MEMORANDUM

To: David Lane, Danvers Public Works Director   **July 8, 2010**

From: Chen-Yuan Wang and Efi Pagitsas

Re: Boston Region MPO Congested and High-Crash Intersections Study:
Poplar Street (Route 62) at Locust Street (Route 35) in Danvers

This memorandum summarizes safety and operations analyses and proposes improvement strategies for the intersection of Poplar Street (Route 62) at Locust Street (Route 35) in Danvers. It contains the following sections:

- Intersection Layout and Traffic Control
- Issues and Concerns
- Crash Data Analysis
- Intersection Capacity Analysis
- Analyses of Improvement Alternatives
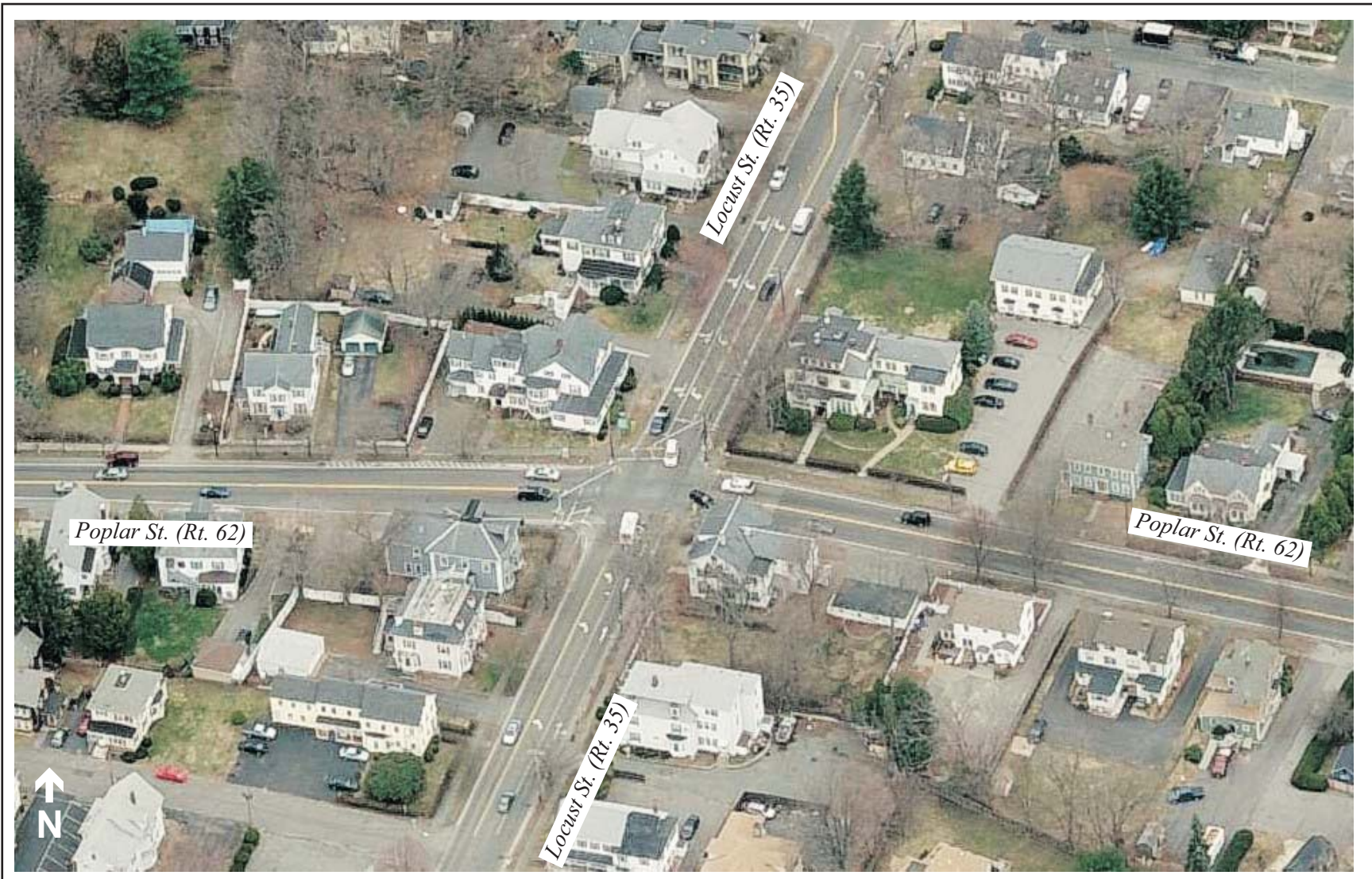- Improvement Recommendations and Discussions

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 signalized intersection is located in the central area of Danvers. Poplar Street, a two-lane roadway running in the east-west direction, is actually State Route 62, which functions as a principal urban arterial and serves the North Shore region and communities farther west. Locust Street, a two-lane roadway running in the north-south direction, is State Route 35, which functions as a minor urban arterial and serves mainly the North Shore region.

Figure 1 shows the intersection layout and the area nearby. Poplar Street has no exclusive right- or left-turn lanes on either approach. The eastbound approach flares out somewhat for a short distance. All movements on Poplar Street basically share a single travel lane. Both approaches of Locust Street are widened to contain two lanes: one exclusively for left turns and one shared by through and right-turn movements. There are crosswalks and sidewalks on all approaches of the intersection. Right turns on red are prohibited on all approaches.

The traffic signal is currently operated in two traffic phases: (1) eastbound/westbound (EB/WB) all movements (left turns permitted) and (2) northbound/southbound (NB/SB) all movements (left turns permitted). The signal control also includes an exclusive pedestrian phase that lasts

FIGURE 1
Poplar Street (Route 62) at Locust Street (Route 35), Danvers

Operational Improvements at Congested and High-Crash Intersections

CTPS

about 23 seconds. When manually activated, the on-call pedestrian phase takes place after the northbound/southbound traffic phase, and all traffic movements are prohibited.

The land use in the vicinity of the intersection is mainly residential. There is densely settled single-family housing on both sides of Poplar Street. Further north are mainly low-density residential areas. South of the intersection, Locust Street connects Maple Street and High Street, which leads to the commercial area of downtown Danvers.

ISSUES AND CONCERNS

The intersection is congested during peak periods on almost all the approaches, depending on the peak direction. Traffic on Poplar Street is heavy in both directions during peak periods. Poplar Street is the middle section of a two-mile stretch of Route 62 that connects Route 128 in the east and Interstate 95 in the west. It also carries local traffic, as it is a major east-west roadway in the town. During peak hours, the heavy approaching traffic sometimes cannot pass the intersection within one signal cycle. Meanwhile, lacking an exclusive left-turn lane, left turns frequently block through traffic and cause delays for the entire approach.

