TECHNICAL MEMORANDUM

HighlandAvenue @ Second Avenue Traffic Signal Operation Analysis

Needham,
Massachusetts

Prepared for **Town of Needham**
Department of Public Works
Public Service Adminstration Building
500 Dedham Avenue
Needham, Massachusetts 02492

Prepared by ***VHB*/Vanasse Hangen Brustlin, Inc.**
Watertown, Massachusetts

February, 2014

Transportation
Land Development
Environmental
Services

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Memorandum

To: Anthony L. Del Gaizo, P.E.
Town Engineer
Public Service Administration Building
500 Dedham Avenue
Needham, MA 02492

Date: February 7, 2013

Project No.: 12570.01

From: Joseph R. Herr, P.E.
Amy Silbovitz, P.E.

Re: Highland Avenue at Second Avenue/Staples Driveway
Needham, MA

INTRODUCTION

This Technical Memorandum has been prepared to respond to a request by the Town of Needham Department of Public Works to evaluate the existing traffic signal operations at the intersection of Highland Avenue at Second Avenue/Staples Driveway in Needham, Massachusetts. Existing geometric/Traffic control, Traffic count data, and capacity analysis are summarized within. This information is reviewed and discussed further in this memorandum.

The intersection of Highland Avenue at Second Avenue/Staples Driveway is currently part of the Highland Avenue corridor project that MassDOT is evaluating for long-term improvements. Currently this project is at the 25% design stage. As part of this project MassDOT is proposing to widen Highland Avenue to provide two through lanes in each direction with exclusive left turn lanes. This technical memorandum provides recommendations for short-term improvements that can be implemented now.

EXISTING CONDITIONS

Roadway Geometrics and Traffic Control

Second Avenue and the Staples Driveway intersect Highland Avenue from the south and north, respectively, to form a four-legged, fully actuated signalized intersection. This intersection is currently under MassDOT jurisdiction. The Second Avenue northbound approach has two lanes: an 11 foot wide exclusive left turn lane and an 11.5 foot wide shared left/through/right lane. The Staples driveway southbound approach has two lanes: a 13 foot wide exclusive right turn lane and an 11 foot wide through/left lane. In both directions, Highland Avenue has two 11 foot wide lanes with one through/left lane and one through/right lane. Signal phasing consists of a Highland Avenue westbound lead phase with protected left turns, followed by an east/west phase with permissive left turns. Second Avenue and Staples Driveway both operate as separate phases. Pedestrian's movement

through the intersection is accommodated with concurrent pedestrian phasing across Second Avenue and across Highland Avenue westbound approach, via pedestrian push button activation. The crosswalk across the Staples driveway has no pedestrian signal indication.

VHB performed a site visit in August 2013 to inventory the existing traffic signal equipment and signal timings and observe traffic operations. Upon review, it was noted that the time clock in the controller was off by 10 hours. This was reset by VHB. Also, at that time it was observed that 12 of the 13 amplifier detectors for the vehicle detection were not working causing the intersection to operate as a pre-timed traffic signal. Also, one of the pedestrian push buttons was stuck which was providing a constant call into the traffic signal controller. These two issues were causing unwanted vehicle delay. MassDOT, District 6 office was notified and it is our understanding that these issues have since been resolved.

TRAFFIC VOLUMES

Traffic volume information for the study intersection was collected manually and mechanically by PDI, LLC of Berlin, Massachusetts, to provide a basis from which to evaluate existing and future traffic conditions. Manual turning movement counts (TMCs) were collected on a typical non-holiday weekday from 7:00 AM – 9:00 AM and from 4:00 PM – 6:00 PM, and on a Saturday midday from 11:00 AM – 2:00 PM during the month of November 2013. These time periods represent the typical peak periods and were studied herein to define the intersection operations.

Based on the TMC data, the peak hours of traffic operation for the study intersection was determined to be 7:45 – 8:45 AM on a typical weekday morning, from 4:45 – 5:45 PM on a typical weekday evening and 11:00 AM to 12:00 PM on a typical Saturday. The 2013 weekday morning, evening and Saturday peak hour volumes are shown in Figure 1. TMCs for the intersection are included in Appendix A.

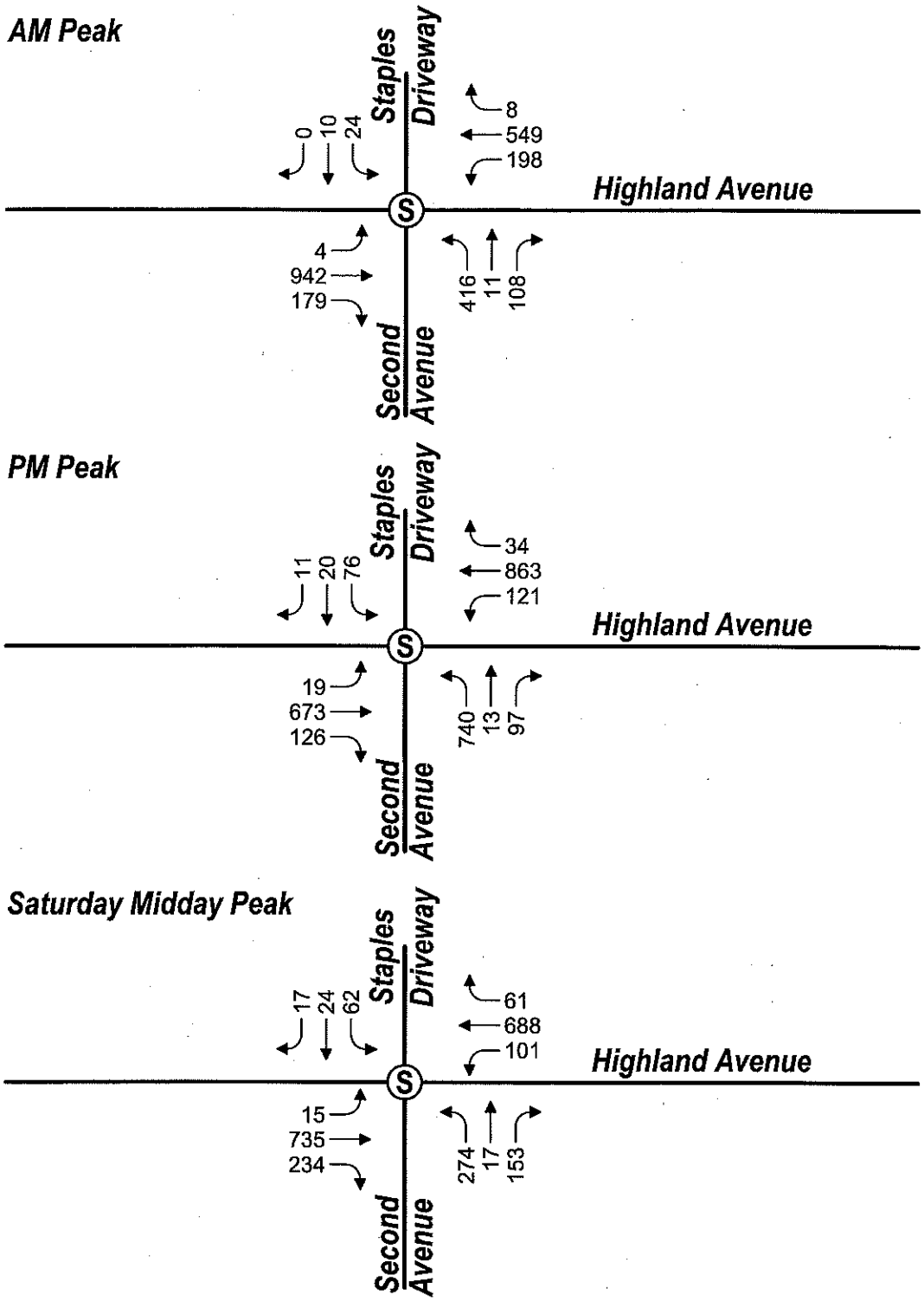
In addition to the TMCs, Automatic Traffic Recorder Counts (ATRs) were conducted for a minimum of 24 hour period along Highland Avenue and on Second Avenue during the months of October and November 2013. These counts were used to confirm daily traffic along the roadways. These counts show an approximate Average Daily Traffic (ADT) of 34,000 vehicles on Highland Avenue and 8,800 vehicles on Second Avenue. This data also confirmed the peak hours for the turning movement counts. ATRs for the intersection are included in Appendix B.

Once the existing peak hour volumes were determined the 2013 traffic volumes were than increased by 0.5% for 10 years to create 2023 traffic volumes for the weekday morning, evening and Midday Saturday volumes. This percent increase was a conservative estimate based on the known traffic growth in the area. The 2023 peak hour volumes are shown in Figure 2.

TRAFFIC OPERATIONS ANALYSIS

Signalized Intersection Procedures

In the Highway Capacity Manual (HCM) approach, capacity at intersections is defined for lane groups rather than for approaches or the intersection as a whole. A lane group may be a single movement, a group of movements, or an entire approach and is defined by the geometry of the intersection and the distribution of movements over the various lanes. Capacity of a lane group is calculated as the maximum rate of flow that may pass through the intersection under prevailing traffic, roadway, and signalization conditions. The rate of flow is generally measured or projected for a 15-minute period and capacity is stated in vehicles



Not to Scale

Vanasse Hangen Brustlin, Inc.

2013 Existing Conditions
Peak Hour Traffic Volumes

Figure 1

per hour. Capacity analysis of intersections involves the computation of volume-to-capacity (v/c) ratio for each lane group, from which an overall intersection v/c ratio may be derived.

Generally, when two opposing flows are moving during a signal phase, one of the lane groups will require more green time than another to process all of its volume. This would be defined as the "critical" lane group for the subject signal phase. The concept of a critical v/c ratio is used to evaluate the intersection as a whole, considering only the critical lane groups or those with the greatest demand for green time within each signal phase. This procedure assumes that green time has been appropriately allocated. Thus it is possible to have an overall intersection v/c of less than 1.00 (under capacity), but still have individual movements be over saturated within the signal cycle if the green time has not been appropriately allocated to the various approaches.

The other major concept in signalized intersection analysis is level of service (LOS), which is an index used to grade intersection operations. Level of service is defined in terms of delay and ranges from LOS A (free-flow conditions) to LOS F (long delays). Delay represents a measure of driver discomfort and frustration, fuel consumption, and lost time. Specifically, level of service delay criteria are stated in terms of average stopped delay per vehicle for a 15-minute analysis period. The criteria are represented in Table 1.

Table 1
Level-of-Service Criteria for Signalized Intersections

Level of Service	Control Delay (sec/veh)
A	≤ 10
B	> 10 - 20
C	> 20 - 35
D	> 35 - 55
E	> 55 - 80
F	>80

Source: Highway Capacity Manual 2000, Transportation Research Board, Washington, DC, 2000.

Delay is a complex measure that depends upon a number of variables such as quality of signal progression, cycle length, allocation of green time, and v/c ratio. Of all the factors cited, v/c ratios have the least effect on delay. Thus, for any given v/c ratio, a range of delay values (and, therefore, level of service) may result. Conversely, for a given level of service, the v/c ratio may lie anywhere within a broad range.

The base saturation flow rate used in the signalized intersection analysis model varies from 1,800 to 1,900 passenger cars per hour of green per lane (pcphgpl). This value is adjusted for prevailing traffic conditions such as lane width, left turns, right turns, heavy vehicles, grades, parking, area type, bus blockage, and left-turn blockage.

Capacity Analysis

Traffic operations for the study intersection were analyzed using Synchro. Existing conditions was analyzed in two different scenarios. The August 2013 existing conditions analysis represents how the intersection was working prior to VHB's field visit in August 2013. The November 2013 existing conditions analysis represents how the intersection was working when the traffic counts were conducted. As shown in Table 1, the updates to the controller time clock and vehicle detection system reduced the overall vehicle delay, up to approximately 25 seconds.

Results of the 2013 existing conditions analysis indicates that the intersection of Highland Avenue at Second Avenue/Staples Driveway operates at an overall LOS C (v/c of 0.94, and delay of 28.1 seconds) during the weekday morning peak hour, LOS E (v/c of 1.14, and delay of 60.3 seconds) during the weekday evening peak hour and LOS C (v/c of 0.88, and delay of 23.8 seconds) during the Saturday peak hour.

Table 1 below summarizes and compares the intersection delays for the November 2013 Condition versus the 2023 Build Condition. Table 2 on the following page provides a more detailed summary of the capacity analysis. As shown in Tables 1 and 2 the existing vehicle delays and queues are close to or over capacity for the majority of the movements at this intersection during all peak periods. A 2023 No-Build scenario was analyzed (2023 Future Volume/Existing Geometry) to see how the signal will operate 10 years in future if no timing adjustments are made. Results showed an overall increase in vehicle delay of approximately 20 seconds during the evening peak hour. The weekday morning and Saturday midday peak periods showed an increase of delay of less than 5 seconds for both time periods.

The Second Avenue left turn lane is currently 50' long which will provide enough storage for 2 or 3 cars to queue up. Any additional cars making a left turn will now block the through and right turn movements. In the 2023 Build scenario the left-turn lane was increased to provide for a 200' storage lane and a right turn lane was added. In addition, timing changes were considered to optimize traffic operations. During the morning and evening peak period, the queue of left turning traffic will likely block access to the new right turn lane, however during other periods of the day this is not expected to be the case.

Results show that with the lane modification/timing changes the intersection can accommodate future traffic growth and provide a slight improvement in LOS and vehicle delay compared 2013 existing conditions.

Table 1
Highland Ave at Second Ave/Staples Driveway Delay Comparison

	November 2013 Existing Volume/ Existing Geometry	*2023 Future Volume/ Future Geometry*	*Comparison*
	Delay[1]	Delay	Delay Reduction
Weekday Morning	28.1	24.2	3.9
Weekday Evening	60.3	45.3	15.0
Saturday	23.8	19.0	4.8

Source: Vanasse Hangen Brustlin, Inc.; based on ATRs conducted November 2013.
1 Average Intersection delay, expressed in seconds per vehicle.

Table 2
Highland Ave at Second Ave/Staples Driveway Capacity Analysis

		August 2013 Existing Volumes/Existing Geometry					November 2013 Existing Volume/ Existing Geometry					2023 Future Volume/ Existing Geometry					2023 Future Volume/ Future Geometry				
	Approach	V/C[1]	Delay[2]	LOS[3]	50th Queue	95th Queue	V/C[1]	Delay[2]	LOS[3]	50th Queue	95th Queue	V/C	Delay	LOS	50th Queue	95th Queue	V/C	Delay	LOS	50th Queue	95th Queue
Weekday Morning	Highland Ave EB Left/Thru/Right	1.07	82.0	F	~458	#594	0.77	18.9	B	227	328	0.78	19.6	B	247	#363	0.72	15.7	B	253	340
	Highland Ave WB Left/Thru/Right	1.15dl	32.9	C	198	#272	1.96dl	38.5	D	185	#333	2.20dl	42.4	D	~214	#361	1.75dl	30.4	C	213	#364
	Second Ave NB Left	0.58	32.1	C	171	267	0.68	34.7	C	130	#260	0.74	38.4	D	138	#281	0.64	38.3	D	128	214
	Second Ave NB Left/Thru/Right	0.24	46.3	D	141	232	0.63	29.3	C	107	#221	0.68	32.1	C	114	#242	n/a	n/a	n/a	n/a	n/a
	Second Ave NB Left/Thru	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.65	38.4	D	130	#218
	Second Ave NB Right	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.26	5.3	A	0	31
	Staples Driveway SB Thru/Left	0.61	37.6	D	24	55	0.23	34.4	C	18	43	0.25	35.1	D	19	45	0.25	43.1	D	23	53
	Staples Driveway SB Right	0	0	0	0	0	0	0	A	0	0	0	0	A	0	0	0.00	0	A	0	0
	Overall	**1.07**	**55.8**	**E**	-	-	**0.94**	**28.1**	**C**	-	-	**0.96**	**30.4**	**C**	-	-	**0.90**	**24.2**	**C**	-	-
Weekday Evening	Highland Ave EB Left/Thru/Right	0.82	30.3	C	218	280	0.67	23.7	C	234	291	0.73	25.9	C	256	317	0.59	17.2	B	209	257
	Highland Ave WB Left/Thru/Right	0.97	40.6	D	193	#337	1.14	102.4	F	~413	#543	1.25	149.2	F	~463	#595	0.97	44.6	D	345	#513
	Second Ave NB Left	0.53	42.6	D	~310	#494	0.87	50.6	D	251	#426	0.90	54.3	D	285	#476	0.94	67.6	E	267	#460
	Second Ave NB Left/Thru/Right	0.04	0.2	A	~290	#477	0.86	48.0	D	72	116	0.89	51.8	D	270	#461	n/a	n/a	n/a	n/a	n/a
	Second Ave NB Left/Thru	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.93	65.8	E	266	#453
	Second Ave NB Right	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.21	4.2	A	0	26
	Staples Driveway SB Thru/Left	1.32	194.7	F	58	98	0.68	61.9	E	72	116	0.71	64.4	E	76	#123	1.15	173.5	F	~94	#180
	Staples Driveway SB Right	1.28	175.5	F	0	0	0.05	0.40	A	0	0	0.06	0.40	A	0	0	0.07	0.6	A	0	0
	Overall	**1.32**	**79.3**	**E**	-	-	**1.14**	**60.3**	**E**	-	-	**1.25**	**78.6**	**E**	-	-	**1.15**	**45.3**	**D**	-	-
Saturday	Highland Ave EB Left/Thru/Right	0.88	33.8	C	*242*	*#364*	0.70	17.4	B	*175*	*255*	0.73	18.4	B	*190*	*276*	0.64	13.6	B	158	241
	Highland Ave WB Left/Thru/Right	0.81	22.9	C	149	#201	0.88	29.3	C	177	#311	0.94	38.0	D	198	#345	0.78	19.6	B	160	261
	Second Ave NB Left	0.46	40.3	D	125	#242	0.66	35.7	D	105	#206	0.70	37.6	D	111	#221	0.52	32.6	C	70	129
	Second Ave NB Left/Thru/Right	0.06	0.4	A	41	112	0.50	15.1	B	33	101	0.53	16.4	B	40	111	n/a	n/a	n/a	n/a	n/a
	Second Ave NB Left/Thru	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.52	32.4	C	70	130
	Second Ave NB Right	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.39	7.6	A	0	46
	Staples Driveway SB Thru/Left	0.76	47.3	D	50	90	0.43	35.2	D	44	81	0.46	35.1	D	45	83	0.60	49.6	D	48	#113
	Staples Driveway SB Right	0.55	17.5	B	0	0	0.06	0.30	A	0	0	0.06	0.30	A	0	0	0.07	.04	A	0	0
	Overall	**0.88**	**29.8**	**C**	-	-	**0.88**	**23.8**	**C**	-	-	**0.94**	**27.5**	**C**	-	-	**0.78**	**19.0**	**B**	-	-

Source: Vanasse Hangen Brustlin, Inc.; based on ATRs conducted November 2013.
1 V/C – Volume-to-capacity ratio.
2 Average intersection delay, expressed in seconds per vehicle.
3 LOS – Level-of-Service.
4 dl = defacto left turn lane
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer.
Queue length shown in feet.

