: I-5 AM

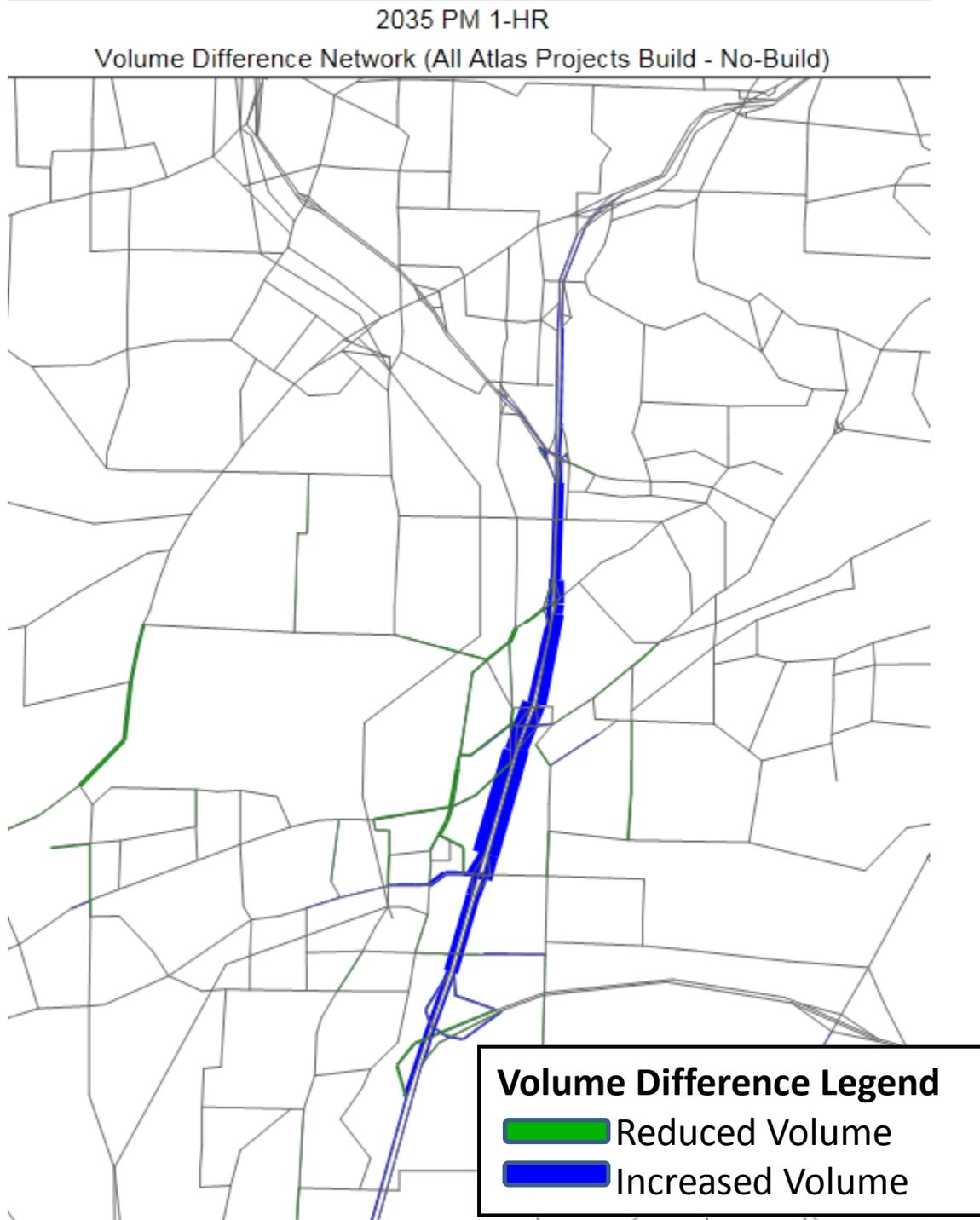


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Figure 1 is a 2035 AM 1-hour volume difference between Build and No-Build for I-5. Below is a more quantitative description of Figure 1. For all facilities not mentioned, the trip difference is insignificant.

