Transportation Impact Assessment

School Street Modification Study
Brookline, Massachusetts

Prepared for:

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EXECUTIVE SUMMARY

Vanasse & Associates, Inc. (VAI) has prepared this Transportation Impact Assessment (TIA) in order to evaluate traffic impacts associated with potential modifications to School Street connected with the revisions to the John R. Pierce School in Brookline, Massachusetts. This study evaluates the existing traffic conditions along School Street and at main intersections in the immediate vicinity of the Brookline downtown area. The goal of this report is to evaluate four alternatives for School Street to provide a safe pedestrian crossing for Pierce School students/staff and the community at all times of the day. The alternatives were analyzed with a recommended improvement plan presented in the Conclusion.

PROJECT DESCRIPTION

The Town of Brookline has been seeking to modify School Street to accommodate a safe pedestrian crossing environment from the Pierce School building to the Pierce School Playground at all times of the day, for Pierce School students/staff and for the general community as well. The Pierce School building is located at the south side of School Street, with the playground located on the north side of School Street. At present, a connection between the school building and playground is provided through an enclosed pedestrian bridge over School Street. As part of the Pierce School redevelopment and community feedback, a variety of deficiencies were encountered with the existing bridge including the following:

- The bridge is only accessible via stairs and has a relatively narrow access point, making two-way pedestrian traffic challenging. The bridge does not meet current Americans with Disabilities Act (ADA) standards; nor can it be used to transfer an injured student back from the playground to the school if incidents occur.

- The playground is currently shared with local recreation programs, daycare entities, and neighbors and is open during school vacation. However, access to the bridge is only provided for school students/staff and only during school hours. Staff members escort students across School Street via the bridge during school hours.

- It was observed that some pedestrians currently avoid using the pedestrian bridge due to the time it takes to cross the bridge. These pedestrians were found crossing School Street at street-level, where there are no pedestrian crossing safety measures in proximity to the playground.

Based on the aforementioned deficiencies, it was determined that the bridge is currently not addressing the needs of the school nor of the community. Maintaining it in place or building a new bridge is not feasible, given current regulations and site constraints. Therefore, a new approach to create a safe pedestrian crossing for school occupants and the community was developed. This approach relied on restriction of some or all of School Street vehicular traffic flow to create a safe area for pedestrians to cross the street. The following four (4) School Street restriction conditions were assessed:

- Scenario 1 - Closing School Street
- Scenario 2 - Temporary closure of School Street 7:00 AM – 3:00 PM
- Scenario 3 - School Street one-way eastbound
- Scenario 4 - School Street one-way westbound

These scenarios were compared against the current condition, which could be called the "status quo" or No-Build alternative. A study area of 21 intersections was developed along with a review of four separate time periods:

- Weekday morning peak hour – between 7:30 and 8:30 AM
- Weekday midday peak hour – between 3:00 and 4:00 PM
- Weekday evening peak hour – between 4:45 and 5:45 PM
- Saturday midday peak hour – between 11:15 AM and 12:15 PM

Pedestrian and bicycle counts also comprised data to be input into the overall assessment of conditions. As documented in a report, 81 percent of Pierce School students walk to the school, and the Brookline Village area in general was observed to be a walking community with hundreds of pedestrians per hour observed at the study area intersections. The presence of the students was clear in the review of the count data, as the weekday morning and weekday afternoon time periods were noted to have the highest numbers of pedestrians of the times reviewed.

Vehicle crash data was obtained from the Brookline Police Department for the study area locations and for School Street for use in the traffic analysis. School Street itself was not a source of many crashes over the 2017-2022 review period. However, the intersections at either end of School Street experienced the highest number of crashes of any locations in the study area. Any option for School Street that increases vehicle delay at these intersections has the potential to increase crash frequencies as motorists become impatient and/or distracted, which is not a desirable outcome.

CONCLUSION

A review of the reassigned traffic volumes for the scenarios listed indicated that most alternate routes utilized by the reassigned traffic from School Street would be expected to increase delay at intersections substantially over the No Build conditions. Some intersections and road links that are heavily traveled by pedestrians (presumably students based on the time periods) would be expected to experience double digit volume increases and substantial intersection delays based on the re-routed traffic from School Street. None of the scenarios reviewed improved delay at all locations, although some locations (along Cypress Street, for example) did experience improvements in delay and reduction in traffic volumes. A summary of the Scenario performance was developed that focuses on the weekday morning and weekday afternoon time periods. Scenario 1 and Scenario 2 (complete closure of School Street) are essentially the same for these time periods; therefore, they are combined in the table below.

Table 1
SUMMARY OF SCENARIO PERFORMANCE

Scenario No.	Vehicle Delay Increase (Number of Intersections)	Traffic-Volume Increase (Number of Intersections)	Impacts at High Pedestrian Routes (>10% traffic-volume increase, >50 pph, Number of Intersections)	Delay Increase to High Crash Locations (>1.5 crash/yr, Number of Intersections)
1-2	7 of 9 signalized 10 of 14 unsignalized	12 of 21:12 to 84% 4 of 21: 4 to 12% 5 of 21: 0 to -32%	11 of 21	4 of 5
3	5 of 9 signalized 8 of 14 unsignalized	9 of 21: 10 to 50% 6 of 21: 1 to 10% 6 of 21: 0 to -15%	9 of 21	3 of 5
4	7 of 9 signalized	6 of 21: 11 to 38% 8 of 21: 2 to 10% 7 of 21: 0 to -16%	5 of 21	5 of 5

Based on this review, none of the scenarios were attractive enough to recommend their adoption. The effects of rerouted School Street traffic are shown to negatively impact most of the intersections in the study area, add traffic at locations where high pedestrian travel was observed, and result in increased vehicle delay at locations exhibiting a high crash frequency. The consequence of the re-routing of vehicular traffic associated with School Street restriction is likely increased driver frustration and potentially increased speeds on residential streets that presently carry large numbers of pedestrians, many of them likely school-age.

In addition to the widespread alteration of drivers' routes that would be affected, including those of residents and businesses in close proximity to School Street that have to use the road daily, the concerns of emergency response vehicles would need to be accounted for, and School Street is the only east-west link between Harvard Street and Washington Street able to be navigated by large response vehicles.

Recommendations have therefore focused on managing the traffic flow in order to accommodate all users of the street. A conceptual improvement design has been prepared that incorporates Traffic Calming Measures including a proposed neckdown (narrowing) of School Street, speed humps, a speed table/raised crosswalk, and a pushbutton-activated Pedestrian Hybrid Beacon signalized crossing device. These measures are proven to reduce vehicle speeds and create safer roadways, resulting in reductions of vehicle speeds and crashes over the past 10 to 20 years.

In summary, this approach provides a more manageable solution with fewer detriments for the area neighborhood than the potential restriction of School Street would create, with its numerous ancillary impacts to pedestrian, bicycle, and vehicular traffic flow. The increase in vehicle-pedestrian conflict at multiple area intersections is an undesirable condition and one that would be experienced on a 24 hours per day/7 days per week schedule, even though the majority of school-related pedestrian crossings of School Street would only occur between the hours of 10:00 AM to 3:00 PM, and only during the weekdays during the school year. It is anticipated that adoption of these measures will address the school's and neighborhood's concerns regarding School Street and improve conditions and safety for all users of this important link in Brookline.

EXISTING CONDITIONS

A comprehensive field inventory and observations of were made to develop an understanding of the existing roadway configurations and traffic flow. The field investigation consisted of an inventory of existing roadway geometrics, pedestrian facilities, traffic volumes, and operating characteristics, as well as posted speed limits and land use information for the major roadways that provide access to School Street including Aspinwall Avenue, Cypress Street, Harvard Street, and Washington Street as well as the intersections which are expected to accommodate the majority of School Street traffic. The study area for the Project is listed below and graphically depicted in Figure 1.