Traffic on Locust Street is busy during peak periods, with a high proportion of left turns on both approaches. It also carries both local and regional traffic, as Route 35 continues to Salem in the east. Locust Street contains an exclusive left-turn lane and a lane shared by through and right-turn movements on both approaches. Through and right-turn traffic usually can pass the intersection, but some left turns cannot pass the intersection within a signal cycle when the opposite through traffic is heavy.

Review of the recent crash data indicates that the intersection has a high number of crashes and a crash rate somewhat higher than other signalized 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 at the intersection
- Traffic congestion during peak hours
- Left-turning vehicles on Poplar Street blocking through traffic
- Noticeable delays for left turns on Locust Street

CRASH DATA ANALYSIS

Based on the 2004–2006 MassDOT Registry Division crash data, Table 1 shows that on average 10 crashes occurred at the intersection each year. Nearly 25% of the total crashes resulted in personal injuries. The crash types consist of 40% angle collisions, nearly 25% rear-end collisions, and about 35% others. No crashes involved pedestrians or bicycles. About 25% of the total crashes occurred during peak periods.

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 0.96 (see Appendix A for the calculation sheet). The rate is higher than the average rate for the signalized locations in MassDOT Highway Division's District 4, which is estimated to be 0.78.[2]

TABLE 1
Summary of Crash Data (2004–2006)
Poplar Street at Locust Street, Danvers

Statistics Period		2004	2005	2006	2004–06	Average
Total number of crashes		7	14	9	30	10
Severity	**Property damage only**	5	8	7	20	7
	Personal injury	1	5	1	7	2
	Fatality	0	0	0	0	0
	Not reported	1	1	1	3	1
Collision Type	**Angle**	5	5	2	12	4
	Rear-end	1	3	3	7	2
	Sideswipe	0	2	1	3	1
	Head-on	0	2	1	3	1
	Single vehicle	1	1	0	2	1
	Not reported	0	1	2	3	1
Crashes involving pedestrian(s)		0	0	0	0	0
Crashes involving cyclist(s)		0	0	0	0	0
Occurred during weekday peak periods*		1	1	4	6	2
Wet or icy pavement conditions		1	4	2	7	2
Dark/lighted conditions		2	2	1	5	2

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

INTERSECTION CAPACITY ANALYSIS

CTPS collected turning-movement counts at the intersection on May 28, 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. The intersection carried about 2,500 vehicles in the morning peak hour from 7:15 to 8:15 and about 2,550 vehicles in the evening peak hour from 5:00 to 6:00 (see Table 2). About 10 pedestrians were observed during each of the two peak hours. No bicycles were observed in the AM peak hour. Two bicycles entering the intersection from Poplar Street EB and WB, respectively, were observed in the PM peak hour.

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[1] Crash rates normalize crash frequency (crashes per year) by 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 a review process for an environmental impact report or functional design report. 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.

TABLE 2
AM and PM Peak Hour Traffic Volumes and Pedestrian Crossings
Poplar Street at Locust Street, Danvers

Street name		Poplar Street (Route 62)						Locust Street (Route 35)						Total
Direction		Eastbound			Westbound			Northbound			Southbound			
Turning movement		LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
AM peak hour	Turning volume	31	695	18	14	723	41	135	254	34	177	312	90	2524
	Approach volume	744			778			423			579			
	Pedestrian crossings	3			3			3			0			9
PM peak hour	Turning volume	52	608	18	12	742	55	164	385	53	118	277	87	2571
	Approach volume	678			809			602			482			
	Pedestrian crossings	1			4			4			1			10

Based on the turning-movement counts and the signal timings measured at the site, the intersection capacity was analyzed using an intersection capacity analysis program, Synchro.[3] Intersection evaluation showed that it operates at level of service (LOS) D with an average delay of about half a minute per vehicle in the AM peak hour, and at LOS E with an average delay of about one minute per vehicle in the PM peak hour (see Table 3). The level of service criteria are based on the Highway Capacity Manual 2000.[4] Detailed analysis settings and results for both the AM and PM peak hour are included in Appendix B.

TABLE 3
Intersection Capacity Analysis, Existing Conditions
Poplar Street at Locust Street, Danvers

Street name		Poplar Street (Route 62)						Locust Street (Route 35)						Overall
Direction		Eastbound			Westbound			Northbound			Southbound			
Turning movement		LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT	
AM peak hour	LOS	C			D			F	C		D	C		D
	Delay (sec/veh)	34			36			82	24		44	33		37
PM peak hour	LOS	D			E			F	D		F	C		E
	Delay (sec/veh)	52			75			111	47		143	34		64

As seen in the table above, traffic on the EB/WB approaches endures noticeable delays, especially the westbound approach, which has no flared-out area for storing left turns. Left turns on the NB/SB approaches also endure extensive delays, as they have to yield to the opposite through traffic during their signal phase. The analysis indicates that the intersection capacity is somewhat insufficient with the existing geometry and traffic demand.

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

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

ANALYSES OF IMPROVEMENT ALTERNATIVES

To improve traffic operations at this intersection, we examined a number of traffic signal and geometric design strategies. The analyses were performed progressively from simple to more involved modifications in the improvement alternatives. As mentioned earlier, the intersection capacity was evaluated using Synchro optimization and simulation software.

The alternatives tested for this intersection include:

1) Retime Traffic Signal with Existing Geometry and Signal Phasing Sequence
2) Retime Traffic Signal with Existing Geometry and Change Locust Street Operation to a Split Signal Phase
3) Retime Traffic Signal with Existing Geometry and Add a Protected Left-Turn Signal Phase on Locust Street
4) Add a Left-Turn Lane on Both EB/WB Approaches and Retime Signal with Existing Phasing Sequence
5) Add a Left-Turn Lane on Both EB/WB Approaches and Change Locust Street Operation to a Split Signal Phase
6) Add a Left-Turn Lane on Both EB/WB Approaches and Add a Protected Left-Turn Signal Phase on All Approaches

In Alternatives 1, 2, and 3, we tested rearrangements of the signal's operation with the existing intersection geometry. Synchro tests indicated that the intersection capacity would deteriorate significantly with split-phase or protected left-turn operations on Locust Street (Alternatives 2 and 3 above). However, the adjustment of signal timing with the existing phasing sequence would reduce the overall intersection delay (Alternative 1 above).