- I-5 NB between I-205 and OR217 has an increase of 2-6% in trips.
- I-5 NB between OR217 and Tigard Interchange has an increase of 1-2% increase in trips.
- The I-5 NB exit ramps at Nyberg, Lower Boones-Ferry, Carman, and OR217 have the volume difference of -11%, -2%, +50%, and +2%, respectively.
- The I-5 NB entrance ramps from I-205, Nyberg, Lower Boones-Ferry, Carman and Kruse Way have the volume difference of +2, +14%, 0%, -9%, and -4%, respectively.
- Local NB parallel roads to the east of I-5 (SW 65th Ave, SW Pilkington Rd, SW Bryant Rd) have a 6-10% decrease in trips per roadway.
- Local NB parallel roads to the west of I-5 (SW 72nd Ave, SW Upper Boones-Ferry Road, SW Boones-Ferry Road, SW Martinazzi Ave) have a 2-8% decrease in trips per roadway.
- OR99W NB in the vicinity of Durham Road has a 5% decrease in trips.
- I-5 SB between OR217 and I-205 has an increase 0-2% in trips.
- The I-5 SB exit ramps at Upper Boones-Ferry, Lower Boones-Ferry, Nyberg, and I-205 have the volume difference of -2%, -2%, +3%, and 0%, respectively.
- The I-5 SB entrance ramps from OR217/Kruse Way, Upper Boones-Ferry, Lower Boones-Ferry, and Nyberg have the volume difference of +1, +6%, +2%, -7%, respectively.
- Local SB parallel roads to the west of I-5 (72nd, Durham) have a 5-10% decrease in trips per roadway.
- OR99W SB in the vicinity of Durham Road has a 2% decrease in trips.
- Tualatin-Sherwood Road between I-5 and Boones-Ferry Road has a 5% increase in trips in the eastbound direction and a 3% decrease in trips in the westbound direction.