1. Brookline Avenue at Washington Street
2. High Street at Washington Street
3. Davis Avenue at Washington Street and Harvard Street at Kent Street
4. Harvard Street at Pierce Street
5. Linden Place at Harvard Street
6. Holden Street at Pierce Street
7. Pierce Street drop-off area
8. School Street at Aspinwall Avenue and Harvard Street
9. St. Paul Street at Aspinwall Avenue
10. Harvard Street at Harvard Avenue
11. Auburn Street at Park Street
12. Harvard Avenue at Park Street
13. Park Street at Washington Street
14. School Street at Pierce School driveway
15. School Street at loading area
16. Cypress Street at Washington Street and School Street
17. Garage access/exit at Washington Street
18. Thayer Street at Washington Street
19. Holden Street at Washington Street
20. Cypress Street at Davis Avenue
21. Boylston Street at Cypress Street

The following describes the study area roadway and intersections:

Figure 1

Study Area Intersections

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EXISTING ROADWAY CONDITIONS

Roadways

School Street

School Street traverses the study area in a general east-west direction and is under Town jurisdiction. School Street generally provides two 10-foot-wide travel lanes in one direction, and one 11-foot-wide lane in the other direction, separated by a double-yellow centerline. Sidewalks are provided along both sides of School Street, with illumination provided by way of streetlamps mounted on black steel poles. Land use along School Street within the study area consists of commercial, municipal, residential properties, and the Project site.

Harvard Street

Harvard Street traverses the study area in a general north-south direction and is under Town jurisdiction. Within the study area, Harvard Street generally provides one 11-foot-wide travel lane in each direction, separated by a double-yellow centerline with 5-foot-wide bicycle lanes in each direction and on-street metered parking. Sidewalk is provided along both sides of Harvard Street, with illumination provided by way of streetlamps mounted on black steel poles. Land use along Harvard Street within the study area consists of commercial, municipal, residential properties, and the Project site.

Washington Street

Washington Street is an urban minor arterial street under local jurisdiction. Washington Street generally extends in a northwest/southeast direction between two commercial districts: Washington Square to the northwest and Brookline Village to the southeast. Washington Street generally provides one travel lane per direction within the study area separated by a double-yellow centerline with additional turn lanes provided at major intersections. On-street bike lanes are present on the northbound side of the corridor within the study area. On-street parking is generally provided along both sides of the roadway between Harvard Street and School Street. Sidewalks are provided continuously along both sides of the roadway. Land use consists of the Project site, and municipal, residential, and commercial uses.

Aspinwall Avenue

Aspinwall Avenue is an urban minor arterial under local jurisdiction. Aspinwall Avenue generally runs in an east-west direction and provides one travel lane in each direction. On-street parking is generally allowed along both sides of Aspinwall Avenue. Sidewalks are provided along both sides of the street. Land use along Aspinwall Avenue is primarily residential.

Cypress Street

Cypress Street is a two-lane urban minor arterial roadway under Town jurisdiction that traverses in a general north-south direction and provides access to Boylston Street (Route 9), Washington Street, and School Street within study area. Cypress Street generally provides two 11- to 17-foot wide travel lanes per direction within the study area separated by a double-yellow centerline with additional turn lanes provided at major intersections. On-street parking is generally prohibited along the roadway within the study area with exception of metered spaces close to the Washington Street intersection with School Street. The posted speed limit is 25 miles per hour (mph). Sidewalks

are provided continuously along both sides of the roadway. Bicycle accommodations are provided by way of a marked bicycle lane or designated by "sharrow" pavement markings. Land use consists of residential and commercial uses.

Intersections

Figure 2 summarizes existing roadway geometry, intersection control, and pedestrian facilities at the study area intersections based on the field inventory performed by Vanasse & Associates, Inc. (VAI).

EXISTING TRAFFIC VOLUMES

In order to determine existing traffic-volume demands and flow patterns within the study area, manual turning movement counts (TMCs) and vehicle classification counts were researched from the Brookline Traffic Department existing traffic counts conducted in June and September 2016, May and November 2017, January 2018, March 2020, and April and June 2021. In addition, supplemental TMCs were conducted in January and February 2022. (A TMC counting collection date map is provided in the Appendix.) All counts were conducted during a typical weekday morning (7:00 to 9:00 AM) period, weekday afternoon (2:00 to 6:00 PM) period, and Saturday midday (11:00 AM to 1:00 PM) at each study area intersection. The majority of the TMCs were performed while schools were in regular session and when weather conditions were generally clear. These time periods were selected for analysis purposes as they are representative of the peak-traffic-volume hours for both the school traffic and the adjacent roadway network.

