



BOSTON REGION METROPOLITAN PLANNING ORGANIZATION

Richard A. Davey, MassDOT Secretary and CEO and MPO Chairman
Karl H. Quackenbush, Executive Director, MPO Staff

MEMORANDUM

DATE June 5, 2014
TO Boston Region Metropolitan Planning Organization (MPO)
FROM Chen-Yuan Wang, MPO Staff
RE Safety and Operations Analyses at Selected Boston Region MPO Intersections, FFY 2013: North/South Franklin Street (Route 37) at Union Street/Plymouth Street (Route 139) in Holbrook

1 INTRODUCTION

This memorandum summarizes safety and operations analyses and proposes improvement strategies for the intersection of North/South Franklin Street (Route 37) at Union Street/Plymouth Street (Route 139) in Holbrook.

The location was approved for study by the Boston Region MPO following a selection process for four locations from a short list of 21 intersections based on a series of criteria, including a high EDPO (Equivalent Property Damage Only) crash rating, the number of pedestrian and bicycle crashes, transit significance, regional significance, and implementation potential.¹

The four locations approved for study are:

- North/South Franklin Street (Route 37) at Union Street/Plymouth Street (Route 139) in Holbrook
- Western Avenue (Route 107) at Washington Street (Route 129) in Lynn
- Lexington Street at Beaver Street in Waltham
- Franklin Street (Route 37) at West Street in Braintree

This intersection is ranked as 37 in the MassDOT's 2008–10 statewide top 200 intersection crash list. The Town expressed a strong interest in studying the location for safety and operational improvements.

The memo contains the following sections:

- Existing Conditions
- Issues and Concerns
- Crash Data Analysis

¹ Mark Abbot and Chen-Yuan Wang, memorandum to Boston Region MPO, "Safety and Operations Analyses at Selected Intersections—FFY 2013, Task 1: Intersection Selection Procedure," November 1, 2012

- Intersection Capacity Analysis
- Improvement Alternatives
- Recommendations and Discussion

It also includes technical appendices that contain the methods and data that were applied in the study and detailed reports of the intersection capacity analyses.

2 EXISTING CONDITIONS

This location can be regarded as the most significant intersection in the town. It is located at the center of the town, where two major state routes, Route 37 and Route 139, meet. The intersection is under the Town's jurisdiction.

Route 37, running in the north–south direction, is a principal arterial that begins in the north end of downtown Brockton. After crossing the Middleborough/Lakeville commuter rail line, it enters Holbrook. It winds through the town and intersects Route 139 at the town center. It then enters Braintree, passing through the town's neighborhoods, Quincy Reservoir, and South Shore Plaza before ending at Interstate 93 (I-93) at Exit 6, just west of the Braintree Split. The section in Holbrook, known as North and South Franklin streets, contains two lanes, one lane in each direction, along most of that section.

Route 139, running in the east–west direction, is also a principal arterial. It begins in Stoughton Square at the southern junction of the Route 27 and Route 138 and heads northeast until its junction with Route 24. After briefly merging with Route 28 in Randolph, it heads east-southeasterly through Holbrook, the southwest corner of Weymouth, the north section of Abington, Rockland, Hanover, the northern edge of Pembroke, and Marshfield, where it connects to the section of Route 3 known as Pilgrims Highway, at Exit 12. The Route 139 section in Holbrook, known as Union Street, Plymouth Street, and Abington Avenue, contains two lanes, one lane in each direction, along most of that section.

Both state routes carry a high proportion of commuting traffic. As a result, traffic at this intersection is congested during the morning and evening peak hours. The Route 139 approaches are especially congested, due to heavy left-turn volumes and limited space for accommodating multiple through or turning lanes.

Figure 1 shows the existing intersection layout and the adjacent land uses. At the intersection, both streets widen to accommodate turning lanes. The Route 37 northbound approach (South Franklin Street) contains three 12-foot lanes, one for left turns, one for through movements, and one for right turns. The Route 37 southbound approach (North Franklin Street) contains a 12-foot left-

turn lane and a 15-foot through and right-turn shared lane. Route 139 is narrower than Route 37 near the intersection. Both the eastbound (Union Street) and westbound (Plymouth Street) approaches contain two 11-foot lanes, one for left turns and one shared by through and right-turn movements. All of the streets contain narrow shoulders of less than 2 feet in width. All of the approaches are fairly level, except the slightly uphill eastbound approach (Union Street).

The adjacent areas are mainly public and commercial land uses. Holbrook Town Hall is located about 250 feet north of the intersection on the west side of North Franklin Street. Next to Town Hall, a small park known as the town green, resides on the northwest corner of the intersection. Holbrook Public Library is also located near the intersection, at the northeast corner, on Plymouth Street.

Commercial developments are mainly located on Route 37. Most prominently, a Walgreens Pharmacy and its parking lot are on the southeast corner of the intersection. North of the intersection, shops and restaurants, including a Tedeschi Food Shops store and Holbrook House of Pizza, are located on the west side of Route 37. South of the intersection, the Corner Grill and Pizzeria and a few retail shops and offices are located on the west side. Walgreens Pharmacy, an auto parts store, and a gas station are located on the east side. The only major commercial development on Route 139 is a Dunkin' Donuts, located on Union Street just east of the town green. Farther away from the intersection, both sides of the two state routes are mainly residential.

There are sidewalks on both sides of Route 37 and Route 139. They are about 5 to 6 feet wide in most sections and about 8 to 10 feet wide at the corners of the intersection. Crosswalks are installed across all the approaches at the intersection. They are all equipped with wheelchair ramps and accessible pedestrian signals.

The intersection's signal equipment appears to have been updated. The signal heads are supported by mast arms at appropriate heights and positions. The signal faces are furnished with black plates to reduce sun glare (Figures 2 and 3).

The pedestrian signals are equipped with a countdown function. When the pedestrian signals are actuated, they are operated in a 25-second exclusive phase (Figures 4 and 5).

Located at the center of the town, the intersection carries a fair number of pedestrian crossings daily. During the most recent traffic count, on November 14, 2012, staff observed about 10 to 15 pedestrian crossings in the peak hour of traffic and about 25 to 40 pedestrian crossings in the two-hour peak traffic



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FIGURE 1
Intersection Layout
and Surrounding Land Uses

Safety and Operations
Analyses at
Selected Intersections

FIGURE 2
Intersection Overview: Northbound Approach



FIGURE 3
Intersection Overview: Eastbound Approach



FIGURE 4
Pedestrian Signal Facilities



FIGURE 5
Pedestrian Crossing on Plymouth Street



period. Crossings occurred in all directions. A high percentage (almost 50 percent) of them occurred on the crosswalk on the westbound approach (Plymouth Street), as it is near a Walgreen's Pharmacy and the town library.

There are few bicycles going through the intersection in the peak traffic periods. During the recent traffic count, staff observed about four bicycles in each of the two-hour peak traffic periods. No specific directions can be identified as a favorable bike path from the low number.

Based on the counts, heavy vehicles (trucks and buses) shared about 3.5 percent and 2.5 percent of total entry traffic of the intersection in the AM and PM peak hour individually. These percentages are considered normal, and no specific turning movements are identified with a high truck demand.

The Massachusetts Bay Transportation Authority (MBTA) bus Route 230, running partly on Route 37 between Montello Commuter Rail Station in Brockton and Quincy Center Station, on the Red Line, goes through this intersection about four to five times during each of the AM and PM peak hours. There are bus stops on both sides of Route 37 north and south of the intersection. They are located about 100 to 150 feet from the intersection. The bus stops appear to be appropriately located, and the bus operations generally do not interfere with the intersection's traffic operations.

3 ISSUES AND CONCERNS

Two major issues, probably related, are identified for the intersection. First, it has a high number of crashes and a high percentage (more than 30 percent) of crashes that cause personal injuries. Second, the intersection is highly congested during the AM and PM peak hours, especially for the Route 139 approaches. During the peak hours, traffic frequently backs up for nearly half a mile in both directions.

Based on the field observations and crash and traffic data analyses, the issues and concerns for the intersection can be summarized as:

- High number of crashes and high crash rate
- High proportion of crashes involving injuries
- Traffic congestion in the peak hours
- Traffic backup on both approaches of Route 139
- No bicycle accommodations on either street

4 CRASH DATA ANALYSIS

Table 1 summarizes the crash statistics at the intersection based on the MassDOT Registry of Motor Vehicles (RMV) 2006–10 crash data. On average, approximately 22 crashes occurred at the intersection each year. About 34

percent of the crashes resulted in personal injuries. The crash types consisted of 43 percent rear-end collisions, 25 percent angle collisions, 7 percent sideswipe collisions, 6 percent single-vehicle collisions, 5 percent head-on collisions, and 15 percent unknown.

In the five-year period, two crashes involved a pedestrian and three crashes involved a bicycle.

About 42 percent of the crashes occurred during peak periods, which indicates that many of the crashes are potentially related to stop-and-go traffic conditions at the intersection.

The crash rate is another effective tool for examining the relative safety of a location. Based on the crash data and the turning-movement counts collected recently by staff, the crash rate for this intersection was calculated as 2.12 (see Appendix A).² This is much higher than the average crash rate for signalized intersections in MassDOT Highway Division District 5, which is estimated to be 0.77.³

Based on vehicle directions, crash locations, most harmful event, and other factors from the MassDOT RMV's 2006–10 crash data, MPO staff identified, to the extent possible from the data available, the types and locations of the crashes and constructed a collision diagram for the intersection. The collision diagram does not include the data for 2006, as they lack descriptions of the involved vehicles' actions (such as stopping, moving straight ahead, or turning) prior to the crashes.

