MEMORANDUM

To: **Jody Kablack** **July 8, 2010**
Director of Planning and Community Development,
Town of Sudbury

From: **Chen-Yuan Wang**

Re: **Boston Region MPO Congested and High-Crash Intersections Study:**
Boston Post Road at Landham Road in Sudbury

This memorandum summarizes safety and operations analyses and proposes improvement strategies for the intersection of Boston Post Road at Landham Road in Sudbury. It contains the following sections:

- Intersection Layout and Traffic Control
- Issues and Concerns
- Crash Data Analysis
- Intersection Capacity Analysis
- Preliminary Analysis of Traffic Signal Warrants
- Analyses of Traffic Signal Options
- Discussion of Questionable Yield Sign Location
- Improvement Recommendations and Discussion

The memorandum also includes a collection of technical appendices that contain methods and data applied in the study and detailed reports of intersection capacity analysis.

INTERSECTION LAYOUT AND TRAFFIC CONTROL

This "T" intersection is located in South Sudbury. Boston Post Road, in the east-west direction, is the major street of the intersection. Functioning as an urban principal arterial, it is a part of U.S. Route 20, which starts from Boston, proceeds through Watertown, Waltham, and several MetroWest communities, and continues west, crossing the Massachusetts-New York border. Landham Road is the minor street of the intersection. It is a two-lane roadway functioning as a major collector that connects to Route 20 at this intersection and continues south becoming Elm Street and Concord Street, which connects to Route 126, Route 30, and Route 9 in Framingham.

Figure 1 shows the intersection layout and the surrounding areas. Traffic entering the intersection on Boston Post Road basically operates in a single lane. The right turns on the eastbound approach are channelized but with no traffic controls. Landham Road flares out near the intersection and the left and right turns from it are channelized. The left turns are controlled by a stop sign and the right turns by a yield sign. Another yield sign is located on the median of

FIGURE 1
Boston Post Road (Route 20) at Landham Road, Sudbury

CTPS

Operational Improvements at Congested and High-Crash Intersections

Landham Road and is intended for the southbound left turns from westbound Boston Post Road to yield to the right turns from eastbound Boston Post Road.

The area in the vicinity of intersection includes mostly residences and vacant lots. There is a popular gas station at the southwest corner of the intersection. The Route 20 corridor from this intersection to Route 27 in Wayland is relatively less developed than the area further west. However, several developments have been proposed in the stretch, including a new town center for Wayland and a few major shops and residential multiplexes.

ISSUES AND CONCERNS

The existing intersection layout and traffic control appears to be inadequate in handling the traffic demand at this intersection. The intersection is congested during peak periods, especially on the minor street approach. Traffic on Landham Road frequently backs up extensively due to the stop control facing the heavy traffic on Boston Post Road.

Traffic on Boston Post Road is notably heavy in both directions during peak periods. Traffic in the westbound direction backs up at times when the through movements are blocked by the left turns waiting to cross the heavy traffic in the eastbound direction. Although traffic in the eastbound direction on Boston Post Road is free of traffic control, it sometimes backs up due to peak traffic surges and occasionally aggressive left-turning drivers from the opposite direction.

The location of the yield control on the southbound Landham Road is problematic. During peak hours, left-turning vehicles wishing to proceed southbound are frequently blocked by the heavy right turns from eastbound Boston Post Road. Three or four southbound vehicles from westbound left turns can quickly extend their queue into the intersection and block the eastbound through movements and the northbound left-turning movements. The queued northbound left turns, in turn, block the right turns from Landham Road to Boston Post Road eastbound. At times, this causes a nearly complete gridlock at the intersection. On the other hand, the eastbound right-turn volume is high and the current free movement operation can avoid blockages of the eastbound Boston Post Road.

Review of the recent crash data indicates that the intersection has a high number of crashes and a crash rate higher than other unsignalized intersections in the area (see the next section for further analysis).

The issues and concerns for this intersection can be summarized as follows:

- High number of crashes and high crash rate
- Traffic congestion during peak hours
- Extensive delays encountered on the minor street approach
- Left-turn vehicles on Boston Post Road blocking the westbound through traffic and causing delays on the entire approach
- Questionable yield control location on southbound Landham Road

CRASH DATA ANALYSIS

Table 1 shows that on the average, nine crashes occurred at the intersection each year between 2005 and 2007. Most of crashes involved property damage only and about 15% of the total crashes resulted in personal injuries. The crash types consisted of about 33% angle collisions and about 52% rear-end collisions. No crashes involved pedestrians or bicycles. About 52% of the crashes occurred during peak periods. The high proportion of rear-end collisions is an indication of stop-and-go conditions through the intersection.

TABLE 1
Summary of RMV Crash Data (2005–2007)

Statistics Period		2005	2006	2007	2005–07	Average
Total number of crashes		12	4	11	27	9
Severity	Property damage only	8	4	10	22	7
	Personal injury	3	0	1	4	1
	Fatality	0	0	0	0	0
	Not reported	1	0	0	1	0
Collision Type	Angle	4	1	4	9	3
	Rear-end	7	2	5	14	5
	Sideswipe	0	1	1	2	1
	Head-on	0	0	0	0	0
	Single vehicle	0	0	1	1	0
	Not reported	1	0	0	1	0
Crashes involved pedestrian(s)		0	0	0	0	0
Crashes involved cyclist(s)		0	0	0	0	0
Occurred during weekday peak periods*		5	1	8	14	5
Wet or icy pavement conditions		4	1	4	9	3
Dark/lighted conditions		1	1	2	4	1

* Peak periods defined as 7:00–10:00 AM and 3:30–6:30 PM.

Crash rate[1] is another effective tool for examining the relative safety of a particular location. Based on the above data and the recently collected traffic volume data, the crash rate for this intersection is calculated as 1.08 (see Appendix A for the calculation sheet). The rate is much higher than the average rate for the unsignalized locations in MassHighway District 3, which is estimated as 0.69.[2]

[1] Crash rates are calculated from the combination of crash frequency (crashes per year) and vehicle exposure (traffic volumes or miles traveled). Crash rates are expressed as "crashes per million entering vehicles" for intersection locations and as "crashes per million miles traveled" for roadway segments.

[2] The average crash rates estimated by the MassDOT Highway Division are based upon a database that contains intersection crash rates submitted to the Highway Division as part of the review process for environmental impact reports or functional design reports. The most recent average crash rates, which are updated on a nearly yearly basis, are based on all entries in the database, not just those entries made within the past year.

INTERSECTION CAPACITY ANALYSIS

CTPS collected turning movement counts at the intersection on May 26, 2009. The data were recorded in 15-minute intervals for the peak traffic periods, in the morning from 7:00 to 9:00 and in the evening from 4:00 to 6:00. As Table 2 shows, the intersection carried about 1,900 vehicles in the morning peak hour from 7:30 to 8:30 and about 2,050 vehicles in the evening peak hour from 4:30 to 5:30.[3] Two pedestrians and no pedestrians were observed during the AM and PM peak hour, respectively. There were one eastbound bicyclist turning right and two westbound (one through and one left-turn) bicycles entering the intersection in the AM and PM peak hour, respectively (not shown in the table).

