TECHNICAL MEMORANDUM

DATE: **May 18, 2017**

TO: **John DePriest, Planning and Development Director, City of Chelsea**

FROM: **Chen-Yuan Wang and Katrina Crocker, MPO Staff**

RE: **Safety and Operations Analyses at Selected Intersections, FFY 2016—Chelsea, Broadway at Fourth and Fifth Street**

This memorandum summarizes the analyses and improvement strategies for two intersections in Chelsea: Broadway at Fourth Street and Broadway at Fifth Street, which were selected through a comprehensive review of 20 potential study locations in the region.[1]

The memorandum contains the following sections:

- Study Background
- Existing Conditions
- Issues and Concerns
- Traffic, Pedestrian, and Bicycle Volumes
- Intersection Operations Analysis
- Crash Data Analysis
- Improvement Alternatives
- Recommendations

It also includes technical appendices that contain data and methods applied in the study.

1 STUDY 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) area's arterial highways—where many crashes occur, and which experience congestion during peak traffic periods, or are in need of improvements for bus, bicycle, and pedestrian travel. For the past ten years, the MPO has been conducting these planning studies, and municipalities in the region are very receptive to them, as the studies give communities an opportunity to begin looking at the needs of

[1] Details of the selection process and criteria may be found in the Central Transportation Planning Staff's (CTPS) technical memorandum, "Safety and Operation at Selected Intersections: Federal Fiscal Year 2016," Seth Asante and Katrina Crocker, March 17, 2016.

problematic locations 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.

2 EXISTING CONDITIONS

The two intersections discussed here are located in Chelsea's downtown area, where major roadways and Massachusetts Bay Transportation Authority (MBTA) bus routes converge. The area is a busy business district with intensive activities generated by pedestrians, bicycles, vehicles, buses, truck deliveries, and on-street parking. Figure 1 shows the locations of the two intersections, existing street layouts, and major developments in the study area.

Broadway at Fifth Street

Broadway at Fifth Street, locally known as Bellingham Square, is the busiest intersection in the city in terms of pedestrian activities. In addition to many local and franchised businesses, the City Hall complex and a branch campus of Bunker Hill Community College are adjacent to the intersection. The square also is the city's bus hub. Two major MBTA bus stops, one for inbound trips on Broadway near Fifth Street and one for outbound trips on Hawthorne Street in front of Bunker Hill Community College, serve riders for MBTA Routes 111, 112, 114, 116, and 117. Buses arrive frequently during peak commuting hours. The stop on Broadway is tight for berthing two buses. If a bus occupies the middle of the allotted space, the second bus is usually double-parked.

The streets at this intersection all operate one-way only. Two main streets, Washington Avenue/Broadway (westbound only) and Hawthorne Street/Broadway (eastbound only), are separated by a strip of concrete pavement to prohibit traffic (except emergency vehicles) from crossing. Two minor streets, Fifth Street (northbound only) and Bellingham Street (southbound only), carry traffic leaving the intersection. The main streets each carry two lanes of traffic, with on-street parking on both sides; the minor streets each carry one lane of traffic, with on-street parking on one side.

Crosswalks exist at all legs of the intersection. The diagonal-line (zebra-type) crosswalks are mostly faded from heavy vehicle traffic. The crosswalks are not fully used by pedestrians; and many people cross freely in the wide intersection outside the marked crosswalks (see Figure 1). Recent counts recorded as many as 500 or more pedestrians crossing outside of the crosswalks per peak hour.

This signalized intersection operates in a simple two-phase mode—one for traffic and one for pedestrians—in approximately one-minute signal cycles. The 21-second pedestrian phase is tight for seniors and children crossing the Washington Street approach. Staff observed pedestrians crossing Washington Avenue, Broadway, and Hawthorne Street without waiting for pedestrian signal phases.

Broadway at Fourth Street

Broadway at Fourth Street, about 600 feet west of Fifth Street, is an unsignalized intersection with stop control on Fourth Street. Broadway operates one-way westbound and Fourth Street operates one-way southbound. Approaching the intersection, Broadway has two travel lanes: one for through movements and one shared by through- and left-turn movements. Fourth Street has two lanes: one for right turns and one for through movements. Broadway is generally busy during peak hours. Fourth Street, connecting to US Route 1 about 500 feet north, carries heavy traffic during PM peak hours; and because of the stop sign control, drivers endure delays and tend to enter the intersection aggressively.

This intersection carries a large number of pedestrian crossings. Crosswalks exist on all four legs of the intersection, but they are located too far from the intersection. Because of the buildings at the intersection corners, drivers have a hard time seeing pedestrians in the crosswalks, especially those turning left from Broadway; and a number of crashes have caused pedestrian injuries at the crosswalk on the south side of the intersection.

An MBTA bus stop, with a shelter and a bench, is located at the northeast corner of the intersection. As the bus berth is not well defined, buses often stop too close to the intersection, blocking the view of drivers from Fourth Street and preventing them from seeing traffic and pedestrians on Broadway. In addition, the shelter and the bench occupy almost half of the sidewalk width, impeding pedestrians.

Broadway between Fifth and Fourth Streets

The section of Broadway between Fourth and Fifth Streets operates as two-lane westbound only, with on-street parking on both sides. Twelve-foot sidewalks exist on both sides of Broadway alongside stores that are popular with local and regional residents, which makes for very busy pedestrian and vehicular traffic during the evening and Saturday midday peak hours.

A municipal parking lot is located behind the buildings north of Broadway. Although this lot provides the downtown area with additional parking spaces, there is no signage to indicate its location or direct visitors. The parking lot can

be accessed only from Cherry Street or Fourth Street. A pedestrian alleyway, Chelsea Walk, connects the parking lot to Broadway

A mid-block crosswalk on Broadway at Chelsea Walk serves pedestrian crossings in the entire section. At both ends of the crosswalk, sidewalks are suitably extended to Broadway. However, the crosswalk is not clearly visible to drivers because it is too narrow, contains faded diagonal lines, and lacks visual forewarning cues.

Currently, there are no dedicated bicycle facilities on Broadway and adjacent side streets; and although there are fewer cyclists than pedestrians, they still are active in the downtown area. Besides commuting trips, many of them appear to be local shopping and recreational trips to downtown or nearby neighborhoods. Staff observed some bicycles traveling in the opposite direction of traffic, as well as on sidewalks.

3 ISSUES AND CONCERNS

Based on MPO staff's field observations, recently collected data and discussions with the Chelsea Department of Planning and Development, major issues and concerns in the study area are:

- Broadway from Bellingham Square to Fourth Street is a high pedestrian-crash location.
- The roadway has a large number of pedestrians crossing during peak traffic hours.
- Many pedestrians cross the streets without using crosswalks.
- Pedestrian signal time is a bit too brief for some crosswalks at Bellingham Square and insufficient to cross the entire width of Broadway.
- Pedestrians often cross Broadway when oncoming traffic has the green light.
- All crosswalks are faded. The diagonal lines are too thin and not visible. The zebra-type crosswalks tend to be eroded by vehicle travel.
- Some left-turning vehicles on Broadway westbound at Bellingham Square do not stop for red lights—a potential cause of crashes with pedestrians.
- MBTA bus stops at Bellingham Square are tight for berthing two buses, especially the stop on Broadway westbound.
- At Fourth Street, crosswalks are located too far (10 to 15 feet) from the intersection, so it is difficult for drivers to see pedestrians.
- Fourth Street traffic endures extensive delays during peak hours. Drivers tend to enter the intersection aggressively and do not pay attention to crossing pedestrians.

- The bus shelter at Broadway and Fourth Street impedes pedestrian movement, as it occupies most of the sidewalk.
- Occasionally buses berth too close to this intersection and block the view of drivers from Fourth Street (see Figure 1).
- There is a lack of bicycle accommodations in the study area.
- Bicycles were observed traveling in the opposite direction of traffic and on sidewalks.
- Double parking on Broadway is frequent.
- There are loading zones on Broadway, but they are not clearly marked, and frequently are occupied by parked cars.
- The mid-block crosswalk on Broadway is not obvious to drivers. It is too narrow, its markings are faded, and it has no signs indicating its location.
- There is a lack of signage about and directions to the off-street municipal parking lot behind the buildings on north Broadway.
- The downtown area needs a wayfinding system.

4 TRAFFIC, PEDESTRIAN, AND BICYCLE VOLUMES

To support this study, MassDOT collected 24-hour traffic volumes on study area roadways, peak-period turning-movement counts at the two intersections (including pedestrian and bicycle volumes), and pedestrian crossing counts at Bellingham Square.

MassDOT collected 24-hour traffic volumes during the weekday period, April 12 to 15, 2016 at five locations in the study area. The data indicate that, on average, approximate weekday traffic volumes were as follows[2]:

1) Washington Avenue at Bellingham Square—10,000 vehicles
2) Broadway (between Fifth and Fourth Streets)—7,000 vehicles
3) Hawthorne Street—9,000 vehicles
4) Bellingham Street—800 vehicles
5) Fourth Street—6,500 vehicles

Appendix A contains 24-hour counts (summarized in hours) for the five count locations.

MassDOT collected turning movement counts during the morning peak period (7:00–9:00 AM) and the evening peak period (4:00–6:00 PM) on Thursday April

[2] During the counting period, Washington Avenue at the bridge over the MBTA Newburyport/Rockport Line (about 1,000 feet north of Bellingham Square) was closed for reconstruction. Through discussions with city planners, staff assumed that the closure would not cause a noticeable reduction in traffic volumes on Broadway, as drivers were able to find alternative routes to get to and from Broadway.

14, 2016, and during the midday peak period (12:00–2:00 PM) on Saturday April 16, 2016, in 15-minute intervals. MassDOT also collected data on the numbers of pedestrians crossing at Bellingham Square (without using the crosswalks) during the same AM, PM, and Saturday midday peak periods.

Figure 2 shows the weekday morning (8:00–9:00) and evening (4:45–5:45) peak-hour traffic, pedestrian, and bicycle volumes at the two intersections. The Fifth Street intersection carried about 1,250 vehicles in the AM peak hour: 749 from Washington Avenue and 507 from Hawthorne Street. In the PM peak hour, it also carried about 1,250 vehicles: 557 from Washington Avenue and 691 from Hawthorne Street. The counts include 61 buses and 37 trucks in the AM peak hour and 61 buses and 8 trucks in the PM peak hour. Appendix B shows the intersection turning movement counts at by vehicle class, and number of bicycles and pedestrians.

Pedestrian crossings were intensive at the Fifth Street intersection, especially in the PM peak hour. Nearly 1,200 pedestrian crossings occurred in the AM peak hour and nearly 2,000 crossings occurred in the PM peak hour. About two-thirds of total crossings (800 in the AM and 1,300 in the PM peak hour) were on Broadway. These crossings occurred at various locations including marked crosswalks on four major legs of the intersection and three unmarked but roughly identifiable paths on Broadway between Washington Avenue and Hawthorne Street. Crossings at the unmarked paths (see Figure 2) count for nearly half of the total Broadway crossings (more than 350 in the AM and more than 550 in the PM). The middle path, diagonally located between the inbound and the outbound bus stops, carried many more crossings than the other two locations. Appendix C shows the hourly pedestrian crossing counts at the three different paths.

The counts show only about two to three on-road bicycles passing through the intersection in both the AM or PM peak hours. Note that cyclists generally are less active in April when the weather is still cold; and that, presumably, bicycle volumes would be higher between May and October. A field trip in November observed more than three bicycles on the road and one on the sidewalk between 3:00 and 4:00 PM.

The Fourth Street intersection carried about 900 vehicles in the AM peak hour: 575 from Broadway and 321 from Fourth Street, and about 850 vehicles in the PM peak hour: 459 from Broadway and 402 from Fourth Street. Note that the counts include 39 buses and 18 trucks in the AM peak hour, and 32 buses and 11 trucks in the PM peak hour.

The intersection also carried heavy pedestrian crossings, especially in the PM peak hour. Nearly 300 pedestrian crossings occurred in the AM peak hour, and

nearly 700 crossings occurred in the PM peak hour. Only two bicycles were observed in the AM peak hour. Appendix D shows the intersection turning movement counts by vehicle class, and number of bicycles and pedestrians.

Figure 3 shows the Saturday midday peak-hour (12:30–1:30 PM) traffic, pedestrian, and bicycle volumes at the two intersections. The Saturday counts are similar to the weekday PM peak-hour counts in terms of volumes and movement patterns. The Fifth Street intersection posted about 1,800 pedestrian crossings. The Fourth Street intersection posted about 800 pedestrian crossings, and more than that in the weekday PM peak hour. The Saturday turning movement counts by hour are included in Appendices B and D separately for the two intersections.

5 INTERSECTION OPERATIONS ANALYSIS

Based on the collected turning movement counts, staff conducted traffic operational analyses for the two intersections using the Synchro traffic analysis and simulation program.[3] Staff also examined the existing and required pedestrian crossing times at different locations, and bicycle and bus operating conditions.

At the Fifth Street intersection, traffic signals and pedestrian crossing signals exist only on the Washington Avenue and Hawthorne Street approaches. The two traffic signals operate synchronously under one controller. Each 61-second signal cycle consists of a 40-second traffic phase and a 21-second pedestrian phase. The signal setting operates 24 hours continuously.

The Synchro analyses indicate that traffic operates at desirable level of service (LOS) B or better, with an average delay of 8 to 10 seconds, on both the Washington Avenue and Hawthorne Street approaches in all three different peak hour periods (AM, PM, and Saturday). Appendix E contains the three peak-hour intersection capacity analyses under existing conditions.

Staff also analyzed traffic operations using predicted 2040 traffic conditions, assuming 15 percent traffic growth from existing volumes.[4] The analyses indicate that traffic still would operate at desirable LOS B or better, with an average delay

[3] Staff used Synchro Version 9.0, developed and distributed by Trafficware Ltd. It can perform capacity analysis and traffic simulation (when combined with SimTraffic) for an individual intersection or a series of intersections in a roadway network.

[4] The forecast is based on a recent MPO transportation-planning model developed for a study of the lower Mystic River area. The model indicates about 10 to 12 percent traffic growth from 2016 to 2040 for the area. Considering Silver Line Gateway Project and the potential developments in Chelsea, staff used 15 percent traffic growth for this study.

of 10 to 12 seconds, in all three peak-hour periods using the existing signal setting.

The analyses did not include traffic congestion and delays caused by the large number of pedestrian crossings, especially those outside of crosswalks and during traffic signal phases. Frequent bus arrivals and departures are the source of even more traffic delays; and Synchro simulations could not fully reflect these conditions, except for showing occasional pedestrian crossings during traffic phases. Based on field observations, staff consider that the existing traffic more likely operates at LOS C, with an average delay of about 15 to 20 seconds.

The existing 21-second pedestrian signal phase is sufficient for pedestrians to cross only one leg of the crosswalks on Washington Avenue, Broadway, or Hawthorne Street. It is tight for seniors and pedestrians with young children to cross the nearly 45-foot-long crosswalk on Washington Avenue or Broadway eastbound. Applying a 3.0-feet per-second walking speed and a 7-second “walk” start-up time, it would barely meet the required total signal time to cross the Washington Avenue.[5]

The 21-second time is not intended to pertain to crossing outside of the crosswalks, or the entire length of Broadway. The shortest distance on Broadway between Washington Avenue and Hawthorne Street is about 55 feet. Those who cross Broadway using the shortest path cannot see the pedestrian signals; they usually cross Broadway when they see traffic stopping. Often when traffic starts to move, they are only halfway through, and thus stuck in the middle of Broadway. The pedestrian counts indicate that there is a strong demand for adequate pedestrian crossing facilities in this section of Broadway, which also would provide safe and convenient access to MBTA buses.

Synchro analysis indicates that traffic at the Fourth Street intersection operates at acceptable LOS E only in the AM peak hour and at LOS F with an average delay of more than two minutes in the PM and Saturday peak hours. Appendix F contains the three peak-hour intersection capacity analyses under existing conditions.

Using the predicted 2040 traffic conditions, the Fourth Street approach would operate at LOS F in the AM with an average delay of more than one minute. The PM and Saturday peak-hour conditions would deteriorate severely. The analyses also did not fully reflect traffic congestion and delays caused by the large number of pedestrian crossings and frequent bus blockages.

[5] The estimate is based on Chapter 4E, Manual on Uniform Traffic Control Devices, 2009 Edition with Revision Numbers 1 and 2 incorporated, May 2012.

Staff conducted a preliminary signal warrant analysis and found that the intersection potentially could qualify for a traffic signal installation. Even though the intersection has a large number of pedestrian crossings, it does not meet the Pedestrian Volume warrant (Warrant 4) because traffic volume on its main street (Broadway) is not relatively significant. It would meet the Crash Experience warrant (Warrant 7), based on the assumption of five or more correctible crashes per year. Appendix G presents this analysis based on recent traffic counts.

Future improvements at the two intersections also should include bicycle accommodations. Staff recommend that both separated- and shared-lane bicycle operations should be explored; and selecting the best option also would require examining right-of-way conditions beyond the Broadway section. At this preliminary stage, it appears that the shared-lane operation is more suitable because, in the study area, Broadway has a limited surface width and a 25-mile per-hour speed regulation, which is applicable for shared-lane bicycle operations.

6 CRASH DATA ANALYSIS

The recent MassDOT Crash Locations report indicates that the Chelsea downtown area is the number one pedestrian crash location in the state based on 2004–13 crash data. In the ten-year period, there were 236 crashes, including one fatal and 176 involving injury. The crash cluster and crash locations map (Appendix H) indicates that the study area, Broadway from Bellingham Square to Fourth Street, had the greatest concentration of pedestrian crashes within the crash cluster.

Figure 4 shows the locations and patterns of crashes in the study area from 2011 to 2015. Staff constructed the collision diagram based on data from a recent MassDOT Road Safety Audit (RSA) in downtown Chelsea[6] and additional data collected from Chelsea Police Department. The RSA study focused on pedestrian and bicycle crashes (involving at least one vehicle and a pedestrian or cyclist). To portray the crash conditions thoroughly, staff collected vehicle-to-vehicle and other single-vehicle crashes in the same time period.

Appendix I contains information about the crashes from the RSA study, which covered a larger area of Broadway than did this study. Appendix J contains additional information about the crashes from Chelsea Police Department data. Staff transferred identification numbers (1–56) of the crashes from the RSA directly and added new numbers for the police department data (57–79).

[6] MassDOT Road Safety Audit: Broadway, Washington Street, Hawthorne Street, and Central Avenue, City of Chelsea, July 27, 2016.

The collision diagram shows that 45 crashes occurred in the five-year period—22 pedestrian and bicycle crashes, and 23 vehicle-to-vehicle and single-vehicle crashes. Two-thirds (30) of these crashes, mostly involving a pedestrian or cyclist, resulted in personal injuries.

At the Fifth Street intersection, 16 crashes occurred in the five-year period, including seven pedestrian crashes (four crossing Broadway), and three bicycle crashes (two crossing Broadway and one traveling in the direction opposite of traffic). The pedestrian and bicycle crashes all resulted in personal injuries. The other crashes were all related to parking maneuvers, except a two-vehicle sideswipe collision and an out-of-control single vehicle crash.

At the Fourth Street intersection, 22 crashes occurred in the five-year period, including 12 pedestrian crashes (six at the crosswalk on the south side, four crossing Broadway, and two at the crosswalk on the north side) and one bicycle crash with a parked vehicle. All but two of the pedestrian crashes resulted in personal injuries. Four vehicle-to-vehicle crashes occurred on Broadway westbound, and three collisions involved a westbound vehicle and a southbound vehicle.

Under stop control, Fourth Street drivers endure extensive delays during peak hours. When traffic on Broadway stops for pedestrian crossings, drivers tend to use it as an opportunity to enter the intersection; and while they are, they may not see the traffic in the left-most lane or pay attention to pedestrians on other approaches, thus causing crashes.

Broadway between Fifth and Fourth Streets had seven crashes in the five-year period—three pedestrian crashes (all outside the mid-block crosswalk, except one nearby), one bicycle crash (traveling in the direction opposite of traffic), and three vehicle-to-vehicle crashes (two rear-end and one sideswipe). The pedestrian and bicycle crashes all resulted in personal injuries.

Note that the wider and busier Fifth Street intersection had fewer pedestrian crashes than did the Fourth Street intersection in the five-year period, probably because the traffic signal at the intersection creates gaps for pedestrians to cross in busy traffic. While at the Fourth Street intersection, pedestrians, even at crosswalks, are exposed to the uncontrolled Broadway traffic, and aggressive Fourth Street traffic.

7 IMPROVEMENT ALTERNATIVES

Based on the above analyses, staff developed short- and long-term improvements to address safety and operational problems. Short-term

improvements may be implemented within a year at relatively low cost. Long-term improvements are more complex and generally include roadway layout modifications and major facility replacements, which would require extensive planning, design, and funding.

7.1 Short-Term Improvements for Study Area

Figure 5 shows the proposed major short-term improvements in the study area.

