CELEBRATING 35 YEARS

MEMORANDUM

Date:	January 05, 2018	Job No.:	5342-09
To:	Paul Scott, Director Department of Public Works		
Cc:	Robert T. Mackie, P.E., BCEE		
From:	Kien Ho, P.E., PTOE Tyler de Ruiter, P.E.		
Subject:	Plainville – Route 106 at George Street & Route 106 at Route 152 Evaluation		

As requested, BETA Group, Inc. (BETA) has evaluated the intersections of East Bacon Street (Route 106) at George Street and Messenger Street (Route 106) at Taunton Street (Route 152) in Plainville (Town), shown in Figure 1.

It is understood that high travel speeds related to the downhill vertical alignment of Route 106 coupled with the wide open geometry of the George Street intersection creates safety concerns as vehicles experience insufficient gaps exiting George Street.

The intersection of Route 106 at Route 152 was examined by the Southeastern Regional Planning and Economic Development District (SRPEDD) in February 2014 as part of their *Route 152 Corridor Study*. In 2009, SRPEDD published *"The Most Dangerous Crash Locations in Southeastern Massachusetts,"* a study that examined crash data from 2006 to 2008, which found this intersection to be ranked 5th out of 100 dangerous intersections in the SRPEDD region. The study noted several explanations for the high number of crashes, primarily with respect to the existing traffic signal operations/visibility and the presence of frequently used retail and commercial driveways immediately adjacent to the intersection. It is also understood that this intersection experiences poor operating conditions throughout the day with significant queueing along all four approaches.

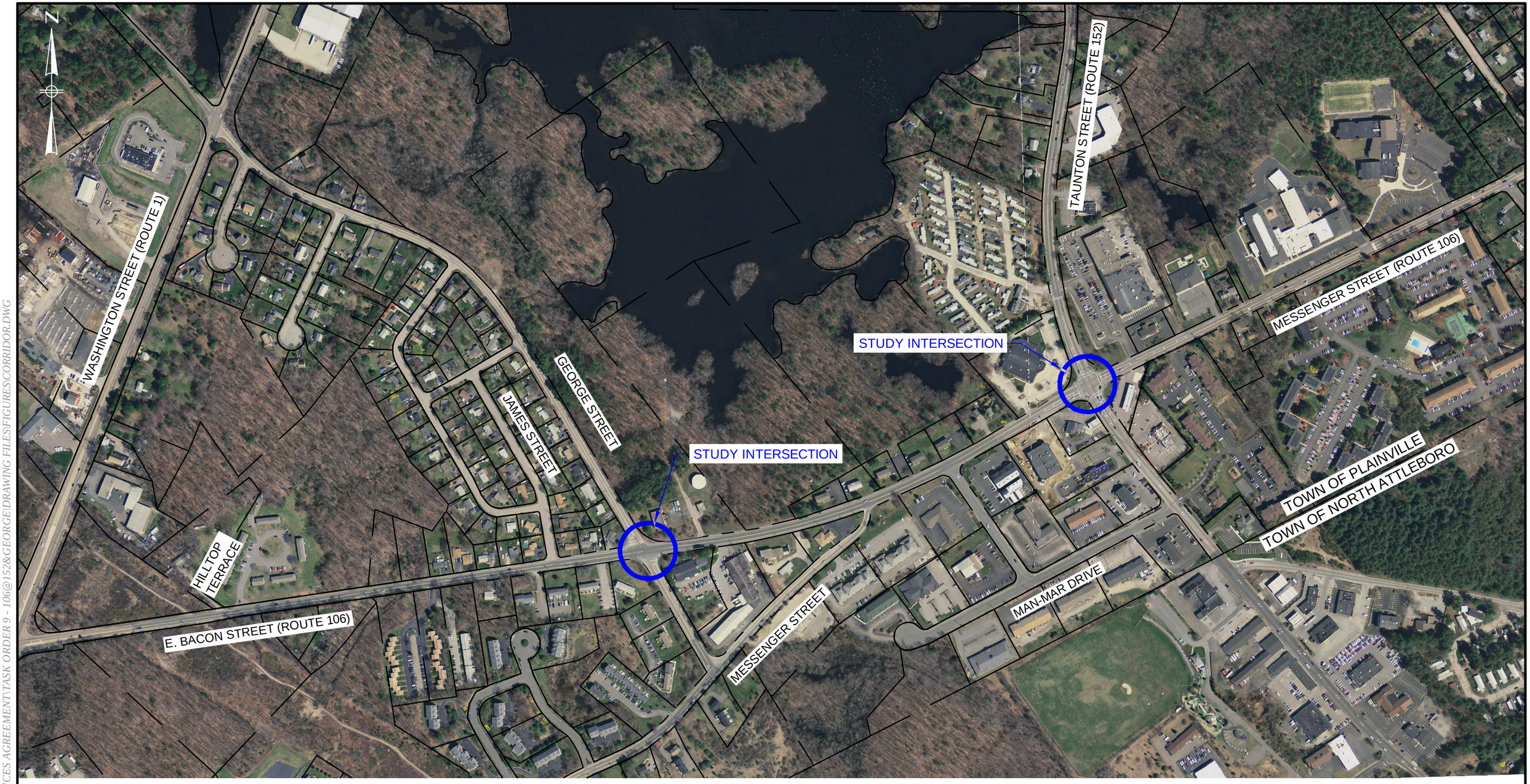
As part of the evaluation, BETA collected updated traffic data to validate the aforementioned concerns. This memorandum serves to provide a summary of BETA's findings as well as recommendations to address the intersection concerns.

EXISTING CONDITIONS

GEOMETRICS

East Bacon Street (Route 106) is an urban minor arterial under Town jurisdiction that generally travels in the east/west direction. Along its length, Route 106 connects South Street (Route 1A) in Plainville with Route 3A in Kingston. Within the study area, Route 106 connects Washington Street (Route 1) with Taunton Street (Route 152). Traveling eastbound, the roadway significantly decreases in grade between Hilltop Terrace and James Street (approximately 380 feet west of George Street).

Route 106 Grade Change (Looking Westbound)



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Route 106 at George Street & Route 106 at Route 152

Plainville, MA

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Figure No. 1

Location Map

East Bacon Street ends approximately 1,000 feet east of George Street at the intersection with Messenger Street. At this location, Route 106 continues eastward as Messenger Street. The roadway generally provides one travel lane in each direction separated by double yellow center line. Shoulder widths were found to be variable along the stretch of Route 106, with some areas of wide (5+ feet) shoulder. The travel lanes were found to have variable widths of 12 to 16 feet. Sidewalk is generally provided along the north side of Route 106. Utility poles are generally located along the southern side of Route 106 west of George Street and the northern side of Route 106 east of George Street.

ROUTE 106 AT GEORGE STREET

George Street is an urban collector under Town jurisdiction that generally travels in the north/south direction. Within the study area, George Street connects Messenger Street with Route 1. While George Street continues north of Route 1, traffic along Route 1 is separated by a row of delineators which prohibit crossing traffic between the southern and northern portions of George Street. The delineators also prohibit left turns on to and off of Route 1 establishing a "right-in, right-out" condition for both George Street approaches. The roadway generally provides one travel lane in each direction separated by double yellow center line. Shoulders were found to be variable in width. Sidewalk is provided along the west side of George Street south of Route 106.

Route 1 at George Street (Looking Northbound)

At the intersection with Route 106, a raised median island is provided on the northern George Street approach. The median island provides separation between southbound vehicles exiting George Street and a large number (112 vph) of westbound right turning vehicles towards George Street. Both George Street approaches flare out to provide wider turning radii. A crosswalk is provided along the northern leg of George Street that proceeds through the median island. An "Intersection Ahead" (W2-1) sign is provided approaching the intersection from the east. A "Stop Ahead" (W3-1A) sign is provided approaching Route 106 from the north and south.

George Street (Looking Southbound)

The northern leg provides two "STOP" (R1-1) signs with one in the median and one in the sidewalk. A large "STOP" pavement marking is provided on both north and south legs of George Street. The Stop Line on this approach was found to be approximately 10 feet north of the crosswalk. Based on this stop line location, sight distance exiting the northern leg is obstructed by vegetation and utility poles looking east and a large tree looking west. Vehicles were observed pulling up into the crosswalk to maximize sight distance. The southern leg provides an oversized "STOP" (R1-1) sign. Sight distance approaching from the south is also inhibited by large trees and an embankment on the eastern side. The intersection is lit by one street lamp on a utility pole located on the northeastern corner.

ROUTE 106 AT ROUTE 152

Taunton Street (Route 152) is an urban minor arterial under Town jurisdiction that generally travels in the north/south direction. Along its length, Route 152 connects Route 1 and Interstate 495 with Rhode Island at the border of Seekonk, Massachusetts.

In the area of its intersection with Route 106, Route 152 generally provides one travel lane in each direction separated by a double yellow center line. South of Route 106, the roadway provides a two way left turn lane which provides access to several commercial businesses and commercial parks. The southern leg of Route 152 provides a left turn lane, through lane, and right turn lane. All other approaches provide a left turn lane and a shared through/right turn lane. Crosswalks are provided across all four legs of the intersection. Sidewalks are provided along all four corners of the intersection and along both sides of all four legs. An additional pedestrian crossing is located approximately 375 feet north of Route 106 connecting the Plainville Crossing Shopping Center with Killarny Drive. Utility poles are located along the north side of Route 106 and the west side of Route 152. Most of the utility poles are located along the front of sidewalk within two feet of the existing curb line though some poles are located further set back from the roadway behind the sidewalk.

Route 152 (Looking Northbound)

As was noted in the SRPEDD study, several business driveways and access ways are located in very close proximity to the intersection, many of which are located within the limits of turning lanes. This requires vehicles entering and exiting driveways to cross multiple lanes of queued traffic during busy periods.

The intersection operates with a fully actuated traffic signal with two time-of-day signal timing plans. One plan is used between 3:30PM and 6:00PM while the other plan is used during all other times. The signal operates with seven phases, as shown in Figure 2. A left turn advance phase is provided for each approach. In addition, left turns are permitted during the regular through phases for each approach which is denoted by "Left Turn Yield on Green Ball" (R10-12) signs on each mast arm. Each mast arm provides a 5-Section "Doghouse" type signal head arrangement to display the protected-permitted left turn configuration. An exclusive pedestrian phase (Ø3) is provided via pushbutton activation that stops all vehicles such that pedestrians may cross any approach. It should be noted that the Route 152 northbound and southbound phases are combined in Phases 7 and 8. For example, should a southbound vehicle call Phase 7 (the left turn advance) both the southbound and northbound left turns would receive a green signal. However, a singular eastbound left turn would only trigger the eastbound left turn green signal while skipping the westbound left turn.