CONCLUSION

Based in our review of field observations, existing conditions, traffic counts and capacity analysis VHB recommends the following improvements:

Operational Recommendations:

1. Adjust the existing curbline on the south side of Second Avenue to provide two lanes beginning approximately 300′ before the intersection and a third lane beginning 125′ before the intersection. Additional survey information is needed to determine the exact location to begin the two lane approach.
2. Provide a 125′ right turn lane on the approach to provide added storage and allow for additional Right Turn on Red movements for vehicles.
3. Stripe a 200′ left turn lane on Second Avenue to provide more storage for the left turning vehicles.
4. Traffic signal timing adjustments to better allocate time to optimize signal operations until such time that MassDOT widens the Highland Avenue corridor. This would include time of day plans for the weekday AM, weekday PM and Saturday peak periods.
5. Installation of a GPS time reference system at the existing traffic signal control cabinet to ensure that the time of day timing programs are active at the scheduled times. (On February 1st, VHB visited the site and determined that the existing GPS signal received at the cabinet location was of sufficient strength to support a GPS time synchronization system of the type commonly used for traffic signal control installations)

Non-operational Recommendations:

1. Refresh existing pavement markings within the intersection.
2. Provide a signalized pedestrian crossing across the Staples Driveway to run concurrent with the Highland Avenue westbound movement.
3. Replace existing pedestrian push buttons with ADA complaint pedestrian push buttons.
4. Replace existing pedestrian signal heads with new pedestrian heads that encompass countdown timers to meet current MUTCD standards.
5. Retime pedestrian clearance intervals to meet current MUTCD standards.
6. Replace/upgrade existing signage to meet current MUTCD standards.

Upon approval by the town, the next step would be for the town to submit this memorandum, along with back-up data, to MassDOT's District 6 office for review and comment.

APPENDIX A
TURNING MOVEMENT COUNTS (TMC'S)

N/S: Staples Driveway/ 2nd Avenue
E/W: Highland Avenue
City, State: Needham, MA
Client: VHB/ A. Silbovitz

PRECISION DATA INDUSTRIES, LLC
P.O. Box 301 Berlin, MA 01503
Office: 508.481.3999 Fax: 508.545.1234
Email: datarequests@pdillc.com

File Name : 133618 A
Site Code : TBA
Start Date : 11/14/2013
Page No : 1

Groups Printed- Cars - Heavy Vehicles

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Int. Total
07:00 AM	0	2	4	0	3	89	28	0	6	0	63	0	64	206	1	0	466
07:15 AM	1	1	5	0	1	123	40	0	16	0	99	0	56	253	0	1	596
07:30 AM	1	1	3	0	3	132	53	0	13	0	119	0	60	247	0	0	632
07:45 AM	0	2	6	0	2	130	52	0	28	2	90	0	52	229	0	0	593
Total	2	6	18	0	9	474	173	0	63	2	371	0	232	935	1	1	2287
08:00 AM	0	1	6	0	3	126	48	0	24	3	115	0	44	225	1	0	596
08:15 AM	0	3	6	0	1	142	41	0	27	1	104	0	48	253	1	0	627
08:30 AM	0	4	6	0	2	151	57	0	29	5	107	1	35	235	2	0	634
08:45 AM	0	11	5	0	9	114	58	0	28	1	91	0	42	217	1	0	577
Total	0	19	23	0	15	533	204	0	108	10	417	1	169	930	5	0	2434
Grand Total	2	25	41	0	24	1007	377	0	171	12	788	1	401	1865	6	1	4721
Apprch %	2.9	36.8	60.3	0	1.7	71.5	26.8	0	17.6	1.2	81.1	0.1	17.6	82.1	0.3	0	
Total %	0	0.5	0.9	0	0.5	21.3	8	0	3.6	0.3	16.7	0	8.5	39.5	0.1	0	
Cars	2	24	34	0	24	974	366	0	159	12	737	1	394	1792	6	1	4526
% Cars	100	96	82.9	0	100	96.7	97.1	0	93	100	93.5	100	98.3	96.1	100	100	95.9
Heavy Vehicles	0	1	7	0	0	33	11	0	12	0	51	0	7	73	0	0	195
% Heavy Vehicles	0	4	17.1	0	0	3.3	2.9	0	7	0	6.5	0	1.7	3.9	0	0	4.1

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:45 AM																					
07:45 AM	0	2	6	0	8	2	130	52	0	184	28	2	90	0	120	52	229	0	0	281	593
08:00 AM	0	1	6	0	7	3	126	48	0	177	24	3	115	0	142	44	225	1	0	270	596
08:15 AM	0	3	6	0	9	1	142	41	0	184	27	1	104	0	132	48	253	1	0	302	627
08:30 AM	0	4	6	0	10	2	151	57	0	210	29	5	107	1	142	35	235	2	0	272	634
Total Volume	0	10	24	0	34	8	549	198	0	755	108	11	416	1	536	179	942	4	0	1125	2450
% App. Total	0	29.4	70.6	0		1.1	72.7	26.2	0		20.1	2.1	77.6	0.2		15.9	83.7	0.4	0		
PHF	.000	.625	1.00	.000	.850	.667	.909	.868	.000	.899	.931	.550	.904	.250	.944	.861	.931	.500	.000	.931	.966
Cars	0	10	22	0	32	8	535	192	0	735	102	11	393	1	507	176	906	4	0	1086	2360
% Cars	0	100	91.7	0	94.1	100	97.4	97.0	0	97.4	94.4	100	94.5	100	94.6	98.3	96.2	100	0	96.5	96.3
Heavy Vehicles	0	0	2	0	2	0	14	6	0	20	6	0	23	0	29	3	36	0	0	39	90
% Heavy Vehicles	0	0	8.3	0	5.9	0	2.6	3.0	0	2.6	5.6	0	5.5	0	5.4	1.7	3.8	0	0	3.5	3.7

N/S: Staples Driveway/ 2nd Avenue
E/W: Highland Avenue
City, State: Needham, MA
Client: VHB/ A. Silbovitz

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07:00 AM	0	0	2	0	0	0	2	0	0	0	4	0	2	10	0	0	20
07:15 AM	0	0	0	0	0	9	0	0	2	0	10	0	0	6	0	0	27
07:30 AM	0	0	3	0	0	6	3	0	2	0	9	0	1	11	0	0	35
07:45 AM	0	0	2	0	0	10	2	0	1	0	6	0	0	11	0	0	32
Total	0	0	7	0	0	25	7	0	5	0	29	0	3	38	0	0	114
08:00 AM	0	0	0	0	0	2	1	0	0	0	4	0	1	11	0	0	19
08:15 AM	0	0	0	0	0	1	1	0	3	0	1	0	1	5	0	0	12
08:30 AM	0	0	0	0	0	1	2	0	2	0	12	0	1	9	0	0	27
08:45 AM	0	1	0	0	0	4	0	0	2	0	5	0	1	10	0	0	23
Total	0	1	0	0	0	8	4	0	7	0	22	0	4	35	0	0	81
Grand Total	0	1	7	0	0	33	11	0	12	0	51	0	7	73	0	0	195
Apprch %	0	12.5	87.5	0	0	75	25	0	19	0	81	0	8.8	91.2	0	0	
Total %	0	0.5	3.6	0	0	16.9	5.6	0	6.2	0	26.2	0	3.6	37.4	0	0	

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:00 AM																					
07:00 AM	0	0	2	0	2	0	0	2	0	2	0	0	4	0	4	2	10	0	0	12	20
07:15 AM	0	0	0	0	0	0	9	0	0	9	2	0	10	0	12	0	6	0	0	6	27
07:30 AM	0	0	3	0	3	0	6	3	0	9	2	0	9	0	11	1	11	0	0	12	35
07:45 AM	0	0	2	0	2	0	10	2	0	12	1	0	6	0	7	0	11	0	0	11	32
Total Volume	0	0	7	0	7	0	25	7	0	32	5	0	29	0	34	3	38	0	0	41	114
% App. Total	0	0	100	0		0	78.1	21.9	0		14.7	0	85.3	0		7.3	92.7	0	0		
PHF	.000	.000	.583	.000	.583	.000	.625	.583	.000	.667	.625	.000	.725	.000	.708	.375	.864	.000	.000	.854	.814

N/S: Staples Driveway/ 2nd Avenue
E/W: Highland Avenue
City, State: Needham, MA
Client: VHB/ A. Silbovitz

PRECISION DATA INDUSTRIES, LLC
P.O. Box 301 Berlin, MA 01503
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File Name : 133618 A
Site Code : TBA
Start Date : 11/14/2013
Page No : 1

Groups Printed- Cars

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Int. Total
07:00 AM	0	2	2	0	3	89	26	0	6	0	59	0	62	196	1	0	446
07:15 AM	1	1	5	0	1	114	40	0	14	0	89	0	56	247	0	1	569
07:30 AM	1	1	0	0	3	126	50	0	11	0	110	0	59	236	0	0	597
07:45 AM	0	2	4	0	2	120	50	0	27	2	84	0	52	218	0	0	561
Total	2	6	11	0	9	449	166	0	58	2	342	0	229	897	1	1	2173
08:00 AM	0	1	6	0	3	124	47	0	24	3	111	0	43	214	1	0	577
08:15 AM	0	3	6	0	1	141	40	0	24	1	103	0	47	248	1	0	615
08:30 AM	0	4	6	0	2	150	55	0	27	5	95	1	34	226	2	0	607
08:45 AM	0	10	5	0	9	110	58	0	26	1	86	0	41	207	1	0	554
Total	0	18	23	0	15	525	200	0	101	10	395	1	165	895	5	0	2353
Grand Total	2	24	34	0	24	974	366	0	159	12	737	1	394	1792	6	1	4526
Apprch %	3.3	40	56.7	0	1.8	71.4	26.8	0	17.5	1.3	81.1	0.1	18	81.7	0.3	0	
Total %	0	0.5	0.8	0	0.5	21.5	8.1	0	3.5	0.3	16.3	0	8.7	39.6	0.1	0	

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:45 AM																					
07:45 AM	0	2	4	0	6	2	120	50	0	172	27	2	84	0	113	52	218	0	0	270	561
08:00 AM	0	1	6	0	7	3	124	47	0	174	24	3	111	0	138	43	214	1	0	258	577
08:15 AM	0	3	6	0	9	1	141	40	0	182	24	1	103	0	128	47	248	1	0	296	615
08:30 AM	0	4	6	0	10	2	150	55	0	207	27	5	95	1	128	34	226	2	0	262	607
Total Volume	0	10	22	0	32	8	535	192	0	735	102	11	393	1	507	176	906	4	0	1086	2360
% App. Total	0	31.2	68.8	0		1.1	72.8	26.1	0		20.1	2.2	77.5	0.2		16.2	83.4	0.4	0		
PHF	.000	.625	.917	.000	.800	.667	.892	.873	.000	.888	.944	.550	.885	.250	.918	.846	.913	.500	.000	.917	.959

N/S: Staples Driveway/ 2nd Avenue
E/W: Highland Avenue
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Groups Printed- Peds and Bikes

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Int. Total
07:00 AM	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
07:15 AM	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2
07:30 AM	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
07:45 AM	0	0	0	2	0	1	0	0	0	0	0	2	0	0	0	0	5
Total	0	0	0	2	0	1	0	1	0	0	0	4	0	1	0	0	9
08:00 AM	0	0	0	4	0	0	0	0	1	0	0	0	0	0	0	0	5
08:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:30 AM	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	3
08:45 AM	0	1	0	5	0	1	0	0	0	0	0	1	0	0	0	0	8
Total	0	1	0	9	0	1	0	1	1	0	0	2	0	1	0	0	16
Grand Total	0	1	0	11	0	2	0	2	1	0	0	6	0	2	0	0	25
Apprch %	0	8.3	0	91.7	0	50	0	50	14.3	0	0	85.7	0	100	0	0	
Total %	0	4	0	44	0	8	0	8	4	0	0	24	0	8	0	0	

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 08:00 AM																					
08:00 AM	0	0	0	4	4	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	5
08:15 AM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08:30 AM	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	1	0	0	1	3
08:45 AM	0	1	0	5	6	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	8
Total Volume	0	1	0	9	10	0	1	0	1	2	1	0	0	2	3	0	1	0	0	1	16
% App. Total	0	10	0	90		0	50	0	50		33.3	0	0	66.7		0	100	0	0		
PHF	.000	.250	.000	.450	.417	.000	.250	.000	.250	.500	.250	.000	.000	.500	.750	.000	.250	.000	.000	.250	.500

N/S: Staples Driveway/ 2nd Avenue
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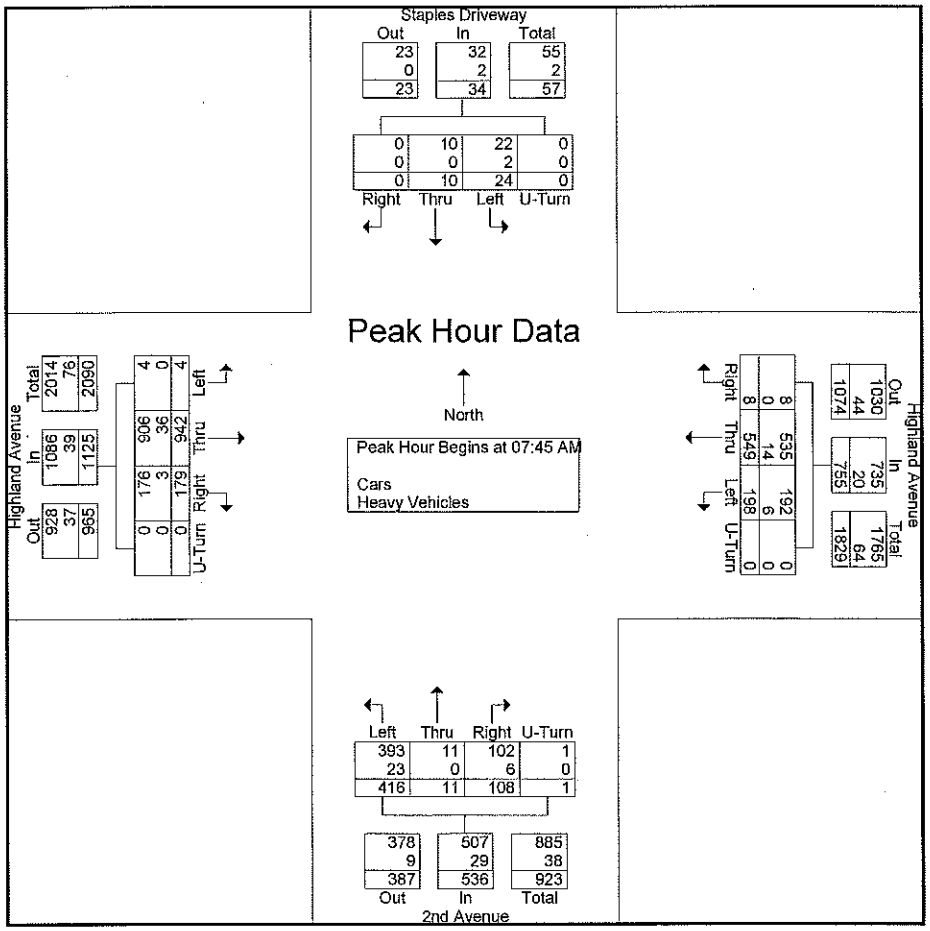
	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 07:45 AM																					
07:45 AM	0	2	6	0	8	2	130	52	0	184	28	2	90	0	120	52	229	0	0	281	593
08:00 AM	0	1	6	0	7	3	126	48	0	177	24	3	115	0	142	44	225	1	0	270	596
08:15 AM	0	3	6	0	9	1	142	41	0	184	27	1	104	0	132	48	253	1	0	302	627
08:30 AM	0	4	6	0	10	2	151	57	0	210	29	5	107	1	142	35	235	2	0	272	634
Total Volume	0	10	24	0	34	8	549	198	0	755	108	11	416	1	536	179	942	4	0	1125	2450
% App. Total	0	29.4	70.6	0		1.1	72.7	26.2	0		20.1	2.1	77.6	0.2		15.9	83.7	0.4	0		
PHF	.000	.625	1.00	.000	.850	.667	.909	.868	.000	.899	.931	.550	.904	.250	.944	.861	.931	.500	.000	.931	.966
Cars	0	10	22	0	32	8	535	192	0	735	102	11	393	1	507	176	906	4	0	1086	2360
% Cars	0	100	91.7	0	94.1	100	97.4	97.0	0	97.4	94.4	100	94.5	100	94.6	98.3	96.2	100	0	96.5	96.3
Heavy Vehicles	0	0	2	0	2	0	14	6	0	20	6	0	23	0	29	3	36	0	0	39	90
% Heavy Vehicles	0	0	8.3	0	5.9	0	2.6	3.0	0	2.6	5.6	0	5.5	0	5.4	1.7	3.8	0	0	3.5	3.7



N/S: Staples Driveway/ 2nd Avenue
E/W: Highland Avenue
City, State: Needham, MA
Client: VHB/ A. Silbovitz

PRECISION DATA INDUSTRIES, LLC
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Groups Printed- Cars - Heavy Vehicles

