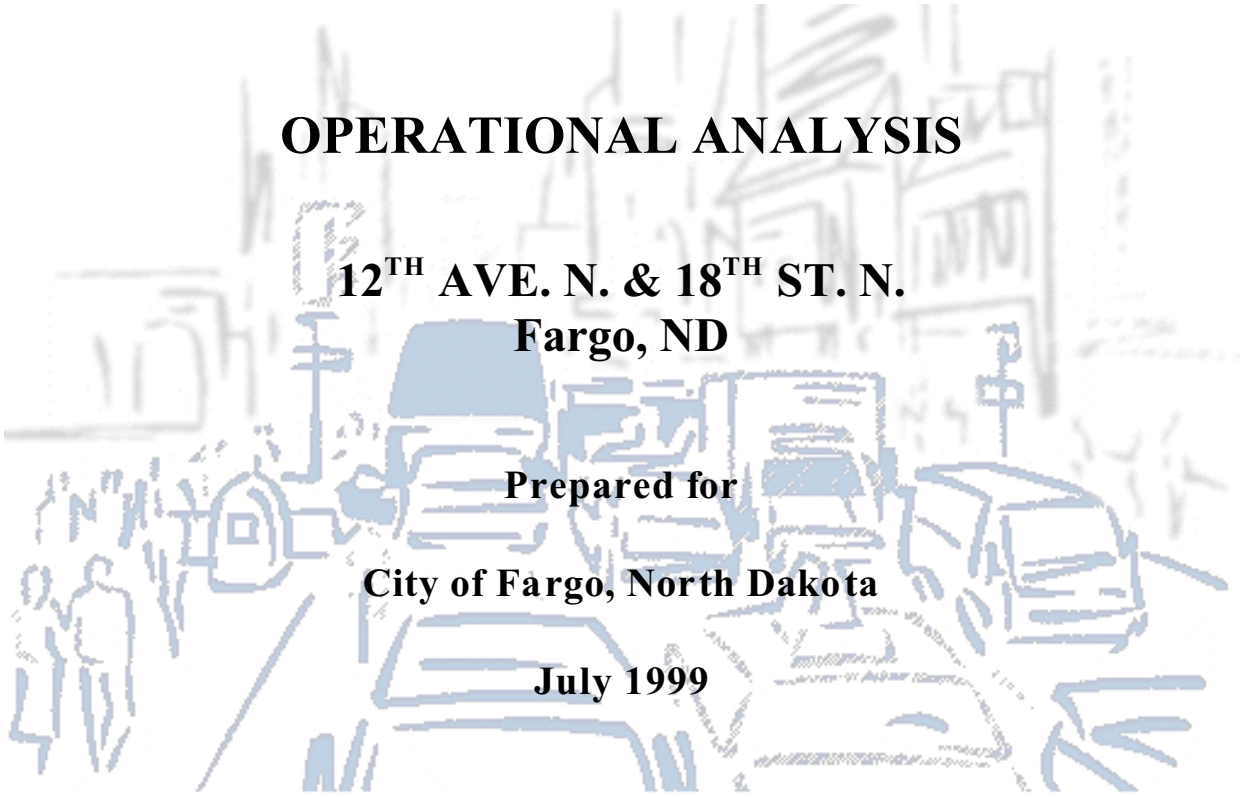
Advanced Traffic Analysis Center



OPERATIONAL ANALYSIS

12TH AVE. N. & 18TH ST. N.
Fargo, ND

Prepared for

City of Fargo, North Dakota

July 1999

Enhancing transportation systems in second-tier cities through the use of advanced traffic analysis and ITS solutions to safety and mobility problems

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BACKGROUND

The 12th Ave. N. corridor in Fargo, ND, serves many industrial, manufacturing, and warehouse facilities, as well as many dwelling units and North Dakota State University (NDSU). The corridor is also heavily used for special events at the Fargodome and NDSU. Currently, a large number of these motorists use the 12th Ave. N. and 18th St. intersection, which is an unsignalized intersection. The average annual daily traffic (AADT) at the 12th Ave. and 18th St. N. intersection ranges from 15,900 to 17,300 vehicles.[1]

Special events cause severe traffic congestion at this intersection primarily for the motorists making an eastbound left turn traveling to NDSU and the Fargodome, while the motorists attempting southbound movements are hindered traveling from the special events. In addition, southbound right turns are restricted during the afternoon peak periods. For these reasons, concerns have been raised over the necessity of a traffic signal at the intersection in Fargo, ND. The North Dakota Department of Transportation (NDDOT) has determined the intersection does not warrant a traffic signal based on the current traffic levels, whereas the City of Fargo has concluded that a signal is warranted.

OBJECTIVES

The Advanced Traffic Analysis Center (ATAC) conducted this study for the City of Fargo Traffic Engineering Department to investigate the following:

- ✓ Traffic signal justification based on MUTCD,
- ✓ Best traffic signal timing plans (if a traffic signal is justified), and
- ✓ The effects of unsignalized and signalized traffic control using a traffic simulation model.

SIGNAL JUSTIFICATION

The Manual on Uniform Traffic Control Devices (MUTCD) exhibits 11 warrants which justify the implementation of a traffic signal. (MUTCD's traffic signal warrants are currently being revised for the 2000 edition.) Each warrant analyzes a different set of conditions where signal control has been an effective approach to ensure safe and efficient intersection operation. It is important to understand that a traffic signal should not be utilized unless one or more of the warrants are met. The 11 warrants for signalized control are as follows:[2]

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[1]Fargo-Moorhead Metropolitan Council of Governments, *1996 Urban Area Traffic Count Map*, Fargo, ND, June 1996.

[2]McShane, William R., Roger P. Roess, and Elena S. Prassas, *Traffic Engineering*, 2nd edition, Prentice-Hall, Inc., Upper Saddle River, NJ, 1998.

- ✓ Warrant 1: Minimum Vehicular Volume (8-hour)
- ✓ Warrant 2: Interruption of Continuous Traffic (8-hour)
- ✓ Warrant 3: Minimum Pedestrian Volume (8-hour)
- ✓ Warrant 4: School Crossing
- ✓ Warrant 5: Progressive Movement
- ✓ Warrant 6: Accident Experience
- ✓ Warrant 7: Systems Warrant
- ✓ Warrant 8: Combination of Warrants
- ✓ Warrant 9: Four-Hour Vehicular Volume
- ✓ Warrant 10: Peak Hour Delay
- ✓ Warrant 11: Peak-hour Vehicular Volume

According to traffic counts taken by the City of Fargo on September 2, 1998, Warrant 11 is met. Warrant 11 deals with the peak hour volume that exists at an intersection. Table 1 illustrates the critical values for the major and minor streets having two or more lanes each, and incorporates the peak-hour traffic counts (shown in gray).

Table 1. Warrant 11 Critical Values and Peak Hour Traffic Counts.

Major Street (Total of Both Approaches)	Minor Street (High Volume Approach)
1800	150
1700	150
1600	165
1565	202*
1500	190

* Exceeds Warrant

The inclusion of vehicles making right turns to justify Warrant 11 has raised concerns about the validity of the warrant. Some agencies, such as the NDDOT, have a legitimate argument that most of these vehicles encounter an acceptable gap to accommodate the turning maneuver. During peak periods, however, right turns may not have the appropriate gap necessary for the maneuver. Heavy major-street (cross) traffic creates an even greater concern when a large majority of right turns occur within the peak-hour period. Traffic counts by the ATAC on May 25, 1999, reported queues of eight vehicles on the southbound left-turn lane. The queues were largely due to insufficient gaps to accommodate these vehicles. It is important to note, that the queues encountered on the southbound approach are higher during NDSU's fall and spring semesters since approximately 10,000 students attend the university, making it a major traffic generator. Further, the afternoon and morning peaks of NDSU coincide with those of 12th Ave. N. Therefore, the traffic counts reported by the City of Fargo, which were conducted during NDSU's Fall 1998 Semester, will be used for analysis purposes.