Figure 2: I-5 PM

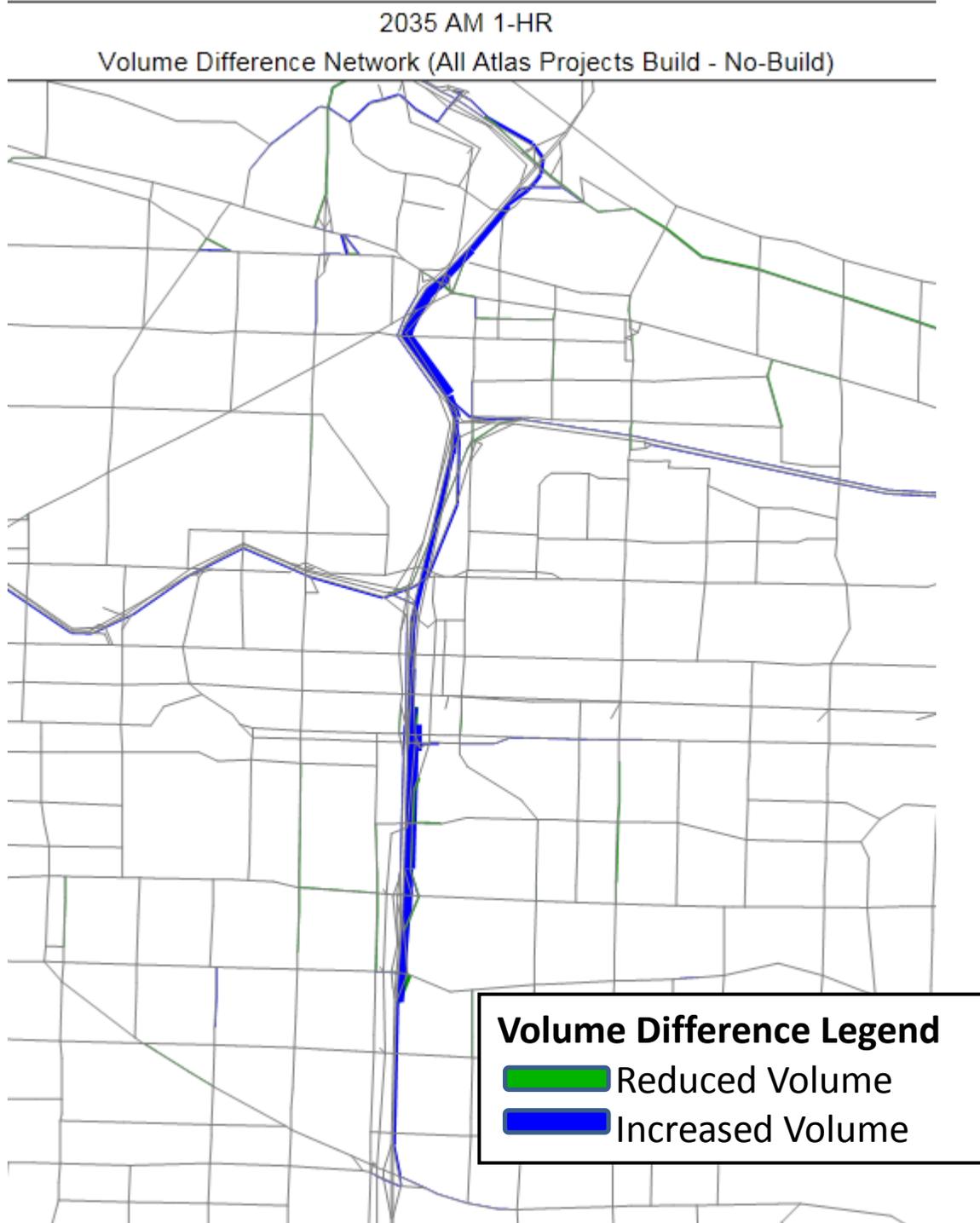


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Figure 2 is a 2035 PM 1-Hour Volume Difference of Build and No-Build for I-5. Below is a more quantitative description of Figure 2. For all facilities not mentioned, the trip difference is insignificant.

- I-5 NB between I-205 and OR217 has an increase of 2-5% in trips.
- I-5 NB between OR217 and Tigard Interchange has an increase of 1% increase in trips.
- The I-5 NB exit ramps at Nyberg, Lower Boones-Ferry, Carman, and OR217 have the volume difference of -3%, +4%, +20%, and +2%, respectively.
- The I-5 NB entrance ramps from I-205, Nyberg, Lower Boones-Ferry, Carman and Kruse Way have the volume difference of +3, +10%, +2%, -9%, and +2%, respectively.
- Local NB parallel roads to the east of I-5 (SW 65th Ave, SW Pilkington Rd, SW Bryant Rd) have a 1-2% decrease in trips per roadway.
- Local NB parallel roads to the west of I-5 (SW 72nd Ave, SW Upper Boones-Ferry Rod, SW Boones-Ferry Road, SW Martinazzi Ave) have a 4-7% decrease in trips per roadway.
- OR99W NB in the vicinity of Durham Road has a 1-3% decrease in trips.
- I-5 SB between OR217 and I-205 has an increase 1-5% in trips.
- The I-5 SB exit ramps at Upper Boones-Ferry, Lower Boones-Ferry, Nyberg, and I-205 have the volume difference of -4%, -12%, +12%, and 2%, respectively.
- The I-5 SB entrance ramps from OR217/Kruse Way, Upper Boones-Ferry, Lower Boones-Ferry, and Nyberg have the volume difference of +1, +5%, +5%, -2%, respectively.
- Local SB parallel roads to the west of I-5 (72nd, Durham) have a 2-8% decrease in trips per roadway.
- Local SB parallel roads to the east of I-5 (SW 65th Ave, SW Pilkington Rd, SW Bryant Rd) have a 2-9% decrease in trips per roadway.
- OR99W SB in the vicinity of Durham Road has a 2-5% decrease in trips.
- Tualatin-Sherwood Road between I-5 and Boones-Ferry Road has a 3% increase in trips in the eastbound direction and a 5% increase in trips in the westbound direction.

