Technical Memorandum

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Subject: Base Year Build Conditions Technical Memorandum

1. Introduction

This technical memo documents the Base Year No-Build and Base Year Build traffic conditions based on Level of Service (LOS) and delay outputs from calibrated AM and PM peak hour VISSIM and Synchro models for the seventeen (17) rail-crossing areas included in Phase 2 of the Point Defiance Bypass Traffic Study.

The purpose of this memo is to present Base Year Build traffic operations for each intersection in the study area as well as provide a comparison of peak hour traffic operations with and without Amtrak *Cascades* trains. The Base Year No-Build condition includes Sound Transit *Sounder* train operations and represents the "No-Build" condition *without* growth for the opening of the *Sounder* Lakewood Extension, which will extend Sound Transit trains from Tacoma Dome Station to Lakewood Station. The Base Year Build condition includes Sound Transit *Sounder* and Amtrak *Cascades* train operations and represents the "Build" condition, *without* roadway traffic growth, for the opening of the Point Defiance Bypass, which would provide a through route for Amtrak trains between Tacoma Dome, Lakewood, and Nisqually; only the segment between Tacoma Dome and Lakewood would be shared between the Sound Transit and Amtrak trains, with the Sound Transit service stopping at the Lakewood station.

Thirty-eight study area intersections were modeled for the seventeen (17) rail-crossings included in Phase 2 of the Point Defiance Bypass Traffic Study. Base Year No-Build (described in a previous technical memo) and Base Year Build traffic operations were modeled using either Synchro or VISSIM software and varied by crossing location. A map and description of the study area intersections and ramp terminals modeled in the cities of Lakewood and Tacoma, WA can be found in the *Base Year No-Build Conditions Technical Memorandum*.

2. Base Year Build VISSIM Simulation Model Development Methodology

Base Year Build condition VISSIM simulation models were developed for seven (7) rail-crossing areas using the calibrated Base Year No-Build models: four (4) in the City of Lakewood and three (3) in the City of Tacoma. The Base Year Build condition includes both Sound Transit *Sounder* and Amtrak *Cascades* train operations and represents the "Build" condition, *without* roadway traffic growth, for the opening of the Point Defiance Bypass. Base Year Build VISSIM simulation model development included Sound Transit and Amtrak trains, crossing warning times, signal preemption and applicable pre-signals. The rail-crossings modeled in VISSIM include Bridgeport Way SW, 108th Street SW, 100th Street SW, Steilacoom Boulevard SW, South 74th Street, South 56th Street and South Pine Street. Sound Transit operations were not

modeled at Bridgeport Way SW because the *Sounder* trains terminate at Lakewood Station, just south of the 108th Street SW crossing.

To establish peak hours for roadway traffic, field counts were taken between 7:00 AM and 9:00 AM, and again between 4:00 PM and 6:00 PM. Additionally, the data collection time period was extended one hour during the AM peak period along Bridgeport Way SW, with field counts beginning at 6:00 AM. The peak hour at each crossing was established as the sixty (60) minute duration with the heaviest traffic and which would be affected by a *Cascades* train.

Sound Transit *Sounder* Commuter Trains

Based on the proposed Sound Transit *Sounder* schedule, each crossing except Bridgeport Way SW will experience a commuter revenue train only once during the AM and PM peak hours. In addition, the 100th Street SW and 108th Street SW crossings will encounter a *Sounder* non-revenue train only once during the PM peak hour, approximately 15-20 minutes after the revenue train. The *Sounder* non-revenue trains have no passengers and are traveling at lower speeds as they transit between Lakewood Station and a train layover facility north of 100th Street SW.

Average train speeds for the *Sounder* revenue trains are estimated to be sixty (60) miles per hour at South Pine Street, South 74th Street, Steilacoom Boulevard SW and 100th Street SW. Average train speeds for the *Sounder* revenue trains are estimated to be forty-five (45) miles per hour at 108th Street SW and twenty (20) miles per hour at South 56th Street, due to stations located in the vicinity of each crossing. Average train speeds for the *Sounder* non-revenue trains are estimated to be ten (10) miles per hour at 100th Street SW and thirty-five (35) miles per hour at 108th Street SW.

Amtrak *Cascades* Trains

Based on the proposed Amtrak *Cascades* schedule, each crossing will experience an Amtrak train only once during the AM and PM peak hours. With the exception of Bridgeport Way SW, the Amtrak trains will cross between one (1) and fourteen (14) minutes after the Sound Transit revenue train. Average train speeds for the Amtrak *Cascades* trains are estimated to be seventy-nine (79) miles per hour at all crossings.

Detailed simulation model development information is presented in Appendix A, including detailed intersection operational performance data for each study area intersection. The detailed operational performance data includes average delay, LOS, and average and maximum queue lengths.

3. Base Year No-Build and Base Year Build VISSIM Simulation Comparison

A comparison of Base Year No-Build and Base Year Build traffic operations for each rail-crossing area modeled using VISSIM is presented in Table 1 through Table 7. The Base Year No-Build and Base Year Build peak hour traffic operations performance measures include intersection LOS and average delay per vehicle (averaged over the peak hour volume, which is the standard measure for delay). Full reporting of queue lengths can be found in Table 8 through Table 14. The overall network performance of each crossing area has also been provided, with average delay per vehicle and LOS based on HCM metrics for signalized intersections. As shown in Table 1 through Table 7, AM and PM peak hour intersection operations were relatively unchanged with the addition of Amtrak *Cascades* trains. In general, average delays per vehicle increased by no more than two (2) seconds, and intersection LOS remained the same at all but two intersections.

The intersection of Bridgeport Way SW and the I-5 southbound ramp terminal went from an LOS A with no train operations to an LOS B during the Base Year Build PM peak hour. The increase in average delay per vehicle, however, was only 0.9 seconds. The AM peak hour delay at the intersection of 100th Street SW and Lakeview Avenue SW increased by only 0.5 seconds; however, since this was close to the LOS threshold, this was enough to change the intersection operation from an LOS A in the Base Year No-Build condition to an LOS B in the Base Year Build condition.

Overall network performance was also relatively unchanged, with average delays per vehicle increasing by no more than one (1) second and LOS remaining the same at all crossing areas.

These results indicate that given the assumptions previously mentioned regarding Sound Transit and Amtrak train operations, overall AM and PM peak hour intersection or overall network performance is not affected by the addition of Amtrak *Cascades* trains.

Table 1: Bridgeport Way SW – Base Year No-Build & Base Year Build Comparison

No.	Intersection Name	AM Peak Hour		PM Peak Hour	
		Base Year No-Build[1]	Base Year Build[2]	Base Year No-Build[1]	Base Year Build[2]
		Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)
3	Bridgeport Way SW & Pacific Highway SW	B (19.1)	B (19.1)	C (21.5)	C (21.6)
4	Bridgeport Way SW & I-5 SB Ramps	B (13.9)	B (13.9)	A (9.3)	B (10.2)
5	Bridgeport Way SW & I-5 NB Ramps	B (14.0)	B (14.1)	B (15.4)	B (15.6)
Network Performance		B (15.7)	B (15.8)	B (15.7)	B (16.1)

Notes: [1] Base Year No-Build intersection delay and LOS without Sound Transit or Amtrak operations.
[2] One northbound Amtrak *Cascades* train during the AM and PM peak hour.