The collision diagram (Figure 6) shows a wide range of the types of collisions that occurred at different locations of the intersection in the four-year period. Rear-end collisions occurred on all the approaches. Many of them (15 of the total 36 crashes) occurred on the westbound approach (Plymouth Street).⁴ A number of left-turn crashes occurred at the intersection from different directions. Most noticeably, six of them involved a vehicle turning left from the

² Crash rates estimates are based on crash frequency (crashes per year) and vehicle exposure (traffic volumes or miles traveled). Per MassDOT guidance, crash rates are expressed as "crashes per million entering vehicles" for intersections and as "crashes per million miles traveled" for roadway segments.

³ The average crash rates estimated by the MassDOT Highway Division (as of January 23, 2013) are based on a database that contains intersection crash rates submitted to MassDOT as part of the review process for an Environmental Impact Report or Functional Design Report.

⁴ Sometimes the high number of rear-end crashes at an intersection is caused by insufficient signal clearance time. However, the intersection's 5-second yellow, plus the all-red clearance time, is considered sufficient for all approaches.

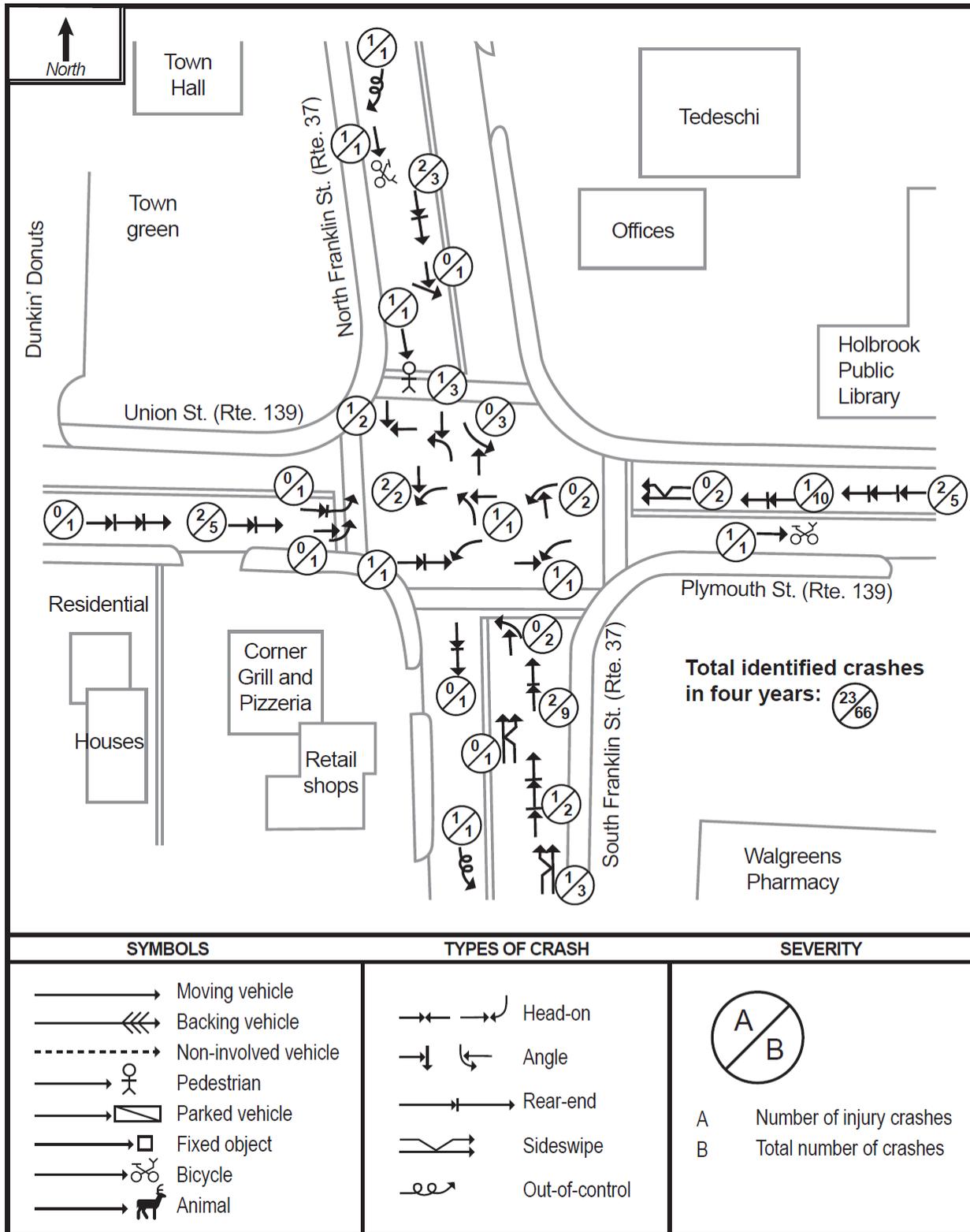
westbound approaches. These left-turn crashes usually are more likely causing personal injuries than the rear-end crashes.

TABLE 1
Intersection Crash Statistics: MassDOT Crash Data, 2006–10

Statistics Period	2006	2007	2008	2009	2010	5-Year Total	Annual Average
Total number of crashes	30	20	26	17	17	110	22.0
Crash Severity:							
Property damage only	16	13	12	9	8	58	11.6
Non-fatal injury	9	5	9	7	7	37	7.4
Fatality	0	0	0	0	0	0	0.0
Not reported/unknown	5	2	5	1	2	15	3.0
Collision type:							
Rear-end	8	8	12	10	9	47	9.4
Angle	8	7	7	1	4	27	5.4
Single vehicle	3	0	2	1	1	7	1.4
Head-on	3	0	1	1	0	5	1
Sideswipe	1	4	1	1	1	8	1.6
Not reported/unknown	7	1	3	3	2	16	3.2
Involved pedestrian(s)	1	0	1	0	0	2	0.4
Involved cyclist(s)	1	0	0	0	2	3	0.6
Occurred during weekday peak periods*	14	5	14	7	6	46	9.2
Wet or icy pavement conditions	5	3	5	5	4	22	4.4
Dark conditions (lit or unlit)	6	5	7	7	6	31	6.2

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

FIGURE 6
Collision Diagram: MassDOT Crash Data, 2007-10



5 INTERSECTION CAPACITY ANALYSIS

Staff collected turning-movement counts at the intersection on Wednesday, November 14, 2012. The weather was cloudy and chilly, with no rain, during the counts. The data were recorded in 15-minute intervals during peak traffic periods in the morning, from 7:00 to 9:00, and in the evening, from 4:00 to 6:00.

The peak traffic hour in each of the two periods was then identified and the associated turning movements and pedestrian crossings were used for the intersection's capacity analysis.

Figure 7 shows the observed vehicular turning-movement counts in the AM peak hour and the PM peak hour. The intersection carried about 2,640 vehicles in the AM peak hour, from 7:30 to 8:30, and about 2,560 vehicles in the PM peak hour, from 5:00 to 6:00 (see Appendix B for detailed 15-minute breakdowns for passenger vehicles, various heavy vehicles, pedestrians, and bicycles in the peak periods and the peak hours).

There were 25 and 41 pedestrians crossing the intersection during the two-hour AM and PM peak period, respectively. During each of the AM and PM peak hours, about 10 pedestrian crossed the intersection. A high percentage (almost 50 percent) of the crossings occurred on the crosswalk on the westbound approach (Plymouth Street). The crosswalk is adjacent to Walgreens Pharmacy and the town library.

Heavy vehicles accounted for about 3.5 percent of the total entering traffic in the AM peak hour and about 2.5 percent in the PM peak hour. The right-turn movement from Plymouth Street to North Franklin Street had the highest share of heavy vehicles—about 25 percent to 30 percent in the each peak hour. However, the total traffic volume of that turning movement is relatively low, at about 30 to 60 vehicles in each peak hour. Overall, the heavy-vehicle percentage at this intersection is in the normal range, and no specific movements have a high heavy-vehicle traffic volume. The heavy-vehicle percentages at individual approaches were used for the intersection capacity analysis.