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Int. Total
04:00 PM	9	9	14	0	12	185	34	0	17	8	175	0	32	148	1	0	644
04:15 PM	6	7	15	0	11	207	24	0	21	5	150	0	28	140	2	0	616
04:30 PM	5	7	18	0	12	209	21	0	14	3	178	0	37	118	5	0	627
04:45 PM	2	6	20	0	6	207	31	0	18	3	186	0	26	158	4	0	667
Total	22	29	67	0	41	808	110	0	70	19	689	0	123	564	12	0	2554
05:00 PM	5	6	22	0	10	228	26	0	25	2	192	0	28	148	2	0	694
05:15 PM	3	2	16	0	7	221	32	0	27	5	185	0	38	191	6	0	733
05:30 PM	1	6	18	0	11	207	32	0	27	3	177	0	34	176	7	0	699
05:45 PM	2	6	6	0	4	210	32	0	27	2	158	0	45	171	2	0	665
Total	11	20	62	0	32	866	122	0	106	12	712	0	145	686	17	0	2791
Grand Total	33	49	129	0	73	1674	232	0	176	31	1401	0	268	1250	29	0	5345
Apprch %	15.6	23.2	61.1	0	3.7	84.6	11.7	0	10.9	1.9	87.1	0	17.3	80.8	1.9	0	
Total %	0.6	0.9	2.4	0	1.4	31.3	4.3	0	3.3	0.6	26.2	0	5	23.4	0.5	0	
Cars	32	49	128	0	72	1642	224	0	170	31	1380	0	261	1232	28	0	5249
% Cars	97	100	99.2	0	98.6	98.1	96.6	0	96.6	100	98.5	0	97.4	98.6	96.6	0	98.2
Heavy Vehicles	1	0	1	0	1	32	8	0	6	0	21	0	7	18	1	0	96
% Heavy Vehicles	3	0	0.8	0	1.4	1.9	3.4	0	3.4	0	1.5	0	2.6	1.4	3.4	0	1.8

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:45 PM																					
04:45 PM	2	6	20	0	28	6	207	31	0	244	18	3	186	0	207	26	158	4	0	188	667
05:00 PM	5	6	22	0	33	10	228	26	0	264	25	2	192	0	219	28	148	2	0	178	694
05:15 PM	3	2	16	0	21	7	221	32	0	260	27	5	185	0	217	38	191	6	0	235	733
05:30 PM	1	6	18	0	25	11	207	32	0	250	27	3	177	0	207	34	176	7	0	217	699
Total Volume	11	20	76	0	107	34	863	121	0	1018	97	13	740	0	850	126	673	19	0	818	2793
% App. Total	10.3	18.7	71	0		3.3	84.8	11.9	0		11.4	1.5	87.1	0		15.4	82.3	2.3	0		
PHF	.550	.833	.864	.000	.811	.773	.946	.945	.000	.964	.898	.650	.964	.000	.970	.829	.881	.679	.000	.870	.953
Cars	11	20	76	0	107	33	854	118	0	1005	93	13	730	0	836	124	663	18	0	805	2753
% Cars	100	100	100	0	100	97.1	99.0	97.5	0	98.7	95.9	100	98.6	0	98.4	98.4	98.5	94.7	0	98.4	98.6
Heavy Vehicles	0	0	0	0	0	1	9	3	0	13	4	0	10	0	14	2	10	1	0	13	40
% Heavy Vehicles	0	0	0	0	0	2.9	1.0	2.5	0	1.3	4.1	0	1.4	0	1.6	1.6	1.5	5.3	0	1.6	1.4

N/S: Staples Driveway/ 2nd Avenue
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Groups Printed- Cars

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Int. Total
04:00 PM	9	9	14	0	12	176	33	0	15	8	171	0	29	146	1	0	623
04:15 PM	5	7	14	0	11	199	23	0	21	5	148	0	28	138	2	0	601
04:30 PM	5	7	18	0	12	206	19	0	14	3	176	0	35	115	5	0	615
04:45 PM	2	6	20	0	5	203	31	0	17	3	183	0	26	153	4	0	653
Total	21	29	66	0	40	784	106	0	67	19	678	0	118	552	12	0	2492
05:00 PM	5	6	22	0	10	225	23	0	24	2	188	0	28	146	2	0	681
05:15 PM	3	2	16	0	7	221	32	0	26	5	184	0	36	189	6	0	727
05:30 PM	1	6	18	0	11	205	32	0	26	3	175	0	34	175	6	0	692
05:45 PM	2	6	6	0	4	207	31	0	27	2	155	0	45	170	2	0	657
Total	11	20	62	0	32	858	118	0	103	12	702	0	143	680	16	0	2757
Grand Total	32	49	128	0	72	1642	224	0	170	31	1380	0	261	1232	28	0	5249
Apprch %	15.3	23.4	61.2	0	3.7	84.7	11.6	0	10.8	2	87.3	0	17.2	81	1.8	0	
Total %	0.6	0.9	2.4	0	1.4	31.3	4.3	0	3.2	0.6	26.3	0	5	23.5	0.5	0	

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 05:00 PM																					
05:00 PM	5	6	22	0	33	10	225	23	0	258	24	2	188	0	214	28	146	2	0	176	681
05:15 PM	3	2	16	0	21	7	221	32	0	260	26	5	184	0	215	36	189	6	0	231	727
05:30 PM	1	6	18	0	25	11	205	32	0	248	26	3	175	0	204	34	175	6	0	215	692
05:45 PM	2	6	6	0	14	4	207	31	0	242	27	2	155	0	184	45	170	2	0	217	657
Total Volume	11	20	62	0	93	32	858	118	0	1008	103	12	702	0	817	143	680	16	0	839	2757
% App. Total	11.8	21.5	66.7	0		3.2	85.1	11.7	0		12.6	1.5	85.9	0		17	81	1.9	0		
PHF	.550	.833	.705	.000	.705	.727	.953	.922	.000	.969	.954	.600	.934	.000	.950	.794	.899	.667	.000	.908	.948

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Groups Printed- Heavy Vehicles

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Int. Total
04:00 PM	0	0	0	0	0	9	1	0	2	0	4	0	3	2	0	0	21
04:15 PM	1	0	1	0	0	8	1	0	0	0	2	0	0	2	0	0	15
04:30 PM	0	0	0	0	0	3	2	0	0	0	2	0	2	3	0	0	12
04:45 PM	0	0	0	0	1	4	0	0	1	0	3	0	0	5	0	0	14
Total	1	0	1	0	1	24	4	0	3	0	11	0	5	12	0	0	62
05:00 PM	0	0	0	0	0	3	3	0	1	0	4	0	0	2	0	0	13
05:15 PM	0	0	0	0	0	0	0	0	1	0	1	0	2	2	0	0	6
05:30 PM	0	0	0	0	0	2	0	0	1	0	2	0	0	1	1	0	7
05:45 PM	0	0	0	0	0	3	1	0	0	0	3	0	0	1	0	0	8
Total	0	0	0	0	0	8	4	0	3	0	10	0	2	6	1	0	34
Grand Total	1	0	1	0	1	32	8	0	6	0	21	0	7	18	1	0	96
Apprch %	50	0	50	0	2.4	78	19.5	0	22.2	0	77.8	0	26.9	69.2	3.8	0	
Total %	1	0	1	0	1	33.3	8.3	0	6.2	0	21.9	0	7.3	18.8	1	0	

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:00 PM																					
04:00 PM	0	0	0	0	0	0	9	1	0	10	2	0	4	0	6	3	2	0	0	5	21
04:15 PM	1	0	1	0	2	0	8	1	0	9	0	0	2	0	2	0	2	0	0	2	15
04:30 PM	0	0	0	0	0	0	3	2	0	5	0	0	2	0	2	2	3	0	0	5	12
04:45 PM	0	0	0	0	0	1	4	0	0	5	1	0	3	0	4	0	5	0	0	5	14
Total Volume	1	0	1	0	2	1	24	4	0	29	3	0	11	0	14	5	12	0	0	17	62
% App. Total	50	0	50	0		3.4	82.8	13.8	0		21.4	0	78.6	0		29.4	70.6	0	0		
PHF	.250	.000	.250	.000	.250	.250	.667	.500	.000	.725	.375	.000	.688	.000	.583	.417	.600	.000	.000	.850	.738

N/S: Staples Driveway/ 2nd Avenue
E/W: Highland Avenue
City, State: Needham, MA
Client: VHB/ A. Silbovitz

PRECISION DATA INDUSTRIES, LLC
P.O. Box 301 Berlin, MA 01503
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File Name : 133618 AA
Site Code : TBA
Start Date : 11/14/2013
Page No : 1

Groups Printed- Peds and Bikes

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Int. Total
04:00 PM	0	0	0	2	0	0	0	0	0	0	0	5	0	0	0	0	7
04:15 PM	0	0	0	2	1	0	0	2	0	0	0	2	0	0	0	0	7
04:30 PM	0	0	0	4	0	0	0	1	0	0	0	1	0	0	0	0	6
04:45 PM	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	0	0	0	9	1	0	0	3	0	0	0	8	0	0	0	0	21
05:00 PM	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
05:15 PM	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	3
05:30 PM	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2
05:45 PM	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	0	0	0	4	0	1	0	2	0	0	0	1	0	0	0	0	8
Grand Total	0	0	0	13	1	1	0	5	0	0	0	9	0	0	0	0	29
Apprch %	0	0	0	100	14.3	14.3	0	71.4	0	0	0	100	0	0	0	0	
Total %	0	0	0	44.8	3.4	3.4	0	17.2	0	0	0	31	0	0	0	0	

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:00 PM																					
04:00 PM	0	0	0	2	2	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	7
04:15 PM	0	0	0	2	2	1	0	0	2	3	0	0	0	2	2	0	0	0	0	0	7
04:30 PM	0	0	0	4	4	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	6
04:45 PM	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total Volume	0	0	0	9	9	1	0	0	3	4	0	0	0	8	8	0	0	0	0	0	21
% App. Total	0	0	0	100		25	0	0	75		0	0	0	100		0	0	0	0		
PHF	.000	.000	.000	.563	.563	.250	.000	.000	.375	.333	.000	.000	.000	.400	.400	.000	.000	.000	.000	.000	.750

N/S: Staples Driveway/ 2nd Avenue
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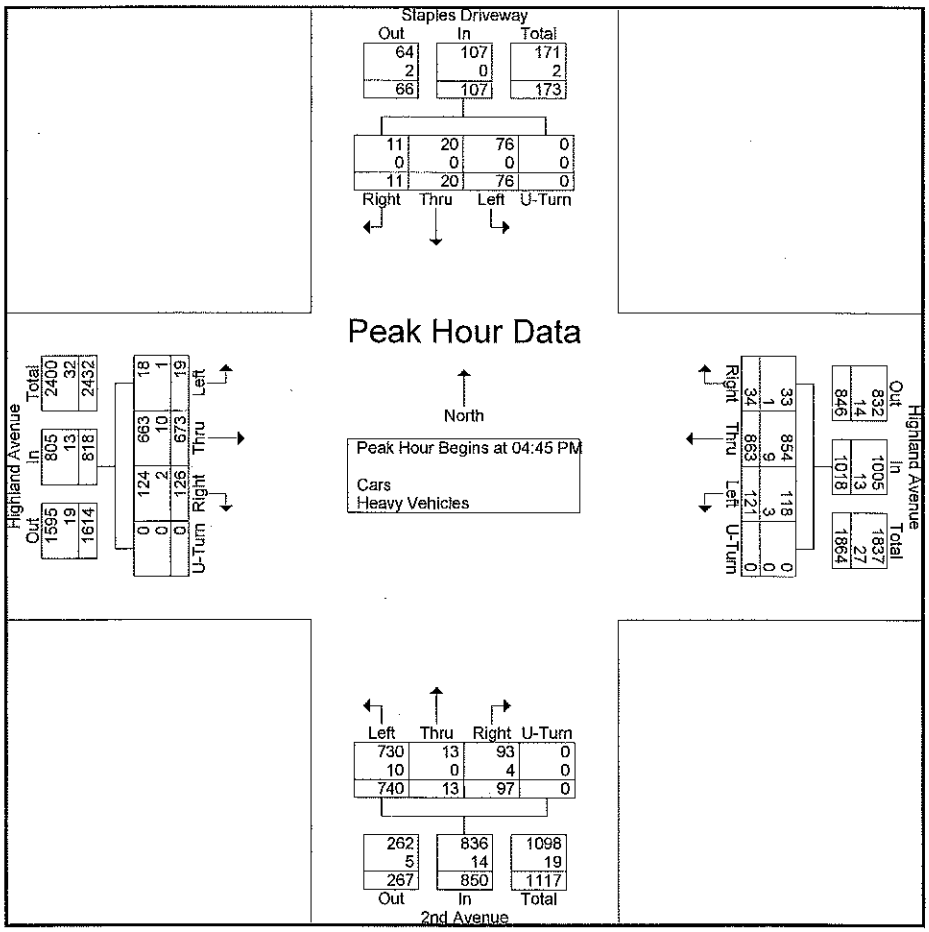
	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 04:45 PM																					
04:45 PM	2	6	20	0	28	6	207	31	0	244	18	3	186	0	207	26	158	4	0	188	667
05:00 PM	5	6	22	0	33	10	228	26	0	264	25	2	192	0	219	28	148	2	0	178	694
05:15 PM	3	2	16	0	21	7	221	32	0	260	27	5	185	0	217	38	191	6	0	235	733
05:30 PM	1	6	18	0	25	11	207	32	0	250	27	3	177	0	207	34	176	7	0	217	699
Total Volume	11	20	76	0	107	34	863	121	0	1018	97	13	740	0	850	126	673	19	0	818	2793
% App. Total	10.3	18.7	71	0		3.3	84.8	11.9	0		11.4	1.5	87.1	0		15.4	82.3	2.3	0		
PHF	.550	.833	.864	.000	.811	.773	.946	.945	.000	.964	.898	.650	.964	.000	.970	.829	.881	.679	.000	.870	.953
Cars	11	20	76	0	107	33	854	118	0	1005	93	13	730	0	836	124	663	18	0	805	2753
% Cars	100	100	100	0	100	97.1	99.0	97.5	0	98.7	95.9	100	98.6	0	98.4	98.4	98.5	94.7	0	98.4	98.6
Heavy Vehicles	0	0	0	0	0	1	9	3	0	13	4	0	10	0	14	2	10	1	0	13	40
% Heavy Vehicles	0	0	0	0	0	2.9	1.0	2.5	0	1.3	4.1	0	1.4	0	1.6	1.6	1.5	5.3	0	1.6	1.4



N/S: Staples Driveway/ 2nd Avenue
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File Name : 133618 AAA
Site Code : TBA
Start Date : 11/16/2013
Page No : 1

Groups Printed- Cars - Heavy Vehicles

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Int. Total
11:00 AM	2	8	16	0	12	180	29	0	39	2	77	0	72	170	7	0	614
11:15 AM	6	7	18	0	26	159	20	0	32	4	67	0	49	194	2	0	584
11:30 AM	4	3	16	0	13	170	32	0	42	3	74	0	61	167	2	0	587
11:45 AM	5	6	12	0	10	179	20	0	40	8	56	0	52	204	4	0	596
Total	17	24	62	0	61	688	101	0	153	17	274	0	234	735	15	0	2381
12:00 PM	4	5	16	0	19	153	35	0	29	2	64	0	45	190	7	0	569
12:15 PM	7	5	11	0	13	177	30	0	32	5	65	0	42	176	3	0	566
12:30 PM	3	3	11	0	11	166	34	0	32	5	87	0	39	179	7	0	577
12:45 PM	2	9	13	0	10	180	44	0	36	6	69	0	41	182	4	0	596
Total	16	22	51	0	53	676	143	0	129	18	285	0	167	727	21	0	2308
01:00 PM	6	9	18	0	17	187	26	0	33	7	90	0	37	177	9	0	616
01:15 PM	3	7	17	0	17	170	31	0	35	5	83	0	45	194	3	0	610
01:30 PM	8	7	6	0	21	170	28	0	40	1	94	0	41	182	3	0	601
01:45 PM	3	4	12	0	19	178	34	0	35	4	63	0	36	191	3	0	582
Total	20	27	53	0	74	705	119	0	143	17	330	0	159	744	18	0	2409
Grand Total	53	73	166	0	188	2069	363	0	425	52	889	0	560	2206	54	0	7098
Apprch %	18.2	25	56.8	0	7.2	79	13.9	0	31.1	3.8	65.1	0	19.9	78.2	1.9	0	
Total %	0.7	1	2.3	0	2.6	29.1	5.1	0	6	0.7	12.5	0	7.9	31.1	0.8	0	
Cars	53	73	165	0	188	2042	355	0	404	51	873	0	552	2168	54	0	6978
% Cars	100	100	99.4	0	100	98.7	97.8	0	95.1	98.1	98.2	0	98.6	98.3	100	0	98.3
Heavy Vehicles	0	0	1	0	0	27	8	0	21	1	16	0	8	38	0	0	120
% Heavy Vehicles	0	0	0.6	0	0	1.3	2.2	0	4.9	1.9	1.8	0	1.4	1.7	0	0	1.7

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 11:00 AM																					
11:00 AM	2	8	16	0	26	12	180	29	0	221	39	2	77	0	118	72	170	7	0	249	614
11:15 AM	6	7	18	0	31	26	159	20	0	205	32	4	67	0	103	49	194	2	0	245	584
11:30 AM	4	3	16	0	23	13	170	32	0	215	42	3	74	0	119	61	167	2	0	230	587
11:45 AM	5	6	12	0	23	10	179	20	0	209	40	8	56	0	104	52	204	4	0	260	596
Total Volume	17	24	62	0	103	61	688	101	0	850	153	17	274	0	444	234	735	15	0	984	2381
% App. Total	16.5	23.3	60.2	0		7.2	80.9	11.9	0		34.5	3.8	61.7	0		23.8	74.7	1.5	0		
PHF	.708	.750	.861	.000	.831	.587	.956	.789	.000	.962	.911	.531	.890	.000	.933	.813	.901	.536	.000	.946	.969
Cars	17	24	62	0	103	61	678	99	0	838	149	17	267	0	433	231	716	15	0	962	2336
% Cars	100	100	100	0	100	100	98.5	98.0	0	98.6	97.4	100	97.4	0	97.5	98.7	97.4	100	0	97.8	98.1
Heavy Vehicles	0	0	0	0	0	0	10	2	0	12	4	0	7	0	11	3	19	0	0	22	45
% Heavy Vehicles	0	0	0	0	0	0	1.5	2.0	0	1.4	2.6	0	2.6	0	2.5	1.3	2.6	0	0	2.2	1.9

N/S: Staples Driveway/ 2nd Avenue
E/W: Highland Avenue
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File Name : 133618 AAA
Site Code : TBA
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Page No : 1