TABLE 2
AM and PM Peak Hour Traffic Volumes and Pedestrian Crossings

Street name		**Boston Post Road (Route 20)**				**Landham Road**		**Total**
Direction		**Eastbound**		**Westbound**		**Northbound**		
Traffic movement		TH	RT	LT	TH	LT	RT	
AM Peak Hour	Movement Volume	710	303	132	342	180	222	1889
	Approach Volume	1013		474		402		
	Pedestrian Crossings	0		1		1		2
PM Peak Hour	Movement Volume	512	292	262	547	211	225	2049
	Approach Volume	804		809		436		
	Pedestrian Crossings	0		0		0		0

Based on the turning movement counts and the signal timings measured at the site, the intersection capacity was analyzed by using the intersection capacity analysis program Synchro.[4] The intersection was modeled as an unsignalized intersection with a stop control on Landham Road. As Table 3 shows, the operation on Landham Road is evaluated to operate at level of service (LOS) F, with delays of much more than three minutes in both the morning and the evening peak hours. The criteria for the level of service are based on Highway Capacity Manual 2000.[5] It should be noted that the westbound left-turn blocking effect due to the yield control on Landham Road could not be modeled in the HCM unsignalized intersection analysis, and delays on the westbound Boston Post Road might be underestimated. Detailed analysis settings and results for both the AM and PM peak hour are included in Appendix B.

[3] It should be noted that the recorded volumes are those passing through the intersection. The demand can be somewhat higher during the peak hours.

[4] Synchro is developed and distributed by Trafficware, Ltd. It can perform intersection capacity analysis and traffic simulation (when combined with SimTraffic) for an individual intersection or a series of intersections.

[5] Transportation Research Board, *Highway Capacity Manual 2000*, National Research Council, Washington D. C., 2000.

TABLE 3
Intersection Capacity Analysis of Existing Conditions

Street name		**Boston Post Road (Route 20)**				**Landham Road**		**Int. Average**
Direction		**Eastbound**		**Westbound**		**Northbound**		
Traffic movement		TH	RT	LT	TH	LT	RT	
AM Peak Hour	LOS	**A**		**A**		**F**		NA
	Delay (sec/veh)	0		4		> 180		150
PM Peak Hour	LOS	**A**		**A**		**F**		NA
	Delay (sec/veh)	0		6		> 180		> 180

PRELIMINARY ANALYSIS OF TRAFFIC SIGNAL WARRANTS

One of the potential improvements for this intersection is to install a traffic control signal. According to the Manual for Uniform Traffic Control Devices[6] (MUTCD), an engineering study of traffic conditions, pedestrian travel characteristics, and physical characteristics of the location should be performed to determine whether installation of a traffic control signal is justified at a particular location. The investigation should include applicable factors contained in the following traffic signal warrants and other factors related to existing operations and safety at the study location:

1. Eight-Hour Vehicular Volume Warrant
2. Four-Hour Vehicular Volume Warrant
3. Peak Hour Warrant
4. Pedestrian Volume Warrant
5. School Crossing Warrant
6. Coordinated Signal System Warrant
7. Crash Experience Warrant
8. Roadway Network Warrant

A traffic control signal should not be installed unless one or more of the factors reflected in these warrants are met. Moreover, the satisfaction of a warrant or warrants in itself does not justify the signal installation unless an engineering study indicates that the installation will improve the overall safety and/or operation of the intersection.

In this study, we performed a preliminary analysis of the applicable traffic signal warrants based on available traffic data. The applicable factors for this intersection are contained in Warrants 1, 2, and 7. Warrant 3 is intended for unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy-vehicle facilities that attract or discharge large numbers of vehicles over a short time. The intersection is regarded as a stand-alone location, not a part of a coordinated traffic system; pedestrian volume is low, and it is not close to any schools. Therefore, Warrants 3, 4, 5, 6 and 8 were not applicable and were not tested.

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[6] Federal Highway Administration, U.S. Department of Transportation, *Chapter 4C. Traffic Control Signal Needs*, 2003 edition with revision numbers 1 and 2 incorporated, December 2007.

Based on three mid-week days' 24-hour automatic traffic counts collected by MassDOT's Highway Division in the week of May 11, 2009 (see Appendix C for the summary of hourly volumes for all the approaches at the intersection), the analysis finds that the intersection meets Warrants 1 and 2 at high satisfaction level. As such, although Warrant 7 is also satisfied (based on the 2007 reported crashes), it was applied as a supportive not as the principal reason for the signalization.

ANALYSES OF TRAFFIC SIGNAL OPTIONS

The preliminary traffic signal warrants analysis indicates that the intersection is a good candidate for the installation of a traffic signal. The traffic signal would interrupt traffic on Boston Post Road at intervals to permit traffic from Landham Road to proceed. Properly designed, it would be expected to reduce the frequency and severity of certain types of crashes, especially right-angle collisions.

This section examines two traffic signal and geometric design strategies to improve the safety and operation of this intersection, including the merging at the southbound side of Landham Road. The analysis was performed progressively from less effective (and less expensive) improvement options to more effective (and more expensive) improvement options.

1. Install Traffic Signal with Existing Intersection Geometry

   Currently, each of the approaches entering the intersection operates as a single lane. The through and left-turn movements on the westbound approach share a lane where little space exists for through traffic to go around left-turning traffic. Also, the northbound right turn on the northbound is channelized, but is frequently blocked when more than two left-turning vehicles are queued on the approach.

   Table 4 shows the evaluation of this option under the existing intersection geometry and existing traffic volumes. The signal is modeled with a cycle length of 130 seconds for traffic phases and a 20-second on-call exclusive pedestrian phase. The timings for the traffic phases are slightly different for the AM and PM peak periods, resulting from the Synchro optimization. Although no pedestrians were observed in the PM peak hour, two pedestrian calls (same as the AM peak hour) were assumed in the intersection capacity analysis. In addition, this analysis assumes that the yield sign, presently facing the southbound left-turn lanes from the east, is now relocated to face the right turns from the west. The reason for this change is discussed in the next section.

   As shown, the intersection would continue to operate at LOS F with an average delay of about two minutes per vehicle in the peak hours. The westbound approach, which formerly experienced some delays with no traffic control, would endure extensive delays. The northbound approach would endure less but still significant delays compared to the existing stop control conditions (see Appendix D for detailed signal settings and analysis results).