Special events, such as sporting events, musical concerts, and special shows or festivals, frequently occur at NDSU and the Fargodome. These events cause significant congestion on many of Fargo's arterials, especially 12th Ave. N. and 19th Ave. N. A traffic signal at 12th Ave. N. and 18th St. N. would more effectively accommodate the increased demand caused by the special events.

BEST SIGNAL TIMING PLANS

A signal plan analysis of the intersection was conducted using Trafficware's Synchro 3.2 software package. The intersection's geometric characteristics, traffic volumes, and pedestrian volumes were entered into the program to determine the appropriate phasing, optimal cycle length, and optimal splits. The intersection analysis recommended a three-phase actuated signal. The three-phase signal exhibits a Level of Service (LOS) of B for AM and PM peak-hour periods, while a two-phase signal had a LOS of B for the AM peak and a LOS of F for the PM peak. The results of the signal analysis can be summarized as follows (Detailed Synchro output is illustrated in Appendix A:)

- ✓ Number of Phases: 3
  - Phases 1 & 5: EBL and WBL protective
  - Phases 2 & 6: EB and WB through with permissive turning
  - Phases 4 & 8: NB and SB through with permissive turning
- ✓ Control Type: Actuated
- ✓ Cycle Length: 90 seconds
- ✓ Intersection Webster Stopped Delay: 10.5 seconds/vehicle (AM Peak)
- ✓ Intersection Webster Stopped Delay: 9.4 seconds/vehicle (PM Peak)
- ✓ Intersection LOS: B (AM and PM Peak)

TRAFFIC SIMULATION

A traffic simulation analysis was conducted to compare the operational characteristics between the unsignalized and signalized traffic control strategies. The analysis used the CORSIM model, a microscopic stochastic simulation model for corridors, which was developed by the Federal Highway Administration (FHWA). CORSIM provides numerical and visual output to evaluate the operational characteristics of a network, such as queue lengths caused by congestion, delay time, and travel time.

Similar to the Synchro analysis, the CORSIM input included the intersection's geometry, traffic volumes, pedestrian volumes, and traffic control. Two simulation cases were analyzed: 1) the current conditions which consist of a two-way stop sign and 2) a traffic signal which uses the optimized Synchro timing plan. Both simulation cases evaluated the current PM peak-hour traffic volumes (September 2, 1998) and traffic growths of 10%, 20%, and 30%. The simulation scenarios were simulated 30 times to represent a normal distribution. The output for the peak 15-minute period was averaged and used for comparing the total delay time, total travel time, and southbound queue lengths. Appendix B contains the CORSIM output comparing the unsignalized and signalized control.

Numerical Output

Based on the simulation's numerical output, the implementation of a traffic signal would cause additional delay time and total time for the intersection at the current traffic levels (Table 2). This experience occurs since a majority of the traffic had uninterrupted flow under the two-way stop sign, while under signalized control the vehicles had to stop when the side street had a green indication. At the current traffic levels, the signalized strategy increased the total delay time and total travel time by 83% and 18%, respectively. However, a traffic signal became more favorable as traffic levels increased. A breakeven point occurred for the signalized and unsignalized control at approximately 14% traffic growth for the total delay time and 19% traffic growth for the total travel time (Appendix Figures B-1 and B-2). As traffic volumes continue to increase, the traffic signal control outperforms the unsignalized control in terms of total travel time and total delay time. When traffic volumes were increased by 30%, installing a traffic signal reduced the total delay time by 36% and the total travel time by 15%.

The queues experienced for the southbound approach, specifically the southbound right-turn lane, were substantially reduced due to the signal implementation (Table 2). The queue time savings at the current traffic levels were approximately 73%, while a 30% increase in traffic volumes created a savings of 93%.

Table 2. CORSIM Numerical Output for Peak 15-minute Period for Unsignalized and Signalized Control.

Unsignalized	**Current**	**10% Increase**	**20% Increase**	**30% Increase**
Total Delay Time (veh–min)	60	102	184	289
Total Travel Time (veh-min)	294	358	448	571
Total SBR Queue Time (veh-min)	79	151	345	628
Signalized	**Current**	**10% Increase**	**20% Increase**	**30% Increase**
Total Delay Time (veh–min)	110	130	162	186
Total Travel Time (veh-min)	346	390	443	484
Total SBR Queue Time (veh-min)	21	27	36	46
% Difference in Total Delay Time	**83.3**	**27.5**	**-12.0**	**-35.6**
% Difference in Total Travel Time	**17.7**	**8.9**	**-1.1**	**-15.2**
% Difference in Total SB Queue Time	**-73.4**	**-82.1**	**-89.6**	**-92.7**

Visual Output

The Visual output of the CORSIM simulations illustrates the traffic conditions, such as congestion levels, of the transportation network. Figures 1-4 illustrate the queues experienced at the intersection based on the current traffic counts (September 2, 1998). Under unsignalized control, the southbound right turns experienced large queues (Figure 1). The eastbound left-turn lane also displayed some queues before executing the turning maneuver (Figure 2). The installation of a traffic signal alleviated the southbound right and eastbound left-turn queues (Figure 3), however, the east-and-west through movements developed some queuing since they are the major movements (Figure 4).

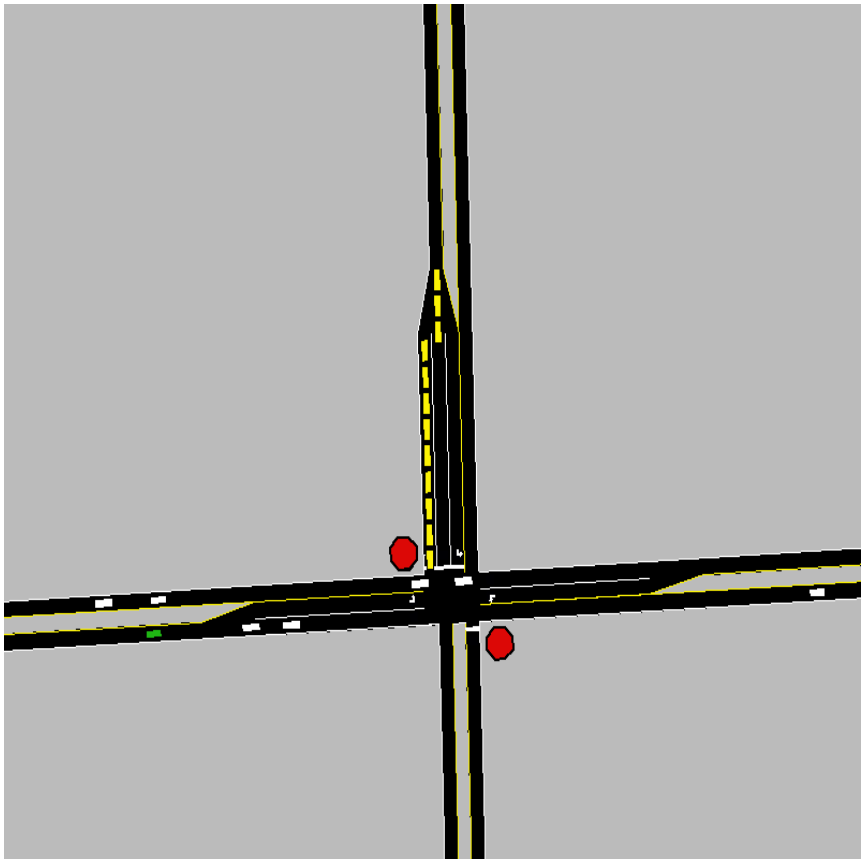


Figure 1. Southbound right-turn queues (unsignalized control).