Groups Printed- Cars

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Int. Total
11:00 AM	2	8	16	0	12	176	28	0	38	2	73	0	70	165	7	0	597
11:15 AM	6	7	18	0	26	158	20	0	32	4	66	0	49	186	2	0	574
11:30 AM	4	3	16	0	13	168	31	0	42	3	72	0	61	165	2	0	580
11:45 AM	5	6	12	0	10	176	20	0	37	8	56	0	51	200	4	0	585
Total	17	24	62	0	61	678	99	0	149	17	267	0	231	716	15	0	2336
12:00 PM	4	5	16	0	19	149	35	0	28	2	63	0	45	188	7	0	561
12:15 PM	7	5	11	0	13	175	30	0	31	5	65	0	42	175	3	0	562
12:30 PM	3	3	11	0	11	163	33	0	21	5	81	0	39	176	7	0	553
12:45 PM	2	9	13	0	10	178	43	0	35	6	69	0	40	176	4	0	585
Total	16	22	51	0	53	665	141	0	115	18	278	0	166	715	21	0	2261
01:00 PM	6	9	17	0	17	186	26	0	31	6	90	0	34	175	9	0	606
01:15 PM	3	7	17	0	17	169	30	0	35	5	82	0	45	193	3	0	606
01:30 PM	8	7	6	0	21	167	27	0	39	1	93	0	40	180	3	0	592
01:45 PM	3	4	12	0	19	177	32	0	35	4	63	0	36	189	3	0	577
Total	20	27	52	0	74	699	115	0	140	16	328	0	155	737	18	0	2381
Grand Total	53	73	165	0	188	2042	355	0	404	51	873	0	552	2168	54	0	6978
Apprch %	18.2	25.1	56.7	0	7.3	79	13.7	0	30.4	3.8	65.7	0	19.9	78.2	1.9	0	
Total %	0.8	1	2.4	0	2.7	29.3	5.1	0	5.8	0.7	12.5	0	7.9	31.1	0.8	0	

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 11:00 AM																					
11:00 AM	2	8	16	0	26	12	176	28	0	216	38	2	73	0	113	70	165	7	0	242	597
11:15 AM	6	7	18	0	31	26	158	20	0	204	32	4	66	0	102	49	186	2	0	237	574
11:30 AM	4	3	16	0	23	13	168	31	0	212	42	3	72	0	117	61	165	2	0	228	580
11:45 AM	5	6	12	0	23	10	176	20	0	206	37	8	56	0	101	51	200	4	0	255	585
Total Volume	17	24	62	0	103	61	678	99	0	838	149	17	267	0	433	231	716	15	0	962	2336
% App. Total	16.5	23.3	60.2	0		7.3	80.9	11.8	0		34.4	3.9	61.7	0		24	74.4	1.6	0		
PHF	.708	.750	.861	.000	.831	.587	.963	.798	.000	.970	.887	.531	.914	.000	.925	.825	.895	.536	.000	.943	.978

N/S: Staples Driveway/ 2nd Avenue
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Page No : 1

Groups Printed- Heavy Vehicles

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Right	Thru	Left	U-Turn	Int. Total
11:00 AM	0	0	0	0	0	4	1	0	1	0	4	0	2	5	0	0	17
11:15 AM	0	0	0	0	0	1	0	0	0	0	1	0	0	8	0	0	10
11:30 AM	0	0	0	0	0	2	1	0	0	0	2	0	0	2	0	0	7
11:45 AM	0	0	0	0	0	3	0	0	3	0	0	0	1	4	0	0	11
Total	0	0	0	0	0	10	2	0	4	0	7	0	3	19	0	0	45
12:00 PM	0	0	0	0	0	4	0	0	1	0	1	0	0	2	0	0	8
12:15 PM	0	0	0	0	0	2	0	0	1	0	0	0	0	1	0	0	4
12:30 PM	0	0	0	0	0	3	1	0	11	0	6	0	0	3	0	0	24
12:45 PM	0	0	0	0	0	2	1	0	1	0	0	0	1	6	0	0	11
Total	0	0	0	0	0	11	2	0	14	0	7	0	1	12	0	0	47
01:00 PM	0	0	1	0	0	1	0	0	2	1	0	0	3	2	0	0	10
01:15 PM	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0	0	4
01:30 PM	0	0	0	0	0	3	1	0	1	0	1	0	1	2	0	0	9
01:45 PM	0	0	0	0	0	1	2	0	0	0	0	0	0	2	0	0	5
Total	0	0	1	0	0	6	4	0	3	1	2	0	4	7	0	0	28
Grand Total	0	0	1	0	0	27	8	0	21	1	16	0	8	38	0	0	120
Apprch %	0	0	100	0	0	77.1	22.9	0	55.3	2.6	42.1	0	17.4	82.6	0	0	
Total %	0	0	0.8	0	0	22.5	6.7	0	17.5	0.8	13.3	0	6.7	31.7	0	0	

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 11:45 AM																					
11:45 AM	0	0	0	0	0	0	3	0	0	3	3	0	0	0	3	1	4	0	0	5	11
12:00 PM	0	0	0	0	0	0	4	0	0	4	1	0	1	0	2	0	2	0	0	2	8
12:15 PM	0	0	0	0	0	0	2	0	0	2	1	0	0	0	1	0	1	0	0	1	4
12:30 PM	0	0	0	0	0	0	3	1	0	4	11	0	6	0	17	0	3	0	0	3	24
Total Volume	0	0	0	0	0	0	12	1	0	13	16	0	7	0	23	1	10	0	0	11	47
% App. Total	0	0	0	0		0	92.3	7.7	0		69.6	0	30.4	0		9.1	90.9	0	0		
PHF	.000	.000	.000	.000	.000	.000	.750	.250	.000	.813	.364	.000	.292	.000	.338	.250	.625	.000	.000	.550	.490

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Groups Printed- Peds and Bikes

	Staples Driveway From North				Highland Avenue From East				2nd Avenue From South				Highland Avenue From West				
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Int. Total
11:00 AM	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	4
11:15 AM	0	0	0	4	0	1	0	2	0	0	0	1	0	0	0	0	8
11:30 AM	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	4
11:45 AM	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4
Total	0	0	0	4	0	2	0	7	0	0	0	7	0	0	0	0	20
12:00 PM	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	3
12:15 PM	0	0	0	1	0	0	0	0	0	0	0	5	0	1	0	0	7
12:30 PM	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	3
12:45 PM	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	10
Total	0	0	0	4	0	0	0	0	0	0	0	18	0	1	0	0	23
01:00 PM	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	7
01:15 PM	0	0	0	2	0	0	0	4	0	0	0	6	0	0	0	0	12
01:30 PM	0	0	0	4	0	0	0	4	0	0	0	4	0	0	0	0	12
01:45 PM	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	3
Total	0	0	0	6	0	0	0	9	0	0	1	18	0	0	0	0	34
Grand Total	0	0	0	14	0	2	0	16	0	0	1	43	0	1	0	0	77
Apprch %	0	0	0	100	0	11.1	0	88.9	0	0	2.3	97.7	0	100	0	0	
Total %	0	0	0	18.2	0	2.6	0	20.8	0	0	1.3	55.8	0	1.3	0	0	

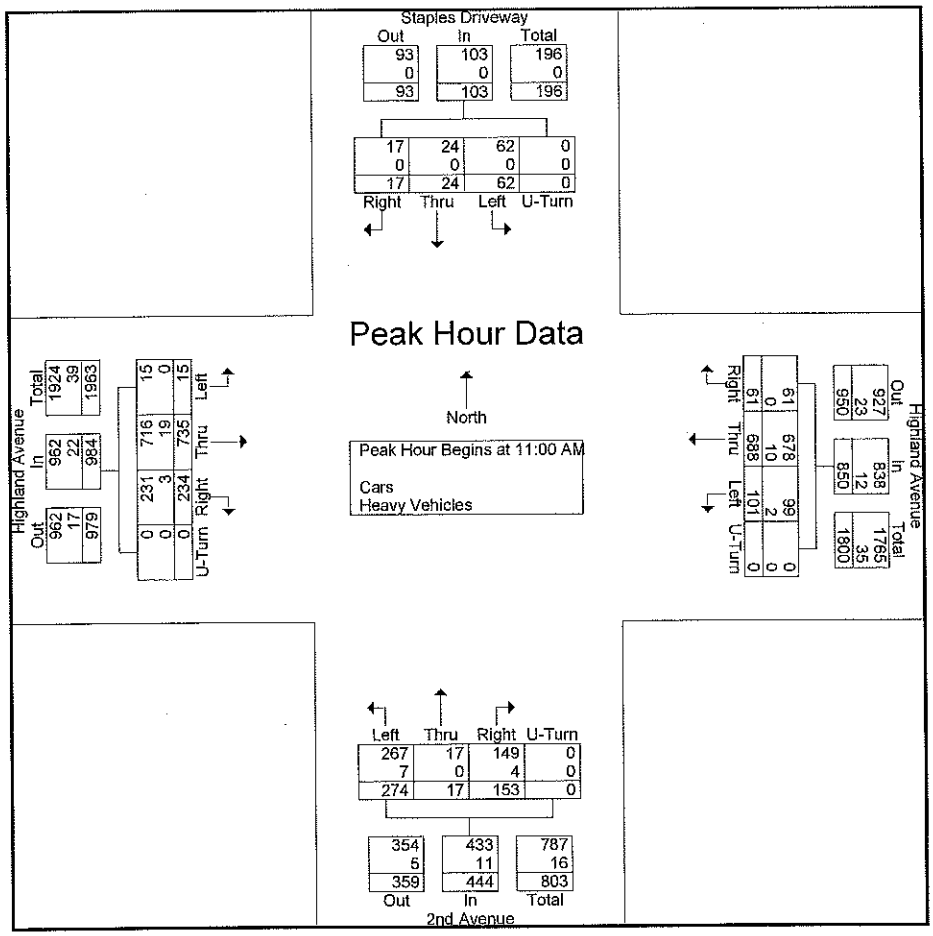
	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 12:00 PM																					
12:00 PM	0	0	0	1	1	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	3
12:15 PM	0	0	0	1	1	0	0	0	0	0	0	0	0	5	5	0	1	0	0	1	7
12:30 PM	0	0	0	2	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	3
12:45 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	0	0	0	0	10
Total Volume	0	0	0	4	4	0	0	0	0	0	0	0	0	18	18	0	1	0	0	1	23
% App. Total	0	0	0	100		0	0	0	0		0	0	0	100		0	100	0	0		
PHF	.000	.000	.000	.500	.500	.000	.000	.000	.000	.000	.000	.000	.000	.450	.450	.000	.250	.000	.000	.250	.575

N/S: Staples Driveway/ 2nd Avenue
E/W: Highland Avenue
City, State: Needham, MA
Client: VHB/ A. Silbovitz

PRECISION DATA INDUSTRIES, LLC
P.O. Box 301 Berlin, MA 01503
Office: 508.481.3999 Fax: 508.545.1234
Email: datarequests@pdillc.com

File Name : 133618 AAA
Site Code : TBA
Start Date : 11/16/2013
Page No : 1

	Staples Driveway From North					Highland Avenue From East					2nd Avenue From South					Highland Avenue From West					
Start Time	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Right	Thru	Left	U-Turn	App. Total	Int. Total
Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1																					
Peak Hour for Entire Intersection Begins at 11:00 AM																					
11:00 AM	2	8	16	0	26	12	180	29	0	221	39	2	77	0	118	72	170	7	0	249	614
11:15 AM	6	7	18	0	31	26	159	20	0	205	32	4	67	0	103	49	194	2	0	245	584
11:30 AM	4	3	16	0	23	13	170	32	0	215	42	3	74	0	119	61	167	2	0	230	587
11:45 AM	5	6	12	0	23	10	179	20	0	209	40	8	56	0	104	52	204	4	0	260	596
Total Volume	17	24	62	0	103	61	688	101	0	850	153	17	274	0	444	234	735	15	0	984	2381
% App. Total	16.5	23.3	60.2	0		7.2	80.9	11.9	0		34.5	3.8	61.7	0		23.8	74.7	1.5	0		
PHF	.708	.750	.861	.000	.831	.587	.956	.789	.000	.962	.911	.531	.890	.000	.933	.813	.901	.536	.000	.946	.969
Cars	17	24	62	0	103	61	678	99	0	838	149	17	267	0	433	231	716	15	0	962	2336
% Cars	100	100	100	0	100	100	98.5	98.0	0	98.6	97.4	100	97.4	0	97.5	98.7	97.4	100	0	97.8	98.1
Heavy Vehicles	0	0	0	0	0	0	10	2	0	12	4	0	7	0	11	3	19	0	0	22	45
% Heavy Vehicles	0	0	0	0	0	0	1.5	2.0	0	1.4	2.6	0	2.6	0	2.5	1.3	2.6	0	0	2.2	1.9



APPENDIX B
AUTOMATIC TRAFFIC RECORDERS (ATR'S)

Highland Avenue
between Charles and Wexford Street
City, State: Needham, MA
Client: VHB/ A. Silbovitz

PRECISION DATA INDUSTRIES, LLC
P.O. Box 301 Berlin, MA 01503
Office: 508.481.3999 Fax: 508.545.1234
Email: datarequests@pdillc.com

133618 A VOLUME
Site Code: TBA
Date Start: 14-Nov-13

Start		EB				WB				Combined			14-Nov-13 Thu
Time	A.M.		P.M.		A.M.		P.M.		A.M.		P.M.		
12:00	15		140		38		146		53		286		
12:15	14		122		12		165		26		287		
12:30	10		118		9		171		19		289		
12:45	11	50	128	508	18	77	208	690	29	127	336	1198	
01:00	4		149		13		151		17		300		
01:15	7		153		10		180		17		333		
01:30	5		155		20		193		25		348		
01:45	8	24	127	584	8	51	203	727	16	75	330	1311	
02:00	3		139		6		208		9		347		
02:15	3		158		2		196		5		354		
02:30	1		133		8		219		9		352		
02:45	6	13	121	551	2	18	240	863	8	31	361	1414	
03:00	5		130		9		227		14		357		
03:15	3		153		11		180		14		333		
03:30	4		123		2		231		6		354		
03:45	5	17	116	522	4	26	256	894	9	43	372	1416	
04:00	12		129		9		233		21		362		
04:15	5		116		5		240		10		356		
04:30	22		120		19		255		41		375		
04:45	35	74	110	475	16	49	218	946	51	123	328	1421	
05:00	32		102		18		226		50		328		
05:15	46		117		31		166		77		283		
05:30	75		99		30		207		105		306		
05:45	108	261	122	440	38	117	179	778	146	378	301	1218	
06:00	125		138		46		236		171		374		
06:15	151		143		61		211		212		354		
06:30	219		143		88		229		307		372		
06:45	205	700	157	581	101	296	206	882	306	996	363	1463	
07:00	247		123		91		222		338		345		
07:15	120		132		114		184		234		316		
07:30	142		135		148		162		290		297		
07:45	119	628	102	492	105	458	178	746	224	1086	280	1238	
08:00	128		89		138		174		266		263		
08:15	154		87		120		187		274		274		
08:30	154		96		111		154		265		250		
08:45	137	573	84	356	140	509	116	631	277	1082	200	987	
09:00	121		85		137		129		258		214		
09:15	167		78		92		144		259		222		
09:30	136		73		128		113		264		186		
09:45	134	558	68	304	111	468	66	452	245	1026	134	756	
10:00	126		61		135		96		261		157		
10:15	161		54		134		69		295		123		
10:30	159		40		113		41		272		81		
10:45	144	590	24	179	140	522	44	250	284	1112	68	429	
11:00	150		24		149		45		299		69		
11:15	160		18		153		40		313		58		
11:30	116		20		144		28		260		48		
11:45	141	567	24	86	145	591	23	136	286	1158	47	222	
Total	4055		5078		3182		7995		7237		13073		
Percent	56.0%		38.8%		44.0%		61.2%						
Day Total		9133				11177				20310			
Peak	06:15	-	00:45	-	11:00	-	03:45	-	06:30	-	03:45	-	-	-
Vol.	822	-	585	-	591	-	984	-	1185	-	1465	-	-	-
P.H.F.	0.832		0.944		0.966		0.961		0.876		0.977			

2nd Avenue
south of Highland Avenue
City, State: Needham, MA
Client: VHB/ A. Silbovitz

PRECISION DATA INDUSTRIES, LLC
P.O. Box 301 Berlin, MA 01503
Office: 508.481.3999 Fax: 508.545.1234
Email: datarequests@pdillc.com

133618 B VOLUME
Site Code: TBA
Date Start: 14-Nov-13

Start	NB				SB				Combined				14-Nov-13 Thu
Time	A.M.		P.M.		A.M.		P.M.		A.M.		P.M.		
12:00	25		206		4		67		29		273		
12:15	5		161		1		95		6		256		
12:30	12		134		8		110		20		244		
12:45	12	54	140	641	2	15	110	382	14	69	250	1023	
01:00	5		148		3		134		8		282		
01:15	1		133		1		121		2		254		
01:30	14		152		3		98		17		250		
01:45	2	22	133	566	3	10	81	434	5	32	214	1000	
02:00	6		158		1		88		7		246		
02:15	2		140		2		87		4		227		
02:30	3		156		3		79		6		235		
02:45	4	15	145	599	2	8	79	333	6	23	224	932	
03:00	6		158		2		68		8		226		
03:15	8		164		2		68		10		232		
03:30	4		210		2		56		6		266		
03:45	4	22	192	724	4	10	56	248	8	32	248	972	
04:00	6		208		8		60		14		268		
04:15	3		176		4		50		7		226		
04:30	16		194		9		56		25		250		
04:45	8	33	216	794	12	33	52	218	20	66	268	1012	
05:00	20		220		13		44		33		264		
05:15	30		196		19		62		49		258		
05:30	28		212		31		62		59		274		
05:45	32	110	180	808	43	106	80	248	75	216	260	1056	
06:00	32		200		28		64		60		264		
06:15	43		134		57		60		100		194		
06:30	46		131		62		67		108		198		
06:45	70	191	131	596	72	219	69	260	142	410	200	856	
07:00	72		146		94		62		166		208		
07:15	127		84		95		52		222		136		
07:30	142		102		110		44		252		146		
07:45	128	469	86	418	102	401	40	198	230	870	126	616	
08:00	138		92		96		39		234		131		
08:15	128		93		98		39		226		132		
08:30	162		69		87		51		249		120		
08:45	119	547	52	306	112	393	37	166	231	940	89	472	
09:00	116		68		92		30		208		98		
09:15	115		33		105		32		220		65		
09:30	166		40		73		30		239		70		
09:45	137	534	20	161	77	347	30	122	214	881	50	283	
10:00	138		30		69		20		207		50		
10:15	110		29		76		19		186		48		
10:30	116		16		72		19		188		35		
10:45	144	508	11	86	72	289	15	73	216	797	26	159	
11:00	116		27		52		8		168		35		
11:15	114		12		56		8		170		20		
11:30	152		10		60		9		212		19		
11:45	151	533	10	59	97	265	11	36	248	798	21	95	
Total	3038		5758		2096		2718		5134		8476		
Percent	59.2%		67.9%		40.8%		32.1%						
Day Total		8796				4814				13610			
Peak	07:45	-	04:45	-	07:30	-	00:30	-	07:30	-	04:45	-	- -
Vol.	556	-	844	-	406	-	475	-	942	-	1064	-	- -
P.H.F.	0.858		0.959		0.923		0.886		0.935		0.971		

