TECHNICAL MEMORANDUM

DATE: **May 18, 2017**
TO: **William Paulitz, City Engineer, Peabody**
FROM: **Seth Asante and Katrina Crocker, MPO Staff**
RE: **Safety and Operations Analyses, FFY 2016**
Andover Street at Esquire Drive and Violet Road in Peabody

This memorandum summarizes the analyses and improvement alternatives developed for the intersection of Andover Street at Esquire Drive and Violet Road in Peabody. The opening sections of the memorandum give a background of the study and describe the existing conditions and concerns of the community. Following that, we describe the various kinds of data collected, and assess the safety and operational problems. The final sections of the memorandum present the improvement alternatives, recommendations, and next steps. This memo also includes appendices that contain methods and data applied in the study, detailed reports of the intersection capacity analyses, and an overview of the project development process.

1 BACKGROUND

The purpose of the Safety and Operations Analyses at Selected Intersections study is to examine safety, operations, and mobility issues at major intersections in the Boston Region Metropolitan Planning Organization (MPO) region's arterial highways—areas where many crashes occur, that experience congestion during peak traffic periods, or are in need of improvements for buses, bicyclists, and pedestrians. For the past ten years, the MPO has been conducting these planning studies, and municipalities in the region are very receptive to them. These studies give communities an opportunity to begin looking at the needs of these locations, starting at the conceptual level, before they commit funds for design and engineering. Eventually, if the project qualifies for federal funds, the study's documentation also is useful to the Massachusetts Department of Transportation (MassDOT). These studies support the MPO's visions and goals, which include increasing transportation safety, maintaining the transportation system, advancing mobility, and reducing congestion.

Following a selection process based on safety conditions[1], congested conditions[2], multimodal significance[3], regional significance[4], regional equity[5], and implementation potential[6], two locations from a short list of 20 intersections were approved for study by the MPO.[7] The two locations approved for study are:

1. Andover Street (Route 114) at Esquire Drive and Violet Road in Peabody
2. Broadway at Fourth Street, Fifth Street, and Hawthorne Street in Chelsea

The location in Peabody was selected because it has safety and traffic operations problems. This intersection is ranked 95 on the 2012–2014 Statewide Top-200 Intersection Crash List. Crashes at the intersection also form part of a Highway Safety Improvement Program (HSIP) crash cluster.[8] Figure 1 shows the location of the intersection and the surrounding roadways.

1.1 Public Participation

MPO staff discussed the safety and operations issues at the intersection and the scope of work for the study with the City of Peabody, which expressed interest and willingness to participate in the study. MassDOT—in collaboration with the City of Peabody, the Metropolitan Area Planning Council (MAPC), and the Central Transportation Planning Staff (CTPS) (to the Boston Region MPO)—conducted a road safety audit (RSA) for this intersection on Monday, November 21, 2016. Staff reviewed the recommendations of the RSA and incorporated them into this memorandum. (Appendix A includes information about the selection process and comments about the study.)

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[1] Safety Conditions: Location has a higher-than-average crash rate for its functional class, contains a Highway Safety Improvement Program (HSIP)-eligible crash cluster, contains a top-200 high crash location, or has a significant number of pedestrian and bicycle crashes (two or more per mile).

[2] Congested Conditions: Travel time index is at least 1.3.

[3] Multimodal Significance: Location carries bus route(s), is adjacent to a transit stop or station; supports bicycle or pedestrian activities or has an implementation project to support one or more of these activities; has need to accommodate pedestrians and bicyclists and improve transit; or high truck traffic serving regional commerce.

[4] Regional Significance: Location is in National Highway System; carries a significant portion of regional traffic (ADT >20,000); lies within 0.5 miles of EJ transportation analysis areas or zones; or is essential for the region's economic, cultural, or recreational development.

[5] Reginal Equity: That is, it was important not to select 1) more than one location in a subregion and 2) a location in same subregion as in the preceding cycle of this study.

[6] Implementation Potential: Location is proposed or endorsed by its roadway administrative agency (agencies); proposed or endorsed by its subregion and is a priority for that subregion; or has strong support from other stakeholders.

[7] Safety and Operations Analyses at Selected Intersections: Federal Fiscal Year 2016, Technical Memorandum to the Boston Region Metropolitan Planning Organization. Seth Asante and Katrina Crocker, March 17, 2016.

[8] In the Boston region, the 921 intersections in the top-five percent have crash clusters with a minimum equivalent property damage only value of 42.

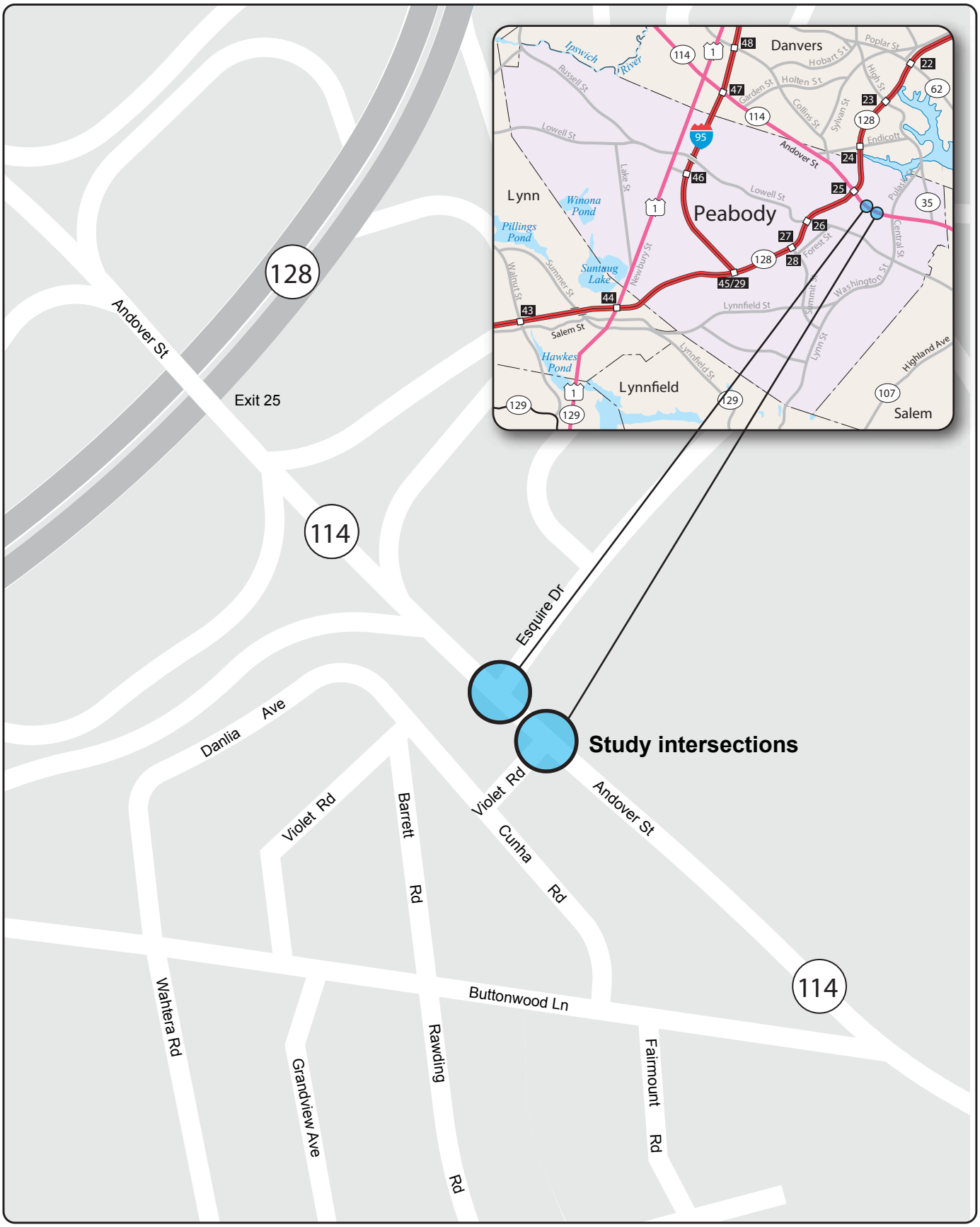

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Figure 1
Study Area Map

Safety and Operations Analyses at Selected Intersections

2 ROADWAY, INTERSECTIONS, AND LAND USES

2.1 Roadway

Andover Street (Route 114)

Andover Street provides access to and from several locations in Peabody as well as communities to the east and west, passing through Marblehead, Salem, Peabody, Danvers, Middleton, North Andover, and Lawrence. Although Andover Street is a state-numbered route, the segment beginning at and to the east of Esquire Drive and Violet Road is under the jurisdiction of the City of Peabody.

The roadway, functionally classified as a principal arterial, is part of the National Highway System (NHS) program and is eligible for federal funds under the program. Andover Street near the Esquire Drive and Violet Road intersection has right-of-way width that varies from 60 feet to 75 feet. To the east of the intersection, Andover Street is a two-lane, two-way arterial, with very wide travel lanes; during peak periods, drivers form two lanes in each direction although they are striped as single lanes. To the west of the intersection, Andover Street is a four-lane arterial, with two travel lanes in each direction. Near the intersection, there are continuous and connected sidewalks (six-to-eight feet wide) on both sides, and posted speed limits of 30 miles per hour eastbound and 35 mph westbound. On-street parking is prohibited in this segment and there are no shoulders, therefore bicyclists share the roadway with motor vehicles, but there are no sharrows lanes for sharing the roadway.

Esquire Drive

Esquire Drive is a city-owned two-lane, two-way local street providing access to a residential area north of the intersection. The right-of-way is approximately 60 feet wide and comprised of two wide travel lanes, a median, and sidewalks with grass buffers on both sides.

Violet Road

Violet Road is a city-owned two-lane, two-way local street providing access to a residential area south of the intersection. The right-of-way is approximately 30 feet wide and comprised of two 11-foot travel lanes and a sidewalk on the east side only.

2.2 Intersection

Figure 2 shows the study intersection layout, lane configurations, and the surrounding land uses.

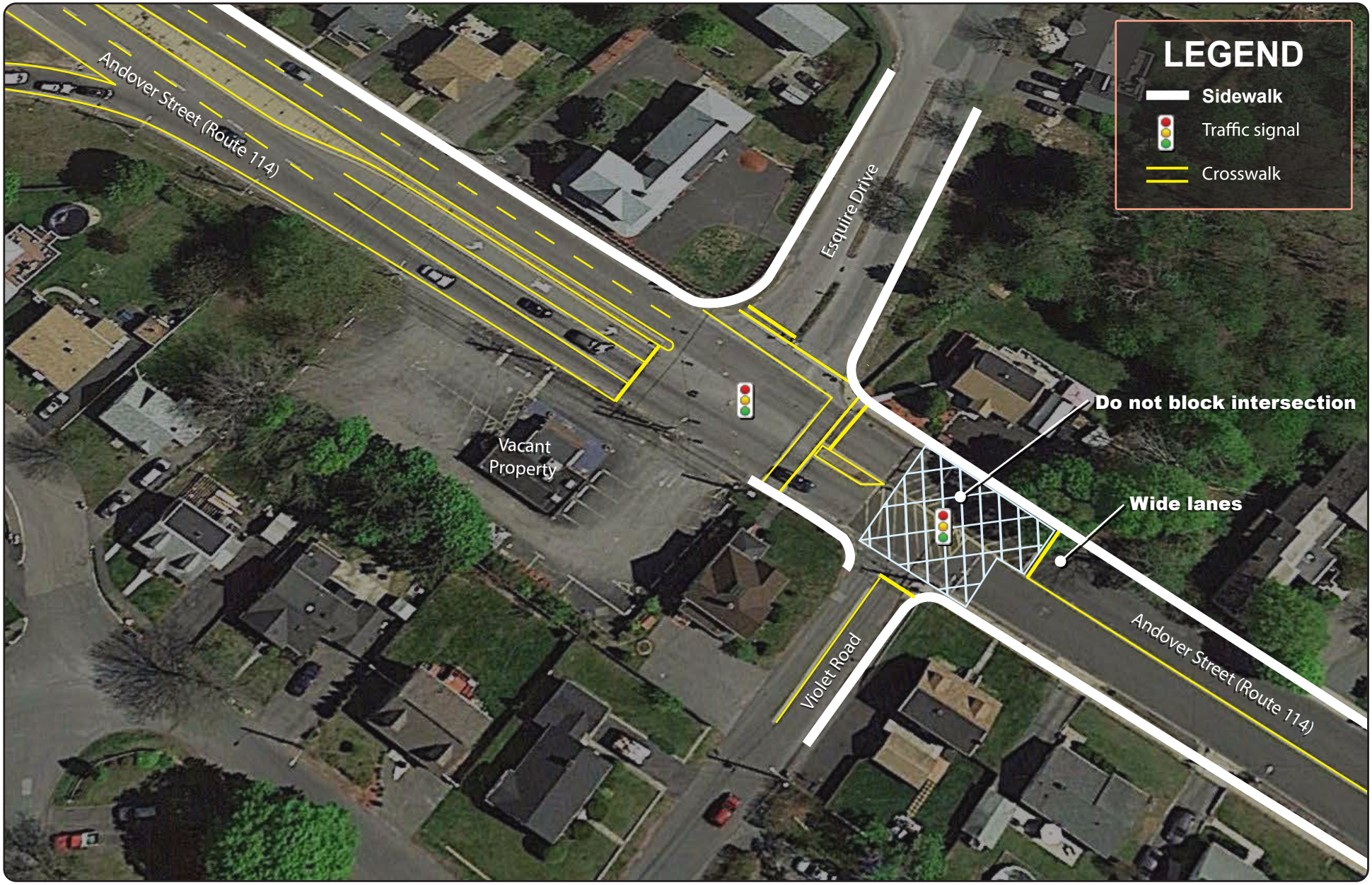

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Figure 2
Study Intersection Existing Conditions

Safety and Operations Analyses at Selected Intersections

As shown in Figure 2, Andover Street, Esquire Drive, Violet Road, and the driveways for Chandler's Ice Cream and a residential house on the opposite side of Violet Road intersect to form a complex signalized intersection. Traffic operation is complicated at the intersection because Violet Road is not directly aligned with Esquire Drive, which creates an offset intersection on Andover Street that put drivers in dilemma. Currently, the Chandler's Ice Cream property is vacant and there is no traffic into and out of that driveway.

The primary traffic flow is along Andover Street; Esquire Drive and Violet Road are low-volume residential streets. The eastbound approach on Andover Street widens to 33 feet at about 200 feet prior to the intersection, and it is striped as two through lanes and an exclusive left-turn lane. The westbound approach lane on Andover Street widens to 21 feet prior to the intersection and continues the same width through the intersection but it is striped as a single lane instead of two travel lanes. Each approach on Esquire Drive and Violet Road has one lane for all traffic movements.

The intersection is equipped with a fully actuated traffic signal but it lacks an Opticom system to handle emergency preemption. The signal heads are mounted on a mixture of span-wire, mast-arm, and post mounts but they lack backplates that would improve signal visibility. In addition, the eastbound Andover Street traffic has a leading protected left-turn phase but the left-turn signal head lacks left-turn arrow signals to communicate the information to the drivers turning left at that approach; this creates confusion as to whether the left turn is a ”protected” or “permitted” turn. Presently, the Andover Street eastbound left-turn signal head shows only circular green, yellow, and red indications.

There is functioning pedestrian signal with pushbuttons only for crossing Andover Street at Esquire Road. There is no crosswalk on Andover Street at the intersection of Violet Road. Some of the crosswalks lack curb ramps and those with curb ramps do not meet MassDOT's Americans with Disabilities Act (ADA) standards; they also lack detection-warning plates, and the cross slopes and landings are substandard. In addition, there is no accommodation for bicyclists at the intersection. The intersection curb radii are adequate for trucks and buses turning onto side streets but not adequate for making U-turns on Andover Street; hence, U-turns are prohibited on Andover Street.

The intersection has U-turn prohibition signs, banning eastbound U-turns on Andover Street and U-turns via Esquire Drive. The audit team observed that drivers do not comply with the U-turn prohibition signs on both Andover Street and Esquire Drive. The main reason for this noncompliance is that going east on Andover Street from the North Shore Mall and Route 128 interchange, it becomes very difficult for drivers to turn around if they find themselves headed

the wrong direction. Therefore, many drivers in this situation make the U-turn at the Andover Street and Esquire Drive intersection, which happens to be the first signalized intersection east of the Route 128 interchange. The two-hour AM and two-hour PM turning movement counts show six U-turn maneuvers on Andover Street eastbound at the intersection; however, the volume may be higher on a daily basis. In addition, the U-turn prohibition signs and obstructions in the median opening onto Esquire Drive are solutions to an existing U-turn problem.

The Massachusetts Bay Transportation Authority's (MBTA) Route 435 bus (Liberty Tree Mall to Central Square in Lynn via Peabody Square) and Route 465 bus (Salem Depot to Liberty Tree Mall via Peabody and Danvers) both stop near the study intersection, with service available on weekdays and on weekends. Route 435 operates Monday through Friday every 30 minutes from 6:40 AM to 11:20 PM; Saturday every 45 minutes from 6:45 AM to 11:43 PM; and Sunday every hour from 11:00 AM to 8:23 PM. Route 465 operates Monday through Friday every hour from 6:55 AM to 7:56 PM; Saturday every hour from 9:00 AM to 7:39 PM; and no Sunday service. The performance evaluation showed that MBTA bus Routes 435 and 465 failed the frequency-of-service and schedule-adherence standards; bus Route 465 had low ridership. The MBTA regularly evaluates performance of its services and recommends and implements service changes through the service planning process. The service planning process includes system-wide quarterly changes, ongoing rolling Service Plan changes, and an annual evaluation to inform the MBTA's budget process.

The land use near the study intersection is primarily residential.

3 DATA COLLECTION AND ANALYSIS

3.1 Data Source

MassDOT Highway Division's Traffic Data Collection Section collected turning-movement counts (TMCs) at the intersection in April 2016, while schools were in session. MassDOT conducted the counts during the weekday AM peak travel period (7:00 AM–9:00 AM), weekday PM peak travel period (4:00 PM–6:00 PM), and Saturday midday travel period (12:00 AM–2:00 PM). Heavy vehicles such as school buses, transit buses, and trucks were counted separately. Pedestrian and bicycle counts were conducted simultaneously with the TMCs. The division collected automatic traffic recorder (ATR) counts at two locations on Andover Street. ATR counts—which are continuous for a 48-hour period—are used to determine the average weekday traffic (AWDT) of a roadway. Finally, MassDOT collected spot speed data—which also are continuous 48-hour records—at the same two locations simultaneous with the ATR counts. (See Appendix B for traffic volume data, pedestrian and bicycle counts, and spot speed data.)

3.2 Vehicular Volumes and Distributions

Figure 3 shows the turning movement volumes at the intersection; and Table 1 presents a summary of ATR traffic data in terms of AWDT, peak hour volumes, and the directional distribution of the peak-hour traffic. Based on the counts, the estimated average daily traffic (ADT) and AWDT on Andover Street were 45,400 and 49,260 vehicles per day, respectively. The primary traffic flow on Andover Street is westbound during the AM peak period and eastbound during the PM peak period. During both AM and PM peak periods, the directional split on Andover Street is about 55 percent. The ADT on Esquire Drive and Violet Road were 2,700 and 1,000 vehicles per day, respectively.

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Figure 3
Existing Turning Movement Volumes and Speeds

Safety and Operations Analyses at Selected Intersections

TABLE 1
Existing 2016 Traffic Volumes

Location	Average Weekday Volume [a]	AM Peak Hour Volume [b]	AM Peak Hour K-Factor [c]	Directional Distribution of Peak Hour Traffic [d]	PM Peak Hour Volume	PM Peak Hour K-Factor	Directional Distribution of Peak Hour Traffic
Andover Street, East of Violet Road	49,260	3,380	6.7	56% WB	3,710	7.5	54% EB
Esquire Drive, North of Andover St	2,650	170	6.4	71% SB	200	7.5	55% NB
Violet Road, South of Andover Street	1,010	65	6.4	62% NB	92	9.1	67% SB

a Daily traffic (both directions) expressed in vehicles per day. b Peak hour volumes (both directions) expressed in vehicles per hour. c Percent of daily traffic that occurs during the peak hour. d Directional distribution of peak hour traffic.
Source: Central Transportation Planning Staff.

The ATR and TMC counts show high traffic volumes on Andover Street during all three peak periods. Therefore, even though commuter volumes are the most critical factor and will drive the design, traffic congestion and delays also are present at the intersection on weekends because of shopping and other trips.

3.3 Pedestrians and Bicycles

Nineteen (19) pedestrians crossed at the intersection during the two-hour weekday AM and two-hour weekday PM peak periods, and another 19 pedestrians crossed during the two-hour Saturday PM peak period. No bicyclists used the intersection during the four-hour weekday and two-hour Saturday PM monitoring period.

3.4 Heavy Vehicles

The percentage of trucks driving through the intersection during the peak travel periods ranged between 3.0 and 4.0 percent, which is not considered high for peak-period traffic conditions.

3.5 Spot Speed

Analysis of the spot speed data, summarized in Figure 3, shows that the average speeds are lower than the posted speed limits; however, the 85th percentile speeds are consistent with posted speed limits—westbound traffic: 32 mph versus the 35 mph posted speed limit and eastbound traffic: 35 mph versus the 30 mph posted speed limit. Analysis of the spot speed data shows that eastbound vehicles travel at much higher speeds than do their westbound counterparts. At the time of data collection, about 41 percent of the westbound drivers were traveling between 19 and 29 mph (10 mph pace speed) and 60 percent of the eastbound drivers were traveling between 24 and 34 mph.

4 SAFETY CONDITIONS

4.1 Crash Summary

The intersection is ranked 95 on the 2012–2014 Statewide Top-200 Intersection Crash List. Crashes at the intersection form part of an HSIP crash cluster.[9] MassDOT defines HSIP-eligible crash clusters as those that rank within the top-five percent of crash clusters for each Regional Planning Agency, based on the equivalent property damage only (EDPO) index.[10] This HSIP crash cluster is comprised of 50 crashes, including ones near Violet Road, and has an EPDO of 118 crashes. CTPS reviewed the Peabody Police Department's 2013–2015 crash records that were used in the RSA. Below, we discuss crashes at the intersection in terms of severity, manner of collision, weather conditions, ambient light conditions, and time of occurrence (also summarized in Appendix C).

4.2 Crash Rate and Pattern

Using MassDOT Highway Division's methodology, CTPS calculated the intersection crash rates for the three-year period, 2013–2015. The average crash rate for the study intersection was 1.03 crashes per million entering vehicles, which exceeds the average crash rate for a signalized intersection in this district. The most recent statewide average crash rate for signalized intersections in MassDOT Highway Division District 4, which includes Peabody, is 0.73 crashes per million entering vehicles.[11] (See Appendix C for the crash rate worksheet.)

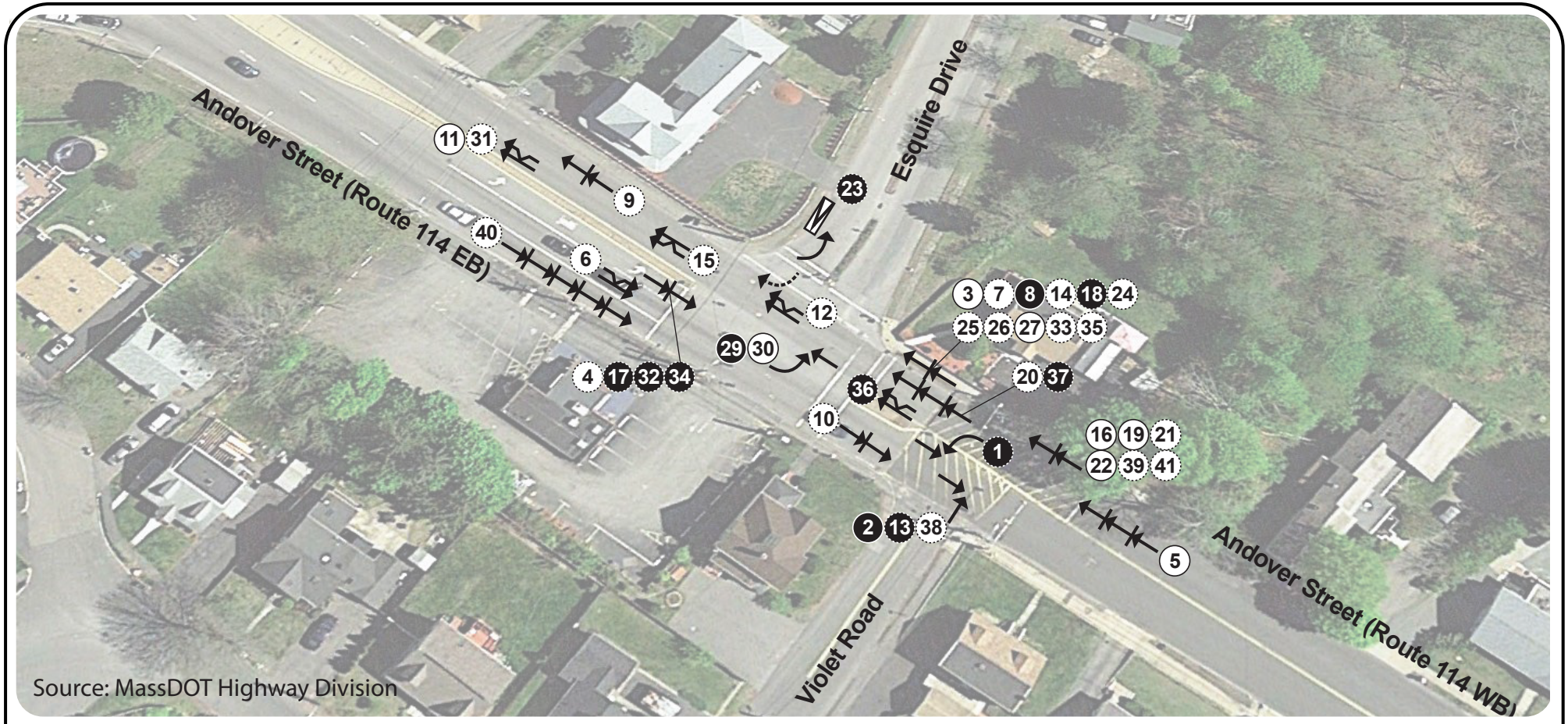
4.3 Collison Diagram

Collision diagrams are useful for examining crash patterns and developing safety strategies. Figure 4 shows the collision diagram prepared by MassDOT using the 2013–2015 crash data obtained from the Peabody Police Department. The numbers in the collision diagram uniquely identify each crash (and for further detail, may be used to cross reference the crash records in Appendix C). On the Andover Street approaches, the most prevalent crash pattern was the rear-end type, which typically are associated with congested signalized intersections.

[9] In the Boston region, the 921 intersections in the top-five percent have crash clusters with a minimum EDPO value of 42.

[10] EPDO Crash Rating = 10 * Fatal Crashes + 5 * Injury Crashes + 1 * Other Crashes (Property Damage Only or Unknown Severity), based on MassDOT top-200 high-crash locations: 2011-13 crash data.

[11] Based on MassDOT Registry of Motor Vehicles crash information queried on February 9, 2016.



SYMBOLS

- Moving Vehicle
- Backing Vehicle
- Noninvolved Vehicle
- Pedestrian
- Parked Vehicle
- Fixed Object
- Bicycle
- Animal

TYPES OF CRASH

- Head On
- Angle
- Rear End
- Sideswipe
- Out of Control

CRASH ID AND SEVERITY

- # Crash Identification Number (Summary Tables in Appendices I and J)
- # Noninjury Crash
- # Injury Crash
- # Nighttime Crash

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Figure 4
Collision Diagram: Andover Street (Route 114) at Esquire Drive and Violet Road
Peabody Police Reports: January 2013–December 2015

Safety and Operations Analyses at Selected Intersections

The majority of the rear-end crashes on Andover Street resulted from following too closely, not paying attention, and taking an improper action. In addition, the most crashes occurred during the off-peak period between 8:00 AM and 4:00 PM and between 6:00PM and 12:00 AM. Another safety issue is lack of driver awareness and poor visibility of the signal heads that are blocked by overgrown vegetation and tree branches near the intersection. Lack of arrow indications for the eastbound Andover Street left turns and drivers forming two lanes at the Andover Street westbound approach during peak periods and single-lane traffic during off-peak periods further confuse drivers.

5 EXISTING TRAFFIC OPERATIONS CONDITIONS

Using the data and information collected, MPO staff built a traffic analysis network (with Synchro[12]) for the AM and PM peak periods to assess the capacity and quality of traffic flow at the intersections. Staff conducted the analyses consistent with Highway Capacity Manual (HCM) methodologies (detailed worksheets of the analyses are included in Appendix D).[13] The HCM methodology demonstrates the driving conditions at signalized and unsignalized intersections in terms of levels of service (LOS) ratings A through F. LOS A represents the best operating conditions (little to no delay), while LOS F represents the worst operating conditions (very long delay). LOS E represents operating conditions at capacity (limit of acceptable delay). Table 2 shows the control delays associated with each LOS for signalized and unsignalized intersections.

TABLE 2
Levels of Service and Control Delays at Intersections

Level of Service	Signalized Intersections Control Delay (seconds per vehicle)	Unsignalized Intersections Control Delay (seconds per vehicle)
A	≤ 10	≤ 10
B	> 10-20	> 10-15
C	> 20-35	> 15-25
D	> 35-55	> 25-35
E	> 55-80	> 35-50
F	> 80	> 50

Source: Central Transportation Planning Staff.

[12] Trafficware Inc., Synchro Studio 8, Synchro plus SimTraffic, Build 801, Version 563, Sugar Land, Texas.

[13] Highway Capacity Manual, HCM 2010, Volume 3: Interrupted Flow, Transportation Research Board of the National Academies, Washington DC, December 2010.