TABLE 4
Intersection Capacity Analysis
Install Traffic Signal under Existing Intersection Geometry
Existing Traffic Conditions

Street name		**Boston Post Road (Route 20)**				**Landham Road**		**Int. Average**
Direction		**Eastbound**		**Westbound**		**Northbound**		
Turning movement		TH	RT	LT	TH	LT	RT	
AM Peak Hour	Level of Service	**C**		**F**		**F**		**F**
	Delay (sec/veh)	22		> 180		179		106
PM Peak Hour	Level of Service	**A**		**F**		**F**		**F**
	Delay (sec/veh)	10		> 180		> 180		159

2. Install Traffic Signal and Modify Intersection Geometry

   Further analyses indicated that the intersection would operate at acceptable levels of service with the following geometric changes:

   - Construct an exclusive lane for westbound left-turns[7]
   - Construct an exclusive lane for the eastbound right-turns[8]
   - Redesign the islands, lengthen the short northbound left-turn lane for storage, and ensure separation between the northbound left and right turns[9]
   - Relocate the yield sign, presently facing the southbound left-turn lanes from the east, to face the right turns from the west

   Review of the aerial photography and highway layout plans in the vicinity of the intersection shows that these geometric modifications could be achieved within the intersection's right-of-way. However, further ROW examination is warranted as part of the eventual functional design report, including examination of potential environmental impacts (wetland area abutting Landham Road near Hop Brook) and other limitations. A bridge over an abandoned railroad is located about 250 feet south of the intersection.

   Table 5 shows the evaluation of this option under existing traffic volumes and the proposed geometric design modifications. The signal is modeled with a cycle length of 80 seconds for traffic phases and a 20-second on-call exclusive pedestrian phase. The timings for the traffic phases are slightly different for the AM and PM peak periods to respond to the different traffic demands. Two pedestrian calls per peak hour were assumed in the intersection capacity analysis. As shown, the intersection would operate at LOS B for both peak periods with an insignificant average delay of nearly 20 seconds per vehicle (see Appendix E for detailed signal settings and analysis results).

[7] A length of about 150 feet would be sufficient.
[8] A length of about 50 feet would be sufficient.
[9] A length of about 200 feet would be required.

TABLE 5
Intersection Capacity Analysis
Install Traffic Signal and Modify Intersection Geometry
Existing Traffic Conditions

Street name		**Boston Post Road (Route 20)**				**Landham Road**		**Int. Average**
Direction		**Eastbound**		**Westbound**		**Northbound**		
Turning movement		TH	RT	LT	TH	LT	RT	
AM Peak Hour	Level of Service	**C**	**A**	**B**	**A**	**D**	**A**	**B**
	Delay (sec/veh)	27	2	12	8	39	9	17
PM Peak Hour	Level of Service	**C**	**A**	**B**	**B**	**D**	**A**	**B**
	Delay (sec/veh)	31	2	18	11	39	8	18

In addition, a future-year scenario of 15% growth over a 20-year planning horizon was tested for the traffic signal option. The growth assumption is based on a review of the traffic projections at the intersection from the recent Boston Region MPO transportation planning model. A higher number of pedestrian calls (five in each peak hour) was assumed in the future-year analysis. As Table 6 shows, the signalized intersection, with the desirable geometric design modifications, is expected to operate at acceptable LOS B in the AM peak hour and LOS C in the PM peak hour under the projected traffic conditions (see Appendix F for details of the analysis results).

TABLE 6
Intersection Capacity Analysis
Install Traffic Signal and Modify Intersection Geometry
Projected Future-Year (2030) Traffic Conditions

Street name		**Boston Post Road (Route 20)**				**Landham Road**		**Int. Average**
Direction		**Eastbound**		**Westbound**		**Northbound**		
Traffic movement		TH	RT	LT	TH	LT	RT	
AM Peak Hour	Level of Service	**C**	**A**	**C**	**A**	**D**	**A**	**B**
	Delay (sec/veh)	26	8	24	8	49	9	19
PM Peak Hour	Level of Service	**C**	**A**	**C**	**B**	**D**	**A**	**C**
	Delay (sec/veh)	33	2	32	11	46	9	22

DISCUSSION OF QUESTIONABLE YIELD SIGN LOCATION

As mentioned, the yield sign is currently located on the median of southbound Landham Road to control the left turns from westbound Boston Post Road. During peak hours, these left turns are frequently blocked by the heavy right turns from eastbound Boston Post Road. Three or four such vehicles can quickly extend their queue into the intersection and block the eastbound through movements and the northbound left-turn movements. The northbound left-turn queue in turn blocks the northbound right turns to Boston Post Road. At times, this can cause a nearly complete gridlock at the intersection.

In addition to delays, the current yield control causes safety concerns for the left turners. They are in a difficult situation in that they have to quickly slow down or stop at the YIELD location soon after they have accelerated to pass through the infrequently available gaps in the eastbound peak-period traffic. The situation can be hazardous for the left-turning vehicles, which follow one another closely in passing through the intersection and can end up being stuck in the middle of the intersection or in a rear-end-collision situation.

To mitigate this situation and help these left turners move southbound away from the intersection more rapidly and avoid blocking the intersection, the yield sign should be relocated to the southwest corner of the intersection facing the right turns from eastbound Boston Post Road. Review of Synchro simulations did not indicate right-turn queues from the relocated yield sign would cause major backups on Boston Post Road.

Another solution towards separating the southbound merging traffic from the east and the west is to reconstruct the southbound direction of Landham Road into two lanes for as far as the environmental impacts and limitations from the location of the nearby bridge allow. Only limited space is available for this geometric change; the bridge is located just about 250 feet south of Boston Post Road. Whether the intersection is signalized or not, the extension would make the merging maneuver easier.

IMPROVEMENT RECOMMENDATIONS AND DISCUSSION

The above analyses indicate that the installation of traffic signal control at this intersection is justified and would significantly improve overall traffic operations. Therefore, we propose that the intersection be signalized with the necessary geometric design modifications for acceptable intersection level of service and safer traffic operations. These modifications include:

- Add a westbound left-turn lane with 150 feet of storage length
- Flare out the eastbound approach to include a 50-foot-long right-turn bay
- Extend the channelized eastbound right-turn lane southward to increase the merging area with the other southbound lane
- Modify the northbound approach as a two-lane section from the existing bridge to the intersection

As mentioned, currently the extensive delays for traffic on Landham Road create many operational and safety problems for the intersection. The traffic signal installation would interrupt traffic on Boston Post Road to permit traffic from Landham Road to proceed and would regulate traffic from all approaches, allowing for the orderly processing of traffic. Although the presently control-free traffic on Boston Post Road will endure some delays with the signalization, the overall intersection operations would improve significantly.[10]

Moreover, in addition to traffic operational benefits, the signalization is expected to improve safety at this intersection. It would reduce the conflicts between the westbound left turns and the eastbound through movements, and between the northbound left turns and the

[10] The signal timing plan tested in this study was set up to optimize delays for all approaches. During design, the future traffic signal operator can adjust the timing plan to provide more green time for traffic on Boston Post Road so as to reduce its delays caused by signalization.

eastbound/westbound traffic. Although traffic signals may not reduce rear-end collisions, they generally are expected to reduce the frequency and severity of right-angle collisions,[11] a common type of crash in unsignalized stop-controlled intersections, especially when a minor high-volume roadway intersects a higher-volume/high-speed roadway such as Boston Post Road.