Doghouse Signal

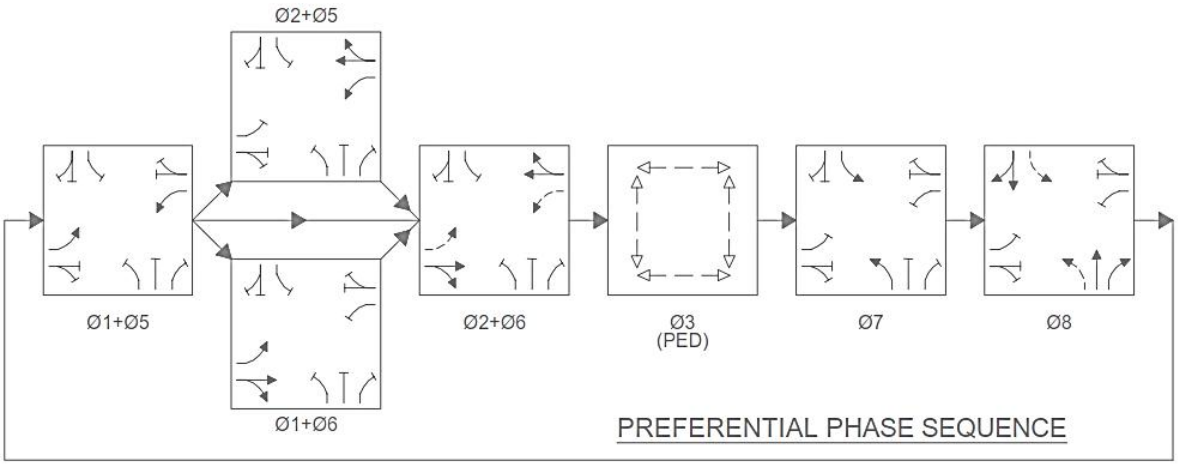


Figure 2: Existing Traffic Signal Phasing

Full timing data for this intersection is provided in Figure 2A.

TRAFFIC DATA

AUTOMATIC TRAFFIC RECORDER

Traffic volumes, speeds, and vehicle classification were collected on Route 106 west of George Street via Automatic Traffic Recorder (ATR) for a continuous 48 hour period between Wednesday, November 14th and Thursday, November 15th, 2017. A summary of traffic volumes is provided in Table 1. As seen in the table, Route 106 carries approximately 8,883 vehicles per day (both directions). The busiest peak hour was found to be the evening commuting peak hour with 883 vehicles per hour (both directions). The morning commuting peak hour approximately 64% of vehicles were found traveling eastbound, while other peaks were found to have relatively even directional splits.

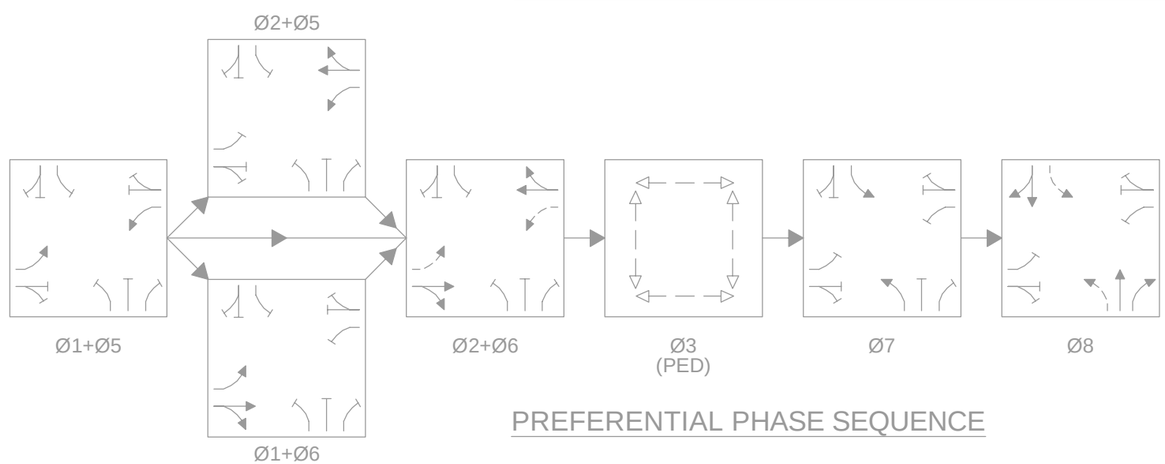
SEQUENCE AND TIMING FOR FULLY ACTUATED TRAFFIC SIGNAL CONTROL (UNCOORDINATED)

PHASE			Ø1			Ø2			Ø3			Ø4			Ø5			Ø6			Ø7			Ø8			Ø9			FLASH OPER.
STREET	DIRECTION	HOUSINGS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
ROUTE 106	EB	A	←G/R	←Y/R	R	R	R	R	R	R	R				R	R	R	G	Y	R	R	R	R	R	R	R				FY
ROUTE 106	EB	B	R	R	R	R	R	R	R	R	R				R	R	R	G	Y	R	R	R	R	R	R	R				FY
ROUTE 106	WB	C	R	R	R	G	Y	R	R	R	R				←G/R	←Y/R	R	R	R	R	R	R	R	R	R	R				FY
ROUTE 106	WB	D	R	R	R	G	Y	R	R	R	R				R	R	R	R	R	R	R	R	R	R	R	R				FY
ROUTE 152	NB	E	R	R	R	R	R	R	R	R	R				R	R	R	R	R	R	←G/R	←Y/R	R	G	Y	R				FR
ROUTE 152	NB	F	R	R	R	R	R	R	R	R	R				R	R	R	R	R	R	R	R	R	G	Y	R				FR
ROUTE 152	SB	G	R	R	R	R	R	R	R	R	R				R	R	R	R	R	R	←G/R	←Y/R	R	G	Y	R				FR
ROUTE 152	SB	H	R	R	R	R	R	R	R	R	R				R	R	R	R	R	R	R	R	R	G	Y	R				FR
PEDESTRIAN	ALL	P1-P8	DW	DW	DW	DW	DW	DW	W	FDW	DW				DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW				OFF
TIMING IN SECONDS																														
MINIMUM GREEN			5			15									5			15			5			10						
VEHICLE EXTENSION			2			2									2			2			2			3						
MAXIMUM GREEN 1			10			40									12			38			10			32						
MAXIMUM GREEN 2			10			36									16			32			10			40						
YELLOW CHANGE				3			3									3			3			3			3					
RED CLEARANCE					1			2									2			1			2			2					
WALK INTERVAL									7																					
PEDESTRIAN CLEARANCE										16																				
RECALL			OFF			OFF			OFF						OFF			OFF			OFF			OFF						
MEMORY			NON-LOCK			NON-LOCK			LOCK						NON-LOCK			NON-LOCK			NON-LOCK			NON-LOCK						

EMERGENCY ONLY

	CYCLE*	TIME PERIOD
MAX 1	111 (138)	ALL OTHER TIMES
MAX 2	117 (144)	3:30 PM - 6:00 PM

* WITHOUT PED PHASE (WITH PED PHASE)



PREFERENTIAL PHASE SEQUENCE

Prepared by:

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Route 106 at George Street & Route 106 at Route 152

Plainville, MA

Figure No. 2A

Route 106 at 152 Existing Timing

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Table 1: E. Bacon Street (Route 106) Traffic Volume Summary

Weekday	Morning Peak Hour (7:15-8:15 AM)			Evening Peak Hour (4:30-5:30 PM)			Lunch Peak Hour (12:00-1:00 PM)		
ADT	PHV	K Factor	Dir. Dist	PHV	K Factor	Dir. Dist	PHV	K Factor	Dir. Dist
8,883	644	7%	EB 64%	883	10%	EB 54%	568	6%	WB 52%

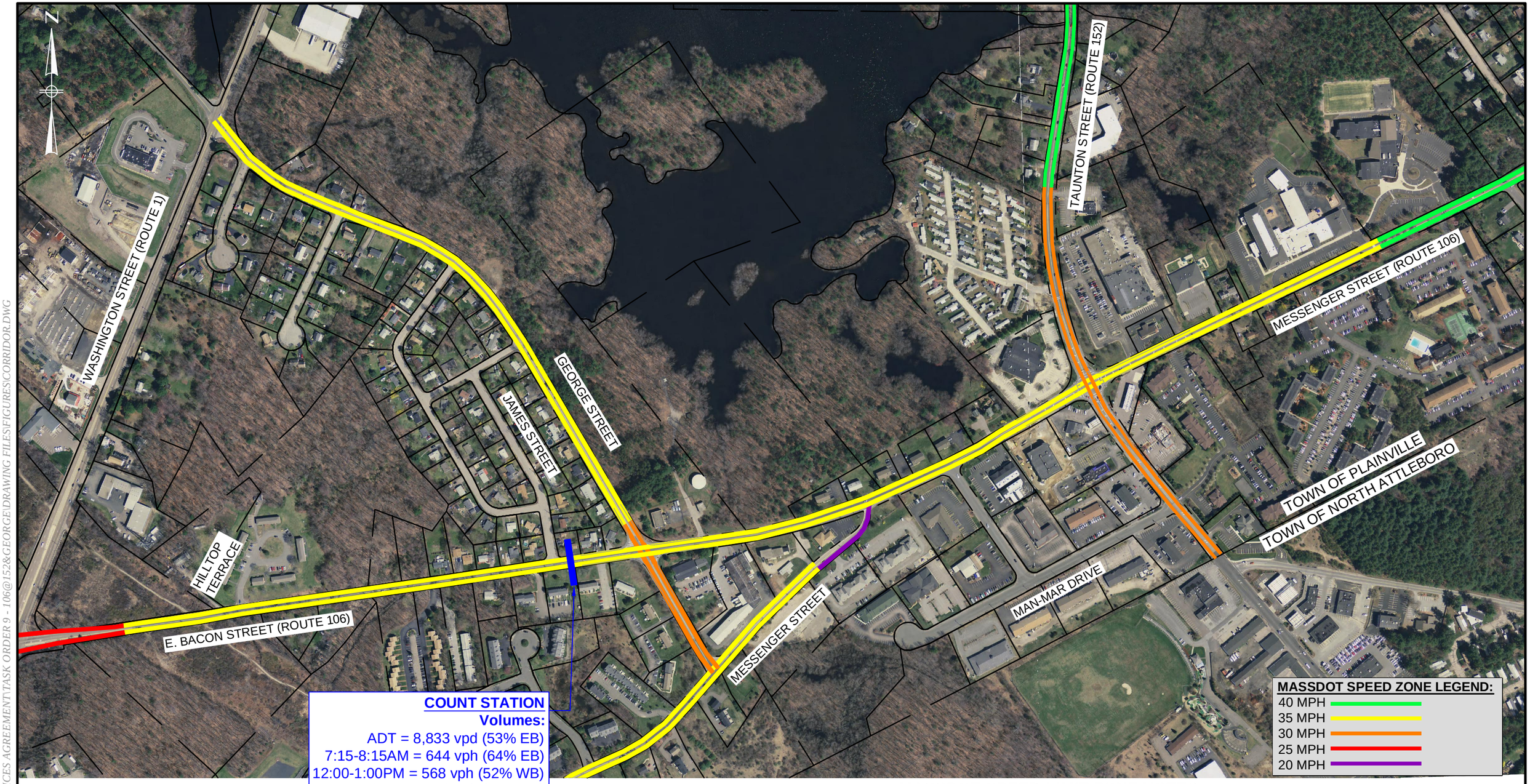
ADT – Average Daily Traffic (vehicles per day) in both directions
PHV - Peak Hour Volume (vehicles per hour) in both directions
K Factor – Percentage of ADT occurring during the peak hour