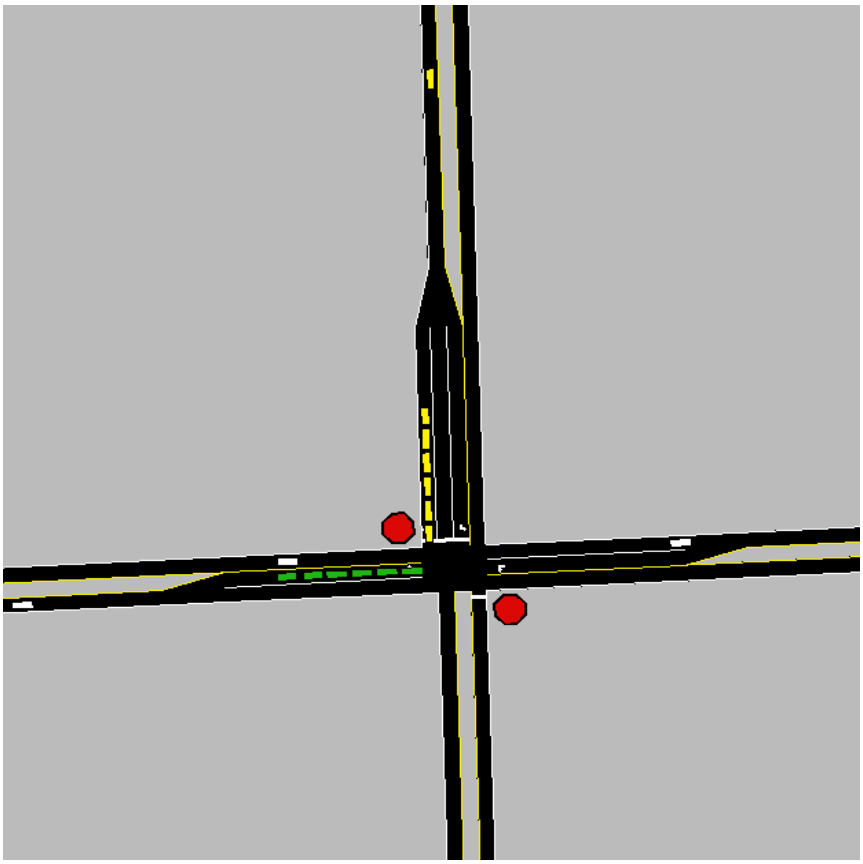


Figure 2. Eastbound left-turn queues (unsignalized control).

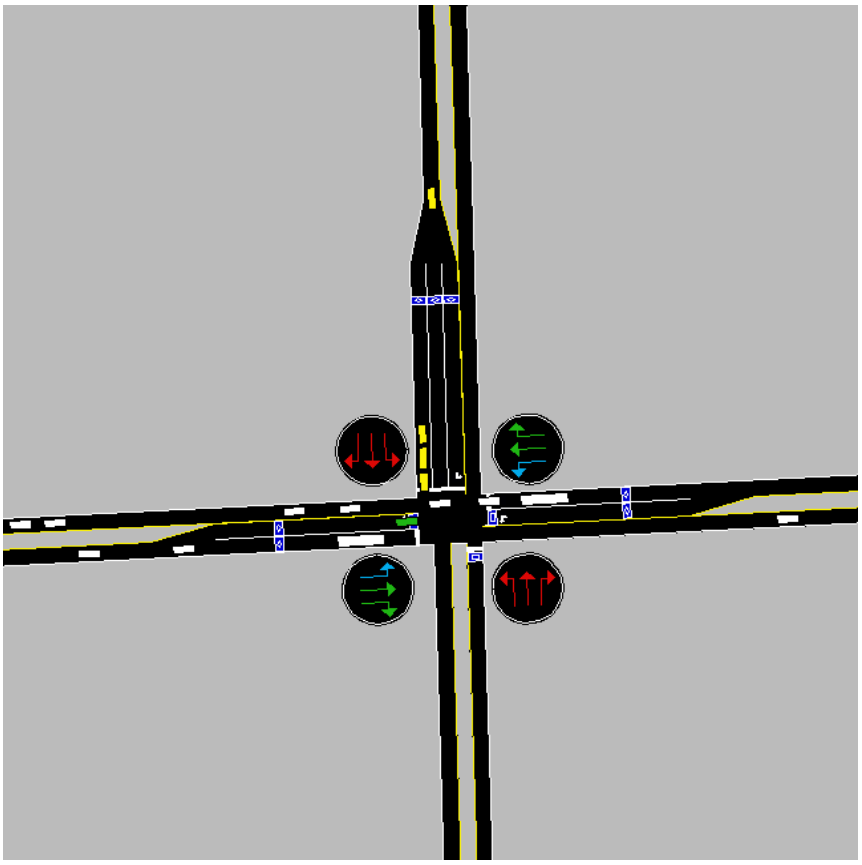


Figure 3. Southbound queues (signalized control).

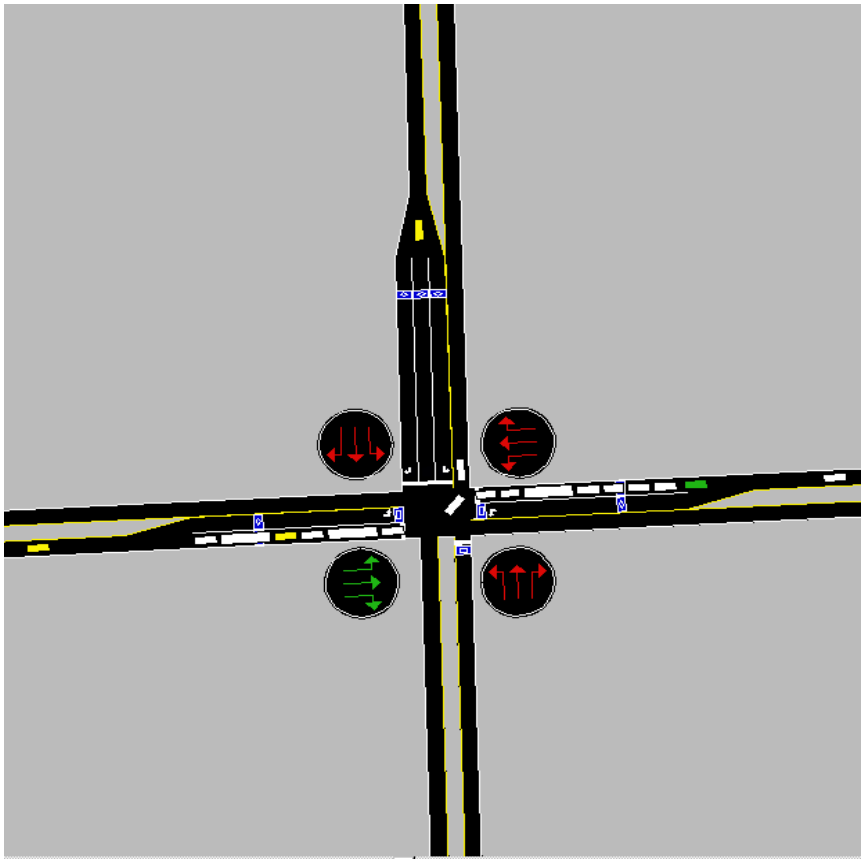


Figure 4. East-and-westbound queues (signalized control).

SUMMARY

This study evaluated the operational effectiveness of the 12th Ave. N. and 18th St. N. intersection. The analysis determined that a traffic signal was justified based on Warrant 11 of the MUTCD (when the right-turn movements were included in the peak-hour volume). A three-phase traffic signal provides the most beneficial intersection LOS. The simulations provided numerical output (i.e., delay time, travel time, etc.) and visual output (i.e., queue lengths) for signalized and unsignalized control at various traffic volumes. At the current traffic levels, signal implementation increases the delay time and travel time for the intersection as a whole, however, the queues caused for the critical turning movements (eastbound left turn and southbound right turn) are reduced.