Proposed Improvements at Fifth Street Intersection:

- Increase pedestrian signal time from 21 to 26 seconds[7]
- Restripe wide (15 to 20 feet) longitudinal-line (ladder-type) markings at all existing crosswalks
- Stripe vehicle yield lines (shark's teeth) in front of the two crosswalks on Broadway
- Restripe stop lines on Washington Avenue and Hawthorne Street to at least 1.5 feet wide.
- Install Manual on Uniform Traffic Devices (MUTCD) No Turn on Red sign (R10-11a) for Washington Avenue left-turn approach
- Stripe diagonal yellow lines with the words, LOADING ZONE, for loading zone on Washington Avenue near Cherry Street
- Clearly define the taxi stand on Hawthorne Street and update its signage
- Consider and examine feasibility of relocating traffic signal head from the mast post to the mast arm on Hawthorne Street (frequently hindered by berthing buses)

Proposed Improvements at Fourth Street Intersection:

- Restripe wide (15 to 20 feet) longitudinal-line markings at all existing crosswalks[8]
- Relocate stop sign on left side of Fourth Street to the stop line, parallel to the one on right side[9]
- Install Do Not Enter (MUTCD R5-1) signs on back of stop signs that face Broadway

[7] The adjustment includes a slight increase of cycle length from 61 to 65 seconds and a one-second reduction from the traffic phase. Synchro tests indicated that traffic would operate at the same desirable LOS with a negligible increase in delay. This adjustment would improve pedestrians' safety and comfort, and would have a marginal impact on traffic under the existing intersection layout and traffic conditions.

[8] The restriped width can be extended from the outside edge of the existing wheelchair ramps toward the intersection.

[9] Currently, the stop sign is not parallel to the one on the right, at the stop line. It also is hidden behind a utility pole, so hard for drivers approaching the intersection from the north to see.

- Restripe stop line on Fourth Street to 1.5 feet wide

Proposed Improvements on Broadway between the two Intersections:

- Restripe wide (20 to 25 feet) longitudinal-line markings at existing mid-block crosswalk
- Stripe vehicle yield lines (shark's teeth) in front of the crosswalk
- Install pedestrian crossing warning sign (MUTCD W11-2) with location plaque (MUTCD W16-7) at corners of sidewalk extensions on both ends of the crosswalk
- Stripe diagonal yellow lines with the words, LOADING ZONE, for loading zone near crosswalk

Proposed Short-Term Improvements for Study Area:

- Install bicycle shared-lane (sharrows) pavement markings on rightmost lane along Washington Avenue, Broadway, and Hawthorne Street
- Examine suitable signs and their locations on Broadway, Fourth, and Fifth Streets to direct visitors to municipal parking lot
- Enforce no double-parking and parking-limitation rules, especially at loading zones

7.2 Long-Term Improvement Alternatives

Long-Term Improvement Alternatives at Fifth Street Intersection:

Figures 6-1 and 6-2 show conceptual plans of four long-term improvement alternatives that staff developed for the Fifth Street intersection.

Alternative One

Alternative 1 adds a wide crosswalk across Broadway, with new traffic and pedestrian signals, to encompass the popular but unmarked crossing area. Key elements include:

- Install new crosswalk (25 to 30 feet wide) diagonally across Broadway between the two bus stops
- Install sidewalk extensions (pedestrian blub-outs) at both ends of new crosswalk
- Install signal indications toward approaching traffic and pedestrian signals at both ends of new crosswalk
- Relocate crosswalks on Washington Avenue and Broadway eastbound, with pedestrian signals and Americans with Disabilities Act (ADA) compliant wheelchair ramps at both ends

- Add new crosswalk, with pedestrian signals and ADA ramps, connecting relocated crosswalks and Bellingham Square Monument
- Maintain existing crosswalks on Broadway (westbound) and Hawthorne Street
- Expand inbound bus stop by extending adjacent sidewalk toward Broadway and removing one on-street parking space

Alternative Two

Alternative 2 provides crosswalks on all approaches at the intersection by adding and relocating crosswalks. Key elements include:

- Install new crosswalk (20 to 25 feet wide) perpendicularly across Broadway connecting Fifth Street and Bellingham Street
- Install pedestrian bulb-outs at both ends of new crosswalk
- Relocate crosswalks on Broadway (westbound) and Hawthorne Street toward intersection, with pedestrian bulb-outs and ADA ramps at both ends
- Install signal indications toward approaching traffic and pedestrian signals at both ends of crosswalks on Broadway
- Maintain existing crosswalks on Washington Avenue and Broadway (eastbound)
- Install traffic and pedestrian signals for crosswalk on Broadway eastbound
- Expand inbound bus stop by extending adjacent sidewalk toward Broadway and removing one on-street parking space

Alternative Three

Alternative 3 is a combination of the proposed changes in Alternatives 1 and 2. It specifies crosswalks on all approaches of the intersection and shortens crossing distances by relocating the crosswalks on Washington Avenue and Broadway eastbound. Key elements include:

- Install all proposed facilities from Alternative 2 (the first four items) at the intersection
- Relocate crosswalks on Washington Avenue and Broadway eastbound, with pedestrian signals and ADA ramps at both ends
- Add new crosswalk, with pedestrian signals and ADA ramps, connecting relocated crosswalks and Bellingham Square Monument
- Expand inbound bus stop as proposed in Alternatives 1 and 2

Alternative Four

Alternative 4 varies slightly from Alternative 3. It combines all the crosswalks at the intersection into a major crossing area by paving the intersection block with

materials that contrast with the existing roadway pavement. The key elements of this alternative are the same as for Alternative 3.

All of the alternatives would require a new traffic and pedestrian signal system that is capable of synchronizing, prioritizing, and balancing the different signal locations based on demands from pedestrians, vehicles, and even bicycles. Synchro tests of a generic setting indicate that the intersection generally would operate at desirable LOS B using the projected 2040 traffic conditions. The tested 65-second cycle length consists of a 30-second traffic phase and a 35-second pedestrian phase. Appendix K presents the signal setting and analysis results for the different peak hours (AM, PM, and Saturday).

Long-Term Improvement Alternatives at Fourth Street Intersection:

Figure 7 shows conceptual plans for two long-term improvement alternatives that staff developed for the Fourth Street intersection.

Alternative One

Alternative 1 proposes to extend sidewalk curbs at the four corners toward Broadway and relocate crosswalks (15 feet wide) accordingly, with ADA-compliant wheelchair ramps.[10] The modification would reduce crossing distances and slow traffic on Broadway; however, it would enhance drivers and pedestrians' views of each other significantly. The curb extension (pedestrian bulb-out) at the northeast corner also serves to prevent buses from berthing too close to the intersection. The proposed layout could be applied under the existing stop control or a new traffic signal (by adding a stop line on the Broadway westbound approach).

Alternative Two

Alternative 2 varies slightly from Alternative 1. In addition to the curb extensions and crosswalk relocations proposed in Alternative 1, it proposes to extend the sidewalk near the bus stop to form a bus blub-out for passengers getting on and off buses. The extension also would increase space for pedestrians to traverse the bus waiting area. The proposed layout could be applied only under a traffic signal control, as drivers on Fourth Street potentially could be hindered by berthing buses.

Traffic signal control at this intersection would improve pedestrian safety and reduce delays on the Fourth Street approach significantly. The signal can operate under a 65-second cycle that consists of a 23-second traffic phase on

[10] The extensions might not be applicable toward Fourth Street, as they could narrow the street and become problematic for emergency vehicles.

Broadway, a 21-second traffic phase on Fourth Street, and a 21-second exclusive pedestrian phase. With careful design and no right turns on red for traffic, pedestrian crossings on the intersection's north and east sides could operate with the Broadway and Fourth Street traffic currently. These operations, in addition to the exclusive signal phase, would provide more opportunities for pedestrians to cross the intersection. Appendix L presents the signal setting and analysis results using projected 2040 traffic conditions for the different peak hours (AM, PM, and Saturday).

8 RECOMMENDATIONS

This study performed a series of safety and operations analyses, identified issues, and proposed short- and long-term improvements at the two intersections and on Broadway between the intersections.

The proposed short-term improvements would enhance safety and operations for the various transportation modes used in the study area. With a high benefit/cost ratio, they should be implemented as soon as resources are available from highway maintenance or local Chapter 90 funding.

For the long term, staff recommend reconstructing the Fifth Street intersection with additional pedestrian crossings and a new traffic and pedestrian signal system that is capable of synchronizing, prioritizing, and balancing the various signal locations based on vehicular, pedestrian, and bicycle volumes. At this planning stage, staff recommend Alternatives 3 or 4. At the design stage, the City of Chelsea should examine all of the alternatives further. It would cost approximately $1,500,000 to $2,000,000 to reconstruct the Fifth Street intersection.[11]

Staff recommend signalizing and reconstructing the Fourth Street intersection with sidewalk extensions, crosswalk enhancements, and a bus blub-out. Staff propose two design alternatives, and prefer Alternative 2, with signalization. At the design stage, the City of Chelsea should examine the signalization requirements and the two alternatives further. It would cost approximately $500,000 to $750,000 to reconstruct and signalize the Fourth Street intersection.

For the entire study area (including downtown), staff recommend the following long-term improvement strategies:

[11] This cost was estimated using general expenses of similar projects. The estimate contains only design and construction costs—not right-of-way, utility relocation, landscape and streetscape, or other contingency costs—and is based on non-inflation-adjusted 2016 dollars.

- Review pedestrian operations and facilities in the downtown area and develop a systematic plan to enhance pedestrian safety and mobility for all locations of concern.[12]
- Review bicycle operations in the city and develop a bicycle plan, including both shared and separated roadways, and docking facilities.
- Review the bus stop locations and needs in the downtown area and explore the possibility of consolidating some of the stops or expanding some of the bus berths and passenger waiting facilities.
- Redesign the municipal parking lot north of Broadway; consider aesthetic enhancements, such as landscaping and wall murals by local artists.
- Review parking demand and facility conditions in the downtown area and develop a comprehensive parking- and access-management plan.
- Develop a wayfinding system for the downtown area.

With the advent of prospective developments, Chelsea's historic downtown section has great potential to become a lively shopping and recreation center just north of Boston. The city recently began a multi-modal comprehensive study of all major roadways in the downtown area, which offers some foresight into major improvements that could be applicable in downtown Chelsea.

Implementing the proposed long-term improvements would require significant effort and collaboration on the part of all stakeholders, including the City of Chelsea, residents and owners of adjacent developments, MassDOT, and the MBTA. Broadway is included in National Highway System, so the city can work with MassDOT Highway Division District 6 to initiate a project, obtain a favorable review from MassDOT's Project Review Committee, and identify potential funding resources, through both MassDOT and the Boston Region MPO.

Appendix M cites details about actions that are required in each step of MassDOT's project development process, including a schematic timetable; further information about this process is located on MassDOT's website, at www.massdot.state.ma.us/planning/Main/PlanningProcess/ProjectDevelopmentProcess.aspx; and at www.massdot.state.ma.us/Portals/8/docs/designGuide/CH_2_a.pdf.

CW/cw

[12] A number of other intersections in the downtown area have similar issues as do the intersection of Broadway at Fourth Street; so, the same proposed improvement strategies for Broadway at Fourth Street also could be considered for those.

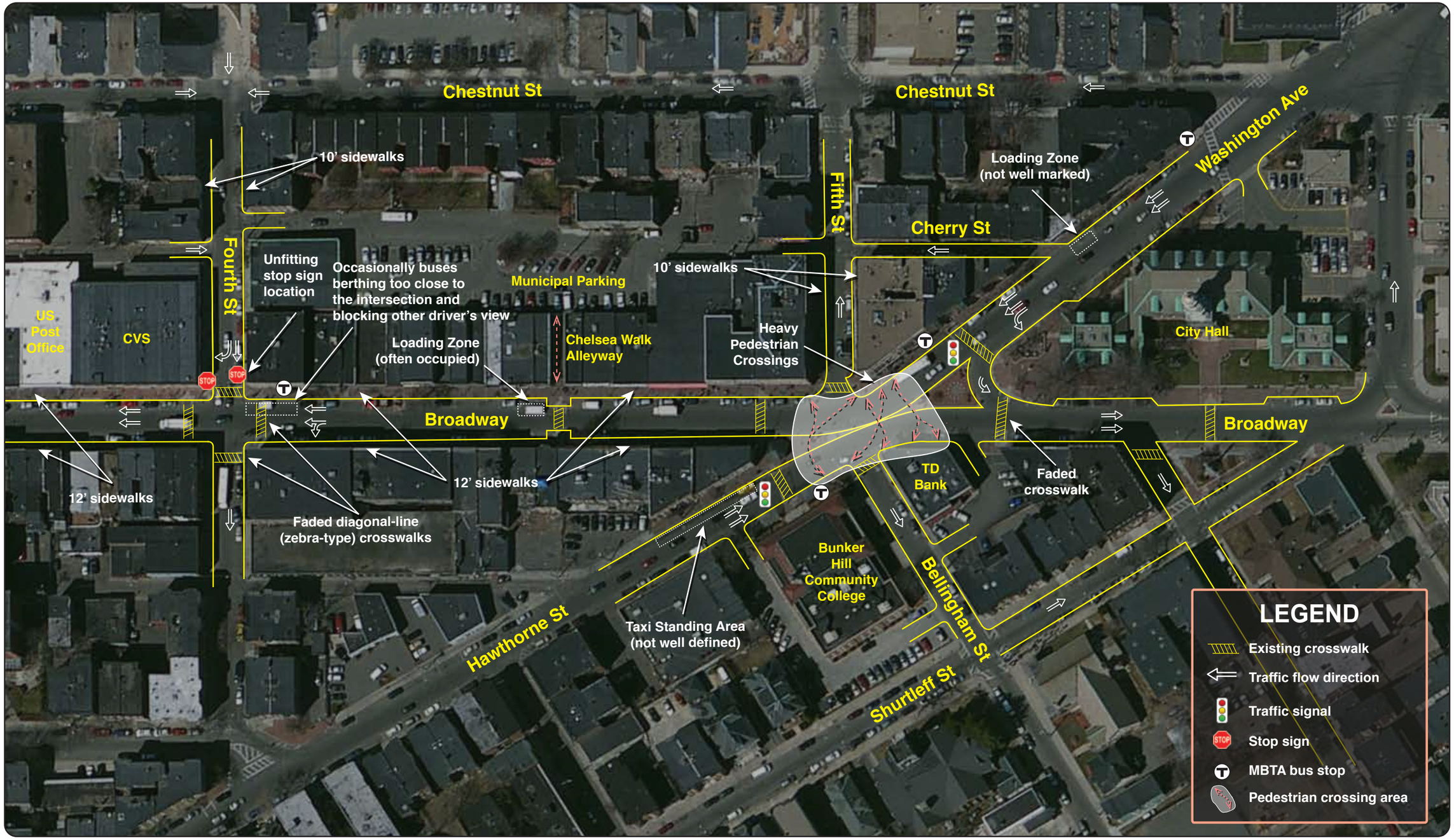

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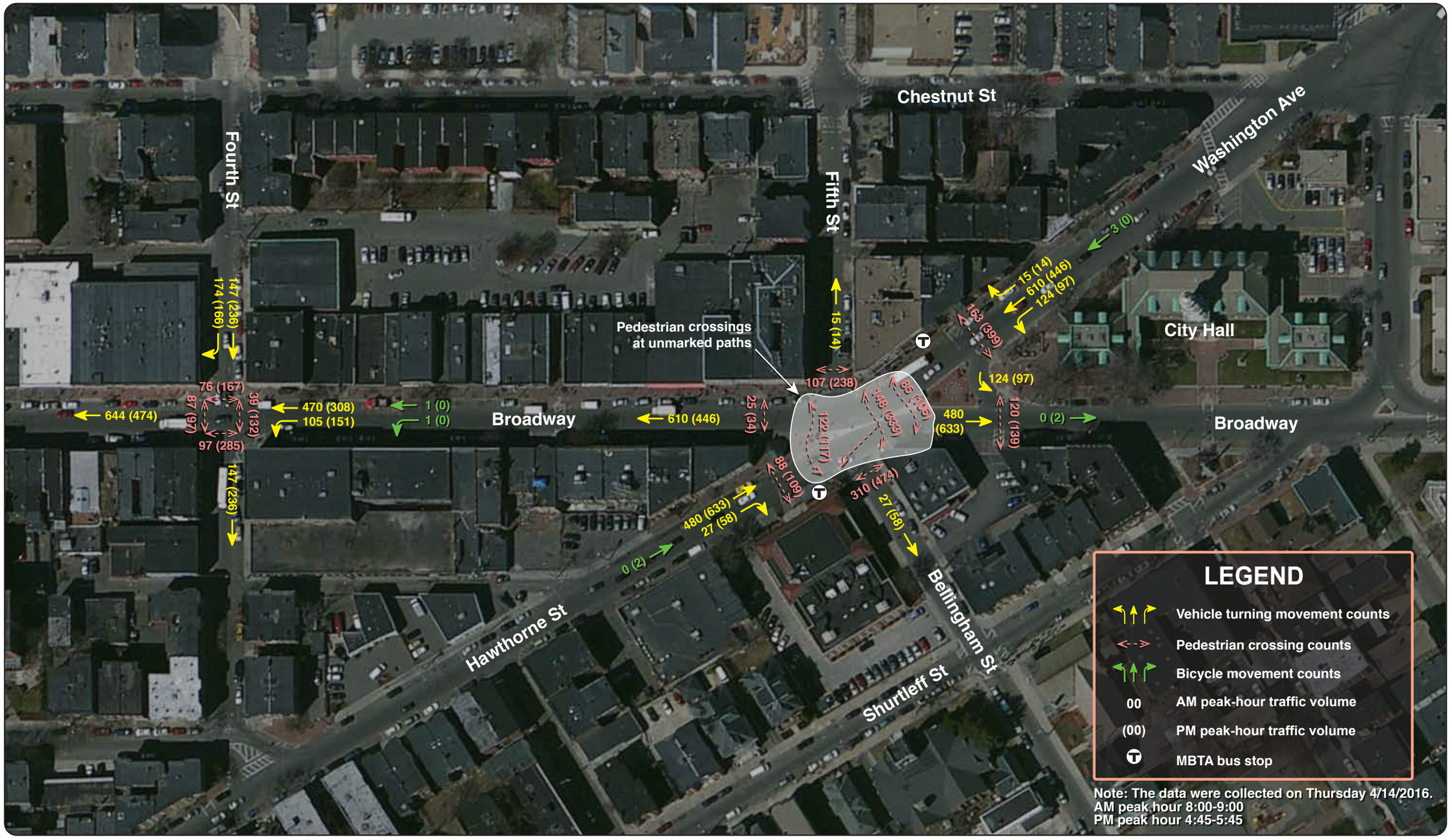
Figure 1
Study Area Existing Conditions
Broadway in Chelsea

Safety and Operations
Analysis at
Selected Intersections



BOSTON
REGION
MPO

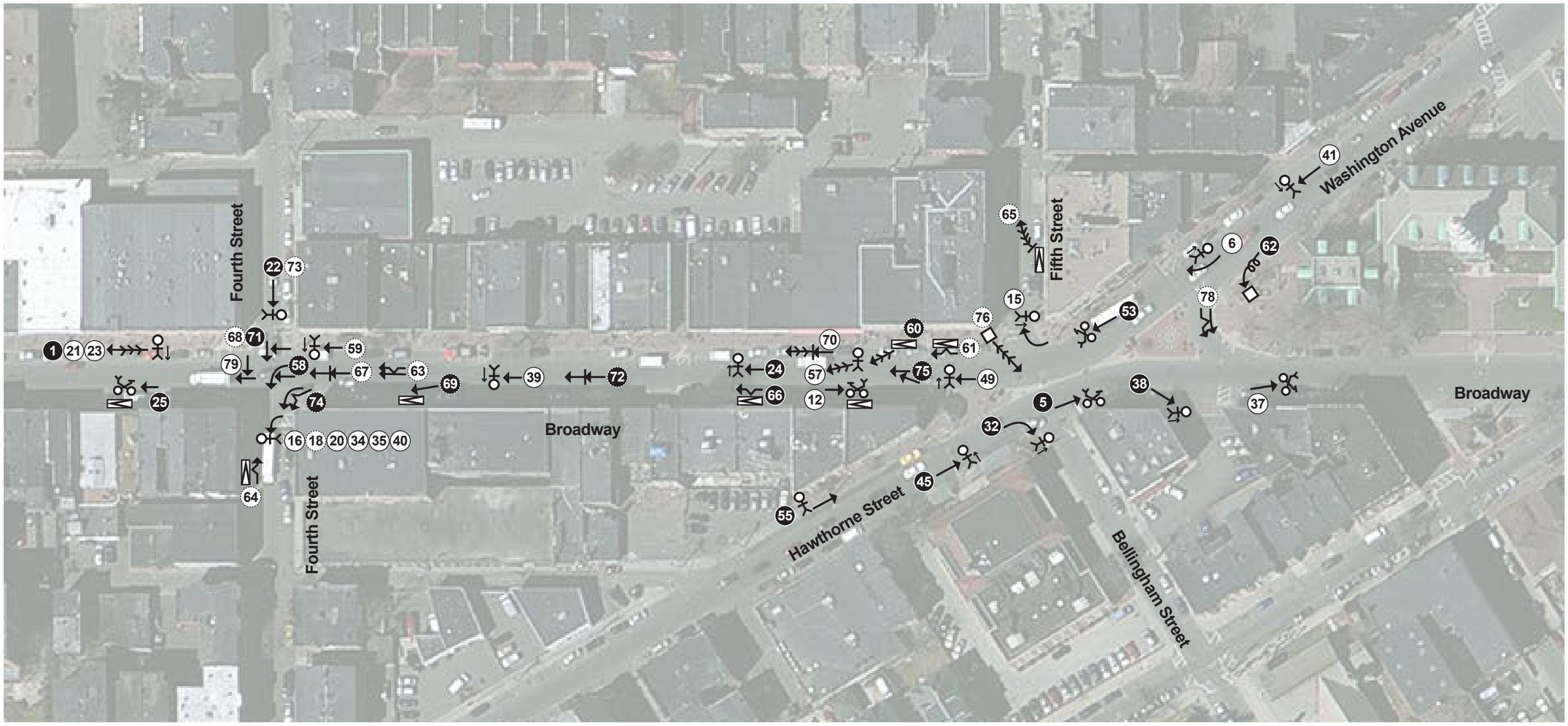
Figure 2
Weekday Peak-Hour Traffic, Pedestrian and Bicycle Volumes
Broadway in Chelsea