The discussed geometric design modifications have to be further examined at the functional design stage in terms of right-of-way, wetlands, and other limitations in the vicinity of the intersection. The westbound exclusive left-turn lane requires a minimum of 150 feet of storage length. We briefly reviewed previous construction plans provided by the MassDOT Highway Division and estimated the right-of-way of Route 20 near the intersection to be about 50 feet wide (including both shoulders). This space is rather tight but possibly sufficient for adding an 11-foot westbound left-turn lane in between two 12-foot normal travel lanes. As the left-turn lane gradually tapers off from the intersection, 6-or-more-foot shoulders could possibly be maintained on both sides of Route 20 beyond the intersection.

The Landham Road approach needs to be widened for as far as possible from the existing bridge to the intersection. This widening is required for northbound storage lanes and a safer southbound merging area. However, it appears that only one or the other goal can be achieved within the available right-of-way. It therefore makes sense to use the available width for the northbound lanes and control the separation of the southbound merging movements by relocating the yield sign to face the eastbound right turns to southbound Landham Road.

Currently there are no crosswalks at the intersection. There is a sidewalk on the north side of Route 20 and one on the west side of Landham Road. The future signalization and reconstruction of the intersection should preserve these sidewalks and add a crosswalk crossing the eastbound approach and connecting the end of the Landham Road sidewalk to the Route 20 sidewalk. The future signal system should include pedestrian signal heads with push buttons and accessible (audible) pedestrian signals in conjunction with an exclusive pedestrian signal phase in the signal phasing/timing plan.

Although there are no bike lanes and none are proposed at this intersection, the future design should also maintain roadway shoulders (6 feet preferred, especially on Route 20) for bike traveling through the intersection. The Massachusetts Bicycle Transportation Plan[12] indicated that a future Bay State Greenway (a multiple-use trail) would run along the abandoned railroad just south of the intersection along Route 20 and connect to an on-road bike path on Route 20 in Wayland.

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[11] *Manual for Uniform Traffic Control Devices, Chapter 4B.03, Advantages and Disadvantages of Traffic Control Signals*, Federal Highway Administration, U.S. Department of Transportation, 2003 edition with revisions numbers 1 and 2 incorporated, December 2007.

[12] *Massachusetts Bicycle Transportation Plan*, September 2008, Executive Office of Transportation, Commonwealth of Massachusetts.

Appendix A

Intersection Crash Rate Calculation
Boston Post Road at Landham Road, Sudbury

MassHighway

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Sudbury COUNT DATE : 5/26/09

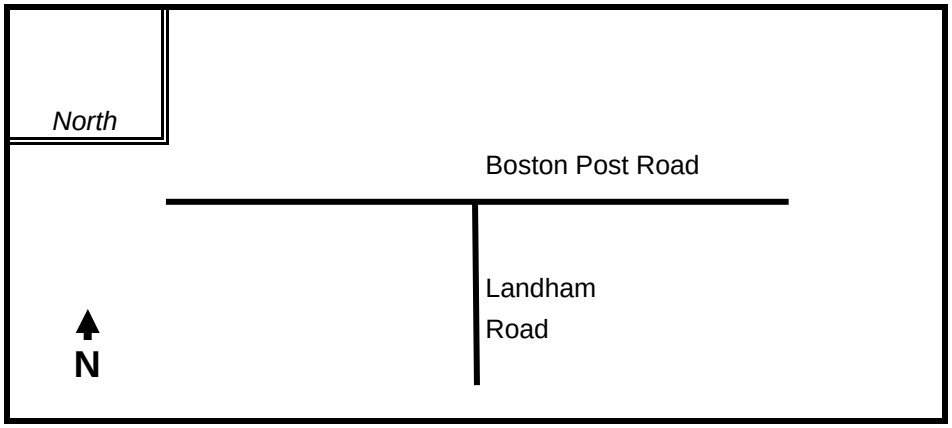
DISTRICT : 3 UNSIGNALIZED : X SIGNALIZED :

~ INTERSECTION DATA ~

MAJOR STREET : Boston Post Road

MINOR STREET(S) : Landham Road

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	EB	WB	NB			
PEAK HOURLY VOLUMES (AM/PM) :	804	809	436			**2,049**

" K " FACTOR : **0.090** INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **22,767**

TOTAL # OF CRASHES : 27 # OF YEARS : 3 AVERAGE # OF CRASHES PER YEAR (**A**) : **9.00**

CRASH RATE CALCULATION : **1.08** RATE = $\frac{(A * 1{,}000{,}000)}{(V * 365)}$

Comments :

Project Title & Date: Boston MPO Congested and High-Crash Intersections Study

Appendix B

AM/PM Peak Hour Intersection Capacity Analysis
Existing Traffic Conditions
Boston Post Road at Landham Road, Sudbury

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	710	303	132	342	180	222
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96
Hourly flow rate (vph)	740	316	138	356	188	231
Pedestrians				1	1	
Lane Width (ft)				14.0	12.0	
Walking Speed (ft/s)				4.0	4.0	
Percent Blockage				0	0	
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			741		1530	899
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			741		1530	899
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			84		0	31
cM capacity (veh/h)			861		107	334

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	1055	494	419
Volume Left	0	138	188
Volume Right	316	0	231
cSH	1700	861	171
Volume to Capacity	0.62	0.16	2.44
Queue Length 95th (ft)	0	14	884
Control Delay (s)	0.0	4.2	709.5
Lane LOS		A	F
Approach Delay (s)	0.0	4.2	709.5
Approach LOS			F

Intersection Summary			
Average Delay	152.1		
Intersection Capacity Utilization	114.8%	ICU Level of Service	H
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	512	292	262	547	211	225
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91
Hourly flow rate (vph)	563	321	288	601	232	247
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume			563		1900	723
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			563		1900	723
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			71		0	42
cM capacity (veh/h)			1009		55	428

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	884	889	479
Volume Left	0	288	232
Volume Right	321	0	247
cSH	1700	1009	99
Volume to Capacity	0.52	0.29	4.82
Queue Length 95th (ft)	0	30	Err
Control Delay (s)	0.0	6.2	Err
Lane LOS		A	F
Approach Delay (s)	0.0	6.2	Err
Approach LOS			F

Intersection Summary			
Average Delay	2130.1		
Intersection Capacity Utilization	123.5%	ICU Level of Service	H
Analysis Period (min)	15		

Appendix C

Summary of Hourly Traffic Volumes
May 12-14, 2009
Boston Post Road at Landham Road, Sudbury

Rt. 20 — Sudbury

Mass Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 5/11/2009

STA. 11 EB

Site Reference: 000000000674
Site ID: 090150001103
Location: RTE. 20, WEST OF LANDHAM ST.
Direction: EAST