We then tried various geometry-modification plans with appropriate signal phasing plans: Alternatives 4, 5, and 6. Our assessment shows that adding a left-turn storage lane on both EB/WB approaches under the existing phasing sequence (Alternative 4) provides maximum benefit to the intersection's traffic operations during both peak periods, with geometric changes within the existing right-of-way. Alternatives 5 and 6 yield undesirable levels of service.

We therefore selected Alternatives 1 and 4 for further analysis.

1. Retime Traffic Signal with Existing Geometry and Phasing Sequence

Currently the intersection's signal cycle is slightly over a minute. Assessment using the existing traffic volumes and intersection geometry indicates that simply extending the total traffic cycle length by five seconds (distributed evenly to the green time on both streets) would improve the intersection operation in the AM peak hour slightly and more significantly in the PM peak hour (see Table 5). As the traffic cycle length increase is minimal, pedestrian level of service would not be affected. Details of the signal settings and analysis results for this alternative for both peak hours are included in Appendix C.

4. Add a Left-Turn Lane on both EB/WB Approaches and Retime Signal with Existing Phasing Sequence

Based on the State Roadway Inventory file, the right-of-way (ROW) of Poplar Street is 62 feet at both sides of the intersection for about 500 feet upstream. The width of the roadway surface is about 40 feet; the grassy buffer zone is about 6 to 7 feet; and the sidewalk is 4 feet. Sidewalks and buffers exist at both sides of the street. It appears feasible to construct an 11-foot left-turn lane on both approaches within the existing pavement width. Analyses indicate that the desirable length for the left-turn lane is about 60 feet for the eastbound approach and 40 feet for the westbound approach. This measure would provide storage for left turns and reduce blocking of traffic on the rest of the approach.

TABLE 5
Intersection Capacity Analysis of Alternative Improvements
Existing Traffic Volumes
Poplar Street at Locust Street, Danvers

Street name		Poplar Street (Route 62)		Locust Street (Route 35)		Overall
Approach		Eastbound	Westbound	Northbound	Southbound	
AM peak hour	Existing	C/34	D/36	D/42	D/37	D/37
	Alternative 1	C/34	C/34	D/42	D/37	D/36
	Alternative 4	C/29	C/33	C/35	C/33	C/32
PM peak hour	Existing	D/52	E/75	E/65	E/61	E/64
	Alternative 1	D/37	D/48	D/41	D/39	D/42
	Alternative 4	C/25	D/42	D/41	D/39	D/37

Note   Performance measures: Level of Service (A to F)/Average Delay (seconds per vehicle)
          Alternative 1: Retime Traffic Signal with Existing Geometry and Phasing Sequence
          Alternative 4: Add a Left-Turn Lane on both EB/WB Approaches and Retime Signal with Existing Phasing Sequence

Synchro tests that include the proposed geometric modification, with the existing signal phasing sequence and traffic volumes, indicate that traffic operations at this intersection would be noticeably improved from the existing conditions. The intersection would operate at LOS C in the AM peak hour and LOS D in the PM peak hour (see Table 5) with an average delay of about half a minute. All the approaches under this alternative would experience much less delay than under the existing conditions. Details of the signal settings and analysis results for both peak hours are included in Appendix D.

More significantly, this alternative would improve traffic operations at the intersection, as traffic on Poplar Street would operate more smoothly with the addition of left-turn storage lanes and traffic on Locust Street would have more portioned green time to pass the intersection. In general, traffic safety and pedestrian safety at an intersection improve if traffic operations are improved and congested conditions are reduced.

In addition, a future-year scenario of 10% growth over a 20-year planning horizon was tested for each of the two alternatives. The growth assumption is based on a review of the traffic projections at the intersection from the Boston Region MPO transportation-planning model. A

higher number than under existing conditions of pedestrian calls (15 in each peak hour) was assumed in the future-year analysis.

Results from Synchro tests of the alternatives with the projected traffic growth are summarized in Table 6. With the existing geometry and signal timing plan and under the projected traffic conditions, the intersection would operate at LOS E in the AM peak hour and LOS F in the PM peak hour with significant average delays. Under Alternative 1, the intersection would operate at LOS D in the AM peak hour, but in the PM peak hour it would operate at LOS E and have an average delay of over one minute. Under Alternative 4, it would operate at acceptable LOS D in both the AM and PM peak hours. Details of the Synchro results for all the alternatives under the projected traffic conditions are included in Appendices E, F, and G.

TABLE 6
Intersection Capacity Analysis of Alternative Improvements
Projected 2030 Traffic Conditions
Poplar Street at Locust Street, Danvers

Street name		Poplar Street (Route 62)		Locust Street (Route 35)		Overall
Approach		**Eastbound**	**Westbound**	**Northbound**	**Southbound**	
AM peak hour	Existing	D/55	D/55	E/78	D/48	E/57
	Alternative 1	D/52	D/51	E/76	D/48	D/54
	Alternative 4	D/37	D/48	E/56	D/41	D/45
PM peak hour	Existing	F/96	F/115	F/109	F/98	F/106
	Alternative 1	E/67	E/76	E/62	E/69	E/69
	Alternative 4	C/31	E/76	D/51	D/53	D/54

Note   Performance measures: Level of Service (A to F)/Average Delay (seconds per vehicle)
        Alternative 1: Retime Traffic Signal with Existing Geometry and Phasing Sequence
        Alternative 4: Add a Left-Turn Lane on Both EB/WB Approaches and Retime Signal with Existing Phasing Sequence

IMPROVEMENT RECOMMENDATIONS AND DISCUSSIONS

To improve traffic operations at this intersection, this study examined a number of traffic signal and geometric design strategies. Analyses indicate that traffic operations at the intersection can be improved by retiming the signal with the existing signal phasing sequence (Alternative 1). Adding an exclusive left-turn lane on both EB/WB approaches and retiming the signal with the existing phasing sequence (Alternative 4) would improve traffic operations at the intersection to a greater degree.

In the short term, we propose Alternative 1: retime the signal under the existing phasing plan by simply increasing the traffic cycle by about five seconds and distributing the increase evenly to the green time on both streets. This simple signal timing change would improve the intersection operation slightly in the AM peak hour but noticeably in the more congested PM peak hour. As the traffic cycle length increase is minimal, pedestrian waiting time would not increase perceptibly.

Synchro tests indicated that traffic operations would have no room to improve under the projected future traffic conditions unless the intersection is modified to include more travel lanes,

especially on Poplar Street. Among various expansion plans, adding a left-turn storage lane on both EB/WB approaches is expected to have minimal impacts to the surroundings and maximum benefit to traffic operations for this intersection.