Safety and Operations
Analysis at
Selected Intersections

BOSTON REGION MPO

Figure 3
Saturday Peak-Hour Traffic, Pedestrian and Bicycle Volumes
Broadway in Chelsea

Safety and Operations Analysis at Selected Intersections



SYMBOLS

- Moving Vehicle
- Backing Vehicle
- Non-Involved Vehicle
- Pedestiran
- Parked Vehicle
- Fixed Object
- Bicycle
- Animal

TYPES OF CRASH

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

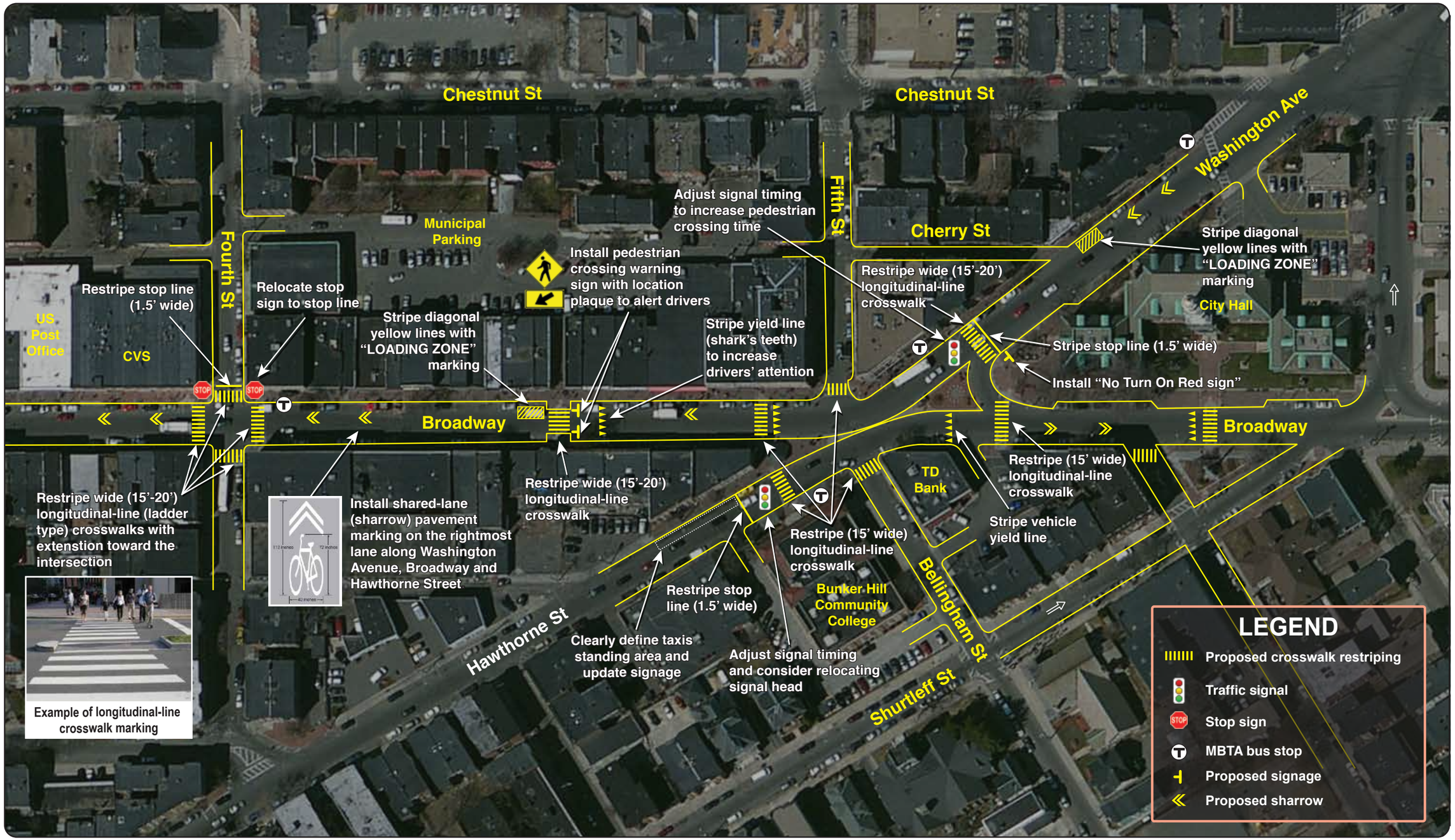
CRASH ID AND SEVERITY

- # Crash Identification Number (Summary Tables in Appendices I and J)
- (#) Non-Injury Crash
- (#) Injury Crash
- # Night Time Crash

BOSTON REGION MPO

Figure 4
Collision Diagram: Chelsea Police Reports 2011-2015
Broadway in Chelsea

Safety and Operations Analysis at Selected Intersections

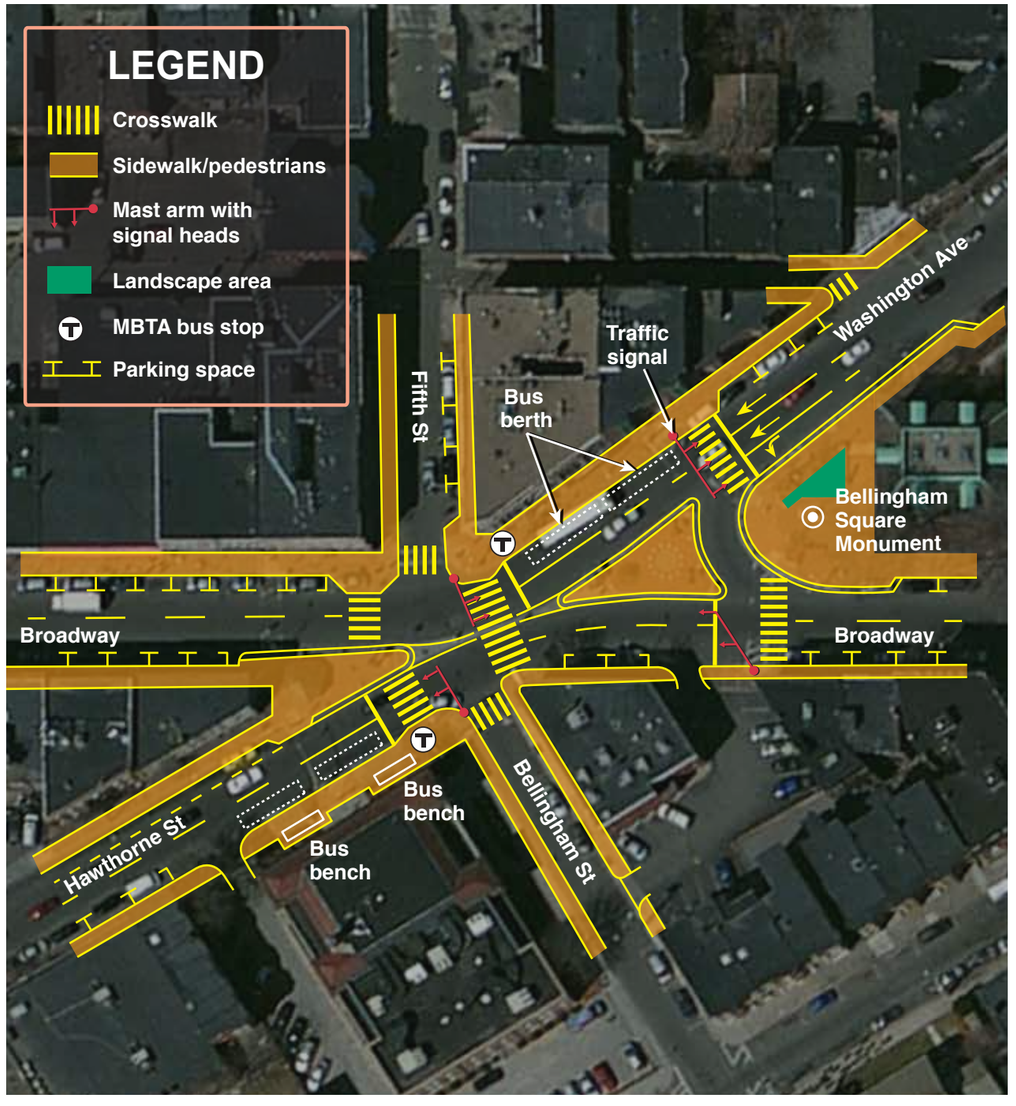


BOSTON REGION MPO

Figure 5
Proposed Key Short-Term Improvements
Broadway in Chelsea

Safety and Operations Analysis at Selected Intersections

Alternative 1



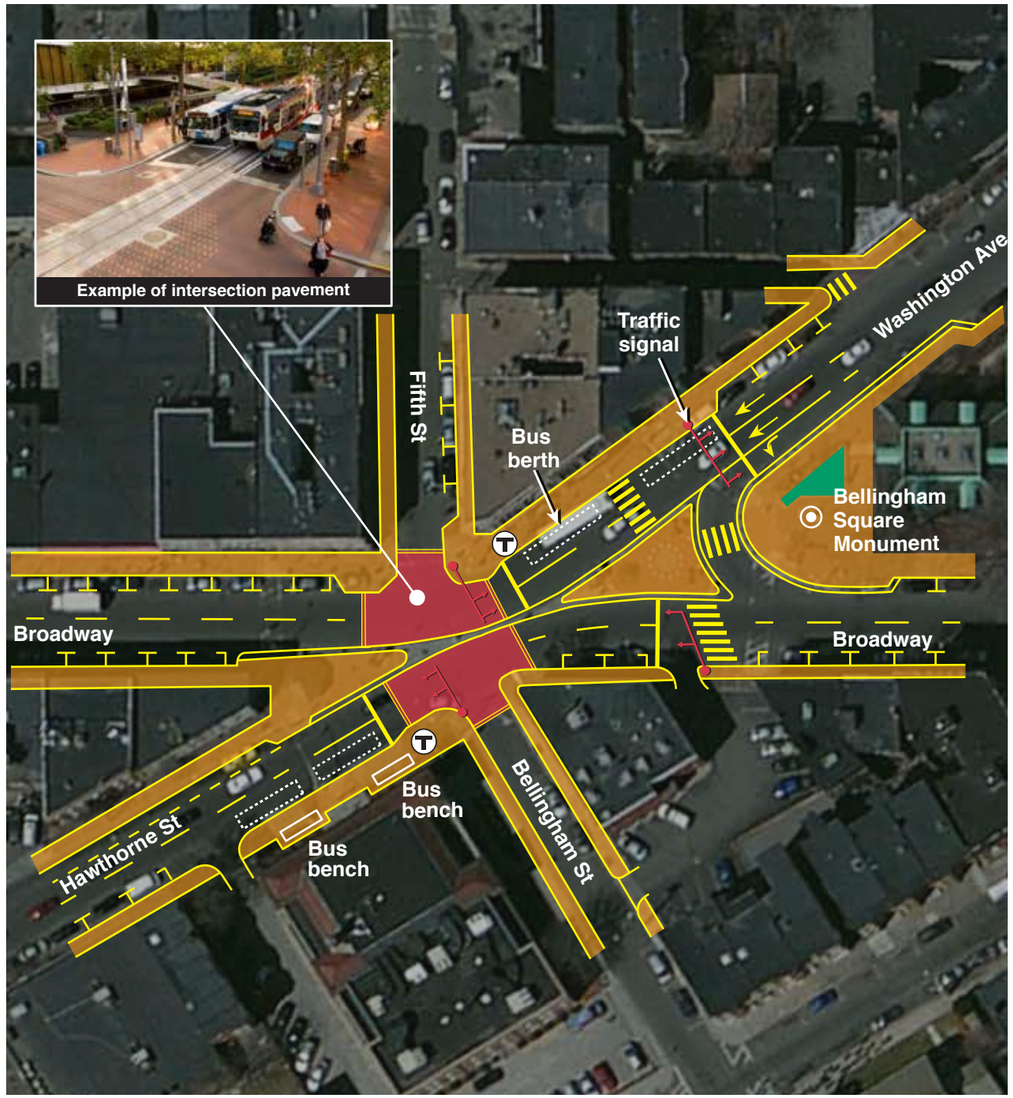
Alternative 2

BOSTON REGION MPO

Figure 6-1
Long-Term Improvement Conceptual Plans: Broadway at Fifth Street Broadway in Chelsea

Safety and Operations Analysis at Selected Intersections

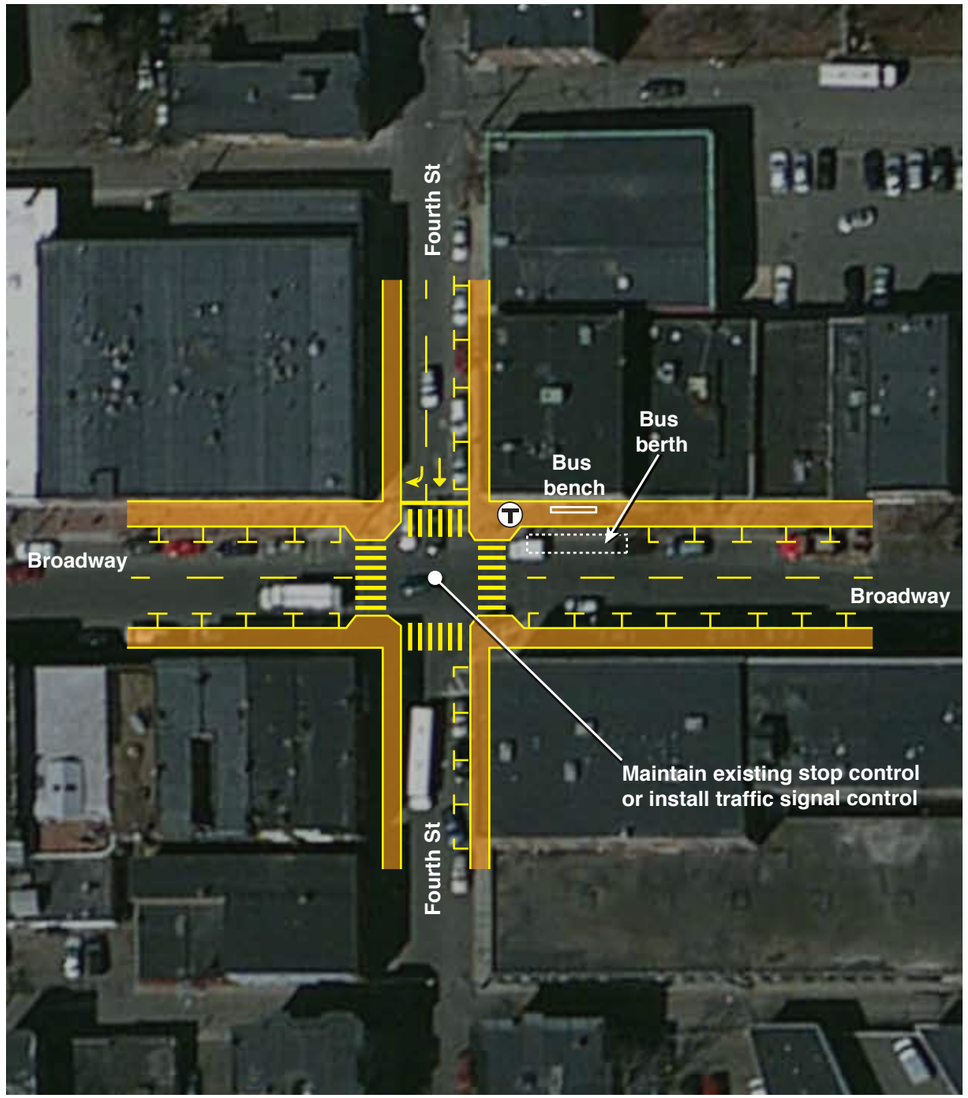
Alternative 3



Alternative 4

BOSTON REGION MPO

Figure 6-2
Long-Term Improvement Conceptual Plans: Broadway at Fifth Street Broadway in Chelsea



Alternative 1

Alternative 2

BOSTON
REGION
MPO

Figure 7
Long-Term Improvement Conceptual Plans: Broadway at Fourth Street
Broadway in Chelsea

Safety and Operations
Analysis at
Selected Intersections

APPENDIX A

Weekday 24-Hour Traffic Counts
April 12 to 15, 2016

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1
Starting: 4/12/2016

STA. 1 SB

1-WAY

Site Reference: 160110000545
Site ID: 000000000102
Location: FOURTH ST., NORTH OF BROADWAY
Direction: SOUTH

File: 102.prn
City: CHELSEA
County: VOL ONE-WAY SB

TIME	MON	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00			87	111	126	108			108	324
02:00			81	80	87	82			82	248
03:00			68	50	64	60			60	182
04:00			46	53	50	49			49	149
05:00			77	62	84	74			74	223
06:00			181	189	171	180			180	541
07:00			265	289	291	281			281	845
08:00			331	356	330	339			339	1017
09:00			340	343	298	327			327	981
10:00			368	350		359			359	718
11:00		392	375	320		362			362	1087
12:00		430	392	330		384			384	1152
13:00		448	433	376		419			419	1257
14:00		394	422	424		413			413	1240
15:00		396	451	487		444			444	1334
16:00		485	492	429		468			468	1406
17:00		527	453	451		477			477	1431
18:00		446	451	461		452			452	1358
19:00		409	488	427		441			441	1324
20:00		347	329	376		350			350	1052
21:00		255	291	296		280			280	842
22:00		256	254	254		254			254	764
23:00		193	210	212		205			205	615
24:00		144	148	184		158			158	476
TOTALS	0	5122	7033	6910	1501	6966	0	0	6966	20566
% AVG WKDY		73.5	100.9	99.1	21.5					
% AVG WEEK		73.5	100.9	99.1	21.5					
AM Times		12:00	12:00	08:00	08:00	12:00			12:00	
AM Peaks		430	392	356	330	384			384	
PM Times		17:00	16:00	15:00		17:00			17:00	
PM Peaks		527	492	487		477			477	

U6

AWD 6966

FAC .93 (.97)

ADT 6,300

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1 Page: 1
Starting: 4/12/2016

STA. 2 NB

1-WAY

Site Reference: 160110000876 File: 201.prn
Site ID: 000000000201 City: CHELSEA
Location: HAWTHRONE ST., SOUTH OF BELLINGHAM ST. County: VOL ONE-WAY NB
Direction: NORTH

TIME	MON	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00			116	143	172	143			143	431
02:00			97	103	81	93			93	281
03:00			75	67	86	76			76	228
04:00			66	51	91	69			69	208
05:00			90	78	102	90			90	270
06:00			213	227	183	207			207	623
07:00			339	325	329	331			331	993
08:00			459	438	463	453			453	1360
09:00			472	503	485	486			486	1460
10:00			486	481		483			483	967
11:00		511	566	523		533			533	1600
12:00		567	597	541		568			568	1705
13:00		626	580	494		566			566	1700
14:00		595	527	636		586			586	1758
15:00		555	651	665		623			623	1871
16:00		654	572	602		609			609	1828
17:00		615	679	680		658			658	1974
18:00		681	664	691		678			678	2036
19:00		531	606	517		551			551	1654
20:00		525	544	564		544			544	1633
21:00		403	436	455		431			431	1294
22:00		366	378	388		377			377	1132
23:00		273	280	298		283			283	851
24:00		195	232	250		225			225	677
TOTALS	0	7097	9725	9720	1992	9663	0	0	9663	28534
% AVG WKDY		73.4	100.6	100.5	20.6					
% AVG WEEK		73.4	100.6	100.5	20.6					
AM Times		12:00	12:00	12:00	09:00	12:00			12:00	
AM Peaks		567	597	541	485	568			568	
PM Times		18:00	17:00	18:00		18:00			18:00	
PM Peaks		681	679	691		678			678	