Based on the counts and the manual traffic signal timing, the intersection was modeled as a fully actuated intersection. The signal cycle consists of the following phases: 1) protected/permissive left turn on Route 37, 2) all movements (left turns permissive) on Route 37, 3) protected-only left turn on Route 139, 4) through/right turn on Route 139, and 5) an on-call 25-second

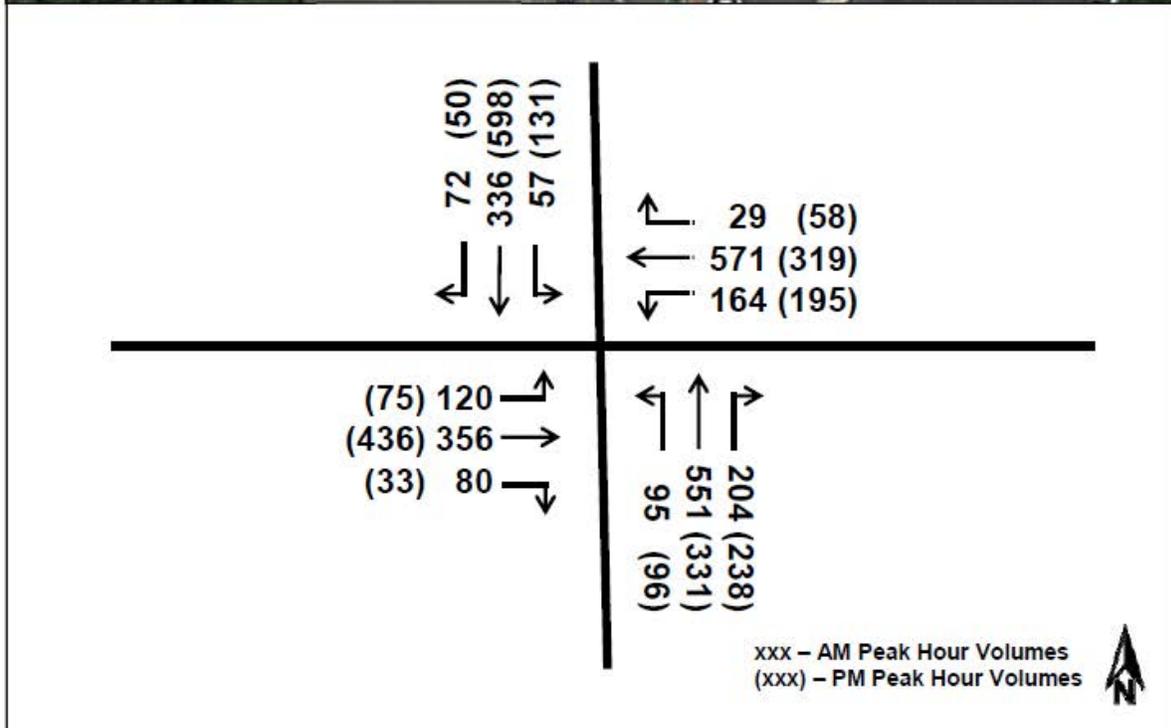
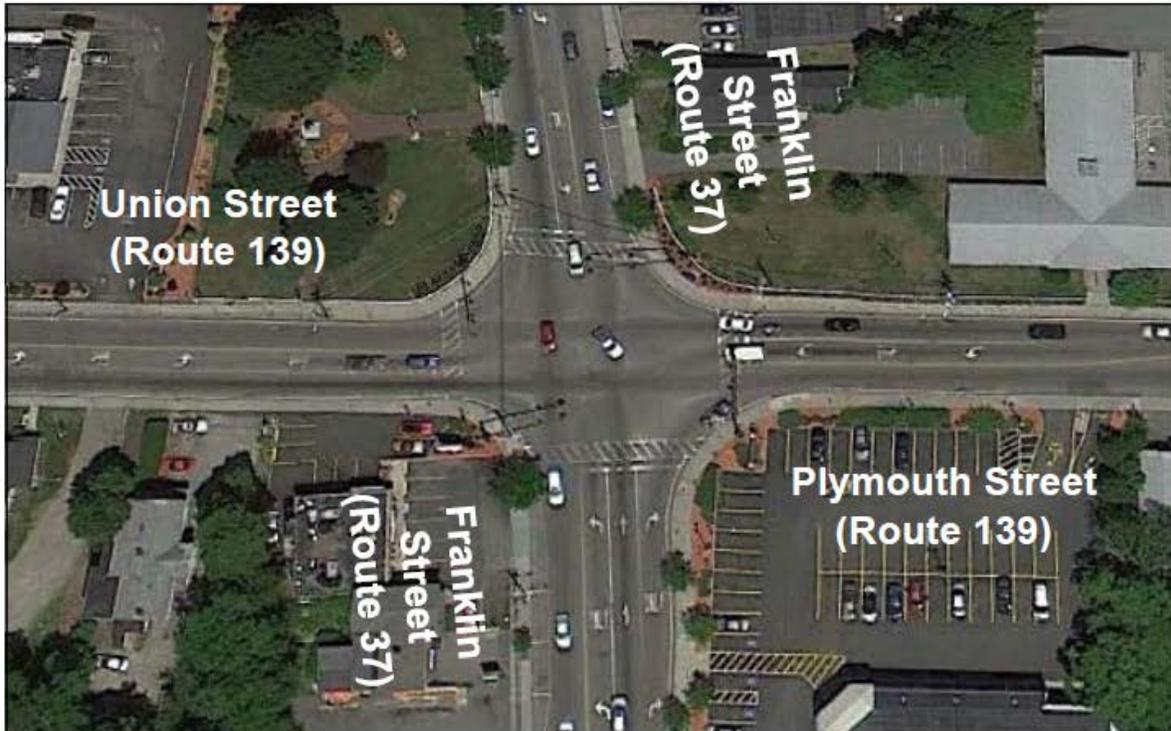


FIGURE 7
Franklin Street (Route 37) at Union/Plymouth
Streets (Route 139), Holbrook - Traffic Volumes

exclusive pedestrian signal phase. Table 2 summarizes the analysis results from applying Synchro to existing conditions in the AM and PM peak hours.⁵

TABLE 2
Intersection Capacity Analysis, Existing Conditions

Street Name	Approach/Movement	LOS¹	Delay per Vehicle
Route 37	NB – Left	C (D)	33 (46)
Route 37	NB – Through	E (D)	59 (43)
Route 37	NB – Right	B (B)	16 (14)
Route 37	SB – Left	C (C)	31 (26)
Route 37	SB – Through/right	E (F)	56 (93)
Route 139	EB – Left	F (F)	90 (90)
Route 139	EB – Through/right	F (F)	95 (96)
Route 139	WB – Left	F (F)	110 (137)
Route 139	WB – Through/right	F (F)	165 (79)
Overall		F (E)	88 (76)

¹ LOS = level of service. The LOS for the AM peak hour is the first letter. The LOS for the PM peak hour is in parentheses.

The analysis indicates that the intersection operates at an undesirable level of service (LOS) of F in the AM peak hour, with an average delay of nearly one and a half minutes per vehicle. In the PM peak hour, the intersection is estimated to operate at LOS E, with an average delay of more than a minute per vehicle.

Both of the Route 139 approaches are estimated to operate at LOS F, with an average delay of more than one and a half minutes per vehicle in both the AM and PM peak hours. The westbound approach is estimated to endure an extensive delay of nearly two minutes per vehicle in the AM peak hour. The Route 37 approaches are estimated as operating at an acceptable level of service, with the exception of the southbound through movement. It is estimated as operating at LOS F, with an average delay of about one and a half minutes per vehicle in the PM peak hour.

The detailed analysis parameters and results for the AM and PM peak hours are in Appendix C.

⁵ Synchro Version 8 is developed and distributed by Trafficware Ltd. The software can perform capacity analysis and traffic simulation (when combined with SimTraffic software, also produced by Trafficware Ltd.) for an individual intersection or a series of intersections.

6 IMPROVEMENT ALTERNATIVES

The intersection's signal equipment appears to have been updated. In addition, the intersection layout is practically optimized, under the current geometry which is limited by the surrounding establishments. The intersection is located at the center of the town and needs to preserve the pedestrian friendly environment. These constraints leave limited options for improving the intersection's traffic operations.

MPO staff tested a number of traffic signal alternatives with various layout modifications, including one with no changes. To simplify the analysis, this memo exhibits only two alternatives: one with no layout changes and one with a layout modification that would have noticeable operational improvements but have the least impact to the surroundings.

The existing signal phasing sequence was not altered, as it is considered appropriate for the existing intersection layout. The two alternatives are:

- Alternative 1: Retime the traffic signal for the existing intersection layout and signal phasing sequence.
- Alternative 2: Add one more left-turn lane on the Route 139 westbound approach and retime the traffic signal.

Tables 3 and 4 summarizes the capacity analyses for the two improvement alternatives in both the AM and PM peak hours. Using Synchro's signal optimization function, staff identified that a cycle length of 150 seconds, including an exclusive 25-second pedestrian signal phase, is appropriate for both alternatives.

Alternative 1, retiming the signal with a reduced cycle length, would improve the overall level of service and reduce delays somewhat, especially for the westbound lane movements.⁶ In addition, the reduction of cycle length is also beneficial to pedestrians because they would have a shorter wait for the traffic cycle to terminate than in the existing signal setting.

Alternative 2, adding one more left-turn lane on the westbound approach, would reduce the approach delay noticeably. However, it would have a significant impact on the surroundings. The negative impacts include land takings on both sides of Route 139 on both the north and south of the intersection, longer and less safe crossings for pedestrians, the loss of two on-street parking spaces on the southbound side of North Franklin Street to accommodate double receiving lanes, and potential land taking on the curbside

⁶ Manual signal timings performed in the field estimated the existing total cycle length to be about 180 seconds.

of the two receiving lanes for the two-lane section to gradually taper into one lane.⁷ Because of these impacts, this alternative is not recommended.

Detailed signal timing settings and analysis results for the two alternatives in both the AM and PM peak hours are shown in Figure 8, Table 5, and Appendices D and E.