Therefore, in the long run, we propose the implementation of Alternative 4: add an exclusive left-turn lane on the EB and WB approaches and retime the traffic signal, maintaining the existing phasing sequence.

According to the State Roadway Inventory file, the right-of-way (ROW) of Poplar Street is 62 feet on both sides of the intersection for a substantial distance. The width of the roadway surface is about 40 feet. The rest of the ROW is used for grassy buffer zones and sidewalks on both sides. Allocating an 11-foot space within the existing pavement width for EB and WB left-turning traffic appears feasible and would improve safety and level of service at this intersection. Based on analyses, we estimate that the desirable length for the left-turn lane is 60 feet for the eastbound approach and 40 feet for the westbound approach in order to prevent left-turn queues from spilling over into the through and right-turn lane. This alternative would improve traffic operations at the intersection, as traffic on Poplar Street would operate more smoothly with the addition of left-turn storage lanes, and the Locust Street approaches could receive somewhat longer green times for traffic to pass the intersection. As traffic operations would be improved and congested conditions would be reduced, traffic and pedestrian safety at the intersection would improve.

The intersection currently has sidewalks and crosswalks on all approaches. These features should be maintained when the intersection is reconstructed for the implementation of Alternative 4. In addition, the potential for adding a bike lane on all the approaches should be explored at the functional design stage. Constructing a bike lane is feasible under Alternative 1 but might not be feasible under Alternative 4 because the width of the grassy buffer zones would have to be reduced under the latter alternative.

Appendix A

Intersection Crash Rate Calculation
Poplar Street at Locust Street, Danvers

MassHighway

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Danvers   COUNT DATE :   5/28/09
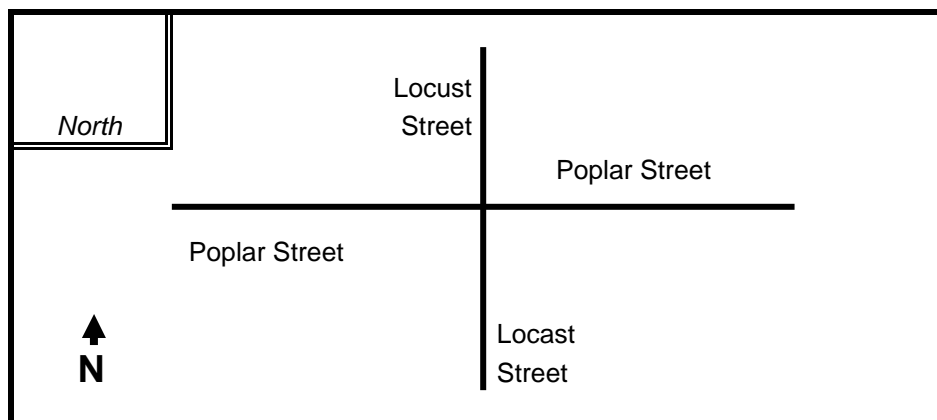
DISTRICT :   4   UNSIGNALIZED :   SIGNALIZED :   **X**

~ INTERSECTION DATA ~

MAJOR STREET :   Poplar Street (Rt. 62)

MINOR STREET(S) :   Locust Street (Rt. 35)

INTERSECTION DIAGRAM (Label Approaches)

North

Locust Street

Poplar Street

Poplar Street

Locast Street

↑ N

PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	NB	SB	EB	WB		
PEAK HOURLY VOLUMES (AM/PM) :	602	482	678	809		**2,571**

" K " FACTOR :	**0.090**	INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME :		**28,567**
TOTAL # OF CRASHES :	30	# OF YEARS :	3	AVERAGE # OF CRASHES PER YEAR (**A**) :	**10.00**

CRASH RATE CALCULATION :   **0.96**   RATE = $\dfrac{(A * 1,000,000)}{(V * 365)}$

Comments : _____

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

Appendix B

AM/PM Peak Hour Intersection Capacity Analysis
Existing Traffic Conditions
Poplar Street at Locust Street, Danvers

Intersection Capacity Analysis
Poplar St @ Locust St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✛			✛		↰	↱		↰	↱	
Volume (vph)	31	695	18	14	723	41	135	254	34	177	312	90
Confl. Peds. (#/hr)			3	3			3		3	3		3
Confl. Bikes (#/hr)												
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	784	0	0	819	0	142	303	0	186	423	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	36.0	36.0	0.0	36.0	36.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Total Split (%)	42.4%	42.4%	0.0%	42.4%	42.4%	0.0%	30.6%	30.6%	0.0%	30.6%	30.6%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	Min	Min		Min	Min		None	None		None	None	
Act Effct Green (s)		32.5			32.5		22.3	22.3		22.3	22.3	
Actuated g/C Ratio		0.49			0.49		0.34	0.34		0.34	0.34	
v/c Ratio		0.91			0.92		0.92	0.54		0.76	0.77	
Control Delay		34.9			35.5		81.6	24.2		44.5	33.4	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		34.9			35.5		81.6	24.2		44.5	33.4	
LOS		C			D		F	C		D	C	
Approach Delay		34.9			35.5			42.5			36.7	
Approach LOS		C			D			D			D	
Queue Length 50th (ft)		236			248		48	87		59	135	
Queue Length 95th (ft)		#714			#742		#203	#236		#227	#406	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)										250		
Base Capacity (vph)		859			890		155	561		246	551	
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		0.91			0.92		0.92	0.54		0.76	0.77	

Intersection Summary

Cycle Length: 85

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	27%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 66.4

Natural Cycle: 150

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.92

Intersection Signal Delay: 36.8   Intersection LOS: D

Intersection Capacity Utilization 93.8%   ICU Level of Service F

Analysis Period (min) 15

\#   95th percentile volume exceeds capacity, queue may be longer.

     Queue shown is maximum after two cycles.