Table 3 presents peak-hour performance in terms of LOS, delay, and queues for existing conditions. Although, traffic operations at the intersection are satisfactory during the weekday AM and PM peak hours and Saturday PM peak hours (LOS D or better), there are traffic queues on Andover Street that extend eastward to Andover Drive and westward beyond the Andover Street ramp-arterial junction. The peak-hour LOS results are satisfactory because drivers form two travel lanes in each direction on Andover Street, which increases the intersection's capacity.

TABLE 3
Andover Street and Esquire Drive Intersection: Peak Hour Level of Service

Improvement Alternative	Move-ment	AM LOS	AM Delay	AM Queue	PM LOS	PM Delay	PM Queue	SAT PM LOS	SAT PM Delay	SAT PM Queue
Existing Conditions (2014):	--	--	--	--	--	--	--	--	--	--
Andover St. Eastbound	L	C	30.4	36	D	49.6	113	D	49.0	86
Andover St. Eastbound	T+R	B	12.9	578	B	14.0	505	B	11.9	446
Andover St. Westbound	L+T	D	35.9	#991	D	45.6	#863	D	51.7	#903
Esquire Dr. Southbound	L+T+R	D	34.8	95	D	49.0	90	D	49.9	95
Violet Rd. Northbound	L+T+R	D	40.4	6	C	29.1	31	C	29.7	26
Total Intersection	**All**	**C**	**25.0**	**--**	**C**	**21.0**	**--**	**C**	**24.0**	**--**
No-Build Conditions (2040):		--	--	--	--	--	--	--	--	--
Andover St. Eastbound	L	C	30.5	31	D	50.2	122	D	50.0	#869
Andover St. Eastbound	T+R	B	14.8	446	B	17.4	705	B	15.3	581
Andover St. Westbound	L+T	E	67.2	#812	F	83.1	#1002	F	86.1	#1012
Esquire Dr. Southbound	L+T+R	D	39.0	131	D	54.7	97	D	50.2	105
Violet Rd. Northbound	L+T+R	E	57.7	11	C	29.5	34	D	43.1	40
Total Intersection	**All**	**D**	**47.0**	**--**	**D**	**41.0**	**--**	**D**	**45.0**	**--**
Build Alternative 1 Conditions (2040):			--	--	--	--	--	--	--	--
Andover St. Eastbound	L	D	51.7	45	D	53.8	125	D	48.8	80
Andover St. Eastbound	T+R	B	11.3	431	B	16.5	508	A	9.1	355
Andover St. Westbound	L+T	C	25.6	#1014	D	46.6	#930	D	43.9	#856
Esquire Dr. Southbound	L+T+R	D	37.1	84	C	33.2	72	C	20.8	52
Violet Rd. Northbound	L+T+R	C	30.4	43	D	40.1	12	D	45.7	8
Total Intersection	**All**	**B**	**15.3**	**--**	**B**	**21.0**	**--**	**B**	**20**	**--**
Build Alternative 2 Conditions (2040):			--	--	--	--	--	--	--	--
Andover St. Eastbound	T+R	B	13.9	463	B	19.6	#671	B	16.2	#570
Andover St. Westbound	L+T	C	21.8	822	C	24.3	#745	C	32.2	#751
Esquire Dr. Southbound	L+T+R	C	29.7	113	C	25.4	56	C	22.7	60
Jug Handle	L+T	D	39.9	37	D	43.6	102	D	38.7	75
Violet Rd. Northbound	L+T+R	B	15.2	9	B	15.5	12	A	9.7	2
Total Intersection	**All**	**B**	**14.2**		**C**	**17.1**		**C**	**21.4**	

a Delay in seconds per vehicle. b 95th percentile queue length in feet. # = the 95th percentile volume exceeds capacity.
Source: Central Transportation Planning Staff.

6 MAJOR PROBLEMS AND CONCERNS

Based on field reconnaissance, analysis of existing traffic conditions and crash data, and discussions from the RSA, MPO staff identified the following problems, some of which are depicted in Figure 5:

Pedestrian and Bicyclist Safety Issues

- Curb ramps not compliant with MassDOT ADA standards—creates problems for people using wheelchairs and strollers
- Crumbled sidewalks—creates poor walking conditions and problems for people with disabilities
- Lack of high-visibility crosswalks—to alert drivers to often-used pedestrian crossings
- Long crossing distance on east leg of Esquire Drive—increases likelihood of pedestrian-vehicle conflicts and crashes
- Lack of accommodation for bicyclists—increases likelihood of bicycle-vehicle conflicts and crashes

Intersection Safety Issues

- Intersection crash rate exceeds MassDOT District 4 average crash rate for signalized intersection—high-crash location
- Intersection ranks 95 on the 2012−2014 Top-200 Intersection Crash List—part of an HSIP crash cluster
- Widespread rear-end-type crashes on Andover Street approaches—type typically associated with congested signalized intersections

Traffic Operations Issues

- Outdated signal equipment—creates inefficient traffic operations; signal equipment not capable of adjusting timing of red, yellow, green lights to accommodate changing traffic patterns, and ease congestion
- Wide westbound approach lane on Andover Street—used as two lanes during peak travel periods and as single lane during off-peak travel periods; can confuse drivers
- Circular indications on Andover Street eastbound left-turn signal head—do not convey leading protected left-turn phase to drivers effectively
- Lack of Opticom receivers in signal equipment—cannot handle emergency preemption
- Lack of U-turn accommodation on Andover Street—forces drivers to use Esquire Drive to turn around
- Poor visibility of signal heads, blocked by overgrown vegetation and tree branches near intersection—contribute to crashes

Crumbled sidewalks

Lack of curb ramps

Gaps in sidewalk network

Signal heads lack backplates

Overgrown vegetation

Drivers form two lanes on Andover Street due to wide travel lanes

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Figure 5
Examples of Problems Identified at the Intersection

Safety and Operations Analyses at Selected Intersections

7 FUTURE TRAFFIC GROWTH

Staff used a planning model to forecast future traffic-volume changes systematically that could result from changes in the transportation network or land use. The model used in this study is the MPO's most recently adopted regional travel demand model set used for the Long-Range Transportation Plan. Its socioeconomic components are based on forecasts produced by MAPC. Using TransCAD software, the model is calibrated at a regional level for 164 cities and towns, including all 101 cities and towns in the MPO region. Based on this regional planning model, traffic on Andover Street would grow at 0.4 percent per year, which results in total growth of five percent between 2016 and 2040.

8 IMPROVEMENT ALTERNATIVES

MPO staff developed and analyzed two alternatives to improve safety and traffic operations, which then were tested using 2040 future turning-movement volumes (Table 3).

8.1 Alternative 1: Renovate the Intersection (Figure 1)

Listed below are the specific safety and operations improvements in Alternative 1. These could be implemented in phases depending on the urgency of the problem, or they could be performed together in a reconstruction project. Based on reconstruction costs of similar projects recorded in MassDOT's project information database, CTPS estimates that the improvements would cost between $2 and $3 million.

Improvements to Increase Safety for Pedestrians

- Reconstruct curb ramps to comply with MassDOT's ADA standards—improve safety for people with disabilities and the elderly
- Upgrade sidewalks at the intersection—improve walking conditions
- Convert standard crosswalk markings to high-visibility markings (ladder type)—to ensure that they are visible to drivers and pedestrians
- Improve lighting—to increase safety and security for pedestrians; make drivers aware of the intersection, helping to reduce nighttime crashes
- Install pedestrian signals with pushbuttons—to make it easier for pedestrians to cross

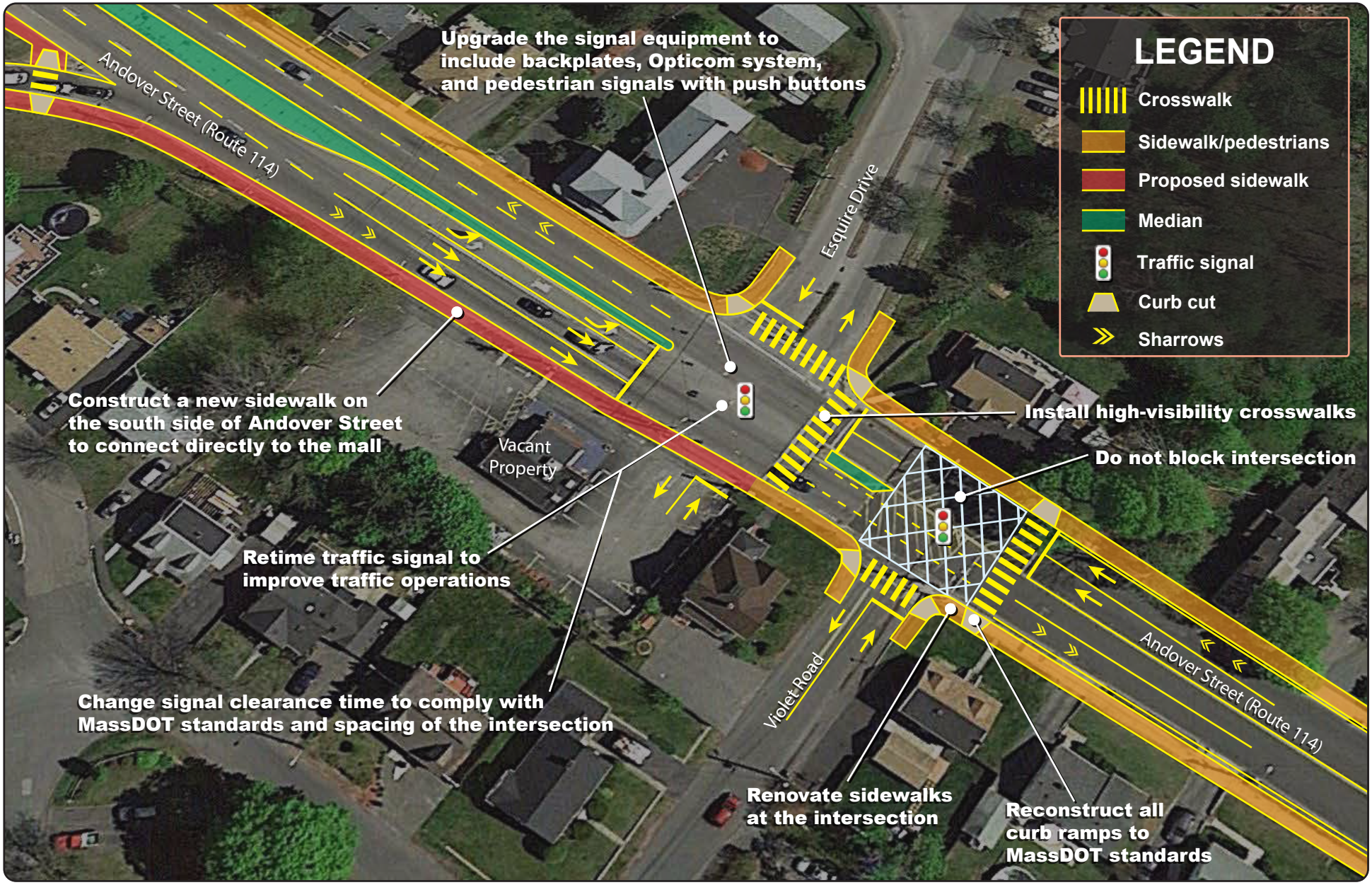

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Figure 6
Proposed Improvements
Alternative 1: Renovate the Intersection

Safety and Operations Analyses at Selected Intersections

Improvements to Increase Safety for Bicyclists

Presently, the existing right-of-way on Andover Street is very narrow, and it would not be possible to add bike lanes. In addition, the houses are already too close to the highway, which places further restrictions on widening Andover Street. Because of these limitations, CTPS suggests the following improvements:

- Install bicycle detectors and bicycle-detector pavement markings at the intersection—improve safety and reduce delays for bicyclists
- Provide shared-lane markings (sharrows) and bicycle signs on Andover Street—provide drivers with awareness of bicyclists

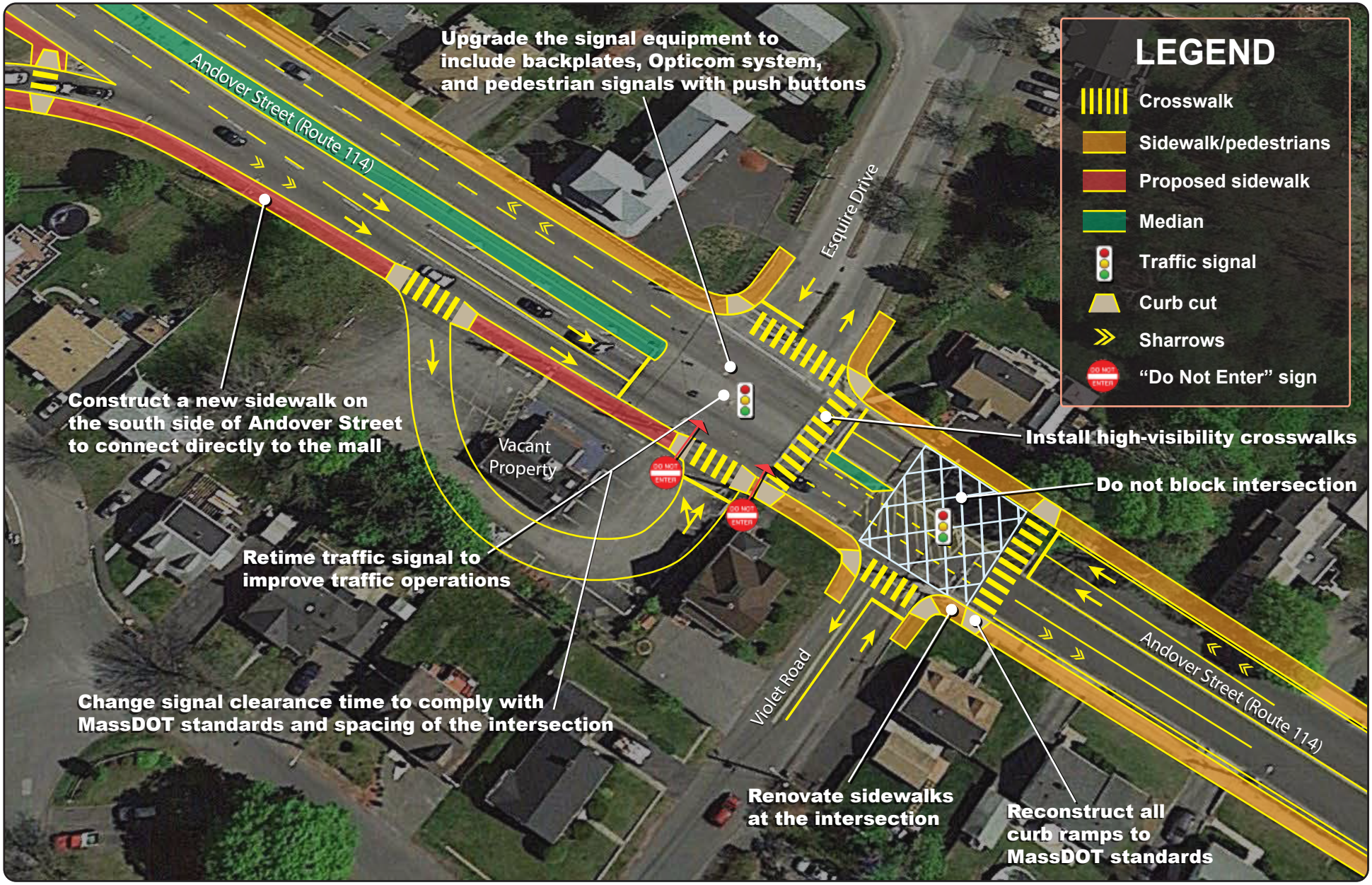
Improvements to Make Traffic Operations More Efficient

- Restripe travel lanes on Andover Street west of Violet Road into two travel lanes in each direction—to improve safety, streamline traffic operations, formalize current driver behavior
- Retime traffic signals with current traffic volumes provided by MassDOT—reduce delays and improve traffic operations
- Replace Andover Street eastbound left-turn circular signal head indications with arrow signal head indications—improve safety and better clarify protected left-turn movement for drivers
- Install intersection lane-control pavement marking — direct drivers through intersection, reduce confusion
- Update traffic signal equipment with 12-inch signal heads with retroreflective backplates to improve visibility of traffic signals. (Structural review of the signal poles, mast-arms, and span wires is needed to ensure they would be able to accommodate additional wind loads.)
- Add Opticom traffic receivers and strobes to signal equipment—to handle emergency preemption services
- Install advance traffic control signs such as the signal ahead (W3-3) sign on Andover Street—warn drivers in advance, and improve awareness of intersection and signal control
- Improve visibility of signal heads by removing overgrown vegetation and tree branches near intersection

8.2 Alternative 2: Jug Handle

Figure 7 shows the improvements in Alternative 2. This alternative was included in the analysis because it was one of the recommendations from the RSA, which included all of the safety and operational improvements in Alternative 1. The major differences between Alternative 2 and Alternative 1 are:

- Removal of the Andover Street eastbound left-turn lane
- Construction of new jug-handle turnaround to accommodate left-turns and U-turns at intersection



BOSTON REGION MPO

N

Figure 7
Proposed Improvements
Alternative 2: Redesign the Intersection to Include a Jug-Handle

Safety and Operations Analyses at Selected Intersections

Presently, there is no space in the northwest quadrant of the intersection to construct improvements that would allow U-turns on Andover Street. One recommendation from the RSA was to acquire the closed Chandlers Ice Cream Shop property to create a jug-handle turnaround there (analyzed in this alternative). The weekday peak period AM and PM turning movement counts show six U-turn maneuvers on Andover Street eastbound at the intersection. Also, the collision diagram did not indicate a crash involving a U-turn maneuver. Based on the reconstruction costs of similar past projects recorded in MassDOT's project information database, MPO staff estimate the improvements to cost between $3 and $4 million. This estimate does not include the land acquisition.

8.3 Level of Service for the Alternatives

No Build Alternative

The 2040 no-build analysis results presented in Table 3 show that traffic operations would deteriorate if no improvements are made at the intersection. Overall, traffic at the intersection would operate at LOS D, and Andover Street westbound would operate at LOS F because of congested conditions with a long traffic queue. In comparison, the 2016 existing conditions show the overall intersection at LOS C and Andover Street westbound at LOS D, but with a traffic queue.

Alternative 1

The analysis in Table 3 indicates that retiming the traffic signals would improve traffic operations. Overall, traffic at the intersection would operate satisfactorily at LOS B during the peak hours of travel, and Andover Street westbound would operate satisfactorily at LOS D, but with a traffic queue.

Alternative 2

The analysis in Table 3 also demonstrates that reconfiguring the intersection to include a jug-handle turnaround and retiming the traffic signals would produce similar LOS as in Alternative 1.

8.4 Advantages and Disadvantages of the Alternatives

No-Build Alternative

The no-build alternative would offer no benefits, and would exacerbate the existing problems at the intersection, such as:

- Increased congestion because of poor signal timing
- Worse traffic operations, resulting in long traffic queues that would extend onto the Route 128 ramps and Andover Street east of the intersection

- Decreased safety for road users, as no improvements would be constructed to prevent the numerous rear-end collisions
- Reduced safety for pedestrians because of lack of curb ramps or non-ADA-compliant curb ramps at crosswalk locations, and crumbled sidewalks
- Less safety for bicyclists by not providing bicycle-detector pavement markings, shared-lane markings (sharrows), and signs to increase drivers' awareness of bicyclists

Alternative 1

Alternative 1 would renovate the intersection to increase safety for motorists, pedestrians, and bicyclists and make traffic operations more efficient by:

- Addressing non- ADA-compliant issues for pedestrians by constructing curb ramps, sidewalks, and crosswalks to MassDOT standards
- Upgrading signal equipment to increase safety for motorists and make traffic flow efficient
- Retiming traffic signals to reduce rear-end crashes, congestion, and queues
- Constructing the improvements in Alternative 1 would not require land takings

The shortcomings of Alternative 1 are:

- Would not address U-turn maneuvers on Andover Street and Esquire Drive
- Might not be enough space on south side of the Andover Street Bridge over Route 128 to construct a minimum five-foot sidewalk leading to the North Shore Mall (a design exception may be required)
- Construction would affect traffic flow moderately, as improvements would necessitate traffic management during construction

Alternative 2

Alternative 2 has many of the benefits listed for Alternative 1, and would increase safety for motorists, pedestrians, and bicyclists and make traffic operations more efficient.

However, the jug-handle turnaround in Alternative 2 presents the following challenges and considerations:

- Would require land takings for the improvements
- Would send traffic very close to the houses on Violet Road; the traffic noise could be an issue
- Would cost significantly more than Alternative 1 because of land acquisition and construction costs

- Distance available for constructing a jug-handle turnaround might be too short (only 300 feet between the Route 128 northbound off-ramp-arterial junction and the intersection of Andover Street and Esquire Drive)
- Vehicles slowing down to turn onto jug-handle could have potential impact on eastbound traffic flow on Andover Street—especially Route 128 northbound heading east on Andover Street
- Peak-period traffic queues on eastbound approach of Andover Street could have impact on effectiveness of jug-handle turnaround; with potential to exacerbate the problem when pedestrian phase is activated and/or Esquire Drive and Violet Road split phases are running
- The jug-handle turnaround would affect pedestrians if the proposed sidewalk on south side Andover Street were implemented
- Construction would affect traffic significantly, as improvements necessitate traffic management during construction

Table 4 summarizes how each alternative would accomplish the goals and objectives of the study. The evaluation criteria are intended to provide qualitative and quantitative measures of the alternatives, providing insight into how the alternatives compare or relate to one another. The main goals and objectives are:

- Promotes healthy transportation
- Increases safety for all road users
- Makes traffic flow efficiently (reduces congestion)
- Creates a pedestrian- and bicyclist-friendly roadway
- Promotes land use and economic and cultural activities

TABLE 4
Summary of Alternatives

Goals and Objectives	No Build	Alternative 1	Alternative 2
Supports study goals and objectives	No benefit	Significant benefit	Significant benefit
Promotes healthy transportation	No benefit	Significant benefit	Significant benefit
Increases safety for all road users	No benefit	Significant benefit	Moderate benefit
Makes traffic flow efficiently	No benefit	Significant benefit	Moderate benefit
Promotes multimodal transportation	No benefit	Significant benefit	Significant benefit
Resolves U-turn maneuvers	No benefit	No benefit	Significant benefit
Avoids property impacts	Significant benefit	Significant benefit	No benefit
Minimizes construction impacts	Significant benefit	Significant benefit	Moderate benefit
Associated construct cost*	Low	Moderate	High

*Associated construction costs for those alternatives, which require an expansion of the right-of-way, as land takings would add to the total cost but are not accounted for in the study.
Source: Central Transportation Planning Staff.

9 CONCLUSIONS AND NEXT STEPS

9.1 Conclusions

The above analyses and evaluation supports the need for renovations that would improve safety and mobility for motorists, pedestrians, and bicyclists at the intersections of Andover Street and Esquire Drive and Violet Road. Alternatives 1 and 2 are capable of addressing many of the identified problems; but their shortcomings need to be considered before selecting a preferred alternative.

Deciding between the two alternatives hinges upon:

- The magnitude of the U-turn problem at the intersection and complaints from the neighborhood
- Whether there is enough space and distance to construct the jug-handle turnaround
- Whether the Chandlers Ice Cream property can be acquired
- Impacts of the jug-handle turnaround on traffic operations
- Impact of U-turns on safety and current traffic operations

In addition, selection of the preferred alternative should be based on cost and effectiveness; therefore, it is important for stakeholders to examine the alternatives with all road users in mind; participation in the selection process by other stakeholders is also important.

MPO staff recommend a total reconstruction of the intersection. However, depending on which alternative is selected, implementing some of the low-cost, short-term improvements, such as converting standard crosswalk markings to high-visibility markings, reconstructing curb ramps to ADA standards, and clarifying signal control would provide immediate benefits.

9.2 Next Steps

The City of Peabody has jurisdiction of the intersection and is responsible for renovations to improve safety, mobility, connectivity, and operations. This study gives the city an opportunity to look at the needs of the intersection and plan for design and engineering. The next step would be to select the preferred alternative that is sensitive to the goals and needs of stakeholders, and then advance the project through the planning process. The intersection is a high crash location and qualifies for HSIP funding. These steps will depend upon cooperation between MassDOT, the City of Peabody, and the MPO to begin the project notification and review process, and complete the project initiation form. After completing the initial steps, the City of Peabody and MassDOT can start preliminary design and engineering to place the project in the Transportation Improvement Program. Transportation decision making is complex, and

influenced by factors such as financial limitations and agency programmatic commitments. Project development is the process that takes transportation improvements from concept to construction (see Appendix E for an overview of this process).

This study supports the MPO's visions and goals, which include increasing transportation safety, maintaining the transportation system, advancing mobility and access, reducing congestion, and expanding the opportunities for walking and bicycling, while also making them safer. If implemented, the improvements proposed in this report would make traffic operations more efficient, while increasing safety and modernizing the roadway to accommodate all users.

SA/sa

cc: John Gregg, Traffic Engineer, MassDOT Highway Division, District 4
Connie Raphael, Planning Coordinator, MassDOT Highway Division, District 4
Sara Timoner, Traffic Engineer, MassDOT Highway Division, District 4

Appendix A: Comments and Selection Process

Comments

Seth Asante

From: Clark, Michael (DOT)
Sent: Monday, March 13, 2017 11:49 AM
To: Seth Asante
Subject: RE: Safety and Operations Analyses at Andover Street at Esquire Drive and Violet Road in Peabody

Hi Seth,

Thank you for the opportunity to review. I have the following comments:

- Note the absence of pavement markings for bicyclists for Andover Street in section 2.1 on p. 4 (i.e. no sharrow lanes for sharing the roadway)
- "Stripped" instead of "striped" in second paragraph on p. 6
- Given the alternatives and recommendations that are later discussed section 2.2 could use more detail on the U-turn's occurring on Andover St. and Esquire Dr. Do you have a degree of the volume that these are occurring? The degree to which these illegal movements are disrupting traffic volume and creating safety concerns would then justify an investment like the jug handle later proposed.
- Are service frequencies available for the Route 435 and 465 bus services on p. 7?
- Some of the data shown regarding speed readings in Figure 3 should be brought into the text of section 3.5 E.g. what 85th percentile speeds and 10 mph pace speeds say about traffic flow.
- Section 8.3 could use a comparison table. Any way to use graphics and/or tables to compare and contrast each of the alternatives is helpful.
- The jug handle conversation is throwing me off a bit. The last bullet on p. 21 notes that the distance available for constructing it appears too short. So why is it looked at as an alternative? Perhaps the language just needs to be softened – instead of "appears to" perhaps "may be"? But if your analysis shows that it's not feasible this should be considered before the alternative is developed further.
- Bulleted list in section 9.1 affirms previous points about the jug handle. The magnitude of the problem should have been further explored in the existing conditions. Space, distance, acquisition are factors you shouldn't be expected to explore here but impact of U-turns on current operations and potential improvements should be discussed further.

Let me know if you want to talk further.

Thanks,
Michael

From: Seth Asante [mailto:sasante@ctps.org]
Sent: Wednesday, March 08, 2017 10:15 AM
To: Clark, Michael (DOT)
Subject: Safety and Operations Analyses at Andover Street at Esquire Drive and Violet Road in Peabody

Hi Michael,

The preliminary draft technical memorandum for the *Safety and Operations Analyses at Andover Street at Esquire Drive and Violet Road in Peabody* is available for review and comment. The attached documents are the memo and appendices.
I will appreciate it if you can provide me with your comments by Friday, March 17. Feel free to contact me if you have any questions.

Thank you,
Seth

Seth A. Asante | Chief Transportation Planner
CENTRAL TRANSPORTATION PLANNING STAFF
857.702.3644 | sasante@ctps.org
www.ctps.org/bostonmpo

Seth Asante

From: William Paulitz
Sent: Friday, April 01, 2016 1:46 PM
To: Katrina Crocker; Karen Sawyer
Cc: Seth Asante; Mark Abbott
Subject: RE: Proposed MPO Study at the Intersection of Route 114/Andover Street and Esquire Drive

Hi Katrina,

I am happy to hear that the MPO is moving forward with Safety and Operations Study for Route 114/Andover Road at Esquire Drive and Violet Road.

How far back would you like for the police crash reports to go?

Thanks,

William G. Paulitz, P.E.
City Engineer

City of Peabody
Department of Public Services
50 Farm Avenue
Peabody, MA 01960
Phone: 978-536-7126
Fax: 978-535-3754
william.paulitz@peabody-ma.gov

From: Katrina Crocker [mailto:kcrocker@ctps.org]
Sent: Friday, April 01, 2016 1:18 PM
To: Karen Sawyer; William Paulitz
Cc: Seth Asante; Mark Abbott
Subject: Proposed MPO Study at the Intersection of Route 114/Andover Street and Esquire Drive

Good afternoon Karen and William,

I'm pleased to announce that the Boston Region MPO staff has completed its evaluation of 20 location in the MPO region and selected Route 114/Andover Road at Esquire Drive and Violet Road in Peabody for the FFY 2016 Safety and Operations Study. (We also selected Broadway between Fourth Street and Fifth Street in Chelsea.) The selection was emailed to the Boston Region MPO members last week, and as no discussion occurred we are moving ahead with the study. The time frame is now through the end of September 2016.

In order to facilitate the study, we would like to begin our data collection and schedule an initial scoping meeting towards the end of April in Peabody to discuss study limits, tasks, and expectations. We are working with MassDOT Office of Transportation Planning to seek assistance for traffic count data collection. We have submitted an initial list of

count locations, attached. We will discuss this at the scoping meeting, and you are also welcome to provide input on this in the meantime if you like.

Before the scoping meeting, could you please send me police crash reports for crashes occurring at or near Route 114/Andover Road at Esquire Drive and Violet Road?