Traffic Adjustments

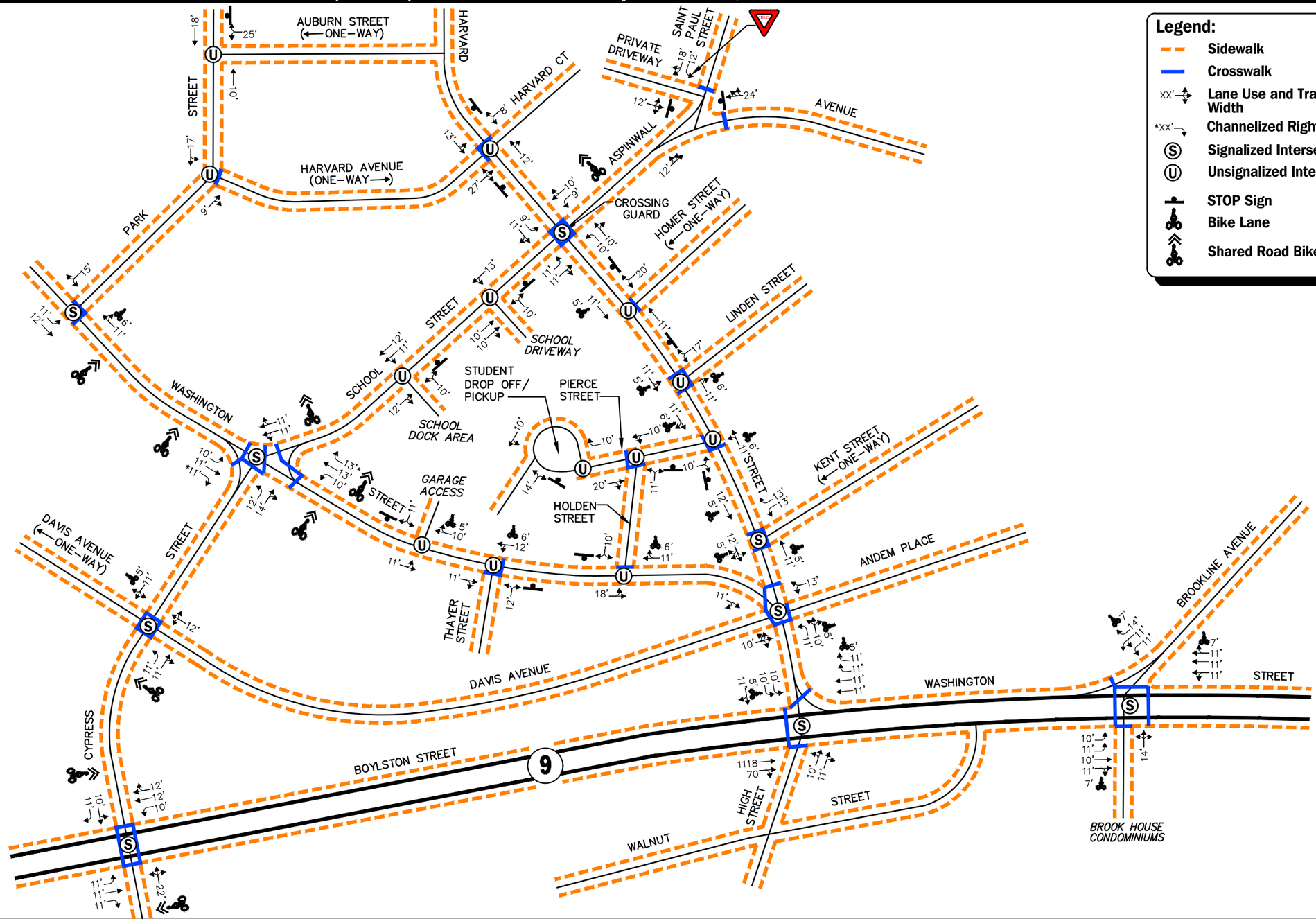
COVID-19 Adjustment

In accordance with Massachusetts Department of Transportation (MassDOT) guidelines, traffic counts collected after March 2020 may not be representative of typical traffic volumes due to the effects from the COVID-19 pandemic.[1],[2] To determine whether a pandemic adjustment should be made to the April and June 2021 and January and February 2022 traffic counts, count data from the MassDOT permanent count station ID AET13, located close by the study area were reviewed.[3] Traffic-volume data collected at this continuous count station in 2021 and 2022 was compared to 2019 traffic volumes that were collected at the same location. The 2019 traffic volumes were expanded to same-year condition by applying a background traffic growth rate of 0.5 percent per year (discussion follows) in order to allow for a comparison of the data. Based on this pre- and post-COVID-19 traffic data comparison, the April and June 2021 traffic-volume data that was collected as a part of this assessment was adjusted upward by an additional 54 and 34 percent respectively. The January and February 2022 traffic-volume data that was collected as a part of this assessment was adjusted upward by an additional 30 percent. These adjustments account for the reduced traffic volumes which is an approach consistent with the phased "Reopening Massachusetts" plan provided by MassDOT. It is important to note that although traffic levels have been steadily increasing over the last several months, available traffic data suggests that traffic conditions have not yet returned to pre-pandemic levels.

[1]Chief Engineer Patricia Leavenworth. MassDOT Engineering Directive E-20-005 – Guidance on Traffic Count Data. May 11, 2020.

[2]Massachusetts Department of Transportation, Highway Division. Guidance on Traffic Count Data; Apr 2020.

[3]MassDOT Transportation Data Management System.



Not To Scale

Figure 2

Intersection Lane Use, Travel Lane Width, and Pedestrian Facilities

Vanasse & Associates inc

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Baseline Traffic Adjustment

In order to establish a 2022 Baseline condition, traffic volumes from TMCs conducted in June and September 2016, May and November 2017, January 2018, March 2020, and April and June 2021, 2022 were expanded to 2022 same-year condition by applying a background traffic growth rate of 0.5 percent per year (discussion follows).

Seasonal Adjustment

In addition to developing correction factors for COVID-19, adjustments were also made to account for seasonal fluctuations in traffic. In order to determine whether traffic volumes collected in June and September 2016, May and November 2017, January 2018, March 2020, April and June 2021, and January and February 2022 were representative of average annual conditions, historical traffic data collected by MassDOT permanent count station ID AET13 was examined. Based on this data, it was determined that some of the traffic volumes are below average-month conditions for this station and were increased appropriately. Traffic volumes that were shown to be above-average monthly conditions were not decreased in order to provide a conservative analysis. Table 2 summarizes seasonal fluctuations by month for each month that the traffic count was collected.

Table 2
SEASONAL FLUCTUATIONS FACTOR

Month Year	Fraction of Average Traffic	Below Annual Average-Month Conditions?	Traffic Increase Percentage
June 2016	1.07	No	--
September 2016	1.03	No	--
May 2017	1.05	No	--
November 2017	1.03	No	--
January 2018	0.89	Yes	11%
March 2020	0.99	Yes	1%
April 2021	1.03	No	--
June 2021	1.02	No	--
January 2022	0.93	Yes	7%
February 2022	0.96	Yes	4%

A review of the peak-period traffic counts within the study area indicates that the weekday morning peak hour generally occurs between 7:30 and 8:30 AM, the weekday afternoon peak hour generally occurs between 3:00 and 4:00 PM, the weekday evening peak hour generally occurs between 4:45 and 5:45 PM, and the Saturday midday peak hour occurs between 11:15 AM and 12:15 PM. Weekday morning, afternoon, evening, and Saturday midday peak-hour traffic volumes are provided in the Appendix.

SCHOOL STREET

In order to understand School Street existing characteristics and usage within the study area, a comprehensive review of available and newly collected data was conducted. This data included existing roadway geometrics and signage, annual daily volume comparisons, speed measurements, and sight distance measurements for the loading driveway expected to remain in place.

School Street is a 0.2-mile two-way street that connects Harvard Street to Washington Street. School Street generally provides one 10- to 14-foot-wide travel lane per direction with an auxiliary left-turn storage lane separated by a double-yellow centerline. The left-turn lanes meet at the approximate midpoint of the street, in vicinity of the existing pedestrian bridge. The overall width along School Street varies between 22 and 36 feet. On-street parking is generally prohibited along both sides of this road. The posted speed limit is 25 mph. School Street is within a school zone with a posted speed limit during school hours of 20 mph. Figure 3 graphically details the existing roadway geometrics and signage for School Street.