Traffic speeds are summarized in Figure 3 which shows a comparison of regulatory speed limits established by the Town of Plainville and MassDOT. Within the study area, Route 106 has a regulatory speed limit of 35 miles per hour (mph) in both directions. At the data collection location, the ATR found 85th percentile speeds to be approximately 48 mph eastbound and 46 mph westbound, more than 10 mph higher than the regulatory speed limit. As noted previously, these high speeds are contributed by the downgrade approaching from the west and the wide roadway which provides approximately 43 feet of pavement width in this area.

The vehicle classification collection found approximately 12 to 13 percent of vehicles traveling along Route 106 to be heavy vehicles or trucks. Approximately one percent of vehicles were found to be buses.

TURNING MOVEMENT COUNTS

Turning movement counts (TMC) were collected on Wednesday, November 8th 2017 at the intersections of Route 106 at George Street and Route 106 at Route 152. The intersection of George Street was continuously counted for 11 hours from 7:00AM to 6:00PM. The intersection of Route 152 was counted for the morning, lunch, and evening peak periods of 7:00-9:00AM, 12:00-2:00PM, and 4:00-6:00PM. A summary of the peak hour turning movement counts for both intersections are provided in Figure 4. As noted in the figure, the peak hours for both intersections were found to be 7:15-8:15AM, 12:00-1:00PM, and 4:45-5:45PM.



MASSDOT SPEED LIMIT ZONE NOTES:

- TOWN OF PLAINVILLE SPECIAL SPEED REGULATION NO. 5005; DATED DECEMBER 29, 1978; FOR ROUTE 106, ROUTE 152, AND MESSENGER STREET
- TOWN OF PLAINVILLE SPECIAL SPEED REGULATION NO. 7127; DATED AUGUST 11, 1982; FOR GEORGE STREET

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Route 106 at George Street & Route 106 at Route 152

Plainville, MA

Plot Date: 12/27/2017 2:45 PM

Figure No. 3

Speed Limits and Traffic Data

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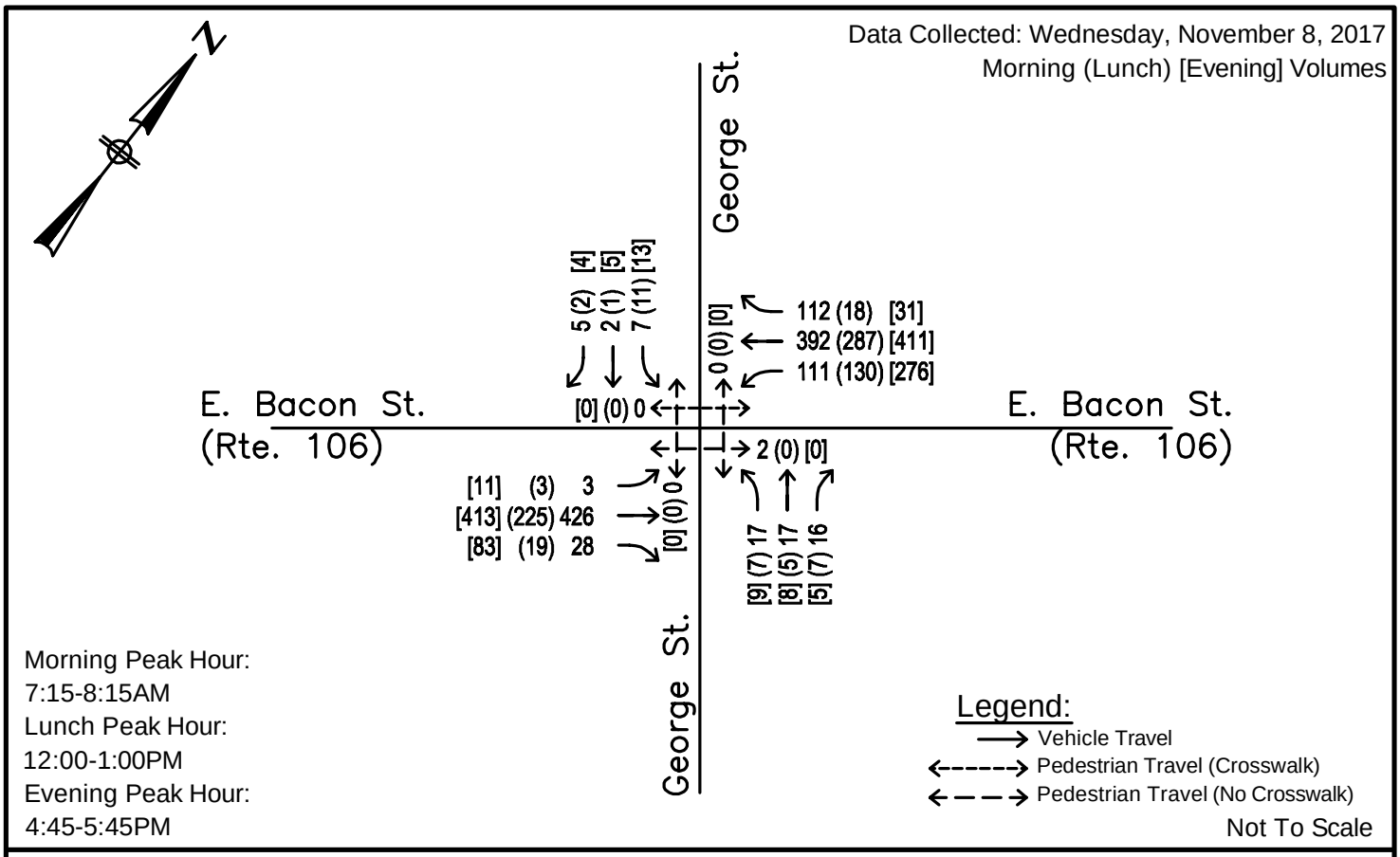

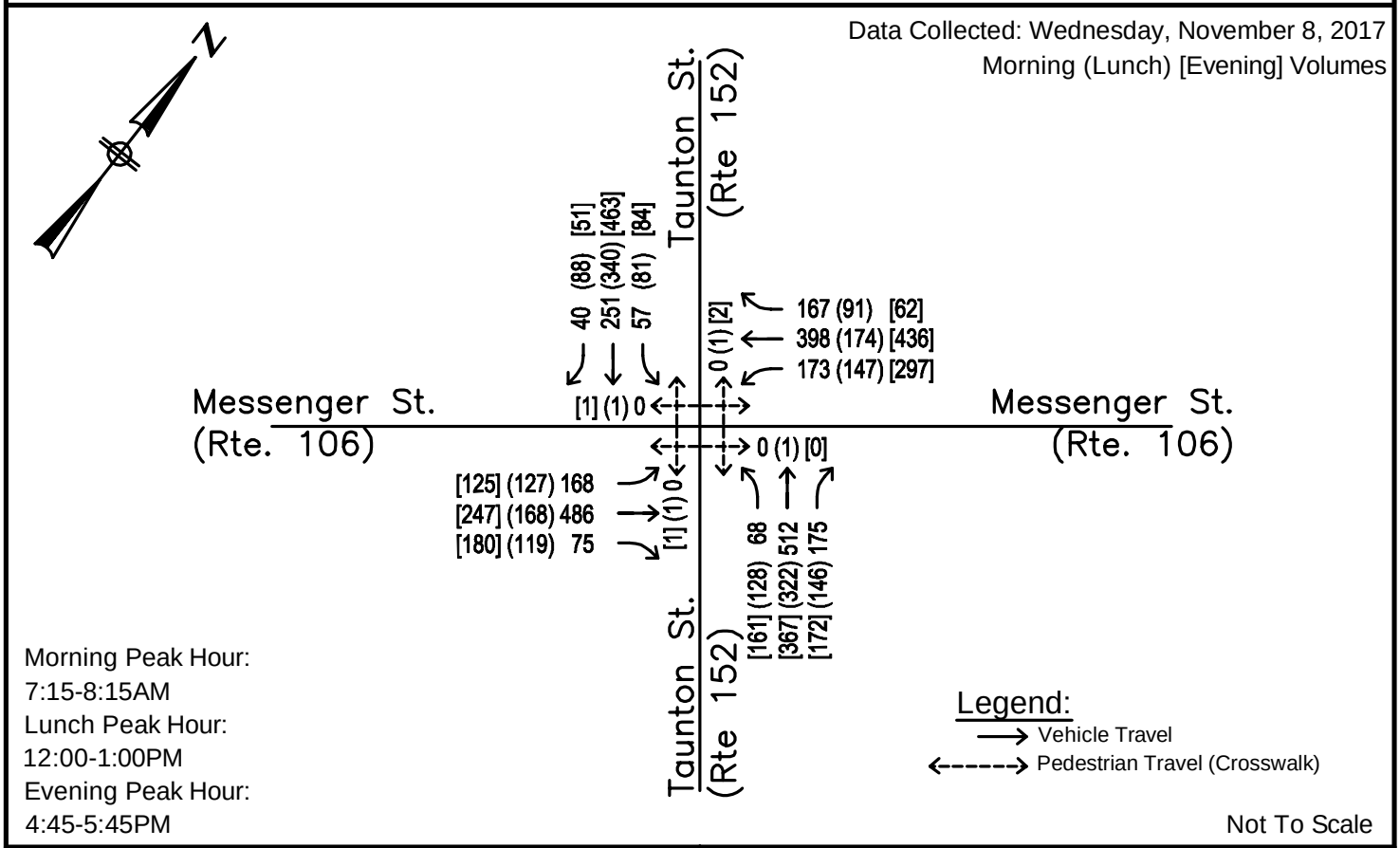

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Figure 4
2017 Existing Volume