File: 1103.prn
City: SUDBURY
County: VOL

TIME	MON 11	TUE 12	WED 13	THU 14	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		13	31	21		21			21	65
02:00		9	11	13		11			11	33
03:00		7	6	7		6			6	20
04:00		14	13	9		12			12	36
05:00		53	51	56		53			53	160
06:00		214	211	207		210			210	632
07:00		745	732	748		741			741	2225
08:00		1021	1032	1012		1021			1021	3065
09:00		1042	950	1016		1002			1002	3008
10:00		810	816	833		819			819	2459
11:00		643	663			653			653	1306
12:00		687	736			711			711	1423
13:00	689	784	711			728			728	2184
14:00	646	731	759			712			712	2136
15:00	680	774	746			733			733	2200
16:00	734	786	824			781			781	2344
17:00	788	796	715			766			766	2299
18:00	859	937	917			904			904	2713
19:00	681	657	709			682			682	2047
20:00	440	430	526			465			465	1396
21:00	371	298	366			345			345	1035
22:00	223	219	241			227			227	683
23:00	121	109	144			124			124	374
24:00	65	54	58			59			59	177
TOTALS	6297	11833	11968	3922	0	11786	0	0	11786	34020
AVG WKDY	53.4	100.3	101.5	33.2						
AVG WEEK	53.4	100.3	101.5	33.2						
AM Times		09:00	08:00	09:00		08:00			08:00	
AM Peaks		1042	1032	1016		1021			1021	
PM Times	18:00	18:00	18:00			18:00			18:00	
PM Peaks	859	937	917			904			904	

U3

EB 11786
WB 10308
COMB AWD 22094
FAC .90(.96)
COMB ADT 19,100

Mass Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 5/11/2009

STA. 12 WB

Site Reference: 000000000799
Site ID: 090150001204
Location: RTE. 20, WEST OF LANDHAM ST.
Direction: WEST

File: 1204.prn
City: SUDBURY
County: VOL

TIME	MON 11	TUE 12	WED 13	THU 14	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		26	51	41		39			39	118
02:00		16	16	23		18			18	55
03:00		9	13	8		10			10	30
04:00		13	8	10		10			10	31
05:00		34	33	36		34			34	103
06:00		96	99	116		103			103	311
07:00		353	352	370		358			358	1075
08:00		581	640	521		580			580	1742
09:00		647	676	649		657			657	1972
10:00		603	569	651		607			607	1823
11:00		612	576			594			594	1188
12:00		699	609			654			654	1308
13:00	628	646	686			653			653	1960
14:00	625	670	654			649			649	1949
15:00	648	740	685			691			691	2073
16:00	700	830	725			751			751	2255
17:00	779	784	764			775			775	2327
18:00	852	872	828			850			850	2552
19:00	801	666	727			731			731	2194
00	564	511	705			593			593	1780
00	389	384	440			404			404	1213
22:00	305	269	314			296			296	888
23:00	142	157	164			154			154	463
24:00	86	114	91			97			97	291
TOTALS	6519	10332	10425	2425	0	10308	0	0	10308	29701
AVG WKDY	63.2	100.2	101.1	23.5						
AVG WEEK	63.2	100.2	101.1	23.5						
AM Times		12:00	09:00	10:00		09:00			09:00	
AM Peaks		699	676	651		657			657	
PM Times	18:00	18:00	18:00			18:00			18:00	
PM Peaks	852	872	828			850			850	

Mass Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 5/11/2009

STA. 13 EB

Site Reference: 000000000637
Site ID: 090150001303
Location: RTE. 20, EAST OF LANDHAM ST.
Direction: EAST

File: 1303.prn
City: SUDBURY
County: VOL

TIME	MON 11	TUE 12	WED 13	THU 14	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		13	26	20		19			19	59
02:00		11	10	15		12			12	36
03:00		7	9	8		8			8	24
04:00		12	11	5		9			9	28
05:00		55	55	63		57			57	173
06:00		241	240	233		238			238	714
07:00		796	823	833		817			817	2452
08:00		1108	1089	1045		1080			1080	3242
09:00		1065	955	996		1005			1005	3016
10:00		765	721	785		757			757	2271
11:00		619	606			612			612	1225
12:00		666	677			671			671	1343
13:00	616	729	685			676			676	2030
14:00	620	677	700			665			665	1997
15:00	697	747	706			716			716	2150
16:00	726	785	807			772			772	2318
17:00	793	861	692			782			782	2346
18:00	844	980	958			927			927	2782
19:00	693	566	661			640			640	1920
00	373	387	444			401			401	1204
00	312	273	291			292			292	876
22:00	211	220	213			214			214	644
23:00	116	100	125			113			113	341
24:00	66	46	54			55			55	166
TOTALS	6067	11729	11558	4003	0	11538	0	0	11538	33357
AVG WKDY	52.5	101.6	100.1	34.6						
AVG WEEK	52.5	101.6	100.1	34.6						
AM Times		08:00	08:00	08:00		08:00			08:00	
AM Peaks		1108	1089	1045		1080			1080	
PM Times	18:00	18:00	18:00			18:00			18:00	
PM Peaks	844	980	958			927			927	

U3

EB 11538
WB 9837
COMB AWD 21375
FAC .90(.96)
COMB ADT 18,500

Mass Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 5/11/2009

STA. 14 WB

Site Reference: 000000000854
Site ID: 090150001404
Location: RTE. 20, EAST OF LANDHAM ST.
Direction: WEST

File: 1404.prn
City: SUDBURY
County: VOL

TIME	MON 11	TUE 12	WED 13	THU 14	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		25	54	37		38			38	116
02:00		15	15	25		18			18	55
03:00		8	8	6		7			7	22
04:00		6	5	6		5			5	17
05:00		25	21	29		25			25	75
06:00		75	74	93		80			80	242
07:00		308	297	326		310			310	931
08:00		531	561	503		531			531	1595
09:00		593	618	595		602			602	1806
10:00		582	524	649		585			585	1755
11:00		608	549			578			578	1157
12:00		678	566			622			622	1244
13:00	553	611	648			604			604	1812
14:00	626	650	634			636			636	1910
15:00	626	688	656			656			656	1970
16:00	688	767	664			706			706	2119
17:00	784	770	734			762			762	2288
18:00	851	890	850			863			863	2591
19:00	785	704	746			745			745	2235
20:00	594	520	676			596			596	1790
21:00	343	359	417			373			373	1119
22:00	258	252	259			256			256	769
23:00	136	153	156			148			148	445
24:00	78	107	90			91			91	275
TOTALS	6322	9925	9822	2269	0	9837	0	0	9837	28338
AVG WKDY	64.2	100.8	99.8	23						
AVG WEEK	64.2	100.8	99.8	23						
AM Times		12:00	09:00	10:00		12:00			12:00	
AM Peaks		678	618	649		622			622	
PM Times	18:00	18:00	18:00			18:00			18:00	
PM Peaks	851	890	850			863			863	

Mass Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 5/11/2009

STA. 15 NB

Site Reference: 000000000780
Site ID: 090150001501
Location: LANDHAM ST., SOUTH OF RTE. 20
Direction: NORTH