Figure 3: I-205 AM



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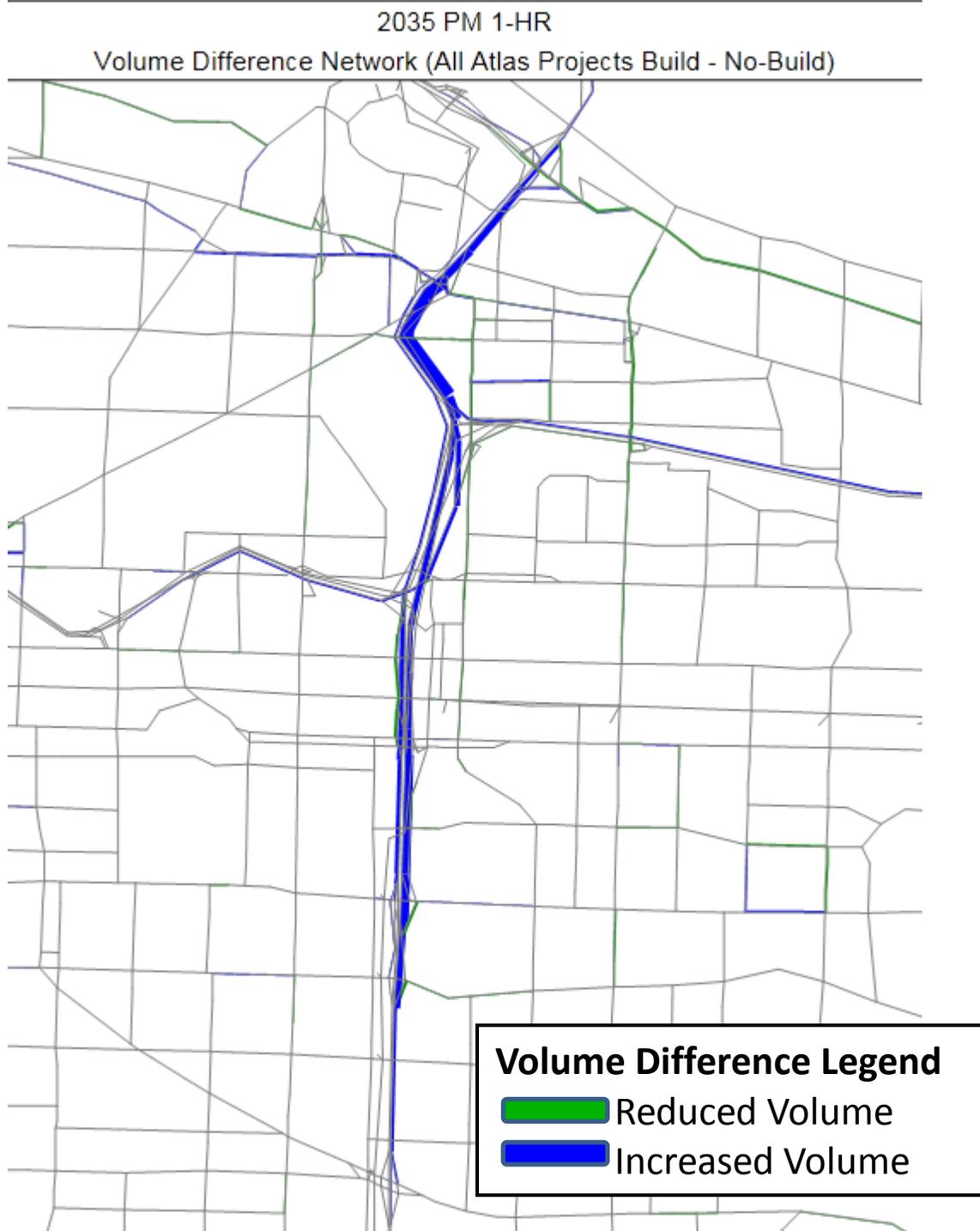
Figure 3 is a 2035 AM 1-Hour Volume Difference of Build and No-Build for I-205. Below is a more quantitative description of Figure 3. For all facilities not mentioned, the trip difference is insignificant.