Splits and Phases: 1: Poplar St & Locust St

Intersection Capacity Analysis
Poplar St @ Locust St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		�			�							
Volume (vph)	52	608	18	12	742	55	164	385	53	118	277	87
Confl. Peds. (#/hr)	1		4	4		1	1		4	4		1
Confl. Bikes (#/hr)						2						1
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	721	0	0	861	0	174	466	0	126	388	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Detector Phase	2	2		6	6		8	8		4	4	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	36.0	36.0	0.0	36.0	36.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Total Split (%)	42.4%	42.4%	0.0%	42.4%	42.4%	0.0%	30.6%	30.6%	0.0%	30.6%	30.6%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	Min	Min		Min	Min		None	None		None	None	
Act Effct Green (s)		32.5			32.5		22.3	22.3		22.3	22.3	
Actuated g/C Ratio		0.49			0.49		0.34	0.34		0.34	0.34	
v/c Ratio		0.99			1.07		1.04	0.90		1.10	0.76	
Control Delay		51.9			74.5		110.9	47.2		142.8	33.8	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		51.9			74.5		110.9	47.2		142.8	33.8	
LOS		D			E		F	D		F	C	
Approach Delay		51.9			74.5			64.5			60.5	
Approach LOS		D			E			E			E	
Queue Length 50th (ft)		233			~314		63	158		~50	123	
Queue Length 95th (ft)		#695			#830		#243	#475		#197	#380	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)										250		
Base Capacity (vph)		729			802		167	515		115	510	
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		0.99			1.07		1.04	0.90		1.10	0.76	

Intersection Summary

Cycle Length: 85

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	27%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 66.4
Natural Cycle: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.10
Intersection Signal Delay: 63.6   Intersection LOS: E
Intersection Capacity Utilization 114.1%   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: Poplar St & Locust St

Appendix C

AM/PM Peak Hour Intersection Capacity Analysis
Alternative 1: Retime Traffic Signal with Existing Phasing and Geometry
Under Existing Traffic Conditions
Poplar Street at Locust Street, Danvers

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		⬥			⬥		↰	↱		↰	↱	
Volume (vph)	31	695	18	14	723	41	135	254	34	177	312	90
Confl. Peds. (#/hr)			3	3			3		3	3		3
Confl. Bikes (#/hr)												
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	784	0	0	819	0	142	303	0	186	423	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Total Split (%)	43.3%	43.3%	0.0%	43.3%	43.3%	0.0%	31.1%	31.1%	0.0%	31.1%	31.1%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None		None	None		None	None	
Act Effct Green (s)		35.5			35.5		24.3	24.3		24.3	24.3	
Actuated g/C Ratio		0.50			0.50		0.34	0.34		0.34	0.34	
v/c Ratio		0.90			0.91		0.90	0.53		0.75	0.76	
Control Delay		33.8			34.1		78.9	24.9		44.7	33.6	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		33.8			34.1		78.9	24.9		44.7	33.6	
LOS		C			C		E	C		D	C	
Approach Delay		33.8			34.1			42.2			37.0	
Approach LOS		C			C			D			D	
Queue Length 50th (ft)		256			269		53	95		64	146	
Queue Length 95th (ft)		#737			#766		#210	243		#234	#417	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)										250		
Base Capacity (vph)		872			904		158	568		248	558	
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		0.90			0.91		0.90	0.53		0.75	0.76	

Intersection Summary

Cycle Length: 90

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	26%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 71.4

Natural Cycle: 150

Control Type: Semi Act-Uncoord

Maximum v/c Ratio: 0.91

Intersection Signal Delay: 36.0   Intersection LOS: D

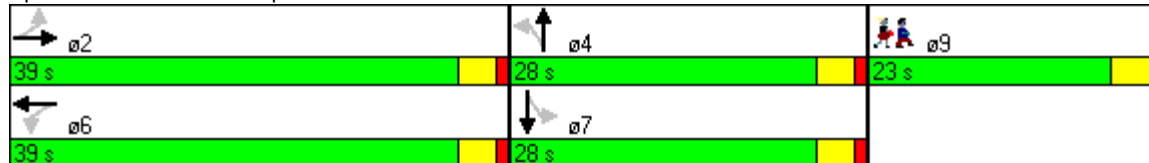Intersection Capacity Utilization 93.8%   ICU Level of Service F

Analysis Period (min) 15

\#   95th percentile volume exceeds capacity, queue may be longer.

   Queue shown is maximum after two cycles.

Splits and Phases: 1: Poplar St & Locust St

ø2	ø4	ø9
39 s	28 s	23 s
ø6	ø7	
39 s	28 s	

Intersection Capacity Analysis
Poplar St @ Locust St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		⬥			⬥		↰	↱		↰	↱	
Volume (vph)	52	608	18	12	742	55	164	385	53	118	277	87
Confl. Peds. (#/hr)	1		4	4		1	1		4	4		1
Confl. Bikes (#/hr)						2						1
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	721	0	0	861	0	174	466	0	126	388	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Total Split (%)	42.2%	42.2%	0.0%	42.2%	42.2%	0.0%	32.2%	32.2%	0.0%	32.2%	32.2%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		Max	Max		None	None		Max	Max	
Act Effct Green (s)		34.4			34.4		25.3	25.3		25.3	25.3	
Actuated g/C Ratio		0.48			0.48		0.35	0.35		0.35	0.35	
v/c Ratio		0.91			0.98		0.85	0.77		0.86	0.65	
Control Delay		37.4			47.5		61.2	33.1		72.3	27.8	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		37.4			47.5		61.2	33.1		72.3	27.8	
LOS		D			D		E	C		E	C	
Approach Delay		37.4			47.5			40.7			38.7	
Approach LOS		D			D			D			D	
Queue Length 50th (ft)		242			306		62	161		45	126	
Queue Length 95th (ft)		#696			#831		#237	#454		#190	#353	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)										250		
Base Capacity (vph)		789			878		204	604		147	597	
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		0.91			0.98		0.85	0.77		0.86	0.65	

Intersection Summary

Cycle Length: 90

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	26%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 71.4

Natural Cycle: 150

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.98

| Intersection Signal Delay: 41.6 | Intersection LOS: D |
| Intersection Capacity Utilization 103.7% | ICU Level of Service G |

Analysis Period (min) 15

\#   95th percentile volume exceeds capacity, queue may be longer.

     Queue shown is maximum after two cycles.