Table 2: 108th Street SW - Base Year No-Build & Base Year Build Comparison

No.	Intersection Name	AM Peak Hour		PM Peak Hour	
		Base Year No-Build[1]	Base Year Build[2]	Base Year No-Build[3]	Base Year Build[4]
		Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)
6	108th Street SW and Lakeview Avenue SW	A (8.8)	A (9.0)	B (11.7)	B (12.0)
7	108th Street SW and Halcyon Road SW	A (6.1)	A (6.1)	A (9.3)	A (9.4)
Network Performance		A (5.1)	A (5.5)	A (6.7)	A (6.9)

Notes:
[1] One *Sounder* commuter train during the AM peak hour.
[2] One *Sounder* commuter train and one Amtrak *Cascades* train during the AM peak hour.
[3] One *Sounder* commuter train and one *Sounder* non-revenue train during the PM peak hour.
[4] One *Sounder* commuter train, one *Sounder* non-revenue train and one Amtrak *Cascades* train during the PM peak hour.

Table 3: 100th Street SW - Base Year No-Build & Base Year Build Comparison

No.	Intersection Name	AM Peak Hour		PM Peak Hour	
		Base Year No-Build[1]	Base Year Build[2]	Base Year No-Build[3]	Base Year Build[4]
		Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)
8	100th Street SW and Lakeview Avenue SW	A (9.8)	B (10.3)	B (14.4)	B (14.8)
Network Performance		A (9.8)	B (10.3)	B (14.4)	B (14.8)

Notes:
[1] One *Sounder* commuter train during the AM peak hour.
[2] One *Sounder* commuter train and one Amtrak *Cascades* train during the AM peak hour.
[3] One *Sounder* commuter train and one *Sounder* non-revenue train during the PM peak hour.
[4] One *Sounder* commuter train, one *Sounder* non-revenue train and one Amtrak *Cascades* train during the PM peak hour.

Table 4: Steilacoom Boulevard SW - Base Year No-Build & Base Year Build Comparison

No.	Intersection Name	AM Peak Hour		PM Peak Hour	
		Base Year No-Build[1]	Base Year Build[2]	Base Year No-Build[1]	Base Year Build[2]
		Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)
9	Steilacoom Blvd. SW and Lakeview Avenue SW	A (6.2)	A (6.4)	A (9.5)	A (9.8)
10	Steilacoom Blvd. SW and Durango Street SW	C (15.7)	C (15.7)	B (12.1)	B (12.2)
Network Performance		A (3.4)	A (3.5)	A (5.2)	A (5.4)

Notes: [1] One *Sounder* commuter train during the AM and PM peak hour.
[2] One *Sounder* commuter train and one Amtrak *Cascades* train during the AM and PM peak hour.

Table 5: South 74th Street - Base Year No-Build & Base Year Build Comparison

No.	Intersection Name	AM Peak Hour		PM Peak Hour	
		Base Year No-Build[1]	Base Year Build[2]	Base Year No-Build[1]	Base Year Build[2]
		Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)
11	South 74th Street and South Tacoma Way	C (28.2)	C (28.6)	D (37.6)	D (38.5)
Network Performance		C (28.2)	C (28.6)	D (37.6)	D (38.5)

Notes: [1] One *Sounder* commuter train during the AM and PM peak hour.
[2] One *Sounder* commuter train and one Amtrak *Cascades* train during the AM and PM peak hour.

Table 6: South 56th Street - Base Year No-Build & Base Year Build Comparison

No.	Intersection Name	AM Peak Hour		PM Peak Hour	
		Base Year No-Build[1]	Base Year Build[2]	Base Year No-Build[1]	Base Year Build[2]
		Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)
15	South 56th Street and South Washington Street	A (8.0)	A (8.2)	B (11.6)	B (12.9)
16	South 56th Street and South Burlington Way	A (3.4)	A (3.8)	A (4.1)	A (4.4)
17	South 56th Street and South Tacoma Way	B (18.7)	B (18.8)	C (24.8)	C (25.0)
18	South 56th Street and South Puget Sound Avenue	A (4.7)	A (4.8)	A (8.0)	A (8.0)
Network Performance		A (9.1)	A (9.3)	B (13.0)	B (13.5)

Notes: [1] One *Sounder* commuter train during the AM and PM peak hour.
[2] One *Sounder* commuter train and one Amtrak *Cascades* train during the AM and PM peak hour.

Table 7: South Pine Street - Base Year No-Build & Base Year Build Comparison

No.	Intersection Name	AM Peak Hour		PM Peak Hour	
		Base Year No-Build[1]	Base Year Build[2]	Base Year No-Build[1]	Base Year Build[2]
		Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)	Intersection LOS (Avg. Delay-sec/veh)
23	South Pine Street and South Tacoma Way	B (14.7)	B (15.0)	C (27.3)	C (28.2)
24	South Pine Street and South Center Street	C (22.2)	C (22.5)	C (33.4)	C (34.4)
Network Performance		B (18.5)	B (18.8)	C (30.5)	C (31.4)

Notes: [1] One *Sounder* commuter train during the AM and PM peak hour.
[2] One *Sounder* commuter train and one Amtrak *Cascades* train during the AM and PM peak hour.

Intersection Approach Queue Length Comparisons

Although overall intersection performance was not affected by the addition of Amtrak *Cascades* operations, individual movements may still be affected. Table 8 through Table 14 compares the VISSIM modeled maximum approach queue lengths for Base Year No-Build conditions to modeled maximum approach queue lengths for Base Year Build conditions in terms of feet. Queue lengths are measured by approach, which includes the through as well as the left-turn or dedicated right-turn movements.

As shown in Table 8 through Table 14, the intersection approaches immediately downstream of the rail-crossing and approaches that are allowed to operate after the track clearance phase during the signal preemption had little, if any, change in maximum queue lengths. Intersection approaches with prohibited movements during the signal preemption experienced increased maximum queue lengths due to the addition of Amtrak crossing operations. In general, the effect on these approaches is short lived, lasting only a cycle or two before returning to normal operations as observed in the simulation models following the train crossing event.

The comparison of approach queue lengths also indicates that the addition of Amtrak *Cascades* trains does not significantly affect intersections that are up or downstream of those intersections immediately adjacent to the rail-crossing. An example of this can be found at the I-5 northbound and I-5 southbound ramp terminals at Bridgeport Way SW and South Tacoma Way and South Puget Sound Avenue along South 56th Street.

Table 8: Bridgeport Way SW – Base Year No-Build & Base Year Build Queue Length Comparison

No.	Intersection	Approach	AM Peak Hour			PM Peak Hour		
			Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)	Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)
3	Bridgeport Way SW & Pacific Highway SW	Eastbound	97	99	2	132	132	0
		Westbound	162	156	-6	149	152	3
		Northbound	232	304	72	302	422	120
		Southbound	251	284	33	332	350	18
4	Bridgeport Way SW & I-5 SB Ramps	Westbound	241	266	25	199	209	10
		Northbound	93	84	-9	146	234	88
		Southbound	230	249	19	156	155	-1
5	Bridgeport Way SW & I-5 NB Ramps	Eastbound	205	219	14	261	260	-1
		Northbound	100	89	-11	196	193	-3
		Southbound	260	246	-14	247	260	13

[1] Average value of 20 VISSIM runs.