TABLE 3
Intersection Capacity Analysis of Level-of-Service for
Existing Conditions and Alternatives

Street Name	Approach	Existing	Alternative 1	Alternative 2
		Conditions	LOS	LOS
		LOS¹	LOS	LOS
Route 37	NB – Left	C (D)	E (E)	E (E)
Route 37	NB – Through	E (D)	E (D)	E (D)
Route 37	NB – Right	B (B)	B (B)	B (B)
Route 37	SB – Left	C (C)	E (C)	E (C)
Route 37	SB – Through/right	E (F)	E (F)	E (E)
Route 139	EB – Left	F (F)	F (F)	F (F)
Route 139	EB – Through/right	F (F)	E (F)	D (E)
Route 139	WB – Left	F (F)	F (F)	E (E)
Route 139	WB – Through/right	F (F)	F (F)	F (E)
Overall		F (E)	E (E)	E (E)

¹ LOS = level of service. The LOS for the AM peak hour is the first letter. The LOS for the PM peak hour is in parentheses.

⁷ To align the travel lanes for safe operations, the modifications would extend beyond the east side of Route 139 to the west side of Route 139 for a substantial distance. In addition, the departure lanes on Route 37 would need to be widened somewhat to accommodate the new turning paths.

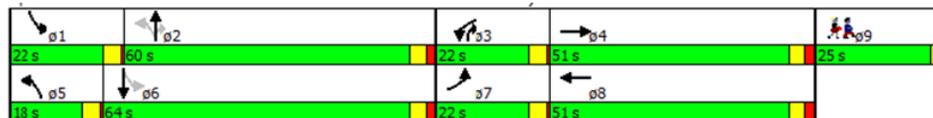
TABLE 4
Intersection Capacity Analysis of Delay for
Existing Conditions and Alternatives

Street Name	Approach	Existing	Alternative 1	Alternative 2
		Conditions	Alternative 1	Alternative 2
		Delay ¹	Delay	Delay
Route 37	NB – Left	33 (46)	62 (64)	62 (63)
Route 37	NB – Through	59 (43)	62 (38)	62 (37)
Route 37	NB – Right	16 (14)	14 (10)	16 (12)
Route 37	SB – Left	31 (26)	58 (26)	58 (25)
Route 37	SB – Through/right	56 (93)	57 (82)	58 (75)
Route 139	EB – Left	90 (90)	97 (87)	97 (87)
Route 139	EB – Through/right	95 (96)	69 (92)	52 (66)
Route 139	WB – Left	110 (137)	92 (122)	68 (79)
Route 139	WB – Through/right	165 (79)	102 (67)	102 (72)
Overall		88 (76)	71 (68)	67 (60)

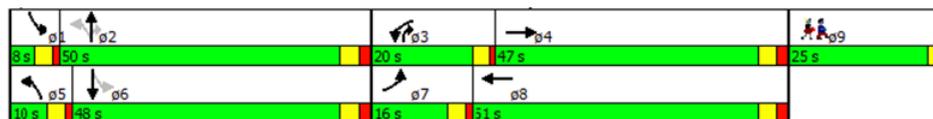
¹ The delay for the AM peak hour is the first number. The delay for the PM peak hour is in parentheses.

FIGURE 8
Intersection Signal Timings and Phasing for
Existing Conditions and Alternatives

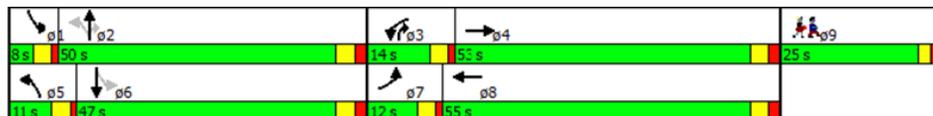
AM Peak Hour - Existing



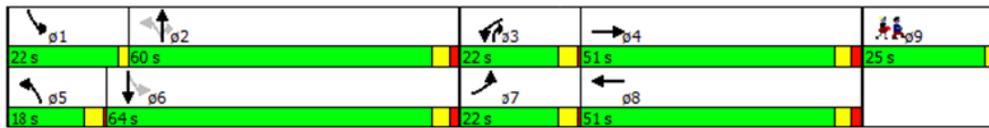
AM Peak Hour – Alternative 1



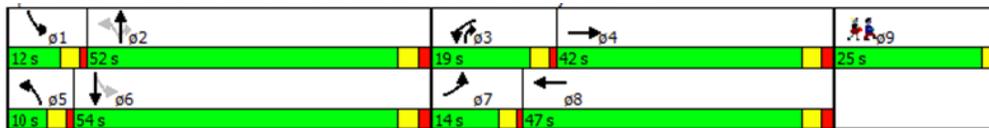
AM Peak Hour – Alternative 2



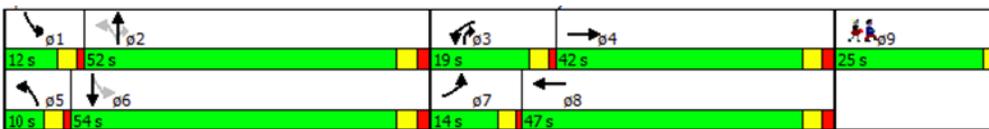
PM Peak Hour – Existing



PM Peak Hour – Alternative 1



PM Peak Hour – Alternative 2



**TABLE 5
Intersection Signal Phasing for
Existing Conditions and Alternatives**

Street Name	Approach	Existing	Alternative 1	Alternative 2
		Conditions	Phase	Phase
Route 37	NB – Left	5	5	5
Route 37	NB – Through	2	2	2
Route 37	NB – Right	2	2	2
Route 37	SB – Left	1	1	1
Route 37	SB – Through/right	6	6	6
Route 139	EB – Left	7	7	7
Route 139	EB – Through/right	4	4	4
Route 139	WB – Left	3	3	3
Route 139	WB – Through/right	8	8	8
Pedestrian	All	9	9	9

7 RECOMMENDATIONS AND DISCUSSION

The study intersection has a high number of crashes and is very congested during the peak hours, especially on the Route 139 approaches. The above analyses indicate that more than 40 percent of the crashes are potentially related to the congested conditions at the intersection.

Nevertheless, the congestion at the intersection is not easy to mitigate. Two major state routes in the region, Route 37 and Route 139, meet at this intersection. Both routes carry a high proportion of commuting traffic. Traffic at the intersection is frequently congested during the morning and evening peak hours. The Route 139 approaches are especially congested, as there are very few alternative east–west routes in the region.

Meanwhile, the intersection is located at the center of the town, near Town Hall, Holbrook Public Library, the town green, and many commercial developments, with significant pedestrian activity. The intersection’s signal equipment appears to be updated, and the layout is appropriate for its current signal operations. Pedestrian facilities, sidewalks, crosswalks, wheelchair ramps, and countdown and accessible pedestrian signals are all appropriately installed and need to be preserved.

These existing conditions leave almost no options for reducing the congestion through intersection layout modifications. The alternatives that involve intersection modifications, including one with double left-turn lanes on Route 139 (Alternative 2 in the last section), are all considered to have significant negative impacts to the surrounding land uses and are not recommended. The signal retiming alternative with no layout changes (Alternative 1 in the last section) is estimated to somewhat improve the operations on Route 139 and reduce the overall intersection delay.

In the short term, staff recommended Alternative 1, with the following considerations:

- Retiming the signal based on the most updated traffic and pedestrian counts
- Frequent monitoring and enforcement of the 25-miles-per-hour (mph) zones in the intersection vicinity⁸
- Continued monitoring of the crash data and statistics⁹

⁸ A review of the crash data indicates that nearly 80 percent of the crashes involving injuries occurred in the off-peak hours. This indicates that approaching vehicles might have been traveling fast when the intersection was not congested. Currently the posted speed limits on all of the approaches within about 500 feet of the intersection are 25 mph. Frequent enforcement could raise drivers’ awareness of the speed limit.

Currently the intersection provides sufficient pedestrian accommodation but no bicycle accommodation. Sharrow markings on the curb lane of all approaches could be considered.

In the long term, the following modifications should be considered when they can be incorporated into future Route 139 and Route 37 reconstruction and resurfacing projects:

- Extend the westbound left-turn lane to at least 300 feet¹⁰
- Widen the shoulders to at least five feet to accommodate bicycle travel

CW/cw

⁹ The recently available MassDOT RMV 2011 crash data show that the intersection had eight crashes (two of them causing injuries) in that year, which is less than in previous years. Overall, the number of crashes at this intersection has been decreasing.

¹⁰ Currently the lane carries the heaviest left turns at the intersection but is the shortest of all the approaches. It can store only about 5 to 6 cars. Left-turning cars usually are stuck in the traffic queue and cannot move up in time for the left-turn signal phase.