Thank you,
Katrina

Katrina Crocker | Transportation Planner
CENTRAL TRANSPORTATION PLANNING STAFF
857.702.3703 | kcrocker@ctps.org
www.ctps.org/bostonmpo

Selection of Study Locations

TECHNICAL MEMORANDUM

DATE: **March 17, 2016**
TO: **Boston Region MPO**
FROM: **Seth Asante and Katrina Crocker**
RE: **Safety and Operations Analyses at Selected Intersections: Federal Fiscal Year 2016**

1 BACKGROUND

This memorandum presents the results of Task 1 of the work program for Safety and Operations Analyses at Selected Intersections: Federal Fiscal Year (FFY) 2016.[1] Task 1, Screen and Select Study Locations, includes a presentation of the results to the Boston Region Metropolitan Planning Organization (MPO) for discussion.

This study builds on recommendations generated by the MPO's Congestion Management Process (CMP) to address safety and congestion problems at intersections in the MPO area. Seven similar studies were completed in previous funding years and received favorable responses from municipalities—which appreciated the MPO's assistance with the conceptual design of low-cost improvements, and with the planning and implementation processes.

Previous studies examined large, complex intersections, simpler intersections, and locations that include two or more adjacent intersections. The focus for FFY 2016 is on simpler intersections. As in the past, the basic requirement for a location to qualify as a study candidate is that it must be located on an arterial roadway in the Boston Region MPO where: 1) many crashes occur, according to the Massachusetts Department of Transportation (MassDOT) crash database; 2) there is congestion during peak periods; and 3) the agencies and/or municipalities with jurisdiction over the roadway are committed to implementing recommended improvements.

A holistic approach to analyzing problems and forming recommendations would consider the needs of all public transportation users equally—whether they are walking, biking, using transit, or driving. Ultimately, this approach would result in

[1] Karl H. Quackenbush, CTPS Executive Director, memorandum of a work program to the Boston Region MPO, "Work Program for: Safety and Operations Analyses at Selected Intersections: FFY 2016," October 15, 2015.

intersections and roadways where it is safe to cross the street, walk or cycle to shops, schools, healthcare services, train stations, or recreational facilities, and where buses could run on time. Typically, the recommended improvements are within a roadway's right-of-way; and take into account the needs of abutters and users, and the interests and support of stakeholders.

2 SELECTION PROCEDURE

The study selection process consisted of four steps, in which MPO staff:

1) Generated a list of potential intersection study locations then narrowed it to 20 locations
2) Gathered detailed data for each of the 20 locations
3) Applied specific criteria to examine potential study locations more closely
4) Scored and rated the 20 locations, and assigned low, medium or high priority to each intersection location

2.1 Generating List of Potential Locations

MPO staff developed an initial list of 140 potential study locations in 44 municipalities in the MPO area, and used the following sources:

- FFY 2014 safety and operations list of potential candidates—the 15 intersections that were presented in the selection memorandum but not ultimately selected for study in FFY 2014
- MassDOT list of 2011–13 and 2010–12 statewide top-200 high-crash locations
- Locations suggested through Unified Planning Work Program outreach

Next, staff developed excluding criteria to reduce the list further. The location needed to be:

- In a municipality that has been selected for this study within the past three years
- In a subregion that has been well- or over-represented in past subregional priority corridor projects in terms of the proportion of population or MassDOT top-200 high-crash locations in the region
- Studied by MPO staff or another agency; included in a Transportation Improvement Program (TIP) project with a status of "advertised" or "programmed"; or included in an active MassDOT or other agency project that is in design (at 25 percent or higher design status), in construction, or recently completed
- Part of a larger potential study area, such as a highway interchange or a long traffic corridor with an extensive area of congestion

- Not at-grade

2.2 Gathering Detailed Data

Staff gathered data to support the excluding criteria and eliminated locations that were not suitable. Figure 1 was used to help determine which subregions were well- or over-represented by past safety and operations studies; it indicates where studies have occurred and overlays the MassDOT top-200 high-crash locations. Twenty locations passed the excluding criteria and were included in the final list.

The assembled data for 20 intersection locations in 14 municipalities in the MPO region are listed below.

- *MassDOT's 2014 Road Inventory File*. To collect the following information for each major arterial segment in each intersection location: roadway jurisdiction, National Highway System (NHS) status, and annual average daily traffic (AADT)
- *MassDOT's 2009–13 Crash Database*. Identify high-crash locations and numbers of crashes
- *MPO CMP Data on Arterial Congestion*. Determine travel time index (that is, travel time in the peak period divided by travel time in free-flow conditions) for each major arterial segment intersection location
- *MPO Data on Bike Network Gaps and MassDOT Bike Facilities:* Identify bicycle needs—including connectivity—and accommodation
- *Data on Massachusetts Bay Transportation Authority (MBTA) Bus Service Performance and Passenger Load*. Determine the percentage of bus trips that do not adhere to the schedule (late service) or to passenger load standards (crowding)
- *Data on MBTA Subway and Commuter Rail Lines*. Identify locations serving MBTA stations
- *Data on the Boston Region MPO's Environmental Justice (EJ) Zones*. Identify EJ areas
- *Also Included:*
    - Data selected from MassDOT's project-information and roadway safety audit databases
    - The MPO's 2016–20 TIP projects
    - MPO planning (and other) studies
    - Municipal websites (to obtain data on projects, studies, and TIP projects planned or programmed for each arterial segment)

Table 1 (at the end of this memorandum) presents the data assembled for each intersection location and cites: the municipality, Metropolitan Area Planning Council (MAPC) subregion, MassDOT district office, jurisdiction, equivalent property damage only crashes, total crashes, fatal crashes, injury crashes, property damage only and non-reported crashes, bicycle and pedestrian crashes, top-200 crash clusters, crash clusters that are eligible for Highway Safety Improvement Program (HSIP) funding, transit routes, a list of relevant studies or projects, and staff comments. It also shows the results of applying the selection criteria, as well as the priority rating, which was performed in the fourth step of this process (described below).

2.3 Applying Criteria

MPO staff further examined the intersection locations by applying the six criteria cited below (each item is worth one point):

- *Safety Conditions, 0–3 Points*
  - Location contains an HSIP-eligible crash cluster
  - Location is on MassDOT's top-200 high-crash locations list
  - Location has a significant number of pedestrian and bicycle crashes per year (more than three) or contains one or more HSIP-eligible bike-pedestrian clusters

- *Congested Conditions, 0–2 Points*
  - Travel time index is at least 1.30, or, in the absence of data, staff-estimated congested conditions
  - Travel time index is at least 1.50

- *Multimodal Significance, 0–3 Points*
  - Location currently supports transit, bicycle, or pedestrian activities
  - Location needs improved transit, bicycle, or pedestrian facilities
  - Location has a high volume of truck traffic serving regional commerce

- *Regional Significance, 0–4 Points*
  - Location is in the NHS
  - Location carries a significant portion of regional traffic (AADT is greater than 20,000 on at least one intersecting road)
  - Location lies within 0.5 miles of an EJ transportation analysis zone
  - Location is essential for the region's economic, cultural, or recreational development

- *Regional equity, 0–2 Points*

    - Location is in an MPO subregion that is at least slightly under-represented in previous safety and operations analyses in terms of the proportion of population or number of MassDOT top-200 high-crash locations in the region
    - Location is in an MPO subregion that is very under-represented in previous safety and operations analyses in terms of the proportion of population or number of MassDOT top-200 high-crash locations in the region

- *Implementation Potential, 0–3 Points*
    - Location has strong potential for implementation based on the urgent need for safety improvements
    - Location is proposed or endorsed by its roadway administrative agency or agencies
    - Location has strong support for improvements from other stakeholders (e.g., municipalities, MassDOT, and subregions)

In addition, no two locations in the same town would be selected.

2.4 Scoring and Rating

Intersection locations with a score of nine or fewer points were rated low priority; those with a score of 10-to-11 points were rated medium priority; and those with a score of 12 or more points were rated high priority. Staff chose these ranges so that roughly one-third of the locations would fall into each rating category. Five locations were given a high-priority rating and seven a medium-priority rating by MPO staff based on safety, operations, multimodal and regional significance, and support from agencies and municipalities. The availability of funding resources determined the number of segments selected.

Staff examined the high- and medium-priority segments more closely. Locations within the following parameters were not suitable candidates for this cycle of safety and operations analyses:

- Recently or currently under study
- Complexity of closely spaced intersections suggest that a corridor study is needed
- Selected for the FFY 2016 Subregional Priority Corridors study

3 SELECTED INTERSECTIONS FOR STUDY: BROADWAY AT FOURTH STREET AND FIFTH STREET IN CHELSEA; AND ROUTE 114/ANDOVER STREET AT ESQUIRE DRIVE AND VIOLET ROAD IN PEABODY

Based on the evaluation above, staff selected two intersections for study: 1) Broadway at Fourth Street and Fifth Street in Chelsea, and 2) Route 114/Andover Street at Esquire Drive and Violet Road in Peabody.

1) *Broadway at Fourth and Fifth Street in Chelsea*: The City of Chelsea asked MPO staff to study the intersections of Broadway at Fourth Street and Fifth Street because of safety concerns, as well as the potential effect of executing planned changes in its downtown area.

   This location is situated within a crash cluster that previously was ranked 141 on MassDOT's list of top-200 crash clusters for 2009−11, and is eligible for HSIP funding. During the five-year period 2009−13, 80 crashes were reported (16 per year), of which 24 resulted in non-fatal injuries. Nineteen crashes involving pedestrians and five crashes involving cyclists were reported.

2) *Route 114/Andover Street at Esquire Drive and Violet Road in Peabody*: The City of Peabody is very interested in addressing the large number of crashes at this location.

   These two adjacent signalized intersections on Route 114/Andover Street are located within a crash cluster that is ranked 130 on MassDOT's list of top-200 crash clusters for 2011–13. This cluster is eligible for HSIP funding. Fifty-six crashes were reported in the five-year period 2009−2013, 15 of which resulted in non-fatal injuries. Nearly three-quarters of the crashes were rear-ending.

4 SUMMARY

The recommended intersection locations meet the selection criteria of this study because of their potential for safety and operations improvements. The work scope for this study assumed that "as many as three" intersections would be selected. Staff selected two locations, each of which contains two intersections, for a total of four intersections.

Staff will submit these recommendations to the MPO for discussion. If the MPO endorses the study selections, staff will meet with officials from Chelsea,

Peabody, and MassDOT to discuss specifics of the study, conduct field visits, collect data, and perform analyses.

SA-KC/sa-kc

TABLE 1. FFY 2016 Safety and Operations for Selected Intersections
Selected locations are highlighted in green

Location	Community	MAPC Subregion	Jurisdiction	Street 1	Route 1	Street 2	EPDO Crashes 2011-13	Total Crashes 2011-13	Injury Crashes 2011-13	Bike/Ped Crashes 2011-13	Top-200 Crash Clusters 2011-13	HSIP-eligible Crash Clusters 2011-13	Transit Routes	TIP Status	Safety Conditions	Congested Conditions	Multimodal Significance	Regional Significance	Regional Equity	Implementation Potential	Total Score	Rating	Comments
1	Chelsea	ICC	City	Broadway		Fifth Street and Fourth Street	105	41	16	14	0	1	MBTA 111, 112, 114, 116, and 117	None	2	1	3	3	2	2	13	High	Potential candidate for a safety and operations study. It has a very high number of bicycle and pedestrian crashes. It is also a high-crash location and classified as a Highway Safety Improvement Program (HSIP)-eligible crash cluster. The City of Chelsea has expressed interest.
2	Boston	ICC	DCR	Jamaicaway		Bynner Street	106	46	15	2	1	1	None	None	2	1	2	4	2	2	13	High	Potential candidate for a safety and operations study. The location is in the current list of Top 200 High-Crash Intersections. The City of Boston expressed interest, but the Department of Conservation and Recreation (DCR) did not indicate interest.
3	Peabody	NSTF	MassDOT and City	Andover Street	Route 114	Esquire Drive	108	48	15	0	1	1	MBTA 435 and 465	None	2	2	2	4	1	2	13	High	Potential candidate for a safety and operations study. The location is in the current list of top-200 high-crash Intersections. The traffic signal is under City jurisdiction, although Route 114 is under MassDOT jurisdiction. Both the City of Peabody and MassDOT District 4 have indicated interest.
4	Chelsea	ICC	Town	Everett Avenue		Mystic Mall	184	108	19	12	1	1	MBTA 112,114	None	3	1	3	3	2	1	13	High	Although the location has high number of crashes and a very high number of bike and pedestrian crashes, it is not suitable for an intersection study because there are five closely spaced intersections including two signalized intersections and an at-grade railroad crossing that need to be evaluated together.
5	Newton	ICC	MassDOT and City	Washington Street	Route 16	South Entrance to Newton-Wellesley Hospital and Beacon Street	72	40	8	2	0	1	MWRTA Routes 1 and 8	None	2	1	2	3	2	2	12	High	Potential candidate for a safety and operations study. This location contains one HSIP-eligible crash cluster and a second cluster nearby would be included in the analysis.
6	Salem	NSTF	Town	North Street	Route 114	Mason Street	108	51	12	7	1	1	MBTA 465	None	3	0	2	4	1	1	11	Medium	This location was not selected because the crash cluster at this location includes two signalized intersections and four unsignalized intersections in a half-mile distance. An arterial segment study is more suitable for this location. In addition, a Route 1A study involving Swampscott, Salem, and Marblehead has been recommended for the MPO FFY 2016 Subregional Priority Corridors Study, and so, because of geographic equity considerations, this location is not recommended for that reason as well.
7	Watertown	ICC	DCR and Town	Galen Street	Route 16	Watertown Street	98	38	15	6	1	1	MBTA 52, 57, 59, 502, 504	None	3	0	2	3	2	1	11	Medium	Although the intersection has high number of bike and pedestrian crashes, it is too complex for a safety and operations study. It is vey close to the Galen Street bridge over the Charles River and Watertown Square, which pose overly difficult challenges as the right-of-way is constrained by buildings, the Charles River, and recreational space.
8	Milton	ICC, TRIC	MassDOT	Randolph Avenue	Route 28	Chickatawbut Road	157	57	25	0	1	1	BAT 12, MBTA 240	Pre-TIP (n.d.) Arterial and Intersection Project 607342	2	0	2	3	2	2	11	Medium	Potential candidate for a safety and operations study. MassDOT District 6 reports that the intersection is congested during commute hours. MassDOT has a project that has not advanced at Route 28/Chickataubaut; an intersection or corridor study would be helpful to address the safety and operations issues because of the high number of injury crashes.
9	Newton	ICC	City	Commonwealth Avenue	Route 30	Washington Street	55	23	8	2	0	1	MBTA 505	None	1	2	2	3	2	1	11	Medium	Potential candidate for a safety and operations analysis.
10	Marlborough	MetroWest	MassDOT	Boston Post Road West	Route 20	Northboro Road East (Shopping Plaza)	124	92	8	5	1	1	MWRTA Route 7	None	3	0	2	3	1	1	10	Medium	A Route 20 study in Marlborough is recommended for the MPO FFY 2016 Subregional Priority Corridors Study. This location was not selected because of the geographic equity consideration applied in the selection study locations.
11	Marlborough	MetroWest	MassDOT	East Main Street	Route 20	Curtis Avenue	220	184	9	2	1	1	MWRTA Route 7	None	2	0	2	4	1	1	10	Medium	This location is included as part of the proposed MPO FFY 2016 Subregional Priority Roadway Study on Route 20 in Marlborough. It has a high number of injury crashes and bike and pedestrian crashes.
12	Peabody	NSTF	MassDOT	Andover Street	Route 114	Northshore Mall	155	107	12	2	1	1	MBTA 435, 436, and 465; CATA Yellow Line	None	2	0	2	4	1	1	10	Medium	It appears that an arterial segment study would be more helpful to address safety and operations problems at four closely-spaced signalized intersections. A recent MassDOT resurfacing project does not appear to have addressed safety issues.
13	Danvers	NSTF	MassDOT	Andover Street	Route 114	Garden Street	98	38	15	1	1	1	None	None	2	0	2	3	1	1	9	Low	This intersection was studied as part of the FFY 2011 Priority Corridors: Route 114 Study in Danvers. That study proposed improvements for addressing safety and operations at the intersection.
14	Cambridge	ICC	DCR and City	Mount Auburn Street and Fresh Pond Parkway	Route 3	Coolidge Hill Road	33	17	4	1	0	0	MBTA 71 and 73	None	0	1	2	4	2	0	9	Low	Comments from MPO outreach indicate pedestrian safety issues and traffic congestion and operations concerns at Mount Auburn Street/Coolidge Hill Road. DCR interest is critical for this study due to the proximity of Route 3/Fresh Pond Parkway at Mount Auburn Street.
15	Boston	ICC	MassDOT	Columbia Road		Buttonwood Street	72	24	12	0	0	1	MBTA 8, 18, and 41	None	1	1	1	3	2	1	9	Low	Potential candidate for a safety and operations study. This unsignalized intersection is located between two busy and closely-spaced signalized intersections.
16	Boston	ICC	City	Dudley Street		Harrison Avenue	58	18	10	0	0	1	MBTA 15, 41, and 45	None	1	0	2	2	2	1	8	Low	This location needs to be analyzed together with several signalized intersections in the vicinity due to traffic circulation and queuing concerns. A subarea study would be more appropriate.
17	Wellesley, Newton	MetroWest, ICC	Town	Washington Street	Route 16	River Street	95	63	8	5	0	1	None	None	2	0	2	2	1	1	8	Low	Potential candidate for safety and operations analysis. A nearby bridge over the Charles River and a signalized intersection about 350 feet east of this intersection in Newton pose difficult challenges. Although the this intersection is in Wellesley, Newton's participation is critical.
18	Natick	MetroWest	Town	Speen Street		Cloverleaf Marketplace Shopping Center	127	79	12	1	1	1	MWRTA Route 9	None	2	0	1	2	1	1	7	Low	This location was studied by a consultant (VHB) for the Town of Natick. VHB proposed several improvements to address pedestrian and bicycle issues, as well as safety and operations problems.
19	Wrentham	SWAP	MassDOT	South Street	Route 1A	Premium Outlet Boulevard	171	99	18	1	1	1	None	None. Nearby Pre-TIP Major Highway Project 603739 does not include location	2	0	1	1	1	1	6	Low	Location is not suitable for an intersection study because it is close to the I-495 and Route 1A ramp-arterial junctions and would probably require signal coordination for four signalized intersections along the stretch. A recent MassDOT resurfacing project does not appear to have addressed safety issues.
20	Sherborn	SWAP	Town	Washington Street	Route 16	S Main Street (Route 27)	49	21	7	0	0	1	None	None	1	1	1	2	1	0	6	Low	Location was studied by CTPS and VHB in 2002 and 2004. Improvements were not implemented. A UPWP comment suggested that this could be a good location for demand response signal.

Source: Central Transportation Planning Staff.

Notes

1. Locations are in order of their ratings based on scoring from selection criteria.
2. EPDO Crash Rating = 10 * Fatal Crashes + 5 * Injury Crashes + 1 * Other Crashes (Property Damage Only or Unknown Severity), based on MassDOT top-200 high-crash locations: 2011-13 crash data.
3. HSIP-eligible crash clusters are defined by MassDOT as crash clusters that rank within the top five percent of crash clusters for each Regional Planning Agency, based on the EDPO index. In the Boston region the 921 intersections in the top five percent have crash clusters with a minimum EDPO value of 42

Selection Criteria

Safety Conditions: Intersection has a HSIP-eligible crash cluster, a top-200 high-crash location, and/or a significant number of or HSIP-eligible clusters of pedestrian or bicycle crashes.
Congested Conditions: Intersection experiences delays during peak periods.
Multimodal Significance: Intersection currently supports transit, bicycle or pedestrian activities, needs improved facilities for these activities, and/or has high truck traffic serving regional commerce.

Regional Significance: Intersection is on the National Highway System, carries a significant proportion of regional traffic, lies within 0.5 miles of Environmental Justice transportation analysis zones, and/or is essential for the region's economic, cultural, or recreational development.
Regional Equity: Intersection is underrepresented in previous safety and operations studies in terms of the proportion of population or number of top-200 high-crash locations.

Implementation Potential: Intersection has strong potential for implementation based on the urgent need for safety improvements, is proposed or endorsed by its roadway administrative agency or agencies, and/or has strong support from other stakeholders.

Acronyms and Abbreviations

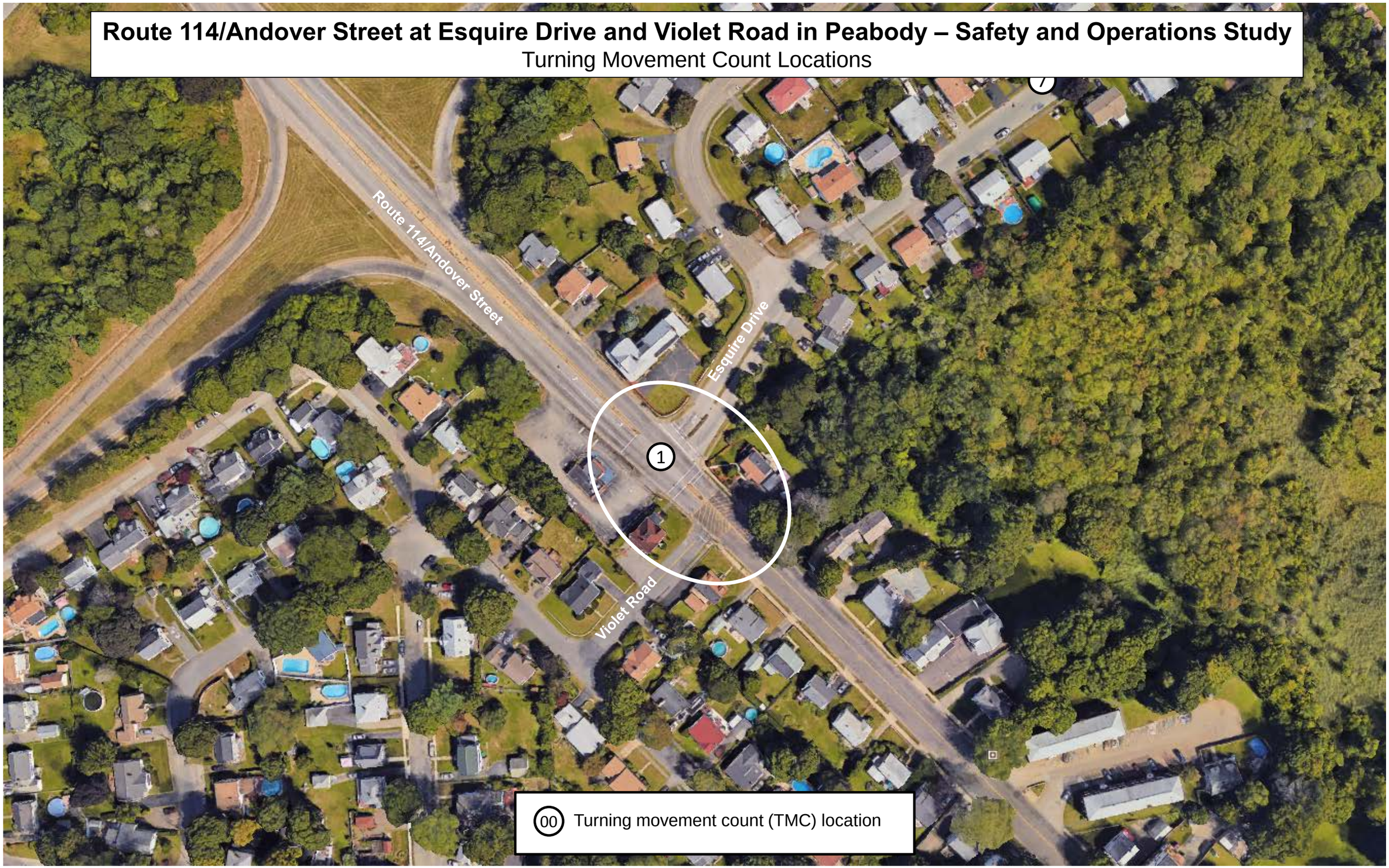
BAT = Brockton Area Transit Authority. CATA = Cape Ann Transit Authority. CTPS = Central Transportation Planning Staff. DCR = Department of Conservation and Recreation. EJ = Environmental justice. EPDO = Equivalent property damage only. FFY = Federal fiscal year. HSIP = Highway Safety Improvement Program. ICC = Inner Core Committee. MAPC = Metropolitan Area Planning Council. MassDOT = Massachusetts Department of Transportation. MBTA = Massachusetts Bay Transportation Authority. MetroWest = MetroWest Regional Collaborative. MPO = Boston Region Metropolitan Planning Organization. MWRTA = MetroWest Regional Transit Authority. NSPC = North Suburban Planning Council. NSTF = North Shore Task Force. SWAP = South West Advisory Planning Committee. TIP = Transportation Improvement Program. TRIC = Three Rivers Interlocal Council. UPWP = Unified Planning Work Program.

Appendix B: Traffic Data Collection

Count Location Maps

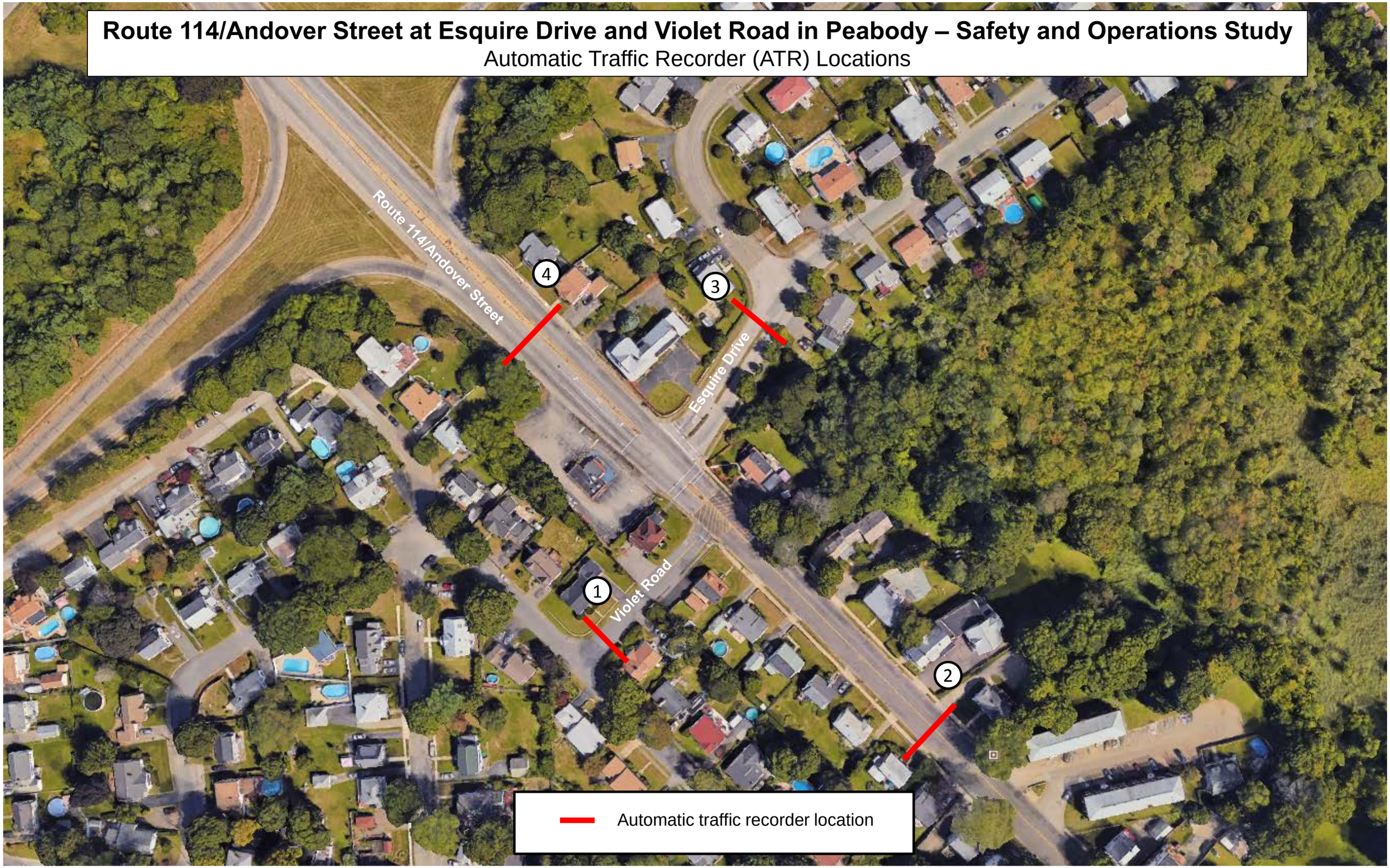
Route 114/Andover Street at Esquire Drive and Violet Road in Peabody – Safety and Operations Study

Turning Movement Count Locations



Route 114/Andover Street at Esquire Drive and Violet Road in Peabody – Safety and Operations Study

Automatic Traffic Recorder (ATR) Locations



Route 114/Andover Street at Esquire Drive and Violet Road in Peabody – Safety and Operations Study

Spot Speed Study Locations

Turning Movement Counts

Thursday

Study Name	Peabody - Route 114 at Square Drive and Violet Road TMC
Start Date	Thursday, April 14, 2016 7:00 AM
End Date	Saturday, April 16, 2016 2:00 PM
Site Code	