- I-205 NB between Foster and Powell has an increase of 1% in trips.
- I-205 NB between Powell and I-84 WB Exit has an increase of 3-6% increase in trips.
- I-205 NB between I-84 WB Exit and Airport Way Exit has an increase of 3-4% in trips.
- The I-205 NB exit ramps at Powell/Division, Washington/Stark, Glisan, I-84 WB, I-84 EB, Sandy/Columbia, Airport Way have the volume difference of -13%, -11%, +43%, +3%, -1%, +4%, and +8%, respectively.
- The I-205 NB entrance ramps from Foster, Powell/Division, Glisan, I-84 EB, I-84 WB, Columbia/Sandy, and Airport Way have the volume difference of +6%, +7%, -2%, +5%, +4%, -4% and 0%, respectively.
- Local NB parallel roads to the east of I-205 (NE 102nd Ave, NE 122nd Ave) have a 1-5% decrease in trips per roadway.
- Local NB parallel roads to the west of I-205 (NE 82nd Ave, NE 92nd Ave) have a 1-4% decrease in trips per roadway.
- Airport Way WB has a 4-6% decrease in trips. (Trips destined to the airport vicinity now stay on I-84 WB to I-205 NB and exit at Airport Way rather than getting off at 181st Ave then travel on Airport Way.)
- I-205 SB between I-84 EB Entrance and Powell/Division Exit has an increase of less than 1% in trips.
- The I-205 SB exit ramps at Powell/Division has an increase of 3% in trips.
- The I-205 SB entrance ramps from I-84 EB Entrance, Glisan Entrance, Washington Entrance, and Powell/Division Entrance have the volume difference of +1, +3%, -1%, and -2%, respectively.
- Local SB parallel roads to the west of I-205 (NE 82nd Ave, NE 92nd Ave) have a 1-2% decrease in trips per roadway.
- Local SB parallel roads to the east of I-205 (NE 102nd Ave, NE 122nd Ave) have a 1-2% decrease in trips per roadway.

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- I-84 EB west of I-205 and I-84 WB east of I-205 each has a 1% increase in trips.

Figure 4: I-205 PM



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Figure 4 is a 2035 PM 1-Hour Volume Difference of Build and No-Build for I-205. Below is a more quantitative description of Figure 4. For all facilities not mentioned, the trip difference is insignificant.

- I-205 NB between Foster and Powell has an increase of less than 1% in trips.
- I-205 NB between Powell and I-84 WB Exit has an increase of 2-3% increase in trips.
- I-205 NB between I-84 WB Exit and Airport Way Exit has an increase of 2-5% increase in trips.
- The I-205 NB exit ramps at Powell/Division, Washington/Stark, Glisan, I-84 WB, I-84EB, Sandy/Columbia, Airport Way have the volume difference of -7%, +5%, 0%, +3%, 0%, +8%, and +18%, respectively.
- The I-5 NB entrance ramps from Foster, Powell/Division, Glisan, I-84 EB, I-84 WB, Columbia/Sandy, and Airport Way have the volume difference of +5%, +3%, +2%, +9%, +3%, -1% and -2%, respectively.
- Local NB parallel roads to the east of I-205 (NE 102nd Ave, NE 122nd Ave) have a 2-4% decrease in trips per roadway.
- Local NB parallel roads to the west of I-205 (NE 82nd Ave, NE 92nd Ave) have a 1-2% decrease in trips per roadway.
- Airport Way WB has a 3-7% decrease in trips. (Trips destined to the airport vicinity now stay on I-84 WB to I-205 NB and exit at Airport Way rather than getting off at 181st Ave then travel on Airport Way.)
- I-205 SB between I-84 EB Entrance and Powell/Division Exit has an increase of 1-2% in trips.
- The I-205 SB exit ramps at Powell/Division has an increase of 3% in trips.
- The I-205 SB entrance ramps from I-84 EB Entrance, Glisan Entrance, Washington Entrance, and Powell/Division Entrance have the volume difference of +1, +1%, -3%, and -1%, respectively.
- Local SB parallel roads to the west of I-205 (NE 82nd Ave, NE 92nd Ave) have a 1% decrease in trips per roadway.
- Local SB parallel roads to the east of I-205 (NE 102nd Ave, NE 122nd Ave) have a 1% decrease in trips per roadway.

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- I-84 EB west of I-205 and I-84 WB east of I-205 each has a 1% increase in trips.