Table 9: 108th Street SW - Base Year No-Build & Base Year Build Queue Length Comparison

No.	Intersection	Approach	AM Peak Hour			PM Peak Hour		
			Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)	Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)
6	108th Street SW & Lakeview Avenue SW	Eastbound	92	132	40	321	320	-1
		Westbound	136	141	5	185	186	1
		Northbound	93	93	0	100	102	2
		Southbound	112	113	1	152	153	1
7	108th Street SW & Halcyon Road SW[2]	Eastbound	N/A	N/A	N/A	N/A	N/A	N/A
		Westbound	N/A	N/A	N/A	N/A	N/A	N/A
		Northbound	0	0	0	0	0	0

[1] Average value of 20 VISSIM runs.
[2] Northbound Halcyon Road is Right-Out only, queues are negligible.
[N/A] Intersection approach not stop controlled.

Table 10: 100th Street SW - Base Year No-Build & Base Year Build Queue Length Comparison

No.	Intersection	Approach	AM Peak Hour			PM Peak Hour		
			Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)	Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)
8	100th Street SW & Lakeview Avenue SW	Eastbound	133	138	5	515	519	4
		Westbound	200	206	6	195	197	2
		Northbound	111	111	0	125	124	-1
		Southbound	155	176	21	288	294	6

[1] Average value of 20 VISSIM runs.

Table 11: Steilacoom Boulevard SW - Base Year No-Build & Base Year Build Queue Length Comparison

No.	Intersection	Approach	AM Peak Hour			PM Peak Hour		
			Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)	Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)
9	Steilacoom Blvd. SW & Lakeview Avenue SW	Eastbound	153	164	11	258	265	7
		Westbound	145	143	-2	144	144	0
		Northbound	150	152	2	192	196	4
10	Steilacoom Blvd. SW & Durango Street SW	Eastbound	34	34	0	31	33	2
		Westbound	N/A	N/A	N/A	N/A	N/A	N/A
		Southbound	55	55	0	66	66	0

[1] Average value of 20 VISSIM runs.
[N/A] Intersection approach not stop controlled.

Table 12: South 74th Street - Base Year No-Build & Base Year Build Queue Length Comparison

No.	Intersection	Approach	AM Peak Hour			PM Peak Hour		
			Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)	Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)
11	South 74th Street & South Tacoma Way	Eastbound	324	331	7	397	393	-4
		Westbound	252	252	0	364	369	5
		Northbound	227	227	0	299	302	3
		Southbound	170	174	4	433	438	5

[1] Average value of 20 VISSIM runs.

Table 13: South 56th Street - Base Year No-Build & Base Year Build Queue Length Comparison

No.	Intersection	Approach	AM Peak Hour			PM Peak Hour		
			Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)	Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)
15	South 56th Street & South Washington Street	Eastbound	203	204	1	192	197	5
		Westbound	317	311	-6	366	378	12
		Northbound	58	58	0	58	58	0
		Southbound	78	83	5	727	793	66
16	South 56th Street & South Burlington Way	Eastbound	297	303	6	370	372	2
		Westbound	126	126	0	141	149	8
		Northbound	54	57	3	60	63	3
		Southbound	29	29	0	38	39	1
17	South 56th Street & South Tacoma Way	Eastbound	179	211	32	280	293	13
		Westbound	163	163	0	322	318	-4
		Northbound	145	145	0	246	245	-1
		Southbound	122	122	0	309	308	-1
18	South 56th Street & South Puget Sound Avenue	Eastbound	144	159	15	160	159	-1
		Westbound	97	99	2	117	120	3
		Northbound	97	97	0	148	148	0
		Southbound	63	63	0	124	124	0

[1] Average value of 20 VISSIM runs.

Table 14: South Pine Street - Base Year No-Build & Base Year Build Queue Length Comparison

No.	Intersection	Approach	AM Peak Hour			PM Peak Hour		
			Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)	Base No-Build Queue (feet) (1)[1]	Base Build Queue (feet) (2)[1]	Difference (2)-(1)
23	South Pine Street & South Tacoma Way	Eastbound	140	140	0	249	254	5
		Westbound	118	119	1	422	445	23
		Northbound	153	153	0	415	420	5
		Southbound	198	199	1	392	409	17
24	South Pine Street & South Center Street	Eastbound	186	186	0	294	311	17
		Westbound	178	181	3	494	532	38
		Northbound	203	205	2	459	469	10
		Southbound	197	200	3	376	373	-3

[1] Average value of 20 VISSIM runs.

The largest increase in maximum approach queue lengths between Base Year No-Build and Base Year Build conditions was at the Bridgeport Way SW and South 56th Street crossings. Base Year Build condition maximum approach queue lengths at the intersection of Bridgeport Way SW and Pacific Highway SW increased seventy-two (72) feet and one-hundred and twenty (120) feet in the northbound direction during the AM and PM peak hours respectively. The increase in queue lengths is due to the prohibited northbound movements during advanced signal preemption and the subsequent train crossing. The northbound approach queue length also increased eighty-eight (88) feet at the I-5 southbound ramp terminal during the PM peak, an indication of minor queue spillback as a result of the prohibited movements at Pacific Highway SW.

The increased queue lengths in the southbound direction along Bridgeport Way SW at Pacific Highway SW (in both the AM and PM peak hours) are the direct result of the crossing pre-signal. In the Base Year No-Build condition there are no Amtrak operations and the pre-signal on southbound Bridgeport Way is continually green. In the Base Year Build condition, the pre-signal prevents traffic from stopping on the railroad tracks, which creates a gap at the crossing and extends the intersection approach queue length by one or two vehicles.

At the South 56th Street crossing, the addition of Amtrak *Cascades* trains resulted in an increased queue length of sixty-six (66) feet (approximately 3 vehicles) in the southbound direction at South Washington Street during the PM peak hour.

Again, the effect on these approaches is short lived, lasting only a cycle or two before returning to normal operations as observed in the simulation models following a train crossing event. All other intersection approaches had negligible increases in maximum queue lengths (less than 2 vehicles) as a result of Amtrak *Cascades* train operations.

Crossing Queue Length Comparisons

A comparison of Base Year No-Build and Base Year Build crossing queue lengths is provided in Table 15. The associated crossing queue lengths represent the maximum queue length measured from the rail-crossing while the gate is closed (note that this is the queue at the crossing gate itself, which occurs at a different location than the queues at the nearby intersections; the latter intersection queues are reported in Table 8 through Table 14).

At 108th Street SW, crossing queue lengths in the eastbound direction during the PM peak hour, rounded to the nearest twenty-five (25) feet, were two-hundred and fifty (250) feet in the Base Year No-Build condition and two-hundred and seventy-five (275) feet in the Base Year Build condition. The approximate distance between the railroad tracks and the edge of the intersection is two-hundred and ten (210) feet, which indicates that queue spillback into the intersection is possible depending on vehicle length. Adding blankout signs for the southbound left-turn and northbound right-turn movements on Lakeview Avenue SW would prevent vehicles from queuing at the eastbound gate during a train crossing event.