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Due to the restrictive configuration of Route 1 at George Street, the volume exiting George Street onto Route 106 is significantly lower than any of the other roadways. The TMC also validate that eastbound and westbound traffic along Route 106 is relatively similar in each direction during all of the peak hours. Westbound right turns to George Street are significant in the morning peak hour, while westbound left turns to George Street are significant in the evening peak hour.

At the intersection of Route 152, the heavier movements were found to be eastbound and northbound in the morning peak hour, with southbound and westbound traffic in the evening peak hour. Southbound turns were found to be lower than all other approaches, possibly due to the presence of alternative routes such as Route 1 and Interstate 495 which may provide quicker travel times to similar areas.

SAFETY ANALYSIS

Crash data for the two study intersections were obtained from the MassDOT Crash Database for the most recent available three years (2013-2015). The MassDOT Crash Database provides crash data summaries for crash reports submitted to the Registry of Motor Vehicles. To supplement this data, BETA received crash reports from the Town of Plainville Police Department. The crash report narratives and crash diagrams were examined to validate the data provided by MassDOT. A summary of this data is provided in Table 2.

The intersection of George Street was found to have seven crashes in three years with half resulting in injury. Nearly all of these crashes were angle crashes, consistent with the unsignalized nature of the intersection. Interestingly, nearly all of the crashes were found to occur during off-peak hours.

The intersection of Route 152 and several driveways surrounding the intersection, falls within Massachusetts' Top 200 Intersection Cluster as Number 40, the 2013-2015 Federal Highway Administration's (FHWA) Highway Safety Improvement Program (HSIP) Cluster, and the 2012-2014 HSIP Cluster.

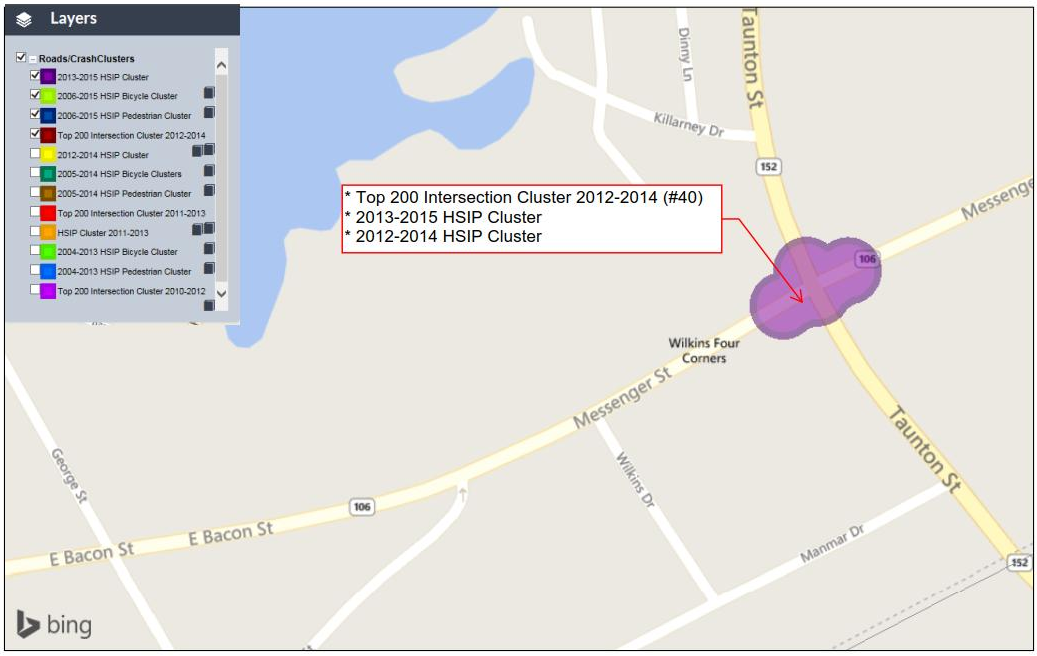

Table 2: Crash Data Summary

Condition	Route 106 at George Street	Route 106 at Route 152
Year:		
2013	2	30
2014	2	38
2015	3	29
Total	7	97
Severity:		
Property Damage Only	3	65
Injury	3	12
Fatal	0	0
Not Reported	1	20
Total	7	97
Type:		
Angle	6	49
Rear End	0	38
Sideswipe	0	4
Head-On	0	3
Parked Vehicle	0	1
Fixed Object	1	1
Pedestrian/Bicycle	0	1
Total	7	97
Road Condition:		
Dry	7	73
Wet	0	20
Snowy/Icy	0	3
Other	0	1
Total	7	97
Weather:		
Clear	6	67
Cloudy	1	18
Rain	0	9
Snow/Slush	0	2
Not Reported	0	1
Total	7	97
Weekday Commuter Peak:		
Weekday AM	1	9
Weekday PM	0	23
Non-Commuter Peak	6	65
Total	7	97

These clusters are used to identify intersections and/or areas of significant safety concern. Clusters are identified by calculating the area's Equivalent Property Damage Only (EPDO) score. The EPDO is a unit that converts all crash severities to an equivalent crash resulting in property damage only. The clusters with the highest EPDO values are ranked as clusters. Similarly, the SRPEDD report, discussed above, classified this intersection as one of the top crash locations within the SRPEDD district.

The intersection of Route 152 was found to have 97 crashes in three years with approximately 12% resulting in injury. The most commonly occurring crashes were angles and rear-ends, consistent with signalized operations that accommodate permitted left turns. In these scenarios, a left turning vehicle starts to make a movement but stops which results in the following vehicle rear-ending the lead vehicle. Angles can occur due to driver frustration such that the driver accepts a smaller gap in traffic than is required to make the turning maneuver. The presence of the commercial driveways is also responsible for many of the angle crashes. These driveways require vehicles to enter and exit driveways by crossing multiple lanes of queued traffic. This condition often creates courtesy crashes which represent conditions where a driver yields right-of-way to a turning vehicle. The vehicle then accepts that courtesy only to enter a collision with a passing vehicle in another lane. Nearly 25% of crashes were noted to occur during the evening commuting period. Several crash reports noted solar glare in this area.

OPERATIONAL CONDITIONS

In order to evaluate existing traffic conditions, a capacity (level of service) analysis was performed. This analysis was performed using methods of the 2000 *Highway Capacity Manual* published by the Transportation Research Board. For intersections, six levels of service, "A"-"F", have been established with "A" representing very good operation and "F" representing very poor operation. For signalized and unsignalized intersections, level of service is defined in terms of total delay and is computed for individual intersection turning movements. Delay is a measure of driver discomfort, frustration, fuel consumption, and lost travel time. The relationship between LOS and delay is summarized in Table 3.

Table 3: Level of Service Criteria

LOS	Unsignalized and Roundabout Intersection Criteria Average Total Delay (Seconds per Vehicle)	Signalized Intersection Criteria Average Total Delay (Seconds per Vehicle)	General Description
A	< 10.0	< 10.0	Free Flow
B	10.1 to 15.0	10.1 to 20.0	Stable flow (slight delays)
C	15.1 to 25.0	20.1 to 35.0	Stable flow (acceptable delays)
D	25.1 to 35.0	35.1 to 55.0	Approaching unstable flow (tolerable delay)
E	35.1 to 50.0	55.1 to 80.0	Unstable flow (intolerable delay)
F	> 50.0	> 80.0	Forced flow (jammed)

A level of service analysis was performed for intersections along the project corridor using Trafficware's Synchro software package (Version 9.1, Build 912.4). A summary of the weekday results of the capacity analysis are shown in Table 4. Complete analysis results are appended to this memorandum.