APPENDIX A

Intersection Crash Rate

APPENDIX B

**Intersection Traffic, Pedestrian, and Bicycle Counts.
November 14, 2012**

South Franklin Street (Rte. 137) at Union Street (Rte. 139) - Holbrook

Start Date: 11/14/2012
 Start Time: 7:00:00 AM
 Site Code: 11141211

**AM Peak Period
All Vehicles**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
07:00 AM	16	160	49	0	0	10	64	19	2	1	16	43	12	0	0	39	130	1	1	0	559
07:15 AM	12	137	45	1	0	9	87	14	0	0	14	72	22	2	0	70	142	10	0	1	634
07:30 AM	29	138	44	0	0	12	114	12	0	0	31	89	25	3	0	45	128	5	3	0	672
07:45 AM	30	123	55	0	0	19	84	20	1	0	24	113	18	1	0	28	172	8	0	0	694
08:00 AM	22	149	48	0	0	13	71	20	1	0	35	74	13	0	0	48	124	8	2	0	625
08:15 AM	14	141	57	1	0	13	67	20	0	0	30	80	24	1	0	43	128	8	3	0	625
08:30 AM	27	119	49	0	0	13	69	14	0	0	18	82	15	1	0	34	134	23	2	0	597
08:45 AM	24	122	56	0	0	16	78	16	0	0	20	79	16	0	0	37	120	15	0	0	599
Total:	174	1089	403	2	0	105	634	135	4	1	188	632	145	8	0	344	1078	78	11	1	5005

**AM Peak Period
Cars**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
07:00 AM	16	152	48	0	0	9	64	15	2	1	16	42	12	0	0	37	125	1	1	0	537
07:15 AM	12	134	42	1	0	8	84	13	0	0	14	67	19	2	0	69	137	10	0	1	609
07:30 AM	29	133	44	0	0	12	112	12	0	0	31	89	24	3	0	45	126	4	3	0	661
07:45 AM	27	119	54	0	0	18	80	19	1	0	24	106	17	1	0	28	168	6	0	0	666
08:00 AM	19	142	48	0	0	12	67	19	1	0	34	69	13	0	0	46	120	8	2	0	597
08:15 AM	14	137	53	1	0	12	64	19	0	0	29	74	23	1	0	42	125	2	3	0	594
08:30 AM	24	111	47	0	0	13	64	13	0	0	18	76	15	1	0	34	126	19	2	0	560
08:45 AM	24	116	55	0	0	15	72	16	0	0	20	75	16	0	0	35	115	14	0	0	573
Total:	165	1044	391	2	0	99	607	126	4	1	186	598	139	8	0	336	1042	64	11	1	4797

**AM Peak Period
MBTA Buses**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
07:00 AM	0	3	0			0	0	0			0	0	0			1	1	0			5
07:15 AM	0	1	0			0	1	0			0	0	0			0	1	0			3
07:30 AM	0	0	0			0	0	0			0	0	0			0	0	0			0
07:45 AM	0	1	0			0	1	0			0	0	0			0	0	0			2
08:00 AM	0	1	0			0	1	0			0	0	0			0	0	0			2
08:15 AM	0	0	0			0	0	0			0	0	0			0	0	2			2
08:30 AM	0	1	0			0	1	0			0	0	0			0	0	0			2
08:45 AM	0	1	0			0	0	0			0	0	0			0	0	0			1
Total:	0	8	0			0	4	0			0	0	0			1	2	2			17

**AM Peak Period
Trucks**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
07:00 AM	0	5	1			1	0	4			0	1	0			1	4	0			17
07:15 AM	0	2	3			1	2	0			0	3	2			1	4	0			18
07:30 AM	0	5	0			0	2	0			0	0	1			0	2	1			11
07:45 AM	0	1	1			1	2	1			0	6	1			0	4	2			19
08:00 AM	1	6	0			1	2	1			1	4	0			1	4	0			21
08:15 AM	0	4	4			1	3	1			1	5	1			1	3	0			24
08:30 AM	1	3	2			0	4	1			0	6	0			0	5	1			23
08:45 AM	0	4	1			1	3	0			0	4	0			2	5	0			20
Total:	2	30	12			6	18	8			2	29	5			6	31	4			153

**AM Peak Period
Large Trucks (Freight)**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
07:00 AM	0	0	0			0	0	0			0	0	0			0	0	0			0
07:15 AM	0	0	0			0	0	1			0	2	1			0	0	0			4
07:30 AM	0	0	0			0	0	0			0	0	0			0	0	0			0
07:45 AM	3	2	0			0	1	0			0	1	0			0	0	0			7
08:00 AM	2	0	0			0	1	0			0	1	0			1	0	0			5
08:15 AM	0	0	0			0	0	0			0	1	0			0	0	4			5
08:30 AM	2	4	0			0	0	0			0	0	0			0	3	3			12
08:45 AM	0	1	0			0	3	0			0	0	0			0	0	1			5
Total:	7	7	0			0	5	1			0	5	1			1	3	8			38

South Franklin Street (Rte. 137) at Union Street (Rte. 139) - Holbrook

Start Date: 11/14/2012
 Start Time: 7:00:00 AM
 Site Code: 11141211

AM Peak Hour All Vehicles

Start Time	South Franklin Street Northbound				North Franklin Street Southbound				Union Street Eastbound				Plymouth Street Westbound				Vehicle Total
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
07:30 AM	29	138	44	0	12	114	12	0	31	89	25	3	45	128	5	3	672
07:45 AM	30	123	55	0	19	84	20	1	24	113	18	1	28	172	8	0	694
08:00 AM	22	149	48	0	13	71	20	1	35	74	13	0	48	124	8	2	625
08:15 AM	14	141	57	1	13	67	20	0	30	80	24	1	43	147	8	3	644
Total:	95	551	204	1	57	336	72	2	120	356	80	5	164	571	29	8	2635
PHF:	0.79	0.92	0.89		0.75	0.74	0.90		0.86	0.79	0.80		0.85	0.83	0.91		0.95
Truck%:	6.32%	3.27%	2.45%		5.26%	3.27%	4.17%		1.67%	5.06%	3.75%		1.83%	2.28%	24.14%		3.49%

AM Peak Period All Vehicles

Start Time	South Franklin Street Northbound				North Franklin Street Southbound				Union Street Eastbound				Plymouth Street Westbound				Vehicle Total
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
07:00 AM	16	160	49	0	10	64	19	2	16	43	12	0	39	130	1	1	559
07:15 AM	12	137	45	1	9	87	14	0	14	72	22	2	70	142	10	0	634
07:30 AM	29	138	44	0	12	114	12	0	31	89	25	3	45	128	5	3	672
07:45 AM	30	123	55	0	19	84	20	1	24	113	18	1	28	172	8	0	694
08:00 AM	22	149	48	0	13	71	20	1	35	74	13	0	48	124	8	2	625
08:15 AM	14	141	57	1	13	67	20	0	30	80	24	1	43	147	8	3	644
08:30 AM	27	119	49	0	13	69	14	0	18	82	15	1	34	149	23	2	612
08:45 AM	24	122	56	0	16	78	16	0	20	79	16	0	37	120	15	0	599
Total:	174	1089	403	2	105	634	135	4	188	632	145	8	344	1112	78	11	5039

South Franklin Street (Rte. 137) at Union Street (Rte. 139) - Holbrook

Start Date: 11/14/2012
 Start Time: 7:00:00 PM
 Site Code: 11141211

**PM Peak Period
All Vehicles**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
4:00 PM	33	73	65	1	2	30	112	14	0	0	21	101	9	0	0	44	78	9	2	1	589
4:15 PM	34	91	74	0	0	36	138	20	0	0	17	83	21	0	0	42	74	18	1	0	648
4:30 PM	26	94	70	1	0	39	113	7	0	0	16	89	11	0	0	53	68	16	7	0	602
4:45 PM	23	75	61	3	0	45	100	11	3	0	15	113	6	1	0	53	84	8	16	0	594
5:00 PM	20	81	50	0	0	35	142	13	0	0	16	111	9	0	1	51	63	8	2	0	599
5:15 PM	28	71	67	0	0	30	136	14	0	0	16	116	11	0	0	53	82	7	0	0	631
5:30 PM	16	99	56	0	0	28	166	6	1	0	24	124	7	0	0	47	107	26	0	0	706
5:45 PM	32	80	65	0	0	38	154	17	0	0	19	85	6	0	0	44	67	17	3	0	624
Total:	212	664	508	5	2	281	1061	102	4	0	144	822	80	1	1	387	623	109	31	1	4993

**PM Peak Period
Cars**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
4:00 PM	33	72	64	1	2	30	108	14	0	0	21	99	9	0	0	43	71	8	2	1	572
4:15 PM	33	87	72	0	0	28	135	19	0	0	16	82	21	0	0	42	70	17	1	0	622
4:30 PM	25	90	69	1	0	39	109	6	0	0	14	86	11	0	0	52	67	16	7	0	584
4:45 PM	23	75	61	3	0	43	99	11	3	0	15	109	6	1	0	53	84	8	16	0	587
5:00 PM	17	80	49	0	0	35	140	13	0	0	16	109	9	0	1	51	62	7	2	0	588
5:15 PM	27	71	67	0	0	30	135	14	0	0	14	111	11	0	0	53	80	3	0	0	616
5:30 PM	16	98	56	0	0	27	162	5	1	0	24	121	7	0	0	46	105	13	0	0	680
5:45 PM	32	77	64	0	0	38	152	17	0	0	19	77	6	0	0	44	67	16	3	0	609
Total:	206	650	502	5	2	270	1040	99	4	0	139	794	80	1	1	384	606	88	31	1	4858

**PM Peak Period
MBTA Buses**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
4:00 PM	0	1	0			0	0	0			0	0	0			0	0	0			1
4:15 PM	0	0	0			0	1	0			0	0	0			0	0	0			1
4:30 PM	0	1	0			0	1	0			0	0	0			0	0	0			2
4:45 PM	0	0	0			0	0	0			0	0	0			0	0	0			0
5:00 PM	0	1	0			0	0	0			0	0	0			0	0	0			1
5:15 PM	0	0	0			0	1	0			0	0	0			0	0	0			1
5:30 PM	0	0	0			0	1	0			0	0	0			0	0	0			1
5:45 PM	0	1	0			0	0	0			0	0	0			0	0	0			1
Total:	0	4	0			0	4	0			0	0	0			0	0	0			8