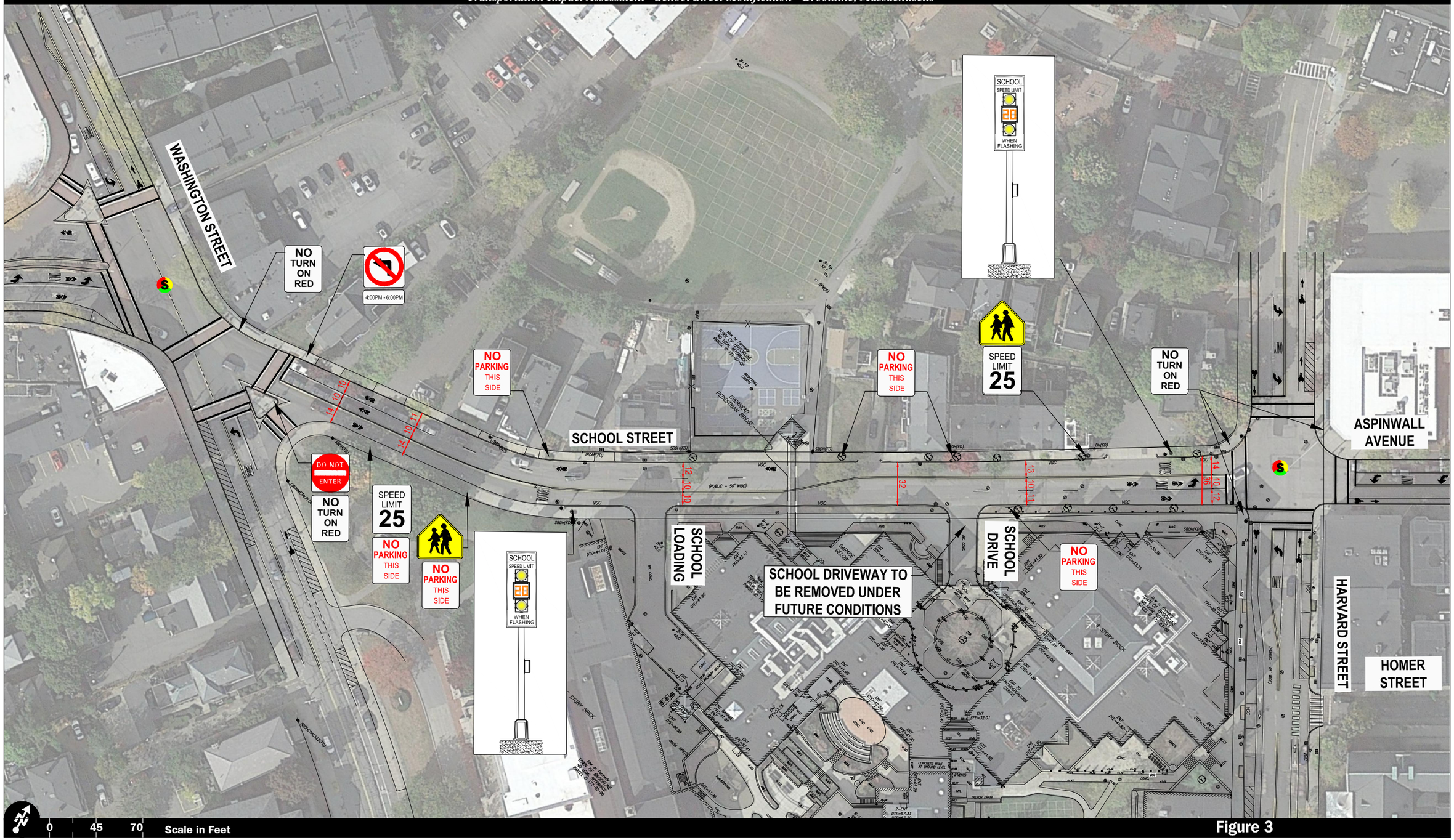

Figure 3

School Street Existing Section Lane Use, Travel Lane Width, and Pedestrian Facilities

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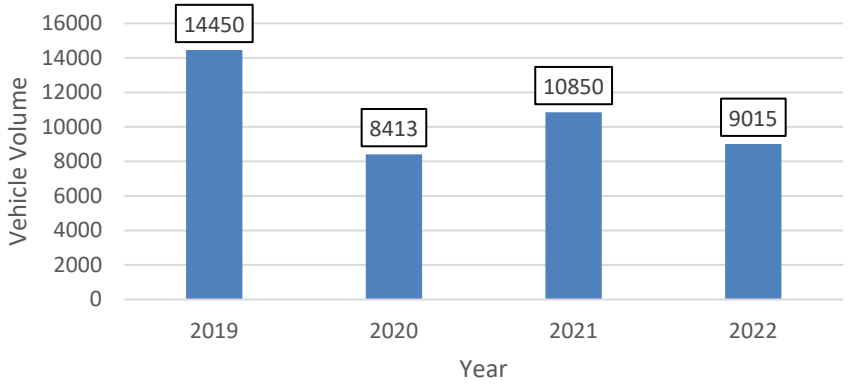
Annual Daily Traffic

Annual average daily traffic (AADT) is an important parameter identifying the level of traffic along School Street on a yearly basis. Figure 4 summarizes AADT from 2019 to 2022. AADT data were obtained from the Brookline Traffic Department existing historical counts, StreetLight[4] data and automatic traffic recorder (ATR) data collected as part of this study.

Figure 4
SCHOOL STREET AADT – 2019-2022

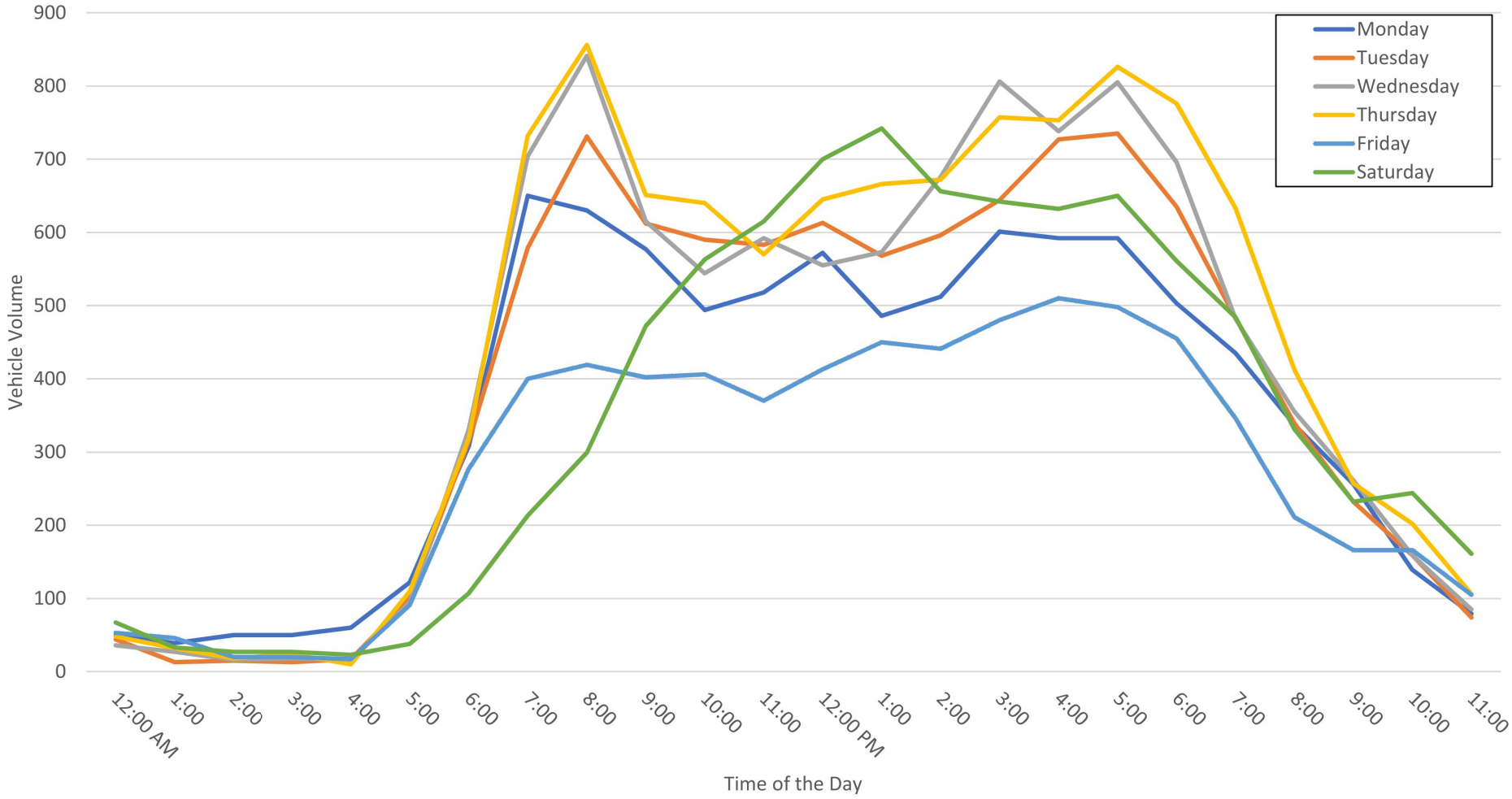


As can be seen on Figure 4, traffic levels have decreased over the past several years, with the decline from 2021 to 2022 likely due to effects of COVID-19. Although traffic levels have been steadily increasing over the last several months, available traffic data suggests that traffic conditions have not yet returned to pre-pandemic levels. It important to note that the volumes from 2022 only reflect part of the year and is likely to change. Based on the existing data, it can be concluded that under normal (pre-pandemic) conditions School Street accommodates approximately 14,450 vehicles per day (vpd) on average.