Highland Avenue
east of 1st Avenue
City, State: Needham, MA
Client: VHB/ A. Silbovitz

PRECISION DATA INDUSTRIES, LLC
P.O.Box 301 Berlin, MA 01503
Office: 508.481.3999 Fax: 508.545.1234
Email: datarequests@pdillc.com

133590 AA volume
Site Code:

Start	EB				WB				Combined				22-Oct-13
Time	A.M.		P.M.		A.M.		P.M.		A.M.		P.M.		Tue
12:00	16		276		14		313		30		589		
12:15	10		270		24		302		34		572		
12:30	18		270		35		312		53		582		
12:45	11	55	278	1094	12	85	290	1217	23	140	568	2311	
01:00	3		239		12		332		15		571		
01:15	10		248		3		291		13		539		
01:30	8		247		4		304		12		551		
01:45	7	28	292	1026	13	32	330	1257	20	60	622	2283	
02:00	7		238		8		366		15		604		
02:15	4		238		3		347		7		585		
02:30	3		244		6		351		9		595		
02:45	10	24	260	980	8	25	346	1410	18	49	606	2390	
03:00	6		239		8		426		14		665		
03:15	10		239		6		392		16		631		
03:30	6		228		6		399		12		627		
03:45	10	32	272	978	4	24	404	1621	14	56	676	2599	
04:00	6		220		3		439		9		659		
04:15	10		210		10		426		20		636		
04:30	20		217		17		400		37		617		
04:45	44	80	225	872	24	54	372	1637	68	134	597	2509	
05:00	42		204		17		432		59		636		
05:15	58		196		34		384		92		580		
05:30	92		138		42		400		134		538		
05:45	118	310	112	650	48	141	386	1602	166	451	498	2252	
06:00	146		141		57		388		203		529		
06:15	192		218		82		406		274		624		
06:30	268		224		118		384		386		608		
06:45	327	933	200	783	130	387	365	1543	457	1320	565	2326	
07:00	314		210		170		310		484		520		
07:15	325		190		213		280		538		470		
07:30	300		152		278		266		578		418		
07:45	280	1219	130	682	274	935	230	1086	554	2154	360	1768	
08:00	250		135		254		215		504		350		
08:15	302		142		264		186		566		328		
08:30	320		129		252		193		572		322		
08:45	340	1212	100	506	278	1048	182	776	618	2260	282	1282	
09:00	348		86		250		136		598		222		
09:15	320		78		237		110		557		188		
09:30	322		66		206		123		528		189		
09:45	317	1307	60	290	204	897	97	466	521	2204	157	756	
10:00	286		50		218		94		504		144		
10:15	250		46		232		76		482		122		
10:30	252		36		242		52		494		88		
10:45	267	1055	33	165	266	958	52	274	533	2013	85	439	
11:00	285		35		266		38		551		73		
11:15	234		25		268		22		502		47		
11:30	267		17		283		24		550		41		
11:45	298	1084	24	101	254	1071	30	114	552	2155	54	215	
Total	7339		8127		5657		13003		12996		21130		
Percent	56.5%		38.5%		43.5%		61.5%						
Day Total		15466				18660				34126			
Peak	08:45	-	12:00	-	10:45	-	03:45	-	08:15	-	03:00	-	-	-
Vol.	1330	-	1094	-	1083	-	1669	-	2354	-	2599	-	-	-
P.H.F.	0.955		0.984		0.957		0.950		0.952		0.961			

Highland Avenue
east of 1st Avenue
City, State: Needham, MA
Client: VHB/ A. Silbovitz

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133590 AA volume
Site Code:

Start	EB				WB				Combined				23-Oct-13
Time	A.M.		P.M.		A.M.		P.M.		A.M.		P.M.		Wed
12:00	18		234		26		281		44		515		
12:15	13		211		18		288		31		499		
12:30	20		230		16		322		36		552		
12:45	10	61	208	883	19	79	276	1167	29	140	484	2050	
01:00	6		214		8		277		14		491		
01:15	4		212		7		284		11		496		
01:30	4		233		8		291		12		524		
01:45	6	20	268	927	7	30	298	1150	13	50	566	2077	
02:00	6		242		6		318		12		560		
02:15	4		250		0		354		4		604		
02:30	12		246		24		372		36		618		
02:45	8	30	244	982	12	42	324	1368	20	72	568	2350	
03:00	4		217		4		376		8		593		
03:15	2		245		4		354		6		599		
03:30	7		209		2		402		9		611		
03:45	12	25	218	889	7	17	394	1526	19	42	612	2415	
04:00	13		216		8		444		21		660		
04:15	11		258		20		398		31		656		
04:30	12		244		15		446		27		690		
04:45	40	76	242	960	9	52	424	1712	49	128	666	2672	
05:00	36		256		15		482		51		738		
05:15	64		269		30		445		94		714		
05:30	84		213		52		446		136		659		
05:45	120	304	228	966	55	152	400	1773	175	456	628	2739	
06:00	152		202		74		407		226		609		
06:15	200		239		100		416		300		655		
06:30	220		235		120		384		340		619		
06:45	300	872	253	929	148	442	342	1549	448	1314	595	2478	
07:00	332		216		182		291		514		507		
07:15	361		191		220		266		581		457		
07:30	303		152		258		217		561		369		
07:45	316	1312	141	700	282	942	203	977	598	2254	344	1677	
08:00	294		102		246		204		540		306		
08:15	306		92		260		170		566		262		
08:30	334		95		265		140		599		235		
08:45	350	1284	94	383	236	1007	119	633	586	2291	213	1016	
09:00	322		94		234		160		556		254		
09:15	322		74		221		98		543		172		
09:30	334		65		234		92		568		157		
09:45	338	1316	66	299	228	917	77	427	566	2233	143	726	
10:00	279		59		222		78		501		137		
10:15	294		58		237		49		531		107		
10:30	230		57		234		74		464		131		
10:45	258	1061	46	220	260	953	42	243	518	2014	88	463	
11:00	248		32		247		57		495		89		
11:15	268		19		275		40		543		59		
11:30	272		25		277		60		549		85		
11:45	221	1009	16	92	274	1073	37	194	495	2082	53	286	
Total	7370		8230		5706		12719		13076		20949		
Percent	56.4%		39.3%		43.6%		60.7%						
Day Total		15600				18425				34025			
Peak	08:30	-	04:30	-	11:00	-	04:30	-	08:15	-	04:30	-	-	-
Vol.	1328	-	1011	-	1073	-	1797	-	2307	-	2808	-	-	-
P.H.F.	0.920		0.940		0.968		0.932		0.963		0.951			

APPENDIX C
INTERSECTION CAPACITY ANALYSIS

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

12/10/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	4	942	179	198	549	8	416	11	108	24	10	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	0		0
Storage Lanes	0		0	0		0	1		0	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.976			0.998			0.938				
Flt Protected					0.987		0.950	0.974			0.966	
Satd. Flow (prot)	0	3399	0	0	3453	0	1618	1560	0	0	1738	1900
Flt Permitted		0.952			0.540		0.950	0.974			0.966	
Satd. Flow (perm)	0	3236	0	0	1889	0	1618	1560	0	0	1738	1900
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		23			1			35				
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.93	0.93	0.93	0.90	0.90	0.90	0.94	0.94	0.94	0.85	0.85	0.85
Heavy Vehicles (%)	0%	4%	2%	3%	3%	0%	6%	0%	6%	8%	0%	0%
Adj. Flow (vph)	4	1013	192	220	610	9	443	12	115	28	12	0
Shared Lane Traffic (%)							34%					
Lane Group Flow (vph)	0	1209	0	0	839	0	292	278	0	0	40	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway 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
Turning Speed (mph)	15		9	15		9	15		9	15		9
Turn Type	Perm	NA		pm+pt	NA		Split	NA		Split	NA	Prot
Protected Phases		6		5	2		8	8		4	4	4
Permitted Phases	6			2								
Minimum Split (s)	31.0	31.0		9.0	20.0		22.0	22.0		11.0	11.0	11.0
Total Split (s)	40.0	40.0		12.0	52.0		35.0	35.0		15.0	15.0	15.0
Total Split (%)	39.2%	39.2%		11.8%	51.0%		34.3%	34.3%		14.7%	14.7%	14.7%
Maximum Green (s)	35.0	35.0		7.0	47.0		30.0	30.0		10.0	10.0	10.0
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Walk Time (s)	6.0	6.0					6.0	6.0				
Flash Dont Walk (s)	20.0	20.0					10.0	10.0				
Pedestrian Calls (#/hr)	0	0					0	0				
Act Effct Green (s)		35.0			47.0		30.0	30.0			10.0	
Actuated g/C Ratio		0.34			0.46		0.29	0.29			0.10	
v/c Ratio		1.07			1.15dl		0.61	0.58			0.24	

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

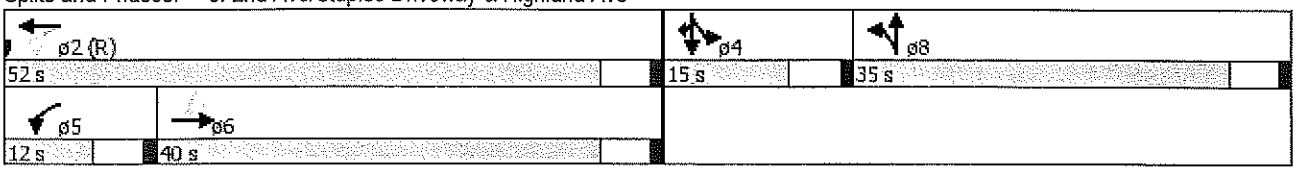
12/10/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Control Delay		82.0			32.9		37.6	32.1			46.3	
Queue Delay		0.0			0.0		0.0	0.0			0.0	
Total Delay		82.0			32.9		37.6	32.1			46.3	
LOS		F			C		D	C			D	
Approach Delay		82.0			32.9			34.9			46.3	
Approach LOS		F			C			C			D	

Intersection Summary

Area Type: Other
Cycle Length: 102
Actuated Cycle Length: 102
Offset: 0 (0%), Referenced to phase 2:WBTL, Start of Green
Natural Cycle: 75
Control Type: Pretimed
Maximum v/c Ratio: 1.07
Intersection Signal Delay: 55.8 Intersection LOS: E
Intersection Capacity Utilization 87.3% ICU Level of Service E
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

12/10/2013

Lane Group	EBT	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	1209	839	292	278	40
v/c Ratio	1.07	1.15dl	0.61	0.58	0.24
Control Delay	82.0	32.9	37.6	32.1	46.3
Queue Delay	0.0	0.0	0.0	0.0	0.0
Total Delay	82.0	32.9	37.6	32.1	46.3
Queue Length 50th (ft)	~458	198	171	141	24
Queue Length 95th (ft)	#594	#272	267	232	55
Internal Link Dist (ft)	342	382		392	168
Turn Bay Length (ft)			50		
Base Capacity (vph)	1125	978	475	483	170
Starvation Cap Reductn	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	1.07	0.86	0.61	0.58	0.24

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

12/10/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	19	673	126	121	863	34	740	13	97	76	20	11
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	0		0
Storage Lanes	0		0	0		0	1		0	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.977			0.995			0.965				0.850
Flt Protected		0.999			0.994		0.950	0.964			0.962	
Satd. Flow (prot)	0	3452	0	0	3529	0	1698	1652	0	0	1828	1615
Flt Permitted		0.910			0.557		0.950	0.964			0.962	
Satd. Flow (perm)	0	3144	0	0	1977	0	1698	1652	0	0	1828	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		29			6			17				162
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.87	0.87	0.87	0.96	0.96	0.96	0.97	0.97	0.97	0.81	0.81	0.81
Heavy Vehicles (%)	5%	2%	2%	2%	1%	3%	1%	0%	4%	0%	0%	0%
Adj. Flow (vph)	22	774	145	126	899	35	763	13	100	94	25	14
Shared Lane Traffic (%)							42%					
Lane Group Flow (vph)	0	941	0	0	1060	0	443	433	0	0	119	14
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway 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
Turning Speed (mph)	15		9	15		9	15		9	15		9
Turn Type	Perm	NA		pm+pt	NA		Split	NA		Split	NA	Prot
Protected Phases		6		5	2		8	8		4	4	4
Permitted Phases	6			2								
Minimum Split (s)	31.0	31.0		9.0	20.0		21.0	21.0		11.0	11.0	11.0
Total Split (s)	34.0	34.0		11.0	45.0		21.0	21.0		15.0	15.0	15.0
Total Split (%)	42.0%	42.0%		13.6%	55.6%		25.9%	25.9%		18.5%	18.5%	18.5%
Maximum Green (s)	29.0	29.0		6.0	40.0		16.0	16.0		10.0	10.0	10.0
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Walk Time (s)	6.0	6.0					6.0	6.0				
Flash Dont Walk (s)	20.0	20.0					10.0	10.0				
Pedestrian Calls (#/hr)	0	0					0	0				
Act Effct Green (s)		29.0			40.0		16.0	16.0			10.0	10.0
Actuated g/C Ratio		0.36			0.49		0.20	0.20			0.12	0.12
v/c Ratio		0.82			0.97		1.32	1.28			0.53	0.04

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

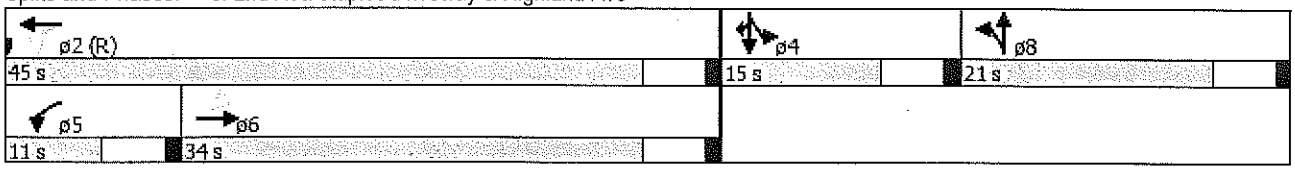
12/10/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Control Delay		30.3			40.6		194.7	175.5			42.6	0.2
Queue Delay		0.0			0.0		0.0	0.0			0.0	0.0
Total Delay		30.3			40.6		194.7	175.5			42.6	0.2
LOS		C			D		F	F			D	A
Approach Delay		30.3			40.6			185.2			38.1	
Approach LOS		C			D			F			D	

Intersection Summary

Area Type: Other
Cycle Length: 81
Actuated Cycle Length: 81
Offset: 0 (0%), Referenced to phase 2:WBTL, Start of Green
Natural Cycle: 90
Control Type: Pretimed
Maximum v/c Ratio: 1.32
Intersection Signal Delay: 79.3 Intersection LOS: E
Intersection Capacity Utilization 94.6% ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

12/10/2013

Lane Group	EBT	WBT	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	941	1060	443	433	119	14
v/c Ratio	0.82	0.97	1.32	1.28	0.53	0.04
Control Delay	30.3	40.6	194.7	175.5	42.6	0.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	30.3	40.6	194.7	175.5	42.6	0.2
Queue Length 50th (ft)	218	193	~310	~290	58	0
Queue Length 95th (ft)	280	#337	#494	#477	98	0
Internal Link Dist (ft)	342	382		392	168	
Turn Bay Length (ft)			50			
Base Capacity (vph)	1144	1094	335	339	225	341
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.82	0.97	1.32	1.28	0.53	0.04

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

12/10/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	735	234	101	688	61	274	17	153	62	24	17
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	0		0
Storage Lanes	0		0	0		0	1		0	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.964			0.989			0.892				0.850
Flt Protected		0.999			0.994		0.950	0.990			0.965	
Satd. Flow (prot)	0	3392	0	0	3484	0	1665	1551	0	0	1834	1615
Flt Permitted		0.934			0.560		0.950	0.990			0.965	
Satd. Flow (perm)	0	3172	0	0	1963	0	1665	1551	0	0	1834	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		57			14			141				162
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.95	0.95	0.95	0.96	0.96	0.96	0.93	0.93	0.93	0.83	0.83	0.83
Heavy Vehicles (%)	0%	3%	1%	2%	2%	0%	3%	0%	3%	0%	0%	0%
Adj. Flow (vph)	16	774	246	105	717	64	295	18	165	75	29	20
Shared Lane Traffic (%)							16%					
Lane Group Flow (vph)	0	1036	0	0	886	0	248	230	0	0	104	20
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway 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
Turning Speed (mph)	15		9	15		9	15		9	15		9
Turn Type	Perm	NA		pm+pt	NA		Split	NA		Split	NA	Prot
Protected Phases		6		5	2		8	8		4	4	4
Permitted Phases	6			2								
Minimum Split (s)	31.0	31.0		9.0	20.0		21.0	21.0		11.0	11.0	11.0
Total Split (s)	34.0	34.0		11.0	45.0		21.0	21.0		15.0	15.0	15.0
Total Split (%)	42.0%	42.0%		13.6%	55.6%		25.9%	25.9%		18.5%	18.5%	18.5%
Maximum Green (s)	29.0	29.0		6.0	40.0		16.0	16.0		10.0	10.0	10.0
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Walk Time (s)	6.0	6.0					6.0	6.0				
Flash Dont Walk (s)	20.0	20.0					10.0	10.0				
Pedestrian Calls (#/hr)	0	0					0	0				
Act Effct Green (s)		29.0			40.0		16.0	16.0			10.0	10.0
Actuated g/C Ratio		0.36			0.49		0.20	0.20			0.12	0.12
v/c Ratio		0.88			0.81		0.76	0.55			0.46	0.06