Report Summary

		Westbound							Northwestbound						Northeastbound						Eastbound						Southeastbound							Crosswalk	
Time Period	Class	BR	T	BL	HL	U	I	O	HR	T	BL	L	U	I	O	R	BR	L	HL	U	I	O	HR	BR	T	HL	U	I	O	HR	R	T	BL	U	I	O	Total		Pedestrians	Total
Peak 1	Motorcycles	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	E	0	0
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	
7:00 AM - 9:00 AM	Cars	51	0	0	17	0	68	29	12	1547	0	0	0	1559	1132	0	0	40	0	0	40	8	0	0	0	0	0	0	0	0	8	1115	17	0	1140	1638	2807	SE	0	0
One Hour Peak	%	88%	0%	0%	81%	0%	85%	74%	71%	90%	0%	0%	0%	90%	85%	0%	0%	85%	0%	0%	85%	62%	0%	0%	0%	0%	0%	0%	0%	0%	67%	85%	77%	0%	85%	90%	88%		0%	
7:30 AM - 8:30 AM	Light Goods Vehicles	4	0	0	2	0	6	4	2	116	0	0	0	118	142	0	0	6	0	0	6	2	0	0	0	0	0	0	0	0	2	140	2	0	144	126	274	SW	0	0
	%	7%	0%	0%	10%	0%	8%	10%	12%	7%	0%	0%	0%	7%	11%	0%	0%	13%	0%	0%	13%	15%	0%	0%	0%	0%	0%	0%	0%	0%	17%	11%	9%	0%	11%	7%	9%		0%	
	Buses	1	0	1	0	0	2	2	2	14	0	0	0	16	10	0	0	1	0	0	1	3	0	0	0	0	0	0	0	0	2	10	0	0	12	16	31	W	0	0
	%	2%	0%	100%	0%	0%	3%	5%	12%	1%	0%	0%	0%	1%	1%	0%	0%	2%	0%	0%	2%	23%	0%	0%	0%	0%	0%	0%	0%	0%	17%	1%	0%	0%	1%	1%	1%		0%	
	Single-Unit Trucks	2	0	0	2	0	4	4	1	33	0	0	0	34	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	3	0	35	35	73	NW	0	0
	%	3%	0%	0%	10%	0%	5%	10%	6%	2%	0%	0%	0%	2%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	14%	0%	3%	2%	2%		0%	
	Articulated Trucks	0	0	0	0	0	0	0	0	7	0	0	0	7	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	12	7	19		0	0
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%	1%			
	Bicycles on Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Total	58	0	1	21	0	80	39	17	1719	0	0	0	1736	1330	0	0	47	0	0	47	13	0	0	0	0	0	0	0	0	12	1309	22	0	1343	1824	3206			
	PHF	0.76	0	0.25	0.48	0	0.67	0.7	0.61	0.93	0	0	0	0.94	0.93	0	0	0.9	0	0	0.9	0.65	0	0	0	0	0	0	0	0	0.75	0.95	0.79	0	0.95	0.94	0.97			
	Approach %						2%	1%						54%	41%						1%	0%						0%	0%						42%	57%				
Peak 2	Motorcycles	0	0	0	0	0	0	0	0	4	0	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	4	6	E	3	3
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
4:00 PM - 6:00 PM	Cars	40	0	0	20	0	60	109	27	1277	0	0	0	1304	1224	0	1	25	0	0	26	57	0	1	2	0	0	3	0	0	57	1203	79	0	1339	1342	2732	SE	0	0
One Hour Peak	%	85%	0%	0%	95%	0%	87%	86%	90%	89%	0%	0%	0%	89%	90%	0%	100%	96%	0%	0%	93%	89%	0%	100%	100%	0%	0%	100%	0%	0%	90%	90%	84%	0%	90%	89%	89%		0%	
5:00 PM - 6:00 PM	Light Goods Vehicles	7	0	1	1	0	9	16	1	136	0	0	0	137	119	1	0	1	0	0	2	7	0	0	0	0	0	0	0	0	6	117	15	0	138	144	286	SW	1	1
	%	15%	0%	100%	5%	0%	13%	13%	3%	9%	0%	0%	0%	9%	9%	100%	0%	4%	0%	0%	7%	11%	0%	0%	0%	0%	0%	0%	0%	0%	10%	9%	16%	0%	9%	10%	9%		100%	
	Buses	0	0	0	0	0	0	0	0	3	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3	4	W	2	2
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
	Single-Unit Trucks	0	0	0	0	0	0	2	2	13	0	0	0	15	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	12	13	27	NW	0	0
	%	0%	0%	0%	0%	0%	0%	2%	7%	1%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%	1%	1%		0%	
	Articulated Trucks	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1		6	6
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Bicycles on Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Total	47	0	1	21	0	69	127	30	1433	0	0	0	1463	1359	1	1	26	0	0	28	64	0	1	2	0	0	3	0	0	63	1336	94	0	1493	1506	3056			
	PHF	0.84	0	0.25	0.66	0	0.78	0.88	0.62	0.96	0	0	0	0.97	0.93	0.25	0.25	0.72	0	0	0.7	0.84	0	0.25	0.5	0	0	0.38	0	0	0.88	0.93	0.84	0	0.95	0.95	0.96			
	Approach %						2%	4%						48%	44%						1%	2%						0%	0%						49%	49%				

Saturday

Study Name	Peabody - Route 114 at Esquire Drive and Violet Road TMC
Start Date	Thursday, April 14, 2016 7:00 AM
End Date	Saturday, April 16, 2016 2:00 PM
Site Code	

Report Summary

		Westbound							Northwestbound						Northeastbound						Eastbound						Southeastbound								Crosswalk	
Time Period	Class.	BR	T	BL	HL	U	I	O	HR	T	BL	L	U	I	O	R	BR	L	HL	U	I	O	HR	BR	T	HL	U	I	O	HR	R	T	BL	U	I	O	Total		Pedestrians	Total
Peak 1	Motorcycles	0	0	0	0	0	0	0	0	2	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	2	5	E	3	3
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
12:00 PM - 2:00 PM	Cars	51	0	0	8	0	59	67	19	1397	0	1	0	1417	1227	2	1	33	0	0	36	35	0	0	0	0	0	0	0	0	34	1217	47	1	1299	1482	2811	SE	0	0
One Hour Peak	%	80%	0%	0%	67%	0%	78%	80%	83%	90%	0%	100%	0%	90%	90%	67%	100%	94%	0%	0%	92%	90%	0%	0%	0%	0%	0%	0%	0%	0%	89%	90%	78%	100%	90%	90%	90%		0%	
12:00 PM - 1:00 PM	Light Goods Vehicles	13	0	0	2	0	15	15	4	130	0	0	0	134	112	1	0	2	0	0	3	4	0	0	0	0	0	0	0	0	4	109	11	0	124	145	276	SW	2	2
	%	20%	0%	0%	17%	0%	20%	18%	17%	8%	0%	0%	0%	9%	8%	33%	0%	6%	0%	0%	8%	10%	0%	0%	0%	0%	0%	0%	0%	0%	11%	8%	18%	0%	9%	9%	9%		100%	
	Buses	0	0	0	0	0	0	0	0	3	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4	3	7	W	2	2
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
	Single-Unit Trucks	0	0	0	2	0	2	2	0	11	0	0	0	11	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	2	0	16	11	29	NW	0	0
	%	0%	0%	0%	17%	0%	3%	2%	0%	1%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%	0%	1%	1%	1%		0%	
	Articulated Trucks	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2		7	7
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Bicycles on Road	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Total	64	0	0	12	0	76	84	23	1545	0	1	0	1569	1362	3	1	35	0	0	39	39	0	0	0	0	0	0	0	0	38	1347	60	1	1446	1645	3130			
	PHF	0.76	0	0	0.5	0	0.7	0.91	0.64	0.96	0	0.25	0	0.96	0.88	0.75	0.25	0.97	0	0	0.98	0.65	0	0	0	0	0	0	0	0	0.68	0.87	0.79	0.25	0.87	0.97	0.94			
	Approach %						2%	3%						50%	44%						1%	1%						0%	0%						46%	53%				

Automatic Traffic Recorder Counts

STA. 1
TOTAL

Site Reference: 160100000645
Site ID: 000000010102
Location: VIOLET RD., SOUTH OF RTE. 114
Direction: ROAD TOTAL

File: V10102.prn
City: PEABODY
County: VOL N&S

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		1	4	2	8	3			3	15
02:00		4	0	2	4	2			2	10
03:00		0	2	1	4	1			1	7
04:00		2	5	2	2	2			2	11
05:00		11	8	13	12	11			11	44
06:00		19	28	28	25	25			25	100
07:00		35	31	47	36	37			37	149
08:00		56	60	58	70	61			61	244
09:00		70	62	60	64	64			64	256
10:00		65	44	69	45	55			55	223
11:00		69	61	53		61			61	183
12:00	61	54	58	52		56			56	225
13:00	58	47	66	74		61			61	245
14:00	58	57	67	57		59			59	239
15:00	53	60	62	69		61			61	244
16:00	85	62	94	90		82			82	331
17:00	57	82	76	88		75			75	303
18:00	78	101	97	92		92			92	368
19:00	72	70	76	85		75			75	303
20:00	43	48	75	55		55			55	221
21:00	30	41	32	38		35			35	141
22:00	19	23	24	21		21			21	87
23:00	15	12	10	9		11			11	46
24:00	3	5	5	12		6			6	25
TOTALS	632	994	1047	1077	270	1011	0	0	1011	4020
% AVG WKDY	62.5	98.3	103.5	106.5	26.7					
% AVG WEEK	62.5	98.3	103.5	106.5	26.7					
AM Times	12:00	09:00	09:00	10:00	08:00	09:00			09:00	
AM Peaks	61	70	62	69	70	64			64	
PM Times	16:00	18:00	18:00	18:00		18:00			18:00	
PM Peaks	85	101	97	92		92			92	
D%	60	70	60	75	75					
K%	13	10	9	9	26					

UO

COMB AWD 1011
FAC 1.00
COMB ADT 1,000

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1
Starting: 4/11/2016

STA. 1 NB

Site Reference: 160100000645
Site ID: 000000010102
Location: VIOLET RD., SOUTH OF RTE. 114
Direction: NORTH

File: V10102.prn
City: PEABODY
County: VOL N&S

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		1	1	1	2	1			1	5
02:00		1	0	0	1	0			0	2
03:00		0	1	0	2	0			0	3
04:00		1	2	2	2	1			1	7
05:00		10	7	11	10	9			9	38
06:00		19	27	24	23	23			23	93
07:00		28	25	35	26	28			28	114
08:00		43	47	49	52	47			47	191
09:00		45	41	37	44	41			41	167
10:00		40	27	37	23	31			31	127
11:00		34	31	24		29			29	89
12:00	25	28	33	25		27			27	111
13:00	33	21	32	42		32			32	128
14:00	26	21	31	27		26			26	105
15:00	21	24	23	27		23			23	95
16:00	33	26	44	37		35			35	140
17:00	16	28	29	44		29			29	117
18:00	25	32	38	22		29			29	117
19:00	24	26	36	31		29			29	117
20:00	20	22	21	19		20			20	82
21:00	8	13	13	6		10			10	40
22:00	7	10	4	8		7			7	29
23:00	3	1	1	3		2			2	8
24:00	0	1	2	3		1			1	6
TOTALS	241	475	516	514	185	480	0	0	480	1931
% AVG WKDY	50.2	98.9	107.5	107	38.5					
% AVG WEEK	50.2	98.9	107.5	107	38.5					
AM Times	12:00	09:00	08:00	08:00	08:00	08:00			08:00	
AM Peaks	25	45	47	49	52	47			47	
PM Times	13:00	18:00	16:00	17:00		16:00			16:00	
PM Peaks	33	32	44	44		35			35	

STA. 1 SB

Site Reference: 160100000645
Site ID: 000000010102
Location: VIOLET RD., SOUTH OF RTE. 114
Direction: SOUTH

File: V10102.prn
City: PEABODY
County: VOL N&S

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		0	3	1	6	2			2	10
02:00		3	0	2	3	2			2	8
03:00		0	1	1	2	1			1	4
04:00		1	3	0	0	1			1	4
05:00		1	1	2	2	1			1	6
06:00		0	1	4	2	1			1	7
07:00		7	6	12	10	8			8	35
08:00		13	13	9	18	13			13	53
09:00		25	21	23	20	22			22	89
10:00		25	17	32	22	24			24	96
11:00		35	30	29		31			31	94
12:00	36	26	25	27		28			28	114
13:00	25	26	34	32		29			29	117
14:00	32	36	36	30		33			33	134
15:00	32	36	39	42		37			37	149
16:00	52	36	50	53		47			47	191
17:00	41	54	47	44		46			46	186
18:00	53	69	59	70		62			62	251
19:00	48	44	40	54		46			46	186
20:00	23	26	54	36		34			34	139
21:00	22	28	19	32		25			25	101
22:00	12	13	20	13		14			14	58
23:00	12	11	9	6		9			9	38
24:00	3	4	3	9		4			4	19
TOTALS	391	519	531	563	85	520	0	0	520	2089
% AVG WKDY	75.1	99.8	102.1	108.2	16.3					
% AVG WEEK	75.1	99.8	102.1	108.2	16.3					
AM Times	12:00	11:00	11:00	10:00	10:00	11:00			11:00	
AM Peaks	36	35	30	32	22	31			31	
PM Times	18:00	18:00	18:00	18:00		18:00			18:00	
PM Peaks	53	69	59	70		62			62	

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1 Page: 1
Starting: 4/11/2016

STA. 2 EB

Site Reference: 160100000455
Site ID: 000000000203
Location: RTE. 114, EAST OF VIOLET RD.
Direction: EAST

File: V2-03.prn
City: PEABODY
County: VOL EB

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		144	140	173	177	158			158	634
02:00		81	90	87	90	87			87	348
03:00		51	32	43	38	41			41	164
04:00		36	38	36	40	37			37	150
05:00		55	59	66	68	62			62	248
06:00		292	315	312	313	308			308	1232
07:00		815	851	894	872	858			858	3432
08:00		1425	1496	1429	1337	1421			1421	5687
09:00		1495	1434	1561	1428	1479			1479	5918
10:00		1226	1291	1178	1231	1231			1231	4926
11:00		1226	1227	1267		1240			1240	3720
12:00	1153	1290	1307	1364		1278			1278	5114
13:00	1245	1362	1242	1379		1307			1307	5228
14:00	1304	1339	1335	1391		1342			1342	5369
15:00	1560	1599	1589	1736		1621			1621	6484
16:00	1683	1621	1626	1928		1714			1714	6858
17:00	2050	1944	1536	2051		1895			1895	7581
18:00	2154	1957	1843	2056		2002			2002	8010
19:00	1506	1595	1527	1914		1635			1635	6542
20:00	1127	1256	1312	1301		1249			1249	4996
21:00	1010	1016	1156	1163		1086			1086	4345
22:00	746	821	887	926		845			845	3380
23:00	483	539	555	627		551			551	2204
24:00	327	327	372	345		342			342	1371
TOTALS	16348	23512	23260	25227	5594	23789	0	0	23789	93941
% AVG WKDY	68.7	98.8	97.7	106	23.5					
% AVG WEEK	68.7	98.8	97.7	106	23.5					
AM Times	12:00	09:00	08:00	09:00	09:00	09:00			09:00	
AM Peaks	1153	1495	1496	1561	1428	1479			1479	
PM Times	18:00	18:00	18:00	18:00		18:00			18:00	
PM Peaks	2154	1957	1843	2056		2002			2002	

U2

EB 23789
WB 25471
COMB AWD 49260
FAC .96 (.96)
COMB ADT 45,400

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1
Starting: 4/11/2016

STA. 2 WB

Site Reference: 160100000564
Site ID: 000000000204
Location: RTE. 114, EAST OF VIOLET RD.
Direction: WEST

File: V2-04.prn
City: PEABODY
County: VOL WB

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		102	85	117	103	101			101	407
02:00		51	78	74	97	75			75	300
03:00		48	58	58	54	54			54	218
04:00		74	73	63	70	70			70	280
05:00		185	172	179	187	180			180	723
06:00		635	625	674	635	642			642	2569
07:00		1525	1497	1488	1406	1479			1479	5916
08:00		2037	1985	1873	1785	1920			1920	7680
09:00		1927	1957	1959	1764	1901			1901	7607
10:00		1613	1475	1493	1433	1503			1503	6014
11:00		1565	1368	1383		1438			1438	4316
12:00	1447	1583	1464	1642		1534			1534	6136
13:00	1533	1609	1500	1536		1544			1544	6178
14:00	1459	1505	1551	1435		1487			1487	5950
15:00	1625	1642	1721	1614		1650			1650	6602
16:00	1906	1959	1853	1813		1882			1882	7531
17:00	1870	1928	1818	1723		1834			1834	7339
18:00	1736	1572	1782	1738		1707			1707	6828
19:00	1377	1264	1313	1378		1333			1333	5332
20:00	1002	1082	1142	1133		1089			1089	4359
21:00	672	773	826	874		786			786	3145
22:00	600	643	663	664		642			642	2570
23:00	354	392	413	417		394			394	1576
24:00	202	243	229	232		226			226	906
TOTALS	15783	25957	25648	25560	7534	25471	0	0	25471	100482
% AVG WKDY	61.9	101.9	100.6	100.3	29.5					
% AVG WEEK	61.9	101.9	100.6	100.3	29.5					
AM Times	12:00	08:00	08:00	09:00	08:00	08:00			08:00	
AM Peaks	1447	2037	1985	1959	1785	1920			1920	
PM Times	16:00	16:00	16:00	16:00		16:00			16:00	
PM Peaks	1906	1959	1853	1813		1882			1882	

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE
Starting: 4/11/2016

STA .3

TOTAL

Site Reference: 160100000536
Site ID: 000000030102
Location: ESQUIRE DR., NORTH OF RTE. 114
Direction: ROAD TOTAL

File: V30102.prn
City: PEABODY
County: VOL N&S

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		16	16	10	13	13			13	55
02:00		12	8	9	9	9			9	38
03:00		10	10	9	10	9			9	39
04:00		10	10	7	9	9			9	36
05:00		19	19	19	26	20			20	83
06:00		61	51	55	62	57			57	229
07:00		132	151	142	126	137			137	551
08:00		158	171	153	160	160			160	642
09:00		170	168	171	182	172			172	691
10:00		127	148	133	136	136			136	544
11:00	118	129	132	138		129			129	517
12:00	166	125	164	143		149			149	598
13:00	171	158	186	151		166			166	666
14:00	160	136	176	136		152			152	608
15:00	201	171	170	215		189			189	757
16:00	211	210	210	190		205			205	821
17:00	205	205	162	199		192			192	771
18:00	196	181	188	241		201			201	806
19:00	149	161	188	217		178			178	715
20:00	141	145	145	156		146			146	587
21:00	87	92	99	96		93			93	374
22:00	63	69	62	79		68			68	273
23:00	41	39	43	53		44			44	176
24:00	19	25	33	23		25			25	100
TOTALS	1928	2561	2710	2745	733	2659	0	0	2659	10677
% AVG WKDY	72.5	96.3	101.9	103.2	27.5					
% AVG WEEK	72.5	96.3	101.9	103.2	27.5					
AM Times	12:00	09:00	08:00	09:00	09:00	09:00			09:00	
AM Peaks	166	170	171	171	182	172			172	
PM Times	16:00	16:00	16:00	18:00		16:00			16:00	
PM Peaks	211	210	210	241		205			205	
D%	55	55	50	55	75					
K%	11	8	8	9	25					

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1
Starting: 4/11/2016

STA. 3 NB

Site Reference: 160100000536
Site ID: 000000030102
Location: ESQUIRE DR., NORTH OF RTE. 114
Direction: NORTH

File: V30102.prn
City: PEABODY
County: VOL N&S

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		12	10	7	7	9			9	36
02:00		4	3	5	3	3			3	15
03:00		2	5	2	4	3			3	13
04:00		2	2	2	4	2			2	10
05:00		4	7	4	9	6			6	24
06:00		6	3	4	7	5			5	20
07:00		19	25	20	20	21			21	84
08:00		30	38	29	32	32			32	129
09:00		51	48	51	50	50			50	200
10:00		41	40	50	47	44			44	178
11:00	39	37	48	48		43			43	172
12:00	58	51	72	57		59			59	238
13:00	84	68	74	59		71			71	285
14:00	66	57	74	65		65			65	262
15:00	95	82	75	88		85			85	340
16:00	91	99	102	83		93			93	375
17:00	110	103	93	105		102			102	411
18:00	98	99	97	135		107			107	429
19:00	77	78	101	86		85			85	342
20:00	71	70	69	81		72			72	291
21:00	53	57	59	60		57			57	229
22:00	34	43	35	40		38			38	152
23:00	30	18	28	34		27			27	110
24:00	13	18	18	14		15			15	63
TOTALS	919	1051	1126	1129	183	1094	0	0	1094	4408
% AVG WKDY	84	96	102.9	103.1	16.7					
% AVG WEEK	84	96	102.9	103.1	16.7					
AM Times	12:00	09:00	12:00	12:00	09:00	12:00			12:00	
AM Peaks	58	51	72	57	50	59			59	
PM Times	17:00	17:00	16:00	18:00		18:00			18:00	
PM Peaks	110	103	102	135		107			107	

HO

NB 1094
SB 1558
COMB AWD 2652
FAC 1.00
COMB ADT 2,700

STA. 3 SB

Site Reference: 160100000536
Site ID: 000000030102
Location: ESQUIRE DR., NORTH OF RTE. 114
Direction: SOUTH

File: V30102.prn
City: PEABODY
County: VOL N&S

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		4	6	3	6	4			4	19
02:00		8	5	4	6	5			5	23
03:00		8	5	7	6	6			6	26
04:00		8	8	5	5	6			6	26
05:00		15	12	15	17	14			14	59
06:00		55	48	51	55	52			52	209
07:00		113	126	122	106	116			116	467
08:00		128	133	124	128	128			128	513
09:00		119	120	120	132	122			122	491
10:00		86	108	83	89	91			91	366
11:00	79	92	84	90		86			86	345
12:00	108	74	92	86		90			90	360
13:00	87	90	112	92		95			95	381
14:00	94	79	102	71		86			86	346
15:00	106	89	95	127		104			104	417
16:00	120	111	108	107		111			111	446
17:00	95	102	69	94		90			90	360
18:00	98	82	91	106		94			94	377
19:00	72	83	87	131		93			93	373
20:00	70	75	76	75		74			74	296
21:00	34	35	40	36		36			36	145
22:00	29	26	27	39		30			30	121
23:00	11	21	15	19		16			16	66
24:00	6	7	15	9		9			9	37
TOTALS	1009	1510	1584	1616	550	1558	0	0	1558	6269
% AVG WKDY	64.7	96.9	101.6	103.7	35.3					
% AVG WEEK	64.7	96.9	101.6	103.7	35.3					
AM Times	12:00	08:00	08:00	08:00	09:00	08:00			08:00	
AM Peaks	108	128	133	124	132	128			128	
PM Times	16:00	16:00	13:00	19:00		16:00			16:00	
PM Peaks	120	111	112	131		111			111	

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1
Starting: 4/11/2016

STA 4 EB

Site Reference: 160100000814
Site ID: 000000000403
Location: RTE. 114, WEST OF ESQUIRE DR.
Direction: EAST

File: V4-03.prn
City: PEABODY
County: VOL EB

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		164	168	192	200	181			181	724
02:00		94	106	101	101	100			100	402
03:00		54	39	50	50	48			48	193
04:00		43	45	38	41	41			41	167
05:00		65	65	72	69	67			67	271
06:00		309	325	329	318	320			320	1281
07:00		861	873	923	869	881			881	3526
08:00		1406	1405	1359	1259	1357			1357	5429
09:00		1466	1394	1461	1360	1420			1420	5681
10:00		1229	1291	1202	1143	1216			1216	4865
11:00		1213	1232	1256		1233			1233	3701
12:00	1185	1277	1298	1360		1280			1280	5120
13:00	1288	1330	1280	1366		1316			1316	5264
14:00	1340	1366	1388	1458		1388			1388	5552
15:00	1578	1558	1593	1657		1596			1596	6386
16:00	1625	1548	1575	1685		1608			1608	6433
17:00	1697	1630	1606	1722		1663			1663	6655
18:00	1749	1799	1656	1692		1724			1724	6896
19:00	1538	1635	1618	1689		1620			1620	6480
20:00	1220	1301	1465	1366		1338			1338	5352
21:00	1098	1113	1244	1229		1171			1171	4684
22:00	843	870	980	987		920			920	3680
23:00	563	608	614	643		607			607	2428
24:00	364	366	406	369		376			376	1505
TOTALS	16088	23305	23666	24206	5410	23471	0	0	23471	92675
% AVG WKDY	68.5	99.2	100.8	103.1	23					
% AVG WEEK	68.5	99.2	100.8	103.1	23					
AM Times	12:00	09:00	08:00	09:00	09:00	09:00			09:00	
AM Peaks	1185	1466	1405	1461	1360	1420			1420	
PM Times	18:00	18:00	18:00	17:00		18:00			18:00	
PM Peaks	1749	1799	1656	1722		1724			1724	

EB 23471
WB 22161
COMB AWD 45632
FAC .96 (.96)
COMB ADT 42,100

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1 Page: 1
Starting: 4/11/2016

STA. 4 WB

Site Reference: 160100000521
Site ID: 000000000404
Location: RTE. 114, WEST OF ESQUIRE DR.
Direction: WEST

File: V4-04.prn
City: PEABODY
County: VOL WB

TIME	MON 11	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		98	83	116	101	99			99	398
02:00		52	78	72	98	75			75	300
03:00		51	56	63	58	57			57	228
04:00		75	75	65	72	71			71	287
05:00		191	175	193	192	187			187	751
06:00		609	628	662	624	630			630	2523
07:00		1349	1330	1338	1258	1318			1318	5275
08:00		1733	1707	1663	1614	1679			1679	6717
09:00		1607	1666	1696	1576	1636			1636	6545
10:00		1373	1311	1323	1339	1336			1336	5346
11:00		1318	1235	1266		1273			1273	3819
12:00	1226	1332	1270	1439		1316			1316	5267
13:00	1263	1311	1293	1374		1310			1310	5241
14:00	1211	1246	1339	1269		1266			1266	5065
15:00	1322	1363	1442	1396		1380			1380	5523
16:00	1554	1486	1542	1565		1536			1536	6147
17:00	1456	1542	1549	1471		1504			1504	6018
18:00	1403	1305	1515	1464		1421			1421	5687
19:00	1166	1106	1179	1242		1173			1173	4693
20:00	891	972	1036	1047		986			986	3946
21:00	614	705	769	793		720			720	2881
22:00	557	579	628	632		599			599	2396
23:00	330	373	380	408		372			372	1491
24:00	191	231	226	222		217			217	870
TOTALS	13184	22007	22512	22779	6932	22161	0	0	22161	87414
% AVG WKDY	59.4	99.3	101.5	102.7	31.2					
% AVG WEEK	59.4	99.3	101.5	102.7	31.2					
AM Times	12:00	08:00	08:00	09:00	08:00	08:00			08:00	
AM Peaks	1226	1733	1707	1696	1614	1679			1679	
PM Times	16:00	17:00	17:00	16:00		16:00			16:00	
PM Peaks	1554	1542	1549	1565		1536			1536	

Spot Speed Survey

MassDOT Highway Division
SPEED SUMMARY
Mon 4/11/2016

STA. 2 EB

Site Reference: 160100000884
Site ID: 110000000203
Location: RTE. 114, EAST OF VIOLET RD.
Direction: EAST
Lane: 1

1 - LANE ONLY

File: CLC2-03.prn
City: PEABODY
County: CLASS EB

TIME	19	24	29	34	39	44	49	54	59	64	69	74	79	85	86+	Tota
12:00	27	53	258	250	90	18	5	0	0	0	0	0	0	0	0	701
13:00	16	89	228	305	85	16	0	0	0	0	0	0	0	0	0	739
14:00	30	114	291	263	105	8	1	0	0	0	0	0	0	0	0	812
15:00	74	132	333	229	63	9	1	0	0	0	0	0	0	0	0	841
16:00	189	137	247	197	38	4	0	0	0	0	0	0	0	0	0	812
17:00	573	3	0	0	0	0	0	0	0	0	0	0	0	0	0	576
18:00	514	7	1	0	0	0	0	0	0	0	0	0	0	0	0	522
19:00	99	152	276	179	61	9	0	0	0	0	0	0	0	0	0	776
20:00	4	55	226	262	87	11	7	0	0	1	0	0	0	0	0	653
21:00	1	27	137	294	151	25	6	0	0	0	0	0	0	0	0	641
22:00	2	6	87	226	145	35	4	1	0	0	0	0	0	0	0	506
23:00	1	0	34	124	130	45	14	0	0	0	0	0	0	0	0	348
24:00	1	2	22	91	81	38	7	0	0	0	0	0	0	0	0	242
DAY TOTAL	1531	777	2140	2420	1036	218	45	1	0	1	0	0	0	0	0	8169
PERCENTS	18.8%	9.6%	26.2%	29.7%	12.6%	2.6%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%

Statistical Information...