Appendix A: Synchro Output

Lanes, Volumes, Timings

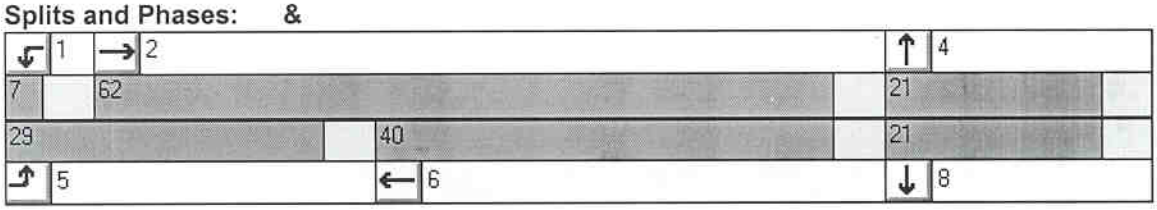
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	14	14	12	14	14	14	14	14	12	12	14
Grade (%)		0%			0%			0%			0%	
Storage Length (ft)	100		0	100		0	0		0	180		180
First Detector (ft)	106	106	0	106	106	0	0	2	0	146	146	146
Last Detector (ft)	100	100	0	100	100	0	0	8	0	140	140	140
Turning Speed (mph)	15		9	15		9	15		9	15		9
Right Turn on Reds			Yes			Yes			Yes			Yes
Frt Protected		0.997	0.850		0.995	0.850		0.882	0.765			0.850
Flt Protected	0.950			0.950			0.950	0.993		0.950		
Satd. Flow (prot)	1752	1962	0	1752	1958	0	0	1775	0	1805	1900	1723
Frt Perm.		0.997	0.850		0.995	0.850		0.882	0.765			0.850
Flt Perm.	0.138			0.108			0.950	0.996		0.904		
Satd. Flow (perm)	255	1962	0	199	1958	0	0	1780	0	1718	1900	1723
Headway Factor	1.00	0.92	0.92	1.00	0.92	0.92	0.92	0.92	0.92	1.00	1.00	0.92
Volume (vph)	250	653	12	6	358	13	1	6	1	13	4	59
Confl. Peds. (#/hr)												
Peak Hour Factor	0.65	0.65	0.65	0.85	0.85	0.85	0.56	0.56	0.56	0.57	0.57	0.57
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	0%	0%	0%	0%	0%	0%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Adj. Flow (vph)	385	1005	18	7	421	15	2	11	2	23	7	104
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lane Group Flow (vph)	385	1023	0	7	436	0	0	15	0	23	7	104
Perm or Prot?	Pm+Pt			Pm+Pt			Perm			Perm		Pm+Ov
Phase Number	5	2		1	6			4			8	
Phase Lagging?	Lead	Lag		Lead	Lag							
Can Lead or Lag?												
Maximum Split (s)	29	62		7	40			21			21	
Maximum Split (%)	32%	69%		8%	44%			23%			23%	
Minimum Split (s)	7	21		7	21			21			21	
Yellow Time (s)	4	4		4	4			4			4	
Lost Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
g/c Ratio	0.73	0.66		0.46	0.41			0.20		0.20	0.20	0.49
Lane Grp Cap (vph)	619	1286		160	805			356		344	380	842
V/C Ratio	0.62	0.80		0.04	0.54			0.04		0.07	0.02	0.12
V/S Ratio Prot	0.18			0.00								0.04
V/S Ratio Perm	0.27	0.52		0.02	0.22			0.01		0.01	0.00	0.02
Critical LG?		Yes		Yes								Yes
Uniform Delay, d1	9.1	8.5		5.2	15.2			22.1		22.2	21.9	8.3
Platoon Factor	0.85	0.85		0.85	0.85			0.85		0.85	0.85	0.85
Incr. Delay, d2	1.4	2.5		0.0	0.6			0.0		0.0	0.0	0.0
Webster's St Delay	9.1	9.7		4.4	13.5			18.8		18.8	18.6	7.1
LOS	B	B		A	B			C		C	C	B
Maximum Green (s)	25	58		3	36			17			17	

Lanes, Volumes, Timings

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Minimum Initial (s)	2	12		2	12			12			12	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			4.0	
Minimum Gap (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Time Before Reduce (s)	0	0		0	0			0			0	
Time To Reduce (s)	0	0		0	0			0			0	
Recall Mode	None	None		None	None			None			None	
Walk Time (s)		7			7			7			7	
Flash Dont Walk (s)		10			10			10			10	
Pedestrian Calls (#/hr)		5			5			5			5	

Area Type: Other
Cycle Length: 90
Natural Cycle: 80
Control Type: Actuated-Uncoordinated
Lost Time: 9
Sum of Critical V/S Ratios: 0.55
Intersection V/C Ratio: 0.61
Intersection Webster Stopped Delay: 10.5
Intersection LOS: B

Splits and Phases: &



Lanes, Volumes, Timings

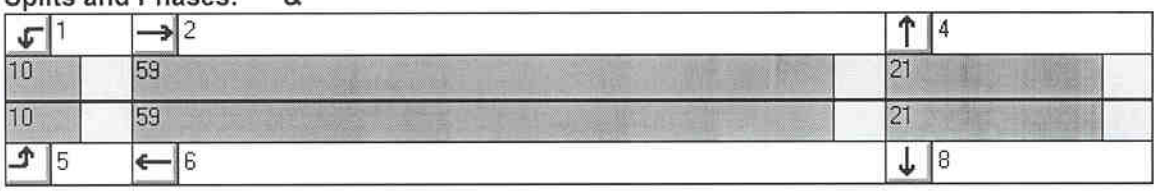
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	14	14	12	14	14	14	14	14	12	12	14
Grade (%)		0%			0%			0%			0%	
Storage Length (ft)	100		0	100		0	0		0	180		180
First Detector (ft)	106	106	0	106	106	0	0	2	0	146	146	146
Last Detector (ft)	100	100	0	100	100	0	0	8	0	140	140	140
Turning Speed (mph)	15		9	15		9	15		9	15		9
Right Turn on Reds			Yes			Yes			Yes			Yes
Frt Protected		0.994	0.850		0.994	0.850		0.875	0.765			0.850
Flt Protected	0.950			0.950			0.950	0.980		0.950		
Satd. Flow (prot)	1752	1956	0	1752	1956	0	0	1738	0	1805	1900	1723
Frt Perm.		0.994	0.850		0.994	0.850		0.875	0.765			0.850
Flt Perm.	0.071			0.077			0.950	0.973		0.869		
Satd. Flow (perm)	131	1956	0	142	1956	0	0	1725	0	1651	1900	1723
Headway Factor	1.00	0.92	0.92	1.00	0.92	0.92	0.92	0.92	0.92	1.00	1.00	0.92
Volume (vph)	139	617	27	5	734	31	9	9	4	14	12	175
Confl. Peds. (#/hr)												
Peak Hour Factor	0.95	0.95	0.95	0.88	0.88	0.88	0.79	0.79	0.79	0.78	0.78	0.78
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	0%	0%	0%	0%	0%	0%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Adj. Flow (vph)	146	649	28	6	834	35	11	11	5	18	15	224
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lane Group Flow (vph)	146	677	0	6	869	0	0	27	0	18	15	224
Perm or Prot?	Pm+Pt			Pm+Pt			Perm			Perm		Pm+Ov
Phase Number	5	2		1	6			4			8	
Phase Lagging?	Lead	Lag		Lead	Lag							
Can Lead or Lag?												
Maximum Split (s)	10	59		10	59			21			21	
Maximum Split (%)	11%	66%		11%	66%			23%			23%	
Minimum Split (s)	7	21		7	21			21			21	
Yellow Time (s)	4	4		4	4			4			4	
Lost Time (s)	3.0	3.0		3.0	3.0			3.0			3.0	
g/c Ratio	0.73	0.62		0.73	0.62			0.20		0.20	0.20	0.28
Lane Grp Cap (vph)	222	1217		229	1217			345		330	380	479
V/C Ratio	0.66	0.56		0.03	0.71			0.08		0.05	0.04	0.47
V/S Ratio Prot	0.05			0.00								0.04
V/S Ratio Perm	0.43	0.35		0.01	0.44			0.02		0.01	0.01	0.09
Critical LG?	Yes				Yes							Yes
Uniform Delay, d1	7.4	7.5		2.5	8.8			22.2		22.1	22.0	18.7
Platoon Factor	0.85	0.85		0.85	0.85			0.85		0.85	0.85	0.85
Incr. Delay, d2	4.7	0.4		0.0	1.4			0.0		0.0	0.0	0.5
Webster's St Delay	11.0	6.8		2.2	8.9			18.9		18.8	18.7	16.4
LOS	B	B		A	B			C		C	C	C
Maximum Green (s)	6	55		6	55			17			17	