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

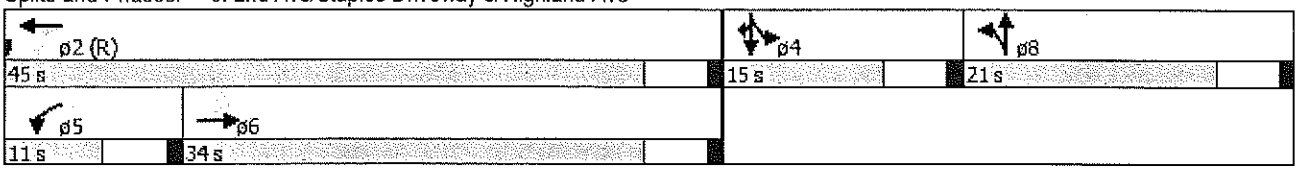
12/10/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Control Delay		33.8			22.9		47.3	17.5			40.3	0.4
Queue Delay		0.0			0.0		0.0	0.0			0.0	0.0
Total Delay		33.8			22.9		47.3	17.5			40.3	0.4
LOS		C			C		D	B			D	A
Approach Delay		33.8			22.9			33.0			33.8	
Approach LOS		C			C			C			C	

Intersection Summary

Area Type: Other
Cycle Length: 81
Actuated Cycle Length: 81
Offset: 0 (0%), Referenced to phase 2:WBTL, Start of Green
Natural Cycle: 75
Control Type: Pretimed
Maximum v/c Ratio: 0.88
Intersection Signal Delay: 29.8 — Intersection LOS: C
Intersection Capacity Utilization 86.5% — ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

12/10/2013

Lane Group	EBT	WBT	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	1036	886	248	230	104	20
v/c Ratio	0.88	0.81	0.76	0.55	0.46	0.06
Control Delay	33.8	22.9	47.3	17.5	40.3	0.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	33.8	22.9	47.3	17.5	40.3	0.4
Queue Length 50th (ft)	242	149	125	41	50	0
Queue Length 95th (ft)	#364	#201	#242	112	90	0
Internal Link Dist (ft)	342	382		392	168	
Turn Bay Length (ft)			50			
Base Capacity (vph)	1172	1089	328	419	226	341
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.88	0.81	0.76	0.55	0.46	0.06

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	4	942	179	198	549	8	416	11	108	24	10	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	0		0
Storage Lanes	0		0	0		0	1		0	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.976			0.998			0.938				
Flt Protected					0.987		0.950	0.974			0.966	
Satd. Flow (prot)	0	3399	0	0	3453	0	1618	1560	0	0	1738	1900
Flt Permitted		0.953			0.528		0.950	0.974			0.966	
Satd. Flow (perm)	0	3239	0	0	1847	0	1618	1560	0	0	1738	1900
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		27			2			34				
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.93	0.93	0.93	0.90	0.90	0.90	0.94	0.94	0.94	0.85	0.85	0.85
Heavy Vehicles (%)	0%	4%	2%	3%	3%	0%	6%	0%	6%	8%	0%	0%
Adj. Flow (vph)	4	1013	192	220	610	9	443	12	115	28	12	0
Shared Lane Traffic (%)							34%					
Lane Group Flow (vph)	0	1209	0	0	839	0	292	278	0	0	40	0
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway 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
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2		1	2		1	2		1	2	1
Detector Template	Left	Thru		Left	Thru		Left	Thru		Left	Thru	Right
Leading Detector (ft)	20	100		20	100		20	100		20	100	20
Trailing Detector (ft)	0	0		0	0		0	0		0	0	0
Detector 1 Position(ft)	0	0		0	0		0	0		0	0	0
Detector 1 Size(ft)	20	6		20	6		20	6		20	6	20
Detector 1 Type	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	Cl+Ex
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Queue (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Delay (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA		pm+pt	NA		Split	NA		Split	NA	Prot
Protected Phases		6		5	2		8	8		4	4	4
Permitted Phases	6			2								

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

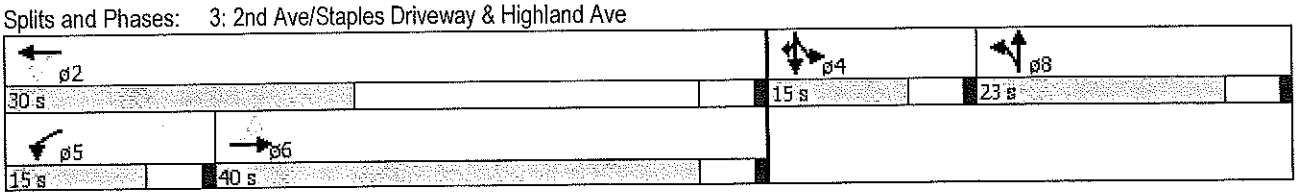
12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Detector Phase	6	6		5	2		8	8		4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		4.0	15.0		6.0	6.0		6.0	6.0	6.0
Minimum Split (s)	31.0	31.0		9.0	20.0		22.0	22.0		11.0	11.0	11.0
Total Split (s)	40.0	40.0		15.0	30.0		23.0	23.0		15.0	15.0	15.0
Total Split (%)	43.0%	43.0%		16.1%	32.3%		24.7%	24.7%		16.1%	16.1%	16.1%
Maximum Green (s)	35.0	35.0		10.0	25.0		18.0	18.0		10.0	10.0	10.0
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	2.0	2.0		2.0	2.0		3.0	3.0		2.0	2.0	2.0
Recall Mode	Min	Min		None	Min		None	None		None	None	None
Walk Time (s)	6.0	6.0					6.0	6.0				
Flash Dont Walk (s)	20.0	20.0					10.0	10.0				
Pedestrian Calls (#/hr)	0	0					0	0				
Act Effct Green (s)		32.2			32.2		17.6	17.6			6.8	
Actuated g/C Ratio		0.48			0.48		0.26	0.26			0.10	
v/c Ratio		0.77			1.96dl		0.68	0.63			0.23	
Control Delay		18.9			38.5		34.7	29.3			34.4	
Queue Delay		0.0			0.0		0.0	0.0			0.0	
Total Delay		18.9			38.5		34.7	29.3			34.4	
LOS		B			D		C	C			C	
Approach Delay		18.9			38.5			32.1			34.4	
Approach LOS		B			D			C			C	

Intersection Summary

Area Type: Other
Cycle Length: 93
Actuated Cycle Length: 66.5
Natural Cycle: 75
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 28.1 — Intersection LOS: C
Intersection Capacity Utilization 87.3% — ICU Level of Service E
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

12/5/2013

Lane Group	EBT	WBT	NBL	NBT	SBT
Lane Group Flow (vph)	1209	839	292	278	40
v/c Ratio	0.77	1.96dl	0.68	0.63	0.23
Control Delay	18.9	38.5	34.7	29.3	34.4
Queue Delay	0.0	0.0	0.0	0.0	0.0
Total Delay	18.9	38.5	34.7	29.3	34.4
Queue Length 50th (ft)	227	185	130	107	18
Queue Length 95th (ft)	328	#333	#260	#221	43
Internal Link Dist (ft)	342	382		392	168
Turn Bay Length (ft)			50		
Base Capacity (vph)	1767	1429	451	459	269
Starvation Cap Reductn	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	0.68	0.59	0.65	0.61	0.15

Intersection Summary

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	19	673	126	121	863	34	740	13	97	76	20	11
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	0		0
Storage Lanes	0		0	0		0	1		0	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.977			0.995			0.965				0.850
Flt Protected		0.999			0.994		0.950	0.964			0.962	
Satd. Flow (prot)	0	3452	0	0	3529	0	1698	1652	0	0	1828	1615
Flt Permitted		0.907			0.589		0.950	0.964			0.962	
Satd. Flow (perm)	0	3134	0	0	2091	0	1698	1652	0	0	1828	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		22			4			15				128
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.87	0.87	0.87	0.96	0.96	0.96	0.97	0.97	0.97	0.81	0.81	0.81
Heavy Vehicles (%)	5%	2%	2%	2%	1%	3%	1%	0%	4%	0%	0%	0%
Adj. Flow (vph)	22	774	145	126	899	35	763	13	100	94	25	14
Shared Lane Traffic (%)							42%					
Lane Group Flow (vph)	0	941	0	0	1060	0	443	433	0	0	119	14
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway 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
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2		1	2		1	2		1	2	1
Detector Template	Left	Thru		Left	Thru		Left	Thru		Left	Thru	Right
Leading Detector (ft)	20	100		20	100		20	100		20	100	20
Trailing Detector (ft)	0	0		0	0		0	0		0	0	0
Detector 1 Position(ft)	0	0		0	0		0	0		0	0	0
Detector 1 Size(ft)	20	6		20	6		20	6		20	6	20
Detector 1 Type	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	Cl+Ex
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Queue (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Delay (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA		pm+pt	NA		Split	NA		Split	NA	Prot
Protected Phases		6		5	2		8	8		4	4	4
Permitted Phases	6			2								

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

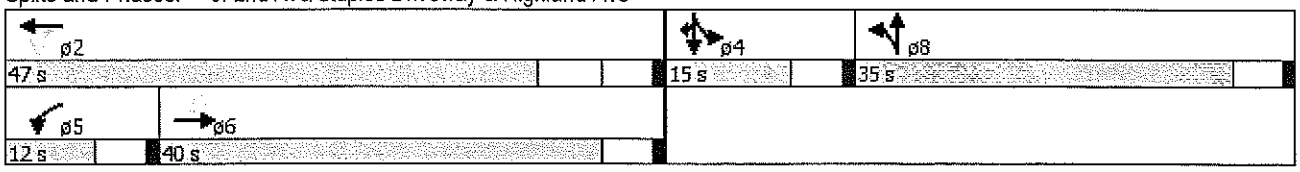
12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Detector Phase	6	6		5	2		8	8		4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		4.0	15.0		6.0	6.0		6.0	6.0	6.0
Minimum Split (s)	31.0	31.0		9.0	20.0		22.0	22.0		11.0	11.0	11.0
Total Split (s)	40.0	40.0		12.0	47.0		35.0	35.0		15.0	15.0	15.0
Total Split (%)	39.2%	39.2%		11.8%	46.1%		34.3%	34.3%		14.7%	14.7%	14.7%
Maximum Green (s)	35.0	35.0		7.0	42.0		30.0	30.0		10.0	10.0	10.0
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	2.0	2.0		2.0	2.0		3.0	3.0		2.0	2.0	2.0
Recall Mode	Min	Min		None	Min		None	None		None	None	None
Walk Time (s)	6.0	6.0					6.0	6.0				
Flash Dont Walk (s)	20.0	20.0					10.0	10.0				
Pedestrian Calls (#/hr)	0	0					0	0				
Act Effct Green (s)		42.1			42.1		28.4	28.4			9.1	9.1
Actuated g/C Ratio		0.45			0.45		0.30	0.30			0.10	0.10
v/c Ratio		0.67			1.14		0.87	0.86			0.68	0.05
Control Delay		23.7			102.4		50.6	48.0			61.9	0.4
Queue Delay		0.0			0.0		0.0	0.0			0.0	0.0
Total Delay		23.7			102.4		50.6	48.0			61.9	0.4
LOS		C			F		D	D			E	A
Approach Delay		23.7			102.4			49.3			55.4	
Approach LOS		C			F			D			E	

Intersection Summary

Area Type: Other
Cycle Length: 102
Actuated Cycle Length: 94.6
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.14
Intersection Signal Delay: 60.3 — Intersection LOS: E
Intersection Capacity Utilization 94.6% — ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

12/5/2013

Lane Group	EBT	WBT	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	941	1060	443	433	119	14
v/c Ratio	0.67	1.14	0.87	0.86	0.68	0.05
Control Delay	23.7	102.4	50.6	48.0	61.9	0.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	23.7	102.4	50.6	48.0	61.9	0.4
Queue Length 50th (ft)	234	~413	267	251	72	0
Queue Length 95th (ft)	291	#543	#444	#426	116	0
Internal Link Dist (ft)	342	382		392	168	
Turn Bay Length (ft)			50			
Base Capacity (vph)	1406	1043	539	535	193	285
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.67	1.02	0.82	0.81	0.62	0.05

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	15	735	234	101	688	61	274	17	153	62	24	17
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	0		0
Storage Lanes	0		0	0		0	1		0	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.964			0.989			0.892				0.850
Flt Protected		0.999			0.994		0.950	0.990			0.965	
Satd. Flow (prot)	0	3392	0	0	3484	0	1665	1551	0	0	1834	1615
Flt Permitted		0.936			0.631		0.950	0.990			0.965	
Satd. Flow (perm)	0	3179	0	0	2212	0	1665	1551	0	0	1834	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		57			14			141				162
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.95	0.95	0.95	0.96	0.96	0.96	0.93	0.93	0.93	0.83	0.83	0.83
Heavy Vehicles (%)	0%	3%	1%	2%	2%	0%	3%	0%	3%	0%	0%	0%
Adj. Flow (vph)	16	774	246	105	717	64	295	18	165	75	29	20
Shared Lane Traffic (%)							16%					
Lane Group Flow (vph)	0	1036	0	0	886	0	248	230	0	0	104	20
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway 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
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2		1	2		1	2		1	2	1
Detector Template	Left	Thru		Left	Thru		Left	Thru		Left	Thru	Right
Leading Detector (ft)	20	100		20	100		20	100		20	100	20
Trailing Detector (ft)	0	0		0	0		0	0		0	0	0
Detector 1 Position(ft)	0	0		0	0		0	0		0	0	0
Detector 1 Size(ft)	20	6		20	6		20	6		20	6	20
Detector 1 Type	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	Cl+Ex
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Queue (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Delay (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA		pm+pt	NA		Split	NA		Split	NA	Prot
Protected Phases		6		5	2		8	8		4	4	4
Permitted Phases	6			2								

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

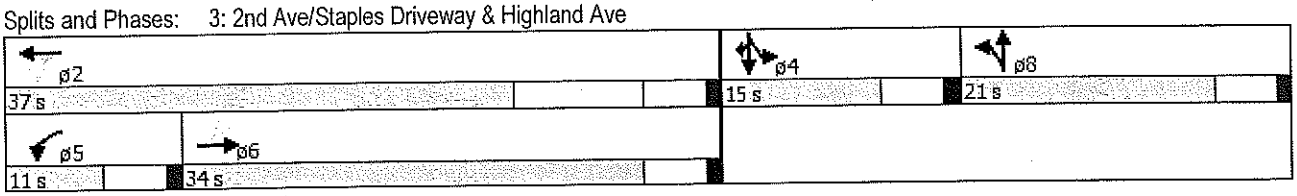
12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Detector Phase	6	6		5	2		8	8		4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		4.0	15.0		6.0	6.0		6.0	6.0	6.0
Minimum Split (s)	31.0	31.0		9.0	20.0		21.0	21.0		11.0	11.0	11.0
Total Split (s)	34.0	34.0		11.0	37.0		21.0	21.0		15.0	15.0	15.0
Total Split (%)	42.0%	42.0%		13.6%	45.7%		25.9%	25.9%		18.5%	18.5%	18.5%
Maximum Green (s)	29.0	29.0		6.0	32.0		16.0	16.0		10.0	10.0	10.0
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	2.0	2.0		2.0	2.0		3.0	3.0		2.0	2.0	2.0
Recall Mode	Min	Min		None	Min		None	None		None	None	None
Walk Time (s)	6.0	6.0					6.0	6.0				
Flash Dont Walk (s)	20.0	20.0					10.0	10.0				
Pedestrian Calls (#/hr)	0	0					0	0				
Act Effct Green (s)		29.2			29.2		14.4	14.4			8.4	8.4
Actuated g/C Ratio		0.45			0.45		0.22	0.22			0.13	0.13
v/c Ratio		0.70			0.88		0.66	0.50			0.43	0.06
Control Delay		17.4			29.3		35.7	15.1			35.2	0.3
Queue Delay		0.0			0.0		0.0	0.0			0.0	0.0
Total Delay		17.4			29.3		35.7	15.1			35.2	0.3
LOS		B			C		D	B			D	A
Approach Delay		17.4			29.3			25.8			29.6	
Approach LOS		B			C			C			C	

Intersection Summary

Area Type: Other
Cycle Length: 81
Actuated Cycle Length: 64.3
Natural Cycle: 75
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.88
Intersection Signal Delay: 23.8 — Intersection LOS: C
Intersection Capacity Utilization 86.5% — ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

12/5/2013

Lane Group	EBT	WBT	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	1036	886	248	230	104	20
v/c Ratio	0.70	0.88	0.66	0.50	0.43	0.06
Control Delay	17.4	29.3	35.7	15.1	35.2	0.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	17.4	29.3	35.7	15.1	35.2	0.3
Queue Length 50th (ft)	175	177	105	33	44	0
Queue Length 95th (ft)	255	#311	#206	101	81	0
Internal Link Dist (ft)	342	382		392	168	
Turn Bay Length (ft)			50			
Base Capacity (vph)	1676	1442	445	518	306	405
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.62	0.61	0.56	0.44	0.34	0.05

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	4	990	188	208	577	9	437	12	114	25	11	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	0		0
Storage Lanes	0		0	0		0	1		0	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.976			0.998			0.938				0.850
Flt Protected					0.987		0.950	0.974			0.967	
Satd. Flow (prot)	0	3399	0	0	3454	0	1618	1560	0	0	1741	1615
Flt Permitted		0.953			0.524		0.950	0.974			0.967	
Satd. Flow (perm)	0	3239	0	0	1833	0	1618	1560	0	0	1741	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		27			2			34				141
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.93	0.93	0.93	0.90	0.90	0.90	0.94	0.94	0.94	0.85	0.85	0.85
Heavy Vehicles (%)	0%	4%	2%	3%	3%	0%	6%	0%	6%	8%	0%	0%
Adj. Flow (vph)	4	1065	202	231	641	10	465	13	121	29	13	1
Shared Lane Traffic (%)							34%					
Lane Group Flow (vph)	0	1271	0	0	882	0	307	292	0	0	42	1
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway 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
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2		1	2		1	2		1	2	1
Detector Template	Left	Thru		Left	Thru		Left	Thru		Left	Thru	Right
Leading Detector (ft)	20	100		20	100		20	100		20	100	20
Trailing Detector (ft)	0	0		0	0		0	0		0	0	0
Detector 1 Position(ft)	0	0		0	0		0	0		0	0	0
Detector 1 Size(ft)	20	6		20	6		20	6		20	6	20
Detector 1 Type	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	Cl+Ex
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Queue (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Delay (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA		pm+pt	NA		Split	NA		Split	NA	Prot
Protected Phases		6		5	2		8	8		4	4	4
Permitted Phases	6			2								