Automatic Traffic Recorder (ATR) Data

ATR counts were collected on School Street in the vicinity of the school driveway over a one-week period, including Saturday, to compile daily traffic flow and vehicle speeds. ATR counts were collected from January 31 to February 6, 2022. Figure 5 graphically illustrates and compares daily traffic levels along School Street during a typical weekday and Saturday. The 2022 Existing traffic volumes (without adjustments) are summarized in Table 3, with the weekday and Saturday peak-hour traffic volumes graphically depicted on Figures 6 and 7, respectively.

[4]Ibid 1.



Source: Automatic Traffic Recorder conducted 1/31/2022 to 02/04/2022.

Figure 5

School Street
Existing Roadway Traffic-Volume
Days of the Week

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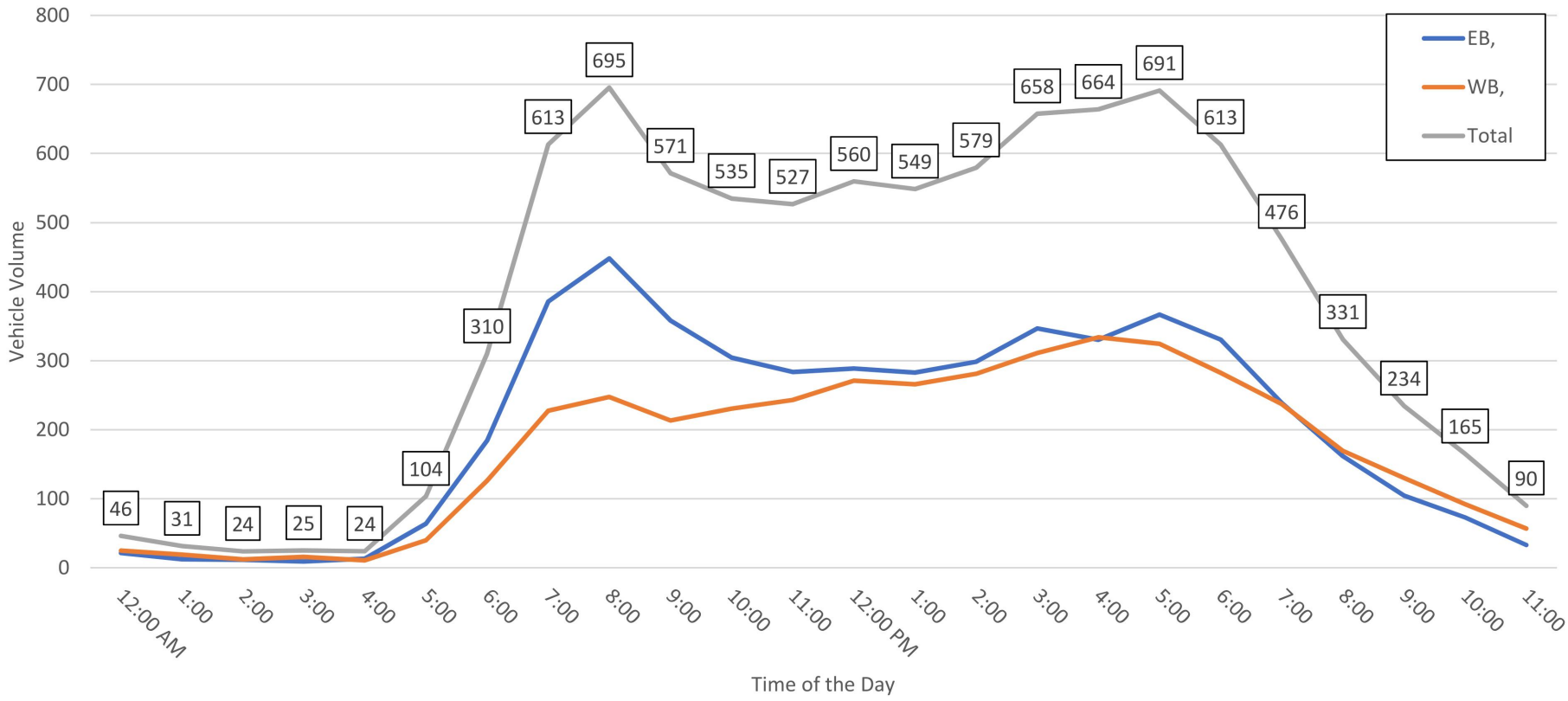

Source: Automatic Traffic Recorder conducted 1/31/2022 to 02/04/2022.

Figure 6

School Street Existing Average Weekday Daily Traffic Volume per direction

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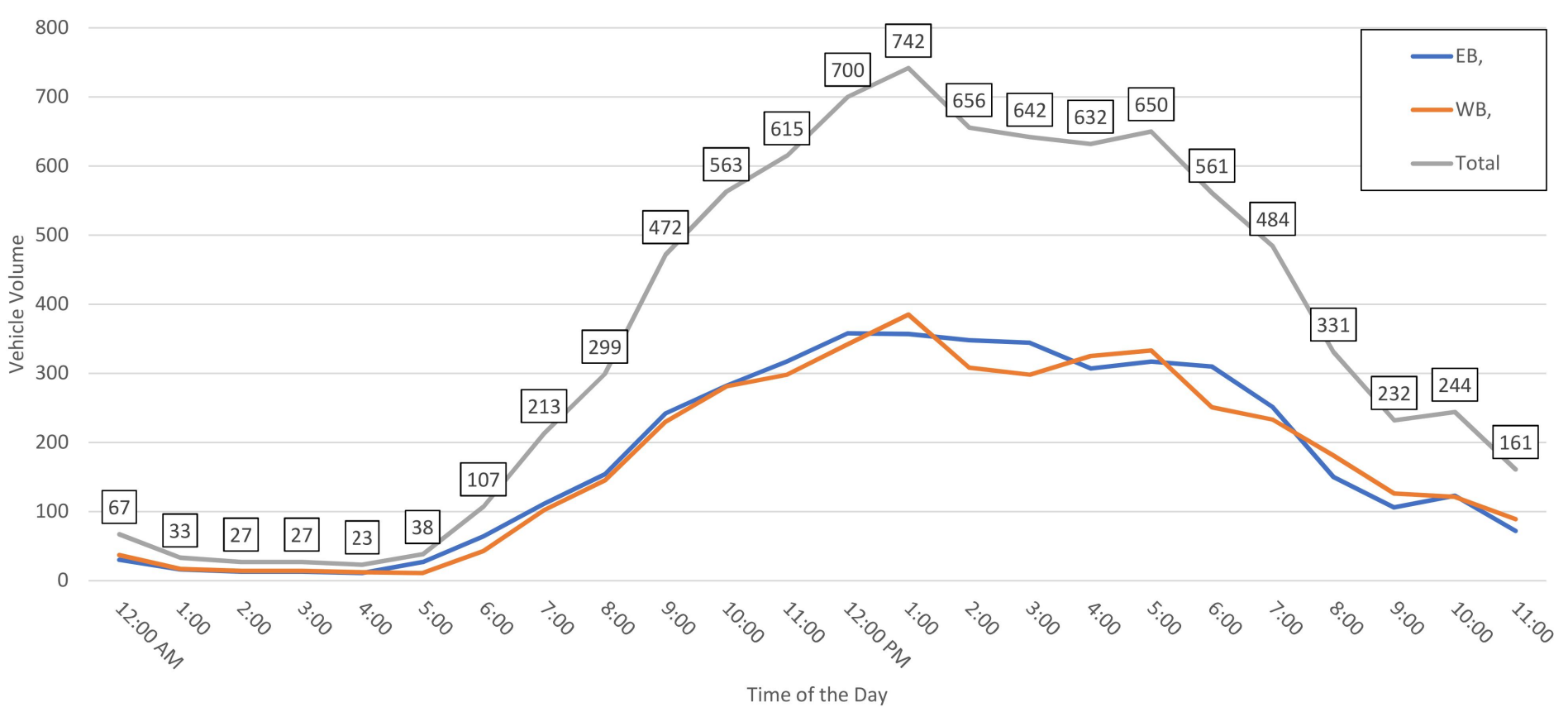