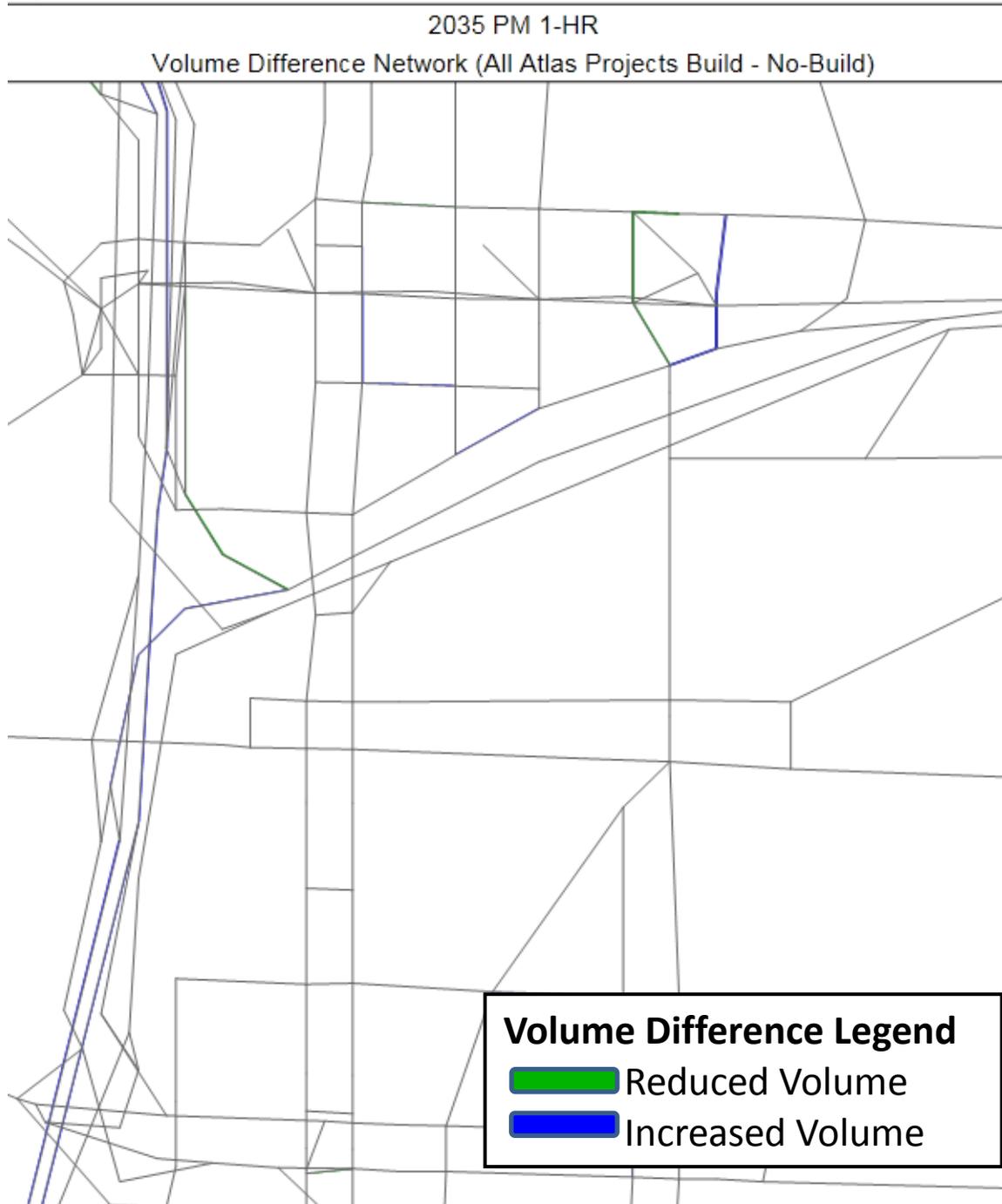
Figure 5: I-84 AM



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Figure 5 is a 2035 AM 1-Hour Volume Difference of Build and No-Build for I-84 at I-5. I-84 in the vicinity of I-5 has trip differences that are insignificant and therefore are not listed.

Figure 6: I-84 PM



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Figure 6 is a 2035 PM 1-Hour Volume Difference of Build and No-Build for I-84 at I-5. I-84 in the vicinity of I-5 has trip differences that are insignificant and therefore are not listed.