**PM Peak Period
Trucks**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
4:00 PM	0	0	1			0	3	0			0	1	0			1	7	1			14
4:15 PM	1	4	2			7	2	1			0	0	0			0	4	1			22
4:30 PM	0	3	1			0	2	0			1	3	0			1	1	0			12
4:45 PM	0	0	0			2	1	0			0	2	0			0	0	0			5
5:00 PM	1	0	0			0	2	0			0	2	0			0	0	0			5
5:15 PM	1	0	0			0	0	0			1	5	0			0	1	0			8
5:30 PM	0	1	0			1	3	1			0	3	0			1	2	0			12
5:45 PM	0	2	1			0	2	0			0	8	0			0	0	0			13
Total:	3	10	5			10	15	2			2	24	0			3	15	2			91

**PM Peak Period
Large Trucks (Freight)**

Start Time	South Franklin Street Northbound					North Franklin Street Southbound					Union Street Eastbound					Plymouth Street Westbound					Vehicle Total
	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	Left	Thru	Right	Peds	Bikes	
4:00 PM	0	0	0			0	1	0			0	1	0			0	0	0			2
4:15 PM	0	0	0			1	0	0			1	1	0			0	0	0			3
4:30 PM	1	0	0			0	1	1			1	0	0			0	0	0			4
4:45 PM	0	0	0			0	0	0			0	2	0			0	0	0			2
5:00 PM	2	0	1			0	0	0			0	0	0			0	1	1			5
5:15 PM	0	0	0			0	0	0			1	0	0			0	1	4			6
5:30 PM	0	0	0			0	0	0			0	0	0			0	0	13			13
5:45 PM	0	0	0			0	0	0			0	0	0			0	0	1			1
Total:	3	0	1			1	2	1			3	4	0			0	2	19			36

South Franklin Street (Rte. 137) at Union Street (Rte. 139) - Holbrook

Start Date: 11/14/2012
 Start Time: 4:00:00 PM
 Site Code: 11141211

PM Peak Hour All Vehicles

Start Time	South Franklin Street Northbound				North Franklin Street Southbound				Union Street Eastbound				Plymouth Street Westbound				Vehicle Total
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
5:00 PM	20	81	50	0	35	142	13	0	16	111	9	0	51	63	8	2	599
5:15 PM	28	71	67	0	30	136	14	0	16	116	11	0	53	82	7	0	631
5:30 PM	16	99	56	0	28	166	6	1	24	124	7	0	47	107	26	0	706
5:45 PM	32	80	65	0	38	154	17	0	19	85	6	0	44	67	17	3	624
Total:	96	331	238	0	131	598	50	1	75	436	33	0	195	319	58	5	2560
PHF:	0.86	0.84	0.89		0.86	0.90	0.74		0.78	0.88	0.75		0.92	0.75	0.56		0.91
Truck%:	4.17%	0.91%	0.84%		0.76%	1.17%	2.00%		2.67%	4.13%	0.00%		0.51%	1.57%	32.76%		2.46%

PM Peak Period All Vehicles

Start Time	South Franklin Street Northbound				North Franklin Street Southbound				Union Street Eastbound				Plymouth Street Westbound				Vehicle Total
	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
4:00 PM	33	73	65	1	30	112	14	0	21	101	9	0	44	78	9	2	589
4:15 PM	34	91	74	0	36	138	20	0	17	83	21	0	42	74	18	1	648
4:30 PM	26	94	70	1	39	113	7	0	16	89	11	0	53	68	16	7	602
4:45 PM	23	75	61	3	45	100	11	3	15	113	6	1	53	84	8	16	594
5:00 PM	20	81	50	0	35	142	13	0	16	111	9	0	51	63	8	2	599
5:15 PM	28	71	67	0	30	136	14	0	16	116	11	0	53	82	7	0	631
5:30 PM	16	99	56	0	28	166	6	1	24	124	7	0	47	107	26	0	706
5:45 PM	32	80	65	0	38	154	17	0	19	85	6	0	44	67	17	3	624
Total:	212	664	508	5	281	1061	102	4	144	822	80	1	387	623	109	31	4993

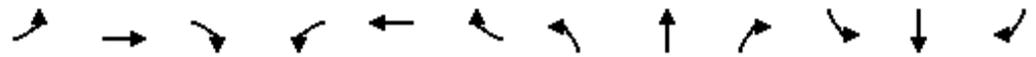
APPENDIX C

AM'UbX'PM Peak-Hour Intersection Capacity Analysis. Existing Conditions

Intersection Capacity Analysis

Route 37 at Route 139, Holbrook

9/18/2013



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	356	80	164	571	29	95	551	204	57	336	72
Confl. Peds. (#/hr)												
Confl. Bikes (#/hr)												
Peak Hour Factor	0.86	0.79	0.80	0.85	0.83	0.91	0.79	0.92	0.89	0.75	0.74	0.90
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	2%	5%	4%	2%	2%	20%	6%	3%	2%	5%	3%	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)	140	551	0	193	720	0	120	599	229	76	534	0
Turn Type	Prot	NA		Prot	NA		pm+pt	NA	pm+ov	pm+pt	NA	
Protected Phases	7	4		3	8		5	2	3	1	6	
Permitted Phases							2		2	6		
Detector Phase	7	4		3	8		5	2	3	1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	8.0	10.0		8.0	10.0		8.0	10.0	8.0	8.0	10.0	
Total Split (s)	22.0	51.0		22.0	51.0		18.0	60.0	22.0	22.0	64.0	
Total Split (%)	12.2%	28.3%		12.2%	28.3%		10.0%	33.3%	12.2%	12.2%	35.6%	
Yellow Time (s)	3.5	3.0		3.5	3.0		3.5	3.0	3.5	3.5	3.0	
All-Red Time (s)	0.5	2.0		0.5	2.0		0.5	2.0	0.5	0.5	2.0	
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	4.0	4.0	5.0	
Lead/Lag	Lead	Lag		Lead	Lag		Lead	Lag	Lead	Lead	Lag	
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes	Yes	
Recall Mode	None	None		None	None		Min	Min	None	Min	Min	
Act Effect Green (s)	16.2	46.2		18.1	48.1		69.5	57.0	80.1	65.3	54.9	
Actuated g/C Ratio	0.11	0.30		0.12	0.32		0.46	0.37	0.53	0.43	0.36	
v/c Ratio	0.74	1.02		0.92	1.24		0.53	0.87	0.27	0.43	0.82	
Control Delay	89.9	94.8		109.6	164.8		32.6	58.6	16.3	31.3	55.8	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	89.9	94.8		109.6	164.8		32.6	58.6	16.3	31.3	55.8	
LOS	F	F		F	F		C	E	B	C	E	
Approach Delay		93.8			153.1			45.1			52.8	
Approach LOS		F			F			D			D	
Queue Length 50th (ft)	129	517		184	-853		64	524	83	39	459	
Queue Length 95th (ft)	#249	#797		#379	#1237		110	#920	177	71	553	
Internal Link Dist (ft)		496			764			516			495	
Turn Bay Length (ft)	350			125			150		85	250		
Base Capacity (vph)	210	540		210	581		255	691	861	272	704	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	0		0	0		0	0	0	0	0	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.67	1.02		0.92	1.24		0.47	0.87	0.27	0.28	0.76	

Intersection Summary

Cycle Length: 180

Intersection Capacity Analysis
 Route 37 at Route 139, Holbrook

9/18/2013

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)	25.0
Total Split (s)	25.0
Total Split (%)	14%
Yellow Time (s)	2.0
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	

Intersection Capacity Analysis

Route 37 at Route 139, Holbrook

9/18/2013

Actuated Cycle Length: 152.1

Natural Cycle: 150

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 1.24

Intersection Signal Delay: 88.4

Intersection LOS: F

Intersection Capacity Utilization 85.8%

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.