Table 4: Level of Service Summary – Existing Conditions

INTERSECTIONS	Morning Peak Hour					Lunch Peak Hour					Evening Peak Hour				
	LOS	Delay (sec/veh)	v/c	50%ile Queue	95%ile Queue	LOS	Delay (sec/veh)	v/c	50%ile Queue	95%ile Queue	LOS	Delay (sec/veh)	v/c	50%ile Queue	95%ile Queue
East Bacon Street (Route 106) at George Street [Unsignalized]															
East Bacon - EB	A	0.1	0.00	-	0	A	0.1	0.00	-	0	A	0.3	0.01	-	1
East Bacon - WB	A	3.0	0.13	-	11	A	3.1	0.10	-	9	A	6.0	0.27	-	28
George - NB (S)	E	38.9	0.38	-	41	C	16.3	0.07	-	6	F	64.7	0.35	-	34
George - SB (S)	D	30.6	0.10	-	8	C	19.5	0.07	-	6	F	76.1	0.40	-	39
Messenger Street (Route 106) at Taunton Street (Route 152) [Signalized]															
Messenger - EBL	D	45.0	0.83	76	# 207	C	20.6	0.39	52	92	C	30.4	0.60	60	100
Messenger - EBTR	E	57.5	0.95	414	# 677	D	35.8	0.73	155	258	E	70.2	0.95	325	# 536
Messenger - WBL	D	43.4	0.82	82	# 196	C	20.3	0.52	61	107	F	88.2	1.02	~ 210	# 394
Messenger - WBTR	E	59.3	0.96	420	# 673	C	30.2	0.62	138	227	D	48.4	0.88	382	# 593
Taunton - NBL	C	24.0	0.27	31	61	B	17.6	0.46	39	90	D	39.4	0.77	74	# 169
Taunton - NBT	F	82.1	1.02	~ 414	# 646	C	25.6	0.58	149	285	C	34.5	0.65	245	353
Taunton - NBR	C	28.8	0.25	41	105	C	20.5	0.12	6	53	C	26.8	0.16	17	68
Taunton - SBL	C	27.3	0.39	27	54	B	15.8	0.23	24	61	C	21.7	0.26	36	67
Taunton - SBTR	C	34.7	0.63	195	294	C	34.6	0.80	217	# 449	E	55.5	0.92	380	# 586
OVERALL	D	54.8	0.94	-	-	C	27.7	0.70	-	-	D	52.3	0.97	-	-

(S) Stop Sign Approach
~ Volume exceeds capacity, queue is theoretically infinite.
# 95th percentile volume exceeds capacity, queue may be longer. Queue shown is maximum after 2 cycles.
* Delay exceeds 300 seconds

As noted above, average total delay per vehicle is displayed with the corresponding level of service. The table also provides the volume to capacity ratio (v/c) for each lane use. Lane uses with v/c ratios greater than 1.0 operate over capacity and are attributed with LOS F even if the delay is less than 80 seconds. The queue lengths shown in the table represent the 50th percentile queue (50^{th} %) and the 95th percentile queues (95^{th} %). The 95^{th} percentile queue represents the queue length that has only a 5-percent chance of being exceeded during the peak hour.

ROUTE 106 AT GEORGE STREET

Synchro examines operating conditions for approaches and lane uses that are controlled in some form. At unsignalized intersections this primarily represents approaches that are controlled by stop signs. The program generally assumes that approaches without stop signs are free flowing and will only stop if a left turning vehicle blocks the travel lane. This is reflected in the table where both East Bacon Street (Route 106) approaches operate with LOS A and minimal delays. Queues were found to be about one vehicle for these approaches which suggests that left turning vehicles generally don't significantly block through traffic on Route 106. The George Street approaches, which are stop sign controlled, were found to operate with acceptable LOS (D or better) in the morning and lunch time peak hours. In the evening peak hour, George Street was found to operate at LOS F with delays of approximately 65 to 76 seconds per vehicle. Despite the longer delays, the 85^{th} percentile queues were found to be approximately one to two vehicles. The poor level of service in the evening peak hour is generated by the steady traffic along Route 106 with few gaps for entering vehicles.

ROUTE 106 AT ROUTE 152

The traffic data collection, discussed above, found approximately two pedestrians crossing in each peak hour. Based on the low number of pedestrians, the pedestrian phase was not included in the analysis. This methodology generally provides a better understanding of how the signal operates from a vehicle standpoint.

While this intersection operates with LOS D in the morning and evening peak hours, the through movements for all approaches experience long queues over 500 feet. The lunch peak hour was found to operate with LOS C with through movement queues over 200 feet, consistent with the lower traffic volumes observed during that period. Long delays and LOS F were found for northbound through traffic in the morning peak hour and westbound left turning traffic in the evening peak hour. The longest queues were found to occur on the eastbound, westbound and northbound approaches in the morning (650-675 feet); and the eastbound, westbound, and southbound approaches in the evening (540-590 feet). The westbound left turning queue was found to be approximately 400 feet in the evening peak hour consistent with the long 400 foot left turn lane currently provided along the leg.

CONCEPTUAL IMPROVEMENTS

In response to the evaluation discussed above, BETA was tasked with examining measures to calm traffic and improve safety by decreasing speeds on Route 106, and improve operations and safety at the intersection of Route 152. This section discusses short term and long term measures that can be implemented to improve conditions at these intersections.

ROUTE 106 SPEEDS

Based on the speed data collected west of George Street, the travel speed along Route 106 is approximately 10 to 13 mph higher than the regulatory speed limit for the roadway. In effort to reduce speeds along the corridor, BETA recommends the installation of electronic speed check signs particularly in the area of the significant downgrade. Speed check signs measure and display vehicle speeds to alert drivers that they are traveling faster than the speed limit. The speed check sign can also be programmed to display messages such as "Slow Down" if vehicle speeds exceed a specified threshold.

ROUTE 106 AT GEORGE STREET

TRAFFIC SIGNAL WARRANT

As examined in the traffic analysis above, the high crossing volume and travel speeds on Route 106 generates delays for vehicles exiting George Street as they struggle they struggle to find adequately sized gaps to enter or cross Route 106. To mitigate this issue, BETA examined whether the intersection satisfies warrants for the installation of a traffic signal.

To justify the installation of a traffic signal at an intersection, one or more of the signal warrants in the Manual on Uniform Traffic Control Devices (MUTCD) must be met. If one or more of the warrants is met and it is felt the installation of a signal would improve the overall safety and operation of the intersection, then installation or continued operation of a signal operation is justified.

Definition of Warrants

As part of this evaluation, traffic signal warrants were examined in accordance to the procedures and criteria described in the MUTCD. Signal warrants outlined in MUTCD are as follows:

- *Warrant 1, Eight Hour Vehicular Volume*

  In order to meet this warrant the vehicle volume during each of any eight (8) hours of an average day on the major street (total of both directions) and on the minor street in one direction (with higher volume) should be the following with respect to approach lanes:

  Condition A: Minimum Vehicular Volume

No. of Approach Lanes	Volume
Major street (1)/minor street (1)	major street (500)/minor street (150)
Major street (2 or more)/minor street (1)	major street (600)/minor street (150)
Major street (2 or more)/minor street (2)	major street (600)/minor street (200)
Major street (1)/minor street (2 or more)	major street (500)/minor street (200)

  Condition B: Interruption of Continuous Traffic

No. of Approach Lanes	Volume
Major street (1)/minor street (1)	major street (750)/minor street (75)
Major street (2 or more)/minor street (1)	major street (900)/minor street (75)
Major street (2 or more)/minor street (2)	major street (900)/minor street (100)
Major street (1)/minor street (2 or more)	major street (750)/minor street (100)

  The warrant is met if either Condition A or Condition B is satisfied.

- *Warrant 2, Four Hour Vehicular Volume*

  Vehicular volumes during each hour for any four (4) hours of an average day on the major street (total of both directions) and on the minor street in one direction (with higher volume) are plotted on a standard graph provided in the MUTCD. If the intersecting points fall above the respective curve in terms of number of approach lanes, the warrant is met.

- *Warrant 3, Peak Hour*

  Vehicular volumes during one (1) hour of any average weekday on the major street (total of both directions) and on the minor street in one direction (with higher volume) are plotted on a standard graph provided in the MUTCD. If the intersecting point falls above the respective curve in terms of number of approach lanes, the warrant is met.

- *Warrant 4, Pedestrian Volume*

  This warrant is met if the pedestrian volume during each of any four (4) hours of an average day crossing the major street is 100 and/or pedestrian volume during any hour of an average day crossing the major street is 190.

- *Warrant 5, School Crossing*

  The need for a traffic control signal shall be considered when an engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of school children at an established school crossing across the major street shows that the number of adequate gaps in the traffic stream during the period when the children are using the crossing is less than the number of minutes in the same period and there are a minimum of 20 students during the highest crossing hour.

- *Warrant 6, Coordinated Signal System*

  This warrant is met if the proposed signal provides the necessary degree of platooning.

- *Warrant 7 Crash experience*

  This warrant is met if the number of correctable crashes is five (5) or more a year, and if 80% of the volume requirements for Warrant 1 are met.

- *Warrant 8, Roadway Network*

  This warrant is met if the intersection of two major routes has a total existing or immediately projected entering volume of at least 1,000 vehicles per hour during the peak hour of a typical weekday.

- *Warrant 9, Intersection Near a Grade Crossing*

  This warrant is met if a grade crossing is located within 140 feet on an approach controlled by a STOP or YIELD sign, and the combination of major street volume, minor street volume, and the clear storage distance falls above the respective curve on a standard graph provided in the MUTCD.

Warrants 1, 2, 3, 4, and 7 were examined for this intersection. The signal warrant analysis revealed the existing pedestrian and vehicular volumes exiting George Street are not large enough to satisfy warrants. As a result, a traffic signal is not recommended at this time.

MEDIAN ISLANDS AND TRUCK APRONS

One potential measure to slow speeds along Route 106 is to narrow the travel lanes of the roadway by implementing traffic calming measures. The existing roadway pavement width is approximately 43 feet wide in the area of George Street which provides two 16 foot wide travel lanes and two wide shoulders (+5'). To slow speeds, the existing travel lanes will be narrowed with the installation of a mountable median island on each Route 106 approach. The existing intersection also provides very wide corners which accommodate turning radii of larger vehicles and trucks. The turning movement counts collected as part of this evaluation found approximately five large trailer trucks making a turning movement at the intersection. All other heavy vehicles were found to be buses or single unit trucks which utilize a much smaller turning radius. To reduce regular vehicle turning speeds the corner radii can be reduced to create a tighter turn for smaller cars and trucks. The tighter radius would be obtained by constructing a mountable truck apron within the existing roadway. This allows for the existing curbing to be retained while also providing a tighter radius for smaller vehicles. For example:

Concept 1, shown in Figure 5, recommends the installation of two six foot wide mountable median islands to separate eastbound and westbound traffic on Route 106. A two foot wide shoulder is recommended surrounding the median island. Travel lanes in the area of the island are reduced to 11 feet wide, with a five foot wide shoulder to accommodate bicycles. The diagram also shows the installation of truck aprons on three of the four corners to the intersection. Truck aprons can also be mountable with a sloped edging treatment similar to the median islands which would discourage smaller vehicles from driving on the truck apron. To accommodate drainage conditions, particularly in the area of the existing crosswalk, a flush truck apron could be used without updating the existing drainage infrastructure. This concept recommends the existing island on George Street be retained as this island helps protect vehicles on George Street from the large number of westbound right turns.

Concept 2, shown in Figure 6, builds on Concept 1 by reducing the five foot shoulder to one foot with a four foot wide mountable truck apron on the outside of the roadway. This treatment would further provide visual cues of roadway narrowing in the area of the intersection. A similar caveat with regard to roadway drainage noted for Concept 1 applies for Concept 2.