15th Percentile Speed
15.2 mph

85th Percentile Speed
34.4 mph

Median Speed
28.2 mph

Average Speed
26.1 mph

10 MPH Pace Speed
24 mph to 34 mph
4560 vehicles in pace
Representing 55.8% of the total vehicles

Vehicles > 65 MPH
0
0.0%

Site Reference: 160100000884
Site ID: 110000000203
Location: RTE. 114, EAST OF VIOLET RD.
Direction: EAST
Lane: 1

File: CLC2-03.prn
City: PEABODY
County: CLASS EB

TIME	19	24	29	34	39	44	49	54	59	64	69	74	79	85	86+	Tota
01:00	1	1	2	36	38	19	5	0	1	0	1	0	0	0	0	104
02:00	0	1	0	24	22	7	4	0	0	0	0	0	0	0	0	58
03:00	0	0	3	7	20	3	3	0	0	0	0	0	0	0	0	36
04:00	0	1	3	8	11	3	3	1	0	0	0	0	0	0	0	30
05:00	1	0	4	5	14	7	2	2	0	0	0	0	0	0	0	35
06:00	5	3	21	67	68	19	3	0	0	0	0	0	0	0	0	186
07:00	7	11	103	216	130	46	7	2	0	0	0	0	0	0	0	522
08:00	23	96	295	284	79	12	1	0	0	0	0	0	0	0	0	790
09:00	50	134	317	226	83	17	1	0	0	0	0	0	0	0	0	828
10:00	17	102	260	253	101	13	0	0	0	0	0	0	0	0	0	746
11:00	32	100	266	230	72	9	1	0	0	0	0	0	0	0	0	710
12:00	14	95	314	255	64	9	0	0	0	0	0	0	0	0	0	751
13:00	12	105	298	275	77	5	1	0	0	0	0	0	0	0	0	773
14:00	17	103	310	291	63	12	0	0	0	0	0	0	0	0	0	796
15:00	69	172	327	227	60	6	0	0	0	0	0	0	0	0	0	861
16:00	160	193	276	126	41	3	2	0	0	0	0	0	0	0	0	801
17:00	505	100	43	10	0	0	0	0	0	0	0	0	0	0	0	658
18:00	372	144	116	48	6	2	0	0	0	0	0	0	0	0	0	688
19:00	133	102	227	248	66	11	2	0	0	0	0	0	0	0	0	789
20:00	12	40	265	262	105	21	1	0	0	0	0	0	0	0	0	706
21:00	9	23	153	271	160	24	6	2	1	0	0	0	0	0	0	649
22:00	3	17	88	245	153	26	7	1	1	0	0	0	0	0	0	541
23:00	3	3	31	130	136	28	18	4	0	0	0	0	0	0	0	353
24:00	2	1	14	67	92	40	9	3	0	0	0	0	0	0	0	228
DAY TOTAL	1447	1547	3736	3811	1661	342	76	15	3	0	1	0	0	0	0	12639
PERCENTS	11.5%	12.3%	29.6%	30.1%	13.1%	2.7%	0.6%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%

Statistical Information...

15th Percentile Speed
20.5 mph

85th Percentile Speed
34.6 mph

Median Speed
28.5 mph

Average Speed
27.3 mph

10 MPH Pace Speed
24 mph to 34 mph
7547 vehicles in pace
Representing 59.7% of the total vehicles

Vehicles > 65 MPH
1
0.0%

MassDOT Highway Division
SPEED SUMMARY
Wed 4/13/2016

Site Reference: 160100000884
Site ID: 110000000203
Location: RTE. 114, EAST OF VIOLET RD.
Direction: EAST
Lane: 1

File: CLC2-03.prn
City: PEABODY
County: CLASS EB

TIME	19	24	29	34	39	44	49	54	59	64	69	74	79	85	86+	Tota
01:00	1	0	6	41	37	9	3	2	0	0	0	0	0	0	0	99
02:00	0	1	4	19	21	8	4	1	0	0	0	0	0	0	0	58
03:00	0	0	1	8	6	3	0	0	0	0	0	0	0	0	0	18
04:00	1	1	1	8	7	4	1	0	0	0	0	0	0	0	0	23
05:00	0	1	3	9	22	8	1	1	0	0	0	0	0	0	0	45
06:00	3	6	19	41	89	31	8	1	0	0	0	0	0	0	0	198
07:00	10	23	70	183	141	45	15	0	0	0	0	0	0	0	0	487
08:00	30	95	270	275	120	16	5	0	0	0	0	0	0	0	0	811
09:00	26	94	283	278	122	23	2	0	0	0	0	0	0	0	0	828
10:00	25	65	283	265	103	26	5	0	0	0	0	0	0	0	0	772
11:00	18	87	254	213	105	22	3	2	0	0	0	0	0	0	0	704
12:00	34	105	255	237	78	8	0	0	0	0	0	0	0	0	0	717
13:00	27	98	285	236	88	12	0	1	0	0	0	0	0	0	0	747
14:00	15	105	337	229	94	14	0	0	0	0	0	0	0	0	0	794
15:00	78	167	341	215	65	9	2	1	0	0	0	0	0	0	0	878
16:00	191	227	250	97	32	0	1	0	0	0	0	0	0	0	0	798
17:00	43	175	338	257	66	8	2	0	0	0	0	0	0	0	0	889
18:00	378	72	146	66	7	0	0	0	0	0	0	0	0	0	0	669
19:00	10	140	362	221	79	13	1	0	0	0	0	0	0	0	0	826
20:00	5	71	253	300	125	20	2	0	0	0	0	0	0	0	0	776
21:00	5	43	215	295	117	18	5	2	0	0	0	0	0	0	0	700
22:00	5	6	118	257	142	33	5	2	0	0	0	0	0	0	0	568
23:00	0	3	35	145	145	39	11	2	0	1	1	0	0	0	0	382
24:00	1	2	14	113	90	23	10	0	0	0	0	0	0	0	0	253
DAY TOTAL	906	1587	4143	4008	1901	392	86	15	0	1	1	0	0	0	0	13040
PERCENTS	7.0%	12.2%	31.8%	30.8%	14.5%	3.0%	0.6%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%

Statistical Information...

15th Percentile Speed
22.3 mph

85th Percentile Speed
35.2 mph

Median Speed
28.9 mph

Average Speed
28.3 mph

10 MPH Pace Speed
24 mph to 34 mph
8151 vehicles in pace
Representing 62.5% of the total vehicles

Vehicles > 65 MPH
1
0.0%

Site Reference: 160100000884
Site ID: 110000000203
Location: RTE. 114, EAST OF VIOLET RD.
Direction: EAST
Lane: 1

File: CLC2-03.prn
City: PEABODY
County: CLASS EB

TIME	19	24	29	34	39	44	49	54	59	64	69	74	79	85	86+	Tota
01:00	0	1	4	45	54	15	10	0	0	0	0	0	0	0	0	129
02:00	0	0	3	9	26	14	4	0	1	0	0	0	0	0	0	57
03:00	0	0	4	10	8	5	1	2	0	0	0	0	0	0	0	30
04:00	0	0	1	5	15	6	1	0	0	0	0	0	0	0	0	28
05:00	0	0	11	11	12	10	2	1	0	0	0	0	0	0	0	47
06:00	0	0	25	66	76	31	1	0	1	0	0	0	0	0	0	200
07:00	10	18	119	202	120	50	11	1	0	0	0	0	0	0	0	531
08:00	29	68	282	285	118	28	4	0	0	0	0	0	0	0	0	814
09:00	40	161	296	256	74	11	1	0	0	0	0	1	0	0	0	840
10:00	10	50	270	276	132	19	3	0	0	0	0	0	0	0	0	760
11:00	35	92	238	242	102	19	0	1	0	0	0	0	0	0	0	729
12:00	38	149	296	219	72	12	0	0	0	0	0	0	0	0	0	786
13:00	25	101	299	279	75	11	2	2	0	0	0	0	0	0	0	794
14:00	16	85	371	267	112	12	3	0	0	0	0	0	0	0	0	866
15:00	222	217	285	100	14	4	0	0	0	0	0	0	0	0	0	842
16:00	471	57	28	10	0	0	0	0	0	0	0	0	0	0	0	566
17:00	515	5	0	0	0	0	0	0	0	0	0	0	0	0	0	520
18:00	565	8	0	0	0	0	0	0	0	0	0	0	0	0	0	573
19:00	406	58	107	68	8	0	0	0	0	0	0	0	0	0	0	647
20:00	23	59	250	297	120	14	1	0	0	0	0	0	0	0	0	764
21:00	5	26	234	310	107	19	7	0	0	0	0	0	0	0	0	708
22:00	1	32	123	249	161	29	8	1	0	0	0	0	0	0	0	604
23:00	2	1	43	162	144	38	6	1	0	0	0	0	0	0	0	397
24:00	3	3	26	83	92	22	9	2	0	0	0	0	0	0	0	240
DAY TOTAL	2416	1191	3315	3451	1642	369	74	11	2	0	0	1	0	0	0	12472
PERCENTS	19.4%	9.6%	26.6%	27.7%	13.2%	3.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%

Statistical Information...

15th Percentile Speed
14.7 mph

85th Percentile Speed
34.7 mph

Median Speed
28.0 mph

Average Speed
26.0 mph

10 MPH Pace Speed
24 mph to 34 mph
6766 vehicles in pace
Representing 54.2% of the total vehicles

Vehicles > 65 MPH
1
0.0%

Site Reference: 160100000884
Site ID: 110000000203
Location: RTE. 114, EAST OF VIOLET RD.
Direction: EAST
Lane: 1

File: CLC2-03.prn
City: PEABODY
County: CLASS EB

TIME	19	24	29	34	39	44	49	54	59	64	69	74	79	85	86+	Tota
01:00	1	0	5	34	53	27	5	3	0	0	0	0	0	0	0	128
02:00	0	1	1	16	32	10	5	0	0	0	0	0	0	0	0	65
03:00	0	0	0	15	8	4	0	0	0	0	0	0	0	0	0	27
04:00	1	0	2	6	8	4	2	1	0	0	0	0	0	0	0	24
05:00	1	0	10	8	19	5	3	0	1	0	0	0	0	0	0	47
06:00	2	1	15	66	71	40	5	1	0	0	0	0	0	0	0	201
07:00	7	15	86	188	158	37	5	0	0	0	0	0	0	0	0	496
08:00	29	59	232	269	121	18	2	0	0	0	0	0	0	0	0	730
09:00	46	76	290	356	102	2	1	0	0	0	0	0	0	0	0	873
10:00	8	85	273	297	87	16	6	1	0	0	0	0	0	0	0	773
DAY TOTAL	95	237	914	1255	659	163	34	6	1	0	0	0	0	0	0	3364
PERCENTS	2.9%	7.1%	27.2%	37.4%	19.5%	4.8%	1.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%

Statistical Information...

15th Percentile Speed
25.0 mph

85th Percentile Speed
36.7 mph

Median Speed
30.7 mph

Average Speed
30.5 mph

10 MPH Pace Speed
24 mph to 34 mph
2169 vehicles in pace
Representing 64.4% of the total vehicles

Vehicles > 65 MPH
0
0.0%

Signal Timing and Phase Plan

ELECTRIC LIGHT
COMPANY INC.

ANDOVER AND ESQUIRE

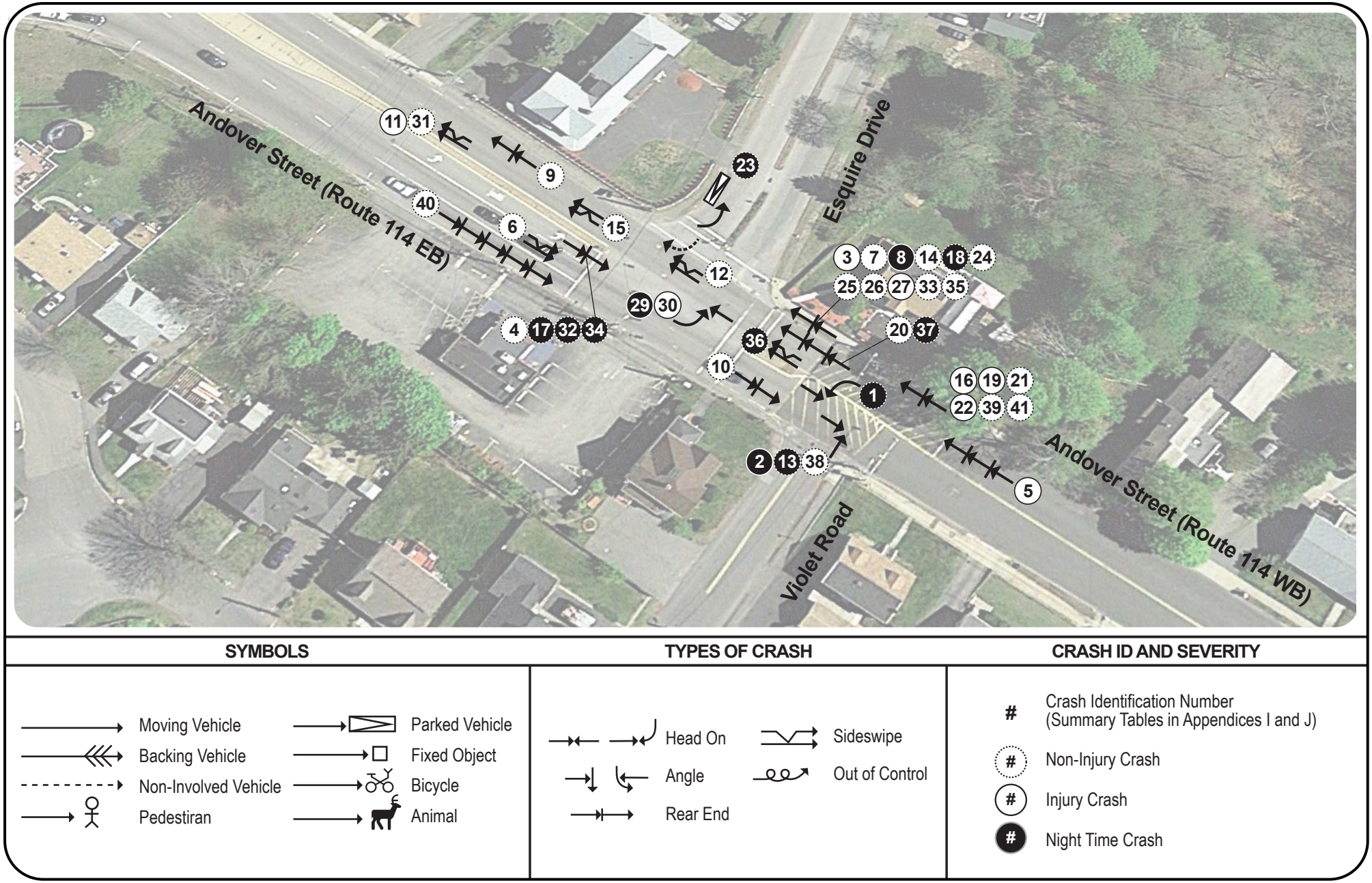
Phase	1	2	3	4	7
MGR	4	12	8	5	
PSG	3	2	3	4	
YEL	4	4	4	4	
RED	2	2	2	2	
MX 1	15	30	15	10	
MX 2	30	40	30	30	
WLK					8
PCL					12

PHASE

1 EB / LEFT TURN
2 EB / WB
3 ESQUIRE
4 VIOLET
7 PEDS

Appendix C: Crash Data and Analysis

Collision Diagram and Crash Statistics



BOSTON REGION MPO

Figure 4
Collision Diagram: Andover Street (Route 114) at Esquire Drive and Violet Road
Peabody Police Reports: January 2013–December 2015

Safety and Operations Analyses at Selected Intersections

Crash Data Summary Table

Andover Street (Route 114) at Esquire Street, Peabody, MA

1/1/2013 - 12/31/2015

Crash Diagram Ref #	Crash Date	Crash Day	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	Ages				Comments
	m/d/y			*Type*	*Type*	*Type*	*Type*	*Type*	*D1*	*D2*	*D3*	*D4*	
1	1/11/13	Friday	8:13 PM	Angle	Dark - lighted roadway	Rain	Wet	Failed to yield right of way	22	20			MV1 TRAVELLING STRAIGHT, EB, ON ANDOVER STREET WHEN MV2 MADE LEFT TURN, SB, ONTO VIOLET ROAD. MV2 FAILED TO YIELD RIGHT OF WAY.
2	3/5/13	Tuesday	8:31 PM	Angle	Dark - lighted roadway	Cloudy	Dry	Operating Vehicle in erratic, reckless, careless, negligent, or aggressive manner	23	20			MV1 EB ON ANDOVER AND RAN TWO CONSECUTIVE RED LIGHTS. MV2 WAS NB OUT OF VIOLET WITH GREEN LIGHT. MV1 HITS MV2.
3	3/8/13	Friday	11:54 AM	Rear-end	Daylight	Snow	Snow	Swerving or avoiding due to wind, slippery surface, vehicle, object, non-motorist in roadway, etc.	41	25			MV1 WB ON ANDOVER ST. MV2 STOPPED AT RED LIGHT AT ESQUIRE, MV1 COULDN'T STOP PROPERLY DUE TO SNOW, REAR-ENDED MV2.
4	5/23/13	Thursday	5:46 PM	Rear-end	Daylight	Clear	Dry	Inattention	65	23			NO NARRATIVE
5	8/6/13	Tuesday	10:33 AM	Rear-end	Daylight	Clear	Dry	Unknown	79	25	22		MV1 STOPPED AT SIGNAL, MV2 WAS BEHIND MV1 CHANGING INTO LEFT LANE. MV3 REAR-ENDED BOTH MV1 AND MV2. MV3 CLAIMS MV2 CHANGED LANES DIRECTLY IN FRONT OF MV3.
6	8/9/13	Friday	3:51 PM	Sideswipe, same direction	Daylight	Cloudy	Wet	Distracted	50	59			MV1 AND MV2 WB ON ANDOVER ST. UNK MV TURNING LEFT ONTO VIOLET. MV2 ATTEMPTED LANE CHANGE AND COLLIDED WITH MV1.
7	9/3/13	Tuesday	8:06 AM	Rear-end	Daylight	Clear	Dry	Followed too closely	54	47			MV1 AND MV2 EB ON ANDOVER ST. SECOND SIGNAL TURNED RED AND MV2 DID NOT REALIZE MV1 STOPPED AT LIGHT, REAR-ENDING MV1.
8	9/9/13	Monday	7:23 PM	Rear-end	Dark - lighted roadway	Cloudy	Dry	Followed too closely	22	49			MV1 AND MV2 WB ON ANDOVER ST. MV1 REAR-ENDED BY MV2 WHEN SIGNAL WAS TURNING RED.
9	9/27/13	Friday	12:40 PM	Rear-end	Daylight	Cloudy	Dry	Swerving or avoiding due to wind, slippery surface, vehicle, object, non-motorist in roadway, etc.	30	24			MV1 AND MV2 WB ON ANDOVER ST. MV2 WAS REAR-ENDED BY MV1. BUS CUT OFF MV2 CAUSING SUDDEN HALT.
10	10/4/13	Friday	12:17 PM	Rear-end	Daylight	Rain	Wet	Followed too closely	19	28			MV1 STOPPED AT SIGNAL. MV2 REAR-ENDED MV1, CLAIMS DIDN'T SEE MV1 STOPPED.
11	10/19/13	Saturday	12:11 PM	Sideswipe, same direction	Daylight	Clear	Dry	Failure to keep in proper lane or running off road	43	63			MV1 AND MV2 WB ON ANDOVER ST. MV2 ATTEMPTED TO CHANGE LANES BUT DID NOT NOTICE MV1 IN DESIRED LANE.
12	11/1/13	Friday	7:37 AM	Sideswipe, same direction	Daylight	Clear	Dry	Other improper action	19	44	60		MV1 AND MV2 WB ON ANDOVER ST. MV3 PULLED OUT FROM ESQUIRE INTO MV2'S LANE. MV2 SWERVED TO AVOID MV3 BUT HIT MV1.
13	11/4/13	Monday	7:15 PM	Angle	Dark - lighted roadway	Cloudy	Dry	Other improper action	56	34			MV1 EB ON ANDOVER, FAILED TO STOP FOR RED SIGNAL. MV2 NB FROM VIOLET WITH GREEN, WAS STRUCK BY MV1.
14	11/7/13	Thursday	12:37 PM	Rear-end	Daylight	Rain	Wet	Unknown	29	56			MV1 AND MV2 WB ON ANDOVER ST. MV1SPED UP TO MAKE FIRST LIGHT THEN STOP AT SECOND LIGHT. MV2, FOLLOWING MV1, BELIEVED MV1 WAS GOING THROUGH BOTH LIGHTS, REAR-ENDED MV1.
15	11/13/13	Wednesday	7:38 AM	Sideswipe, same direction	Daylight	Clear	Dry	Swerving or avoiding due to wind, slippery surface, vehicle, object, non-motorist in roadway, etc.	36	47			MV1 WB SWERVED TO AVOID A COLLISION, HIT MV2 IN NEXT LANE, THEN COLLIDED WITH MV2 IN REAR. MV1 CLAIMS TRYING TO AVOID UNKNOWN VEHICLE.
16	11/18/13	Monday	8:47 AM	Rear-end	Daylight	Cloudy	Wet	Followed too closely	42	24			MV1 AND MV2 WB ON ANDOVER ST. UNKNOWN MV STOPPED SUDDENLY IN FRONT OF MVS. MV2 COULD NOT REACT IN TIME, REAR-ENDED MV1.
17	12/28/13	Saturday	10:19 PM	Rear-end	Dark - lighted roadway	Clear	Dry	Followed too closely	50	21			MV1 AND MV2 EB ON ANDOVER ST. MV1 STOPPED AT RED SIGNAL, MV2 REAR-ENDED MV1.
18	3/21/14	Friday	9:30 PM	Rear-end	Dark - lighted roadway	Cloudy	Dry	Followed too closely	17	26			MV1 AND MV2 WB ON ANDOVER ST, MV1 FAILED TO STOP BEHIND MV2, WHO WAS STOPPED AT RED SIGNAL.
19	3/23/14	Sunday	6:54 PM	Rear-end	Dusk	Clear	Sand, mud, dirt, oil, gravel	Inattention	37	26			MV1 AND MV2 STOPPED AT SIGNAL IN FRONT OF VIOLET, WB. SIGNAL IN FRONT OF ESQUIRE TURNED GREEN AND MV2 BEGAN TO MOVE BUT MV1 DID NOT CAUSING MV2 TO REAR-END MV1.
20	3/26/14	Wednesday	1:11 PM	Rear-end	Daylight	Clear	Dry	No Improper Driving	64	30	45		MV1, MV2 AND MV3 WB ON ANDOVER BEFORE ESQUIRE. MV1 AND MV2 STOPPED FOR RED SIGNAL. MV3 REAR-ENDED MV2 CAUSING CHAIN REACTION.
21	4/23/14	Wednesday	3:00 PM	Rear-end	Daylight	Clear	Dry	Followed too closely	24	57			MV1 AND MV2 WB ON ANDOVER AT VIOLET. MV2 STOPPED DUE TO RED SIGNAL, MV1 COULD NOT STOP IN TIME, REAR-ENDED MV2.
22	5/16/14	Friday	10:39 PM	Rear-end	Dark - lighted roadway	Rain	Wet	Inattention	32	59			MV1 STOPPED AT FIRST SET OF LIGHTS WHEN MV2 REAR-ENDED MV1. WB ACROSS FROM VIOLET.
23	5/16/14	Friday	10:53 PM	Angle	Dark - lighted roadway	Clear	Dry	Over-correcting/over-steering	46	24			MV2 MADE LEFT TURN ONTO ESQUIRE, SIDESWIPING A PARKED MV1.
24	5/28/14	Wednesday	3:08 PM	Rear-end	Daylight	Rain	Wet	Followed too closely	37	73			MV1 AND MV2 WB AT ESQUIRE SIGNAL. MV1 STOPPED SHORT, CAUSING MV2 TO REAR-END MV1.

Crash Data Summary Table

Andover Street (Route 114) at Esquire Street, Peabody, MA

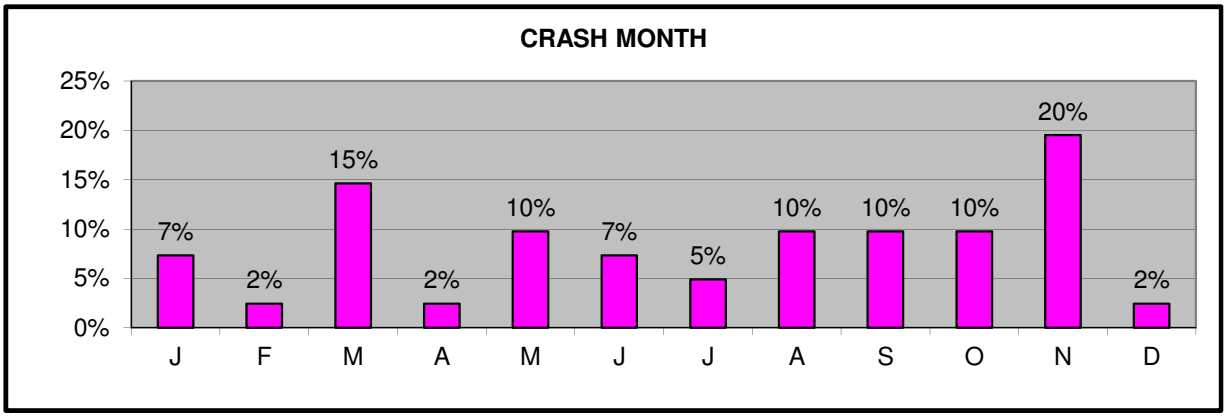
1/1/2013 - 12/31/2015

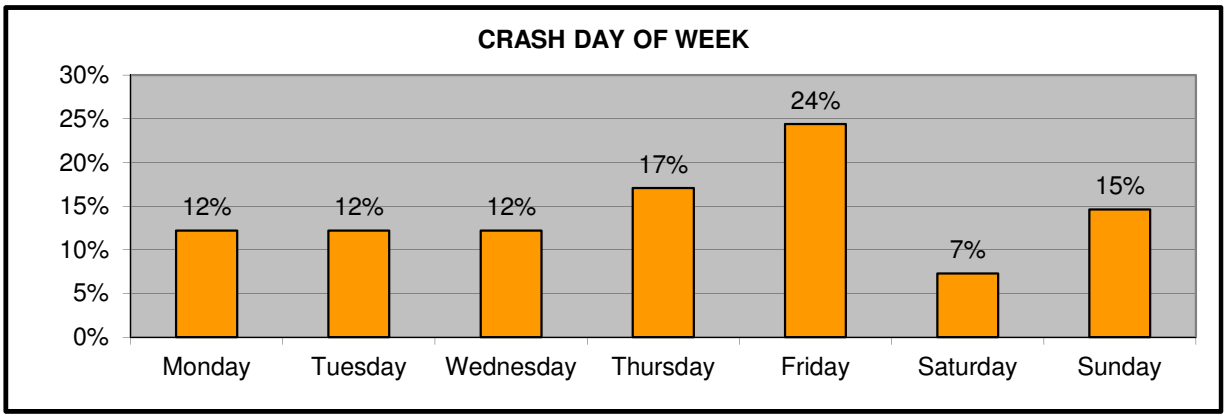
Crash Diagram Ref #	Crash Date	Crash Day	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	Ages				Comments
	m/d/y			*Type*	*Type*	*Type*	*Type*	*Type*	*D1*	*D2*	*D3*	*D4*	
25	7/27/14	Sunday	10:55 AM	Rear-end	Daylight	Clear	Dry	No Improper Driving	21	56			MV1 AND MV2 WB AT ESQUIRE SIGNAL. MV1 STOPPED AT RED LIGHT WHEN MV2 REAR-ENDED MV1.
26	7/28/14	Monday	8:07 AM	Rear-end	Daylight	Rain	Wet	No Improper Driving	32	66			MV1 WB, STOPPED AT SECOND LIGHT AFTER FIRST LIGHT TURNED YELLOW. MV2 REAR-ENDED MV1 AT RED LIGHT AFTER PROCEEDING THROUGH FIRST YELLOW LIGHT.
27	8/19/14	Tuesday	1:22 PM	Rear-end	Daylight	Clear	Dry	Inattention	53	21			MV2 WB, STOPPED AT ESQUIRE RED SIGNAL. MV1 REAR-ENDED MV2
28	8/19/14	Tuesday	6:17 PM	Rear-end	Daylight	Clear	Dry	Operating Vehicle in erratic, reckless, careless, negligent, or aggressive manner	30	28			MV1 STOPPED AT RED SIGNAL, WB ON ANDOVER ST, REAR-ENDED BY MV2. MV2 WAS UNCONSCIOUS.
29	9/27/14	Saturday	11:02 PM	Angle	Dark - lighted roadway	Cloudy	Dry	Unknown	34	24			MV1 EB ON ANDOVER MAKING LEFT TURN ONTO ESQUIRE. MV2 WB WITH GREEN LIGHT. WITNESS STATES LEFT TURN WAS RED.
30	10/9/14	Thursday	8:08 AM	Angle	Daylight	Clear	Dry	Operating Vehicle in erratic, reckless, careless, negligent, or aggressive manner	23	68			MV1 ATTEMPTING LEFT TURN ONTO ESQUIRE WITH GREEN TURN SIGNAL. MV2 WB RAN RED SIGNAL, COLLISION IN INTERSECTION.
31	11/13/14	Thursday	10:27 AM	Sideswipe, same direction	Daylight	Clear	Dry	Inattention	60	23			MV1 AND MV2 WB ON ANDOVER ST. MV2 ATTEMPTED TO CHANGE LANES BUT DID NOT NOTICE MV1 IN DESIRED LANE.
32	11/23/14	Sunday	6:32 PM	Rear-end	Dark - lighted roadway	Clear	Dry	No Improper Driving	56	19			MV1 EB STOPPED AT RED LIGHT. MV2 REAR-ENDED MV1, TRIED SWERVING BUT COULD NOT AVOID MV1.
33	11/28/14	Friday	12:34 PM	Rear-end	Daylight	Cloudy	Wet	No Improper Driving	23	55			MV1 STOPPING AT RED SIGNAL, REAR-ENDED BY MV2. MV2 HAD TROUBLES STOPPING DUE TO ROAD CONDITIONS.
34	1/4/15	Sunday	6:22 PM	Rear-end	Dark - lighted roadway	Cloudy	Wet	No Improper Driving	32	20			MV1 STOPPED AT RED LIGHT WHEN REAR-ENDED BY MV2. SLICK ROAD CONDITIONS.
35	1/21/15	Wednesday	9:48 AM	Rear-end	Daylight	Cloudy	Dry	Inattention	53	48			MV1 AND MV2 WB. MV1 STOPPED DUE TO TRAFFIC, MV2 DIDN'T NOTICE MV1 STOPPING AND REAR-ENDED MV1.
36	2/22/15	Sunday	4:14 AM	Sideswipe, same direction	Dark - lighted roadway	Clear	Ice	No Improper Driving	32	29			WB, MV2 SWERVED INTO SIDE OF MV1.
37	3/5/15	Thursday	7:15 PM	Rear-end	Dark - lighted roadway	Clear	Dry	Physical Impairment	33	18	44		MV3 REAR-ENDED MV2, WHICH REAR-ENDED MV1. WB ON ANDOVER BEFORE ESQUIRE SIGNAL.
38	6/18/15	Thursday	1:48 PM	Angle	Daylight	Other	Dry	Physical Impairment	58	57			MV1 EB ON ANDOVER. MV2 EXITING VIOLET WITHOUT YIELDING TO TRAFFIC. MV2 STRUCK MV1 WHICH COLLIDED WITH AN ADDITIONAL MV ON OPPOSITE SIDE OF STREET.
39	6/28/15	Sunday	1:52 PM	Rear-end	Daylight	Rain	Dry	Unknown	47	26			MV1 AND MV2 WB. MV1 CLAIMED TO STOP SHORT DUE TO UNK MV IN FRONT. MV2 COULD NOT STOP IN TIME AND REAR-ENDED MV1.
40	6/29/15	Monday	3:17 PM	Rear-end	Daylight	Clear	Dry	Operating Vehicle in erratic, reckless, careless, negligent, or aggressive manner	54	38	42	27	5 MV CRASH. MV5 REAR-ENDED MV4 CAUSING A CHAIN COLLISION. ALL 4 MVS STOPPED OR STOPPING AT SIGNAL, EB. MV5-OUI, AGE 45
41	10/29/15	Thursday	7:02 AM	Rear-end	Daylight	Rain	Wet	Unknown	68	22			MV1 WB STOPPING AT RED SIGNAL. MV2 REAR-ENDED MV1.