Table 15: Base Year No-Build & Base Year Build Crossing Queue Length Comparison

Crossing	AM Peak Hour				PM Peak Hour			
	Base Year No-Build[1]		Base Year Build[2]		Base Year No-Build[1]		Base Year Build[2]	
	Crossing Queue Length[3] - feet (Direction)		Crossing Queue Length[3] - feet (Direction)		Crossing Queue Length[3] - feet (Direction)		Crossing Queue Length[3] - feet (Direction)	
Bridgeport Way SW[5]	0 (Southbound)[4]	0 (Northbound)[4]	125 (Southbound)	25 Northbound)	0 (Southbound)[4]	0 (Northbound)[4]	175 (Southbound)	50 (Northbound)
108th Street SW[6]	50 (Eastbound)	125 (Westbound)	125 (Eastbound)	175 (Westbound)	250 (Eastbound)	175 (Westbound)	275 (Eastbound)	175 (Westbound)
100th Street SW[6]	25 (Eastbound)	225 (Westbound)	25 (Eastbound)	250 (Westbound)	25 (Eastbound)	300 (Westbound)	25 (Eastbound)	325 (Westbound)
Steilacoom Boulevard	25 (Eastbound)	200 (Westbound)	25 (Eastbound)	225 (Westbound)	25 (Eastbound)	175 (Westbound)	25 (Eastbound)	200 (Westbound)
South 74th Street	175 (Eastbound)	25 (Westbound)	175 (Eastbound)	50 (Westbound)	200 (Eastbound)	25 (Westbound)	200 (Eastbound)	25 (Westbound)
South 56th Street	50 (Eastbound)	25 (Westbound)	50 (Eastbound)	25 (Westbound)	50 (Eastbound)	75 (Westbound)	75 (Eastbound)	75 (Westbound)
South Pine street	50 (Southbound)	75 (Northbound)	50 (Southbound)	75 (Northbound)	125 (Southbound)	125 (Northbound)	150 (Southbound)	175 (Northbound)

Notes:
[1] One Sound Transit *Sounder* train during the AM and PM peak hour.
[2] One Sound Transit *Sounder* train and one Amtrak *Cascades* train during the AM and PM peak hour.
[3] Queue lengths from railroad crossing while gate closed. Max queue length output from VISSIM. Queue lengths rounded to nearest 25 feet.
[4] No Sound Transit or Amtrak operations in Base Year No-Build condition at Bridgeport Way SW, thus there is no queue at the crossing itself.
[5] No Sound Transit *Sounder* operations during the Base Year Build condition at Bridgeport Way SW.
[6] One additional Sound Transit *Sounder* non-revenue train during the PM peak hour.

4. Base Year Build Synchro Delay

As a macroscopic traffic analysis software, Synchro does not represent the operation of the crossing gates or the changes in traffic signal operations that result from railroad advance preemption sequences. Synchro was selected as the analysis tool at these intersections due to the generally low volumes and simplicity of the intersections, and is consistent with analysis typically performed for environmental documentation or planning level studies. For calibration and comparison purposes, Synchro was used to determine Existing Year intersection operations *without* Sound Transit trains. In order to account for the delay introduced by passing trains and the subsequent gate down-time, basic queuing theory equations from Traffic Flow Fundamentals (Adolf D. May, 1990) were used to estimate delays due to Sound Transit *Sounder* commuter trains and Amtrak *Cascades* trains in the Base Year Build scenario.

The parameters that affect traffic delay at at-grade crossings are train frequency, train blockage time, hourly traffic volume and traffic departure capacity. Train blockage time includes the gate warning and closing cycle, the train crossing time and the time for the gates to fully open after the train has passed. It has been assumed that all vehicles will stop at the crossing and a queue will begin to form once the crossing gates begin to descend.

Detailed derivation of the delay calculation is included in *Appendix F* of the *Base Year No-Build Conditions Technical Memorandum*. Total crossing delay is measured in the unit of vehicle-hours per hour (veh-hrs/hr) and quantifies the total delay occurred amongst all vehicles at the rail-crossing during the AM and PM peak hours. The average delay per vehicle is calculated based on the total hourly delay and the expected number of arrival vehicles at the crossing from both the upstream and downstream intersections during the peak hour.

The rail-crossings modeled in Synchro include Clover Creek Drive SW, South 60th Street, South 50th Street, South 35th Street, South Wilkeson Street, South Alaska Street, South Chandler Street, South C Street, East C Street and East D Street. Based on the proposed Sound Transit *Sounder* schedule, each crossing in the Base Year No-Build condition will experience a commuter revenue train only once during the AM and PM peak hours, with the exception of Clover Creek Drive SW. Clover Creek Drive SW was not included in the Base Year No-Build analysis because the *Sounder* train terminates just south of the 108th Street SW crossing. Based on the proposed Amtrak *Cascades* schedule, each crossing in the Base Year Build condition will also experience an Amtrak train once during the AM and PM peak hours.

Table 16 summarizes the estimated delays at the rail-crossings modeled in Synchro for the Base Year Build condition. With the exception of Clover Creek Drive SW, the blockage time used to determine total crossing delay is a combination of both Sound Transit *Sounder* and Amtrak *Cascades* trains. As shown in Table 16, the average delay per vehicle averaged over the peak hour volume at the rail-crossings during a Sound Transit *Sounder* commuter and Amtrak *Cascades* train crossing event is less than two (2) seconds per vehicle during the AM and PM peak hours. For comparison purposes, the average delay per vehicle at the rail-crossings during a Sound Transit *Sounder* commuter train event only was less than one (1) second per vehicle during the AM and PM peak hours.

Table 16: Base Year Build Synchro Delay Summary

Crossing Location	2010 AM Peak Hour[1]				2010 PM Peak Hour[1]			
	Peak Crossing Volume (veh/hr)	Blockage Time (seconds)	Total Crossing Delay[3] (seconds)	Average Delay Per Vehicle (seconds)	Peak Crossing Volume (veh/hr)	Blockage Time (seconds)	Total Crossing Delay[3] (seconds)	Average Delay Per Vehicle (seconds)
East D Street	384	144	662	1.72	523	144	887	1.70
East C Street	223	127	311	1.40	152	127	182	1.20
South C Street	135	103	105	0.77	182	103	145	0.80
South Chandler Street	36	105	28	0.78	46	105	36	0.78
South Alaska Street	25	103	19	0.74	20	103	15	0.74
South Wilkeson Street	446	98	407	0.91	632	98	680	1.08
South 35th Street	263	94	187	0.71	366	94	267	0.73
South 50th Street	69	90	40	0.58	82	90	48	0.58
South 60th Street	54	103	42	0.78	74	103	58	0.78
Clover Cr. Drive SW[2]	93	42	24	0.25	128	42	33	0.26

Notes:
[1]One *Sounder* commuter train and one Amtrak *Cascades* train during the peak hour with various blockage times (including gates down & up).
[2]One Amtrak *Cascades* train only during the peak hour with various blockage times (including gates down & up)
[3]Total crossing delay is for the peak hour volume crossing the tracks from both the upstream and downstream intersections of the crossing.