The recommended improvements in Concept 1 and Concept 2 could be installed independently in incremental phases.

ROUTE 106 AT ROUTE 152

Since this intersection is located at the crossing of two State Numbered Routes, all four of the approaches experience high traffic volumes during the peak hours. This puts a strain on the traffic signal as all four approaches require a similar amount of green time to accommodate the high volumes. To help improve the long queues and delays at the intersection, BETA has offered the following incremental improvements.

SHORT TERM

The intersection is operating near capacity with the existing lane use configuration. However, the existing roadway geometry does not provide adequate space to safely increase capacity by adding lanes. These short term improvements explore methods to improve operations and safety; such as changes to phasing, timings, and signal displays; while maintaining the existing roadway geometry and lane uses.

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N

James Street

George Street

East Bacon Street (Route 106)

RET EXIST ISLAND

TRUCK APRON

6 FOOT MOUNTABLE ISLAND

East Bacon Street (Route 106)

TRUCK APRON

6 FOOT MOUNTABLE ISLAND

11 FOOT TRAVEL LANES

5 FOOT SHOULDERS

TRUCK APRON

SPEED CHECK SIGN

YOUR SPEED

George Street

Route 106 at George Street & Route 106 at Route 152

Plainville, MA

Scale: 1" = 60'

Figure No. 5

George Street Concept 1

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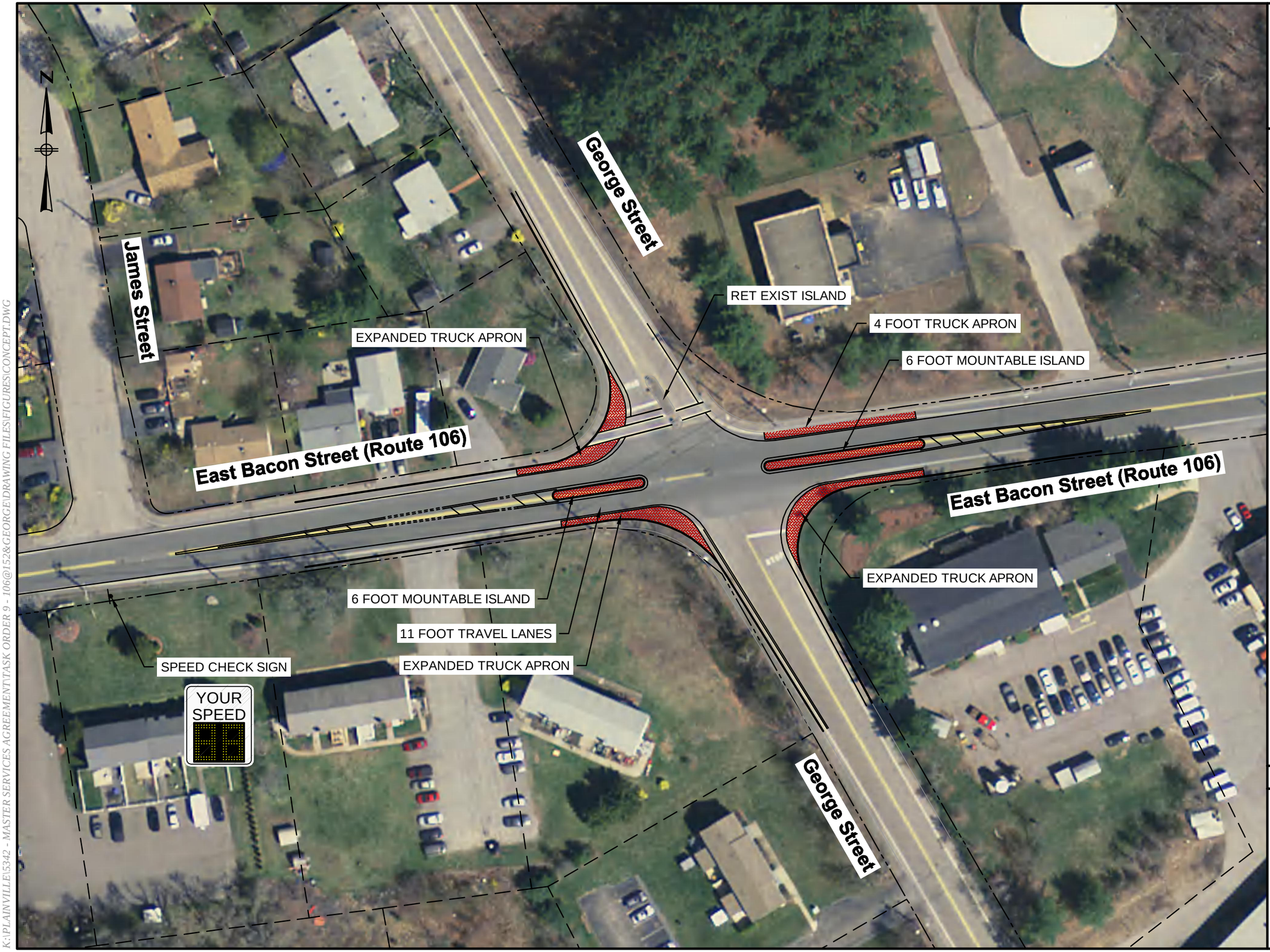

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Route 106 at George Street & Route 106 at Route 152

Plainville, MA

Scale: 1" = 60'

Figure No. 6

George Street Concept 2

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PHASING

The SRPEDD study noted that a significant number of collisions or near-misses occurred due to the existing protected-permitted left turn phasing for each of the approaches. One way to mitigate these conflicts is to remove the permitted left turn, forcing left vehicles to only turn with the display of a green arrow. Given the high number of left turns at this intersection, a protected only left turn would be detrimental to the capacity of the intersection which will increase delays and queues for the left turning vehicles. Since left turns would be forced to wait longer periods before receiving a green, disgruntled drivers may become more aggressive and abuse the yellow and red clearance intervals which will inadvertently decrease safety at the intersection. As a result, the protected only left turn phasing is not recommended at this time.

Conversely, the intersection could be improved by splitting the northbound and southbound detection into individual phases similar to the operation of the eastbound and westbound detection, see Figure 7. This would allow the controller to skip phases with no vehicle demand and allocate more green to phases with vehicle demand. To obtain this, the pedestrian phase would be moved from Phase 3 to Phase 9 such that the northbound and southbound approaches can follow the NEMA scheme of Phases 3 to 8.

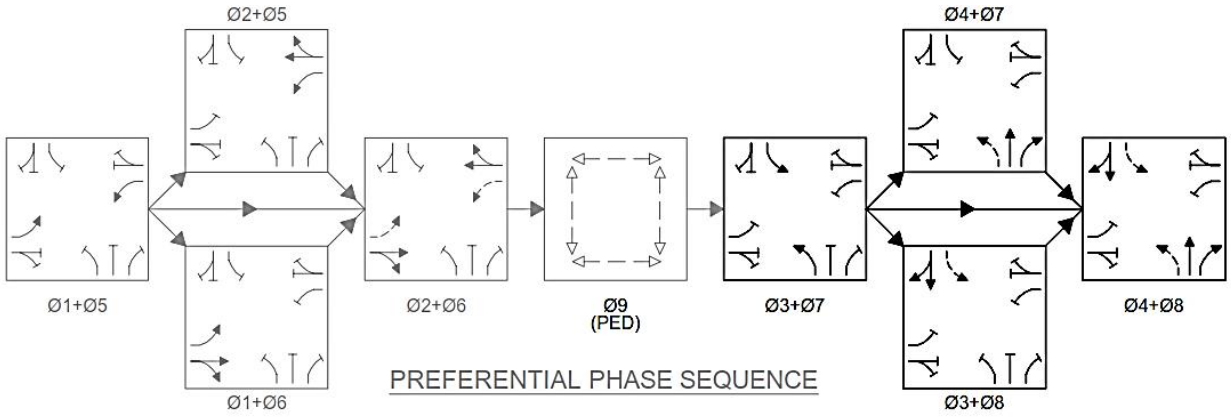

Figure 7: Proposed Phasing Adjustments

To accommodate this phasing sequence, two additional load switches are required in the controller cabinet.

FLASHING YELLOW ARROW

An alternative to the doghouse style traffic signal arrangement is to provide a flashing yellow arrow (FYA) arrangement. This arrangement displays four left arrow signal heads: Red, Yellow, Flashing Yellow, and Green. Under the protected phase, the standard green arrow, yellow arrow, and red arrow would appear in their typical intervals. During the permitted phase vehicles receive a flashing yellow arrow which alerts drivers that they may proceed but must yield to oncoming traffic. For clarity, a "Left Turn Yield on Flashing Yellow Arrow" (MA-R10-12a) sign should be installed adjacent to the new signal arrangement.

Flashing Yellow Arrow

Below is an excerpt from the MassDOT website on flashing yellow arrows:

> *Extensive research and implementation of FYA for Protected-Permissive Left-Turn phasing has shown significant safety benefits. Studies have shown that, on average, left turn crashes are reduced by approximately 20%. Drivers typically find the FYA display to be self-explanatory and need no further instruction. However, drivers that do not understand the meaning of the Flashing Yellow Left Arrow tend to make a safe maneuver, i.e. stopping and yielding to oncoming traffic, whereas left turning drivers that do not understand the meaning of the traditional Steady Circular Green often do just the opposite.*[1]

Since the existing mast arms provide one doghouse and one standard three section (Red, Yellow, Green) signal head arrangement, the conversion from doghouse to FYA would require the installation of a second three section (Red, Yellow, Green) signal head arrangement within the cone of vision for each approach to maintain compliance with the MUTCD. BETA recommends this signal head be installed on the mast arm post of each approach. A new traffic signal controller is required to provide flashing yellow arrow operations. A graphical representation of this configuration is provided in Figure 8.

TIMINGS AND SPLITS

In addition to the upgrades to the traffic signal hardware, alterations to the intersection's timings and splits were examined. Separating the northbound and southbound approaches allows for these two directions to have separate split times such that one direction may receive more green time than the other during peak periods. As recommended in the SRPEDD study, the pedestrian clearance (Flashing Don't Walk) time was increased from 16 seconds to 18 seconds to be compliant with current standards. Based on the phasing configuration, updated phase splits and cycle lengths were developed. A summary of the updated traffic signal timings, phasing, and signal head adjustments (discussed above) are provided in Figure 9.