Lanes, Volumes, Timings

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Minimum Initial (s)	2	12		2	12			12			12	
Vehicle Extension (s)	3.0	3.0		3.0	3.0			3.0			4.0	
Minimum Gap (s)	3.0	3.0		3.0	3.0			3.0			3.0	
Time Before Reduce (s)	0	0		0	0			0			0	
Time To Reduce (s)	0	0		0	0			0			0	
Recall Mode	None	None		None	None			None			None	
Walk Time (s)		7			7			7			7	
Flash Dont Walk (s)		10			10			10			10	
Pedestrian Calls (#/hr)		5			5			5			5	

Area Type: Other
Cycle Length: 90
Natural Cycle: 70
Control Type: Actuated-Uncoordinated
Lost Time: 9
Sum of Critical V/S Ratios: 0.59
Intersection V/C Ratio: 0.65
Intersection Webster Stopped Delay: 9.4
Intersection LOS: B

Splits and Phases: &



Lanes, Volumes, Timings

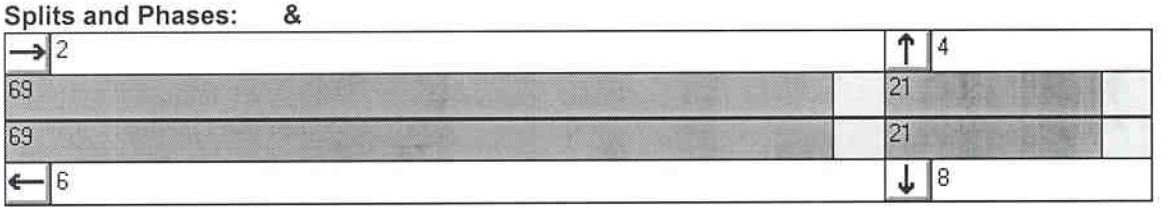
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	14	14	12	14	14	14	14	14	12	12	14
Grade (%)		0%			0%			0%			0%	
Storage Length (ft)	100		0	100		0	0		0	180		180
First Detector (ft)	106	106	0	106	106	0	0	2	0	146	146	146
Last Detector (ft)	100	100	0	100	100	0	0	8	0	140	140	140
Turning Speed (mph)	15		9	15		9	15		9	15		9
Right Turn on Reds			Yes			Yes			Yes			Yes
Frt Protected		0.997	0.850		0.993	0.850		0.882	0.765			0.850
Flt Protected	0.950			0.950			0.950	0.993		0.950		
Satd. Flow (prot)	1752	1962	0	1752	1954	0	0	1775	0	1805	1900	1723
Frt Perm.		0.997	0.850		0.993	0.850		0.882	0.765			0.850
Flt Perm.	0.305			0.061			0.950	0.996		0.910		
Satd. Flow (perm)	563	1962	0	113	1954	0	0	1780	0	1729	1900	1723
Headway Factor	1.00	0.92	0.92	1.00	0.92	0.92	0.92	0.92	0.92	1.00	1.00	0.92
Volume (vph)	250	653	12	6	358	18	1	6	1	13	4	59
Confl. Peds. (#/hr)												
Peak Hour Factor	0.65	0.65	0.65	0.85	0.85	0.85	0.56	0.56	0.56	0.57	0.57	0.57
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	0%	0%	0%	0%	0%	0%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Adj. Flow (vph)	385	1005	18	7	421	21	2	11	2	23	7	104
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lane Group Flow (vph)	385	1023	0	7	442	0	0	15	0	23	7	104
Perm or Prot?	Perm			Perm			Perm			Perm		Perm
Phase Number		2			6			4			8	
Phase Lagging?												
Can Lead or Lag?												
Maximum Split (s)		69			69			21			21	
Maximum Split (%)		77%			77%			23%			23%	
Minimum Split (s)		21			21			21			21	
Yellow Time (s)		4			4			4			4	
Lost Time (s)		3.0			3.0			3.0			3.0	
g/c Ratio	0.73	0.73		0.73	0.73			0.20		0.20	0.20	0.20
Lane Grp Cap (vph)	413	1439		83	1433			356		346	380	345
V/C Ratio	0.93	0.71		0.08	0.31			0.04		0.07	0.02	0.30
V/S Ratio Prot												
V/S Ratio Perm	0.68	0.52		0.06	0.23			0.01		0.01	0.00	0.06
Critical LG?	Yes											Yes
Uniform Delay, d1	7.7	5.1		2.6	3.1			22.1		22.2	21.9	23.3
Platoon Factor	0.85	0.85		0.85	0.85			0.85		0.85	0.85	0.85
Incr. Delay, d2	20.2	1.2		0.0	0.0			0.0		0.0	0.0	0.2
Webster's St Delay	26.7	5.5		2.2	2.7			18.8		18.8	18.6	20.0
LOS	D	B		A	A			C		C	C	C
Maximum Green (s)		65			65			17			17	

Lanes, Volumes, Timings

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Minimum Initial (s)		12			12			12			12	
Vehicle Extension (s)		3.0			3.0			3.0			4.0	
Minimum Gap (s)		3.0			3.0			3.0			3.0	
Time Before Reduce (s)		0			0			0			0	
Time To Reduce (s)		0			0			0			0	
Recall Mode		None			None			None			None	
Walk Time (s)		7			7			7			7	
Flash Dont Walk (s)		10			10			10			10	
Pedestrian Calls (#/hr)		5			5			5			5	

Area Type: Other
Cycle Length: 90
Natural Cycle: 100
Control Type: Actuated-Uncoordinated
Lost Time: 6
Sum of Critical V/S Ratios: 0.74
Intersection V/C Ratio: 0.80
Intersection Webster Stopped Delay: 10.0
Intersection LOS: B