In order to make a comparison between Base Year No-Build and Base Year Build intersection performance for the crossings modeled in Synchro, the crossing delay was applied to the adjacent intersections to estimate the change in intersection LOS and delay as a result of Sound Transit *Sounder* and Amtrak *Cascades* train operations, thus artificially "moving" the delay to the upstream intersection in order to use Synchro to estimate the additional intersection delay that would occur while the crossing volumes are prohibited from moving.

The methodology used to estimate intersection delay during a train crossing event was only applied to adjacent signalized intersections. Delay and LOS for an unsignalized intersection is based on the worst movement and the majority of the peak hour crossing volumes from the unsignalized intersections is from movements that are not stop-controlled and therefore have no delay under normal operations. A comparison of Base Year No-Build and Base Year Build traffic operations for the adjacent signalized intersections modeled in Synchro is presented in Table 17.

Table 17: Base Year No-Build & Base Year Build Comparison for Adjacent Signalized Intersections

No.	Intersection Name	2010 AM Peak Hour				2010 PM Peak Hour			
		Total Intersection Volume (veh/hr)	Crossing Delay[3] - sec (Direction)	Base Year No-Build[1] LOS (Avg. Delay-sec/veh)	Base Year Build[2] LOS (Avg. Delay-sec/veh)	Total Intersection Volume (veh/hr)	Crossing Delay[3] - sec (Direction)	Base Year No-Build[1] LOS (Avg. Delay-sec/veh)	Base Year Build[2] LOS (Avg. Delay-sec/veh)
21	South 35th Street and South Tacoma Way	875	96 (Westbound)	A (6.5)	A (6.5)	1422	136 (Westbound)	B (17.1)	B (17.2)
25	South Wilkeson Street and South Tacoma Way	1211	271 (Northbound)	B (10.4)	B (10.5)	1949	213 (Northbound)	B (13.4)	B (13.4)
26	South Wilkeson Street and South Center Street	1683	137 (Southbound)	B (12.4)	B (12.5)	2248	467 (Southbound)	C (24.2)	C (24.3)
34	East C Street and East 25th Street	435	24 (Southbound)	B (10.8)	B (10.9)	504	111 (Southbound)	B (10.1)	B (10.2)
35	East D Street and East 26th Street	969	578 (Northbound)	A (8.6)	A (8.9)	1291	328 (Northbound)	B (10.8)	B (11.0)
36	East D Street and East 25th Street	616	83 (Southbound)	A (9.9)	A (9.9)	889	559 (Southbound)	B (13.1)	B (13.4)

Notes:
[1]One *Sounder* commuter train during the peak hour with various blockage times (including gates down & up).
[2]One *Sounder* commuter train and one Amtrak *Cascades* train during the peak hour with various blockage times (including gates down & up).
[3] Directional crossing delay is for the peak hour volume crossing the tracks from the upstream intersection only.

As shown in Table 17, AM and PM peak hour intersection operations were relatively unchanged with the addition of Amtrak *Cascades* trains. In general, average delays per vehicle increased by no more than 0.3 seconds and intersection LOS remained the same.

These results indicate that given the assumptions used to determine crossing and intersection delays, estimated AM and PM peak hour intersection performance is not impacted with the addition of Amtrak *Cascades* trains.

As well as estimating the delays at each crossing, queue lengths were also calculated based on the estimated number of vehicles stopped during a train event. This average number of vehicles stopped was multiplied by an average vehicle length of twenty-five (25) feet to determine an average queue length by direction. Table 18 summarizes the estimated average queue lengths per direction at the rail-crossings during a Sound Transit *Sounder* train crossing event. Table 19 summarizes the estimated average queue lengths per direction at the rail-crossings during an Amtrak *Cascades* train crossing event.

Table 18: Base Year Build Synchro Queue Length Summary – Sound Transit *Sounder* Train

Crossing Location	Dir	2010 AM Peak Hour[1]				2010 PM Peak Hour[1]			
		Peak Volume	Blockage Time (seconds)	Average Number of Vehicles Stopped	Average Queue Length (feet)[2]	Peak Volume	Blockage Time (seconds)	Average Number of Vehicles Stopped	Average Queue Length (feet)[2]
East D Street	NB	328	70	7	175	202	70	4	100
	SB	56	70	2	50	321	70	7	175
East C Street	NB	202	62	4	100	59	62	2	50
	SB	21	62	1	25	93	62	2	50
South C Street	NB	61	51	1	25	53	51	1	25
	SB	74	51	2	50	129	51	2	50
South Chandler Street	NB	21	52	1	25	21	52	1	25
	SB	15	52	1	25	25	52	1	25
South Alaska Street	NB	13	51	1	25	8	51	1	25
	SB	12	51	1	25	12	51	1	25
South Wilkeson Street	NB	280	50	4	100	238	50	4	100
	SB	166	50	3	75	394	50	6	150
South 35th Street	EB	124	48	2	50	173	48	3	75
	WB	139	48	2	50	193	48	3	75
South 50th Street	EB	30	46	1	25	63	46	1	25
	WB	39	46	1	25	19	46	1	25
South 60th Street	EB	34	61	1	25	32	61	1	25
	WB	20	61	1	25	42	61	1	25

Notes:
[1]One *Sounder* commuter train during the peak hour with various blockage times (including gates down & up).
[2] Assumes average vehicle length is 25 feet.

Table 19: Base Year Build Synchro Queue Length Summary – Amtrak *Cascades* Train

Crossing Location	Dir	2010 AM Peak Hour[1]				2010 PM Peak Hour[1]			
		Peak Volume	Blockage Time (seconds)	Average Number of Vehicles Stopped	Average Queue Length (feet)[2]	Peak Volume	Blockage Time (seconds)	Average Number of Vehicles Stopped	Average Queue Length (feet)[2]
East D Street	NB	328	74	7	175	202	74	5	125
	SB	56	74	2	50	321	74	7	175
East C Street	NB	202	65	4	100	59	65	2	50
	SB	21	65	1	25	93	65	2	50
South C Street	NB	61	52	1	25	53	52	1	25
	SB	74	52	2	50	129	52	2	50
South Chandler Street	NB	21	53	1	25	21	53	1	25
	SB	15	53	1	25	25	53	1	25
South Alaska Street	NB	13	52	1	25	8	52	1	25
	SB	12	52	1	25	12	52	1	25
South Wilkeson Street	NB	280	48	4	100	238	48	4	100
	SB	166	48	3	75	394	48	6	150
South 35th Street	EB	124	46	2	50	173	46	3	75
	WB	139	46	2	50	193	46	3	75
South 50th Street	EB	30	44	1	25	63	44	1	25
	WB	39	44	1	25	19	44	1	25
South 60th Street	EB	34	42	1	25	32	42	1	25
	WB	20	42	1	25	42	42	1	25
Clover Creek Drive SW	EB	61	42	1	25	43	42	1	25
	WB	32	42	1	25	85	42	1	25

Notes:
[1]One Amtrak *Cascades* train during the peak hour with various blockage times (including gates down & up).
[2] Assumes average vehicle length is 25 feet.