Splits and Phases: 1: Poplar St & Locust St

ø2	ø4	ø9
38 s	29 s	23 s
ø6	ø7	
38 s	29 s	

Appendix D

AM/PM Peak Hour Intersection Capacity Analysis
Alternative 4: Add EB/WB Left-Turn Lanes and Retime Signal with Existing Sequence
Under Existing Traffic Conditions
Poplar Street at Locust Street, Danvers

Intersection Capacity Analysis
Poplar St @ Locust St

1/28/2010

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↱	↟		↱	↟		↱	↟		↱	↟	
Volume (vph)	31	695	18	14	723	41	135	254	34	177	312	90
Confl. Peds. (#/hr)			3	3			3		3	3		3
Confl. Bikes (#/hr)												
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	33	751	0	15	804	0	142	303	0	186	423	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	25.0	25.0		25.0	25.0		25.0	25.0		25.0	25.0	
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Total Split (%)	42.2%	42.2%	0.0%	42.2%	42.2%	0.0%	32.2%	32.2%	0.0%	32.2%	32.2%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None		None	None		None	None	
Act Effct Green (s)	34.4	34.4		34.4	34.4		25.3	25.3		25.3	25.3	
Actuated g/C Ratio	0.48	0.48		0.48	0.48		0.36	0.36		0.36	0.36	
v/c Ratio	0.33	0.84		0.15	0.90		0.81	0.51		0.70	0.73	
Control Delay	26.0	28.9		18.2	33.6		59.0	23.3		38.5	30.7	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	26.0	28.9		18.2	33.6		59.0	23.3		38.5	30.7	
LOS	C	C		B	C		E	C		D	C	
Approach Delay		28.8			33.4			34.7			33.1	
Approach LOS		C			C			C			C	
Queue Length 50th (ft)	7	239		3	267		50	93		62	143	
Queue Length 95th (ft)	#51	#667		21	#730		#196	231		#218	#394	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)	75			75						250		
Base Capacity (vph)	100	889		101	895		176	594		267	583	
Starvation Cap Reductn	0	0		0	0		0	0		0	0	
Spillback Cap Reductn	0	0		0	0		0	0		0	0	
Storage Cap Reductn	0	0		0	0		0	0		0	0	
Reduced v/c Ratio	0.33	0.84		0.15	0.90		0.81	0.51		0.70	0.73	

Intersection Summary

Cycle Length: 90

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	26%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 71

Natural Cycle: 130

Control Type: Semi Act-Uncoord

Maximum v/c Ratio: 0.90

Intersection Signal Delay: 32.2   Intersection LOS: C

Intersection Capacity Utilization 80.0%   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: Poplar St & Locust St

ø2	ø4	ø9
38 s	29 s	23 s
ø6	ø7	
38 s	29 s	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↱		↰	↱		↰	↱		↰	↱	
Volume (vph)	52	608	18	12	742	55	164	385	53	118	277	87
Confl. Peds. (#/hr)	1		4	4		1	1		4	4		1
Confl. Bikes (#/hr)						2						1
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	55	666	0	13	848	0	174	466	0	126	388	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Total Split (%)	42.2%	42.2%	0.0%	42.2%	42.2%	0.0%	32.2%	32.2%	0.0%	32.2%	32.2%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	Min	Min		Min	Min		None	None		None	None	
Act Effct Green (s)	34.4	34.4		34.4	34.4		25.3	25.3		25.3	25.3	
Actuated g/C Ratio	0.48	0.48		0.48	0.48		0.35	0.35		0.35	0.35	
v/c Ratio	0.54	0.74		0.08	0.95		0.85	0.77		0.86	0.65	
Control Delay	41.4	23.3		15.3	42.2		61.2	33.1		72.3	27.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	41.4	23.3		15.3	42.2		61.2	33.1		72.3	27.8	
LOS	D	C		B	D		E	C		E	C	
Approach Delay		24.7			41.8			40.7			38.7	
Approach LOS		C			D			D			D	
Queue Length 50th (ft)	14	194		3	295		62	161		45	126	
Queue Length 95th (ft)	#94	#572		18	#811		#237	#454		#190	#353	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)	75			75						250		
Base Capacity (vph)	102	903		153	888		204	604		147	597	
Starvation Cap Reductn	0	0		0	0		0	0		0	0	
Spillback Cap Reductn	0	0		0	0		0	0		0	0	
Storage Cap Reductn	0	0		0	0		0	0		0	0	
Reduced v/c Ratio	0.54	0.74		0.08	0.95		0.85	0.77		0.86	0.65	

Intersection Summary

Cycle Length: 90

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	26%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 71.4

Natural Cycle: 150

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 0.95

Intersection Signal Delay: 36.5   Intersection LOS: D

Intersection Capacity Utilization 83.3%   ICU Level of Service E

Analysis Period (min) 15

\#   95th percentile volume exceeds capacity, queue may be longer.

    Queue shown is maximum after two cycles.

Splits and Phases: 1: Poplar St & Locust St

Appendix E

AM/PM Peak Hour Intersection Capacity Analysis
Existing Geometry and Signal Timing/Phasing
Under Projected Traffic Conditions
Poplar Street at Locust Street, Danvers

Intersection Capacity Analysis
Poplar St @ Locust St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		⊕			⊕		↰	↱		↰	↱	
Volume (vph)	31	695	18	14	723	41	135	254	34	177	312	90
Confl. Peds. (#/hr)			3	3			3		3	3		3
Confl. Bikes (#/hr)												
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Growth Factor	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	862	0	0	900	0	156	333	0	205	465	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	36.0	36.0	0.0	36.0	36.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Total Split (%)	42.4%	42.4%	0.0%	42.4%	42.4%	0.0%	30.6%	30.6%	0.0%	30.6%	30.6%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	Min	Min		Min	Min		None	None		None	None	
Act Effct Green (s)		32.5			32.5		22.3	22.3		22.3	22.3	
Actuated g/C Ratio		0.49			0.49		0.34	0.34		0.34	0.34	
v/c Ratio		1.01			1.01		1.25	0.59		0.92	0.84	
Control Delay		54.7			54.4		189.4	25.9		69.7	38.9	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		54.7			54.4		189.4	25.9		69.7	38.9	
LOS		D			D		F	C		E	D	
Approach Delay		54.7			54.4			78.0			48.3	
Approach LOS		D			D			E			D	
Queue Length 50th (ft)		285			298		~73	98		70	154	
Queue Length 95th (ft)		#810			#840		#237	#287		#262	#459	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)										250		
Base Capacity (vph)		852			888		125	561		224	551	
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		1.01			1.01		1.25	0.59		0.92	0.84	

Intersection Summary

Cycle Length: 85

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	27%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 66.4