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

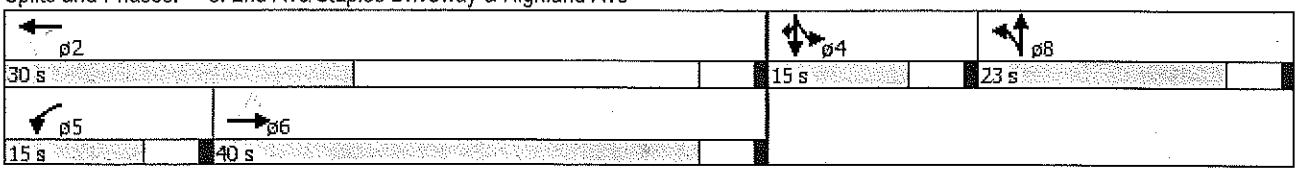
12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Detector Phase	6	6		5	2		8	8		4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		4.0	15.0		6.0	6.0		6.0	6.0	6.0
Minimum Split (s)	31.0	31.0		9.0	20.0		22.0	22.0		11.0	11.0	11.0
Total Split (s)	40.0	40.0		15.0	30.0		23.0	23.0		15.0	15.0	15.0
Total Split (%)	43.0%	43.0%		16.1%	32.3%		24.7%	24.7%		16.1%	16.1%	16.1%
Maximum Green (s)	35.0	35.0		10.0	25.0		18.0	18.0		10.0	10.0	10.0
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	2.0	2.0		2.0	2.0		3.0	3.0		2.0	2.0	2.0
Recall Mode	Min	Min		None	Min		None	None		None	None	None
Walk Time (s)	6.0	6.0					6.0	6.0				
Flash Dont Walk (s)	20.0	20.0					10.0	10.0				
Pedestrian Calls (#/hr)	0	0					0	0				
Act Effct Green (s)		35.3			35.3		18.1	18.1			6.8	6.8
Actuated g/C Ratio		0.50			0.50		0.26	0.26			0.10	0.10
v/c Ratio		0.78			2.20dl		0.74	0.68			0.25	0.00
Control Delay		19.6			42.4		38.4	32.1			35.1	0.0
Queue Delay		0.0			0.0		0.0	0.0			0.0	0.0
Total Delay		19.6			42.4		38.4	32.1			35.1	0.0
LOS		B			D		D	C			D	A
Approach Delay		19.6			42.4			35.3			34.3	
Approach LOS		B			D			D			C	

Intersection Summary

Area Type: Other
Cycle Length: 93
Actuated Cycle Length: 70.4
Natural Cycle: 80
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.96
Intersection Signal Delay: 30.4 — Intersection LOS: C
Intersection Capacity Utilization 90.8% — ICU Level of Service E
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

12/5/2013

Lane Group	EBT	WBT	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	1271	882	307	292	42	1
v/c Ratio	0.78	2.20dl	0.74	0.68	0.25	0.00
Control Delay	19.6	42.4	38.4	32.1	35.1	0.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	19.6	42.4	38.4	32.1	35.1	0.0
Queue Length 50th (ft)	247	~214	138	114	19	0
Queue Length 95th (ft)	#363	#361	#281	#242	45	0
Internal Link Dist (ft)	342	382		392	168	
Turn Bay Length (ft)			50			
Base Capacity (vph)	1637	1313	417	427	249	351
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.78	0.67	0.74	0.68	0.17	0.00

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	707	132	127	907	36	778	14	102	80	21	13
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	0		0
Storage Lanes	0		0	0		0	1		0	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.977			0.995			0.965				0.850
Flt Protected		0.999			0.994		0.950	0.964			0.962	
Satd. Flow (prot)	0	3452	0	0	3529	0	1698	1652	0	0	1828	1615
Flt Permitted		0.875			0.568		0.950	0.964			0.962	
Satd. Flow (perm)	0	3024	0	0	2016	0	1698	1652	0	0	1828	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		22			5			15				128
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.87	0.87	0.87	0.96	0.96	0.96	0.97	0.97	0.97	0.81	0.81	0.81
Heavy Vehicles (%)	5%	2%	2%	2%	1%	3%	1%	0%	4%	0%	0%	0%
Adj. Flow (vph)	23	813	152	132	945	38	802	14	105	99	26	16
Shared Lane Traffic (%)							42%					
Lane Group Flow (vph)	0	988	0	0	1115	0	465	456	0	0	125	16
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway 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
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2		1	2		1	2		1	2	1
Detector Template	Left	Thru		Left	Thru		Left	Thru		Left	Thru	Right
Leading Detector (ft)	20	100		20	100		20	100		20	100	20
Trailing Detector (ft)	0	0		0	0		0	0		0	0	0
Detector 1 Position(ft)	0	0		0	0		0	0		0	0	0
Detector 1 Size(ft)	20	6		20	6		20	6		20	6	20
Detector 1 Type	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	Cl+Ex
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Queue (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Delay (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA		pm+pt	NA		Split	NA		Split	NA	Prot
Protected Phases		6		5	2		8	8		4	4	4
Permitted Phases	6			2								

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

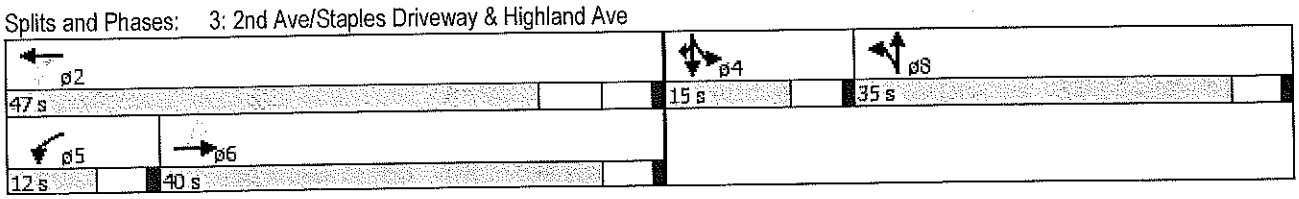
12/3/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Detector Phase	6	6		5	2		8	8		4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		4.0	15.0		6.0	6.0		6.0	6.0	6.0
Minimum Split (s)	31.0	31.0		9.0	20.0		22.0	22.0		11.0	11.0	11.0
Total Split (s)	40.0	40.0		12.0	47.0		35.0	35.0		15.0	15.0	15.0
Total Split (%)	39.2%	39.2%		11.8%	46.1%		34.3%	34.3%		14.7%	14.7%	14.7%
Maximum Green (s)	35.0	35.0		7.0	42.0		30.0	30.0		10.0	10.0	10.0
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	2.0	2.0		2.0	2.0		3.0	3.0		2.0	2.0	2.0
Recall Mode	Min	Min		None	Min		None	None		None	None	None
Walk Time (s)	6.0	6.0					6.0	6.0				
Flash Dont Walk (s)	20.0	20.0					10.0	10.0				
Pedestrian Calls (#/hr)	0	0					0	0				
Act Effct Green (s)		42.1			42.1		29.1	29.1			9.2	9.2
Actuated g/C Ratio		0.44			0.44		0.31	0.31			0.10	0.10
v/c Ratio		0.73			1.25		0.90	0.89			0.71	0.06
Control Delay		25.9			149.2		54.3	51.8			64.4	0.4
Queue Delay		0.0			0.0		0.0	0.0			0.0	0.0
Total Delay		25.9			149.2		54.3	51.8			64.4	0.4
LOS		C			F		D	D			E	A
Approach Delay		25.9			149.2			53.0			57.1	
Approach LOS		C			F			D			E	

Intersection Summary

Area Type: Other
Cycle Length: 102
Actuated Cycle Length: 95.4
Natural Cycle: 100
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.25
Intersection Signal Delay: 78.6 — Intersection LOS: E
Intersection Capacity Utilization 98.4% — ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

12/5/2013

Lane Group	EBT	WBT	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	988	1115	465	456	125	16
v/c Ratio	0.73	1.25	0.90	0.89	0.71	0.06
Control Delay	25.9	149.2	54.3	51.8	64.4	0.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.9	149.2	54.3	51.8	64.4	0.4
Queue Length 50th (ft)	256	~463	285	270	76	0
Queue Length 95th (ft)	317	#595	#476	#461	#123	0
Internal Link Dist (ft)	342	382		392	168	
Turn Bay Length (ft)			50			
Base Capacity (vph)	1345	997	534	530	191	284
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.73	1.12	0.87	0.86	0.65	0.06

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

12/5/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	16	773	246	106	723	64	288	18	161	65	25	18
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	50		0	0		0
Storage Lanes	0		0	0		0	1		0	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.964			0.989			0.893				0.850
Flt Protected		0.999			0.994		0.950	0.990			0.965	
Satd. Flow (prot)	0	3392	0	0	3484	0	1665	1553	0	0	1834	1615
Flt Permitted		0.934			0.608		0.950	0.990			0.965	
Satd. Flow (perm)	0	3172	0	0	2131	0	1665	1553	0	0	1834	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		57			14			139				162
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.95	0.95	0.95	0.96	0.96	0.96	0.93	0.93	0.93	0.83	0.83	0.83
Heavy Vehicles (%)	0%	3%	1%	2%	2%	0%	3%	0%	3%	0%	0%	0%
Adj. Flow (vph)	17	814	259	110	753	67	310	19	173	78	30	22
Shared Lane Traffic (%)							16%					
Lane Group Flow (vph)	0	1090	0	0	930	0	260	242	0	0	108	22
Enter Blocked Intersection	No	No	No	No	No	No	No	No	No	No	No	No
Lane Alignment	Left	Left	Right	Left	Left	Right	Left	Left	Right	Left	Left	Right
Median Width(ft)		0			0			12			12	
Link Offset(ft)		0			0			0			0	
Crosswalk Width(ft)		16			16			16			16	
Two way Left Turn Lane												
Headway 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
Turning Speed (mph)	15		9	15		9	15		9	15		9
Number of Detectors	1	2		1	2		1	2		1	2	1
Detector Template	Left	Thru		Left	Thru		Left	Thru		Left	Thru	Right
Leading Detector (ft)	20	100		20	100		20	100		20	100	20
Trailing Detector (ft)	0	0		0	0		0	0		0	0	0
Detector 1 Position(ft)	0	0		0	0		0	0		0	0	0
Detector 1 Size(ft)	20	6		20	6		20	6		20	6	20
Detector 1 Type	Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex		Cl+Ex	Cl+Ex	Cl+Ex
Detector 1 Channel												
Detector 1 Extend (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Queue (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 1 Delay (s)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	0.0
Detector 2 Position(ft)		94			94			94			94	
Detector 2 Size(ft)		6			6			6			6	
Detector 2 Type		Cl+Ex			Cl+Ex			Cl+Ex			Cl+Ex	
Detector 2 Channel												
Detector 2 Extend (s)		0.0			0.0			0.0			0.0	
Turn Type	Perm	NA		pm+pt	NA		Split	NA		Split	NA	Prot
Protected Phases		6		5	2		8	8		4	4	4
Permitted Phases	6			2								

Lanes, Volumes, Timings
3: 2nd Ave/Staples Driveway & Highland Ave

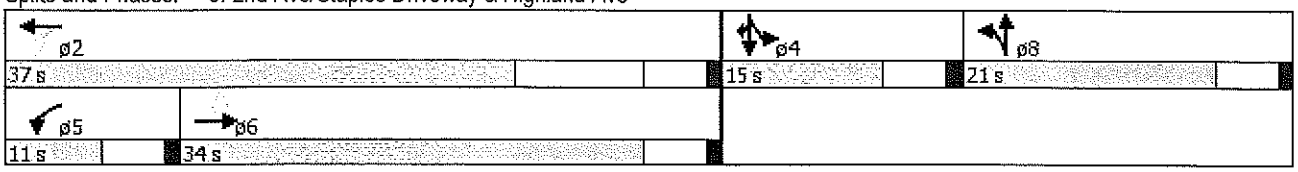
12/5/2013

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Detector Phase	6	6		5	2		8	8		4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		4.0	15.0		6.0	6.0		6.0	6.0	6.0
Minimum Split (s)	31.0	31.0		9.0	20.0		21.0	21.0		11.0	11.0	11.0
Total Split (s)	34.0	34.0		11.0	37.0		21.0	21.0		15.0	15.0	15.0
Total Split (%)	42.0%	42.0%		13.6%	45.7%		25.9%	25.9%		18.5%	18.5%	18.5%
Maximum Green (s)	29.0	29.0		6.0	32.0		16.0	16.0		10.0	10.0	10.0
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Vehicle Extension (s)	2.0	2.0		2.0	2.0		3.0	3.0		2.0	2.0	2.0
Recall Mode	Min	Min		None	Min		None	None		None	None	None
Walk Time (s)	6.0	6.0					6.0	6.0				
Flash Dont Walk (s)	20.0	20.0					10.0	10.0				
Pedestrian Calls (#/hr)	0	0					0	0				
Act Effct Green (s)		30.1			30.1		14.6	14.6			8.4	8.4
Actuated g/C Ratio		0.46			0.46		0.22	0.22			0.13	0.13
v/c Ratio		0.73			0.94		0.70	0.53			0.46	0.06
Control Delay		18.4			38.0		37.6	16.4			36.1	0.3
Queue Delay		0.0			0.0		0.0	0.0			0.0	0.0
Total Delay		18.4			38.0		37.6	16.4			36.1	0.3
LOS		B			D		D	B			D	A
Approach Delay		18.4			38.0			27.4			30.0	
Approach LOS		B			D			C			C	

Intersection Summary

Area Type: Other
Cycle Length: 81
Actuated Cycle Length: 65.4
Natural Cycle: 75
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.94
Intersection Signal Delay: 27.5 — Intersection LOS: C
Intersection Capacity Utilization 89.8% — ICU Level of Service E
Analysis Period (min) 15

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

12/5/2013

Lane Group	EBT	WBT	NBL	NBT	SBT	SBR
Lane Group Flow (vph)	1090	930	260	242	108	22
v/c Ratio	0.73	0.94	0.70	0.53	0.46	0.06
Control Delay	18.4	38.0	37.6	16.4	36.1	0.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	18.4	38.0	37.6	16.4	36.1	0.3
Queue Length 50th (ft)	190	198	111	40	45	0
Queue Length 95th (ft)	276	#345	#221	111	83	0
Internal Link Dist (ft)	342	382		392	168	
Turn Bay Length (ft)			50			
Base Capacity (vph)	1613	1375	427	502	294	395
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.68	0.68	0.61	0.48	0.37	0.06

Intersection Summary

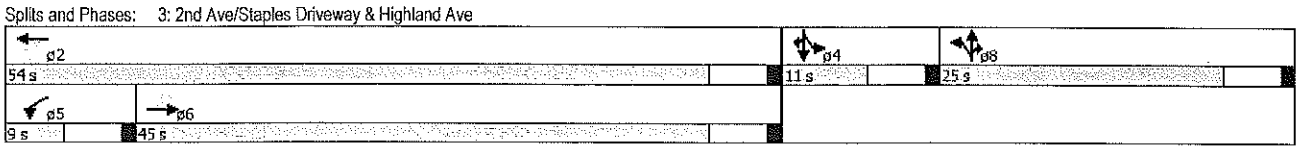
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	4	990	188	208	577	9	437	12	114	25	11	1
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	200		125	0		0
Storage Lanes	0		0	0		0	1		1	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.976			0.998				0.850			0.850
Flt Protected					0.987		0.950	0.955			0.967	
Satd. Flow (prot)	0	3399	0	0	3454	0	1618	1631	1524	0	1741	1615
Flt Permitted		0.953			0.518		0.950	0.955			0.967	
Satd. Flow (perm)	0	3239	0	0	1812	0	1618	1631	1524	0	1741	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		31			2				145			145
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.93	0.93	0.93	0.90	0.90	0.90	0.94	0.94	0.94	0.85	0.85	0.85
Heavy Vehicles (%)	0%	4%	2%	3%	3%	0%	6%	0%	6%	8%	0%	0%
Adj. Flow (vph)	4	1065	202	231	641	10	465	13	121	29	13	1
Shared Lane Traffic (%)							49%					
Lane Group Flow (vph)	0	1271	0	0	882	0	237	241	121	0	42	1
Turn Type	Perm	NA		pm+pt	NA		Split	NA	Prot	Split	NA	Prot
Protected Phases		6		5	2		8	8	8	4	4	4
Permitted Phases	6			2								
Detector Phase	6	6		5	2		8	8	8	4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		4.0	15.0		6.0	6.0	6.0	6.0	6.0	6.0
Minimum Split (s)	31.0	31.0		9.0	20.0		22.0	22.0	22.0	11.0	11.0	11.0
Total Split (s)	45.0	45.0		9.0	54.0		25.0	25.0	25.0	11.0	11.0	11.0
Total Split (%)	50.0%	50.0%		10.0%	60.0%		27.8%	27.8%	27.8%	12.2%	12.2%	12.2%
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0	5.0		5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Recall Mode	Min	Min		None	Min		None	None	None	None	None	None
Act Effct Green (s)		38.4			38.4		16.2	16.2	16.2		6.8	6.8
Actuated g/C Ratio		0.54			0.54		0.23	0.23	0.23		0.10	0.10
v/c Ratio		0.72			1.75dl		0.64	0.65	0.26		0.25	0.00
Control Delay		15.7			30.4		38.3	38.4	5.3		43.1	0.0
Queue Delay		0.0			0.0		0.0	0.0	0.0		0.0	0.0
Total Delay		15.7			30.4		38.3	38.4	5.3		43.1	0.0
LOS		B			C		D	D	A		D	A
Approach Delay		15.7			30.4			31.7			42.1	
Approach LOS		B			C			C			D	