As shown in Table 18 and Table 19, average queue lengths at the rail-crossings during a Sound Transit *Sounder* commuter train or Amtrak *Cascades* train event were one-hundred and seventy-five (175) feet or less based on an average vehicle length of twenty-five (25) feet. As previously noted in the *Base Year No-Build Conditions Technical Memorandum*, some crossings have a higher percentage of heavy vehicles, such as South 35th Street, and queue lengths may, at times, be longer.

A comparison of the average queue lengths at the rail-crossings during a Sound Transit *Sounder* commuter train and Amtrak *Cascades* train event indicate that average queue lengths rounded to the nearest twenty-five (25) feet are identical for all approaches except for the northbound direction on East D Street. The average queue length for the northbound approach at the East D Street rail-crossing is approximately twenty-five (25) feet longer during an Amtrak *Cascades* train crossing event.

It is important to note that the average northbound queue lengths at the East D Street rail-crossings during the AM peak hour and southbound queue lengths during the PM peak hour are estimated to be at or exceed the distance between the crossing and the adjacent signalized intersections in the Base Year Build condition. These queue lengths, however, would be distributed at the upstream intersections due to signal preemption. Signal preemption at East 25th Street and East 26th Street would prohibit traffic from entering the section of East D Street between East 25th and East 26th Streets during a train crossing event.

5. Conclusions

As described above, there is a negligible increase (less than 4 vehicles) in maximum intersection approach queue lengths during the peak hour at thirty-seven (37) of the thirty-eight (38) study area intersections as a result of the addition of Amtrak *Cascades* trains. At the intersection of Bridgeport Way SW and Pacific Highway SW, the intersection approach queue length increased one-hundred and twenty (120) feet in the northbound direction during the PM peak hour as a result of the advanced signal preemption and subsequent train crossing.

Likewise, there is no deterioration in level of service at any adjacent crossing intersection except for the intersections of Bridgeport Way SW and the I-5 SB Ramps and 100th Street SW and Lakeview Avenue, which increases average delays by 0.9 and 0.5 seconds per vehicle, respectively, and changes intersection operations from an LOS A in the Base Year No-Build condition to an LOS B in the Base Year Build condition. Overall network performance at all crossings except 100th Street SW is unchanged with the addition of Amtrak *Cascades* trains, with average delays per vehicle increasing by no more than one (1) second and LOS remaining the same at all crossing areas. At the 100th Street SW crossing, which is made up of only one study intersection, average delays per vehicle increased 0.5 seconds and network operations changed from an LOS A in the Base Year No-Build condition to an LOS B in the Base Year Build condition.

Appendix A

Base Year Build VISSIM Model Development

1. Base Year Build VISSIM Model Development Methodology and Assumptions

Base Year Build VISSIM models for Phase 2 of the Point Defiance Bypass Traffic Study were developed using the Base Year No-Build VISSIM models. The Base Year Build condition includes Amtrak *Cascades* train and Sound Transit *Sounder* train operations and represents the "Build" condition *without* roadway traffic growth for the opening of the Point Defiance Bypass. Model assumptions and network coding techniques are discussed below.

1.1 Amtrak and Sound Transit Trains

The Base Year Build condition assumes Amtrak *Cascades* trains and Sound Transit *Sounder* commuter trains at all crossings modeled in VISSIM with the exception of Bridgeport Way SW. Sound Transit operations were not modeled at Bridgeport Way SW because the *Sounder* train terminates just south of the 108th Street SW crossing. The total warning time, advance preemption time and average estimated train speed used at each crossing is provided in Table A-1 and Table A-2. For modeling purposes, each Sound Transit *Sounder* commuter train included one locomotive and seven (7) coach cars. Each Amtrak *Cascades* train included two locomotives and eight (8) coach cars. The default values in VISSIM resulted in an overall Sound Transit train length of 630 feet and an overall Amtrak train length of 780 feet.

Based on the proposed Sound Transit *Sounder* schedule it was determined that each crossing will experience a commuter revenue train only once during the AM and PM peak hours. In addition, the 100th Street SW and 108th Street SW crossings will encounter a *Sounder* non-revenue train only once during the PM peak hour, approximately 15-20 minutes after the revenue train. The *Sounder* non-revenue trains have no passengers and are traveling at lower speeds as they return to a layover facility north of 100th Street SW. Proposed AM and PM peak hour train crossing times for Sound Transit *Sounder* trains are shown below in Table A-1.

Table A-1: Simulation Parameters for *Sounder* Commuter Trains

Crossing	Total Warning Time (seconds)	Advance Preemption Time (seconds)	Estimated Train Speed (mph)	AM Peak		PM Peak	
				Sounder Crossing Times[1]	Non-Revenue Crossing Times	*Sounder* Crossing Times[1]	Non-Revenue Crossing Times
South Pine Street	41	10	60	8:22 AM	---	4:59 PM	---
South 56th Street	60	25	20	8:24 AM	---	5:01 PM	---
South 74th Street	54	14	60	8:26 AM	---	5:03 PM	---
Steilacoom Boulevard SW	50	18	60	8:27 AM	---	5:04 PM	---
100th Street SW	55	21	60	8:27 AM	---	5:04 PM	---
			10	---	---	---	5:23 PM[2]
108th Street SW	54	23	45	8:28 AM	---	5:05 PM	---
			35	---	---	---	5:20 PM[2]
Bridgeport Way SW	60	26	---	---	---	---	---

[1] *Sounder* Revenue Train
[2] *Sounder* Non-Revenue Train

Based on the proposed Amtrak *Cascades* schedule it was determined that each crossing will experience an Amtrak *Cascades* train only once during the AM and PM peak hours. With the exception of Bridgeport Way SW, the Amtrak *Cascades* trains will cross between one (1) and fourteen (14) minutes after the Sound Transit *Sounder* trains. Proposed AM and PM peak hour train crossing times for Amtrak *Cascades* trains are shown below in Table A-2.

Table A-2: Simulation Parameters for Amtrak *Cascades* Trains

Crossing	Total Warning Time (seconds)	Advance Preemption Time (seconds)	Estimated Train Speed (mph)	AM Peak		PM Peak	
				Amtrak Crossing Times	Minutes After *Sounder* Train	Amtrak Crossing Times	Minutes After *Sounder* Train
South Pine Street	41	10	79	8:31 AM	9	5:13 PM	14
South 56th Street	60	25	79	8:30 AM	6	5:12 PM	11
South 74th Street	54	14	79	8:30 AM	4	5:12 PM	9
Steilacoom Boulevard SW	50	18	79	8:29 AM	2	5:11 PM	7
100th Street SW	55	21	79	8:29 AM	2	5:11 PM	7
108th Street SW	54	23	79	8:29 AM	1	5:11 PM	6
Bridgeport Way SW	60	26	79	8:28 AM	---	5:10 PM	---

During the AM peak hour, an Amtrak *Cascades* train crosses the study area, between South Pine Street and Bridgeport Way SW, approximately one hour before a second *Cascades* train, between 7:14 AM and 7:21 AM, but given that the general AM peak hour is 7:30 AM – 8:30 AM and that train schedules can vary by up to five (5) minutes, the later Amtrak *Cascades* crossing times were used to represent a worst-case scenario in which each rail-crossing (sans Bridgeport Way SW) will experience both a Sound Transit *Sounder* and Amtrak *Cascades* train within fifteen (15) minutes of one another.