Natural Cycle: 150

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 1.25

Intersection Signal Delay: 57.1 — Intersection LOS: E

Intersection Capacity Utilization 102.1% — ICU Level of Service G

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: Poplar St & Locust St

ø2	ø4	ø9
36 s	26 s	23 s

ø6	ø7	
36 s	26 s	

Intersection Capacity Analysis
Poplar St @ Locust St

1/15/2010

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✛			✛		↰	↱		↰	↱	
Volume (vph)	52	608	18	12	742	55	164	385	53	118	277	87
Confl. Peds. (#/hr)	1		4	4		1	1		4	4		1
Confl. Bikes (#/hr)						2						1
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Growth Factor	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	793	0	0	946	0	192	513	0	138	426	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			8			4	
Permitted Phases	2			6			8			4		
Detector Phase	2	2		6	6		8	8		4	4	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	36.0	36.0	0.0	36.0	36.0	0.0	26.0	26.0	0.0	26.0	26.0	0.0
Total Split (%)	42.4%	42.4%	0.0%	42.4%	42.4%	0.0%	30.6%	30.6%	0.0%	30.6%	30.6%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	Min	Min		Min	Min		None	None		None	None	
Act Effct Green (s)		32.5			32.5		22.3	22.3		22.3	22.3	
Actuated g/C Ratio		0.49			0.49		0.34	0.34		0.34	0.34	
v/c Ratio		1.13			1.18		1.36	1.00		1.45	0.84	
Control Delay		96.1			115.1		226.7	65.4		280.0	39.2	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		96.1			115.1		226.7	65.4		280.0	39.2	
LOS		F			F		F	E		F	D	
Approach Delay		96.1			115.1			109.3			98.2	
Approach LOS		F			F			F			F	
Queue Length 50th (ft)		~340			~422		~95	182		~71	140	
Queue Length 95th (ft)		#792			#931		#280	#534		#225	#428	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)										250		
Base Capacity (vph)		703			801		141	515		95	510	
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		1.13			1.18		1.36	1.00		1.45	0.84	

Intersection Summary

Cycle Length: 85

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	27%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 66.4

Natural Cycle: 150

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 1.45

Intersection Signal Delay: 105.6   Intersection LOS: F

Intersection Capacity Utilization 124.5%   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: Poplar St & Locust St

Appendix F

AM/PM Peak Hour Intersection Capacity Analysis
Alternative 1: Retime Traffic Signal with Existing Phasing and Geometry
Under Projected Traffic Conditions
Poplar Street at Locust Street, Danvers

Intersection Capacity Analysis
Poplar St @ Locust St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		⊕			⊕		↰	↱		↰	↱	
Volume (vph)	31	695	18	14	723	41	135	254	34	177	312	90
Confl. Peds. (#/hr)			3	3			3		3	3		3
Confl. Bikes (#/hr)												
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Growth Factor	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	862	0	0	900	0	156	333	0	205	465	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	39.0	39.0	0.0	39.0	39.0	0.0	28.0	28.0	0.0	28.0	28.0	0.0
Total Split (%)	43.3%	43.3%	0.0%	43.3%	43.3%	0.0%	31.1%	31.1%	0.0%	31.1%	31.1%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None		None	None		None	None	
Act Effct Green (s)		35.5			35.5		24.3	24.3		24.3	24.3	
Actuated g/C Ratio		0.50			0.50		0.34	0.34		0.34	0.34	
v/c Ratio		1.00			1.00		1.23	0.59		0.92	0.83	
Control Delay		51.8			50.9		180.7	26.5		69.8	38.8	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		51.8			50.9		180.7	26.5		69.8	38.8	
LOS		D			D		F	C		E	D	
Approach Delay		51.8			50.9			75.7			48.3	
Approach LOS		D			D			E			D	
Queue Length 50th (ft)		309			323		~78	107		76	167	
Queue Length 95th (ft)		#839			#869		#245	#292		#273	#474	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)										250		
Base Capacity (vph)		863			902		127	568		224	558	
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		1.00			1.00		1.23	0.59		0.92	0.83	

Intersection Summary

Cycle Length: 90

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	26%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 71.4

Natural Cycle: 150

Control Type: Semi Act-Uncoord

Maximum v/c Ratio: 1.23

Intersection Signal Delay: 54.7   Intersection LOS: D

Intersection Capacity Utilization 102.1%   ICU Level of Service G

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: Poplar St & Locust St

ø2	ø4	ø9
39 s	28 s	23 s
ø6	ø7	
39 s	28 s	

Intersection Capacity Analysis
Poplar St @ Locust St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✛			✛		↰	↱		↰	↱	
Volume (vph)	52	608	18	12	742	55	164	385	53	118	277	87
Confl. Peds. (#/hr)	1		4	4		1	1		4	4		1
Confl. Bikes (#/hr)						2						1
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Growth Factor	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	793	0	0	946	0	192	513	0	138	426	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Total Split (%)	42.2%	42.2%	0.0%	42.2%	42.2%	0.0%	32.2%	32.2%	0.0%	32.2%	32.2%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		Max	Max		None	None		Max	Max	
Act Effct Green (s)		34.4			34.4		25.3	25.3		25.3	25.3	
Actuated g/C Ratio		0.48			0.48		0.35	0.35		0.35	0.35	
v/c Ratio		1.04			1.08		1.09	0.85		1.23	0.71	
Control Delay		67.2			75.5		123.5	38.7		187.8	30.3	
Queue Delay		0.0			0.0		0.0	0.0		0.0	0.0	
Total Delay		67.2			75.5		123.5	38.7		187.8	30.3	
LOS		E			E		F	D		F	C	
Approach Delay		67.2			75.5			61.8			68.8	
Approach LOS		E			E			E			E	
Queue Length 50th (ft)		300			~390		~87	184		~69	143	
Queue Length 95th (ft)		#802			#937		#276	#515		#225	#404	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)										250		
Base Capacity (vph)		759			877		176	604		112	597	
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		1.04			1.08		1.09	0.85		1.23	0.71	

Intersection Summary

Cycle Length: 90

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	26%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 71.4

Natural Cycle: 150

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 1.23

Intersection Signal Delay: 68.8   Intersection LOS: E

Intersection Capacity Utilization 113.1%   ICU Level of Service H

Analysis Period (min) 15

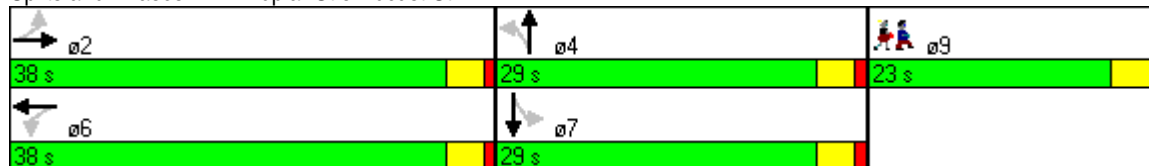~   Volume exceeds capacity, queue is theoretically infinite.
    Queue shown is maximum after two cycles.