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Figure 7

School Street Existing Average Saturday Daily Traffic Volume per direction

Table 3
EXISTING SCHOOL STREET TRAFFIC-VOLUME SUMMARY

Location	Volume[b]	Percent of Daily Traffic[c]	Predominant Flow
Weekday Daily	9,114		
Weekday Morning Peak Hour	695	7.6	64% EB
Weekday Afternoon Peak Hour	664	7.3	51% WB
Weekday Evening Peak Hour	691	7.6	53% EB
Saturday Daily	8,519		
Saturday Midday Peak Hour	742	8.7	52% WB

[a]Two-way daily traffic expressed in vehicles per day.
[b]ATR conducted in January through February 2022. The existing traffic volumes were not adjusted.
[c]The percent of daily traffic that occurs during the peak hour.
EB= eastbound, WB= westbound.

As can be seen in Table 3, School Street was found to accommodate approximately 9,114 vehicles on an average weekday (24-hour, two-way volume), with approximately 695 vehicles per hour (vph) during the weekday morning peak hour, 664 vph during the weekday afternoon peak hour, and 664 vph during the weekday evening peak hour. The predominant flow on School Street during the weekday morning and evening is in the eastbound direction and during the weekday afternoon and Saturday is in the westbound direction.

A review of the peak-period along School Street indicates that the weekday morning peak hour generally occurs between 8:00 and 9:00 AM, the weekday afternoon peak hour generally occurs between 3:00 and 4:00 PM, and the weekday evening peak hour generally occurrs between 5:00 and 6:00 PM. During a typical Saturday midday, the peak hour occurs between 1:00 and 2:00 PM.

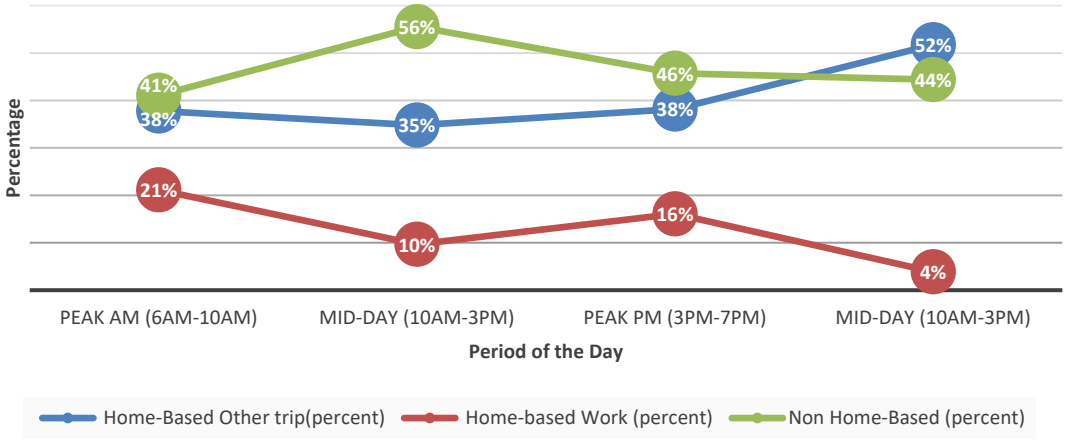
Trip Purpose

In order to understand School Street traveler's trip purpose, StreetLight data were analyzed. Based upon this data, three types of trips were identified along School Street:

- Home-Based Work (HBW), Travel between home and work in either direction;
- Home-Based Other (HBO), Travel to and from the home, to anywhere other than work;
- Non-Home Based (NHB), All travel not to or from home.

Figure 8 graphically illustrate School Street travelers trip purpose.

Figure 8
SCHOOL STREET TRAVELERS TRIP PURPOSE



As shown on Figure 8, during a typical weekday, School Street is primarily used by travelers driving from a non-home base, which is common for urban area peak-hour trips. During Saturday, School Street is mostly used for trips that begin or end at home.

Home/Work Base Location

StreetLight data were also used to identify School Street user home and work base locations. Figures 9 and 10 graphically illustrate home and work base distances from School Street. As shown on these exhibits, the majority of travelers on School Street live and/or work within 1 to 5 miles away of School Street.

School Street Top Routes

School Street data identifying the most used route choices were obtained from the StreetLight platform. This data provides a detailed picture of the trip patterns and travel choices of drivers that use School Street. The data confirm that School Street is a major connector road for vehicles traveling to/from the north and east of the school and to/from the south and the west. Motorists originating north and west of School Street also use School Street to access the Longwood Hospital area through Aspinwall Avenue and vice versa. Table 4 and Figures 11 and 12 summarize the top routes to and from School Street.