U5

AWD 9663

FAC .93 (.97)

ADT 8,700

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1
Starting: 4/12/2016

STA. 35B

Site Reference: 160110000807
Site ID: 000000000302
Location: WASHINGTON AVE., NORTH OF BROADWAY.
Direction: SOUTH

1-WAY

File: 302.prn
City: CHELSEA
County: VOL ONE-WAY SB

TIME	MON	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00			96	124	101	107			107	321
02:00			65	61	68	64			64	194
03:00			54	47	52	51			51	153
04:00			50	60	72	60			60	182
05:00			103	125	112	113			113	340
06:00			287	328	282	299			299	897
07:00			492	477	265	411			411	1234
08:00			625	570	561	585			585	1756
09:00			745	842	773	786			786	2360
10:00			589	645		617			617	1234
11:00		586	575	593		584			584	1754
12:00		650	643	591		628			628	1884
13:00		595	645	608		616			616	1848
14:00		591	622	721		644			644	1934
15:00		559	621	602		594			594	1782
16:00		600	653	648		633			633	1901
17:00		650	630	669		649			649	1949
18:00		647	666	631		648			648	1944
19:00		598	658	639		631			631	1895
20:00		523	456	538		505			505	1517
21:00		340	459	523		440			440	1322
22:00		294	365	362		340			340	1021
23:00		274	241	269		261			261	784
24:00		156	179	196		177			177	531
TOTALS	0	7063	10519	10869	2286	10443	0	0	10443	30737
% AVG WKDY		67.6	100.7	104	21.8					
% AVG WEEK		67.6	100.7	104	21.8					
AM Times		12:00	09:00	09:00	09:00	09:00			09:00	
AM Peaks		650	745	842	773	786			786	
PM Times		17:00	18:00	14:00		17:00			17:00	
PM Peaks		650	666	721		649			649	

US

AWD 10443

FAC .93 (.97)

ADT 9,400

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1
Starting: 4/12/2016

STA. 4 EB
1-WAY

Site Reference: 160110000782
Site ID: 000000000403
Location: BELLINGHAM ST., EAST OF BROADWAY.
Direction: EAST

File: 403.prn
City: CHELSEA
County: VOL ONE-WAY WB

TIME	MON	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00			18	11	9	12			12	38
02:00			9	10	7	8			8	26
03:00			12	2	9	7			7	23
04:00			11	9	10	10			10	30
05:00			14	14	9	12			12	37
06:00			15	12	17	14			14	44
07:00			21	29	28	26			26	78
08:00			42	39	25	35			35	106
09:00			40	38	40	39			39	118
10:00			67	57		62			62	124
11:00		43	58	45		48			48	146
12:00		55	50	39		48			48	144
13:00		80	64	58		67			67	202
14:00		75	43	54		57			57	172
15:00		49	50	55		51			51	154
16:00		57	58	62		59			59	177
17:00		65	53	47		55			55	165
18:00		75	66	79		73			73	220
19:00		49	42	43		44			44	134
20:00		28	53	50		43			43	131
21:00		39	42	44		41			41	125
22:00		30	39	28		32			32	97
23:00		25	20	27		24			24	72
24:00		16	24	21		20			20	61
TOTALS	0	686	911	873	154	887	0	0	887	2624
% AVG WKDY		77.3	102.7	98.4	17.3					
% AVG WEEK		77.3	102.7	98.4	17.3					
AM Times		12:00	10:00	10:00	09:00	10:00			10:00	
AM Peaks		55	67	57	40	62			62	
PM Times		13:00	18:00	18:00		18:00			18:00	
PM Peaks		80	66	79		73			73	

U6
AWD 887
FAC .93 (.97)
ADT 800

MassDOT Highway Division
WEEKLY SUMMARY FOR LANE 1
Starting: 4/12/2016

STA. 5 WB

1-WAY

Site Reference: 160110000462
Site ID: 000000000504
Location: BROADWAY., EAST OF FOURTH ST.
Direction: WEST

File: 504.prn
City: CHELSEA
County: VOL ONE-WAY WB

TIME	MON	TUE 12	WED 13	THU 14	FRI 15	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00			70	104	40	71			71	214
02:00			58	46	54	52			52	158
03:00			42	34	43	39			39	119
04:00			46	53	60	53			53	159
05:00			79	98	87	88			88	264
06:00			205	224	197	208			208	626
07:00			340	352	330	340			340	1022
08:00			427	411	404	414			414	1242
09:00			533	606	545	561			561	1684
10:00			449	400		424			424	849
11:00			449	389		419			419	838
12:00		430	267	422		373			373	1119
13:00		463	416	317		398			398	1196
14:00		430	432	479		447			447	1341
15:00		407	411	434		417			417	1252
16:00		438	459	451		449			449	1348
17:00		420	445	455		440			440	1320
18:00		436	486	430		450			450	1352
19:00		405	410	461		425			425	1276
20:00		380	352	390		374			374	1122
21:00		307	339	401		349			349	1047
22:00		221	256	265		247			247	742
23:00		209	188	213		203			203	610
24:00		125	144	126		131			131	395
TOTALS	0	4671	7303	7561	1760	7372	0	0	7372	21295
% AVG WKDY		63.3	99	102.5	23.8					
% AVG WEEK		63.3	99	102.5	23.8					
AM Times		12:00	09:00	09:00	09:00	09:00			09:00	
AM Peaks		430	533	606	545	561			561	
PM Times		13:00	18:00	14:00		18:00			18:00	
PM Peaks		463	486	479		450			450	

43

AWD 7372

FAC .93(.97)

ADT 6,700

APPENDIX B

Intersection Turning Movement Counts
Broadway at Fifth Street
April 14 and 16, 2016

Thursday

Study Name	Chelsea - Broadway, Washington Ave., Bellingham,Fifth and Hawthorne Streets TM2 TMC
Start Date	Thursday, April 14, 2016 7:00 AM
End Date	Saturday, April 16, 2016 2:00 PM
Site Code	

Report Summary

		Southbound						Southwestbound		Westbound		Northbound						Northeastbound		Eastbound				Crosswalk	
Time Period	Class.	R	BR	L	HL	I	O	I	O	I	O	R	BR	L	HL	I	O	I	O	I	O	Total		Pedestrians	Total
Peak 1	Motorcycles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	N	88	88
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
7:00 AM - 9:00 AM	Cars	13	508	0	102	623	0	0	484	0	21	21	382	0	0	403	0	0	508	0	13	1026	NE	25	25
One Hour Peak	%	87%	83%	0%	82%	83%	0%	0%	80%	0%	78%	78%	80%	0%	0%	79%	0%	0%	83%	0%	87%	82%		100%	
8:00 AM - 9:00 AM	Light Goods Vehicles	1	55	0	14	70	0	0	72	0	1	1	58	0	0	59	0	0	55	0	1	129	E	107	107
	%	7%	9%	0%	11%	9%	0%	0%	12%	0%	4%	4%	12%	0%	0%	12%	0%	0%	9%	0%	7%	10%		100%	
	Buses	0	32	0	1	33	0	0	26	0	3	3	25	0	0	28	0	0	32	0	0	61	S	163	163
	%	0%	5%	0%	1%	4%	0%	0%	4%	0%	11%	11%	5%	0%	0%	6%	0%	0%	5%	0%	0%	5%		100%	
	Single-Unit Trucks	1	11	0	7	19	0	0	19	0	2	2	12	0	0	14	0	0	11	0	1	33	SW	120	120
	%	7%	2%	0%	6%	3%	0%	0%	3%	0%	7%	7%	3%	0%	0%	3%	0%	0%	2%	0%	7%	3%		100%	
	Articulated Trucks	0	1	0	0	1	0	0	3	0	0	0	3	0	0	3	0	0	1	0	0	4	W	310	310
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%		100%	
	Bicycles on Road	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3		**813**	**813**
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Total	**15**	**610**	**0**	**124**	**749**	**0**	**0**	**604**	**0**	**27**	**27**	**480**	**0**	**0**	**507**	**0**	**0**	**610**	**0**	**15**	**1256**			
	PHF	0.62	0.88	0	0.82	0.87	0	0	0.93	0	0.75	0.75	0.96	0	0	0.96	0	0	0.88	0	0.62	0.9			
	Approach %					60%	0%	0%	48%	0%	2%					40%	0%	0%	49%	0%	1%				
Peak 2	Motorcycles	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	N	109	109
Specified Period	%	0%	0%	0%	1%	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	14	366	0	87	467	0	0	595	0	49	49	508	0	0	557	0	0	366	0	14	1024	NE	34	34
One Hour Peak	%	100%	82%	0%	90%	84%	0%	0%	82%	0%	84%	84%	80%	0%	0%	81%	0%	0%	82%	0%	100%	82%		100%	
4:45 PM - 5:45 PM	Light Goods Vehicles	0	48	0	9	57	0	0	96	0	8	8	87	0	0	95	0	0	48	0	0	152	E	238	238
	%	0%	11%	0%	9%	10%	0%	0%	13%	0%	14%	14%	14%	0%	0%	14%	0%	0%	11%	0%	0%	12%		100%	
	Buses	0	31	0	0	31	0	0	29	0	1	1	29	0	0	30	0	0	31	0	0	61	S	399	399
	%	0%	7%	0%	0%	6%	0%	0%	4%	0%	2%	2%	5%	0%	0%	4%	0%	0%	7%	0%	0%	5%		100%	
	Single-Unit Trucks	0	1	0	0	1	0	0	6	0	0	0	6	0	0	6	0	0	1	0	0	7	SW	139	139
	%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	1%	0%	0%	1%	0%	0%	0%	0%	0%	1%		100%	
	Articulated Trucks	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	W	474	474
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
	Bicycles on Road	0	0	0	0	0	0	0	2	0	0	0	2	0	0	2	0	0	0	0	0	2		**1393**	**1393**
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Total	**14**	**446**	**0**	**97**	**557**	**0**	**0**	**730**	**0**	**58**	**58**	**633**	**0**	**0**	**691**	**0**	**0**	**446**	**0**	**14**	**1248**			
	PHF	0.7	0.94	0	0.84	0.97	0	0	0.93	0	0.91	0.91	0.94	0	0	0.94	0	0	0.94	0	0.7	0.99			
	Approach %					45%	0%	0%	58%	0%	5%					55%	0%	0%	36%	0%	1%				

Saturday

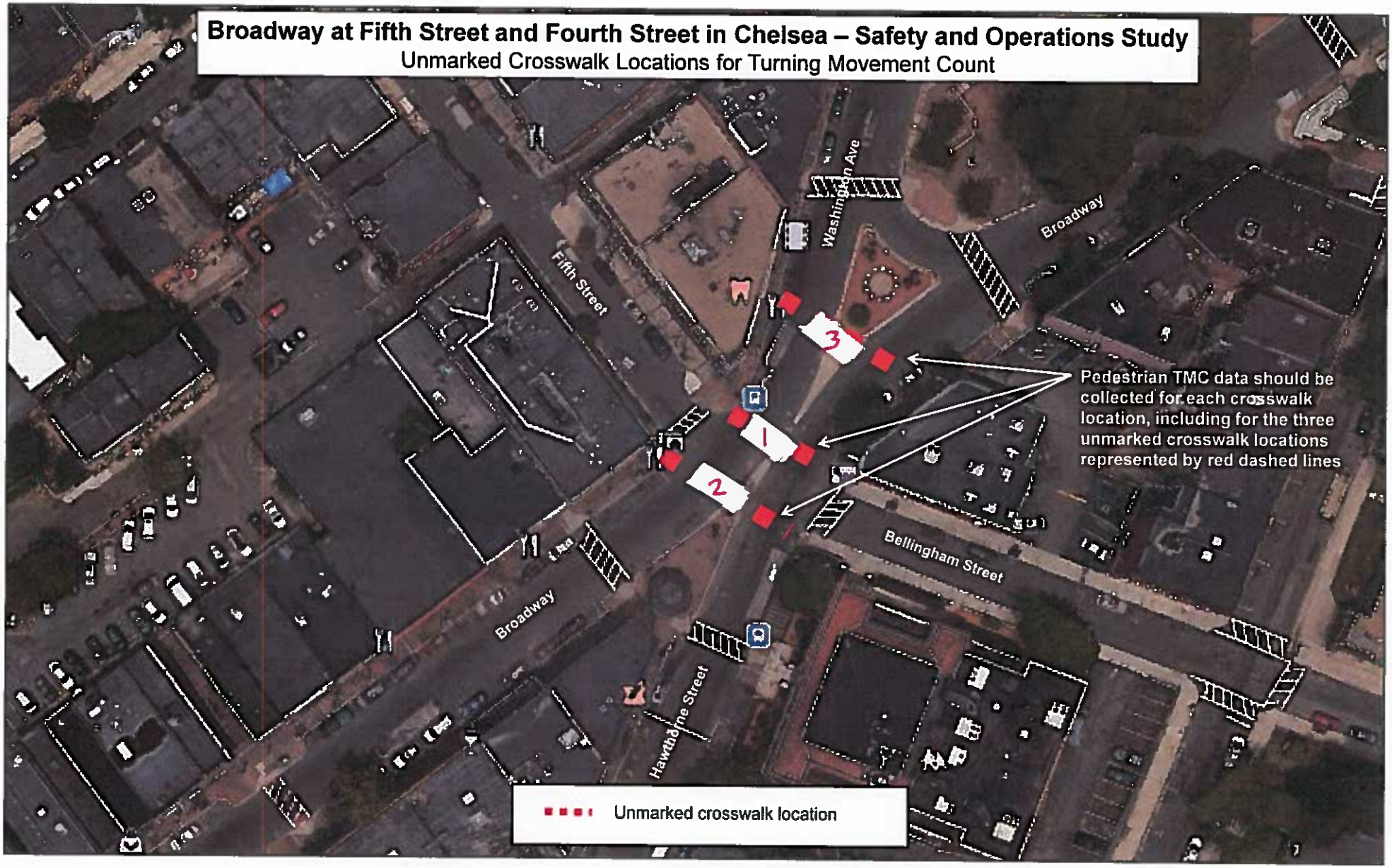
Study Name	Chelsea - Broadway, Washington Ave., Bellingham,Fifth and Hawthorne Streets TM2 TMC
Start Date	Thursday, April 14, 2016 7:00 AM
End Date	Saturday, April 16, 2016 2:00 PM
Site Code	

Report Summary

		Southbound						Southwestbound		Westbound		Northbound						Northeastbound		Eastbound				Crosswalk	
Time Period	**Class.**	**R**	**BR**	**L**	**HL**	**I**	**O**	**I**	**O**	**I**	**O**	**R**	**BR**	**L**	**HL**	**I**	**O**	**I**	**O**	**I**	**O**	**Total**		**Pedestrians**	**Total**
Peak 1	Motorcycles	0	4	0	0	4	0	0	3	0	0	0	3	0	0	3	0	0	4	0	0	7	N	110	110
Specified Period	%	0%	1%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	1%		100%	
12:00 PM - 2:00 PM	Cars	25	419	0	61	505	0	0	634	0	41	41	573	0	1	615	0	0	420	0	25	1120	NE	41	41
One Hour Peak	%	83%	86%	0%	88%	86%	0%	0%	86%	0%	87%	87%	86%	0%	100%	86%	0%	0%	86%	0%	83%	86%		100%	
12:30 PM - 1:30 PM	Light Goods Vehicles	5	37	0	8	50	0	0	74	0	3	3	66	0	0	69	0	0	37	0	5	119	E	203	203
	%	17%	8%	0%	12%	9%	0%	0%	10%	0%	6%	6%	10%	0%	0%	10%	0%	0%	8%	0%	17%	9%		100%	
	Buses	0	15	0	0	15	0	0	14	0	1	1	14	0	0	15	0	0	15	0	0	30	S	325	325
	%	0%	3%	0%	0%	3%	0%	0%	2%	0%	2%	2%	2%	0%	0%	2%	0%	0%	3%	0%	0%	2%		100%	
	Single-Unit Trucks	0	9	0	0	9	0	0	12	0	2	2	12	0	0	14	0	0	9	0	0	23	SW	144	144
	%	0%	2%	0%	0%	2%	0%	0%	2%	0%	4%	4%	2%	0%	0%	2%	0%	0%	2%	0%	0%	2%		100%	
	Articulated Trucks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	W	419	419
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
	Bicycles on Road	0	1	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	2		1242	1242
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Total	**30**	**485**	**0**	**69**	**584**	**0**	**0**	**738**	**0**	**47**	**47**	**669**	**0**	**1**	**717**	**0**	**0**	**486**	**0**	**30**	**1301**			
	PHF	0.75	0.9	0	0.91	0.91	0	0	0.89	0	0.78	0.78	0.89	0	0.25	0.91	0	0	0.9	0	0.75	0.96			
	Approach %					45%	0%	0%	57%	0%	4%					55%	0%	0%	37%	0%	2%				

APPENDIX C

Pedestrian Crossings outside Marked Crosswalks
Broadway at Fifth Street
April 14 and 16, 2016


Broadway at Fifth Street and Fourth Street in Chelsea – Safety and Operations Study
Unmarked Crosswalk Locations for Turning Movement Count
Fifth Street
Washington Ave
Broadway
3
1
2
Pedestrian TMC data should be collected for each crosswalk location, including for the three unmarked crosswalk locations represented by red dashed lines
Bellingham Street
Broadway
Hawthorne Street
Unmarked crosswalk location

Study Name Chelsea - Broadway to/from Washington Avenue Pathway 1
Start Date 04/14/2016
Start Time 7:00 AM
Site Code

Channel	Fifth Street/Washington Avenue to Broadway/Bellingham Street	Broadway/Bellingham Street to Fifth Street/Washington Avenue
Direction	Southbound	Northbound
7:00 AM	15	27
7:15 AM	8	32
7:30 AM	13	44
7:45 AM	8	21
8:00 AM	12	30
8:15 AM	18	15
8:30 AM	17	21
8:45 AM	18	17
4:00 PM	30	36
4:15 PM	67	41
4:30 PM	41	36
4:45 PM	35	40
5:00 PM	60	51
5:15 PM	58	36
5:30 PM	36	27
5:45 PM	47	37
12:00 PM	23	39
12:15 PM	39	36
12:30 PM	22	25
12:45 PM	30	38
1:00 PM	41	29
1:15 PM	41	19
1:30 PM	29	51
1:45 PM	41	38

Study Name Chelsea - Broadway/Bellingham and Hawthorne/Bellingham Streets Pathway 2
Start Date 04/14/2016
Start Time 7:00 AM
Site Code

Channel	Broadway/5th Street to Hawthrone/Bellingham Streets	Hawthrone/Bellingham Streets to Broadway/5th
Direction	Southbound	Northbound
7:00 AM	19	32
7:15 AM	7	38
7:30 AM	7	35
7:45 AM	9	25
8:00 AM	4	32
8:15 AM	11	29
8:30 AM	5	15
8:45 AM	9	17
4:00 PM	11	21
4:15 PM	47	16
4:30 PM	37	20
4:45 PM	18	31
5:00 PM	12	13
5:15 PM	13	12
5:30 PM	12	6
5:45 PM	15	22
12:00 PM	13	16
12:15 PM	11	15
12:30 PM	11	16
12:45 PM	24	14
1:00 PM	12	8
1:15 PM	17	24
1:30 PM	12	14
1:45 PM	22	18

Study Name Chelsea - Broadway to/from Washington Avenue Pathway 3
Start Date 04/14/2016
Start Time 7:00 AM
Site Code

Channel	Washington Avenue to Broadway	Broadway to Washington Avenue
Direction	Southbound	Northbound
7:00 AM	9	39
7:15 AM	3	35
7:30 AM	5	42
7:45 AM	2	29
8:00 AM	3	29
8:15 AM	9	20
8:30 AM	1	9
8:45 AM	4	10
4:00 PM	10	14
4:15 PM	27	11
4:30 PM	24	12
4:45 PM	8	23
5:00 PM	17	7
5:15 PM	11	12
5:30 PM	12	16
5:45 PM	6	17
12:00 PM	5	12
12:15 PM	17	18
12:30 PM	10	30
12:45 PM	18	12
1:00 PM	7	18
1:15 PM	8	25
1:30 PM	2	17
1:45 PM	6	14

APPENDIX D

Intersection Turning Movement Counts
Broadway at Fourth Street
April 14 and 16, 2016

Thursday

Study Name	Chelsea - Broadway and Fourth Street TM1 TMC
Start Date	Thursday, April 14, 2016 7:00 AM
End Date	Saturday, April 16, 2016 2:00 PM
Site Code	