File: 1501.prn
City: SUDBURY
County: VOL

TIME	MON 11	TUE 12	WED 13	THU 14	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		7	13	10		10			10	30
02:00		5	9	8		7			7	22
03:00		3	7	6		5			5	16
04:00		7	4	8		6			6	19
05:00		15	13	14		14			14	42
06:00		49	53	52		51			51	154
07:00		194	191	178		187			187	563
08:00		371	388	359		372			372	1118
09:00		414	388	412		404			404	1214
10:00		250	217	273		246			246	740
11:00		236	197			216			216	433
12:00		263	239			251			251	502
13:00	185	218	266			223			223	669
14:00	206	271	293			256			256	770
15:00	240	303	284			275			275	827
16:00	258	394	353			335			335	1005
17:00	307	363	316			328			328	986
18:00	304	398	383			361			361	1085
19:00	258	218	262			246			246	738
[illegible]:00	138	207	256			200			200	601
00	144	179	179			167			167	502
22:00	136	134	148			139			139	418
23:00	48	52	75			58			58	175
24:00	29	27	28			28			28	84
TOTALS	2253	4578	4562	1320	0	4385	0	0	4385	12713
AVG WKDY	51.3	104.4	104	30.1						
AVG WEEK	51.3	104.4	104	30.1						
AM Times		09:00	08:00	09:00		09:00			09:00	
AM Peaks		414	388	412		404			404	
PM Times	17:00	18:00	18:00			18:00			18:00	
PM Peaks	307	398	383			361			361	

45

NB 4385
SB 5026
COMB AWD 9411
FAC .90 (.98)
COMB ADT 8,300

Mass Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 5/11/2009

STA. 165B

Site Reference: 000000000494
Site ID: 090150001602
Location: LANDHAM ST., SOUTH OF RTE. 20
Direction: SOUTH

File: 1602.prn
City: SUDBURY
County: VOL

TIME	MON 11	TUE 12	WED 13	THU 14	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		10	20	10		13			13	40
02:00		2	9	11		7			7	22
03:00		1	2	3		2			2	6
04:00		4	5	5		4			4	14
05:00		4	5	6		5			5	15
06:00		19	19	20		19			19	58
07:00		116	88	85		96			96	289
08:00		299	315	324		312			312	938
09:00		394	384	425		401			401	1203
10:00		305	291	331		309			309	927
11:00		275	258			266			266	533
12:00		305	292			298			298	597
13:00	282	280	312			291			291	874
14:00	285	344	354			327			327	983
15:00	309	323	322			318			318	954
16:00	346	402	355			367			367	1103
17:00	418	378	366			387			387	1162
18:00	493	493	482			489			489	1468
19:00	343	391	403			379			379	1137
20:00	301	286	335			307			307	922
21:00	190	188	242			206			206	620
22:00	122	119	130			123			123	371
23:00	57	63	78			66			66	198
24:00	30	38	34			34			34	102
TOTALS	3176	5039	5101	1220	0	5026	0	0	5026	14536
AVG WKDY	63.1	100.2	101.4	24.2						
AVG WEEK	63.1	100.2	101.4	24.2						
AM Times		09:00	09:00	09:00		09:00			09:00	
AM Peaks		394	384	425		401			401	
PM Times	18:00	18:00	18:00			18:00			18:00	
PM Peaks	493	493	482			489			489	

Appendix D

AM/PM Peak Hour Intersection Capacity Analysis
Install Traffic Signal with Existing Intersection Geometry
Boston Post Road at Landham Road, Sudbury

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø9
Lane Configurations							
Volume (vph)	710	303	132	342	180	222	
Confl. Peds. (#/hr)		1	1			1	
Confl. Bikes (#/hr)							
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	
Growth Factor	100%	100%	100%	100%	100%	100%	
Heavy Vehicles (%)	4%	3%	3%	3%	4%	4%	
Bus Blockages (#/hr)	0	0	0	0	0	0	
Parking (#/hr)							
Mid-Block Traffic (%)	0%			0%	0%		
Shared Lane Traffic (%)							
Lane Group Flow (vph)	1056	0	0	494	419	0	
Turn Type			pm+pt				
Protected Phases	4		3	8	2		9
Permitted Phases			8				
Detector Phase	4		3	8	2		
Switch Phase							
Minimum Initial (s)	4.0		3.0	4.0	4.0		4.0
Minimum Split (s)	20.0		8.0	20.0	20.0		20.0
Total Split (s)	69.0	0.0	8.0	77.0	23.0	0.0	20.0
Total Split (%)	57.5%	0.0%	6.7%	64.2%	19.2%	0.0%	17%
Yellow Time (s)	3.5		2.0	3.5	3.0		2.0
All-Red Time (s)	1.5		1.0	1.5	1.5		1.5
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	5.0	4.0	3.0	5.0	4.5	4.0	
Lead/Lag	Lag		Lead				
Lead-Lag Optimize?	Yes		Yes				
Recall Mode	Min		None	Min	None		None
Act Effct Green (s)	72.4			72.4	18.6		
Actuated g/C Ratio	0.70			0.70	0.18		
v/c Ratio	0.86			1.42	1.28		
Control Delay	22.2			222.8	178.8		
Queue Delay	0.0			0.0	0.0		
Total Delay	22.2			222.8	178.8		
LOS	C			F	F		
Approach Delay	22.2			222.8	178.8		
Approach LOS	C			F	F		
Queue Length 50th (ft)	396			~418	~311		
Queue Length 95th (ft)	#1090			#534	#617		
Internal Link Dist (ft)	671			610	706		
Turn Bay Length (ft)							
Base Capacity (vph)	1226			349	328		
Starvation Cap Reductn	0			0	0		
Spillback Cap Reductn	0			0	0		
Storage Cap Reductn	0			0	0		
Reduced v/c Ratio	0.86			1.42	1.28		

Intersection Summary
Cycle Length: 120

Actuated Cycle Length: 103.9
Natural Cycle: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.42
Intersection Signal Delay: 105.8 Intersection LOS: F
Intersection Capacity Utilization 116.9% ICU Level of Service H
Analysis Period (min) 15
~ 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.