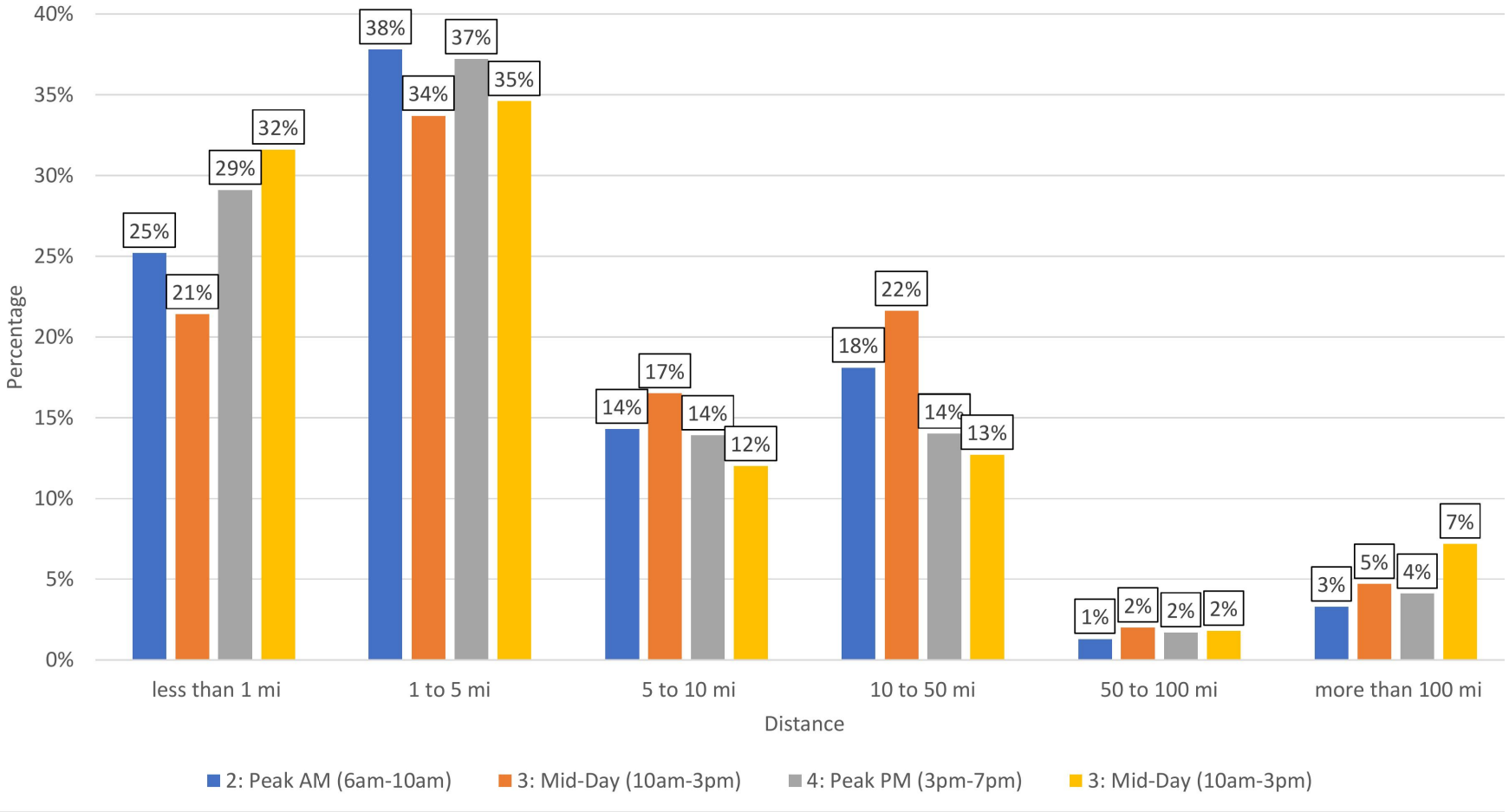


Figure 9

School Street
Drivers Home Base Location

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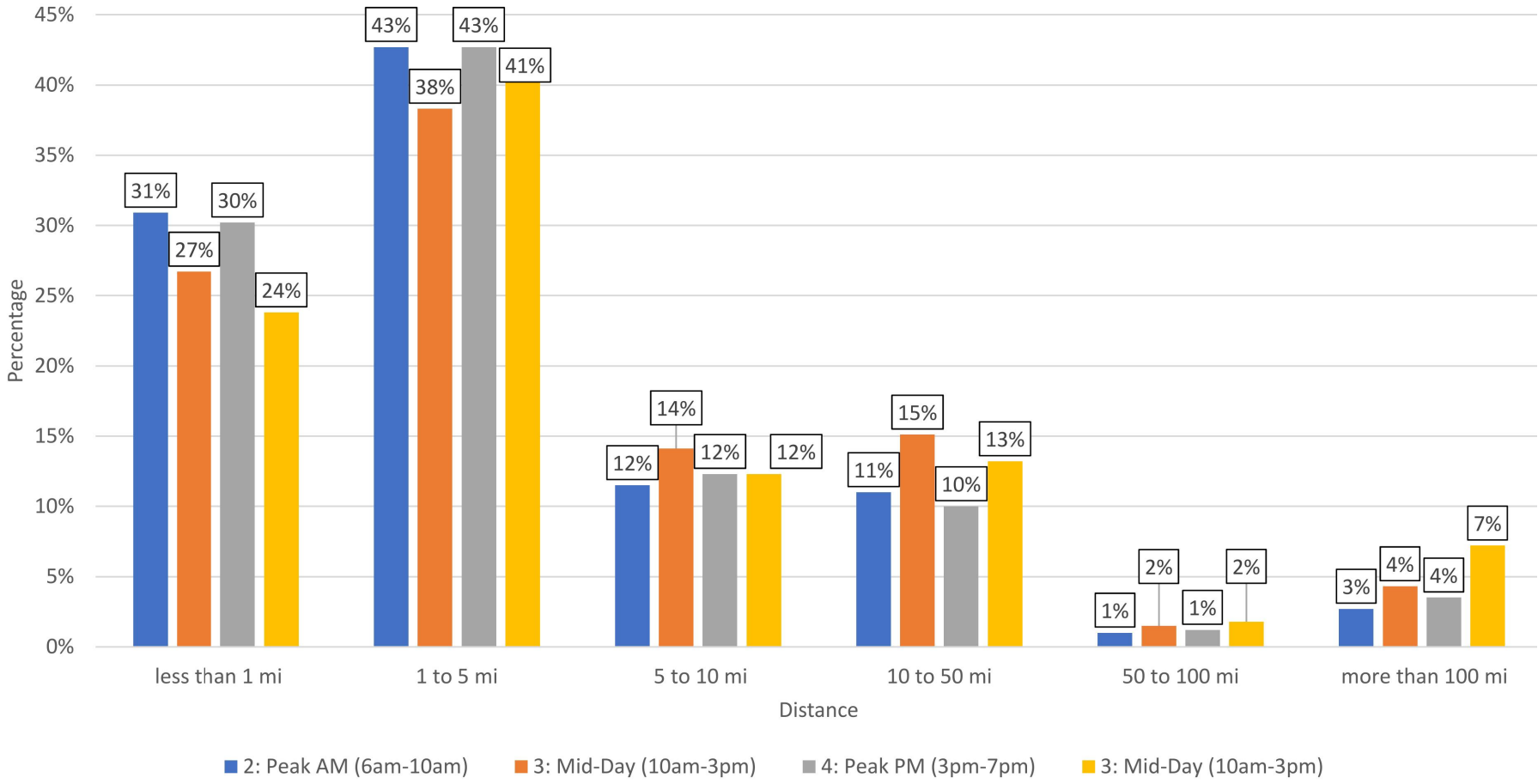

Figure 10

School Street
Drivers Work Base Location

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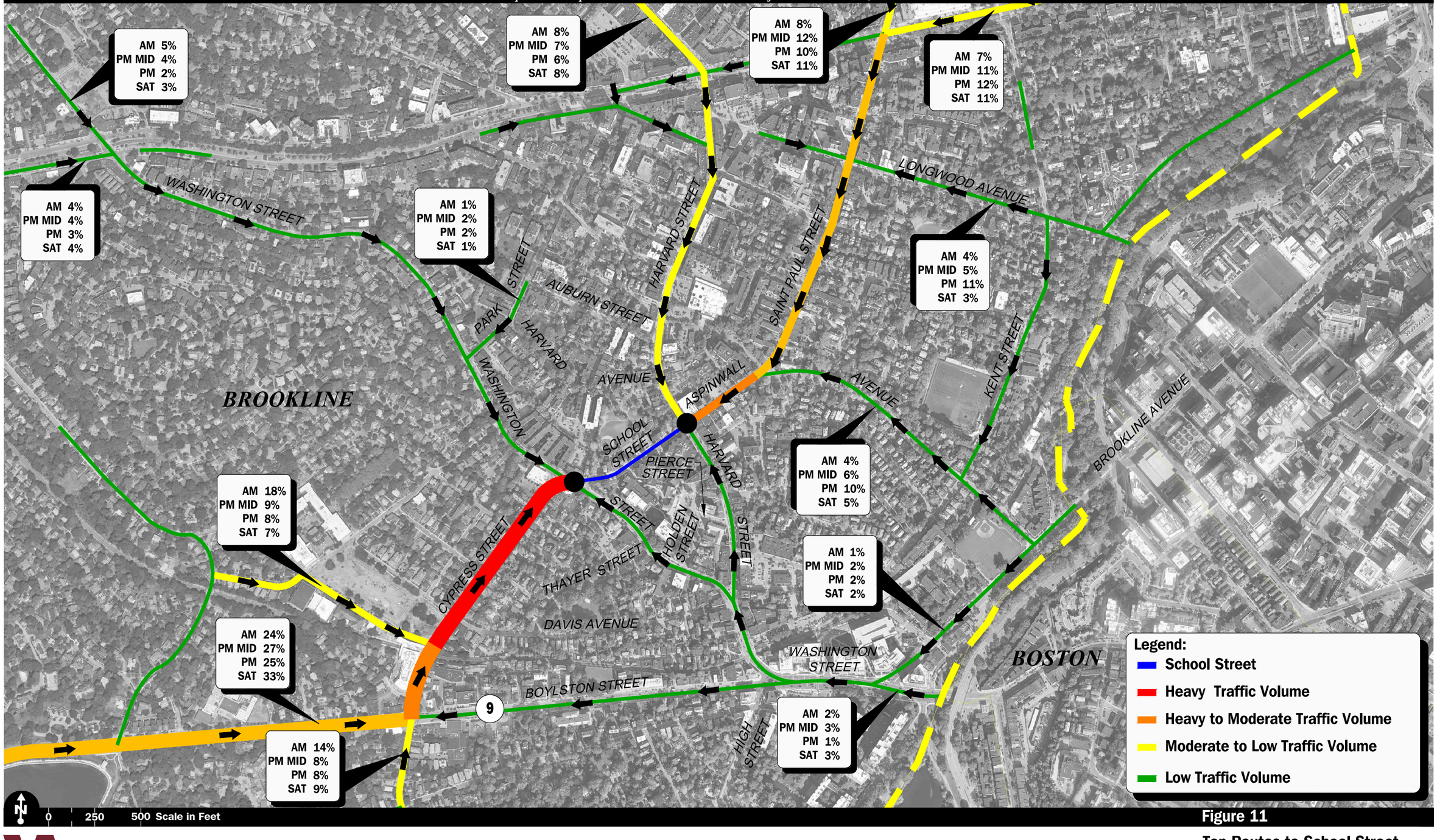