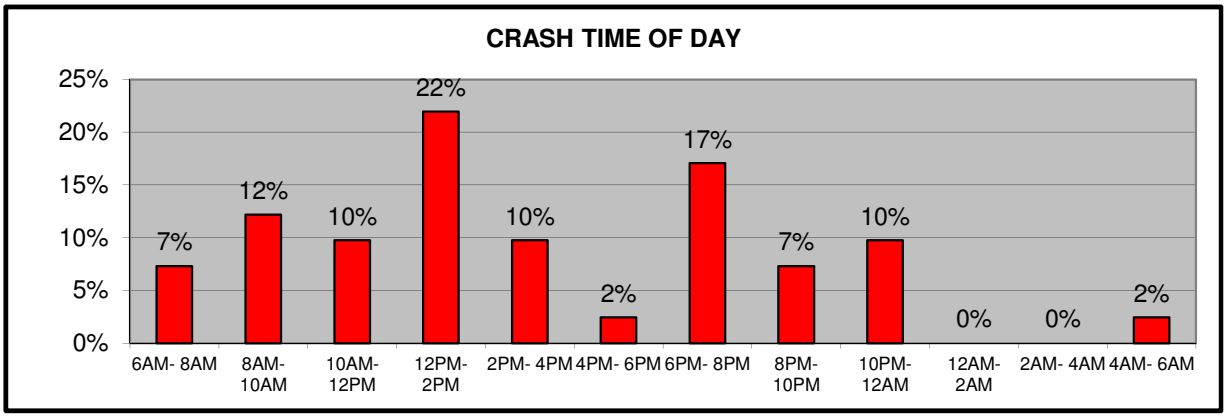
Summary based on Crash Reports obtained from the Local Police

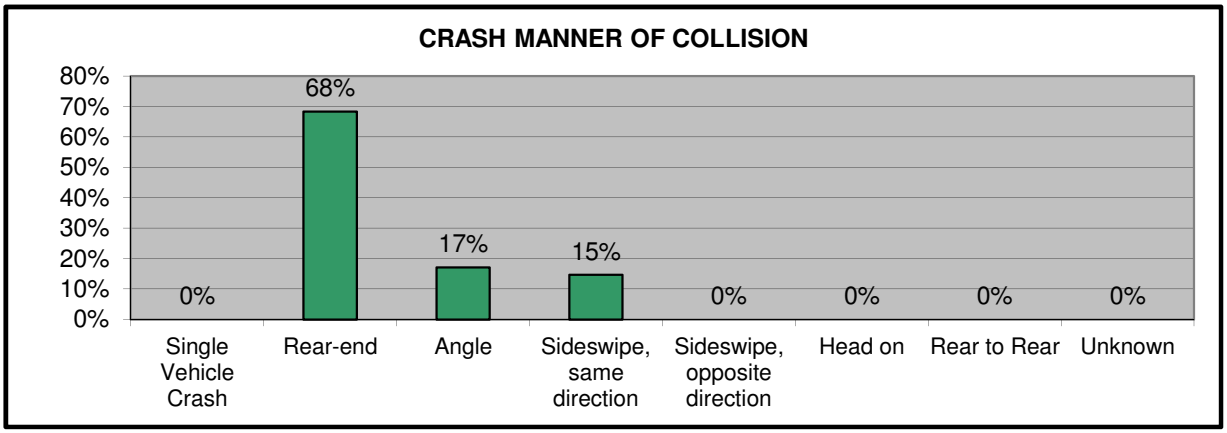
Crash Data Summary Tables and Charts

Andover Street (Route 114) at Esquire Street, Peabody, MA



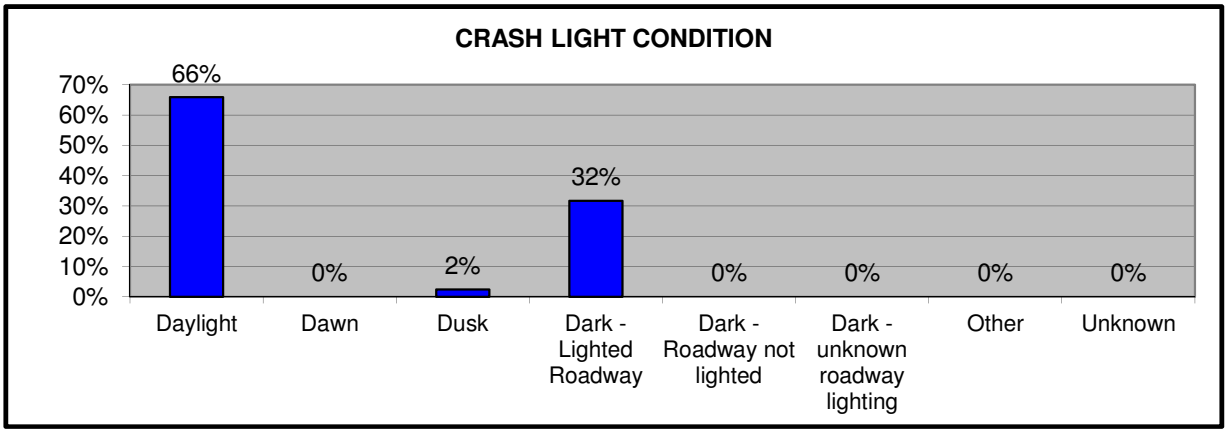


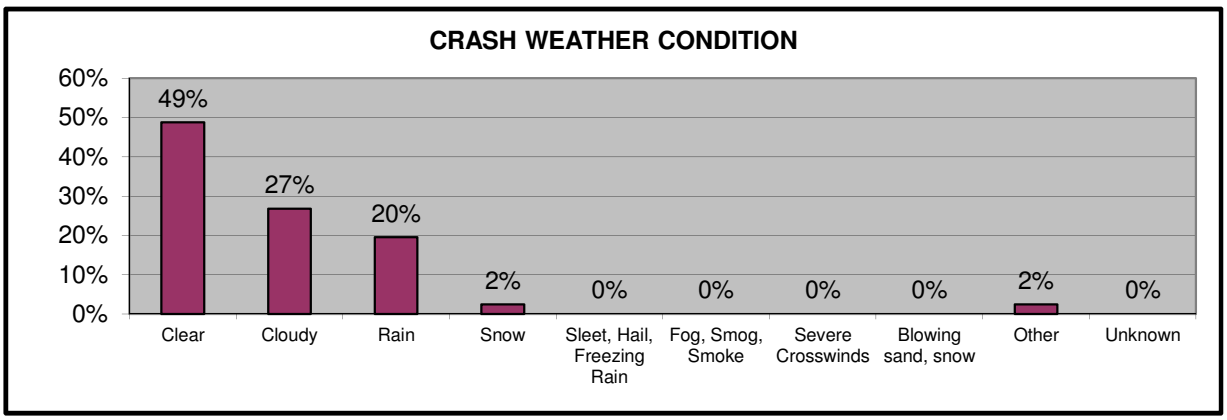


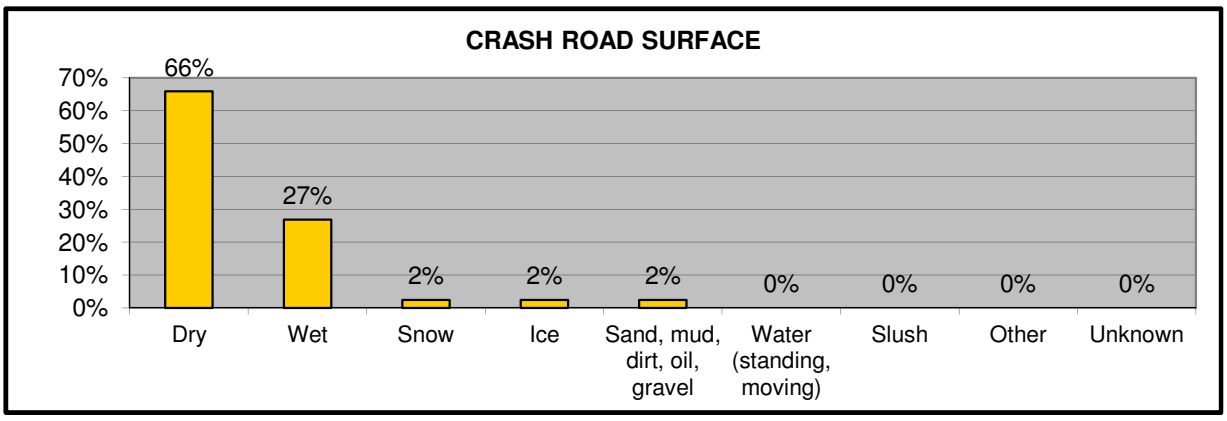


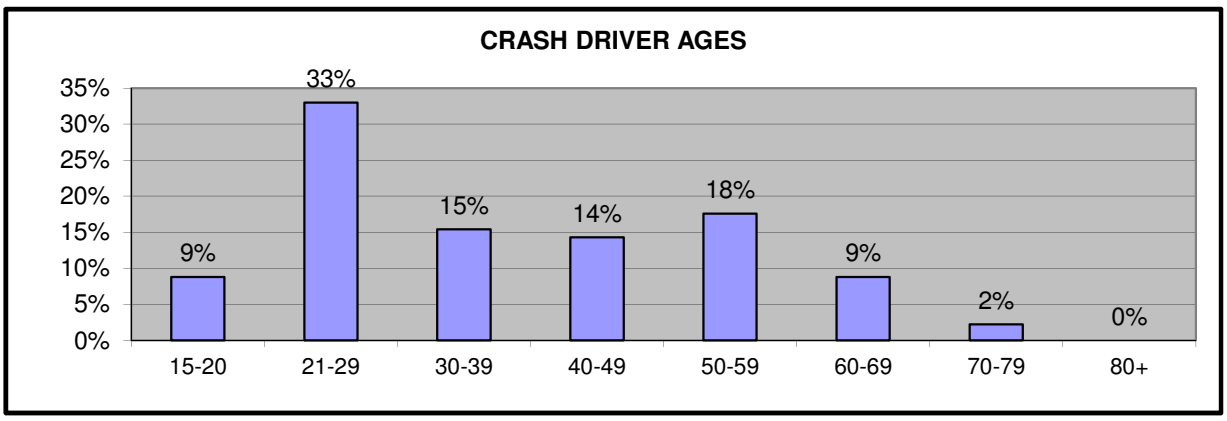
Crash Data Summary Tables and Charts

Andover Street (Route 114) at Esquire Street, Peabody, MA









Intersection Crash Rate

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Peabody COUNT DATE : April 2016

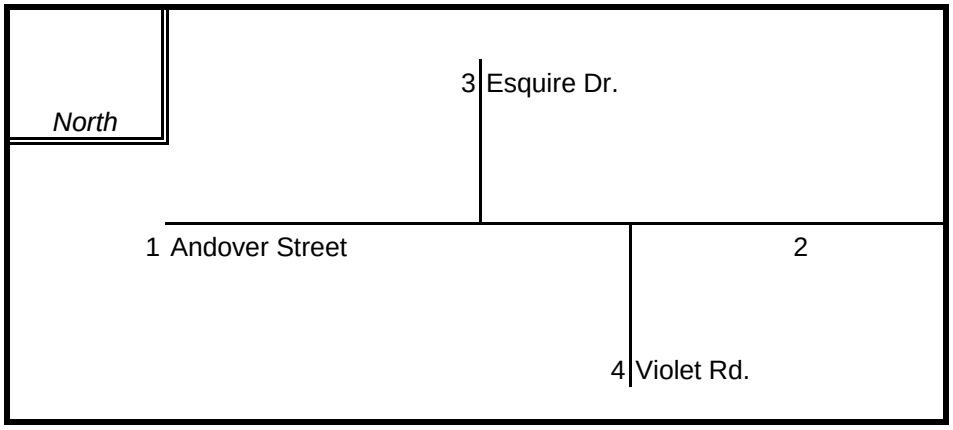
DISTRICT : 4 UNSIGNALIZED : SIGNALIZED : X

~ INTERSECTION DATA ~

MAJOR STREET : Andover Street (Route 114)

MINOR STREET(S) : Esquire Drive and Violet Road

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	EB	WB	SB	NB		
PEAK HOURLY VOLUMES (AM/PM) :	1,493	1,464	69	28		**3,054**

" K " FACTOR : **0.084** INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **36,357**

TOTAL # OF CRASHES : 41 # OF YEARS : 3 AVERAGE # OF CRASHES PER YEAR (**A**) : **13.67**

CRASH RATE CALCULATION : **1.03** RATE = $\frac{(A * 1{,}000{,}000)}{(V * 365)}$

Comments :

Project Title & Date:

Appendix D: Intersection Levels of Service

2016 Existing Conditions Analysis

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	22	1321	0	0	1754	17	0	0	0	22	0	58
Future Volume (vph)	22	1321	0	0	1754	17	0	0	0	22	0	58
Satd. Flow (prot)	1678	3002	0	0	2999	0	0	0	0	0	1571	0
Flt Permitted	0.950										0.986	
Satd. Flow (perm)	1678	3002	0	0	2999	0	0	0	0	0	1571	0
Satd. Flow (RTOR)					1							
Lane Group Flow (vph)	23	1362	0	0	1826	0	0	0	0	0	83	0
Turn Type	Prot	NA			NA					Split	NA	
Protected Phases	5	2			6					4	4	
Permitted Phases												
Total Split (s)	15.0	45.0			30.0					15.0	15.0	
Total Lost Time (s)	6.0	6.0			6.0						6.0	
Act Effct Green (s)	6.5	43.9			38.7						8.6	
Actuated g/C Ratio	0.10	0.67			0.59						0.13	
v/c Ratio	0.14	0.68			1.03						0.40	
Control Delay	30.4	12.6			37.8						34.2	
Queue Delay	0.0	0.0			1.7						0.6	
Total Delay	30.4	12.6			39.5						34.8	
LOS	C	B			D						C	
Approach Delay		12.9			39.5						34.8	
Approach LOS		B			D						C	
Queue Length 50th (ft)	9	228			~460						34	
Queue Length 95th (ft)	29	320			m#613						73	
Internal Link Dist (ft)		867			34			27			61	
Turn Bay Length (ft)	200											
Base Capacity (vph)	230	2000			1766						215	
Starvation Cap Reductn	0	0			8						0	
Spillback Cap Reductn	0	2			0						26	
Storage Cap Reductn	0	0			0						0	
Reduced v/c Ratio	0.10	0.68			1.04						0.44	

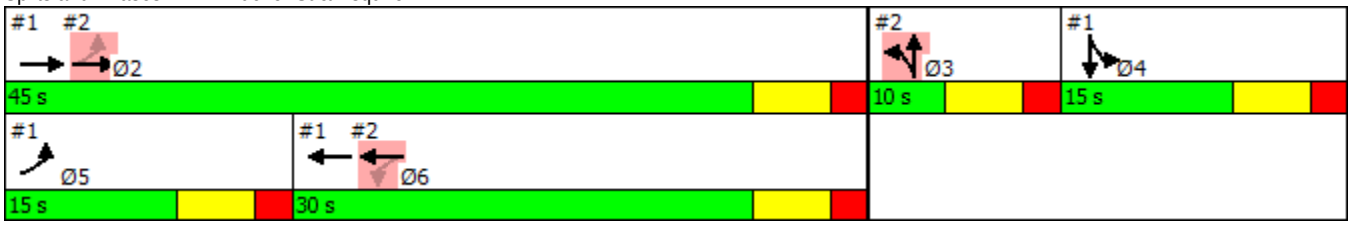
Intersection Summary	
Cycle Length: 70	
Actuated Cycle Length: 65.8	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.03	
Intersection Signal Delay: 28.2	Intersection LOS: C
Intersection Capacity Utilization 71.5%	ICU Level of Service C
Analysis Period (min) 15	

~ 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.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Andover St & Esquire Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1331	12	1	1736	0	47	0	1	0	0	0
Future Volume (vph)	1	1331	12	1	1736	0	47	0	1	0	0	0
Satd. Flow (prot)	0	3352	0	0	3355	0	0	1678	0	0	0	0
Flt Permitted		0.903			0.954			0.953				
Satd. Flow (perm)	0	3027	0	0	3201	0	0	1678	0	0	0	0
Satd. Flow (RTOR)		2						*100				
Lane Group Flow (vph)	0	1385	0	0	1791	0	0	49	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		3	3				
Permitted Phases	2			6								
Total Split (s)	45.0	45.0		30.0	30.0		10.0	10.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		43.9			38.7			4.0				
Actuated g/C Ratio		0.67			0.59			0.06				
v/c Ratio		0.69			0.95			0.25				
Control Delay		3.1			34.3			4.6				
Queue Delay		0.0			1.6			35.8				
Total Delay		3.1			35.9			40.4				
LOS		A			D			D				
Approach Delay		3.1			35.9			40.4				
Approach LOS		A			D			D				
Queue Length 50th (ft)		18			~375			0				
Queue Length 95th (ft)		25			#720			8				
Internal Link Dist (ft)		34			769			120			9	
Turn Bay Length (ft)												
Base Capacity (vph)		2018			1884			196				
Starvation Cap Reductn		23			0			0				
Spillback Cap Reductn		0			33			139				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.69			0.97			0.86				

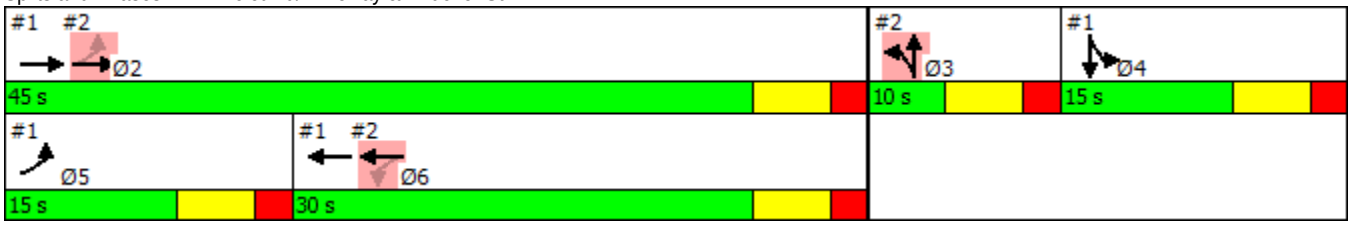
Intersection Summary	
Cycle Length: 70	
Actuated Cycle Length: 65.8	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.03	
Intersection Signal Delay: 21.9	Intersection LOS: C
Intersection Capacity Utilization 62.0%	ICU Level of Service B
Analysis Period (min) 15	

* User Entered Value

~ 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: 2: Violet Rd/Driveway & Andover St



1: Andover St & Esquire Dr

Direction	All
Future Volume (vph)	3195
Total Delay / Veh (s/v)	28

2: Violet Rd/Driveway & Andover St

Direction	All
Future Volume (vph)	3128
Total Delay / Veh (s/v)	22

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	25
Performance Index	50.1

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	94	1399	0	0	1459	30	0	0	0	22	0	47
Future Volume (vph)	94	1399	0	0	1459	30	0	0	0	22	0	47
Satd. Flow (prot)	1678	2826	0	0	2817	0	0	0	0	0	1578	0
Flt Permitted	0.950										0.984	
Satd. Flow (perm)	1678	2826	0	0	2817	0	0	0	0	0	1578	0
Satd. Flow (RTOR)					1							
Lane Group Flow (vph)	98	1457	0	0	1551	0	0	0	0	0	72	0
Turn Type	Prot	NA			NA					Split	NA	
Protected Phases	5	2			6					4	4	
Permitted Phases												
Total Split (s)	30.0	70.0			40.0					30.0	30.0	
Total Lost Time (s)	6.0	6.0			6.0						6.0	
Act Effct Green (s)	10.8	67.1			53.5						10.2	
Actuated g/C Ratio	0.12	0.73			0.58						0.11	
v/c Ratio	0.50	0.71			0.95						0.41	
Control Delay	49.6	13.9			14.1						49.0	
Queue Delay	0.0	0.1			3.0						0.1	
Total Delay	49.6	14.0			17.1						49.0	
LOS	D	B			B						D	
Approach Delay		16.2			17.1						49.0	
Approach LOS		B			B						D	
Queue Length 50th (ft)	59	314			~586						43	
Queue Length 95th (ft)	113	505			m#677						90	
Internal Link Dist (ft)		804			34			27			61	
Turn Bay Length (ft)	200											
Base Capacity (vph)	448	2064			1641						422	
Starvation Cap Reductn	0	0			49						0	
Spillback Cap Reductn	0	50			0						46	
Storage Cap Reductn	0	0			0						0	
Reduced v/c Ratio	0.22	0.72			0.97						0.19	

Intersection Summary

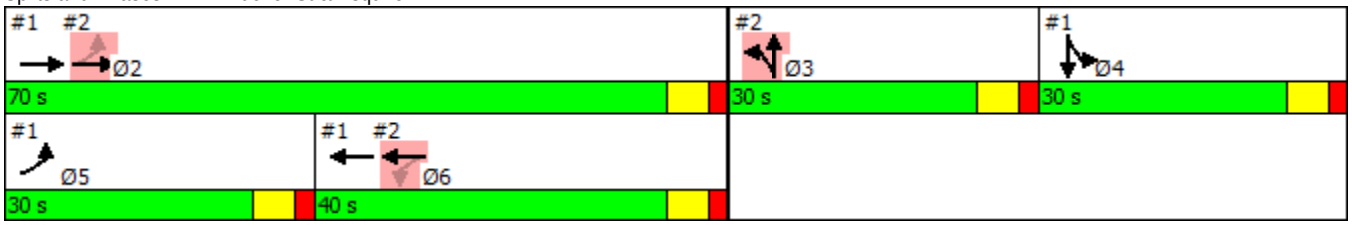
Cycle Length: 130
Actuated Cycle Length: 91.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.97
Intersection Signal Delay: 17.4 — Intersection LOS: B
Intersection Capacity Utilization 75.9% — ICU Level of Service D
Analysis Period (min) 15

~ 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.

m Volume for 95th percentile queue is metered by upstream signal.

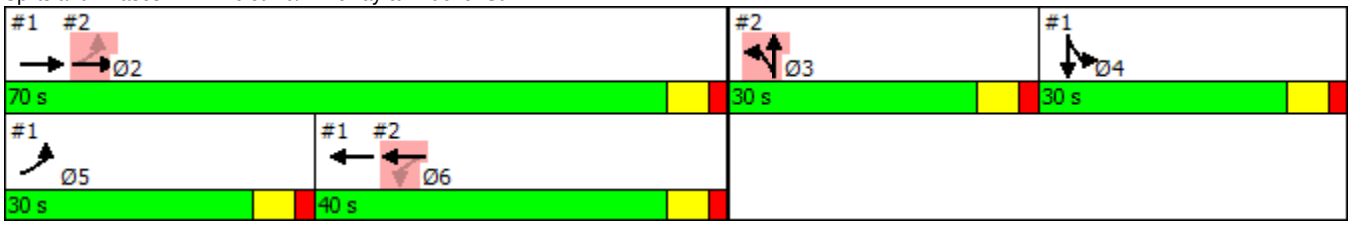
Splits and Phases: 1: Andover St & Esquire Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1358	63	1	1463	0	26	0	2	0	0	0
Future Volume (vph)	1	1358	63	1	1463	0	26	0	2	0	0	0
Satd. Flow (prot)	0	2806	0	0	2826	0	0	1409	0	0	0	0
Flt Permitted		0.954			0.954			0.956				
Satd. Flow (perm)	0	2677	0	0	2696	0	0	1409	0	0	0	0
Satd. Flow (RTOR)		5						*25				
Lane Group Flow (vph)	0	1482	0	0	1525	0	0	29	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		3	3				
Permitted Phases	2			6								
Total Split (s)	70.0	70.0		40.0	40.0		30.0	30.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		67.1			53.5			7.4				
Actuated g/C Ratio		0.73			0.58			0.08				
v/c Ratio		0.76			0.97			0.21				
Control Delay		4.6			44.2			23.5				
Queue Delay		0.0			1.4			5.7				
Total Delay		4.6			45.6			29.1				
LOS		A			D			C				
Approach Delay		4.6			45.6			29.1				
Approach LOS		A			D			C				
Queue Length 50th (ft)		21			~609			2				
Queue Length 95th (ft)		#48			#863			31				
Internal Link Dist (ft)		34			769			120			6	
Turn Bay Length (ft)												
Base Capacity (vph)		1956			1570			395				
Starvation Cap Reductn		0			0			0				
Spillback Cap Reductn		0			15			327				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.76			0.98			0.43				

Intersection Summary	
Cycle Length: 130	
Actuated Cycle Length: 91.8	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.97	
Intersection Signal Delay: 25.4	Intersection LOS: C
Intersection Capacity Utilization 62.2%	ICU Level of Service B
Analysis Period (min) 15	
* User Entered Value	
~ 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: 2: Violet Rd/Driveway & Andover St



1: Andover St & Esquire Dr

Direction	All
Future Volume (vph)	3051
Total Delay / Veh (s/v)	17

2: Violet Rd/Driveway & Andover St

Direction	All
Future Volume (vph)	2915
Total Delay / Veh (s/v)	25

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	21
Performance Index	41.1

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	61	1385	0	0	1592	23	0	0	0	12	0	64
Future Volume (vph)	61	1385	0	0	1592	23	0	0	0	12	0	64
Satd. Flow (prot)	1678	3002	0	0	2996	0	0	0	0	0	1552	0
Flt Permitted	0.950										0.992	
Satd. Flow (perm)	1678	3002	0	0	2996	0	0	0	0	0	1552	0
Satd. Flow (RTOR)					1							
Lane Group Flow (vph)	63	1428	0	0	1665	0	0	0	0	0	78	0
Turn Type	Prot	NA			NA					Split	NA	
Protected Phases	5	2			6					4	4	
Permitted Phases												
Total Split (s)	30.0	70.0			40.0					30.0	30.0	
Total Lost Time (s)	6.0	6.0			6.0						6.0	
Act Effct Green (s)	9.0	69.2			56.9						10.5	
Actuated g/C Ratio	0.09	0.73			0.60						0.11	
v/c Ratio	0.40	0.65			0.93						0.46	
Control Delay	49.6	12.2			13.7						49.9	
Queue Delay	0.0	0.2			8.1						0.0	
Total Delay	49.6	12.3			21.8						49.9	
LOS	D	B			C						D	
Approach Delay		13.9			21.8						49.9	
Approach LOS		B			C						D	
Queue Length 50th (ft)	38	286			~619						47	
Queue Length 95th (ft)	81	446			m#701						95	
Internal Link Dist (ft)		842			34			27			61	
Turn Bay Length (ft)	200											
Base Capacity (vph)	428	2192			1797						396	
Starvation Cap Reductn	0	0			128						0	
Spillback Cap Reductn	0	155			0						0	
Storage Cap Reductn	0	0			0						0	
Reduced v/c Ratio	0.15	0.70			1.00						0.20	