Report Summary

		Southwestbound				Northwestbound		Northeastbound		Southeastbound						Crosswalk	
Time Period	Class.	T	L	I	O	I	O	I	O	R	T	I	O	Total		Pedestrians	Total
Peak 1	Motorcycles	0	0	0	0	0	0	0	0	0	0	0	0	0	NE	87	87
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
7:00 AM - 9:00 AM	Cars	407	100	507	0	0	230	0	557	150	130	280	0	787	SE	76	76
One Hour Peak	%	87%	95%	88%	0%	0%	91%	0%	88%	90%	88%	89%	0%	89%		100%	
8:00 AM - 9:00 AM	Light Goods Vehicles	19	3	22	0	0	15	0	27	8	12	20	0	42	SW	39	39
	%	4%	3%	4%	0%	0%	6%	0%	4%	5%	8%	6%	0%	5%		100%	
	Buses	33	1	34	0	0	5	0	34	1	4	5	0	39	NW	97	97
	%	7%	1%	6%	0%	0%	2%	0%	5%	1%	3%	2%	0%	4%		100%	
	Single-Unit Trucks	9	0	9	0	0	1	0	15	6	1	7	0	16		**299**	**299**
	%	2%	0%	2%	0%	0%	0%	0%	2%	4%	1%	2%	0%	2%			
	Articulated Trucks	1	0	1	0	0	0	0	2	1	0	1	0	2			
	%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%			
	Bicycles on Road	1	1	2	0	0	1	0	1	0	0	0	0	2			
	%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Total	**470**	**105**	**575**	**0**	**0**	**252**	**0**	**636**	**166**	**147**	**313**	**0**	888			
	PHF	0.9	0.85	0.89	0	0	0.8	0	0.94	0.88	0.77	0.97	0	0.92			
	Approach %			65%	0%	0%	28%	0%	72%			35%	0%				
Peak 2	Motorcycles	1	0	1	0	0	0	0	1	0	0	0	0	1	NE	97	97
Specified Period	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		100%	
4:00 PM - 6:00 PM	Cars	247	130	377	0	0	331	0	400	153	201	354	0	731	SE	167	167
One Hour Peak	%	80%	86%	82%	0%	0%	86%	0%	83%	88%	85%	86%	0%	84%		100%	
4:45 PM - 5:45 PM	Light Goods Vehicles	29	21	50	0	0	48	0	46	17	27	44	0	94	SW	132	132
	%	9%	14%	11%	0%	0%	12%	0%	10%	10%	11%	11%	0%	11%		100%	
	Buses	29	0	29	0	0	3	0	29	0	3	3	0	32	NW	285	285
	%	9%	0%	6%	0%	0%	1%	0%	6%	0%	1%	1%	0%	4%		100%	
	Single-Unit Trucks	2	0	2	0	0	5	0	6	4	5	9	0	11		**681**	**681**
	%	1%	0%	0%	0%	0%	1%	0%	1%	2%	2%	2%	0%	1%			
	Articulated Trucks	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%			
	Total	**308**	**151**	**459**	**0**	**0**	**387**	**0**	**482**	**174**	**236**	**410**	**0**	869			
	PHF	0.92	0.94	0.93	0	0	0.99	0	0.89	0.75	0.94	0.88	0	0.93			
	Approach %			53%	0%	0%	45%	0%	55%			47%	0%				

Saturday

Study Name	Chelsea - Broadway and Fourth Street TM1 TMC
Start Date	Thursday, April 14, 2016 7:00 AM
End Date	Saturday, April 16, 2016 2:00 PM
Site Code	

Report Summary

		Southwestbound				Northwestbound		Northeastbound		Southeastbound						Crosswalk	
Time Period	**Class.**	**T**	**L**	**I**	**O**	**I**	**O**	**I**	**O**	**R**	**T**	**I**	**O**	**Total**		**Pedestrians**	**Total**
Peak 1	Motorcycles	3	0	3	0	0	0	0	3	0	0	0	0	3	NE	133	133
Specified Period	%	1%	0%	1%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%		100%	
12:00 PM - 2:00 PM	Cars	292	123	415	0	0	319	0	462	170	196	366	0	781	SE	235	235
One Hour Peak	%	85%	91%	87%	0%	0%	89%	0%	88%	93%	88%	90%	0%	89%		100%	
12:30 PM - 1:30 PM	Light Goods Vehicles	26	10	36	0	0	31	0	37	11	21	32	0	68	SW	105	105
	%	8%	7%	8%	0%	0%	9%	0%	7%	6%	9%	8%	0%	8%		100%	
	Buses	14	1	15	0	0	3	0	14	0	2	2	0	17	NW	377	377
	%	4%	1%	3%	0%	0%	1%	0%	3%	0%	1%	0%	0%	2%		100%	
	Single-Unit Trucks	6	1	7	0	0	4	0	8	2	3	5	0	12		**850**	**850**
	%	2%	1%	1%	0%	0%	1%	0%	2%	1%	1%	1%	0%	1%			
	Articulated Trucks	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	1	0	1	0	0	0	0	1	0	0	0	0	1			
	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
	Total	**342**	**135**	**477**	**0**	**0**	**357**	**0**	**525**	**183**	**222**	**405**	**0**	**882**			
	PHF	0.89	0.87	0.88	0	0	0.91	0	0.95	0.95	0.77	0.86	0	0.95			
	Approach %			54%	0%	0%	40%	0%	60%			46%	0%				

APPENDIX E

Intersection Capacity Analyses
2016 Existing Conditions
Broadway at Fifth Street

Intersection Capacity Analysis
1: Broadway/Washington Avenue

Lane Group	NBL	NBR	NET	NER	SWL	SWT	Ø2
Lane Configurations							
Traffic Volume (vph)	0	0	0	0	124	625	
Future Volume (vph)	0	0	0	0	124	625	
Satd. Flow (prot)	0	0	0	0	1321	2621	
Flt Permitted					0.950		
Satd. Flow (perm)	0	0	0	0	1285	2621	
Satd. Flow (RTOR)							
Confl. Peds. (#/hr)	85	163		30	30		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.87	0.87	
Heavy Vehicles (%)	2%	2%	2%	2%	7%	7%	
Bus Blockages (#/hr)	0	0	0	0	0	30	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	0	0	0	0	143	718	
Turn Type					Split	NA	
Protected Phases					1	1	2
Permitted Phases						1	
Minimum Split (s)					40.0	40.0	21.0
Total Split (s)					40.0	40.0	21.0
Total Split (%)					65.6%	65.6%	34%
Yellow Time (s)					4.0	4.0	2.0
All-Red Time (s)					2.0	2.0	2.0
Lost Time Adjust (s)					0.0	0.0	
Total Lost Time (s)					6.0	6.0	
Lead/Lag					Lead	Lead	Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)					34.0	34.0	
Actuated g/C Ratio					0.56	0.56	
v/c Ratio					0.19	0.49	
Control Delay					7.6	9.7	
Queue Delay					0.0	0.0	
Total Delay					7.6	9.7	
LOS					A	A	
Approach Delay						9.3	
Approach LOS						A	
Queue Length 50th (ft)					23	75	
Queue Length 95th (ft)					46	108	
Internal Link Dist (ft)	1		94			200	
Turn Bay Length (ft)					150		
Base Capacity (vph)					736	1460	
Starvation Cap Reductn					0	0	
Spillback Cap Reductn					0	0	
Storage Cap Reductn					0	0	
Reduced v/c Ratio					0.19	0.49	

Intersection Summary
Cycle Length: 61
Actuated Cycle Length: 61
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection

Natural Cycle: 65	
Control Type: Pretimed	
Maximum v/c Ratio: 0.49	
Intersection Signal Delay: 9.3	Intersection LOS: A
Intersection Capacity Utilization 50.0%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 1: Broadway/Washington Avenue

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø2
Lane Configurations							
Traffic Volume (vph)	507	0	0	0	0	0	
Future Volume (vph)	507	0	0	0	0	0	
Satd. Flow (prot)	2573	0	0	0	0	0	
Flt Permitted							
Satd. Flow (perm)	2573	0	0	0	0	0	
Satd. Flow (RTOR)							
Confl. Peds. (#/hr)		100	100		88	122	
Peak Hour Factor	0.96	0.96	0.92	0.92	0.92	0.92	
Heavy Vehicles (%)	9%	9%	2%	2%	2%	2%	
Bus Blockages (#/hr)	30	30	0	0	0	0	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	528	0	0	0	0	0	
Turn Type	NA						
Protected Phases	1						2
Permitted Phases							
Minimum Split (s)	40.0						21.0
Total Split (s)	40.0						21.0
Total Split (%)	65.6%						34%
Yellow Time (s)	4.0						2.0
All-Red Time (s)	2.0						2.0
Lost Time Adjust (s)	0.0						
Total Lost Time (s)	6.0						
Lead/Lag	Lead						Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)	34.0						
Actuated g/C Ratio	0.56						
v/c Ratio	0.37						
Control Delay	8.4						
Queue Delay	0.0						
Total Delay	8.4						
LOS	A						
Approach Delay	8.4						
Approach LOS	A						
Queue Length 50th (ft)	51						
Queue Length 95th (ft)	79						
Internal Link Dist (ft)	128			9	1		
Turn Bay Length (ft)							
Base Capacity (vph)	1434						
Starvation Cap Reductn	0						
Spillback Cap Reductn	0						
Storage Cap Reductn	0						
Reduced v/c Ratio	0.37						

Intersection Summary
Cycle Length: 61
Actuated Cycle Length: 61
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection

Natural Cycle: 65	
Control Type: Pretimed	
Maximum v/c Ratio: 0.49	
Intersection Signal Delay: 8.4	Intersection LOS: A
Intersection Capacity Utilization 49.8%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 3: Hawthorn Street

Intersection Capacity Analysis
1: Broadway/Washington Avenue

Lane Group	NBL	NBR	NET	NER	SWL	SWT	Ø2
Lane Configurations							
Traffic Volume (vph)	0	0	0	0	97	460	
Future Volume (vph)	0	0	0	0	97	460	
Satd. Flow (prot)	0	0	0	0	1413	2646	
Flt Permitted					0.950		
Satd. Flow (perm)	0	0	0	0	1350	2646	
Satd. Flow (RTOR)							
Confl. Peds. (#/hr)	106	399		50	50		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.97	0.97	
Heavy Vehicles (%)	2%	2%	2%	2%	0%	6%	
Bus Blockages (#/hr)	0	0	0	0	0	30	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	0	0	0	0	100	474	
Turn Type					Split	NA	
Protected Phases					1	1	2
Permitted Phases						1	
Minimum Split (s)					40.0	40.0	21.0
Total Split (s)					40.0	40.0	21.0
Total Split (%)					65.6%	65.6%	34%
Yellow Time (s)					4.0	4.0	2.0
All-Red Time (s)					2.0	2.0	2.0
Lost Time Adjust (s)					0.0	0.0	
Total Lost Time (s)					6.0	6.0	
Lead/Lag					Lead	Lead	Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)					34.0	34.0	
Actuated g/C Ratio					0.56	0.56	
v/c Ratio					0.13	0.32	
Control Delay					7.0	8.0	
Queue Delay					0.0	0.0	
Total Delay					7.0	8.0	
LOS					A	A	
Approach Delay						7.8	
Approach LOS						A	
Queue Length 50th (ft)					16	44	
Queue Length 95th (ft)					35	69	
Internal Link Dist (ft)	1		94			200	
Turn Bay Length (ft)					150		
Base Capacity (vph)					787	1474	
Starvation Cap Reductn					0	0	
Spillback Cap Reductn					0	0	
Storage Cap Reductn					0	0	
Reduced v/c Ratio					0.13	0.32	

Intersection Summary
Cycle Length: 61
Actuated Cycle Length: 61
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection

Natural Cycle: 65	
Control Type: Pretimed	
Maximum v/c Ratio: 0.50	
Intersection Signal Delay: 7.8	Intersection LOS: A
Intersection Capacity Utilization 50.0%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 1: Broadway/Washington Avenue

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø2
Lane Configurations							
Traffic Volume (vph)	701	0	0	0	0	0	
Future Volume (vph)	701	0	0	0	0	0	
Satd. Flow (prot)	2671	0	0	0	0	0	
Flt Permitted							
Satd. Flow (perm)	2671	0	0	0	0	0	
Satd. Flow (RTOR)							
Confl. Peds. (#/hr)		100	100		109	117	
Peak Hour Factor	0.94	0.94	0.92	0.92	0.92	0.92	
Heavy Vehicles (%)	5%	5%	2%	2%	2%	2%	
Bus Blockages (#/hr)	30	30	0	0	0	0	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	746	0	0	0	0	0	
Turn Type	NA						
Protected Phases	1						2
Permitted Phases							
Minimum Split (s)	40.0						21.0
Total Split (s)	40.0						21.0
Total Split (%)	65.6%						34%
Yellow Time (s)	4.0						2.0
All-Red Time (s)	2.0						2.0
Lost Time Adjust (s)	0.0						
Total Lost Time (s)	6.0						
Lead/Lag	Lead						Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)	34.0						
Actuated g/C Ratio	0.56						
v/c Ratio	0.50						
Control Delay	9.8						
Queue Delay	0.0						
Total Delay	9.8						
LOS	A						
Approach Delay	9.8						
Approach LOS	A						
Queue Length 50th (ft)	79						
Queue Length 95th (ft)	119						
Internal Link Dist (ft)	128			9	1		
Turn Bay Length (ft)							
Base Capacity (vph)	1488						
Starvation Cap Reductn	0						
Spillback Cap Reductn	0						
Storage Cap Reductn	0						
Reduced v/c Ratio	0.50						

Intersection Summary
Cycle Length: 61
Actuated Cycle Length: 61
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection

Natural Cycle: 65	
Control Type: Pretimed	
Maximum v/c Ratio: 0.50	
Intersection Signal Delay: 9.8	Intersection LOS: A
Intersection Capacity Utilization 49.8%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 3: Hawthorn Street

Lane Group	NBL	NBR	NET	NER	SWL	SWT	Ø2
Lane Configurations							
Traffic Volume (vph)	0	0	0	0	69	515	
Future Volume (vph)	0	0	0	0	69	515	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	0	0		0	150		
Storage Lanes	0	0		0	1		
Taper Length (ft)	25				25		
Satd. Flow (prot)	0	0	0	0	1413	2671	
Flt Permitted					0.950		
Satd. Flow (perm)	0	0	0	0	1350	2671	
Right Turn on Red		No		No	No		
Satd. Flow (RTOR)							
Link Speed (mph)	25		25			25	
Link Distance (ft)	56		174			280	
Travel Time (s)	1.5		4.7			7.6	
Confl. Peds. (#/hr)	128	325		50	50		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.91	0.91	
Heavy Vehicles (%)	2%	2%	2%	2%	0%	5%	
Bus Blockages (#/hr)	0	0	0	0	0	30	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	0	0	0	0	76	566	
Turn Type					Split	NA	
Protected Phases					1	1	2
Permitted Phases						1	
Minimum Split (s)					40.0	40.0	21.0
Total Split (s)					40.0	40.0	21.0
Total Split (%)					65.6%	65.6%	34%
Yellow Time (s)					4.0	4.0	2.0
All-Red Time (s)					2.0	2.0	2.0
Lost Time Adjust (s)					0.0	0.0	
Total Lost Time (s)					6.0	6.0	
Lead/Lag					Lead	Lead	Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)					34.0	34.0	
Actuated g/C Ratio					0.56	0.56	
v/c Ratio					0.10	0.38	
Control Delay					6.8	8.5	
Queue Delay					0.0	0.0	
Total Delay					6.8	8.5	
LOS					A	A	
Approach Delay						8.3	
Approach LOS						A	
Queue Length 50th (ft)					12	55	
Queue Length 95th (ft)					28	84	
Internal Link Dist (ft)	1		94			200	
Turn Bay Length (ft)					150		
Base Capacity (vph)					787	1488	
Starvation Cap Reductn					0	0	

Lane Group	NBL	NBR	NET	NER	SWL	SWT	Ø2
Spillback Cap Reductn					0	0	
Storage Cap Reductn					0	0	
Reduced v/c Ratio					0.10	0.38	

Intersection Summary			
Area Type:	CBD		
Cycle Length: 61			
Actuated Cycle Length: 61			
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection			
Natural Cycle: 65			
Control Type: Pretimed			
Maximum v/c Ratio: 0.53			
Intersection Signal Delay: 8.3		Intersection LOS: A	
Intersection Capacity Utilization 50.0%		ICU Level of Service A	
Analysis Period (min) 15			

Splits and Phases: 1: Broadway/Washington Avenue

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø2
Lane Configurations							
Traffic Volume (vph)	717	0	0	0	0	0	
Future Volume (vph)	717	0	0	0	0	0	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Satd. Flow (prot)	2671	0	0	0	0	0	
Flt Permitted							
Satd. Flow (perm)	2671	0	0	0	0	0	
Right Turn on Red		Yes				Yes	
Satd. Flow (RTOR)							
Link Speed (mph)	25			25	25		
Link Distance (ft)	208			89	51		
Travel Time (s)	5.7			2.4	1.4		
Confl. Peds. (#/hr)		100	100		110	122	
Peak Hour Factor	0.91	0.91	0.92	0.92	0.92	0.92	
Heavy Vehicles (%)	5%	5%	2%	2%	2%	2%	
Bus Blockages (#/hr)	30	30	0	0	0	0	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	788	0	0	0	0	0	
Turn Type	NA						
Protected Phases	1						2
Permitted Phases							
Minimum Split (s)	40.0						21.0
Total Split (s)	40.0						21.0
Total Split (%)	65.6%						34%
Yellow Time (s)	4.0						2.0
All-Red Time (s)	2.0						2.0
Lost Time Adjust (s)	0.0						
Total Lost Time (s)	6.0						
Lead/Lag	Lead						Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)	34.0						
Actuated g/C Ratio	0.56						
v/c Ratio	0.53						
Control Delay	10.1						
Queue Delay	0.0						
Total Delay	10.1						
LOS	B						
Approach Delay	10.1						
Approach LOS	B						
Queue Length 50th (ft)	85						
Queue Length 95th (ft)	128						
Internal Link Dist (ft)	128			9	1		
Turn Bay Length (ft)							
Base Capacity (vph)	1488						
Starvation Cap Reductn	0						
Spillback Cap Reductn	0						
Storage Cap Reductn	0						
Reduced v/c Ratio	0.53						

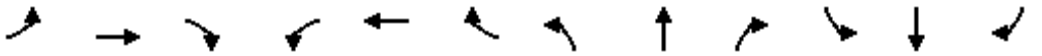
Intersection Summary			
Area Type:	CBD		
Cycle Length: 61			
Actuated Cycle Length: 61			
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection			
Natural Cycle: 65			
Control Type: Pretimed			
Maximum v/c Ratio: 0.53			
Intersection Signal Delay: 10.1		Intersection LOS: B	
Intersection Capacity Utilization 49.8%		ICU Level of Service A	
Analysis Period (min) 15			

Splits and Phases: 3: Hawthorn Street

APPENDIX F

Intersection Capacity Analyses
2016 Existing Conditions
Broadway at Fourth Street

HCM Unsignalized Intersection Capacity Analysis
8: 4th Street & Broadway

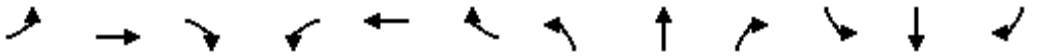


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	105	470	0	0	0	0	0	147	174
Future Volume (Veh/h)	0	0	0	105	470	0	0	0	0	0	147	174
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.89	0.89	0.89	0.92	0.92	0.92	0.97	0.97	0.97
Hourly flow rate (vph)	0	0	0	118	528	0	0	0	0	0	152	179
Pedestrians		87			39			97			76	
Lane Width (ft)		0.0			11.0			0.0			11.0	
Walking Speed (ft/s)		3.5			3.5			3.5			3.5	
Percent Blockage		0			3			0			7	
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)					764							
pX, platoon unblocked												
vC, conflicting volume	604			97			939	937	136	879	937	427
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	604			97			939	937	136	879	937	427
tC, single (s)	4.1			4.2			7.5	6.5	6.9	7.6	6.6	7.0
tC, 2 stage (s)												
tF (s)	2.2			2.3			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			92			100	100	100	100	32	67
cM capacity (veh/h)	905			1458			60	226	857	193	224	535

Direction, Lane #	WB 1	WB 2	SB 1	SB 2
Volume Total	294	352	152	179
Volume Left	118	0	0	0
Volume Right	0	0	0	179
cSH	1458	1700	224	535
Volume to Capacity	0.08	0.21	0.68	0.33
Queue Length 95th (ft)	7	0	107	36
Control Delay (s)	3.5	0.0	49.2	15.1
Lane LOS	A		E	C
Approach Delay (s)	1.6		30.8	
Approach LOS			D	

Intersection Summary				
Average Delay	11.5			
Intersection Capacity Utilization	42.0%	ICU Level of Service	A	
Analysis Period (min)	15			