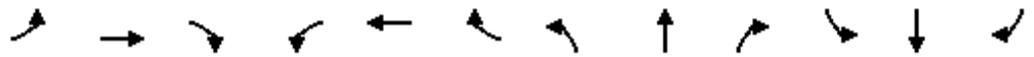
Splits and Phases: 3: S. Franklin Street/N. Franlin Street & Union Street/Plymouth Street

 ϕ_1	 ϕ_2	 ϕ_3	 ϕ_4	 ϕ_9
22 s	60 s	22 s	51 s	25 s
 ϕ_5	 ϕ_6	 ϕ_7	 ϕ_8	
18 s	64 s	22 s	51 s	

Intersection Capacity Analysis

Route 37 at Route 139, Holbrook

9/18/2013



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	75	436	33	195	319	58	96	331	238	131	598	50
Confl. Peds. (#/hr)												
Confl. Bikes (#/hr)												
Peak Hour Factor	0.78	0.88	0.75	0.92	0.75	0.56	0.86	0.84	0.89	0.86	0.90	0.74
Growth Factor	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	3%	4%	0%	1%	2%	33%	4%	1%	1%	1%	1%	2%
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)	96	539	0	212	529	0	112	394	267	152	732	0
Turn Type	Prot	NA		Prot	NA		pm+pt	NA	pm+ov	pm+pt	NA	
Protected Phases	7	4		3	8		5	2	3	1	6	
Permitted Phases							2		2	6		
Detector Phase	7	4		3	8		5	2	3	1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	8.0	20.0		8.0	20.0		8.0	20.0	8.0	8.5	20.0	
Total Split (s)	22.0	51.0		22.0	51.0		18.0	60.0	22.0	22.0	64.0	
Total Split (%)	12.2%	28.3%		12.2%	28.3%		10.0%	33.3%	12.2%	12.2%	35.6%	
Yellow Time (s)	3.5	3.0		3.5	3.0		3.5	3.0	3.5	2.0	3.0	
All-Red Time (s)	0.5	2.0		0.5	2.0		0.5	2.0	0.5	0.0	2.0	
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	4.0	2.0	5.0	
Lead/Lag	Lead	Lag		Lead	Lag		Lead	Lag	Lead	Lead	Lag	
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes	Yes	
Recall Mode	None	None		None	None		None	Min	None	None	Min	
Act Effect Green (s)	13.4	46.1		18.0	50.7		73.6	60.4	83.5	74.9	59.2	
Actuated g/C Ratio	0.09	0.29		0.11	0.32		0.47	0.38	0.53	0.48	0.38	
v/c Ratio	0.64	1.01		1.03	0.95		0.62	0.54	0.30	0.38	1.05	
Control Delay	89.8	95.6		137.4	78.8		46.3	42.7	14.1	25.5	93.2	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	89.8	95.6		137.4	78.8		46.3	42.7	14.1	25.5	93.2	
LOS	F	F		F	E		D	D	B	C	F	
Approach Delay		94.7			95.6			33.4			81.5	
Approach LOS		F			F			C			F	
Queue Length 50th (ft)	95	541		~220	511		59	299	80	80	~780	
Queue Length 95th (ft)	149	#916		#464	#699		141	468	184	146	#1245	
Internal Link Dist (ft)		496			764			516			495	
Turn Bay Length (ft)	350			125			150		85	250		
Base Capacity (vph)	201	533		205	556		202	724	899	464	700	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	0		0	0		0	0	0	0	0	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.48	1.01		1.03	0.95		0.55	0.54	0.30	0.33	1.05	

Intersection Summary

Cycle Length: 180

Intersection Capacity Analysis
 Route 37 at Route 139, Holbrook

9/18/2013

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)	25.0
Total Split (s)	25.0
Total Split (%)	14%
Yellow Time (s)	2.0
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	

Intersection Capacity Analysis

Route 37 at Route 139, Holbrook

9/18/2013

Actuated Cycle Length: 157

Natural Cycle: 145

Control Type: Actuated-Uncoordinated

Maximum v/c Ratio: 1.05

Intersection Signal Delay: 75.4

Intersection LOS: E

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: 3: S. Franklin Street/N. Franlin Street & Union Street/Plymouth Street

 ϕ_1	 ϕ_2	 ϕ_3	 ϕ_4	 ϕ_9
22 s	60 s	22 s	51 s	25 s
 ϕ_5	 ϕ_6	 ϕ_7	 ϕ_8	
18 s	64 s	22 s	51 s	

APPENDIX D

AM'UbX'PM Peak-Hour Intersection Capacity Analysis. Alternative 1: Retiming Traffic Signal

Intersection Capacity Analysis
Route 37 at Route 139, Holbrook

9/18/2013



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	120	356	80	164	571	29	95	551	204	57	336	72
Peak Hour Factor	0.86	0.79	0.80	0.85	0.83	0.91	0.79	0.92	0.89	0.75	0.74	0.90
Heavy Vehicles (%)	2%	5%	4%	2%	2%	20%	6%	3%	2%	5%	3%	4%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	140	551	0	193	720	0	120	599	229	76	534	0
Turn Type	Prot	NA		Prot	NA		pm+pt	NA	pm+ov	pm+pt	NA	
Protected Phases	7	4		3	8		5	2	3	1	6	
Permitted Phases							2		2	6		
Detector Phase	7	4		3	8		5	2	3	1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	8.0	10.0		8.0	10.0		8.0	10.0	8.0	8.0	10.0	
Total Split (s)	16.0	47.0		20.0	51.0		10.0	50.0	20.0	8.0	48.0	
Total Split (%)	10.7%	31.3%		13.3%	34.0%		6.7%	33.3%	13.3%	5.3%	32.0%	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0		1.0	2.0	1.0	1.0	2.0	
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	4.0	4.0	5.0	
Lead/Lag	Lead	Lag		Lead	Lag		Lead	Lag	Lead	Lead	Lag	
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes	Yes	
Recall Mode	None	None		None	None		Min	Min	None	Min	Min	
Act Effct Green (s)	12.0	42.1		16.1	46.1		52.2	45.1	66.2	48.2	43.1	
Actuated g/C Ratio	0.09	0.33		0.12	0.36		0.41	0.35	0.51	0.37	0.33	
v/c Ratio	0.85	0.95		0.88	1.09		0.79	0.93	0.27	0.68	0.88	
Control Delay	97.3	68.7		91.5	102.6		61.6	62.3	13.6	58.0	57.5	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	97.3	68.7		91.5	102.6		61.6	62.3	13.6	58.0	57.5	
LOS	F	E		F	F		E	E	B	E	E	
Approach Delay		74.5			100.2			50.4			57.6	
Approach LOS		E			F			D			E	
Queue Length 50th (ft)	113	423		155	-642		58	456	64	36	396	
Queue Length 95th (ft)	#253	#635		#316	#952		#126	#840	147	#81	498	
Internal Link Dist (ft)		496			764			516			495	
Turn Bay Length (ft)	350			125			150		85	250		
Base Capacity (vph)	165	581		220	658		152	646	848	111	607	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	0		0	0		0	0	0	0	0	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.85	0.95		0.88	1.09		0.79	0.93	0.27	0.68	0.88	

Intersection Summary

Cycle Length: 150	
Actuated Cycle Length: 128.8	
Natural Cycle: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.09	
Intersection Signal Delay: 71.4	Intersection LOS: E
Intersection Capacity Utilization 85.8%	ICU Level of Service E

Intersection Capacity Analysis
 Route 37 at Route 139, Holbrook

9/18/2013

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Peak Hour Factor	
Heavy Vehicles (%)	
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)	25.0
Total Split (s)	25.0
Total Split (%)	17%
Yellow Time (s)	2.0
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	

Intersection Capacity Analysis

Route 37 at Route 139, Holbrook

9/18/2013

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: 3: S. Franklin Street/N. Franlin Street & Union Street/Plymouth Street

 $\phi 1$	 $\phi 2$	 $\phi 3$	 $\phi 4$	 $\phi 9$
8 s	50 s	20 s	47 s	25 s
 $\phi 5$	 $\phi 6$	 $\phi 7$	 $\phi 8$	
10 s	48 s	16 s	51 s	

Intersection Capacity Analysis
Route 37 at Route 139, Holbrook

9/18/2013



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↖	↗		↖	↗		↖	↗	↗	↖	↗	↖
Volume (vph)	75	436	33	195	319	58	96	331	238	131	598	50
Peak Hour Factor	0.78	0.88	0.75	0.92	0.75	0.56	0.86	0.84	0.89	0.86	0.90	0.74
Heavy Vehicles (%)	3%	4%	0%	1%	2%	33%	4%	1%	1%	1%	1%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	96	539	0	212	529	0	112	394	267	152	732	0
Turn Type	Prot	NA		Prot	NA		pm+pt	NA	pm+ov	pm+pt	NA	
Protected Phases	7	4		3	8		5	2	3	1	6	
Permitted Phases							2		2	6		
Detector Phase	7	4		3	8		5	2	3	1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	8.0	20.0		8.0	20.0		8.0	20.0	8.0	8.0	20.0	
Total Split (s)	14.0	42.0		19.0	47.0		10.0	52.0	19.0	12.0	54.0	
Total Split (%)	9.3%	28.0%		12.7%	31.3%		6.7%	34.7%	12.7%	8.0%	36.0%	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0		1.0	2.0	1.0	1.0	2.0	
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	4.0	4.0	5.0	
Lead/Lag	Lead	Lag		Lead	Lag		Lead	Lag	Lead	Lead	Lag	
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes	Yes	
Recall Mode	None	None		None	None		None	Min	None	None	Min	
Act Effct Green (s)	9.9	37.1		15.0	42.3		54.2	47.2	67.2	58.2	49.2	
Actuated g/C Ratio	0.08	0.29		0.12	0.33		0.42	0.37	0.52	0.45	0.38	
v/c Ratio	0.72	1.03		1.02	0.94		0.81	0.57	0.30	0.45	1.03	
Control Delay	87.1	91.7		122.7	66.9		63.7	37.8	10.3	26.5	81.5	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	87.1	91.7		122.7	66.9		63.7	37.8	10.3	26.5	81.5	
LOS	F	F		F	E		E	D	B	C	F	
Approach Delay		91.0			82.9			32.0			72.0	
Approach LOS		F			F			C			E	
Queue Length 50th (ft)	77	-436		174	403		49	249	55	68	-590	
Queue Length 95th (ft)	#150	#797		#401	#554		#162	394	138	135	#1061	
Internal Link Dist (ft)		496			764			516			495	
Turn Bay Length (ft)	350			125			150		85	250		
Base Capacity (vph)	136	524		208	565		138	688	895	336	709	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	0		0	0		0	0	0	0	0	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.71	1.03		1.02	0.94		0.81	0.57	0.30	0.45	1.03	