The optimized timings were found to reduce the operating cycle length slightly from 138 seconds to 137 seconds in the Morning and Lunch peak periods and from 144 seconds to 141 seconds in the Evening peak period. While a shorter cycle can require vehicles towards the back of the queue to wait multiple cycles to advance through the intersection, a shorter cycle length reduces overall queues as vehicles spend less time sitting still at a single red signal.

[1] https://www.massdot.state.ma.us/highway/Departments/TrafficandSafetyEngineering/TrafficSignals/FlashingYellowArrow.aspx

REPLACE SIGNAL EQUIPMENT AND SIGNS AS SHOWN FOR ALL MAST ARMS

Taunton Street (Route 152)

Messenger Street (Route 106)

FLASHING

LOCATIONS A,D,G,K

LOCATIONS B,C,E,F,H,J,L,M

SIGNAL HEADS

RET MAST ARMS (TYP)

FLASHING

PROP

REM

LEFT TURN YIELD ON GREEN

REM

LEFT TURN YIELD ON FLASHING

PROP

PROP

INSTALL TWO ADDITIONAL LOAD SWITCHES AND NEW TRAFFIC SIGNAL CONTROLLER IN EXIST CABINET

A B C D E F G H J K L M

Taunton Street (Route 152)

Messenger Street (Route 106)

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Route 106 at George Street & Route 106 at Route 152

Plainville, MA

Scale: 1" = 60'

Figure No. 8

Flashing Yellow Arrow

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SEQUENCE AND TIMING FOR FULLY ACTUATED TRAFFIC SIGNAL CONTROL (UNCOORDINATED)

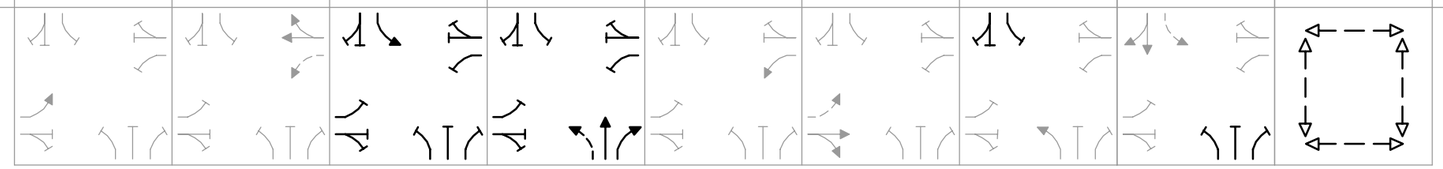
PHASE			Ø1			Ø2			Ø3			Ø4			Ø5			Ø6			Ø7			Ø8			Ø9			FLASH OPER.
STREET	DIRECTION	HOUSINGS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
ROUTE 106	EB	A	~~G~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~FY~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~FR~~
ROUTE 106	EB	B,C	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	G	Y	R	R	R	R	R	R	R	R	R	R	FY
ROUTE 106	WB	D	~~R~~	~~R~~	~~R~~	~~FY~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~G~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~FR~~
ROUTE 106	WB	E,F	R	R	R	G	Y	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	FY
ROUTE 152	NB	G	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~FY~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~G~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~FR~~
ROUTE 152	NB	H,J	R	R	R	R	R	R	R	R	R	G	Y	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	FR
ROUTE 152	SB	K	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~G~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~R~~	~~FY~~	~~Y~~	~~R~~	~~R~~	~~R~~	~~FR~~
ROUTE 152	SB	L,M	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	G	Y	R	R	R	R	FR
PEDESTRIAN	ALL	P1-P8	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	W	FDW	DW	OFF
TIMING IN SECONDS																														
MINIMUM GREEN			5			15			5			10			5			15			5			10						
VEHICLE EXTENSION			2			2			2			3			2			2			2			3						
MAXIMUM GREEN 1			10			~~40~~37			10			32			~~12~~10			~~38~~37			10			32						
MAXIMUM GREEN 2			10			~~36~~38			10			35			16			32			10			~~40~~35						
YELLOW CHANGE				3			3			3			3			3			3			3			3						
RED CLEARANCE					1			2			2			2			2			1			2			2					
WALK INTERVAL																											7			
PEDESTRIAN CLEARANCE																												18	4	
RECALL			OFF			SOFT			OFF			OFF			OFF			SOFT			OFF			OFF			OFF			
MEMORY			NON-LOCK			NON-LOCK			NON-LOCK			NON-LOCK			NON-LOCK			NON-LOCK			NON-LOCK			NON-LOCK			LOCK			

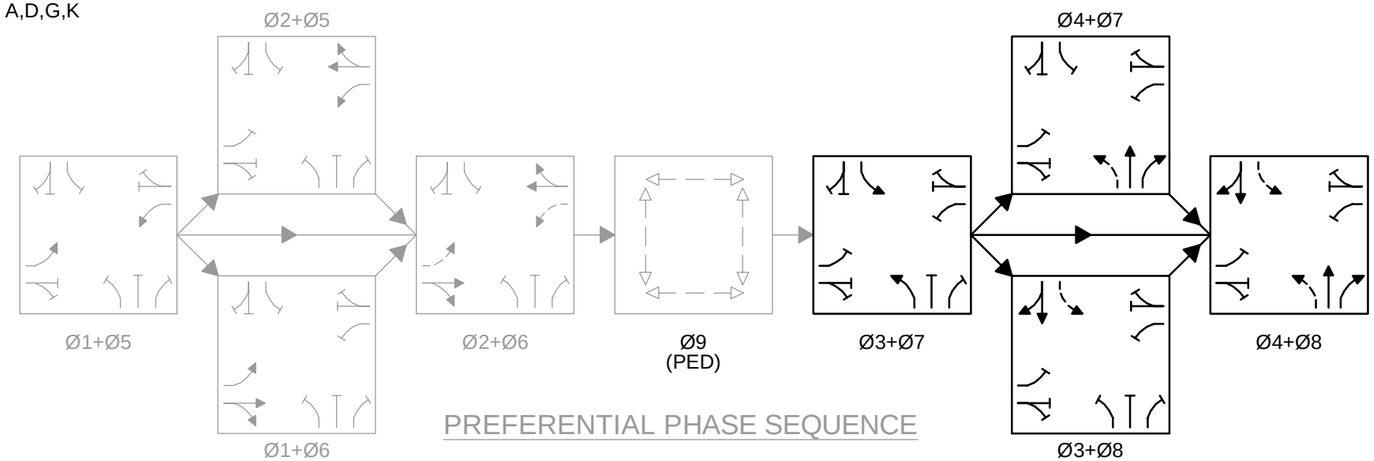
EMERGENCY ONLY

R
Y
FY
G

LOCATIONS
A,D,G,K

LOCATIONS
B,C,E,F,H,J,L,M





PREFERENTIAL PHASE SEQUENCE

PROPOSED

	CYCLE*	TIME PERIOD
MAX 1	108 (137)	ALL OTHER TIMES
MAX 2	112 (141)	3:30 PM - 6:00 PM

* WITHOUT PED PHASE (WITH PED PHASE)

EXISTING

	CYCLE*	TIME PERIOD
MAX 1	111 (138)	ALL OTHER TIMES
MAX 2	117 (144)	3:30 PM - 6:00 PM

* WITHOUT PED PHASE (WITH PED PHASE)

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Route 106 at George Street & Route 106 at Route 152
Plainville, MA

Figure No. 9

Route 106 at 152 Adjusted Timing

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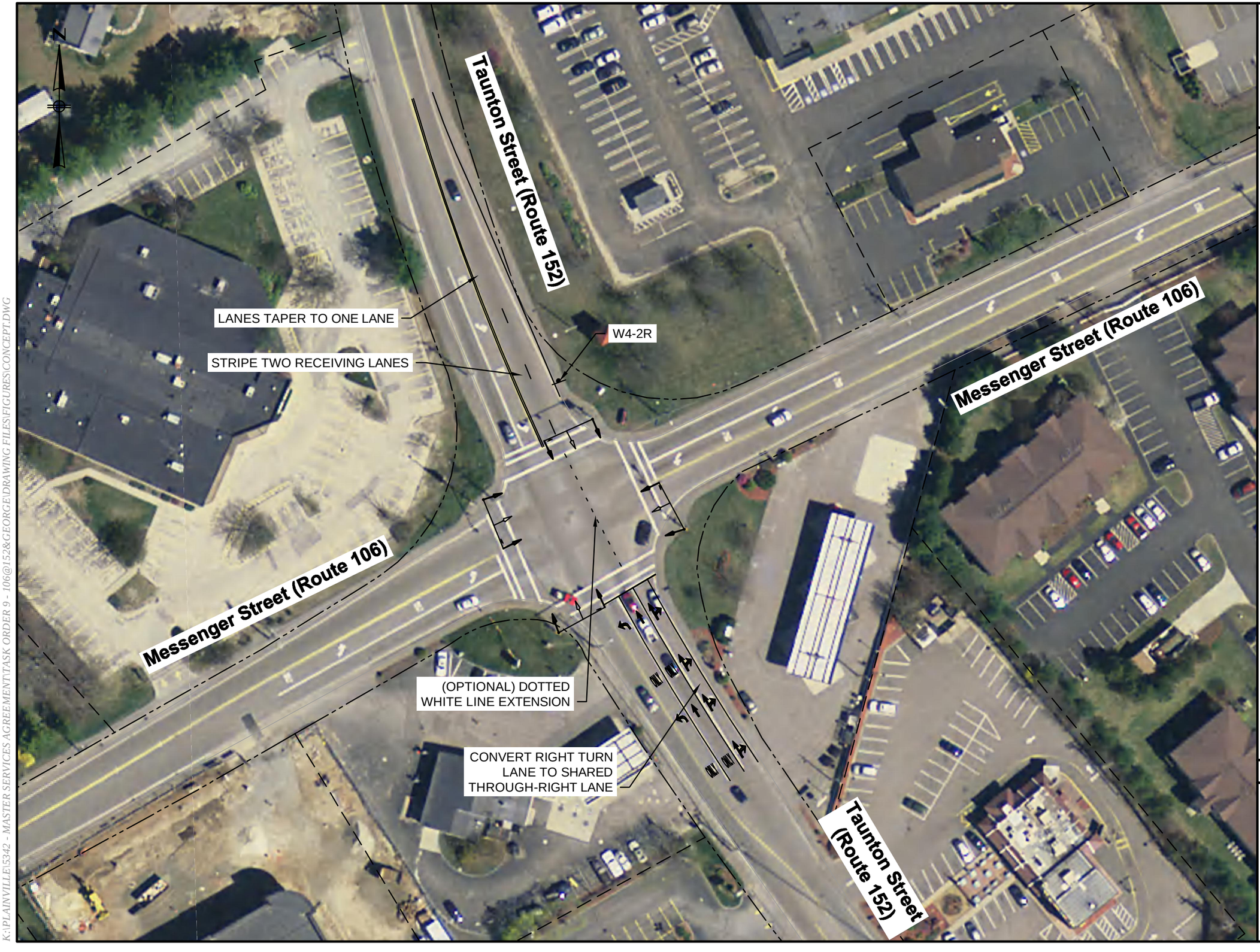
MID TERM