HCM Unsignalized Intersection Capacity Analysis
8: 4th Street & Broadway

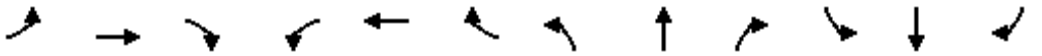


Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	151	308	0	0	0	0	0	236	166
Future Volume (Veh/h)	0	0	0	151	308	0	0	0	0	0	236	166
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.93	0.93	0.93	0.92	0.92	0.92	0.93	0.93	0.93
Hourly flow rate (vph)	0	0	0	162	331	0	0	0	0	0	254	178
Pedestrians		97			132			285			167	
Lane Width (ft)		0.0			11.0			0.0			11.0	
Walking Speed (ft/s)		3.5			3.5			3.5			3.5	
Percent Blockage		0			12			0			15	
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)					764							
pX, platoon unblocked												
vC, conflicting volume	498			285			1176	1107	417	954	1107	430
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	498			285			1176	1107	417	954	1107	430
tC, single (s)	4.1			4.2			7.5	6.5	6.9	7.6	6.6	7.0
tC, 2 stage (s)												
tF (s)	2.2			2.3			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			87			0	100	100	100	0	64
cM capacity (veh/h)	907			1246			0	155	517	128	154	488

Direction, Lane #	WB 1	WB 2	SB 1	SB 2
Volume Total	272	221	254	178
Volume Left	162	0	0	0
Volume Right	0	0	0	178
cSH	1246	1700	154	488
Volume to Capacity	0.13	0.13	1.65	0.36
Queue Length 95th (ft)	11	0	446	41
Control Delay (s)	5.4	0.0	371.0	16.6
Lane LOS	A		F	C
Approach Delay (s)	3.0		224.9	
Approach LOS			F	

Intersection Summary				
Average Delay	106.7			
Intersection Capacity Utilization	38.3%	ICU Level of Service	A	
Analysis Period (min)	15			

HCM Unsignalized Intersection Capacity Analysis
8: 4th Street & Broadway



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	0	0	0	135	342	0	0	0	0	0	222	183
Future Volume (Veh/h)	0	0	0	135	342	0	0	0	0	0	222	183
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.88	0.88	0.88	0.92	0.92	0.92	0.86	0.86	0.86
Hourly flow rate (vph)	0	0	0	153	389	0	0	0	0	0	258	213
Pedestrians		133			105			377			235	
Lane Width (ft)		0.0			11.0			0.0			11.0	
Walking Speed (ft/s)		3.5			3.5			3.5			3.5	
Percent Blockage		0			9			0			21	
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)					764							
pX, platoon unblocked												
vC, conflicting volume	624			377			1352	1307	482	1035	1307	562
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	624			377			1352	1307	482	1035	1307	562
tC, single (s)	4.1			4.2			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			87			0	100	100	100	0	43
cM capacity (veh/h)	758			1164			0	109	482	103	110	376

Direction, Lane #	WB 1	WB 2	SB 1	SB 2
Volume Total	283	259	258	213
Volume Left	153	0	0	0
Volume Right	0	0	0	213
cSH	1164	1700	110	376
Volume to Capacity	0.13	0.15	2.34	0.57
Queue Length 95th (ft)	11	0	568	84
Control Delay (s)	5.2	0.0	692.5	26.4
Lane LOS	A		F	D
Approach Delay (s)	2.7		391.3	
Approach LOS			F	

Intersection Summary				
Average Delay	183.4			
Intersection Capacity Utilization	40.9%	ICU Level of Service	A	
Analysis Period (min)	15			

APPENDIX G

Preliminary Traffic Signal Warrants Analysis
Broadway at Fourth Street, Chelsea

Summary of Hourly Volumes and Warrant Analyses
Broadway at Fourth Street, Chelsea

Hourly period starting	Broadway (main street) Traffic Volume	Fourth Street (minor street) Traffic Volume	Pedestrians Crossing Main Street	Volumes above the required minimum on main/minor street			
	WB	SB		Warrant 1	Warrant 2	Warrant 4	Warrant 7
6:00	340	281	-				
7:00	414	339	130				√
8:00	561	327	126	√			√
9:00	424	359	-				√
10:00	419	362	-				√
11:00	373	384	-				
12:00	398	419	-				√
13:00	447	413	-				√
14:00	417	444	-				√
15:00	449	468	-				√
16:00	440	477	246				√
17:00	450	452	208				√
18:00	425	441	-				√
19:00	374	350	-				

Warrants 1, 2, 4 and 7 in MUTCD Chapter 4C were analyzed for this intersection.

Warrant 1 (8-Hour Volume) is not fulfilled. It requires that the traffic conditions (observed vehicular volumes higher than the specified minimum volumes) exist for each of any 8 hours of an average day. The interruption of continuous traffic (Conditions B) was applied in this case. The volume threshold for a major street (two-lane) is 480 vehicles per hour (vph) and for a minor street (two-lane) is 160 vph.

Warrant 2 (4-Hour Volume) is not fulfilled. It requires that the traffic conditions (the data point of main street and minor street volumes falling above an applicable curve) exist for each of any 4 hours of an average day. The data points all locate below the applicable curve .

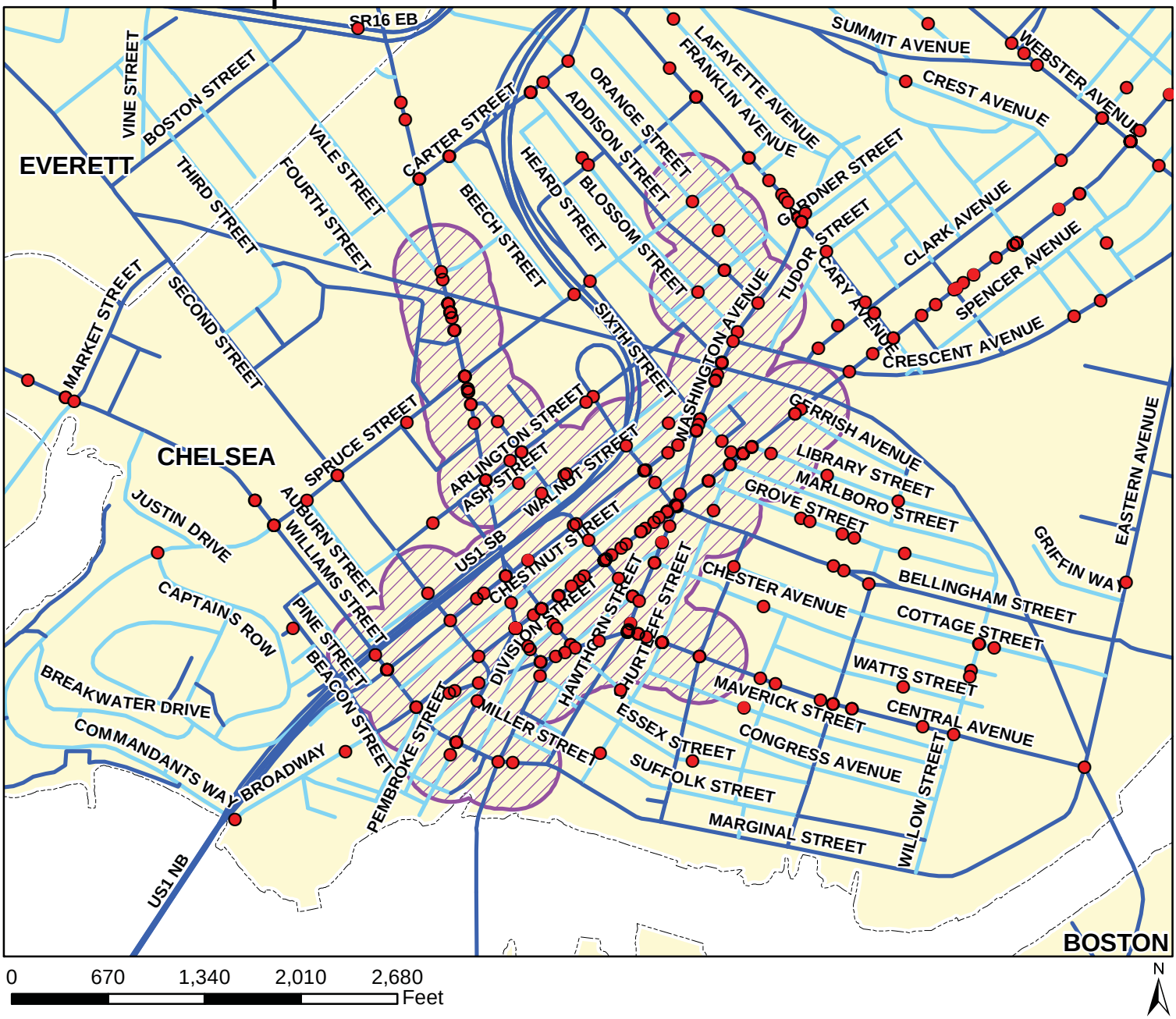
Warrant 4 (Pedestrian Volume) is not fulfilled. It requires that the traffic conditions (the data point of main street traffic volume and pedestrian crossing falling above an applicable curve) exist for each of any 4 hours of an average day. The data points all locate below the applicable curve .

Warrant 7 (Crash Experience) is fulfilled. Traffic conditions in more than eight hours met the 80% threshold in Warrant 1. Meanwhile, there were more than five correctable crashes in the recent 12-month period.

APPENDIX H

Top Pedestrian Crash Cluster 2004–13
Downtown Chelsea

Top Pedestrian Crash Cluster 2004 - 2013



RANK 1

CHELSEA

MassDOT District 6
RPA MAPC
EPDO 949
Number of Fatal Crashes 1
Number of Injury Crashes 176
Number of Non-Injury Crashes 59
Total Crashes 236

Legend

- Crash Locations 2004-2013
- All Functional Classification Except Local Roads
- Local Roads
- Top Pedestrian Crash Cluster
- Municipal Boundary

massDOT
Massachusetts Department of Transportation
Highway Division

APPENDIX I

Collision Diagrams and Crash Data Summary
MassDOT Road Safety Audit
July 27, 2016

massDOT
Massachusetts Department of Transportation
Highway Division

COLLISION DIAGRAM

SYMBOLS

Involved / Non-Involved
- Moving Vehicle
- Backing Vehicle
- Non-Involved Vehicle
- Pedestrian
- Bicycle
- Animal
- Direction of Motion
- Parked Vehicle
- Fixed Object

TYPE OF CRASH
- Head on
- Rear End
- Angle
- Turning Movement
- Sideswipe
- Out of Control
- Night Time Crash

SEVERITY
- Injury
- Fatal

CHELSEA, MA

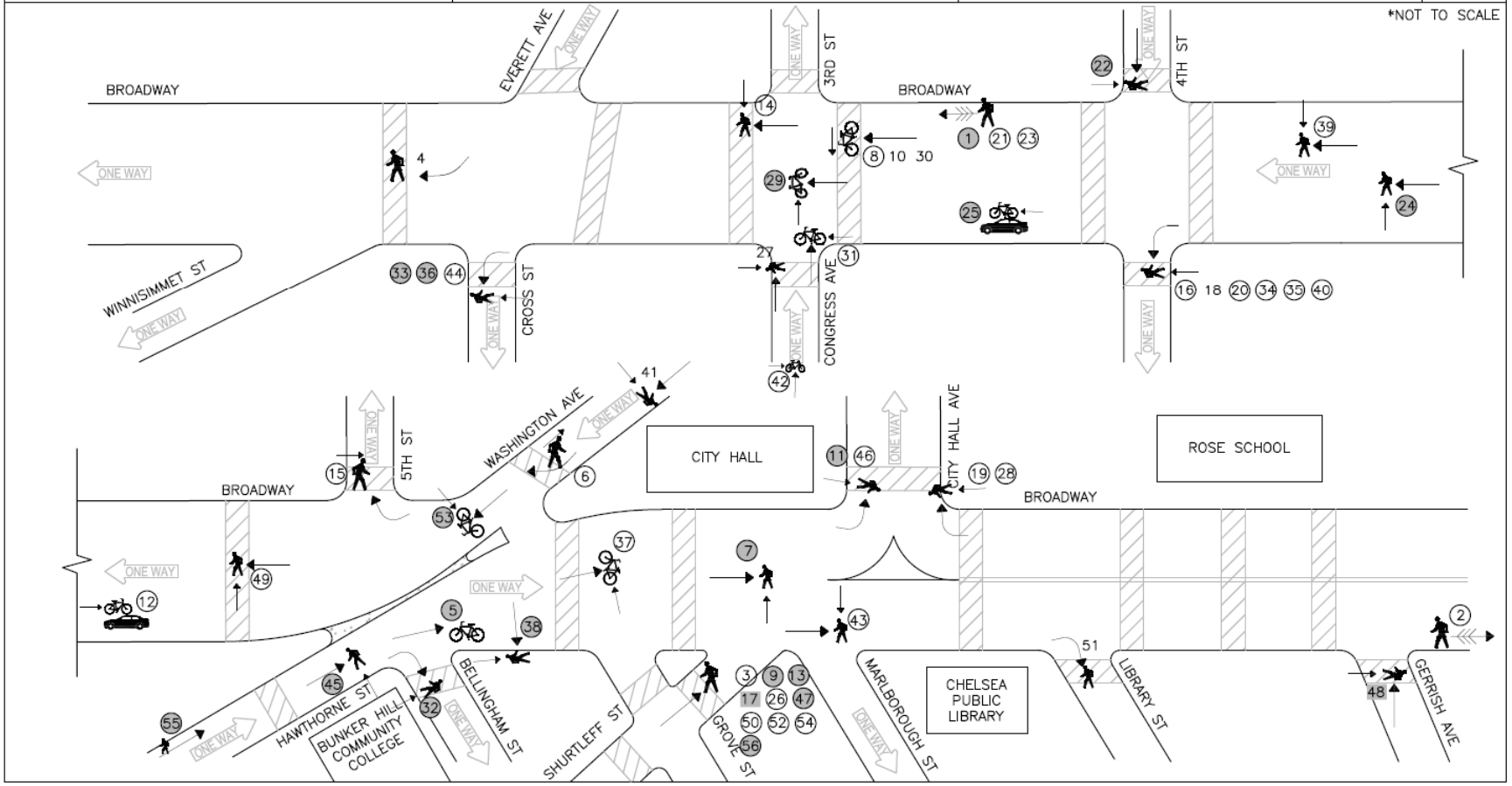
BROADWAY

REGION: METROPOLITAN AREA PLANNING COUNCIL

TIME PERIOD ANALYZED: 2011 – 2015
SOURCE OF CRASH REPORTS: LOCAL POLICE
DATE PREPARED: MAY 2016
PREPARED BY:

SHEET 1 OF 1

*NOT TO SCALE



Crash Data Summary Table

Broadway, Chelsea, MA

2011 - 2015

Crash Diagram	Crash Date	Crash Day	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	Ages				Comments
1	1/22/11	Saturday	5:25 PM	Single Vehicle Crash	Dark - lighted roadway	Clear	Slush	Inattention	21				MV1 was backing up when struck pedetrian. Pedestrian was crossing street behind vehicle, not at crosswalk.
2	4/10/11	Sunday	4:38 PM	Rear-end	Daylight	Clear	Dry	No Improper Driving	21				MV1 ws backing out of parking spot, hitting pedestrian that was standing behind MV1. MV1 did not notice pedestrian.
3	6/4/11	Saturday	8:54 AM	Single Vehicle Crash	Daylight	Clear	Dry	Unknown	UNK				MV1 struck pedestrian in crosswalk. No information from MV1
4	6/5/11	Sunday	7:48 PM	Single Vehicle Crash	Dusk	Clear	Dry	careless, negligent, or aggressive	39				MV1 made a right turn, attempted to manuever around pedestrians that were
5	6/6/11	Monday	2:37 AM	Angle	Dark - lighted roadway	Clear	Dry	Driving too fast for conditions	UNK				Cyclist had pulled over to let MV1 pass. MV1 struck cyclist and fled scene.
6	9/2/11	Friday	1:04 PM	Single Vehicle Crash	Daylight	Clear	Dry	No Improper Driving	25				Pedestrian (motorized wheelchair) was travelling wrong way on one way. MV1 was stopped at red signal, turning left as light changed to green. MV1 did not see pedestrian during turn.
7	9/5/11	Monday	10:41 PM	Single Vehicle Crash	Dark - lighted roadway	Clear	Dry	Unknown	64				MV1 states "pedestrian ran into road and could not avoid accident." Pedestrian states "walking across street when operator hit them."
8	9/18/11	Sunday	4:59 PM	Angle	Daylight	Clear	Dry	Unknown	64				MV1 SB. Bicycle EB crossing roadway inside crosswalk. MV1 states "bicycle suddenly crossed roadway." Bicycle states "another operator allowed them to cross." MV1 could not stop in time.
9	11/17/11	Thursday	10:21 PM	Head on	Dark - lighted roadway	Clear	Dry	Inattention	34				Pedestrian inside crosswalk. MV1 stops, then accidentally hits pedestrian.
10	3/22/12	Thursday	5:16 PM	Angle	Daylight	Clear	Dry	No Improper Driving	73				Cyclist approached intersection, travelling wrong way on one-way, failed to yield right of way. MV1 hits bicyclist in intersection.
11	4/7/12	Saturday	7:37 PM	Single Vehicle Crash	Dark - roadway not lighted	Cloudy	Dry	Unknown	46				MV1 making left turn, did not see pedestrian in roadway.
12	7/19/12	Thursday	3:01 PM	Single Vehicle Crash	Daylight	Clear	Dry	Unknown	34				MV1 recently parked vehicle. Rear-passenger opened door, didn't see bicyclist approaching.
13	7/29/12	Sunday	9:15 PM	Single Vehicle Crash	Dark - lighted roadway	Clear	Dry	Unknown	37				MV1 stopped at stop sign allowing a pedestrian to cross. MV1 began moving when an additional pedestrian attempted to cross.
14	8/11/12	Saturday	5:16 PM	Single Vehicle Crash	Daylight	Clear	Dry	Failed to yield right of way	69				Pedestrian in crosswalk when MV1 struck pedestrian. MV1 cited for failure to yield.
15	1/23/13	Wednesday	4:03 PM	Single Vehicle Crash	Daylight	Clear	Dry	Unknown	24				MV1 turning right, did not see pedestrian due to sun.
16	1/23/13	Wednesday	3:25 PM	Head on	Daylight	Clear	Dry	Failed to yield right of way	61				MV1 turning left. Pedestrian in crosswalk, struck by MV1 during turn.
17	1/24/13	Thursday	5:25 PM	Single Vehicle Crash	Dark, unknown roadway lighting	Clear	Dry	Unknown	66				Pedestrian in crosswalk. MV1 struck pedestrian in crosswalk.
18	2/4/13	Monday	10:43 AM	Single Vehicle Crash	Daylight	Clear	Dry	No Improper Driving	38				MV1 claims "pedestrian jumped into vehicle." Pedestrian states " struck by MV1 in leg."
19	3/9/13	Saturday	4:11 PM	Single Vehicle Crash	Daylight	Clear	Dry	Unknown	51				MV1 turning right. Pedestrians were walking in crosswalk. MV1 did not see pedestrians.
20	3/30/13	Saturday	1:09 PM	Single Vehicle Crash	Daylight	Clear	Dry	Failed to yield right of way	49				MV1 turning left. Pedestrian was walking in crosswalk. MV1 did not see pedestrian.
21	4/4/13	Thursday	11:20 AM	Single Vehicle Crash	Daylight	Clear	Dry	Inattention	54				MV1 backing into parking space, hits pedestrian.
22	4/12/13	Friday	8:26 PM	Single Vehicle Crash	Dark - lighted roadway	Rain	Wet	Unknown	27				MV1 claims "stopped at stop sign and looked both ways, then proceeded through intersection. Pedestrian ran out into street." No comment from pedestrian.
23	4/25/13	Thursday	12:56 PM	Single Vehicle Crash	Daylight	Clear	Dry	Unknown	UNK				Pedestrian standing in front of double-parked vehicle. MV1 backed into pedestrian.
24	5/23/13	Thursday	10:28 PM	Single Vehicle Crash	Dark - lighted roadway	Rain	Wet	Unknown	39				Pedetrian crossing street, was struck by MV1 who did not notice pedestrian.
25	5/26/13	Sunday	10:01 PM	Single Vehicle Crash	Dark - lighted roadway	Clear	Dry	Unknown	UNK				MV1 operator exited driver side door and struck bicyclist with door. Operator did not see cyclist.
26	6/14/13	Friday	7:37 PM	Single Vehicle Crash	Daylight	Clear	Dry	Unknown	61				MV1 claims "pedestrian on phone and walked into left front of vehicle." Witnesses claim "pedestrian in crosswalk when MV1 drove over foot."
27	6/18/13	Tuesday	3:20 PM	Unknown	Daylight	Rain	Wet	No Improper Driving	34				Pedestrian entered croswalk with bicycle, claiming "MV1 struck rear tire of bicycle." MV1 claims "didn't ake contact."
28	6/21/13	Friday	5:36 AM	Single Vehicle Crash	Daylight	Clear	Dry	No Improper Driving	55				MV1 turning right, did not see pedestrian crossing street. Pedestrian was not in a crosswalk area.
29	7/31/13	Wednesday	10:59 PM	Angle	Dark - lighted roadway	Clear	Dry	No Improper Driving	46				Bicyclist with passenger rides through stop sign. MV1, perpendicular to cyclist, are established in intersection. Bicyclist collides with MV1 in intersection.
30	8/10/13	Saturday	4:45 PM	Single Vehicle Crash	Daylight	Clear	Dry	No Improper Driving	40				Cyclist travelling wrong way on one-way. MV1 (bus) could not stop in time for bicyclist. Cyclist made no attemp to stop.
31	9/7/13	Saturday	10:06 AM	Single Vehicle Crash	Daylight	Clear	Dry	Unknown	37				Bicyclist claims "struck by nail on MV1's trailer." MV1 claims "stopped at stop sign, observed bicyclist in street. Continued to drive and did not strike cyclist."