Intersection Summary	
Cycle Length: 130	
Actuated Cycle Length: 94.8	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.00	
Intersection Signal Delay: 18.9	Intersection LOS: B
Intersection Capacity Utilization 67.4%	ICU Level of Service C
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.
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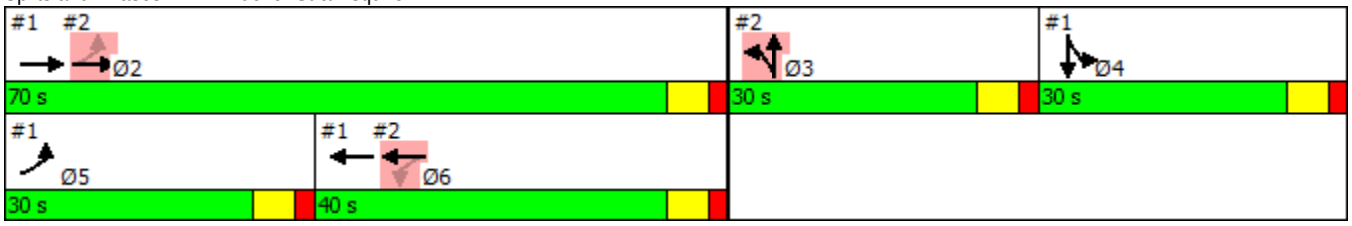
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Andover St & Esquire Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1359	38	1	1569	0	35	0	4	0	0	0
Future Volume (vph)	1	1359	38	1	1569	0	35	0	4	0	0	0
Satd. Flow (prot)	0	2814	0	0	2826	0	0	1666	0	0	0	0
Flt Permitted		0.954			0.954			0.957				
Satd. Flow (perm)	0	2685	0	0	2696	0	0	1666	0	0	0	0
Satd. Flow (RTOR)		3						*50				
Lane Group Flow (vph)	0	1441	0	0	1619	0	0	40	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		3	3				
Permitted Phases	2			6								
Total Split (s)	70.0	70.0		40.0	40.0		30.0	30.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		69.2			56.9			7.0				
Actuated g/C Ratio		0.73			0.60			0.07				
v/c Ratio		0.73			1.00			0.24				
Control Delay		4.7			49.3			13.6				
Queue Delay		0.0			2.4			16.1				
Total Delay		4.7			51.7			29.7				
LOS		A			D			C				
Approach Delay		4.7			51.7			29.7				
Approach LOS		A			D			C				
Queue Length 50th (ft)		35			~660			0				
Queue Length 95th (ft)		29			#903			26				
Internal Link Dist (ft)		34			769			120			1	
Turn Bay Length (ft)												
Base Capacity (vph)		1961			1617			462				
Starvation Cap Reductn		0			0			0				
Spillback Cap Reductn		0			15			402				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.73			1.01			0.67				

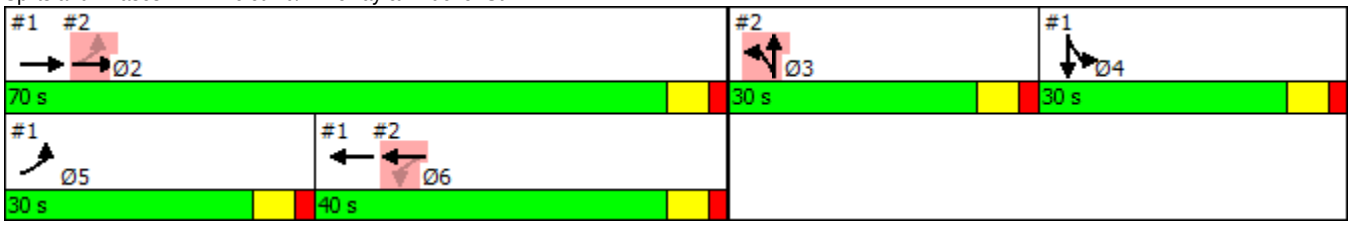
Intersection Summary	
Cycle Length: 130	
Actuated Cycle Length: 94.8	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.00	
Intersection Signal Delay: 29.6	Intersection LOS: C
Intersection Capacity Utilization 65.7%	ICU Level of Service C
Analysis Period (min) 15	

* User Entered Value

~ 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: 2: Violet Rd/Driveway & Andover St



1: Andover St & Esquire Dr

Direction	All
Future Volume (vph)	3137
Total Delay / Veh (s/v)	19

2: Violet Rd/Driveway & Andover St

Direction	All
Future Volume (vph)	3007
Total Delay / Veh (s/v)	30

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	24
Performance Index	47.0

2040 No Build Alternative

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	23	1387	0	0	1842	18	0	0	0	23	0	61
Future Volume (vph)	23	1387	0	0	1842	18	0	0	0	23	0	61
Satd. Flow (prot)	1678	3002	0	0	2999	0	0	0	0	0	1571	0
Flt Permitted	0.950										0.986	
Satd. Flow (perm)	1678	3002	0	0	2999	0	0	0	0	0	1571	0
Satd. Flow (RTOR)					1							
Lane Group Flow (vph)	25	1501	0	0	2013	0	0	0	0	0	91	0
Turn Type	Prot	NA			NA					Split	NA	
Protected Phases	5	2			6					4	4	
Permitted Phases												
Total Split (s)	15.0	45.0			30.0					15.0	15.0	
Total Lost Time (s)	6.0	6.0			6.0						6.0	
Act Effct Green (s)	6.6	43.9			38.7						8.6	
Actuated g/C Ratio	0.10	0.67			0.59						0.13	
v/c Ratio	0.15	0.75			1.14						0.44	
Control Delay	30.5	14.8			80.7						35.3	
Queue Delay	0.0	0.0			0.0						3.7	
Total Delay	30.5	14.8			80.8						39.0	
LOS	C	B			F						D	
Approach Delay		15.1			80.8						39.0	
Approach LOS		B			F						D	
Queue Length 50th (ft)	10	275			~551						37	
Queue Length 95th (ft)	31	#446			m#616						80	
Internal Link Dist (ft)		831			34			27			61	
Turn Bay Length (ft)	200											
Base Capacity (vph)	230	2000			1763						215	
Starvation Cap Reductn	0	0			8						0	
Spillback Cap Reductn	0	5			0						66	
Storage Cap Reductn	0	0			0						0	
Reduced v/c Ratio	0.11	0.75			1.15						0.61	

Intersection Summary

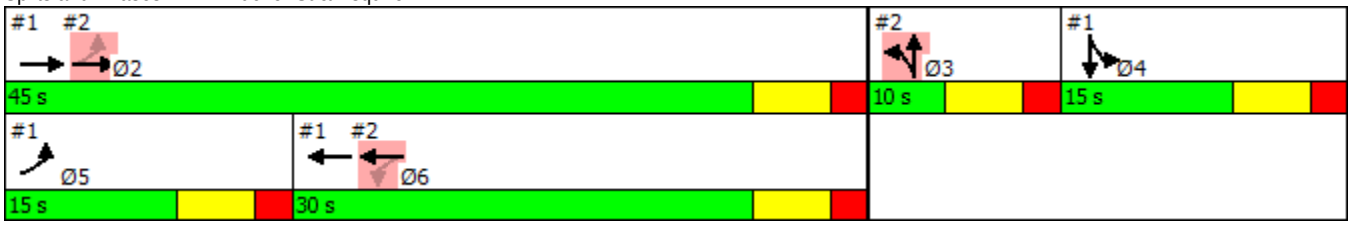
Cycle Length: 70
Actuated Cycle Length: 65.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.14
Intersection Signal Delay: 52.1 — Intersection LOS: D
Intersection Capacity Utilization 77.1% — ICU Level of Service D
Analysis Period (min) 15

~ 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.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Andover St & Esquire Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1398	13	1	1823	0	49	0	1	0	0	0
Future Volume (vph)	1	1398	13	1	1823	0	49	0	1	0	0	0
Satd. Flow (prot)	0	3352	0	0	3355	0	0	1678	0	0	0	0
Flt Permitted		0.864			0.954			0.953				
Satd. Flow (perm)	0	2896	0	0	3201	0	0	1678	0	0	0	0
Satd. Flow (RTOR)		2						*100				
Lane Group Flow (vph)	0	1528	0	0	1974	0	0	54	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		3	3				
Permitted Phases	2			6								
Total Split (s)	45.0	45.0		30.0	30.0		10.0	10.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		43.9			38.7			4.0				
Actuated g/C Ratio		0.67			0.59			0.06				
v/c Ratio		0.79			1.05			0.28				
Control Delay		6.3			58.1			5.9				
Queue Delay		0.0			9.2			51.8				
Total Delay		6.3			67.2			57.7				
LOS		A			E			E				
Approach Delay		6.3			67.2			57.7				
Approach LOS		A			E			E				
Queue Length 50th (ft)		20			~522			0				
Queue Length 95th (ft)		#456			#812			11				
Internal Link Dist (ft)		34			769			120			1	
Turn Bay Length (ft)												
Base Capacity (vph)		1930			1881			196				
Starvation Cap Reductn		4			0			0				
Spillback Cap Reductn		0			40			139				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.79			1.07			0.95				

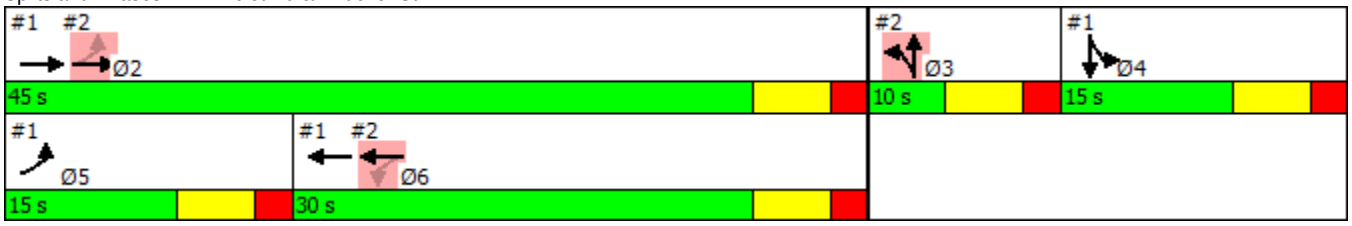
Intersection Summary	
Cycle Length: 70	
Actuated Cycle Length: 65.8	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.14	
Intersection Signal Delay: 40.9	Intersection LOS: D
Intersection Capacity Utilization 67.0%	ICU Level of Service C
Analysis Period (min) 15	

* User Entered Value

~ 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: 2: Violet Rd & Andover St



1: Andover St & Esquire Dr

Direction	All
Future Volume (vph)	3521
Total Delay / Veh (s/v)	52

2: Violet Rd & Andover St

Direction	All
Future Volume (vph)	3449
Total Delay / Veh (s/v)	41

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	47
Performance Index	97.0

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	99	1469	0	0	1532	32	0	0	0	23	0	49
Future Volume (vph)	99	1469	0	0	1532	32	0	0	0	23	0	49
Satd. Flow (prot)	1678	2826	0	0	2817	0	0	0	0	0	1578	0
Flt Permitted	0.950										0.984	
Satd. Flow (perm)	1678	2826	0	0	2817	0	0	0	0	0	1578	0
Satd. Flow (RTOR)					2							
Lane Group Flow (vph)	108	1607	0	0	1711	0	0	0	0	0	79	0
Turn Type	Prot	NA			NA					Split	NA	
Protected Phases	5	2			6					4	4	
Permitted Phases												
Total Split (s)	30.0	70.0			40.0					30.0	30.0	
Total Lost Time (s)	6.0	6.0			6.0						6.0	
Act Effct Green (s)	11.3	67.1			53.1						10.5	
Actuated g/C Ratio	0.12	0.73			0.57						0.11	
v/c Ratio	0.53	0.78			1.06						0.44	
Control Delay	50.2	17.0			42.1						49.6	
Queue Delay	0.0	0.4			12.6						0.1	
Total Delay	50.2	17.4			54.7						49.7	
LOS	D	B			D						D	
Approach Delay		19.5			54.7						49.7	
Approach LOS		B			D						D	
Queue Length 50th (ft)	65	397			~710						48	
Queue Length 95th (ft)	122	#705			m#682						97	
Internal Link Dist (ft)		790			34			27			61	
Turn Bay Length (ft)	200											
Base Capacity (vph)	446	2053			1619						419	
Starvation Cap Reductn	0	0			46						0	
Spillback Cap Reductn	0	121			0						51	
Storage Cap Reductn	0	0			0						0	
Reduced v/c Ratio	0.24	0.83			1.09						0.21	

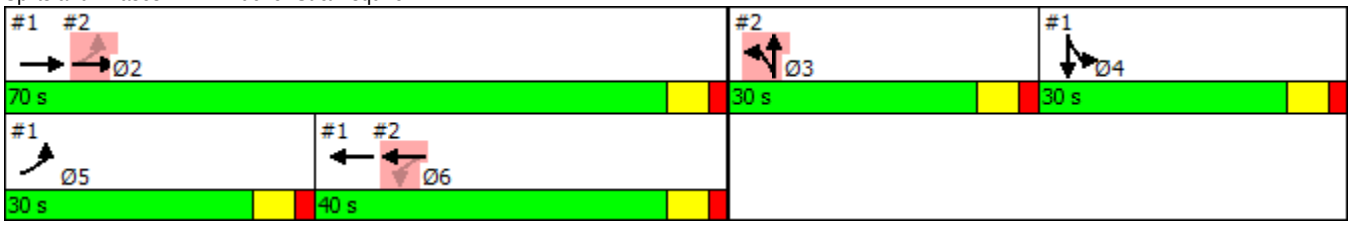
Intersection Summary	
Cycle Length: 130	
Actuated Cycle Length: 92.4	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.09	
Intersection Signal Delay: 37.4	Intersection LOS: D
Intersection Capacity Utilization 81.5%	ICU Level of Service D
Analysis Period (min) 15	

~ 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.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Andover St & Esquire Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1426	66	1	1536	0	27	0	2	0	0	0
Future Volume (vph)	1	1426	66	1	1536	0	27	0	2	0	0	0
Satd. Flow (prot)	0	2806	0	0	2826	0	0	1409	0	0	0	0
Flt Permitted		0.954			0.954			0.955				
Satd. Flow (perm)	0	2677	0	0	2696	0	0	1409	0	0	0	0
Satd. Flow (RTOR)		5						*25				
Lane Group Flow (vph)	0	1633	0	0	1681	0	0	32	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		3	3				
Permitted Phases	2			6								
Total Split (s)	70.0	70.0		40.0	40.0		30.0	30.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		67.1			53.1			7.6				
Actuated g/C Ratio		0.73			0.57			0.08				
v/c Ratio		0.84			1.09			0.23				
Control Delay		7.1			77.1			25.4				
Queue Delay		0.0			6.0			4.2				
Total Delay		7.1			83.1			29.5				
LOS		A			F			C				
Approach Delay		7.1			83.1			29.5				
Approach LOS		A			F			C				
Queue Length 50th (ft)		23			~731			4				
Queue Length 95th (ft)		#744			#1002			34				
Internal Link Dist (ft)		34			769			120			5	
Turn Bay Length (ft)												
Base Capacity (vph)		1946			1549			393				
Starvation Cap Reductn		1			0			0				
Spillback Cap Reductn		0			20			312				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.84			1.10			0.40				

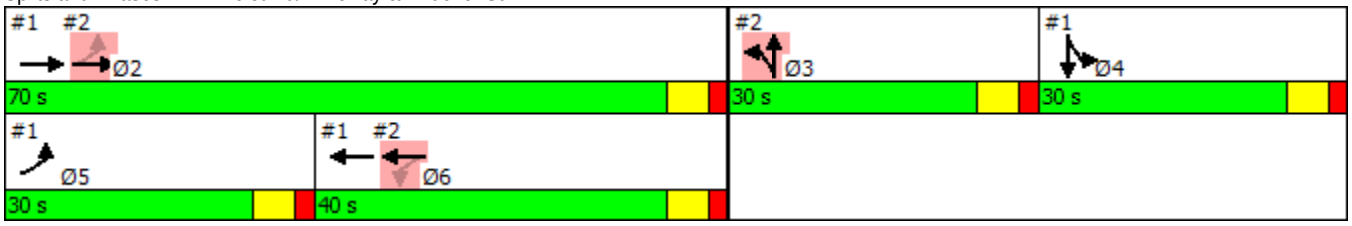
Intersection Summary	
Cycle Length: 130	
Actuated Cycle Length: 92.4	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.09	
Intersection Signal Delay: 45.5	Intersection LOS: D
Intersection Capacity Utilization 67.1%	ICU Level of Service C
Analysis Period (min) 15	

* User Entered Value

~ 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: 2: Violet Rd/Driveway & Andover St



1: Andover St & Esquire Dr

Direction	All
Future Volume (vph)	3366
Total Delay / Veh (s/v)	37

2: Violet Rd/Driveway & Andover St

Direction	All
Future Volume (vph)	3213
Total Delay / Veh (s/v)	46

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	41
Performance Index	82.0

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	64	1454	0	0	1672	24	0	0	0	13	0	67
Future Volume (vph)	64	1454	0	0	1672	24	0	0	0	13	0	67
Satd. Flow (prot)	1678	3002	0	0	2996	0	0	0	0	0	1554	0
Flt Permitted	0.950										0.992	
Satd. Flow (perm)	1678	3002	0	0	2996	0	0	0	0	0	1554	0
Satd. Flow (RTOR)												
Lane Group Flow (vph)	69	1574	0	0	1836	0	0	0	0	0	87	0
Turn Type	Prot	NA			NA					Split	NA	
Protected Phases	5	2			6					4	4	
Permitted Phases												
Total Split (s)	30.0	70.0			40.0					30.0	30.0	
Total Lost Time (s)	6.0	6.0			6.0						6.0	
Act Effct Green (s)	9.4	67.6			55.1						11.2	
Actuated g/C Ratio	0.10	0.72			0.59						0.12	
v/c Ratio	0.41	0.73			1.04						0.47	
Control Delay	50.0	15.1			34.7						50.2	
Queue Delay	0.0	0.2			24.1						0.0	
Total Delay	50.0	15.3			58.8						50.2	
LOS	D	B			E						D	
Approach Delay		16.7			58.8						50.2	
Approach LOS		B			E						D	
Queue Length 50th (ft)	42	362			~757						53	
Queue Length 95th (ft)	89	581			m#692						105	
Internal Link Dist (ft)		817			34			27			61	
Turn Bay Length (ft)	200											
Base Capacity (vph)	439	2167			1764						406	
Starvation Cap Reductn	0	0			125						0	
Spillback Cap Reductn	0	99			0						0	
Storage Cap Reductn	0	0			0						0	
Reduced v/c Ratio	0.16	0.76			1.12						0.21	

Intersection Summary

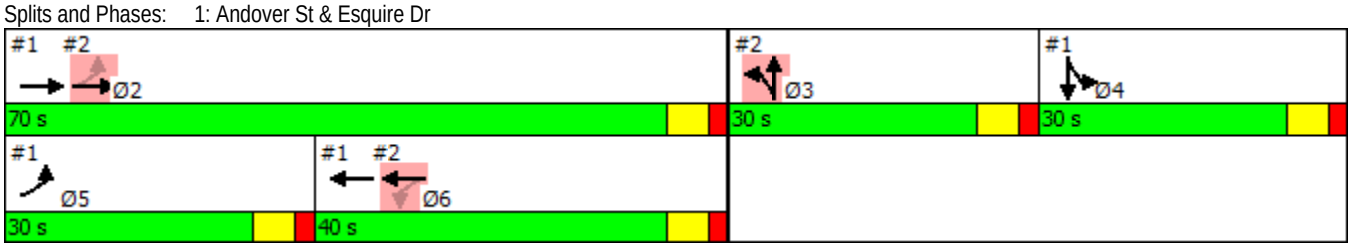
Cycle Length: 130
Actuated Cycle Length: 93.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.12
Intersection Signal Delay: 39.2 — Intersection LOS: D
Intersection Capacity Utilization 72.5% — ICU Level of Service C
Analysis Period (min) 15

~ 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.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Andover St & Esquire Dr



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1427	40	1	1647	0	37	0	4	0	0	0
Future Volume (vph)	1	1427	40	1	1647	0	37	0	4	0	0	0
Satd. Flow (prot)	0	2814	0	0	2826	0	0	1670	0	0	0	0
Flt Permitted		0.951			0.954			0.957				
Satd. Flow (perm)	0	2676	0	0	2696	0	0	1670	0	0	0	0
Satd. Flow (RTOR)		3						*35				
Lane Group Flow (vph)	0	1589	0	0	1784	0	0	44	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		3	3				
Permitted Phases	2			6								
Total Split (s)	70.0	70.0		40.0	40.0		30.0	30.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		67.6			55.1			7.6				
Actuated g/C Ratio		0.72			0.59			0.08				
v/c Ratio		0.82			1.12			0.26				
Control Delay		7.4			91.2			23.5				
Queue Delay		0.0			0.0			19.7				
Total Delay		7.4			91.2			43.1				
LOS		A			F			D				
Approach Delay		7.4			91.2			43.1				
Approach LOS		A			F			D				
Queue Length 50th (ft)		48			~792			5				
Queue Length 95th (ft)		#722			#1064			40				
Internal Link Dist (ft)		34			769			120			1	
Turn Bay Length (ft)												
Base Capacity (vph)		1932			1587			462				
Starvation Cap Reductn		0			0			0				
Spillback Cap Reductn		0			22			401				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.82			1.14			0.72				

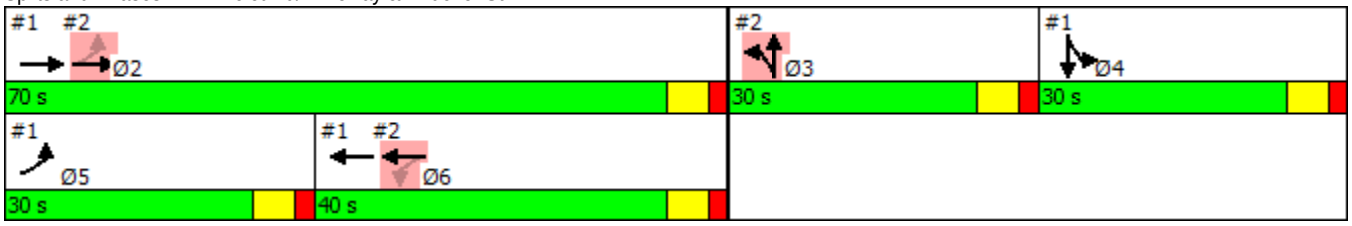
Intersection Summary	
Cycle Length: 130	
Actuated Cycle Length: 93.6	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.12	
Intersection Signal Delay: 51.6	Intersection LOS: D
Intersection Capacity Utilization 71.0%	ICU Level of Service C
Analysis Period (min) 15	

* User Entered Value

~ 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: 2: Violet Rd/Driveway & Andover St



1: Andover St & Esquire Dr

Direction	All
Future Volume (vph)	3459
Total Delay / Veh (s/v)	39

2: Violet Rd/Driveway & Andover St

Direction	All
Future Volume (vph)	3314
Total Delay / Veh (s/v)	52

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	45
Performance Index	92.0

2040 Build Alternative 1

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	23	1387	0	0	1842	18	0	0	0	23	0	61
Future Volume (vph)	23	1387	0	0	1842	18	0	0	0	23	0	61
Satd. Flow (prot)	1678	3002	0	0	2999	0	0	0	0	0	1571	0
Flt Permitted	0.950										0.986	
Satd. Flow (perm)	1678	3002	0	0	2999	0	0	0	0	0	1571	0
Satd. Flow (RTOR)					1							
Lane Group Flow (vph)	25	1501	0	0	2013	0	0	0	0	0	91	0
Turn Type	Prot	NA			NA					Split	NA	
Protected Phases	5	2			6					4	4	
Permitted Phases												
Total Split (s)	15.0	79.0			64.0					20.0	20.0	
Total Lost Time (s)	6.0	6.0			6.0						6.0	
Act Effct Green (s)	7.1	77.9			69.8						11.2	
Actuated g/C Ratio	0.07	0.74			0.66						0.11	
v/c Ratio	0.22	0.68			1.01						0.54	
Control Delay	52.5	12.1			26.8						57.9	
Queue Delay	0.0	0.0			0.9						0.8	
Total Delay	52.5	12.1			27.7						58.7	
LOS	D	B			C						E	
Approach Delay		12.8			27.7						58.7	
Approach LOS		B			C						E	
Queue Length 50th (ft)	17	313			~873						60	
Queue Length 95th (ft)	45	432			m#1022						114	
Internal Link Dist (ft)		831			34			27			61	
Turn Bay Length (ft)	200											
Base Capacity (vph)	143	2222			1989						209	
Starvation Cap Reductn	0	0			6						0	
Spillback Cap Reductn	0	0			0						23	
Storage Cap Reductn	0	0			0						0	
Reduced v/c Ratio	0.17	0.68			1.02						0.49	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 105.3
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.01
Intersection Signal Delay: 22.2 — Intersection LOS: C
Intersection Capacity Utilization 77.1% — ICU Level of Service D
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.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Andover St & Esquire Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1398	13	1	1823	0	49	0	1	0	0	0
Future Volume (vph)	1	1398	13	1	1823	0	49	0	1	0	0	0
Satd. Flow (prot)	0	3352	0	0	3355	0	0	1678	0	0	0	0
Flt Permitted		0.954			0.955			0.953				
Satd. Flow (perm)	0	3198	0	0	3204	0	0	1678	0	0	0	0
Satd. Flow (RTOR)		2						*100				
Lane Group Flow (vph)	0	1528	0	0	1974	0	0	54	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		3	3				
Permitted Phases	2			6								
Total Split (s)	79.0	79.0		64.0	64.0		11.0	11.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		77.9			69.8			5.0				
Actuated g/C Ratio		0.74			0.66			0.05				
v/c Ratio		0.65			0.93			0.31				
Control Delay		1.9			31.3			6.1				
Queue Delay		0.1			0.4			43.8				
Total Delay		2.0			31.8			49.9				
LOS		A			C			D				
Approach Delay		2.0			31.8			49.9				
Approach LOS		A			C			D				
Queue Length 50th (ft)		24			~817			0				
Queue Length 95th (ft)		27			#1014			8				
Internal Link Dist (ft)		34			769			120			1	
Turn Bay Length (ft)												
Base Capacity (vph)		2367			2124			174				
Starvation Cap Reductn		136			0			0				
Spillback Cap Reductn		0			21			115				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.68			0.94			0.92				

Intersection Summary	
Cycle Length: 110	
Actuated Cycle Length: 105.3	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.01	
Intersection Signal Delay: 19.2	Intersection LOS: B
Intersection Capacity Utilization 67.0%	ICU Level of Service C
Analysis Period (min) 15	

* User Entered Value

~ 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: 2: Violet Rd & Andover St

1: Andover St & Esquire Dr

Direction	All
Future Volume (vph)	3521
Total Delay / Veh (s/v)	22

2: Violet Rd & Andover St

Direction	All
Future Volume (vph)	3449
Total Delay / Veh (s/v)	19

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	21
Performance Index	46.6

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	99	1469	0	0	1532	32	0	0	0	23	0	49
Future Volume (vph)	99	1469	0	0	1532	32	0	0	0	23	0	49
Satd. Flow (prot)	1678	2826	0	0	2817	0	0	0	0	0	1578	0
Flt Permitted	0.950										0.984	
Satd. Flow (perm)	1678	2826	0	0	2817	0	0	0	0	0	1578	0
Satd. Flow (RTOR)					3							
Lane Group Flow (vph)	108	1607	0	0	1711	0	0	0	0	0	79	0
Turn Type	Prot	NA			NA					Split	NA	
Protected Phases	5	2			6					4	4	
Permitted Phases												
Total Split (s)	20.0	80.0			60.0					20.0	20.0	
Total Lost Time (s)	6.0	6.0			6.0						6.0	
Act Effct Green (s)	11.1	76.6			62.6						10.6	
Actuated g/C Ratio	0.11	0.77			0.63						0.11	
v/c Ratio	0.58	0.74			0.97						0.47	
Control Delay	56.9	12.9			13.3						54.3	
Queue Delay	0.0	0.1			4.3						0.5	
Total Delay	56.9	13.0			17.6						54.8	
LOS	E	B			B						D	
Approach Delay		15.7			17.6						54.8	
Approach LOS		B			B						D	
Queue Length 50th (ft)	71	362			~710						52	
Queue Length 95th (ft)	130	532			m#732						101	
Internal Link Dist (ft)		790			34			27			61	
Turn Bay Length (ft)	200											
Base Capacity (vph)	238	2165			1765						224	
Starvation Cap Reductn	0	0			46						0	
Spillback Cap Reductn	0	56			0						27	
Storage Cap Reductn	0	0			0						0	
Reduced v/c Ratio	0.45	0.76			1.00						0.40	

Intersection Summary	
Cycle Length: 110	
Actuated Cycle Length: 99.9	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.00	
Intersection Signal Delay: 17.5	Intersection LOS: B
Intersection Capacity Utilization 81.5%	ICU Level of Service D
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.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Andover St & Esquire Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1426	66	1	1536	0	27	0	2	0	0	0
Future Volume (vph)	1	1426	66	1	1536	0	27	0	2	0	0	0
Satd. Flow (prot)	0	2806	0	0	2826	0	0	1409	0	0	0	0
Flt Permitted		0.954			0.954			0.955				
Satd. Flow (perm)	0	2677	0	0	2696	0	0	1409	0	0	0	0
Satd. Flow (RTOR)		9						*60				
Lane Group Flow (vph)	0	1633	0	0	1681	0	0	32	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		3	3				
Permitted Phases	2			6								
Total Split (s)	80.0	80.0		60.0	60.0		10.0	10.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		76.6			62.6			4.1				
Actuated g/C Ratio		0.77			0.63			0.04				
v/c Ratio		0.80			1.00			0.28				
Control Delay		4.6			47.1			10.0				
Queue Delay		0.0			1.8			29.9				
Total Delay		4.6			48.9			39.9				
LOS		A			D			D				
Approach Delay		4.6			48.9			39.9				
Approach LOS		A			D			D				
Queue Length 50th (ft)		24			~731			0				
Queue Length 95th (ft)		#38			#928			12				
Internal Link Dist (ft)		34			769			120			5	
Turn Bay Length (ft)												
Base Capacity (vph)		2053			1688			114				
Starvation Cap Reductn		2			0			0				
Spillback Cap Reductn		0			13			72				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.80			1.00			0.76				

Intersection Summary	
Cycle Length: 110	
Actuated Cycle Length: 99.9	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.00	
Intersection Signal Delay: 27.2	Intersection LOS: C
Intersection Capacity Utilization 67.1%	ICU Level of Service C
Analysis Period (min) 15	

* User Entered Value
~ 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: 2: Violet Rd/Driveway & Andover St