Splits and Phases: &



Lanes, Volumes, Timings

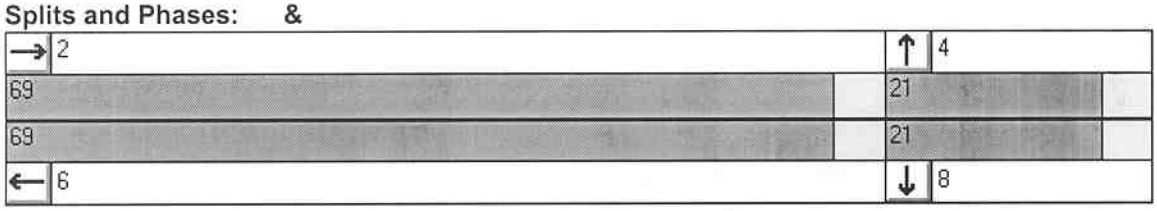
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	14	14	12	14	14	14	14	14	12	12	14
Grade (%)		0%			0%			0%			0%	
Storage Length (ft)	100		0	100		0	0		0	180		180
First Detector (ft)	106	106	0	106	106	0	0	2	0	146	146	146
Last Detector (ft)	100	100	0	100	100	0	0	8	0	140	140	140
Turning Speed (mph)	15		9	15		9	15		9	15		9
Right Turn on Reds			Yes			Yes			Yes			Yes
Frt Protected		0.994	0.850		0.994	0.850		0.875	0.765			0.850
Flt Protected	0.950			0.950			0.950	0.980		0.950		
Satd. Flow (prot)	1752	1956	0	1752	1956	0	0	1738	0	1805	1900	1723
Frt Perm.		0.994	0.850		0.994	0.850		0.875	0.765			0.850
Flt Perm.	0.068			0.120			0.950	0.975		0.879		
Satd. Flow (perm)	125	1956	0	221	1956	0	0	1729	0	1670	1900	1723
Headway Factor	1.00	0.92	0.92	1.00	0.92	0.92	0.92	0.92	0.92	1.00	1.00	0.92
Volume (vph)	139	617	27	5	734	31	9	9	4	14	12	175
Confl. Peds. (#/hr)												
Peak Hour Factor	0.95	0.95	0.95	0.88	0.88	0.88	0.79	0.79	0.79	0.78	0.78	0.78
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	3%	3%	3%	3%	3%	3%	0%	0%	0%	0%	0%	0%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Adj. Flow (vph)	146	649	28	6	834	35	11	11	5	18	15	224
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lane Group Flow (vph)	146	677	0	6	869	0	0	27	0	18	15	224
Perm or Prot?	Perm			Perm			Perm			Perm		Perm
Phase Number		2			6			4			8	
Phase Lagging?												
Can Lead or Lag?												
Maximum Split (s)		69			69			21			21	
Maximum Split (%)		77%			77%			23%			23%	
Minimum Split (s)		21			21			21			21	
Yellow Time (s)		4			4			4			4	
Lost Time (s)		3.0			3.0			3.0			3.0	
g/c Ratio	0.73	0.73		0.73	0.73			0.20		0.20	0.20	0.20
Lane Grp Cap (vph)	92	1434		162	1434			346		334	380	345
V/C Ratio	1.59	0.47		0.04	0.61			0.08		0.05	0.04	0.65
V/S Ratio Prot												
V/S Ratio Perm	1.17	0.35		0.03	0.44			0.02		0.01	0.01	0.13
Critical LG?	Yes											Yes
Uniform Delay, d1	Error	3.7		2.5	4.4			22.2		22.1	22.0	25.1
Platoon Factor	0.85	0.85		0.85	0.85			0.85		0.85	0.85	0.85
Incr. Delay, d2	Error	0.2		0.0	0.5			0.0		0.0	0.0	3.0
Webster's St Delay	Error	3.4		2.2	4.3			18.9		18.8	18.7	24.3
LOS	F	A		A	A			C		C	C	C
Maximum Green (s)		65			65			17			17	

Lanes, Volumes, Timings

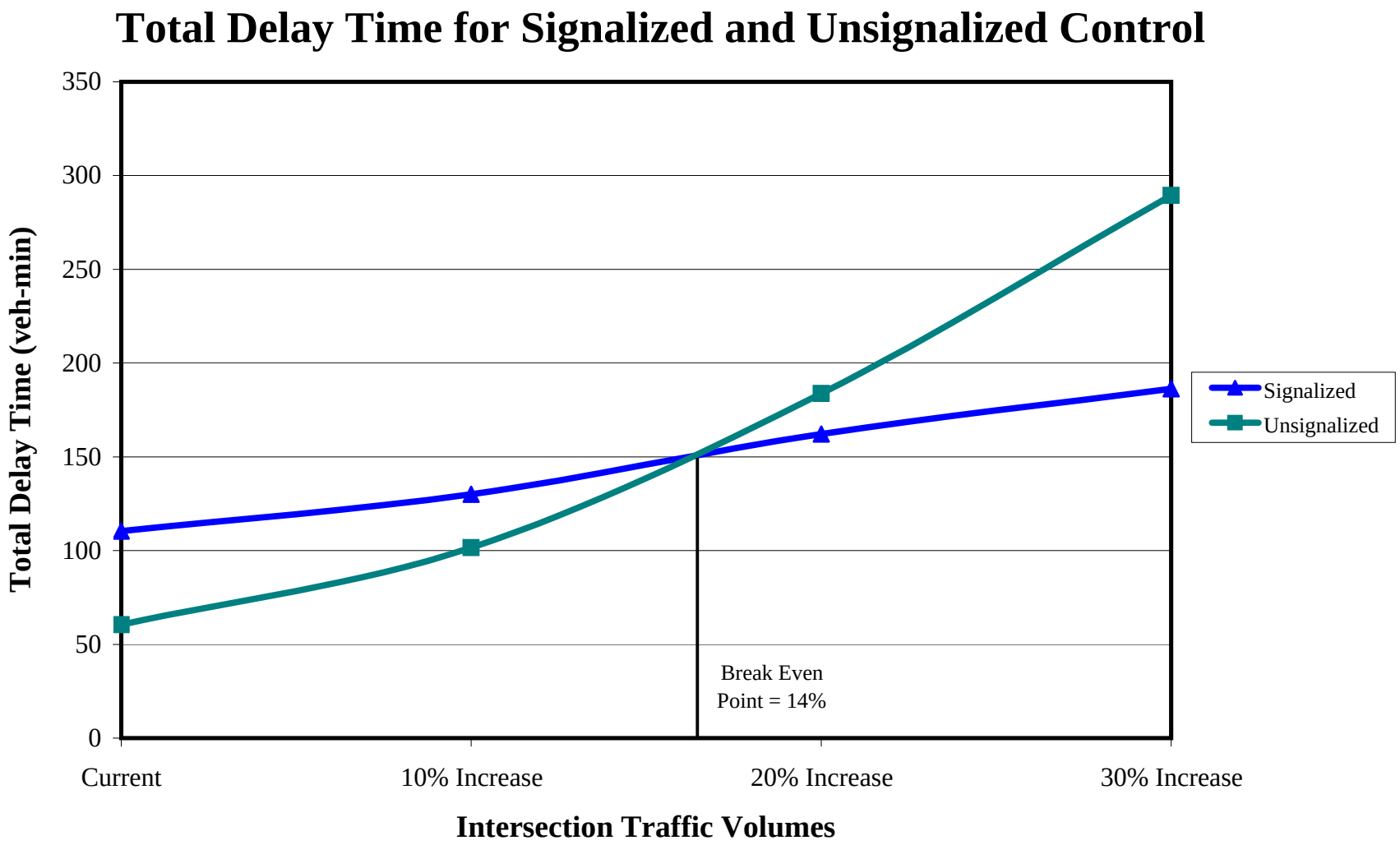
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Minimum Initial (s)		12			12			12			12	
Vehicle Extension (s)		3.0			3.0			3.0			4.0	
Minimum Gap (s)		3.0			3.0			3.0			3.0	
Time Before Reduce (s)		0			0			0			0	
Time To Reduce (s)		0			0			0			0	
Recall Mode		None			None			None			None	
Walk Time (s)		7			7			7			7	
Flash Dont Walk (s)		10			10			10			10	
Pedestrian Calls (#/hr)		5			5			5			5	

Area Type: Other
Cycle Length: 90
Natural Cycle: 50
Control Type: Actuated-Uncoordinated
Lost Time: 6
Sum of Critical V/S Ratios: 1.30
Intersection V/C Ratio: 1.39
Intersection Webster Stopped Delay: Error
Intersection LOS: F