Crash Data Summary Table

Broadway, Chelsea, MA

2011 - 2015

Crash Diagram	Crash Date	Crash Day	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	Ages				Comments
32	11/17/13	Sunday	7:52 PM	Single Vehicle Crash	Dark - lighted roadway	Rain	Wet	Inattention	24				MV1 after making right hand turn claims "lightly hit pedestrian standing in street, then pedestrian threw himself on hood of vehicle." Witness claims the same.
33	1/10/14	Friday	7:11 PM	Unknown	Dark - lighted roadway	Clear	Dry	Unknown	36				MV1 turning left, did not see pedestrian run out to cross street. Pedestrian was approximately 25 feet from crosswalk.
34	2/7/14	Friday	10:04 AM	Single Vehicle Crash	Daylight	Clear	Dry	No Improper Driving	31				MV1 was making a left turn, did not see pedestrian, who was in crosswalk.
35	2/12/14	Wednesday	12:39 PM	Single Vehicle Crash	Daylight	Clear	Dry	Unknown	29				Pedestrian was crosing street in crosswalk. MV1 tried to stop but noticed pedestrian too late.
36	3/30/14	Sunday	7:04 PM	Single Vehicle Crash	Dusk	Rain	Wet	Inattention	52				Pedestrian was in crosswalk when hit by MV1. MV1 was performing left turn.
37	4/29/14	Tuesday	12:31 PM	Single Vehicle Crash	Daylight	Clear	Dry	No Improper Driving	20				MV1 travelling on roadway when bicyclist entered roadway. MV1 could not avoid cyclist. Cyclist did not notice MV1 when entering roadway.
38	5/11/14	Sunday	7:59 PM	Single Vehicle Crash	Dusk	Clear	Dry	Inattention	48				MV1 made improper right hand turn in order to enter parking lot. Pedestrian was on sidewalk when hit by MV1 pulling into lot.
39	6/17/14	Tuesday	1:01 PM	Single Vehicle Crash	Daylight	Clear	Dry	No Improper Driving	50				MV1 travelling straight when kid jumps out onto street. MV1 claims "swerved to avoid child but hits pins another pedestrian behind parked vehicle." Witness states "MV1 did not swerve but rather drove straight into parked vehicle."
40	7/5/14	Saturday	5:13 PM	Single Vehicle Crash	Daylight	Clear	Dry	No Improper Driving	36				MV1 (police) was responding to a call, making a left turn with lights actived. Pedestrian walked into vehicle.
41	8/13/14	Wednesday	2:23 PM	Single Vehicle Crash	Daylight	Rain	Wet	Inattention	36				Pedestrian in motorized wheelchair states "MV1 struck them while in traffic." MV1 claims "at full stop when pedestrian hit MV1."
42	8/16/14	Saturday	3:11 PM	Head on	Daylight	Clear	Dry	No Improper Driving	31				Cyclist crossing intersection claims "MV1 stopped briefly then continued driving, striking the cyclist." MV1 claims "cyclist did not stop or look before crossing." Occurred at Congress and Division.
43	10/9/14	Thursday	4:35 PM	Head on	Daylight	Clear	Dry	Inattention	21				Pedestrian attempted to cross road without crosswalk. MV1 states "pedestrian ran in front of vehicle and MV1 couldn't stop in time."
44	10/24/14	Friday	11:30 AM	Angle	Daylight	Rain	Wet	Inattention	30				MV1 turning left, allowed pedestrian to cross street. MV1 claims "after allowing pedestrians to cross, an additional pedestrian abruptly entered crosswalk, which they didn't notice." Witness states "pedestrian did not look and quickly entered path of MV1."
45	10/29/14	Wednesday	9:27 PM	Sideswipe, same direction	Dark - lighted roadway	Rain	Wet	Unknown	29				Pedestrian was crosing street to catch bus, while in street was struck by MV1. No comment from MV1.
46	11/17/14	Monday	8:49 AM	Angle	Daylight	Rain	Wet	Unknown	28				MV1 states "did not see pedestrian while making left turn." Pedestrian states "in crosswalk when MV1 struck them."
47	12/9/14	Tuesday	8:22 PM	Angle	Dark - roadway not lighted	Rain	Wet	Inattention	38				Pedestrian crosing street when MV1 stopped then continued and struck pedestrian with right side of vehicle.
48	1/14/15	Wednesday	6:15 PM	Single Vehicle Crash	Dark - lighted roadway	Clear	Dry	No Improper Driving	36				Pedestrian in crosswalk hit by MV1. MV1 states "did not see pedestrian."
49	2/16/15	Monday	4:20 PM	Single Vehicle Crash	Daylight	Clear	Dry	Glare	26				MV1 claims "blinded by glare and tapped pedestrian in crosswalk." Pedestrian was walking in crosswalk.
50	2/22/15	Sunday	10:59 AM	Single Vehicle Crash	Daylight	Cloudy	Wet	Other improper action	36				Pedestrians in crosswalk when MV1 did not stop. MV1 claims "did not hit pedestrians and stopped at stop sign, then proceeded and didn't see pedestrians." Reviewing video shows MV1 did not stop at stop sign and hit one of the pedestrians.
51	4/8/15	Wednesday	7:41 PM	Angle	Dark - lighted roadway	Rain	Wet	No Improper Driving	66				MV1 turning with three pedestrians in street. MV1 states "2 pedestrians tells 1 pedestrian to lay down in front of vehicle." Witness confirm that MV1 did not hit any pedestrian.
52	5/22/15	Friday	11:45 AM	Angle	Daylight	Clear	Dry	Unknown	31				MV1 came to stop at intersection. MV1 proceeded to enter intersection when MV1 struck a pedestrian. No information.
53	9/17/15	Thursday	7:42 PM	Single Vehicle Crash	Dark - lighted roadway	Clear	Dry	Unknown	63				MV1 and cyclist with conflicting stories. MV1: cyclist crossed street and struck MV1. Cyclist: Cyclist crossed street when MV1 struck his bicycle.
54	9/19/15	Saturday	2:27 PM	Single Vehicle Crash	Daylight	Clear	Dry	Unknown	45				Pedestrian walking across street, struck by MV1. No info from MV1.
55	12/27/15	Sunday	11:52 PM	Single Vehicle Crash	Dusk	Rain	Wet	No Improper Driving	53				MV1 (cab) was stopped at cab stand. Two men were pushing each other and MV1 started to pull away. One pedestrian opened MV1's back door but operator did not notice and ran over pedestrian.
56	12/30/15	Wednesday	9:49 PM	Single Vehicle Crash	Dark - lighted roadway	Rain	Ice	Unknown	32				Witnessed by police. Pedestrian was struck by MV1 in crosswalk.

*Courtesy Crash - A term used to describe a crash that occurs subsequent to a non-involved mainline driver who gives the right of way, contrary to the rules of the road, to another driver.

APPENDIX J

Crash Data Summary
Additional Data from Chelsea Police Department

Crash Diagram	Crash Date	Crash Day	Time of Day	Manner of Collision	Light Condition	Weather Condition	Road Surface	Injury Status	Driver Contributing Code	Comments
57	7/10/2011	Sunday	8:49AM	Rear-end	Daylight	Clear	Dry	Non-incapacitating	Unknown	Pedestrian was crossing the street in the cross walk when MV1 reversed and made contact with her left arm. She complained of left elbow pain and was treated and transported to the Whidden by Cataldo. MV1 stated that the victim was in the crosswalk, but he was reversing very slow to get a parking spot and does not believe he made contact with the victim.
58	9/23/2011	Friday	9:08PM	Angle	Dark - Lighted Roadway	Rain	Wet	No Injury	No Improper Driving	MV1 intents on make the left turn onto Fourth Street. MV2 then passed MV1 on the right side, then makes sudden left turn in front of MV1. MV2 rear left strikes MV1 front right, taking off MV1's front bumper. MV2 continued on Fourth Street without stopping, making a turn onto Hawthorne street. MV2 could only be described as an older model green Chevrolet pick up truck.
59	10/23/2011	Sunday	9:49AM	Single Vehicle Crash	Daylight	Clear	Dry	No Injury	Inattention	MV1 proceeded south on Broadway through intersection at Fourth St. At the same time pedestrian(#2) while operating a motorized chair crossed into lane of traffic beside marked pedestrian crosswalk when collision occurred.
60	12/24/2011	Saturday	6:06PM	Angle	Dark - Lighted Roadway	Clear	Dry	No Injury	No Improper Driving	Owner of MV1 stated he parked his vehicle legally in a parking spot to go into a store; when he returned he observed MV2 had struck his parked vehicle causing damage to the driver's side front headlight, bumper, and hood. Operator of MV2 stated that he was moving the vehicle to get out of someone else's way and he backed into MV1. MV2 had damage to the rear bumper passenger side and rear taillight.
61	4/16/2012	Monday	1:07PM	Sideswipe, same direction	Daylight	Clear	Dry	No Injury	Unknown	MV1 states his car was parked, and when he came out and observed damage to the front driver side of the MV. It appears that a MV drove by and sideswiped the car then drove off. He was advised to contact his insurance carrier.
62	5/27/2012	Sunday	1:12AM	Single Vehicle Crash	Dark - Lighted Roadway	Clear	Dry	Possible	No Improper Driving	Vehicle was turning from Washington Ave on Broadway, driver lost control, hit curb and also struck cement barrier. Impact caused deployment of 2 front air bags, minor damage to bumper and wheel, as well as control arm. The head of the driver and passenger hit the windshield causing windshield to crack. Both refused Medical on the scene. Vehicle towed by Todisco Towing.
63	9/21/2012	Friday	1:00PM	Sideswipe, same direction	Daylight	Cloudy	Dry	No Injury	No Improper Driving	Operator MV2 was driving when a vehicle from behind him sideswiped him. Operator of MV1 stated that he tried to go around MV2 when he hit it. No injuries were reported.
64	10/15/2012	Monday	10:13AM	Sideswipe, same direction	Daylight	Clear	Dry	Unknown	Unknown	Operator of MV1 stated he parked and went into a store and observed through a window, a truck drive and sideswipe his MV then turn right and go down Broadway. He was unable to get a plate number or description of MV2. He was advised to contact his insurance carrier.
65	2/25/2013	Monday	10:08AM	Rear-end	Daylight	Clear	Wet	No Injury	Inattention	MV1, a city of Chelsea DPW dump truck, was backing up and struck unoccupied vehicle #2, which was parked. The city of Chelsea vehicle had very minor damage to its rear bumper, and MV2 had minor damage to its front hood. No parties were injured and no vehicles were towed.
66	3/31/2013	Sunday	7:59PM	Sideswipe, same direction	Dark - Lighted Roadway	Clear	Dry	Unknown	Unknown	Owner of MV2 stated she went into Heller's Liquor Mart and when she came out someone had struck her motor vehicle. The damage to motor vehicle was the entire passenger's side. No one observed the license plate of MV1.
67	11/13/2013	Wednesday	5:36PM	Rear-End	Dark - Lighted Roadway	Clear	Dry	No Injury	No Improper Driving	MV1 was traveling on Broadway and slowed due to traffic crossing on Fourth St. MV2 struck MV1 in the rear.
68	12/27/2013	Friday	10:58AM	Angle	Daylight	Clear	Wet	No Injury	Visibility Obstructed	MV2 struck as it was entering the intersection of Broadway and Fourth Street. View of MV1 at the intersection was blocked by and MBTA bus stopped at a bus stop.
69	12/27/2013	Friday	6:16PM	Single Vehicle Crash	Dark - Lighted Roadway	Clear	Dry	No Injury	No Improper Driving	Owner of MV1 stated she was informed her vehicle was struck by an unknown vehicle. MV1 sustained heavy damage to the rear passenger tire. Officers on scene followed debris to the address of MV2, which an arrest was made. MV2 had heavy front damage to the driver's side tire.
70	5/13/2014	Tuesday	4:20PM	Unknown	Daylight	Cloudy	Dry	Non-incapacitating	Inattention	MV1 backed into a MBTA bus. Operator of MV1 was complaining of head pain and transported to the Whidden Hospital.
71	6/16/2014	Monday	2:29AM	Head-on	Dark - Lighted Roadway	Clear	Dry	Possible	Unknown	Collision at the intersection of Fourth street and Broadway.
72	8/17/2014	Sunday	12:38AM	Rear-end	Dark - Lighted Roadway	Clear	Dry	No Injury	Followed too closely	MV1 was struck from behind by MV2 when MV1 had to stop abruptly for another MV.
73	8/26/2014	Tuesday	12:54PM	Unknown	Daylight	Clear; Cloudy	Dry	No Injury	Unknown	Pedestrian struck by a black MV while crossing the street.
74	9/13/2014	Saturday	11:41PM	Sideswipe, same direction	Dark - Lighted Roadway	Clear	Dry	No Injury	Unknown	MV1 was turning left on to Fourth St. from Broadway. MV2 was also turning left on to Fourth St. and made contact with MV1.
75	9/18/2014	Thursday	8:35PM	Angle	Dark - Lighted Roadway	Clear; Cloudy	Dry	No Injury	Inattention	The operator of MV stated that she did not know the MVs had collided. Operator of MV2 stated she did not see any damage until after operator of MV1 left the area.
76	4/25/2015	Saturday	11:55AM	Single Vehicle Crash	Daylight	Clear	Dry	No Injury	Operating defective equipment	MVs brakes failed. MV rolled backwards across Hawthorne St. and Broadway and struck a trash receptacle.
78	5/29/2015	Friday	4:56PM	Sideswipe, same direction	Daylight	Clear	Dry	No Injury	Inattention	MV1 was making a left turn when it collided with MV2. MV2 was turning left when it was struck by the trailer's rear tire of MV1.
79	8/24/2015	Monday	8:54AM	Angle	Daylight	Clear	Dry	Possible	Unknown	Collision at the intersection of Fourth street and Broadway.

APPENDIX K

Intersection Capacity Analyses
Proposed Signal Setting under 2040 Projected Conditions
Broadway at Fifth Street

Lane Group	NBL	NBR	NET	NER	SWL	SWT	Ø2
Lane Configurations							
Traffic Volume (vph)	0	0	0	0	124	625	
Future Volume (vph)	0	0	0	0	124	625	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	0	0		0	150		
Storage Lanes	0	0		0	1		
Taper Length (ft)	25				25		
Satd. Flow (prot)	0	0	0	0	1321	2621	
Flt Permitted					0.950		
Satd. Flow (perm)	0	0	0	0	1276	2621	
Right Turn on Red		No		No	No		
Satd. Flow (RTOR)							
Link Speed (mph)	25		25			25	
Link Distance (ft)	56		174			280	
Travel Time (s)	1.5		4.7			7.6	
Confl. Peds. (#/hr)	85	163		30	30		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.87	0.87	
Growth Factor	115%	115%	115%	115%	115%	115%	
Heavy Vehicles (%)	2%	2%	2%	2%	7%	7%	
Bus Blockages (#/hr)	0	0	0	0	0	30	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	0	0	0	0	164	826	
Turn Type					Split	NA	
Protected Phases					1	1	2
Permitted Phases						1	
Minimum Split (s)					35.0	35.0	30.0
Total Split (s)					35.0	35.0	30.0
Total Split (%)					53.8%	53.8%	46%
Yellow Time (s)					4.0	4.0	2.0
All-Red Time (s)					2.0	2.0	2.0
Lost Time Adjust (s)					0.0	0.0	
Total Lost Time (s)					6.0	6.0	
Lead/Lag					Lead	Lead	Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)					29.0	29.0	
Actuated g/C Ratio					0.45	0.45	
v/c Ratio					0.28	0.71	
Control Delay					13.0	18.7	
Queue Delay					0.0	0.0	
Total Delay					13.0	18.7	
LOS					B	B	
Approach Delay						17.7	
Approach LOS						B	
Queue Length 50th (ft)					39	132	
Queue Length 95th (ft)					74	184	
Internal Link Dist (ft)	1		94			200	
Turn Bay Length (ft)					150		
Base Capacity (vph)					589	1169	

Lane Group	NBL	NBR	NET	NER	SWL	SWT	Ø2
Starvation Cap Reductn					0	0	
Spillback Cap Reductn					0	0	
Storage Cap Reductn					0	0	
Reduced v/c Ratio					0.28	0.71	

Intersection Summary			
Area Type:	CBD		
Cycle Length: 65			
Actuated Cycle Length: 65			
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection			
Natural Cycle: 65			
Control Type: Pretimed			
Maximum v/c Ratio: 0.71			
Intersection Signal Delay: 17.7		Intersection LOS: B	
Intersection Capacity Utilization 43.7%		ICU Level of Service A	
Analysis Period (min) 15			

Splits and Phases: 1: Broadway/Washington Avenue

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø2
Lane Configurations							
Traffic Volume (vph)	507	0	0	0	0	0	
Future Volume (vph)	507	0	0	0	0	0	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Satd. Flow (prot)	2573	0	0	0	0	0	
Flt Permitted							
Satd. Flow (perm)	2573	0	0	0	0	0	
Right Turn on Red		Yes				Yes	
Satd. Flow (RTOR)							
Link Speed (mph)	25			25	25		
Link Distance (ft)	208			89	51		
Travel Time (s)	5.7			2.4	1.4		
Confl. Peds. (#/hr)		100	100		88	122	
Peak Hour Factor	0.96	0.96	0.92	0.92	0.92	0.92	
Growth Factor	115%	115%	115%	115%	115%	115%	
Heavy Vehicles (%)	9%	9%	2%	2%	2%	2%	
Bus Blockages (#/hr)	30	30	0	0	0	0	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	607	0	0	0	0	0	
Turn Type	NA						
Protected Phases	1						2
Permitted Phases							
Minimum Split (s)	35.0						30.0
Total Split (s)	35.0						30.0
Total Split (%)	53.8%						46%
Yellow Time (s)	4.0						2.0
All-Red Time (s)	2.0						2.0
Lost Time Adjust (s)	0.0						
Total Lost Time (s)	6.0						
Lead/Lag	Lead						Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)	29.0						
Actuated g/C Ratio	0.45						
v/c Ratio	0.53						
Control Delay	15.2						
Queue Delay	0.0						
Total Delay	15.2						
LOS	B						
Approach Delay	15.2						
Approach LOS	B						
Queue Length 50th (ft)	87						
Queue Length 95th (ft)	131						
Internal Link Dist (ft)	128			9	1		
Turn Bay Length (ft)							
Base Capacity (vph)	1147						
Starvation Cap Reductn	0						
Spillback Cap Reductn	0						
Storage Cap Reductn	0						

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø2
Reduced v/c Ratio	0.53						

Intersection Summary			
Area Type:	CBD		
Cycle Length: 65			
Actuated Cycle Length: 65			
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection			
Natural Cycle: 65			
Control Type: Pretimed			
Maximum v/c Ratio: 0.71			
Intersection Signal Delay: 15.2		Intersection LOS: B	
Intersection Capacity Utilization 39.4%		ICU Level of Service A	
Analysis Period (min) 15			