Intersection Summary

Cycle Length: 150	
Actuated Cycle Length: 128.8	
Natural Cycle: 145	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.03	
Intersection Signal Delay: 68.5	Intersection LOS: E
Intersection Capacity Utilization 90.6%	ICU Level of Service E

Intersection Capacity Analysis
Route 37 at Route 139, Holbrook

9/18/2013

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Peak Hour Factor	
Heavy Vehicles (%)	
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)	25.0
Total Split (s)	25.0
Total Split (%)	17%
Yellow Time (s)	2.0
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	

Intersection Capacity Analysis

Route 37 at Route 139, Holbrook

9/18/2013

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: 3: S. Franklin Street/N. Franlin Street & Union Street/Plymouth Street

 ϕ1	 ϕ2	 ϕ3	 ϕ4	 ϕ9
12 s	52 s	19 s	42 s	25 s
 ϕ5	 ϕ6	 ϕ7	 ϕ8	
10 s	54 s	14 s	47 s	

APPENDIX E

**AM'UbX'PM Peak-Hour Intersection Capacity Analysis.
Alternative 2: Doubling Left-Turn Lanes on Route 139**

Intersection Capacity Analysis

Route 37 at Route 139, Holbrook

9/18/2013



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↔↔	↗		↔↔	↕		↖	↕	↗	↖	↗	↖
Volume (vph)	120	356	80	164	571	29	95	551	204	57	336	72
Peak Hour Factor	0.86	0.79	0.80	0.85	0.83	0.91	0.79	0.92	0.89	0.75	0.74	0.90
Heavy Vehicles (%)	2%	5%	4%	2%	2%	20%	6%	3%	2%	5%	3%	4%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	140	551	0	193	720	0	120	599	229	76	534	0
Turn Type	Prot	NA		Prot	NA		pm+pt	NA	pm+ov	pm+pt	NA	
Protected Phases	7	4		3	8		5	2	3	1	6	
Permitted Phases							2		2	6		
Detector Phase	7	4		3	8		5	2	3	1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	8.0	10.0		8.0	10.0		8.0	10.0	8.0	8.0	10.0	
Total Split (s)	12.0	53.0		14.0	55.0		11.0	50.0	14.0	8.0	47.0	
Total Split (%)	8.0%	35.3%		9.3%	36.7%		7.3%	33.3%	9.3%	5.3%	31.3%	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0		1.0	2.0	1.0	1.0	2.0	
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	4.0	4.0	5.0	
Lead/Lag	Lead	Lag		Lead	Lag		Lead	Lag	Lead	Lead	Lag	
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes	Yes	
Recall Mode	None	None		None	None		Min	Min	None	Min	Min	
Act Effect Green (s)	8.0	48.2		10.0	50.2		53.2	45.1	60.2	47.2	42.1	
Actuated g/C Ratio	0.06	0.37		0.08	0.39		0.41	0.35	0.47	0.37	0.33	
v/c Ratio	0.66	0.83		0.72	1.01		0.77	0.93	0.30	0.68	0.90	
Control Delay	74.8	48.8		74.5	74.5		57.5	62.3	16.7	58.1	60.9	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	74.8	48.8		74.5	74.5		57.5	62.3	16.7	58.1	60.9	
LOS	E	D		E	E		E	E	B	E	E	
Approach Delay		54.1			74.5			50.7			60.5	
Approach LOS		D			E			D			E	
Queue Length 50th (ft)	58	389		79	566		58	456	74	36	401	
Queue Length 95th (ft)	#108	543		#142	#901		#131	#840	163	#81	#512	
Internal Link Dist (ft)		496			764			516			495	
Turn Bay Length (ft)	350			125			150		85	250		
Base Capacity (vph)	213	664		267	716		156	646	775	111	593	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	0		0	0		0	0	0	0	0	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.66	0.83		0.72	1.01		0.77	0.93	0.30	0.68	0.90	

Intersection Summary

Cycle Length: 150	
Actuated Cycle Length: 128.8	
Natural Cycle: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.01	
Intersection Signal Delay: 60.2	Intersection LOS: E
Intersection Capacity Utilization 82.6%	ICU Level of Service E

Intersection Capacity Analysis
 Route 37 at Route 139, Holbrook

9/18/2013

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Peak Hour Factor	
Heavy Vehicles (%)	
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)	25.0
Total Split (s)	25.0
Total Split (%)	17%
Yellow Time (s)	2.0
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	

Intersection Capacity Analysis

Route 37 at Route 139, Holbrook

9/18/2013

Analysis Period (min) 15

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

Queue shown is maximum after two cycles.

Splits and Phases: 3: S. Franklin Street/N. Franlin Street & Union Street/Plymouth Street

 $\phi 1$	 $\phi 2$	 $\phi 3$	 $\phi 4$	 $\phi 9$
8 s	50 s	14 s	53 s	25 s
 $\phi 5$	 $\phi 6$	 $\phi 7$	 $\phi 8$	
11 s	47 s	12 s	55 s	

Intersection Capacity Analysis
Route 37 at Route 139, Holbrook

9/18/2013



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↖↗	↗		↖↗	↗		↖	↗	↗	↖	↗	↗
Volume (vph)	75	436	33	195	319	58	96	331	238	131	598	50
Peak Hour Factor	0.78	0.88	0.75	0.92	0.75	0.56	0.86	0.84	0.89	0.86	0.90	0.74
Heavy Vehicles (%)	3%	4%	0%	1%	2%	33%	4%	1%	1%	1%	1%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	96	539	0	212	529	0	112	394	267	152	732	0
Turn Type	Prot	NA		Prot	NA		pm+pt	NA	pm+ov	pm+pt	NA	
Protected Phases	7	4		3	8		5	2	3	1	6	
Permitted Phases							2		2	6		
Detector Phase	7	4		3	8		5	2	3	1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0		4.0	4.0	4.0	4.0	4.0	
Minimum Split (s)	8.0	20.0		8.0	20.0		8.0	20.0	8.0	8.0	20.0	
Total Split (s)	14.0	46.0		14.0	46.0		10.0	53.0	14.0	12.0	55.0	
Total Split (%)	9.3%	30.7%		9.3%	30.7%		6.7%	35.3%	9.3%	8.0%	36.7%	
Yellow Time (s)	3.0	3.0		3.0	3.0		3.0	3.0	3.0	3.0	3.0	
All-Red Time (s)	1.0	2.0		1.0	2.0		1.0	2.0	1.0	1.0	2.0	
Lost Time Adjust (s)	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	5.0		4.0	5.0		4.0	5.0	4.0	4.0	5.0	
Lead/Lag	Lead	Lag		Lead	Lag		Lead	Lag	Lead	Lead	Lag	
Lead-Lag Optimize?	Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes	Yes	
Recall Mode	None	None		None	None		None	Min	None	None	Min	
Act Effct Green (s)	8.7	41.1		10.0	42.5		55.2	48.2	63.2	59.2	50.2	
Actuated g/C Ratio	0.07	0.32		0.08	0.33		0.43	0.37	0.49	0.46	0.39	
v/c Ratio	0.42	0.93		0.79	0.93		0.81	0.56	0.32	0.44	1.01	
Control Delay	64.4	66.2		79.1	66.0		63.3	36.7	12.1	25.4	75.5	
Queue Delay	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0	
Total Delay	64.4	66.2		79.1	66.0		63.3	36.7	12.1	25.4	75.5	
LOS	E	E		E	E		E	D	B	C	E	
Approach Delay		66.0			69.8			32.1			66.9	
Approach LOS		E			E			C			E	
Queue Length 50th (ft)	38	413		88	403		48	246	62	67	577	
Queue Length 95th (ft)	65	#747		#178	#566		#162	389	150	133	#1048	
Internal Link Dist (ft)		496			764			516			495	
Turn Bay Length (ft)	350			125			150		85	250		
Base Capacity (vph)	265	580		270	568		138	703	846	347	724	
Starvation Cap Reductn	0	0		0	0		0	0	0	0	0	
Spillback Cap Reductn	0	0		0	0		0	0	0	0	0	
Storage Cap Reductn	0	0		0	0		0	0	0	0	0	
Reduced v/c Ratio	0.36	0.93		0.79	0.93		0.81	0.56	0.32	0.44	1.01	

Intersection Summary

Cycle Length: 150	
Actuated Cycle Length: 128.8	
Natural Cycle: 145	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.01	
Intersection Signal Delay: 58.5	Intersection LOS: E
Intersection Capacity Utilization 85.3%	ICU Level of Service E

Intersection Capacity Analysis
Route 37 at Route 139, Holbrook

9/18/2013

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Peak Hour Factor	
Heavy Vehicles (%)	
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)	25.0
Total Split (s)	25.0
Total Split (%)	17%
Yellow Time (s)	2.0
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	

Intersection Capacity Analysis

Route 37 at Route 139, Holbrook

9/18/2013

Analysis Period (min) 15

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

Queue shown is maximum after two cycles.

Splits and Phases: 3: S. Franklin Street/N. Franlin Street & Union Street/Plymouth Street

 ø1	 ø2	 ø3	 ø4	 ø9
12 s	53 s	14 s	46 s	25 s
 ø5	 ø6	 ø7	 ø8	
10 s	55 s	14 s	46 s	