Splits and Phases: 1: Int

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø9
Lane Configurations							
Volume (vph)	512	292	262	547	211	225	
Confl. Peds. (#/hr)							
Confl. Bikes (#/hr)							
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	
Growth Factor	100%	100%	100%	100%	100%	100%	
Heavy Vehicles (%)	1%	1%	2%	2%	1%	1%	
Bus Blockages (#/hr)	0	0	0	0	0	0	
Parking (#/hr)							
Mid-Block Traffic (%)	0%			0%	0%		
Shared Lane Traffic (%)							
Lane Group Flow (vph)	884	0	0	889	479	0	
Turn Type			pm+pt				
Protected Phases	4		3	8	2		9
Permitted Phases			8				
Detector Phase	4		3	8	2		
Switch Phase							
Minimum Initial (s)	4.0		4.0	4.0	4.0		4.0
Minimum Split (s)	21.0		9.0	21.0	21.0		20.0
Total Split (s)	68.0	0.0	10.0	78.0	22.0	0.0	20.0
Total Split (%)	56.7%	0.0%	8.3%	65.0%	18.3%	0.0%	17%
Yellow Time (s)	3.5		2.5	3.5	3.0		2.0
All-Red Time (s)	1.5		1.5	1.5	1.5		1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	5.0	4.0	4.0	5.0	4.5	4.0	
Lead/Lag	Lag		Lead				
Lead-Lag Optimize?	Yes		Yes				
Recall Mode	Min		None	Min	Min		None
Act Effct Green (s)	73.0			73.0	17.5		
Actuated g/C Ratio	0.73			0.73	0.18		
v/c Ratio	0.67			1.51	1.46		
Control Delay	10.0			258.4	251.6		
Queue Delay	0.0			0.0	0.0		
Total Delay	10.0			258.4	251.6		
LOS	A			F	F		
Approach Delay	10.0			258.4	251.6		
Approach LOS	A			F	F		
Queue Length 50th (ft)	242			~416	~402		
Queue Length 95th (ft)	363			#656	#602		
Internal Link Dist (ft)	671			610	706		
Turn Bay Length (ft)							
Base Capacity (vph)	1316			588	329		
Starvation Cap Reductn	0			0	0		
Spillback Cap Reductn	0			0	0		
Storage Cap Reductn	0			0	0		
Reduced v/c Ratio	0.67			1.51	1.46		

Intersection Summary
Cycle Length: 120

Actuated Cycle Length: 100
Natural Cycle: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.51
Intersection Signal Delay: 159.4 Intersection LOS: F
Intersection Capacity Utilization 125.6% ICU Level of Service H
Analysis Period (min) 15
~ 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.

Splits and Phases: 1: Int

Appendix E

AM/PM Peak Hour Intersection Capacity Analysis
Install Traffic Signal and Modify Intersection Geometry
Under Existing Traffic Conditions
Boston Post Road at Landham Road, Sudbury

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø9
Lane Configurations							
Volume (vph)	710	303	132	342	180	222	
Confl. Peds. (#/hr)		1	1			1	
Confl. Bikes (#/hr)							
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	
Growth Factor	100%	100%	100%	100%	100%	100%	
Heavy Vehicles (%)	4%	3%	3%	3%	4%	4%	
Bus Blockages (#/hr)	0	0	0	0	0	0	
Parking (#/hr)							
Mid-Block Traffic (%)	0%			0%	0%		
Shared Lane Traffic (%)							
Lane Group Flow (vph)	740	316	138	356	188	231	
Turn Type		pm+ov	pm+pt			Perm	
Protected Phases	4	2	3	8	2		9
Permitted Phases		4	8			2	
Detector Phase	4	2	3	8	2	2	
Switch Phase							
Minimum Initial (s)	4.0	4.0	3.0	4.0	4.0	4.0	4.0
Minimum Split (s)	21.0	15.0	8.0	21.0	15.0	15.0	20.0
Total Split (s)	51.0	19.0	10.0	61.0	19.0	19.0	20.0
Total Split (%)	51.0%	19.0%	10.0%	61.0%	19.0%	19.0%	20%
Yellow Time (s)	3.5	3.0	3.0	3.5	3.0	3.0	2.0
All-Red Time (s)	1.5	1.5	1.0	1.5	1.5	1.5	1.5
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	5.0	4.5	4.0	5.0	4.5	4.5	
Lead/Lag	Lag		Lead				
Lead-Lag Optimize?	Yes		Yes				
Recall Mode	Min	None	Min	Min	None	None	None
Act Effct Green (s)	34.5	48.0	46.1	45.0	13.0	13.0	
Actuated g/C Ratio	0.49	0.68	0.65	0.64	0.18	0.18	
v/c Ratio	0.83	0.28	0.48	0.30	0.59	0.49	
Control Delay	26.6	1.6	12.3	7.8	39.0	9.2	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	26.6	1.6	12.3	7.8	39.0	9.2	
LOS	C	A	B	A	D	A	
Approach Delay	19.1			9.1	22.6		
Approach LOS	B			A	C		
Queue Length 50th (ft)	242	6	18	55	71	0	
Queue Length 95th (ft)	#645	31	#69	173	#220	67	
Internal Link Dist (ft)	671			610	706		
Turn Bay Length (ft)		120	120			120	
Base Capacity (vph)	1248	1163	288	1494	374	508	
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	0.59	0.27	0.48	0.24	0.50	0.45	

Intersection Summary
Cycle Length: 100

Actuated Cycle Length: 70.8
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.83
Intersection Signal Delay: 17.3 Intersection LOS: B
Intersection Capacity Utilization 66.0% ICU Level of Service C
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Int

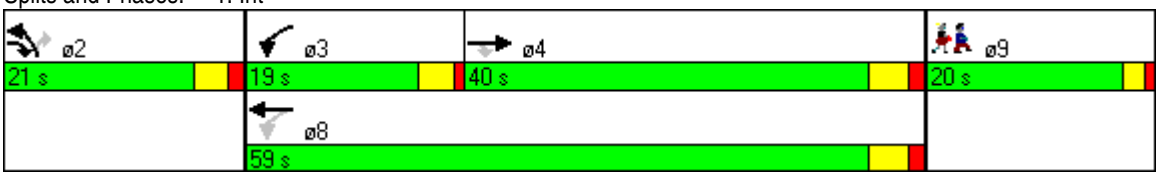
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø9
Lane Configurations							
Volume (vph)	512	292	262	547	211	225	
Confl. Peds. (#/hr)							
Confl. Bikes (#/hr)							
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	
Growth Factor	100%	100%	100%	100%	100%	100%	
Heavy Vehicles (%)	1%	1%	2%	2%	1%	1%	
Bus Blockages (#/hr)	0	0	0	0	0	0	
Parking (#/hr)							
Mid-Block Traffic (%)	0%			0%	0%		
Shared Lane Traffic (%)							
Lane Group Flow (vph)	563	321	288	601	232	247	
Turn Type		pm+ov	pm+pt			Perm	
Protected Phases	4	2	3	8	2		9
Permitted Phases		4	8			2	
Detector Phase	4	2	3	8	2	2	
Switch Phase							
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Minimum Split (s)	21.0	15.0	9.0	21.0	15.0	15.0	20.0
Total Split (s)	40.0	21.0	19.0	59.0	21.0	21.0	20.0
Total Split (%)	40.0%	21.0%	19.0%	59.0%	21.0%	21.0%	20%
Yellow Time (s)	3.5	3.0	3.0	3.5	3.0	3.0	2.0
All-Red Time (s)	1.5	1.5	1.0	1.5	1.5	1.5	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	5.0	4.5	4.0	5.0	4.5	4.5	
Lead/Lag	Lag		Lead				
Lead-Lag Optimize?	Yes		Yes				
Recall Mode	Min	None	None	Min	None	None	None
Act Effct Green (s)	27.2	46.5	44.8	43.8	14.7	14.7	
Actuated g/C Ratio	0.38	0.65	0.63	0.61	0.21	0.21	
v/c Ratio	0.79	0.28	0.64	0.49	0.63	0.47	
Control Delay	30.6	2.1	17.8	10.5	38.5	8.1	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	30.6	2.1	17.8	10.5	38.5	8.1	
LOS	C	A	B	B	D	A	
Approach Delay	20.2			12.9	22.8		
Approach LOS	C			B	C		
Queue Length 50th (ft)	208	8	46	120	91	0	
Queue Length 95th (ft)	#509	28	#198	333	#259	67	
Internal Link Dist (ft)	671			610	706		
Turn Bay Length (ft)		120	120			120	
Base Capacity (vph)	980	1183	520	1548	439	579	
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	0.57	0.27	0.55	0.39	0.53	0.43	