Splits and Phases: 3: Hawthorn Street

Intersection Capacity Analysis
1: Broadway/Washington Avenue

Lane Group	NBL	NBR	NET	NER	SWL	SWT	Ø2
Lane Configurations							
Traffic Volume (vph)	0	0	0	0	97	460	
Future Volume (vph)	0	0	0	0	97	460	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	0	0		0	150		
Storage Lanes	0	0		0	1		
Taper Length (ft)	25				25		
Satd. Flow (prot)	0	0	0	0	1413	2646	
Flt Permitted					0.950		
Satd. Flow (perm)	0	0	0	0	1334	2646	
Right Turn on Red		No		No	No		
Satd. Flow (RTOR)							
Link Speed (mph)	25		25			25	
Link Distance (ft)	56		174			280	
Travel Time (s)	1.5		4.7			7.6	
Confl. Peds. (#/hr)	106	399		50	50		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.97	0.97	
Growth Factor	115%	115%	115%	115%	115%	115%	
Heavy Vehicles (%)	2%	2%	2%	2%	0%	6%	
Bus Blockages (#/hr)	0	0	0	0	0	30	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	0	0	0	0	115	545	
Turn Type					Split	NA	
Protected Phases					1	1	2
Permitted Phases						1	
Total Split (s)					35.0	35.0	30.0
Total Lost Time (s)					6.0	6.0	
Act Effct Green (s)					29.0	29.0	
Actuated g/C Ratio					0.45	0.45	
v/c Ratio					0.18	0.46	
Control Delay					11.9	14.2	
Queue Delay					0.0	0.0	
Total Delay					11.9	14.2	
LOS					B	B	
Approach Delay						13.8	
Approach LOS						B	
Queue Length 50th (ft)					26	75	
Queue Length 95th (ft)					55	114	
Internal Link Dist (ft)	1		94			200	
Turn Bay Length (ft)					150		
Base Capacity (vph)					630	1180	
Starvation Cap Reductn					0	0	
Spillback Cap Reductn					0	0	
Storage Cap Reductn					0	0	
Reduced v/c Ratio					0.18	0.46	

Intersection Summary	
Area Type:	CBD

Cycle Length: 65	
Actuated Cycle Length: 65	
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection	
Control Type: Pretimed	
Maximum v/c Ratio: 0.72	
Intersection Signal Delay: 13.8	Intersection LOS: B
Intersection Capacity Utilization 38.3%	ICU Level of Service A
Analysis Period (min) 15	

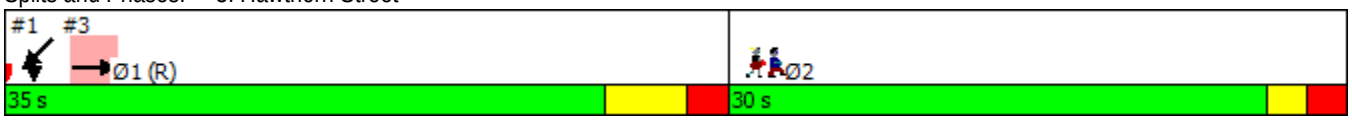
Splits and Phases: 1: Broadway/Washington Avenue

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø2
Lane Configurations							
Traffic Volume (vph)	701	0	0	0	0	0	
Future Volume (vph)	701	0	0	0	0	0	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Satd. Flow (prot)	2671	0	0	0	0	0	
Flt Permitted							
Satd. Flow (perm)	2671	0	0	0	0	0	
Right Turn on Red		Yes				Yes	
Satd. Flow (RTOR)							
Link Speed (mph)	25			25	25		
Link Distance (ft)	208			89	51		
Travel Time (s)	5.7			2.4	1.4		
Confl. Peds. (#/hr)		100	100		109	117	
Peak Hour Factor	0.94	0.94	0.92	0.92	0.92	0.92	
Growth Factor	115%	115%	115%	115%	115%	115%	
Heavy Vehicles (%)	5%	5%	2%	2%	2%	2%	
Bus Blockages (#/hr)	30	30	0	0	0	0	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	858	0	0	0	0	0	
Turn Type	NA						
Protected Phases	1						2
Permitted Phases							
Total Split (s)	35.0						30.0
Total Lost Time (s)	6.0						
Act Effct Green (s)	29.0						
Actuated g/C Ratio	0.45						
v/c Ratio	0.72						
Control Delay	19.0						
Queue Delay	0.0						
Total Delay	19.0						
LOS	B						
Approach Delay	19.0						
Approach LOS	B						
Queue Length 50th (ft)	138						
Queue Length 95th (ft)	203						
Internal Link Dist (ft)	128			9	1		
Turn Bay Length (ft)							
Base Capacity (vph)	1191						
Starvation Cap Reductn	0						
Spillback Cap Reductn	0						
Storage Cap Reductn	0						
Reduced v/c Ratio	0.72						

Intersection Summary	
Area Type:	CBD
Cycle Length: 65	
Actuated Cycle Length: 65	
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection	

Control Type: Pretimed	
Maximum v/c Ratio: 0.72	
Intersection Signal Delay: 19.0	Intersection LOS: B
Intersection Capacity Utilization 46.2%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 3: Hawthorn Street

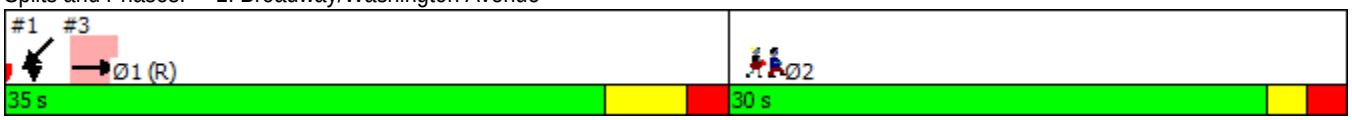


Lane Group	NBL	NBR	NET	NER	SWL	SWT	Ø2
Lane Configurations							
Traffic Volume (vph)	0	0	0	0	69	515	
Future Volume (vph)	0	0	0	0	69	515	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Storage Length (ft)	0	0		0	150		
Storage Lanes	0	0		0	1		
Taper Length (ft)	25				25		
Satd. Flow (prot)	0	0	0	0	1413	2671	
Flt Permitted					0.950		
Satd. Flow (perm)	0	0	0	0	1334	2671	
Right Turn on Red		No		No	No		
Satd. Flow (RTOR)							
Link Speed (mph)	25		25			25	
Link Distance (ft)	56		174			280	
Travel Time (s)	1.5		4.7			7.6	
Confl. Peds. (#/hr)	128	325		50	50		
Peak Hour Factor	0.92	0.92	0.92	0.92	0.91	0.91	
Growth Factor	115%	115%	115%	115%	115%	115%	
Heavy Vehicles (%)	2%	2%	2%	2%	0%	5%	
Bus Blockages (#/hr)	0	0	0	0	0	30	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	0	0	0	0	87	651	
Turn Type					Split	NA	
Protected Phases					1	1	2
Permitted Phases						1	
Minimum Split (s)					35.0	35.0	30.0
Total Split (s)					35.0	35.0	30.0
Total Split (%)					53.8%	53.8%	46%
Yellow Time (s)					4.0	4.0	2.0
All-Red Time (s)					2.0	2.0	2.0
Lost Time Adjust (s)					0.0	0.0	
Total Lost Time (s)					6.0	6.0	
Lead/Lag					Lead	Lead	Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)					29.0	29.0	
Actuated g/C Ratio					0.45	0.45	
v/c Ratio					0.14	0.55	
Control Delay					11.4	15.3	
Queue Delay					0.0	0.0	
Total Delay					11.4	15.3	
LOS					B	B	
Approach Delay						14.9	
Approach LOS						B	
Queue Length 50th (ft)					19	94	
Queue Length 95th (ft)					43	141	
Internal Link Dist (ft)	1		94			200	
Turn Bay Length (ft)					150		
Base Capacity (vph)					630	1191	

Lane Group	NBL	NBR	NET	NER	SWL	SWT	Ø2
Starvation Cap Reductn					0	0	
Spillback Cap Reductn					0	0	
Storage Cap Reductn					0	0	
Reduced v/c Ratio					0.14	0.55	

Intersection Summary			
Area Type:	CBD		
Cycle Length: 65			
Actuated Cycle Length: 65			
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection			
Natural Cycle: 65			
Control Type: Pretimed			
Maximum v/c Ratio: 0.76			
Intersection Signal Delay: 14.9		Intersection LOS: B	
Intersection Capacity Utilization 39.9%		ICU Level of Service A	
Analysis Period (min) 15			

Splits and Phases: 1: Broadway/Washington Avenue



Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø2
Lane Configurations							
Traffic Volume (vph)	717	0	0	0	0	0	
Future Volume (vph)	717	0	0	0	0	0	
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	
Satd. Flow (prot)	2671	0	0	0	0	0	
Flt Permitted							
Satd. Flow (perm)	2671	0	0	0	0	0	
Right Turn on Red		Yes				Yes	
Satd. Flow (RTOR)							
Link Speed (mph)	25			25	25		
Link Distance (ft)	208			89	51		
Travel Time (s)	5.7			2.4	1.4		
Confl. Peds. (#/hr)		100	100		110	122	
Peak Hour Factor	0.91	0.91	0.92	0.92	0.92	0.92	
Growth Factor	115%	115%	115%	115%	115%	115%	
Heavy Vehicles (%)	5%	5%	2%	2%	2%	2%	
Bus Blockages (#/hr)	30	30	0	0	0	0	
Parking (#/hr)	0	0	0	0	0	0	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	906	0	0	0	0	0	
Turn Type	NA						
Protected Phases	1						2
Permitted Phases							
Minimum Split (s)	35.0						30.0
Total Split (s)	35.0						30.0
Total Split (%)	53.8%						46%
Yellow Time (s)	4.0						2.0
All-Red Time (s)	2.0						2.0
Lost Time Adjust (s)	0.0						
Total Lost Time (s)	6.0						
Lead/Lag	Lead						Lag
Lead-Lag Optimize?							Yes
Act Effct Green (s)	29.0						
Actuated g/C Ratio	0.45						
v/c Ratio	0.76						
Control Delay	20.2						
Queue Delay	0.0						
Total Delay	20.2						
LOS	C						
Approach Delay	20.2						
Approach LOS	C						
Queue Length 50th (ft)	150						
Queue Length 95th (ft)	220						
Internal Link Dist (ft)	128			9	1		
Turn Bay Length (ft)							
Base Capacity (vph)	1191						
Starvation Cap Reductn	0						
Spillback Cap Reductn	0						
Storage Cap Reductn	0						

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø2
Reduced v/c Ratio	0.76						

Intersection Summary			
Area Type:	CBD		
Cycle Length: 65			
Actuated Cycle Length: 65			
Offset: 0 (0%), Referenced to phase 1:SWTL, Start of Green, Master Intersection			
Natural Cycle: 65			
Control Type: Pretimed			
Maximum v/c Ratio: 0.76			
Intersection Signal Delay: 20.2		Intersection LOS: C	
Intersection Capacity Utilization 46.8%		ICU Level of Service A	
Analysis Period (min) 15			

Splits and Phases: 3: Hawthorn Street

APPENDIX L

Intersection Capacity Analyses
Proposed Signal Setting under 2040 Projected Conditions
Broadway at Fourth Street

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	0	0	0	105	470	0	0	0	0	0	147	174
Future Volume (vph)	0	0	0	105	470	0	0	0	0	0	147	174
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Satd. Flow (prot)	0	0	0	0	2789	0	0	0	0	0	1444	1228
Flt Permitted					0.991							
Satd. Flow (perm)	0	0	0	0	2695	0	0	0	0	0	1444	1093
Right Turn on Red			No	No		No			No			No
Satd. Flow (RTOR)												
Link Speed (mph)		25			25			25			25	
Link Distance (ft)		381			317			190			193	
Travel Time (s)		10.4			8.6			5.2			5.3	
Confl. Peds. (#/hr)	76		97	97		76	87		39	39		87
Peak Hour Factor	0.92	0.92	0.92	0.89	0.89	0.89	0.92	0.92	0.92	0.97	0.97	0.97
Growth Factor	115%	115%	115%	115%	115%	115%	115%	115%	115%	115%	115%	115%
Heavy Vehicles (%)	2%	2%	2%	6%	6%	6%	2%	2%	2%	3%	3%	3%
Parking (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	0	0	0	743	0	0	0	0	0	174	206
Turn Type				Perm	NA						NA	Perm
Protected Phases					1						2	
Permitted Phases				1								2
Detector Phase				1	1						2	2
Switch Phase												
Minimum Initial (s)				5.0	5.0						5.0	5.0
Minimum Split (s)				21.0	21.0						21.0	21.0
Total Split (s)				23.0	23.0						21.0	21.0
Total Split (%)				35.4%	35.4%						32.3%	32.3%
Yellow Time (s)				3.0	3.0						3.0	3.0
All-Red Time (s)				1.0	1.0						1.0	1.0
Lost Time Adjust (s)					0.0						0.0	0.0
Total Lost Time (s)					4.0						4.0	4.0
Lead/Lag				Lead	Lead						Lag	Lag
Lead-Lag Optimize?				Yes	Yes						Yes	Yes
Recall Mode				Max	Max						None	None
Act Effct Green (s)					22.2						14.2	14.2
Actuated g/C Ratio					0.40						0.26	0.26
v/c Ratio					0.69						0.47	0.74
Control Delay					24.3						24.0	39.5
Queue Delay					0.0						0.0	0.0
Total Delay					24.3						24.0	39.5
LOS					C						C	D
Approach Delay					24.3						32.4	
Approach LOS					C						C	
Queue Length 50th (ft)					150						58	74
Queue Length 95th (ft)					#252						112	#171
Internal Link Dist (ft)		301			237			110			113	
Turn Bay Length (ft)												
Base Capacity (vph)					1075						464	351

Lane Group	Ø3
Lane Configurations	
Traffic Volume (vph)	
Future Volume (vph)	
Ideal Flow (vphpl)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Right Turn on Red	
Satd. Flow (RTOR)	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Parking (#/hr)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	3
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	5.0
Minimum Split (s)	21.0
Total Split (s)	21.0
Total Split (%)	32%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	

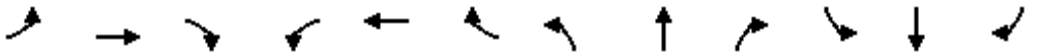
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Starvation Cap Reductn					0						0	0
Spillback Cap Reductn					0						0	0
Storage Cap Reductn					0						0	0
Reduced v/c Ratio					0.69						0.38	0.59

Intersection Summary			
Area Type:	CBD		
Cycle Length: 65			
Actuated Cycle Length: 55.6			
Natural Cycle: 65			
Control Type: Semi Act-Uncoord			
Maximum v/c Ratio: 0.74			
Intersection Signal Delay: 27.0		Intersection LOS: C	
Intersection Capacity Utilization 46.5%		ICU Level of Service A	
Analysis Period (min) 15			

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

Splits and Phases: 8: 4th Street & Broadway

Intersection Capacity Analysis
8: 4th Street & Broadway



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	0	0	0	151	308	0	0	0	0	0	236	166
Future Volume (vph)	0	0	0	151	308	0	0	0	0	0	236	166
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Satd. Flow (prot)	0	0	0	0	2770	0	0	0	0	0	1444	1228
Flt Permitted					0.984							
Satd. Flow (perm)	0	0	0	0	2306	0	0	0	0	0	1444	1079
Right Turn on Red			No	No		No			No			No
Satd. Flow (RTOR)												
Link Speed (mph)		25			25			25			25	
Link Distance (ft)		381			317			190			193	
Travel Time (s)		10.4			8.6			5.2			5.3	
Confl. Peds. (#/hr)	167		285	285		167	97		132	132		97
Peak Hour Factor	0.92	0.92	0.92	0.93	0.93	0.93	0.92	0.92	0.92	0.93	0.93	0.93
Growth Factor	115%	115%	115%	115%	115%	115%	115%	115%	115%	115%	115%	115%
Heavy Vehicles (%)	2%	2%	2%	6%	6%	6%	2%	2%	2%	3%	3%	3%
Parking (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	0	0	0	568	0	0	0	0	0	292	205
Turn Type				Perm	NA						NA	Perm
Protected Phases					1						2	
Permitted Phases				1								2
Total Split (s)				23.0	23.0						21.0	21.0
Total Lost Time (s)					4.0						4.0	4.0
Act Effct Green (s)					20.4						14.6	14.6
Actuated g/C Ratio					0.38						0.27	0.27
v/c Ratio					0.65						0.75	0.70
Control Delay					23.5						35.3	36.7
Queue Delay					0.0						0.0	0.0
Total Delay					23.5						35.3	36.7
LOS					C						D	D
Approach Delay					23.5						35.9	
Approach LOS					C						D	
Queue Length 50th (ft)					110						107	74
Queue Length 95th (ft)					#195						#222	#170
Internal Link Dist (ft)		301			237			110			113	
Turn Bay Length (ft)												
Base Capacity (vph)					870						487	364
Starvation Cap Reductn					0						0	0
Spillback Cap Reductn					0						0	0
Storage Cap Reductn					0						0	0
Reduced v/c Ratio					0.65						0.60	0.56

Intersection Summary	
Area Type:	CBD
Cycle Length: 65	
Actuated Cycle Length: 54.1	
Control Type: Semi Act-Uncoord	
Maximum v/c Ratio: 0.75	

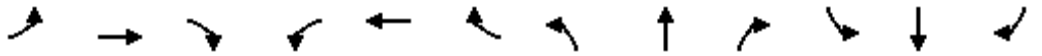
Lane Group	Ø3
Lane Configurations	
Traffic Volume (vph)	
Future Volume (vph)	
Ideal Flow (vphpl)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Right Turn on Red	
Satd. Flow (RTOR)	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Parking (#/hr)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	3
Permitted Phases	
Total Split (s)	21.0
Total Lost Time (s)	
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Intersection Signal Delay: 29.3	Intersection LOS: C
Intersection Capacity Utilization 42.3%	ICU Level of Service A
Analysis Period (min) 15	

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

Splits and Phases: 8: 4th Street & Broadway



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	0	0	0	135	342	0	0	0	0	0	222	183
Future Volume (vph)	0	0	0	135	342	0	0	0	0	0	222	183
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Satd. Flow (prot)	0	0	0	0	2829	0	0	0	0	0	1473	1252
Flt Permitted					0.986							
Satd. Flow (perm)	0	0	0	0	2394	0	0	0	0	0	1473	1050
Right Turn on Red			No	No		No			No			No
Satd. Flow (RTOR)												
Link Speed (mph)		25			25			25			25	
Link Distance (ft)		381			317			190			193	
Travel Time (s)		10.4			8.6			5.2			5.3	
Confl. Peds. (#/hr)	235		377	377		235	133		105	105		133
Peak Hour Factor	0.92	0.92	0.92	0.88	0.88	0.88	0.92	0.92	0.92	0.86	0.86	0.86
Growth Factor	115%	115%	115%	115%	115%	115%	115%	115%	115%	115%	115%	115%
Heavy Vehicles (%)	2%	2%	2%	4%	4%	4%	2%	2%	2%	1%	1%	1%
Parking (#/hr)	0	0	0	0	0	0	0	0	0	0	0	0
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	0	0	0	623	0	0	0	0	0	297	245
Turn Type				Perm	NA						NA	Perm
Protected Phases					1						2	
Permitted Phases				1								2
Detector Phase				1	1						2	2
Switch Phase												
Minimum Initial (s)				5.0	5.0						5.0	5.0
Minimum Split (s)				21.0	21.0						21.0	21.0
Total Split (s)				23.0	23.0						21.0	21.0
Total Split (%)				35.4%	35.4%						32.3%	32.3%
Yellow Time (s)				3.0	3.0						3.0	3.0
All-Red Time (s)				1.0	1.0						1.0	1.0
Lost Time Adjust (s)					0.0						0.0	0.0
Total Lost Time (s)					4.0						4.0	4.0
Lead/Lag				Lead	Lead						Lag	Lag
Lead-Lag Optimize?				Yes	Yes						Yes	Yes
Recall Mode				Max	Max						None	None
Act Effct Green (s)					20.0						16.4	16.4
Actuated g/C Ratio					0.36						0.29	0.29
v/c Ratio					0.73						0.68	0.79
Control Delay					26.2						30.8	44.0
Queue Delay					0.0						0.0	0.0
Total Delay					26.2						30.8	44.0
LOS					C						C	D
Approach Delay					26.2						36.8	
Approach LOS					C						D	
Queue Length 50th (ft)					123						109	93
Queue Length 95th (ft)					#208						#207	#202
Internal Link Dist (ft)		301			237			110			113	
Turn Bay Length (ft)												
Base Capacity (vph)					859						473	337

Lane Group	Ø3
Lane Configurations	
Traffic Volume (vph)	
Future Volume (vph)	
Ideal Flow (vphpl)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Right Turn on Red	
Satd. Flow (RTOR)	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Parking (#/hr)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	3
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	5.0
Minimum Split (s)	21.0
Total Split (s)	21.0
Total Split (%)	32%
Yellow Time (s)	3.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Starvation Cap Reductn					0						0	0
Spillback Cap Reductn					0						0	0
Storage Cap Reductn					0						0	0
Reduced v/c Ratio					0.73						0.63	0.73

Intersection Summary			
Area Type:	CBD		
Cycle Length: 65			
Actuated Cycle Length: 55.6			
Natural Cycle: 70			
Control Type: Semi Act-Uncoord			
Maximum v/c Ratio: 0.79			
Intersection Signal Delay: 31.1		Intersection LOS: C	
Intersection Capacity Utilization 45.0%		ICU Level of Service A	
Analysis Period (min) 15			

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

Splits and Phases: 8: 4th Street & Broadway

APPENDIX M

MassDOT 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 Highway 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 Highway 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 Highway 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