Given that VISSIM simulates vehicle inputs based on 15-minute flow rates, AM peak hour Sound Transit revenue trains were added to the network during the last fifteen (15) minutes of simulation and PM peak hour Sound Transit revenue trains were added at the halfway point. Sound Transit non-revenue trains at 100th Street SW and 108th Street SW were added nineteen (19) and fifteen (15) minutes later, respectively. With the exception of Bridgeport Way SW, Amtrak *Cascades* trains were added to the network between one (1) and (14) minutes after the AM and PM peak hour Sound Transit trains. At Bridgeport Way SW, AM peak hour Amtrak trains were added to the network during the last fifteen (15) minutes of simulation and PM peak hour Amtrak trains were added at the halfway point. With only one (1) minute between the Sound Transit *Sounder* and Amtrak *Cascades* trains at the 108th Street SW crossing, it was determined that the gates would only be open for eleven (11) seconds before the Amtrak *Cascades* train arrives, requiring that the gates remain closed until after the Amtrak *Cascades* train has crossed.

Results may vary slightly depending on when the trains pass through the crossing, but twenty (20) VISSIM simulations were performed to account for the randomness of intersection operations during the 15-minute period in which the trains were added.

1.2 Warning Time and Advance Preemption

Total warning and advance signal preemption times were modeled for each crossing. The total warning time is the amount of time that elapses between detection of the incoming train and its arrival at the crossing. When the warning time is initiated, a period of advance signal preemption begins that attempts to clear traffic that may be stopped on the tracks by stopping all intersection traffic except for the approach downstream of the crossing.

After the advance preemption ends, the track clearance phase at the downstream traffic signal is still in effect but the crossing warning lights begin to flash and the gates start to close. When the track clearance phase has ended, some intersection movements are allowed to operate until the train has passed through the crossing.

When modeled in VISSIM, check-in detectors were used to detect the incoming train and initiate signal preemption. The location of these detectors was determined based on the estimated train speed and the total warning time. A check-out detector was used to end signal preemption when the train is fifty (50) feet beyond the crossing. A second set of detectors were used to operate the crossing gate, beginning after the advance preemption time and ending when the train is fifty (50) feet beyond the crossing. When the gates begin to open, it takes approximately ten (10) seconds before traffic is allowed to proceed.

1.3 Blankout Signs

Blankout signs were modeled in VISSIM, where appropriate, to stop specific intersection movements from operating during traffic signal preemption. Blankout signs were used for right-turn and permitted left-turn movements to prevent queuing at the downstream rail-crossing that could spillback into the intersection. In addition, a northbound right-turn blankout sign was modeled at the intersection of South 56th Street and South Washington Street to reduce queuing between South Washington Street and South Tacoma Way, providing additional storage for eastbound traffic that has been stopped at South Burlington Way.

1.4 Pre-Signals

Pre-signals were modeled in VISSIM on South 74th Street and South Pine Street in order to prevent queuing traffic from stopping on the railroad tracks. Priority rules were used to simulate pre-signal operations and keep traffic from stopping on the tracks if the downstream queue approached the crossing. Simulated pre-signals were placed on the eastbound approach of South 74th Street at South Tacoma Way and the southbound approach of South Pine Street at South Tacoma Way.

2. Base Year Build Simulation Results

Table A-3 through Table A-9 includes detailed AM and PM peak hour Base Year Build traffic conditions for all study intersections based on calibrated VISSIM models. These results include Average Delay, Average Queue length and Maximum Queue length. It is important to note that VISSIM tends to report a zero (0) queue length for certain right-turn movements if there are sufficient gaps in opposing traffic and right-turn-on-red is permitted. This is especially the case for low volume right-turn only lanes. Vehicles are stopping but are not queuing to the extent that they are captured as part of the queue length in the simulation results.

Table A-3: Bridgeport Way SW – Base Year Build VISSIM Outputs

No.	Intersection	Movement	AM Peak Hour			PM Peak Hour		
			Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)	Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)
3	Bridgeport Way SW & Pacific Highway SW	EBL	53.0	12	99	50.3	20	127
		EBR	3.7	0	0	3.2	0	0
		EBT	48.7	7	78	45.0	25	132
		NBL	51.7	13	234	49.0	32	339
		NBR	3.1	17	304	4.8	44	422
		NBT	9.2	17	304	13.8	44	422
		SBL	48.6	13	101	47.5	23	153
		SBR	12.3	26	229	16.0	39	252
		SBT	13.5	26	229	16.7	39	252
		WBL	44.0	34	156	44.1	35	152
		WBR	2.2	0	0	3.8	0	0
		WBT	40.9	18	108	39.3	16	102
		All	19.1	---	---	21.6	---	---
4	Bridgeport Way SW & I-5 SB Ramps	NBL	7.4	3	84	10.3	12	234
		NBT	2.8	3	84	5.2	12	234
		SBR	9.2	3	163	5.8	0	75
		SBT	15.5	30	249	7.4	15	155
		WBL	39.2	47	266	41.9	39	209
		WBR	15.1	8	181	17.4	5	124
		All	13.9	---	---	10.2	---	---
5	Bridgeport Way SW & I-5 NB Ramps	EBL	40.7	56	219	38.9	69	260
		EBR	7.8	0	0	7.5	0	0
		NBR	3.7	0	6	7.4	1	112
		NBT	9.0	6	89	13.5	20	193
		SBL	11.1	14	246	16.4	20	260
		SBT	2.7	14	246	3.7	20	260
		All	14.1	---	---	15.6	---	---

Table A-4: 108th Street SW - Base Year Build VISSIM Outputs

No.	Intersection	Movement	AM Peak Hour			PM Peak Hour		
			Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)	Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)
6	108th Street SW & Lakeview Avenue SW	EBL	7.1	1	40	10.9	2	54
		EBR	2.9	1	40	7.3	3	223
		EBT	6.5	4	132	9.3	16	320
		NBL	19.7	0	21	26.5	0	22
		NBR	6.4	0	0	10.0	0	15
		NBT	24.6	8	93	25.5	10	102
		SBL	27.0	7	90	30.4	17	126
		SBR	11.4	0	22	14.0	0	64
		SBT	25.2	8	113	25.8	15	153
		WBL	5.3	2	87	8.7	2	93
		WBR	3.5	1	94	4.4	2	137
		WBT	4.2	5	141	5.1	8	186
		All	9.0	---	---	12.0	---	---
7	108th Street SW & Halcyon Road SW	EBR	0.0	0	0	0.0	0	0
		EBT	0.1	0	0	0.1	0	0
		NBR	6.1	0	0	9.4	0	0
		WBT	2.0	2	195[1]	1.7	0	61[1]
		All	1.3	---	---	0.8	---	---

[1] Max queue length from rail-crossing exceeded Halcyon Road.