Intersection Summary

Area Type: Other
Cycle Length: 90
Actuated Cycle Length: 71.3
Natural Cycle: 80
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 24.2 Intersection LOS: C
Intersection Capacity Utilization 87.3% ICU Level of Service E
Analysis Period (min) 15
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Lane Group	EBT	WBT	NBL	NBT	NBR	SBT	SBR
Lane Group Flow (vph)	1271	882	237	241	121	42	1
v/c Ratio	0.72	1.75dl	0.64	0.65	0.26	0.25	0.00
Control Delay	15.7	30.4	38.3	38.4	5.3	43.1	0.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	15.7	30.4	38.3	38.4	5.3	43.1	0.0
Queue Length 50th (ft)	253	213	128	130	0	23	0
Queue Length 95th (ft)	340	#364	214	#218	31	53	0
Internal Link Dist (ft)	342	382		392		168	
Turn Bay Length (ft)			200		125		
Base Capacity (vph)	2234	1314	516	520	584	166	285
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.57	0.67	0.46	0.46	0.21	0.25	0.00

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

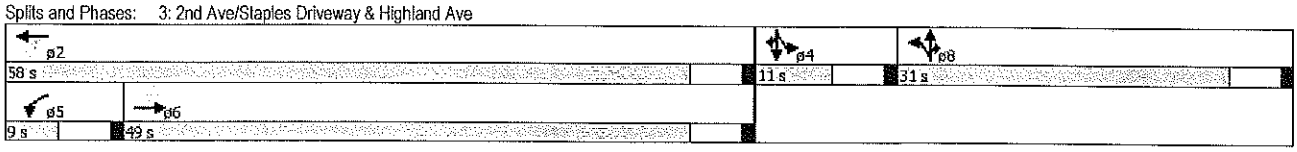
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	20	707	132	127	907	36	778	14	102	80	21	13
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	200		125	0		0
Storage Lanes	0		0	0		0	1		1	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.977			0.995				0.850			0.850
Flt Protected		0.999			0.994		0.950	0.954			0.962	
Satd. Flow (prot)	0	3452	0	0	3529	0	1698	1706	1553	0	1828	1615
Flt Permitted		0.907			0.606		0.950	0.954			0.962	
Satd. Flow (perm)	0	3134	0	0	2151	0	1698	1706	1553	0	1828	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		27			5				131			131
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.87	0.87	0.87	0.96	0.96	0.96	0.97	0.97	0.97	0.81	0.81	0.81
Heavy Vehicles (%)	5%	2%	2%	2%	1%	3%	1%	0%	4%	0%	0%	0%
Adj. Flow (vph)	23	813	152	132	945	38	802	14	105	99	26	16
Shared Lane Traffic (%)							49%					
Lane Group Flow (vph)	0	988	0	0	1115	0	409	407	105	0	125	16
Turn Type	Perm	NA		pm+pt	NA		Split	NA	Prot	Split	NA	Prot
Protected Phases		6		5	2		8	8	8	4	4	4
Permitted Phases	6			2								
Detector Phase	6	6		5	2		8	8	8	4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		4.0	15.0		6.0	6.0	6.0	6.0	6.0	6.0
Minimum Split (s)	31.0	31.0		9.0	20.0		22.0	22.0	22.0	11.0	11.0	11.0
Total Split (s)	49.0	49.0		9.0	58.0		31.0	31.0	31.0	11.0	11.0	11.0
Total Split (%)	49.0%	49.0%		9.0%	58.0%		31.0%	31.0%	31.0%	11.0%	11.0%	11.0%
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0	5.0		5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Recall Mode	Min	Min		None	Min		None	None	None	None	None	None
Act Effct Green (s)		53.0			53.0		25.6	25.6	25.6		6.0	6.0
Actuated g/C Ratio		0.53			0.53		0.26	0.26	0.26		0.06	0.06
v/c Ratio		0.59			0.97		0.94	0.93	0.21		1.15	0.07
Control Delay		17.2			44.6		67.6	65.8	4.2		173.5	0.6
Queue Delay		0.0			0.0		0.0	0.0	0.0		0.0	0.0
Total Delay		17.2			44.6		67.6	65.8	4.2		173.5	0.6
LOS		B			D		E	E	A		F	A
Approach Delay		17.2			44.6			59.6			153.9	
Approach LOS		B			D			E			F	

Intersection Summary

Area Type: Other
Cycle Length: 100
Actuated Cycle Length: 99.6
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.15
Intersection Signal Delay: 45.3 — Intersection LOS: D
Intersection Capacity Utilization 95.3% — ICU Level of Service F
Analysis Period (min) 15

Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Queues
3: 2nd Ave/Staples Driveway & Highland Ave

Lane Group	EBT	WBT	NBL	NBT	NBR	SBT	SBR
Lane Group Flow (vph)	988	1115	409	407	105	125	16
v/c Ratio	0.59	0.97	0.94	0.93	0.21	1.15	0.07
Control Delay	17.2	44.6	67.6	65.8	4.2	173.5	0.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	17.2	44.6	67.6	65.8	4.2	173.5	0.6
Queue Length 50th (ft)	209	345	267	266	0	~94	0
Queue Length 95th (ft)	257	#513	#460	#453	26	#180	0
Internal Link Dist (ft)	342	382		392		168	
Turn Bay Length (ft)			200		125		
Base Capacity (vph)	1679	1146	443	445	501	109	220
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.59	0.97	0.92	0.91	0.21	1.15	0.07

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

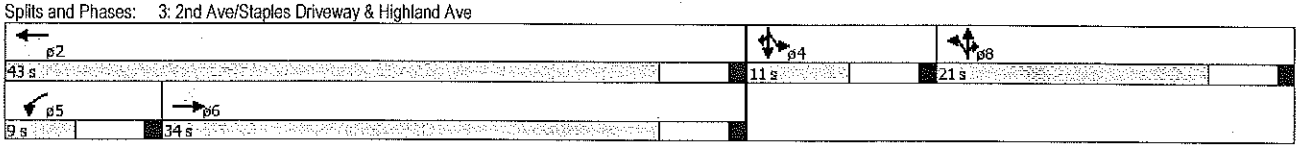
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	16	773	246	106	723	64	288	18	161	65	25	18
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Storage Length (ft)	0		0	0		0	200		125	0		0
Storage Lanes	0		0	0		0	1		1	0		1
Taper Length (ft)	25			25			25			25		
Lane Util. Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00	1.00	1.00
Frt		0.964			0.989				0.850			0.850
Flt Protected		0.999			0.994		0.950	0.958			0.965	
Satd. Flow (prot)	0	3392	0	0	3484	0	1665	1684	1568	0	1834	1615
Flt Permitted		0.935			0.645		0.950	0.958			0.965	
Satd. Flow (perm)	0	3175	0	0	2261	0	1665	1684	1568	0	1834	1615
Right Turn on Red			Yes			Yes			Yes			Yes
Satd. Flow (RTOR)		64			15				175			175
Link Speed (mph)		30			30			30			30	
Link Distance (ft)		422			462			472			248	
Travel Time (s)		9.6			10.5			10.7			5.6	
Peak Hour Factor	0.95	0.95	0.95	0.96	0.96	0.96	0.93	0.93	0.93	0.83	0.83	0.83
Heavy Vehicles (%)	0%	3%	1%	2%	2%	0%	3%	0%	3%	0%	0%	0%
Adj. Flow (vph)	17	814	259	110	753	67	310	19	173	78	30	22
Shared Lane Traffic (%)							47%					
Lane Group Flow (vph)	0	1090	0	0	930	0	164	165	173	0	108	22
Turn Type	Perm	NA		pm+pt	NA		Split	NA	Prot	Split	NA	Prot
Protected Phases		6		5	2		8	8	8	4	4	4
Permitted Phases	6			2								
Detector Phase	6	6		5	2		8	8	8	4	4	4
Switch Phase												
Minimum Initial (s)	15.0	15.0		4.0	15.0		6.0	6.0	6.0	6.0	6.0	6.0
Minimum Split (s)	31.0	31.0		9.0	20.0		21.0	21.0	21.0	11.0	11.0	11.0
Total Split (s)	34.0	34.0		9.0	43.0		21.0	21.0	21.0	11.0	11.0	11.0
Total Split (%)	45.3%	45.3%		12.0%	57.3%		28.0%	28.0%	28.0%	14.7%	14.7%	14.7%
Yellow Time (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)		0.0			0.0		0.0	0.0	0.0		0.0	0.0
Total Lost Time (s)		5.0			5.0		5.0	5.0	5.0		5.0	5.0
Lead/Lag	Lag	Lag		Lead								
Lead-Lag Optimize?	Yes	Yes		Yes								
Recall Mode	Min	Min		None	Min		None	None	None	None	None	None
Act Effct Green (s)		33.9			33.9		12.3	12.3	12.3		6.4	6.4
Actuated g/C Ratio		0.52			0.52		0.19	0.19	0.19		0.10	0.10
v/c Ratio		0.64			0.78		0.52	0.52	0.39		0.60	0.07
Control Delay		13.6			19.6		32.6	32.4	7.6		49.6	0.4
Queue Delay		0.0			0.0		0.0	0.0	0.0		0.0	0.0
Total Delay		13.6			19.6		32.6	32.4	7.6		49.6	0.4
LOS		B			B		C	C	A		D	A
Approach Delay		13.6			19.6			23.9			41.3	
Approach LOS		B			B			C			D	

Intersection Summary

Area Type: Other
Cycle Length: 75
Actuated Cycle Length: 64.8
Natural Cycle: 75
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.78
Intersection Signal Delay: 19.0 Intersection LOS: B
Intersection Capacity Utilization 82.4% ICU Level of Service E
Analysis Period (min) 15

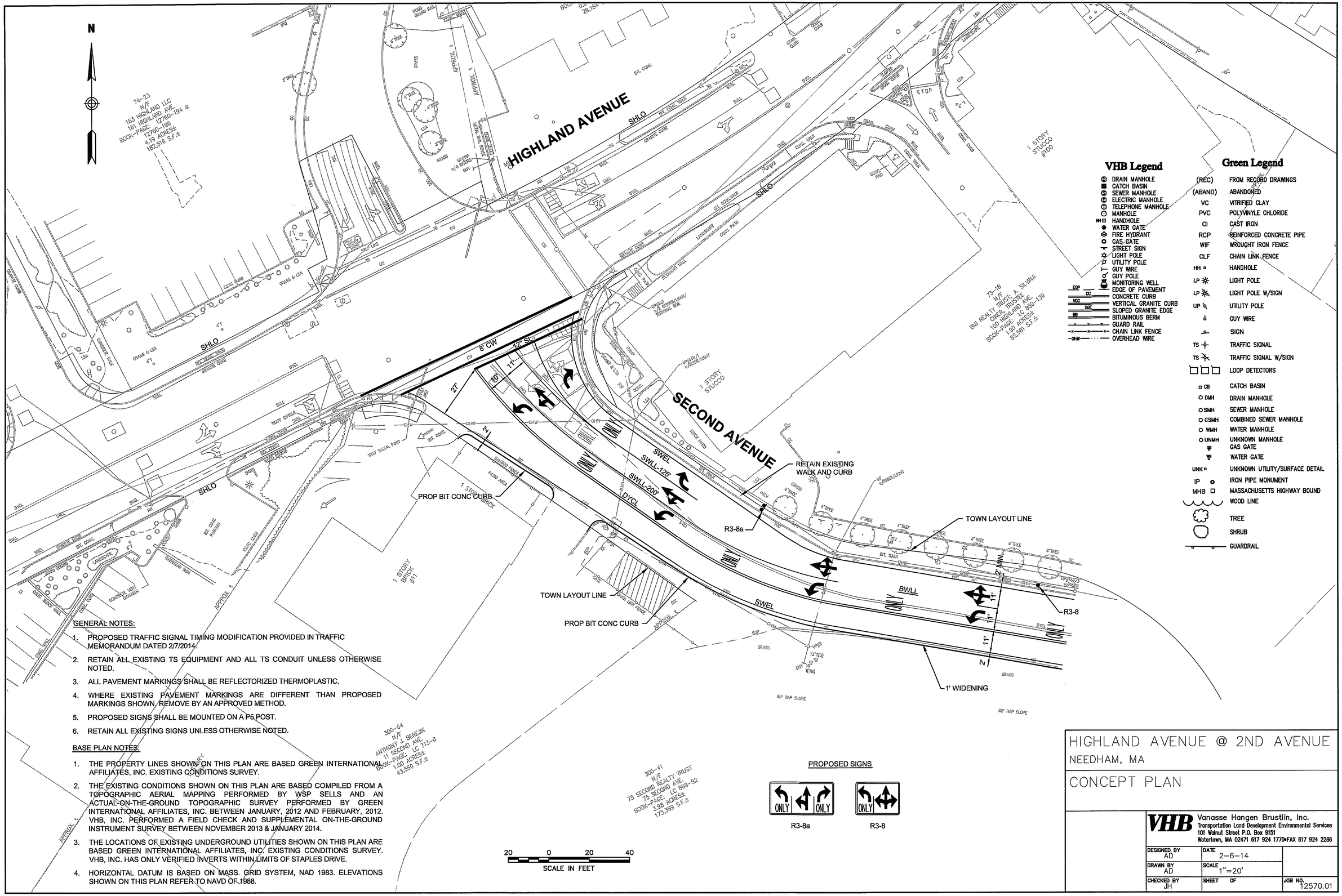
Splits and Phases: 3: 2nd Ave/Staples Driveway & Highland Ave



Lane Group	EBT	WBT	NBL	NBT	NBR	SBT	SBR
Lane Group Flow (vph)	1090	930	164	165	173	108	22
v/c Ratio	0.64	0.78	0.52	0.52	0.39	0.60	0.07
Control Delay	13.6	19.6	32.6	32.4	7.6	49.6	0.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	13.6	19.6	32.6	32.4	7.6	49.6	0.4
Queue Length 50th (ft)	158	160	70	70	0	48	0
Queue Length 95th (ft)	241	261	129	130	46	#113	0
Internal Link Dist (ft)	342	382		392		168	
Turn Bay Length (ft)			200		125		
Base Capacity (vph)	1796	1413	436	441	540	180	316
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.61	0.66	0.38	0.37	0.32	0.60	0.07

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.



VHB Legend

- DRAIN MANHOLE
- CATCH BASIN
- SEWER MANHOLE
- ELECTRIC MANHOLE
- TELEPHONE MANHOLE
- MANHOLE
- HANDHOLE
- WATER GATE
- FIRE HYDRANT
- GAS GATE
- STREET SIGN
- LIGHT POLE
- UTILITY POLE
- GUY WIRE
- GUY POLE
- MONITORING WELL
- EDGE OF PAVEMENT
- CONCRETE CURB
- VERTICAL GRANITE CURB
- SLOPED GRANITE EDGE
- BITUMINOUS BERM
- GUARD RAIL
- CHAIN LINK FENCE
- OVERHEAD WIRE

Green Legend

(REC)	FROM RECORD DRAWINGS
(ABAND)	ABANDONED
VC	VITRIFIED CLAY
PVC	POLYVINYLE CHLORIDE
CI	CAST IRON
RCP	REINFORCED CONCRETE PIPE
WIF	WROUGHT IRON FENCE
CLF	CHAIN LINK FENCE
HH	HANDHOLE
LP	LIGHT POLE
LP	LIGHT POLE W/SIGN
UP	UTILITY POLE
	GUY WIRE
	SIGN
TS	TRAFFIC SIGNAL
TS	TRAFFIC SIGNAL W/SIGN
	LOOP DETECTORS
CB	CATCH BASIN
DMH	DRAIN MANHOLE
SMH	SEWER MANHOLE
CSMH	COMBINED SEWER MANHOLE
WMH	WATER MANHOLE
UNMH	UNKNOWN MANHOLE
	GAS GATE
	WATER GATE
UNK	UNKNOWN UTILITY/SURFACE DETAIL
IP	IRON PIPE MONUMENT
MHB	MASSACHUSETTS HIGHWAY BOUND
	WOOD LINE
	TREE
	SHRUB
	GUARDRAIL

GENERAL NOTES:

1. PROPOSED TRAFFIC SIGNAL TIMING MODIFICATION PROVIDED IN TRAFFIC MEMORANDUM DATED 2/7/2014.
2. RETAIN ALL EXISTING TS EQUIPMENT AND ALL TS CONDUIT UNLESS OTHERWISE NOTED.
3. ALL PAVEMENT MARKINGS SHALL BE REFLECTORIZED THERMOPLASTIC.
4. WHERE EXISTING PAVEMENT MARKINGS ARE DIFFERENT THAN PROPOSED MARKINGS SHOWN, REMOVE BY AN APPROVED METHOD.
5. PROPOSED SIGNS SHALL BE MOUNTED ON A P5 POST.
6. RETAIN ALL EXISTING SIGNS UNLESS OTHERWISE NOTED.

BASE PLAN NOTES:

1. THE PROPERTY LINES SHOWN ON THIS PLAN ARE BASED GREEN INTERNATIONAL AFFILIATES, INC. EXISTING CONDITIONS SURVEY.
2. THE EXISTING CONDITIONS SHOWN ON THIS PLAN ARE BASED COMPILED FROM A TOPOGRAPHIC AERIAL MAPPING PERFORMED BY WSP SELLS AND AN ACTUAL ON-THE-GROUND TOPOGRAPHIC SURVEY PERFORMED BY GREEN INTERNATIONAL AFFILIATES, INC. BETWEEN JANUARY, 2012 AND FEBRUARY, 2012. VHB, INC. PERFORMED A FIELD CHECK AND SUPPLEMENTAL ON-THE-GROUND INSTRUMENT SURVEY BETWEEN NOVEMBER 2013 & JANUARY 2014.
3. THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES SHOWN ON THIS PLAN ARE BASED GREEN INTERNATIONAL AFFILIATES, INC. EXISTING CONDITIONS SURVEY. VHB, INC. HAS ONLY VERIFIED INVERTS WITHIN LIMITS OF STAPLES DRIVE.
4. HORIZONTAL DATUM IS BASED ON MASS. GRID SYSTEM, NAD 1983. ELEVATIONS SHOWN ON THIS PLAN REFER TO NAVD OF 1988.

PROPOSED SIGNS

R3-8a R3-8

HIGHLAND AVENUE @ 2ND AVENUE

NEEDHAM, MA

CONCEPT PLAN

VHB Vanasse Hangen Brustlin, Inc.
Transportation Land Development Environmental Services
101 Walnut Street P.O. Box 9151
Watertown, MA 02471 617 924 1770•FAX 617 924 2286

DESIGNED BY AD	DATE 2-6-14	
DRAWN BY AD	SCALE 1"=20'	
CHECKED BY JH	SHEET OF	JOB NO. 12570.01

12570-CONCEPT_2.DWG Plotted on 7-Feb-2014 3:28 PM