Summary

The travel demand model shows similar travel results across the roadway network, as summarized below:

- For projects where the improvement is a minor restriping such as I-405S at US30 Entrance and I-84W at I-5, there is an insignificant change in trips.
- For freeway sections where there are series of improvements, the trip difference is more discernable, as consistent with the goal of relieving localized bottlenecks. There is generally 1-6% trip increases on the freeway section within the project area and extended to one interchange downstream.
- Outside of this project influence area, the freeway trip changes are insignificant.
 - The 2035 travel demand model has two-way total volumes on I-5 mainline in the project influence area¹ ranging from 11,800-16,700 and 12,200-17,500 for the AM peak hour and PM peak hour, respectively. There are -5 AM and +34 PM trip differences to the south of the project influence area. There are +35 AM and +41 PM trip differences to the north of the project influence area.
 - The 2035 travel demand model has two-way total volumes on I-205 mainline in the project influence area ranging from 10,800-13,500 and 10,000-13,400 for the AM peak hour and PM peak hour, respectively. There are +7 AM and +12 PM trip differences to the south of the project influence area. There are +15 AM and +15 PM trip differences to the north of the project influence area.

For each freeway facility, latent travel demand is not seen on a corridor-wide basis. Nor is there any inclination for mode shift since this typically occurs where travel is improved for longer distance (corridor-wide travel time improvement).

- As a result of C-BOS projects' objective of breaking up bottlenecks, longer-distance trips are staying on the freeway a little longer by 1-2 interchanges, providing relief to the local facilities. This is seen in the trip differences on local roads, exit ramps and entrance ramps.
 - Local roads parallel or adjacent to the freeway project area generally are seen to have a positive impact from trip changes.
 - ❖ For I-5 S, more trips are now able to get to Tualatin-Sherwood Road and not using the local roadways as a cut-through route.
 - ❖ For I-5 N, more trips are now able to get to Upper Boones-Ferry Road/Carman and not getting off at Nyberg and using the local roadways as a cut-through route.

¹ For this modeling objective, project influence area includes one interchange beyond the project area in each direction.

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- ❖ For I-205 N impacts, trips on I-84 W and I-84 E destined to the airport area are no longer exiting early to avoid the congestion at the connections to I-205.
- In the direction of travel within each bottleneck section where there is an improvement project, upstream freeway exit-ramps experience a decrease in trips while downstream exit-ramps experience an increase in trips. Under No-Build, trips avoid bottlenecks or constrained capacity downstream by taking earlier exits and routing through local roads to reach their destination. Under Build conditions, trips are taking a more direct route to their destination by staying on the freeway longer and typically taking 1-2 exits later and decreasing the travel distance on parallel local roads.
- In the direction of travel within each bottleneck section where there is an improvement project, upstream freeway entrance-ramps experience an increase in trips while downstream entrance-ramps experience a decrease in trips. Under No-Build, trips avoid bottlenecks or constrained capacity on the freeway by routing through the local roads longer and taking a later freeway entrance-ramp. Under Build conditions, trips are taking a more direct route onto the freeway and reducing the distance traveled on local roads.
- The travel demand model takes into account the influence of ramp metering. Ramp metering is not only effective in regulating the traffic flow onto the freeway, it also will continue to deter using the freeway for short distance travel.

The modeling results are consistent with the purpose of the CBOS improvement projects, which is to enhance traffic safety and operations at freeway entrance and exit ramp junctions which are experiencing safety and operational issues. By breaking up the recurring freeway bottlenecks, freeway traffic will experience improved operations and will also be using the exit and entrance ramps that are more direct to reach their destination and reducing the cut-through traffic on the local roadway network. The results do not support any reasons for latent demand or mode shift to take place.

The ultimate goal is to improve safety and CBOS was developed in accordance with the guidelines established in the FHWA Localized Bottleneck Reduction (LBR) program. CBOS and the FHWA LBR program share the same common theme, that is, reducing potential crashes within weaving and merging areas has a positive safety impact and is highly cost effective.²

² FHWA – “Recurring Traffic Bottlenecks: A Primer”, Report No FHWA-HOP-12-012, pg. 16.
Appendix D CBOS Regional Modeling Results
May 2013