Table A-5: 100th Street SW - Base Year Build VISSIM Outputs

No.	Intersection	Movement	AM Peak Hour			PM Peak Hour		
			Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)	Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)
8	100th Street SW & Lakeview Avenue SW	EBL	37.6	7	77	48.1	6	73
		EBR	5.8	9	138	13.7	7	365
		EBT	8.4	9	138	15.4	40	519
		NBL	21.4	2	52	24.1	2	46
		NBR	5.4	0	46	8.4	1	52
		NBT	19.2	10	111	20.0	12	124
		SBL	29.9	17	176	35.7	30	294
		SBR	9.0	1	36	14.6	3	151
		SBT	19.6	6	106	22.7	20	217
		WBL	25.4	5	102	32.9	11	165
		WBR	4.4	7	173	5.2	5	146
		WBT	6.3	16	206	6.9	19	197
		All	10.3	---	---	14.8	---	---

Table A-6: Steilacoom Boulevard SW - Base Year Build VISSIM Outputs

No.	Intersection	Movement	AM Peak Hour			PM Peak Hour		
			Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)	Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)
9	Steilacoom Blvd. SW & Lakeview Avenue SW	EBR	5.4	0	48	8.5	2	151
		EBT	7.3	11	164	10.4	24	265
		NBL	34.4	20	152	36.2	31	196
		NBR	6.4	1	63	7.9	2	78
		WBL	8.2	3	95	12.8	6	124
		WBT	2.6	6	143	3.6	8	144
		All	6.4	---	---	9.8	---	---
10	Steilacoom Blvd. SW & Durango Street SW	EBL	6.3	0	34	5.6	0	33
		EBT	0.1	0	0	0.3	0	0
		SBL	15.7	1	55	12.2	2	66
		SBR	7.6	0	0	7.5	0	0
		WBR	0.6	0	0	0.6	0	0
		WBT	0.1	0	0	0.1	0	0
		All	0.3	---	---	0.5	---	---

Table A-7: South 74th Street - Base Year Build VISSIM Outputs

No.	Intersection	Movement	AM Peak Hour			PM Peak Hour		
			Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)	Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)
11	South 74th Street & South Tacoma Way	EBL	46.2	15	114	64.3	24	140
		EBR	20.8	18	239	30.7	35	302
		EBT	23.0	60	331	34.6	85	393
		NBL	46.5	45	227	65.0	58	293
		NBR	5.2	0	0	7.5	0	18
		NBT	29.8	40	206	34.0	53	302
		SBL	52.3	11	94	69.0	38	213
		SBR	28.8	30	170	39.7	95	434
		SBT	37.9	36	174	41.3	98	438
		WBL	56.3	33	209	74.5	48	280
		WBR	17.4	7	163	29.0	23	279
		WBT	22.3	43	252	33.6	70	369
		All	28.6	---	---	38.5	---	---

Table A-8: South 56th Street - Base Year Build VISSIM Outputs

No.	Intersection	Movement	AM Peak Hour			PM Peak Hour		
			Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)	Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)
15	South 56th Street & South Washington Street	EBL	7.2	8	204	12.3	11	197
		EBR	2.6	6	187	3.4	11	186
		EBT	3.3	6	187	5.2	11	186
		NBL	43.9	2	44	40.9	3	50
		NBR	3.4	5	58	11.3	4	58
		NBT	39.2	4	56	34.7	4	56
		SBL	40.1	5	56	47.7	13	265
		SBR	6.6	2	83	26.0	86	793
		SBT	36.0	4	51	45.5	14	358
		WBL	12.8	1	54	12.2	1	38
		WBR	8.9	12	274	3.3	23	378
		WBT	10.7	22	311	6.5	23	378
		All	8.2	---	---	12.9	---	---
16	South 56th Street & South Burlington Way	EBL	5.3	0	21	11.6	0	26
		EBR	3.9	4	218	6.9	6	287
		EBT	5.2	11	303	7.1	16	372
		NBL	35.1	1	28	45.1	3	40
		NBR	7.9	1	57	8.6	1	63
		NBT	0.0	0	49	33.9	1	61
		SBL	44.3	1	29	0.0	0	0
		SBR	7.1	0	0	7.7	0	0
		SBT	22.4	0	16	17.5	0	39
		WBL	4.9	0	40	7.7	2	98
		WBR	1.2	0	61	1.0	1	105
		WBT	1.2	2	126	1.4	4	149
		All	3.8	---	---	4.4	---	---

Table A-8: South 56th Street - Base Year Build VISSIM Outputs

No.	Intersection	Movement	AM Peak Hour			PM Peak Hour		
			Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)	Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)
17	South 56th Street & South Tacoma Way	EBL	43.2	5	66	53.0	15	112
		EBR	10.9	25	211	14.1	10	204
		EBT	13.0	25	211	17.9	43	293
		NBL	25.3	14	132	27.2	14	134
		NBR	18.0	1	69	22.9	12	169
		NBT	28.8	26	145	28.2	49	245
		SBL	24.1	5	75	23.4	7	85
		SBR	18.4	0	18	27.7	16	212
		SBT	31.9	23	122	31.6	68	308
		WBL	42.2	10	93	48.3	21	249
		WBR	7.8	1	91	15.6	22	245
		WBT	12.0	17	163	20.7	53	318
		All	18.8	---	---	25.0	---	---
18	South 56th Street & South Puget Sound Avenue	EBL	5.6	0	25	9.1	0	33
		EBR	2.0	1	92	3.2	1	92
		EBT	2.0	3	159	2.9	7	159
		NBL	39.7	1	29	40.5	2	53
		NBR	11.7	1	55	17.1	4	106
		NBT	35.0	8	97	40.3	15	148
		SBL	36.2	2	42	44.2	8	94
		SBR	8.6	0	10	18.0	1	78
		SBT	36.0	4	63	39.3	14	124
		WBL	6.2	0	36	8.3	1	48
		WBR	2.5	0	30	3.3	0	51
		WBT	3.3	4	99	5.6	6	120
		All	4.8	---	---	8.0	---	---

Table A-9: South Pine Street – Base Year Build VISSIM Outputs

No.	Intersection	Movement	AM Peak Hour			PM Peak Hour		
			Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)	Average Delay (sec/veh)	Average Queue (feet)	Max Queue (feet)
23	South Pine Street & South Tacoma Way	EBL	14.5	7	102	26.6	14	166
		EBR	10.5	0	56	23.9	8	170
		EBT	17.1	15	140	32.4	41	254
		NBL	12.4	2	60	25.2	6	88
		NBR	10.1	17	153	22.8	71	420
		NBT	15.4	17	153	26.4	71	420
		SBL	12.2	3	106	29.0	12	281
		SBR	10.8	17	199	22.5	65	409
		SBT	14.5	17	199	25.0	65	409
		WBL	14.3	2	59	31.0	31	391
		WBR	11.6	1	66	30.0	45	392
		WBT	20.7	13	119	34.9	77	445
		All	15.0	---	---	28.2	---	---
24	South Pine Street & South Center Street	EBL	21.2	10	112	34.7	11	101
		EBR	14.9	2	104	32.7	19	228
		EBT	27.9	22	186	40.8	63	311
		NBL	16.4	5	88	30.8	39	409
		NBR	16.1	6	140	22.9	36	404
		NBT	22.1	30	205	25.9	65	469
		SBL	16.9	6	91	21.6	12	128
		SBR	18.5	4	122	26.9	34	296
		SBT	25.7	32	200	29.9	76	373
		WBL	18.7	2	48	39.0	14	150
		WBR	18.2	26	181	45.1	129	532
		WBT	30.0	26	181	49.1	129	532
		All	22.5	---	---	34.4	---	---