Intersection Summary
Cycle Length: 100

Actuated Cycle Length: 71.3	
Natural Cycle: 90	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.79	
Intersection Signal Delay: 17.9	Intersection LOS: B
Intersection Capacity Utilization 64.4%	ICU Level of Service C
Analysis Period (min) 15	

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

Splits and Phases: 1: Int



Appendix F

AM/PM Peak Hour Intersection Capacity Analysis
Install Traffic Signal and Modify Intersection Geometry
Under Future-Year (2030) Traffic Conditions
Boston Post Road at Landham Road, Sudbury

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø9
Lane Configurations							
Volume (vph)	710	303	132	342	180	222	
Confl. Peds. (#/hr)		1	1			1	
Confl. Bikes (#/hr)							
Peak Hour Factor	0.96	0.96	0.96	0.96	0.96	0.96	
Growth Factor	115%	115%	115%	115%	115%	115%	
Heavy Vehicles (%)	4%	3%	3%	3%	4%	4%	
Bus Blockages (#/hr)	0	0	0	0	0	0	
Parking (#/hr)							
Mid-Block Traffic (%)	0%			0%	0%		
Shared Lane Traffic (%)							
Lane Group Flow (vph)	851	363	158	410	216	266	
Turn Type		pm+ov	pm+pt			Perm	
Protected Phases	4	2	3	8	2		9
Permitted Phases		4	8			2	
Detector Phase	4	2	3	8	2	2	
Switch Phase							
Minimum Initial (s)	4.0	4.0	3.0	4.0	4.0	4.0	4.0
Minimum Split (s)	21.0	15.0	8.0	21.0	15.0	15.0	20.0
Total Split (s)	51.0	20.0	9.0	60.0	20.0	20.0	20.0
Total Split (%)	51.0%	20.0%	9.0%	60.0%	20.0%	20.0%	20%
Yellow Time (s)	3.5	3.0	3.0	3.5	3.0	3.0	2.0
All-Red Time (s)	1.5	1.5	1.0	1.5	1.5	1.5	1.5
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	5.0	4.5	4.0	5.0	4.5	4.5	
Lead/Lag	Lag		Lead				
Lead-Lag Optimize?	Yes		Yes				
Recall Mode	Min	None	Min	Min	None	None	None
Act Effct Green (s)	46.4	61.2	56.5	55.5	14.3	14.3	
Actuated g/C Ratio	0.56	0.74	0.68	0.67	0.17	0.17	
v/c Ratio	0.83	0.30	0.67	0.33	0.72	0.55	
Control Delay	25.7	1.7	24.1	8.1	48.6	9.5	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	25.7	1.7	24.1	8.1	48.6	9.5	
LOS	C	A	C	A	D	A	
Approach Delay	18.5			12.5	27.0		
Approach LOS	B			B	C		
Queue Length 50th (ft)	310	7	22	70	100	0	
Queue Length 95th (ft)	#801	40	#119	209	#252	71	
Internal Link Dist (ft)	671			610	706		
Turn Bay Length (ft)		120	120			120	
Base Capacity (vph)	1027	1226	237	1240	328	503	
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	0.83	0.30	0.67	0.33	0.66	0.53	

Intersection Summary
Cycle Length: 100

Actuated Cycle Length: 82.6	
Natural Cycle: 90	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.83	
Intersection Signal Delay: 18.8	Intersection LOS: B
Intersection Capacity Utilization 74.2%	ICU Level of Service D
Analysis Period (min) 15	

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

Splits and Phases: 1: Int

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø9
Lane Configurations							
Volume (vph)	512	292	262	547	211	225	
Confl. Peds. (#/hr)							
Confl. Bikes (#/hr)							
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	
Growth Factor	115%	115%	115%	115%	115%	115%	
Heavy Vehicles (%)	1%	1%	2%	2%	1%	1%	
Bus Blockages (#/hr)	0	0	0	0	0	0	
Parking (#/hr)							
Mid-Block Traffic (%)	0%			0%	0%		
Shared Lane Traffic (%)							
Lane Group Flow (vph)	647	369	331	691	267	284	
Turn Type		pm+ov	pm+pt			Perm	
Protected Phases	4	2	3	8	2		9
Permitted Phases		4	8			2	
Detector Phase	4	2	3	8	2	2	
Switch Phase							
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Minimum Split (s)	21.0	15.0	9.0	21.0	15.0	15.0	20.0
Total Split (s)	40.0	22.0	18.0	58.0	22.0	22.0	20.0
Total Split (%)	40.0%	22.0%	18.0%	58.0%	22.0%	22.0%	20%
Yellow Time (s)	3.5	3.0	3.0	3.5	3.0	3.0	2.0
All-Red Time (s)	1.5	1.5	1.0	1.5	1.5	1.5	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	5.0	4.5	4.0	5.0	4.5	4.5	
Lead/Lag	Lag		Lead				
Lead-Lag Optimize?	Yes		Yes				
Recall Mode	Min	None	None	Min	None	None	None
Act Effct Green (s)	34.3	55.1	53.5	52.5	16.5	16.5	
Actuated g/C Ratio	0.42	0.67	0.65	0.64	0.20	0.20	
v/c Ratio	0.82	0.32	0.79	0.54	0.74	0.53	
Control Delay	33.1	2.4	32.4	11.6	46.0	9.2	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	33.1	2.4	32.4	11.6	46.0	9.2	
LOS	C	A	C	B	D	A	
Approach Delay	21.9			18.3	27.0		
Approach LOS	C			B	C		
Queue Length 50th (ft)	267	14	91	154	123	6	
Queue Length 95th (ft)	#629	36	#320	419	#301	81	
Internal Link Dist (ft)	671			610	706		
Turn Bay Length (ft)		120	120			120	
Base Capacity (vph)	815	1180	418	1303	387	557	
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	0.79	0.31	0.79	0.53	0.69	0.51	

Intersection Summary
Cycle Length: 100

Actuated Cycle Length: 81.8	
Natural Cycle: 90	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.82	
Intersection Signal Delay: 21.6	Intersection LOS: C
Intersection Capacity Utilization 72.4%	ICU Level of Service C
Analysis Period (min) 15	

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

Splits and Phases: 1: Int