1: Andover St & Esquire Dr

Direction	All
Future Volume (vph)	3366
Total Delay / Veh (s/v)	18

2: Violet Rd/Driveway & Andover St

Direction	All
Future Volume (vph)	3213
Total Delay / Veh (s/v)	27

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	22
Performance Index	47.1

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	64	1454	0	0	1672	24	0	0	0	13	0	67
Future Volume (vph)	64	1454	0	0	1672	24	0	0	0	13	0	67
Satd. Flow (prot)	1678	3002	0	0	2996	0	0	0	0	0	1554	0
Flt Permitted	0.950										0.992	
Satd. Flow (perm)	1678	3002	0	0	2996	0	0	0	0	0	1554	0
Satd. Flow (RTOR)												
Lane Group Flow (vph)	69	1574	0	0	1836	0	0	0	0	0	87	0
Turn Type	Prot	NA			NA					Split	NA	
Protected Phases	5	2			6					4	4	
Permitted Phases												
Total Split (s)	25.0	80.0			55.0					25.0	25.0	
Total Lost Time (s)	6.0	6.0			6.0						6.0	
Act Effct Green (s)	9.8	77.0			64.3						11.6	
Actuated g/C Ratio	0.09	0.73			0.61						0.11	
v/c Ratio	0.45	0.72			1.00						0.51	
Control Delay	56.7	14.2			18.8						56.9	
Queue Delay	0.0	0.3			26.9						0.0	
Total Delay	56.7	14.5			45.7						56.9	
LOS	E	B			D						E	
Approach Delay		16.2			45.7						56.9	
Approach LOS		B			D						E	
Queue Length 50th (ft)	47	362			~789						59	
Queue Length 95th (ft)	94	531			m#738						111	
Internal Link Dist (ft)		817			34			27			61	
Turn Bay Length (ft)	200											
Base Capacity (vph)	308	2199			1831						285	
Starvation Cap Reductn	0	0			128						0	
Spillback Cap Reductn	0	168			0						0	
Storage Cap Reductn	0	0			0						0	
Reduced v/c Ratio	0.22	0.77			1.08						0.31	

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 105.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.08
Intersection Signal Delay: 32.4 — Intersection LOS: C
Intersection Capacity Utilization 72.5% — ICU Level of Service C
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.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Andover St & Esquire Dr

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1427	40	1	1647	0	37	0	4	0	0	0
Future Volume (vph)	1	1427	40	1	1647	0	37	0	4	0	0	0
Satd. Flow (prot)	0	2814	0	0	2826	0	0	1670	0	0	0	0
Flt Permitted		0.954			0.954			0.957				
Satd. Flow (perm)	0	2685	0	0	2696	0	0	1670	0	0	0	0
Satd. Flow (RTOR)		4						*100				
Lane Group Flow (vph)	0	1589	0	0	1784	0	0	44	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		3	3				
Permitted Phases	2			6								
Total Split (s)	80.0	80.0		55.0	55.0		15.0	15.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		77.0			64.3			6.6				
Actuated g/C Ratio		0.73			0.61			0.06				
v/c Ratio		0.81			1.08			0.22				
Control Delay		6.0			75.5			2.6				
Queue Delay		0.0			4.2			19.3				
Total Delay		6.0			79.7			21.8				
LOS		A			E			C				
Approach Delay		6.0			79.7			21.8				
Approach LOS		A			E			C				
Queue Length 50th (ft)		46			~830			0				
Queue Length 95th (ft)		#726			#1071			0				
Internal Link Dist (ft)		34			769			120			1	
Turn Bay Length (ft)												
Base Capacity (vph)		1968			1648			236				
Starvation Cap Reductn		0			0			0				
Spillback Cap Reductn		0			15			175				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.81			1.09			0.72				

Intersection Summary	
Cycle Length: 120	
Actuated Cycle Length: 105.1	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.08	
Intersection Signal Delay: 44.7	Intersection LOS: D
Intersection Capacity Utilization 71.0%	ICU Level of Service C
Analysis Period (min) 15	

* User Entered Value

~ 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: 2: Violet Rd/Driveway & Andover St

1: Andover St & Esquire Dr

Direction	All
Future Volume (vph)	3459
Total Delay / Veh (s/v)	32

2: Violet Rd/Driveway & Andover St

Direction	All
Future Volume (vph)	3314
Total Delay / Veh (s/v)	45

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	38
Performance Index	79.0

2040 Build Alternative 2

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	0	1387	0	0	1842	18	5	18	0	23	0	61
Future Volume (vph)	0	1387	0	0	1842	18	5	18	0	23	0	61
Satd. Flow (prot)	0	3002	0	0	2999	0	0	1748	0	0	1571	0
Flt Permitted								0.918			0.899	
Satd. Flow (perm)	0	3002	0	0	2999	0	0	1621	0	0	1432	0
Satd. Flow (RTOR)					2						*50	
Lane Group Flow (vph)	0	1501	0	0	2013	0	0	24	0	0	91	0
Turn Type		NA			NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases							8			4		
Total Split (s)		65.0			65.0		20.0	20.0		20.0	20.0	
Total Lost Time (s)		6.0			6.0			6.0			6.0	
Act Effct Green (s)		64.0			64.0			9.4			9.4	
Actuated g/C Ratio		0.70			0.70			0.10			0.10	
v/c Ratio		0.71			0.95			0.14			0.47	
Control Delay		13.9			13.2			39.9			29.0	
Queue Delay		0.0			0.2			0.0			0.7	
Total Delay		13.9			13.4			39.9			29.7	
LOS		B			B			D			C	
Approach Delay		13.9			13.4			39.9			29.7	
Approach LOS		B			B			D			C	
Queue Length 50th (ft)		292			~672			13			23	
Queue Length 95th (ft)		463			#877			37			69	
Internal Link Dist (ft)		831			34			65			61	
Turn Bay Length (ft)												
Base Capacity (vph)		2116			2115			251			263	
Starvation Cap Reductn		0			6			0			0	
Spillback Cap Reductn		0			0			0			47	
Storage Cap Reductn		0			0			0			0	
Reduced v/c Ratio		0.71			0.95			0.10			0.42	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 90.8	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.95	
Intersection Signal Delay: 14.2	Intersection LOS: B
Intersection Capacity Utilization 78.1%	ICU Level of Service D
Analysis Period (min) 15	

* User Entered Value

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

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

Splits and Phases: 1: Jug Handle/Esquire Dr & Andover St

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1398	13	1	1823	0	49	0	1	0	0	0
Future Volume (vph)	1	1398	13	1	1823	0	49	0	1	0	0	0
Satd. Flow (prot)	0	3352	0	0	3355	0	0	1678	0	0	0	0
Flt Permitted		0.954			0.955			0.953				
Satd. Flow (perm)	0	3198	0	0	3204	0	0	1678	0	0	0	0
Satd. Flow (RTOR)		2						*100				
Lane Group Flow (vph)	0	1528	0	0	1974	0	0	54	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		9	9				
Permitted Phases	2			6								
Total Split (s)	65.0	65.0		65.0	65.0		15.0	15.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		64.0			64.0			6.6				
Actuated g/C Ratio		0.70			0.70			0.07				
v/c Ratio		0.68			0.87			0.25				
Control Delay		2.2			20.8			4.5				
Queue Delay		0.1			0.9			10.8				
Total Delay		2.4			21.8			15.2				
LOS		A			C			B				
Approach Delay		2.4			21.8			15.2				
Approach LOS		A			C			B				
Queue Length 50th (ft)		19			501			0				
Queue Length 95th (ft)		28			#822			9				
Internal Link Dist (ft)		34			769			120			1	
Turn Bay Length (ft)												
Base Capacity (vph)		2255			2259			257				
Starvation Cap Reductn		121			0			0				
Spillback Cap Reductn		0			101			174				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.72			0.91			0.65				

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 90.8	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.95	
Intersection Signal Delay: 13.3	Intersection LOS: B
Intersection Capacity Utilization 67.0%	ICU Level of Service C
Analysis Period (min) 15	
* User Entered Value	
# 95th percentile volume exceeds capacity, queue may be longer.	
Queue shown is maximum after two cycles.	

Splits and Phases: 2: Violet Rd & Andover St

1: Jug Handle/Esquire Dr & Andover St

Direction	All
Future Volume (vph)	3520
Total Delay / Veh (s/v)	14

2: Violet Rd & Andover St

Direction	All
Future Volume (vph)	3449
Total Delay / Veh (s/v)	13

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	14
Performance Index	33.6

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	0	1469	0	0	1532	32	25	65	0	23	0	49
Future Volume (vph)	0	1469	0	0	1532	32	25	65	0	23	0	49
Satd. Flow (prot)	0	2826	0	0	2817	0	0	1741	0	0	1578	0
Flt Permitted								0.910			0.877	
Satd. Flow (perm)	0	2826	0	0	2817	0	0	1607	0	0	1406	0
Satd. Flow (RTOR)					3						*50	
Lane Group Flow (vph)	0	1607	0	0	1711	0	0	98	0	0	79	0
Turn Type		NA			NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases							8			4		
Total Split (s)		60.0			60.0		25.0	25.0		25.0	25.0	
Total Lost Time (s)		6.0			6.0			6.0			6.0	
Act Effct Green (s)		59.3			59.3			10.9			10.9	
Actuated g/C Ratio		0.70			0.70			0.13			0.13	
v/c Ratio		0.81			0.87			0.48			0.35	
Control Delay		19.0			8.2			43.6			21.6	
Queue Delay		0.6			0.6			0.0			3.8	
Total Delay		19.6			8.7			43.6			25.4	
LOS		B			A			D			C	
Approach Delay		19.6			8.7			43.6			25.4	
Approach LOS		B			A			D			C	
Queue Length 50th (ft)		398			~31			53			15	
Queue Length 95th (ft)		#671			m#702			102			56	
Internal Link Dist (ft)		790			34			45			61	
Turn Bay Length (ft)												
Base Capacity (vph)		1973			1967			363			356	
Starvation Cap Reductn		0			59			0			0	
Spillback Cap Reductn		109			0			0			209	
Storage Cap Reductn		0			0			0			0	
Reduced v/c Ratio		0.86			0.90			0.27			0.54	

Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 85	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.89	
Intersection Signal Delay: 15.1	Intersection LOS: B
Intersection Capacity Utilization 70.7%	ICU Level of Service C
Analysis Period (min) 15	

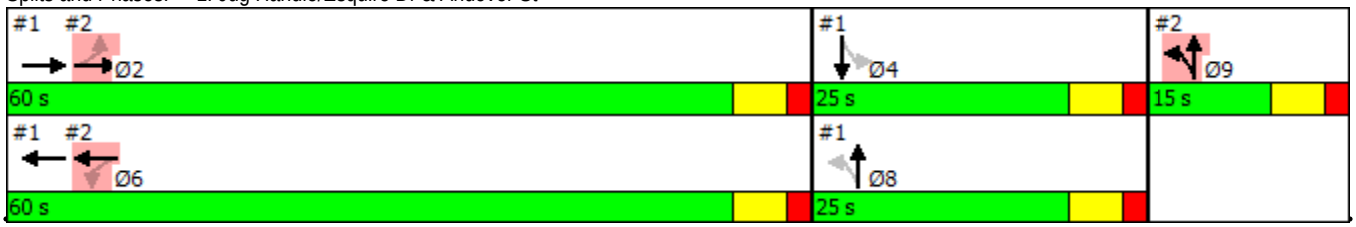
* User Entered Value

~ 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.

m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Jug Handle/Esquire Dr & Andover St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1426	66	1	1536	0	27	0	2	0	0	0
Future Volume (vph)	1	1426	66	1	1536	0	27	0	2	0	0	0
Satd. Flow (prot)	0	2806	0	0	2826	0	0	1409	0	0	0	0
Flt Permitted		0.954			0.954			0.955				
Satd. Flow (perm)	0	2677	0	0	2696	0	0	1409	0	0	0	0
Satd. Flow (RTOR)		7						*60				
Lane Group Flow (vph)	0	1633	0	0	1681	0	0	32	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		9	9				
Permitted Phases	2			6								
Total Split (s)	60.0	60.0		60.0	60.0		15.0	15.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		59.3			59.3			6.7				
Actuated g/C Ratio		0.70			0.70			0.08				
v/c Ratio		0.87			0.89			0.19				
Control Delay		9.6			24.3			6.6				
Queue Delay		0.0			0.1			8.9				
Total Delay		9.6			24.3			15.5				
LOS		A			C			B				
Approach Delay		9.6			24.3			15.5				
Approach LOS		A			C			B				
Queue Length 50th (ft)		~33			~540			0				
Queue Length 95th (ft)		#700			#745			12				
Internal Link Dist (ft)		34			769			120			5	
Turn Bay Length (ft)												
Base Capacity (vph)		1871			1882			204				
Starvation Cap Reductn		0			0			0				
Spillback Cap Reductn		0			5			143				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.87			0.90			0.52				

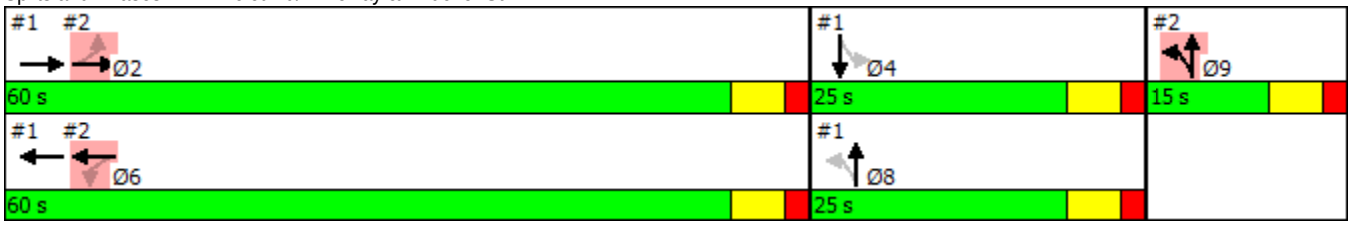
Intersection Summary	
Cycle Length: 100	
Actuated Cycle Length: 85	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.89	
Intersection Signal Delay: 17.1	Intersection LOS: B
Intersection Capacity Utilization 67.1%	ICU Level of Service C
Analysis Period (min) 15	

* User Entered Value

~ 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: 2: Violet Rd/Driveway & Andover St



1: Jug Handle/Esquire Dr & Andover St

Direction	All
Future Volume (vph)	3356
Total Delay / Veh (s/v)	15

2: Violet Rd/Driveway & Andover St

Direction	All
Future Volume (vph)	3213
Total Delay / Veh (s/v)	17

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	16
Performance Index	36.0

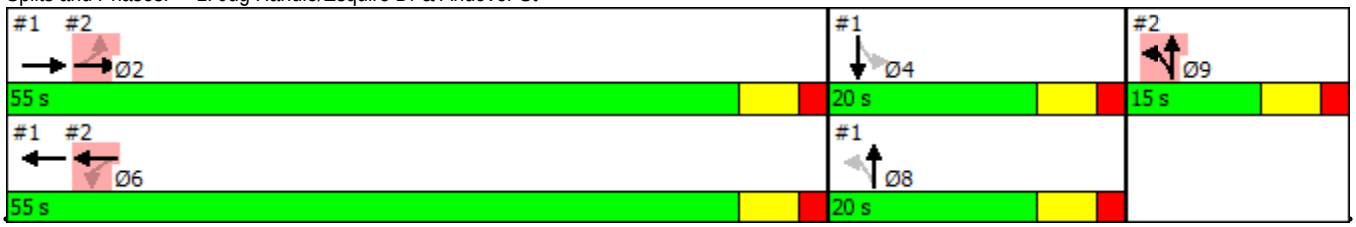
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	0	1454	0	0	1672	24	25	40	0	13	0	67
Future Volume (vph)	0	1454	0	0	1672	24	25	40	0	13	0	67
Satd. Flow (prot)	0	3002	0	0	2996	0	0	1732	0	0	1554	0
Flt Permitted								0.886			0.938	
Satd. Flow (perm)	0	3002	0	0	2996	0	0	1565	0	0	1469	0
Satd. Flow (RTOR)					2						*50	
Lane Group Flow (vph)	0	1574	0	0	1836	0	0	70	0	0	87	0
Turn Type		NA			NA		Perm	NA		Perm	NA	
Protected Phases		2			6			8			4	
Permitted Phases							8			4		
Total Split (s)		55.0			55.0		20.0	20.0		20.0	20.0	
Total Lost Time (s)		6.0			6.0			6.0			6.0	
Act Effct Green (s)		54.2			54.2			9.7			9.7	
Actuated g/C Ratio		0.69			0.69			0.12			0.12	
v/c Ratio		0.76			0.89			0.36			0.39	
Control Delay		15.9			8.8			38.7			22.7	
Queue Delay		0.3			3.0			0.0			0.0	
Total Delay		16.2			11.8			38.7			22.7	
LOS		B			B			D			C	
Approach Delay		16.2			11.8			38.7			22.7	
Approach LOS		B			B			D			C	
Queue Length 50th (ft)		334			~52			34			18	
Queue Length 95th (ft)		#570			m#608			74			60	
Internal Link Dist (ft)		817			34			43			61	
Turn Bay Length (ft)												
Base Capacity (vph)		2072			2069			282			305	
Starvation Cap Reductn		0			150			0			0	
Spillback Cap Reductn		113			0			0			0	
Storage Cap Reductn		0			0			0			0	
Reduced v/c Ratio		0.80			0.96			0.25			0.29	

Intersection Summary

Cycle Length: 90
Actuated Cycle Length: 78.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.96
Intersection Signal Delay: 14.5 — Intersection LOS: B
Intersection Capacity Utilization 72.5% — ICU Level of Service C
Analysis Period (min) 15

* User Entered Value
~ 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.
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 1: Jug Handle/Esquire Dr & Andover St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	1	1427	40	1	1647	0	37	0	4	0	0	0
Future Volume (vph)	1	1427	40	1	1647	0	37	0	4	0	0	0
Satd. Flow (prot)	0	2814	0	0	2826	0	0	1670	0	0	0	0
Flt Permitted		0.954			0.954			0.957				
Satd. Flow (perm)	0	2685	0	0	2696	0	0	1670	0	0	0	0
Satd. Flow (RTOR)		5						*100				
Lane Group Flow (vph)	0	1589	0	0	1784	0	0	44	0	0	0	0
Turn Type	Perm	NA		Perm	NA		Split	NA				
Protected Phases		2			6		9	9				
Permitted Phases	2			6								
Total Split (s)	55.0	55.0		55.0	55.0		15.0	15.0				
Total Lost Time (s)		6.0			6.0			6.0				
Act Effct Green (s)		54.2			54.2			6.6				
Actuated g/C Ratio		0.69			0.69			0.08				
v/c Ratio		0.86			0.96			0.19				
Control Delay		9.6			31.6			1.8				
Queue Delay		0.0			0.6			7.9				
Total Delay		9.6			32.2			9.7				
LOS		A			C			A				
Approach Delay		9.6			32.2			9.7				
Approach LOS		A			C			A				
Queue Length 50th (ft)		43			~565			0				
Queue Length 95th (ft)		#617			#751			2				
Internal Link Dist (ft)		34			769			120			1	
Turn Bay Length (ft)												
Base Capacity (vph)		1855			1861			281				
Starvation Cap Reductn		0			0			0				
Spillback Cap Reductn		0			11			202				
Storage Cap Reductn		0			0			0				
Reduced v/c Ratio		0.86			0.96			0.56				

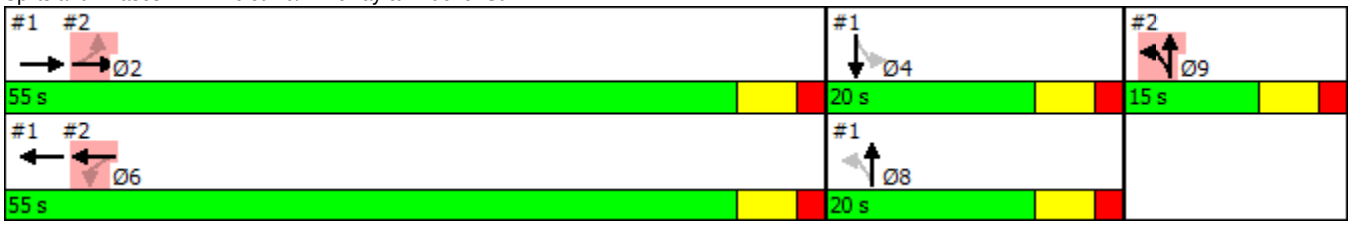
Intersection Summary	
Cycle Length: 90	
Actuated Cycle Length: 78.5	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.96	
Intersection Signal Delay: 21.4	Intersection LOS: C
Intersection Capacity Utilization 71.0%	ICU Level of Service C
Analysis Period (min) 15	

* User Entered Value

~ 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: 2: Violet Rd/Driveway & Andover St



1: Jug Handle/Esquire Dr & Andover St

Direction	All
Future Volume (vph)	3460
Total Delay / Veh (s/v)	15

2: Violet Rd/Driveway & Andover St

Direction	All
Future Volume (vph)	3314
Total Delay / Veh (s/v)	21

Network Totals

Number of Intersections	2
Total Delay / Veh (s/v)	18
Performance Index	40.4

Appendix E: MassDOT Highway Division's Project Development Process

Overview of the Project Development Process

Transportation decision-making is complex and can be influenced by legislative mandates, environmental regulations, financial limitations, agency programmatic commitments, and partnering opportunities. Decision-makers and reviewing agencies, when consulted early and often throughout the project development process, can ensure that all participants understand the potential impact these factors can have on project implementation. Project development is the process that takes a transportation improvement from concept through construction.

The MassDOT Highway Division has developed a comprehensive project development process which is contained in Chapter 2 of the *MassDOT Highway Division's Project Development and Design Guide*. The eight-step process covers a range of activities extending from identification of a project need, through completion of a set of finished contract plans, to construction of the project. The sequence of decisions made through the project development process progressively narrows the project focus and, ultimately, leads to a project that addresses the identified needs. The descriptions provided below are focused on the process for a highway project, but the same basic process will need to be followed for non-highway projects as well.

1. Needs Identification

For each of the locations at which an improvement is to be implemented, MassDOT leads an effort to define the problem, establishes project goals and objectives, and defines the scope of the planning needed for implementation. To that end, it has to complete a Project Need Form (PNF), which states in general terms the deficiencies or needs related to the transportation facility or location. The PNF documents the problems and explains why corrective action is needed. For this study, the information defining the need for the project will be drawn primarily, perhaps exclusively, from the present report. Also, at this point in the process, MassDOT meets with potential participants, such as the Metropolitan Planning Organization (MPO) and community members, to allow for an informal review of the project.

The PNF is reviewed by the MassDOT Highway Division district office whose jurisdiction includes the location of the proposed project. MassDOT also sends the PNF to the MPO, for informational purposes. The outcome of this step determines whether the project requires further planning, whether it is already well supported by prior planning studies, and, therefore, whether it is ready to move forward into the design phase, or whether it should be dismissed from further consideration.

2. Planning

This phase will likely not be required for the implementation of the improvements proposed in this planning study, as this planning report should constitute the outcome of this step. However, in general, the purpose of this implementation step is for the project proponent to identify issues, impacts, and approvals that may need to be obtained, so that the subsequent design and permitting processes are understood.

The level of planning needed will vary widely, based on the complexity of the project. Typical tasks include: define the existing context, confirm project need, establish goals and objectives, initiate public outreach, define the project, collect data, develop and analyze alternatives, make recommendations, and provide documentation. Likely outcomes include consensus on the project definition to enable it to move forward into environmental documentation (if needed) and design, or a recommendation to delay the project or dismiss it from further consideration.

3. Project Initiation

At this point in the process, the proponent, MassDOT Highway Division, fills out a Project Initiation Form (PIF) for each improvement, which is reviewed by its Project Review Committee (PRC) and the MPO. The PRC is composed of the Chief Engineer, each District Highway Director, and representatives of the Project Management, Environmental, Planning, Right-of-Way, Traffic, and Bridge departments, and the MassDOT Federal Aid Program Office (FAPO). The PIF documents the project type and description, summarizes the project planning process, identifies likely funding and project management responsibility, and defines a plan for interagency and public participation. First the PRC reviews and evaluates the proposed project based on the MassDOT's statewide priorities and criteria. If the result is positive, MassDOT Highway Division moves the project forward to the design phase, and to programming review by the MPO. The PRC may provide a Project Management Plan to define roles and responsibilities for subsequent steps. The MPO review includes project evaluation based on the MPO's regional priorities and criteria. The MPO may assign project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

4. Environmental Permitting, Design, and Right-of-Way Process

This step has four distinct but closely integrated elements: public outreach, environmental documentation and permitting (if required), design, and right-of-way acquisition (if required). The outcome of this step is a fully designed and permitted project ready for construction. However, a project does not have to be fully designed in order for the MPO to program it in the TIP. The sections below provide more detailed information on the four elements of this step of the project development process.

Public Outreach

Continued public outreach in the design and environmental process is essential to maintain public support for the project and to seek meaningful input on the design elements. The public outreach is often in the form of required public hearings, but can also include less formal dialogues with those interested in and affected by a proposed project.

Environmental Documentation and Permitting

The project proponent, in coordination with the Environmental Services section of the MassDOT Highway Division, will be responsible for identifying and complying with all applicable federal, state, and local environmental laws and requirements. This includes determining the appropriate project category for both the Massachusetts Environmental Protection Act (MEPA) and the National Environmental Protection Act (NEPA). Environmental documentation and permitting is often completed in conjunction with the **Preliminary Design** phase described below.

Design

There are three major phases of design. The first is **Preliminary Design**, which is also referred to as the 25-percent submission. The major components of this phase include full survey of the project area, preparation of base plans, development of basic geometric layout, development of preliminary cost estimates, and submission of a functional design report. Preliminary Design, although not required to, is often completed in conjunction with the Environmental Documentation and Permitting. The next phase is **Final Design**, which is also referred to as the 75-percent and 100-percent submission. The major components of this phase include preparation of a subsurface exploratory plan (if required), coordination of utility relocations, development of traffic management plans through construction zones, development of final cost estimates, and refinement and finalization of the construction plans. Once Final Design is complete, a full set of **Plans, Specifications, and Estimates (PS&E)** is developed for the project.

Right-of-Way Acquisition
A separate set of Right-of-Way plans are required for any project that requires land acquisition or easements. The plans must identify the existing and proposed layout lines, easements, property lines, names of property owners, and the dimensions and areas of estimated takings and easements.

5. Programming (Identification of Funding)
Programming, which typically begins during the design phase, can actually occur at any time during the process, from planning to design. In this step, which is distinct from project initiation, the proponent requests that the MPO place the project in the region's Transportation Improvement Program (TIP). The proponent requesting the project's listing on the TIP can be the community or it can be one of the MPO member agencies (the Regional Planning Agency, MassDOT, and the Regional Transit Authority). The MPO then considers the project in terms of state and regional needs, evaluation criteria, and compliance with the regional Transportation Plan and decides whether to place it in the draft TIP for public review and then in the final TIP.

6. Procurement
Following project design and programming of a highway project, the MassDOT Highway Division publishes a request for proposals. It then reviews the bids and awards the contract to the qualified bidder with the lowest bid.

7. Construction
After a construction contract is awarded, MassDOT Highway Division and the contractor develop a public participation plan and a management plan for the construction process.

8. Project Assessment
The purpose of this step is to receive constituents' comments on the project development process and the project's design elements. MassDOT Highway Division can apply what is learned in this process to future projects.

Project Development Schematic Timetable

Description	Schedule Influence	Typical Duration
Step I: Problem/Need/Opportunity Identification The proponent completes a Project Need Form (PNF). This form is then reviewed by the MassDOT District office which provides guidance to the proponent on the subsequent steps of the process.	The Project Need Form has been developed so that it can be prepared quickly by the proponent, including any supporting data that is readily available. The District office shall return comments to the proponent within one month of PNF submission.	1 to 3 months
Step II: Planning Project planning can range from agreement that the problem should be addressed through a clear solution to a detailed analysis of alternatives and their impacts.	For some projects, no planning beyond preparation of the Project Need Form is required. Some projects require a planning study centered on specific project issues associated with the proposed solution or a narrow family of alternatives. More complex projects will likely require a detailed alternatives analysis.	Project Planning Report: 3 to 24+ months
Step III: Project Initiation The proponent prepares and submits a Project Initiation Form (PIF) and a Transportation Evaluation Criteria (TEC) form in this step. The PIF and TEC are informally reviewed by the Metropolitan Planning Organization (MPO) and MassDOT District office, and formally reviewed by the PRC.	The PIF includes refinement of the preliminary information contained in the PNF. Additional information summarizing the results of the planning process, such as the Project Planning Report, are included with the PIF and TEC. The schedule is determined by PRC staff review (dependent on project complexity) and meeting schedule.	1 to 4 months
Step IV: Design, Environmental, and Right of Way The proponent completes the project design. Concurrently, the proponent completes necessary environmental permitting analyses and files applications for permits. Any right of way needed for the project is identified and the acquisition process begins.	The schedule for this step is dependent upon the size of the project and the complexity of the design, permitting, and right-of-way issues. Design review by the MassDOT district and appropriate sections is completed in this step.	3 to 48+ months
Step V: Programming The MPO considers the project in terms of its regional priorities and determines whether or not to include the project in the draft Regional Transportation Improvement Program (TIP) which is then made available for public comment. The TIP includes a project description and funding source.	The schedule for this step is subject to each MPO's programming cycle and meeting schedule. It is also possible that the MPO will not include a project in its Draft TIP based on its review and approval procedures.	3 to 12+ months
Step VI: Procurement The project is advertised for construction and a contract awarded.	Administration of competing projects can influence the advertising schedule.	1 to 12 months
Step VII: Construction The construction process is initiated including public notification and any anticipated public involvement. Construction continues to project completion.	The duration for this step is entirely dependent upon project complexity and phasing.	3 to 60+ months
Step VIII: Project Assessment The construction period is complete and project elements and processes are evaluated on a voluntary basis.	The duration for this step is dependent upon the proponent's approach to this step and any follow-up required.	1 month

Source: MassDOT Highway Division Project Development and Design Guide