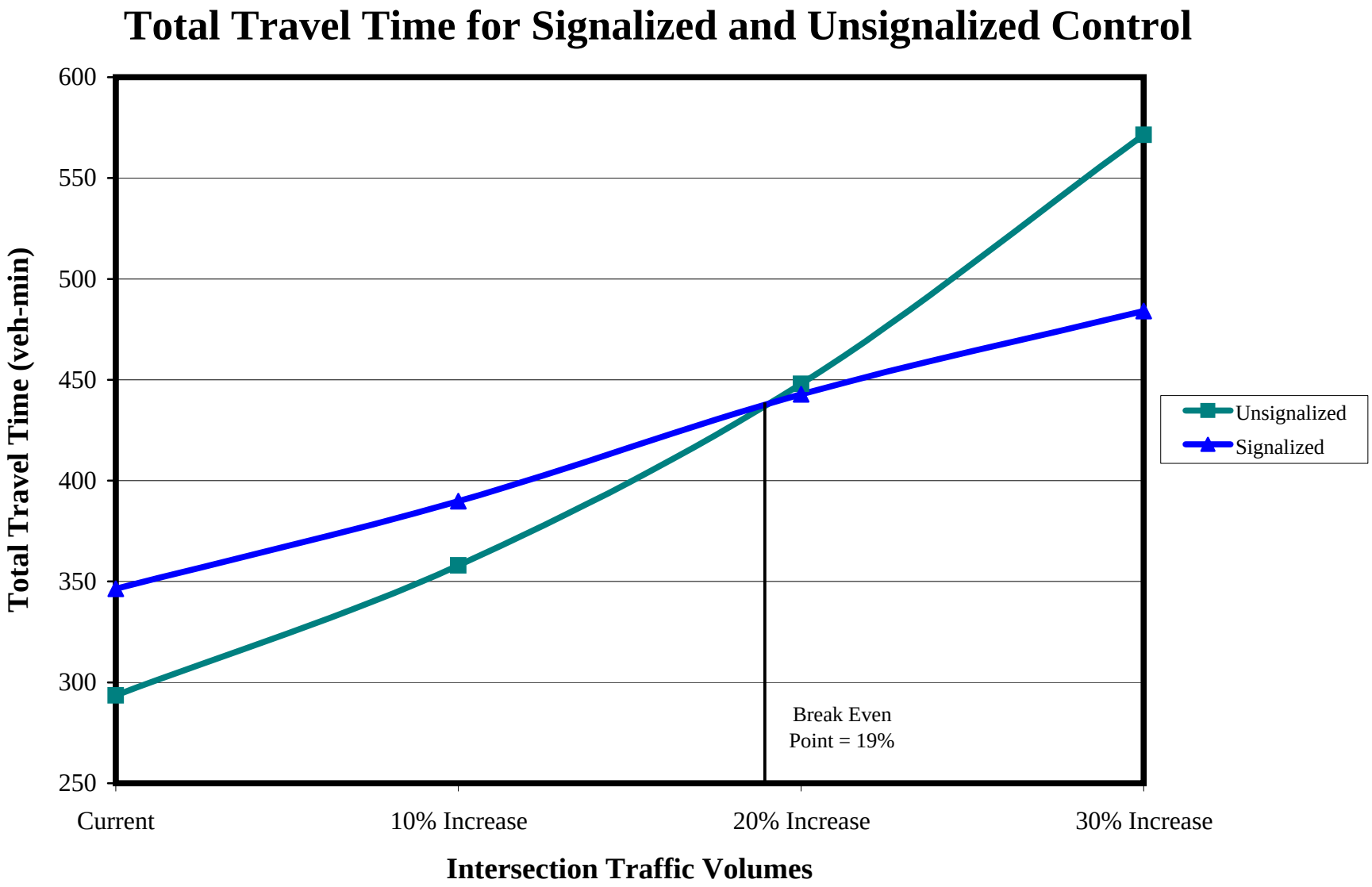
Splits and Phases: &



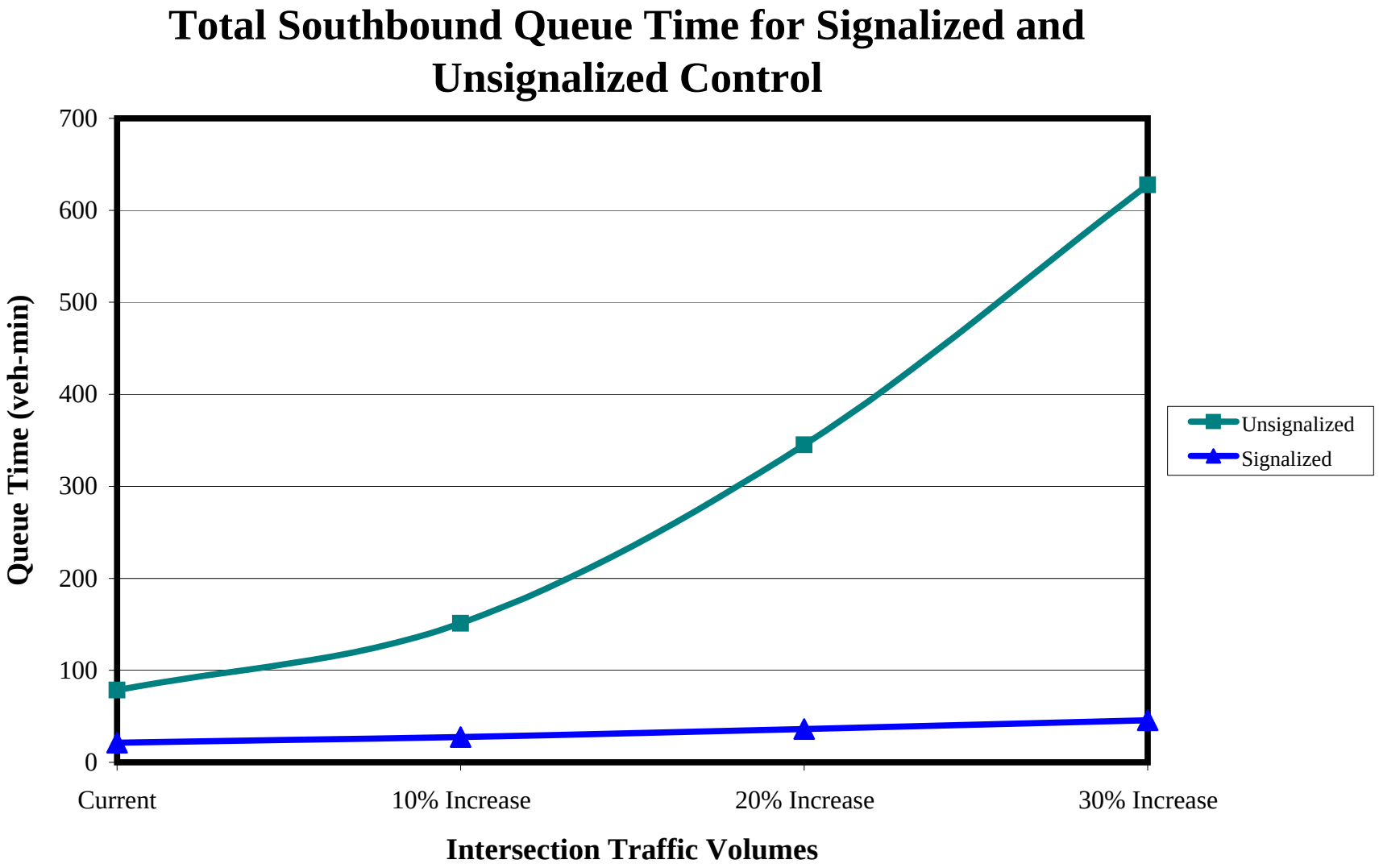
Appendix B: CORSIM Output



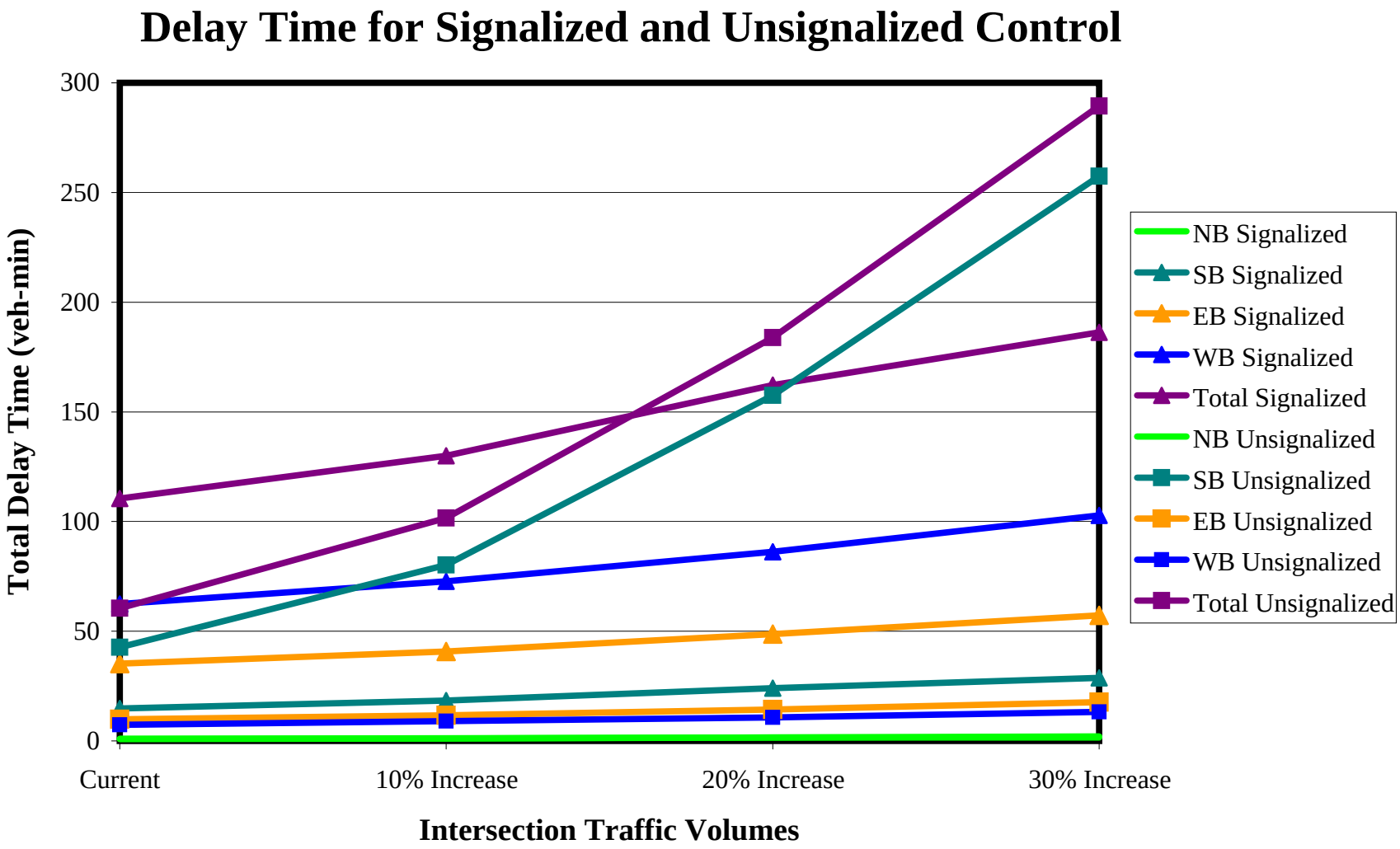
Appendix figure B-1. Total delay time for signalized and unsignalized control.



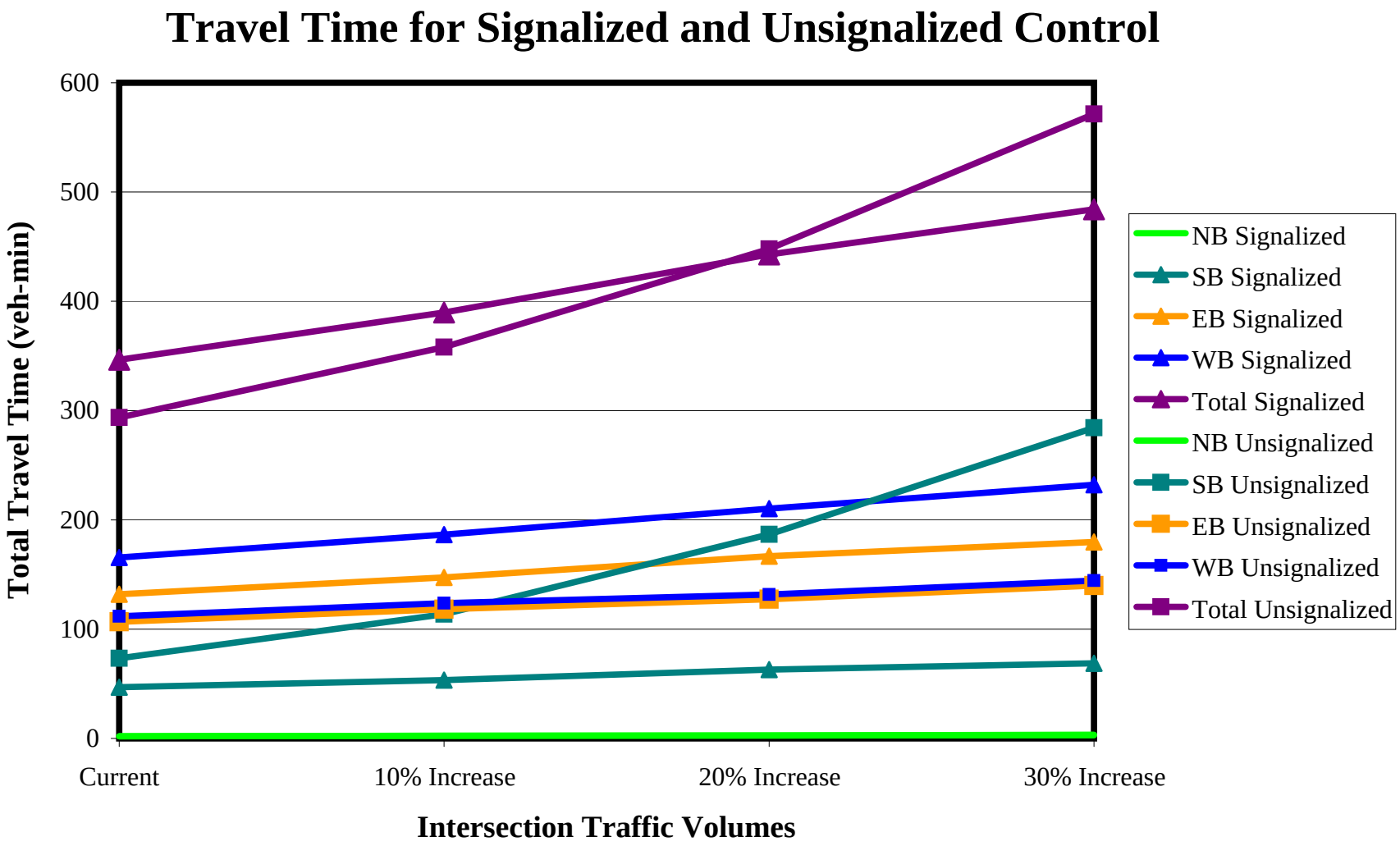
Appendix Figure B-2. Total travel time for signalized and unsignalized control.



Appendix Figure B-3. Total southbound queue time for signalized and unsignalized control.



Appendix Figure B-1. Delay time for signalized and unsignalized control.



Appendix Figure B-5. Travel time for signalized and unsignalized control.