The existing roadway geometry does not provide significant space for the addition of travel lanes. Due to the configuration of the northbound approach, which provides three designated travel lanes, the receiving lane on the northern leg is very large (±25 feet). To increase capacity for northbound traffic the existing right turn lane could be converted to a shared through-right turn lane such that the approach provides two through lanes. The corresponding receiving lane would be split into two receiving lanes which taper down to one lane approximately 75 to 100 feet north of the intersection, as shown in Figure 10. To alert drivers of the new condition, the installation of a "Right Lane Ends" (W4-2R) sign is recommended. In addition, the existing lane use sign located south of the intersection should be updated to denote the new lane configuration.

While this configuration increases capacity for the northbound approach which receives heavy volumes during the morning peak period, it increases the number of lanes that southbound left turning vehicles must cross as part of their maneuver thereby increasing the number of conflict points where a collision might occur. To reduce safety impacts as a result of this configuration, the southbound left turn will need to be converted to a "protected only" left turn by removing the flashing yellow arrow. These turns would receive a solid red arrow for all phases other than their designated left turn phase. The reduction of permitted green time for this movement will increase queues for the southbound left turn lane. These queues will require monitoring to ensure that they will not block the southbound through lane. If the monitoring reveals that queues have begun to block through traffic, the left turn timing will be adjusted to avoid blockages of the southbound through lane.

LONG TERM

As a long term measure for improvement, the intersections' capacity can be increased by mimicking the northbound three lane configuration on all other approaches such that each approach receives a left turn lane, through lane, and right turn lane. Increasing the number of travel lanes will require roadway widening, reconstruction of sidewalks, relocation of utility poles, reconstruction of traffic signal equipment, and right-of-way impact. The addition of turn lanes will impact nearby commercial driveways. In an effort to increase safety, these driveways should be closed or converted to a "right-in, right-out" configuration to discourage vehicles crossing three travel lanes to enter and exit the driveway. The closure or repurposing of commercial driveways was recommended as part of the SRPEDD study. A schematic of this potential configuration is provided in Figure 11. Further engineering and design is required to perform a detailed evaluation for these long term improvements. Further evaluation would evaluate the recommendations of the SRPEDD study which recommended a five lane section for each approach that includes two receiving lanes, one dedicated left turn lane, one dedicated through lane, and one shared through-right lane. Since this intersection is noted as a Top 200 Crash Location and falls within multiple Highway Safety Improvement Program (HSIP) crash clusters, long term improvements to this intersection could be a good candidate for federal or state funding from the HSIP and/or Transportation Improvement Program (TIP). A Road Safety Audit (RSA) will need to be performed by the Town as part of the application process for these programs.



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Route 106 at George Street & Route 106 at Route 152

Plainville, MA

Scale: 1" = 60'

Figure No. 10

Route 106 at 152 Mid Term

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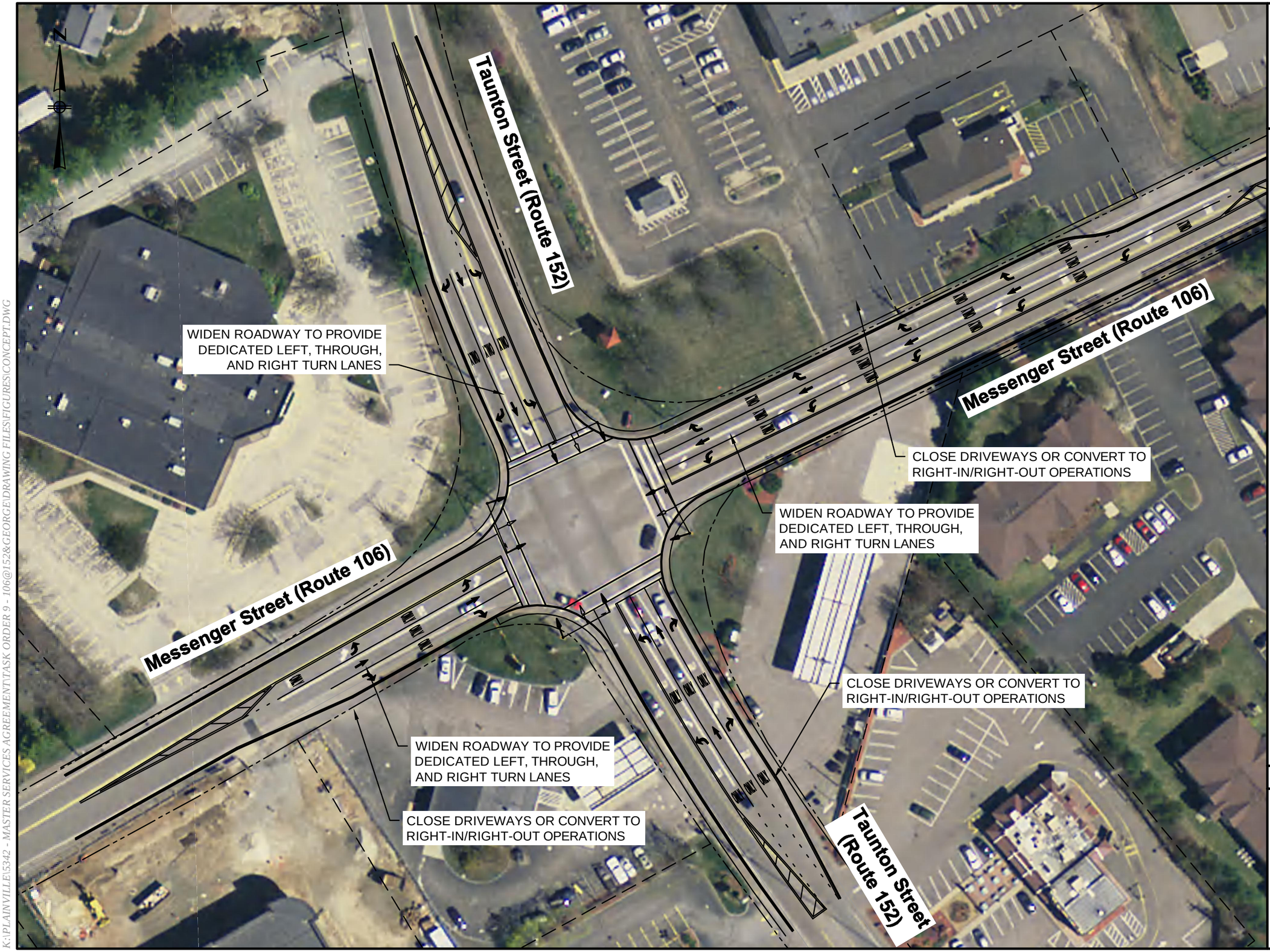

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Route 106 at George Street & Route 106 at Route 152

Plainville, MA

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Figure No. 11

Route 106 at 152 Long Term

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CONCLUSION

The evaluation of traffic data collected in November 2017 validated concerns regarding high speeds along Route 106 and the significant number of crashes at the intersection of Route 106 at Route 152. BETA recommends instituting traffic calming practices to slow speeds along Route 106. This includes methods such as the installation of speed check signage and narrowing the travel way (road dieting).

ROUTE 106 AT GEORGE STREET

Constructing mountable median islands for the Route 106 approaches at George Street can help to reduce travel speeds within the intersection as they shift the travel path and provide a visual obstruction that vehicles must maneuver around. The mountable nature of the island permits larger vehicles to pass over the island should they require a larger turning radius. In addition, narrowing corner radii with the use of truck aprons was discussed to reduce the turning speeds of smaller vehicles.

ROUTE 106 AT ROUTE 152

The intersection of Route 106 at Route 152 was found to operate with significant delays and queues as it is nearing capacity. Increasing intersection capacity will require substantial changes to the roadway geometry such as roadway widening, reconstruction of sidewalk, relocation of utilities, and right-of-way impact.

Short term measures were examined to improve safety at the intersection by replacing the existing five section doghouse left turn signals with the flashing yellow arrow configuration currently being promoted by MassDOT. Studies have shown that drivers react and make safer decisions when faced with a flashing yellow arrow than a steady green ball. Updates to intersection phasing were also discussed to convert the northbound and southbound approaches to their own individual phases to follow NEMA standards. This will allow each approach to be skipped if demand is not present such that the opposing approach may receive more dedicated time. With the implementation of new phasing, the existing signal timings and splits were also examined and updated. The adjusted timings reflect a slightly shortened cycle length. The shortened cycle length provides more turnover which reduces queueing generated by vehicles waiting for a green signal.

In the Mid Term, intersection capacity can be increased by converting the existing northbound right turn lane to a shared through-right lane. However, this configuration negatively impacts southbound left turns which will increase southbound queueing in the evening peak period.

A Long Term improvement for the intersection would be to increase capacity by increasing the number of lanes on each approach which will have

Since this intersection is noted as a Top 200 Crash Location and falls within multiple Highway Safety Improvement Program (HSIP) crash clusters, long term improvements to this intersection could be a good candidate for federal or state funding from the HSIP and/or Transportation Improvement Program (TIP). A Road Safety Audit (RSA) will need to be performed by the Town as part of the application and submission process for these programs.