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

Splits and Phases: 1: Poplar St & Locust St

ø2		ø4		ø9	
38 s		29 s		23 s	
ø6		ø7			
38 s		29 s			

Appendix G

AM/PM Peak Hour Intersection Capacity Analysis
Alternative 4: Add EB/WB Left-Turn Lanes and Retime Signal with Existing Sequence
Under Projected Traffic Conditions
Poplar Street at Locust Street, Danvers

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↱		↰	↱		↰	↱		↰	↱	
Volume (vph)	31	695	18	14	723	41	135	254	34	177	312	90
Confl. Peds. (#/hr)			3	3			3		3	3		3
Confl. Bikes (#/hr)												
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Growth Factor	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%
Heavy Vehicles (%)	3%	3%	3%	2%	2%	2%	4%	4%	4%	4%	4%	4%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	36	826	0	16	884	0	156	333	0	205	465	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	25.0	25.0		25.0	25.0		25.0	25.0		25.0	25.0	
Total Split (s)	38.0	38.0	0.0	38.0	38.0	0.0	29.0	29.0	0.0	29.0	29.0	0.0
Total Split (%)	42.2%	42.2%	0.0%	42.2%	42.2%	0.0%	32.2%	32.2%	0.0%	32.2%	32.2%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None		None	None		None	None	
Act Effct Green (s)	34.4	34.4		34.4	34.4		25.3	25.3		25.3	25.3	
Actuated g/C Ratio	0.48	0.48		0.48	0.48		0.36	0.36		0.36	0.36	
v/c Ratio	0.36	0.93		0.16	0.99		1.07	0.56		0.84	0.80	
Control Delay	28.0	37.6		18.5	48.8		123.6	24.5		54.7	34.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	28.0	37.6		18.5	48.8		123.6	24.5		54.7	34.8	
LOS	C	D		B	D		F	C		D	C	
Approach Delay		37.2			48.3			56.1			40.9	
Approach LOS		D			D			E			D	
Queue Length 50th (ft)	8	282		3	318		~65	104		73	163	
Queue Length 95th (ft)	#56	#759		23	#828		#231	257		#257	#448	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)	75			75						250		
Base Capacity (vph)	100	889		101	895		146	594		243	583	
Starvation Cap Reductn	0	0		0	0		0	0		0	0	
Spillback Cap Reductn	0	0		0	0		0	0		0	0	
Storage Cap Reductn	0	0		0	0		0	0		0	0	
Reduced v/c Ratio	0.36	0.93		0.16	0.99		1.07	0.56		0.84	0.80	

Intersection Summary

Cycle Length: 90

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	26%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

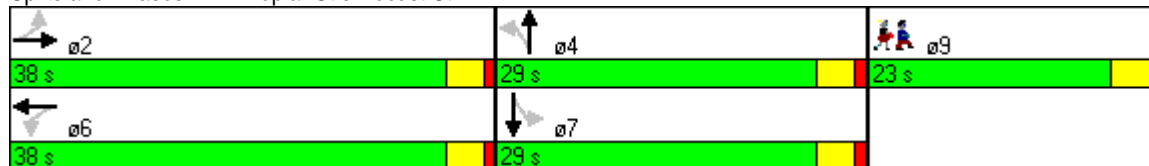|	
Actuated Cycle Length: 71	
Natural Cycle: 150	
Control Type: Semi Act-Uncoord	
Maximum v/c Ratio: 1.07	
Intersection Signal Delay: 44.6	Intersection LOS: D
Intersection Capacity Utilization 87.0%	ICU Level of Service E
Analysis Period (min) 15	

~ 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: Poplar St & Locust St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	⇱	↟		⇱	↟		⇱	↟		⇱	↟	
Volume (vph)	52	608	18	12	742	55	164	385	53	118	277	87
Confl. Peds. (#/hr)	1		4	4		1	1		4	4		1
Confl. Bikes (#/hr)						2						1
Peak Hour Factor	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Growth Factor	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%	110%
Heavy Vehicles (%)	1%	1%	1%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Parking (#/hr)												
Mid-Block Traffic (%)		0%			0%			0%			0%	
Shared Lane Traffic (%)												
Lane Group Flow (vph)	61	732	0	14	932	0	192	513	0	138	426	0
Turn Type	Perm			Perm			Perm			Perm		
Protected Phases		2			6			4			7	
Permitted Phases	2			6			4			7		
Detector Phase	2	2		6	6		4	4		7	7	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0		4.0	4.0	
Minimum Split (s)	21.0	21.0		21.0	21.0		21.0	21.0		21.0	21.0	
Total Split (s)	37.0	37.0	0.0	37.0	37.0	0.0	30.0	30.0	0.0	30.0	30.0	0.0
Total Split (%)	41.1%	41.1%	0.0%	41.1%	41.1%	0.0%	33.3%	33.3%	0.0%	33.3%	33.3%	0.0%
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
All-Red Time (s)	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	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	Min	Min		Min	Min		None	None		None	None	
Act Effct Green (s)	33.4	33.4		33.4	33.4		26.3	26.3		26.3	26.3	
Actuated g/C Ratio	0.47	0.47		0.47	0.47		0.37	0.37		0.37	0.37	
v/c Ratio	0.60	0.84		0.14	1.08		1.00	0.82		1.08	0.69	
Control Delay	47.1	29.1		19.0	77.1		94.4	35.0		130.7	28.3	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Total Delay	47.1	29.1		19.0	77.1		94.4	35.0		130.7	28.3	
LOS	D	C		B	E		F	D		F	C	
Approach Delay		30.5			76.3			51.2			53.3	
Approach LOS		C			E			D			D	
Queue Length 50th (ft)	17	234		3	~389		74	179		~57	139	
Queue Length 95th (ft)	#105	#670		22	#927		#268	#504		#217	#392	
Internal Link Dist (ft)		733			900			460			390	
Turn Bay Length (ft)	75			75						250		
Base Capacity (vph)	102	876		101	862		192	627		128	621	
Starvation Cap Reductn	0	0		0	0		0	0		0	0	
Spillback Cap Reductn	0	0		0	0		0	0		0	0	
Storage Cap Reductn	0	0		0	0		0	0		0	0	
Reduced v/c Ratio	0.60	0.84		0.14	1.08		1.00	0.82		1.08	0.69	

Intersection Summary

Cycle Length: 90

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Bus Blockages (#/hr)	
Parking (#/hr)	
Mid-Block Traffic (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	7.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	26%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 71.4

Natural Cycle: 150

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 1.08

Intersection Signal Delay: 54.0   Intersection LOS: D

Intersection Capacity Utilization 90.6%   ICU Level of Service E

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: Poplar St & Locust St