Figure 11

Top Routes to School Street
Weekday and Saturday

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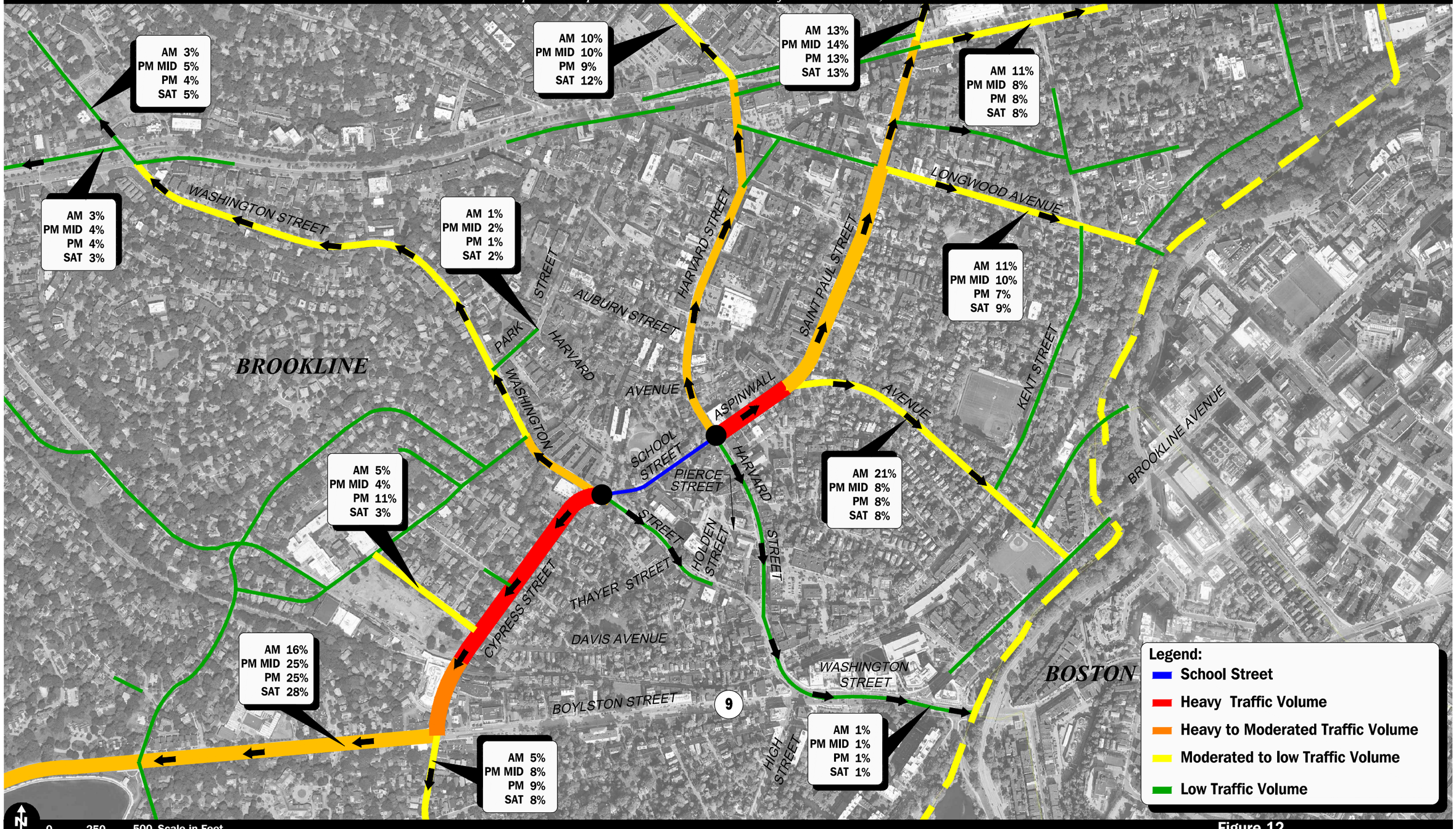


Figure 12

Top Routes From School Street
Weekday and Saturday

Vanasse & Associates inc

Table 4
TOP ROUTES PERCENTAGE - TO SCHOOL STREET

	School Street Origin			
	Morning	Afternoon	Evening	Saturday Midday
Aspinwall Avenue	4%	6%	10%	5%
Beacon Street	7%	11%	12%	11%
Boylston Street	24%	27%	25%	33%
Brookline Avenue	1%	2%	2%	2%
Cypress Street	14%	8%	8%	9%
Harvard Street	8%	7%	6%	8%
Longwood Avenue	4%	5%	11%	3%
Park Street	1%	2%	2%	1%
St. Paul Street	8%	12%	10%	11%
Tappan Street Extension	18%	9%	8%	7%
Washington Street	5%	4%	2%	3%
Beacon Street	4%	4%	3%	4%
Washington Street	2%	3%	1%	3%
Total	**100%**	**100%**	**100%**	**100%**

Table 5
TOP ROUTES PERCENTAGE - FROM SCHOOL STREET

	School Street Destination			
	Morning	Afternoon	Evening	Saturday Midday
Aspinwall Avenue	21%	9%	8%	8%
Beacon Street	11%	8%	8%	8%
Beacon Street	3%	4%	4%	3%
Boylston Street	16%	25%	25%	28%
Cypress Street	5%	8%	9%	8%
Davis Avenue	5%	4%	11%	3%
Harvard Street	10%	10%	9%	12%
Longwood Avenue	11%	10%	7%	9%
Park Street	1%	2%	1%	2%
St. Paul Street	13%	14%	13%	13%
Washington Street	3%	5%	4%	5%
Washington Street	1%	1%	1%	1%
Total	**100%**	**100%**	**100%**	**100%**

Spot Speed Measurements

Vehicle travel speed measurements were performed on School Street in proximity to the existing Pierce School driveways. Figure 13 graphically depicts the percentage of vehicles per speed per direction. Table 6 summarizes the mean and 85th percentile vehicle travel speed measurements.

Table 6
VEHICLE TRAVEL SPEED MEASUREMENTS

Characteristic	School Street Eastbound (mph)	School Street Westbound (mph)
Overall Mean Travel Speed	22	21
Overall 85th Percentile Speed	25	25
Speed Limit	25[a]/20[b]	

mph = miles per hour.
[a]Posted Speed Limited outside school hours.
[b]Posted Speed Limited during school hours.

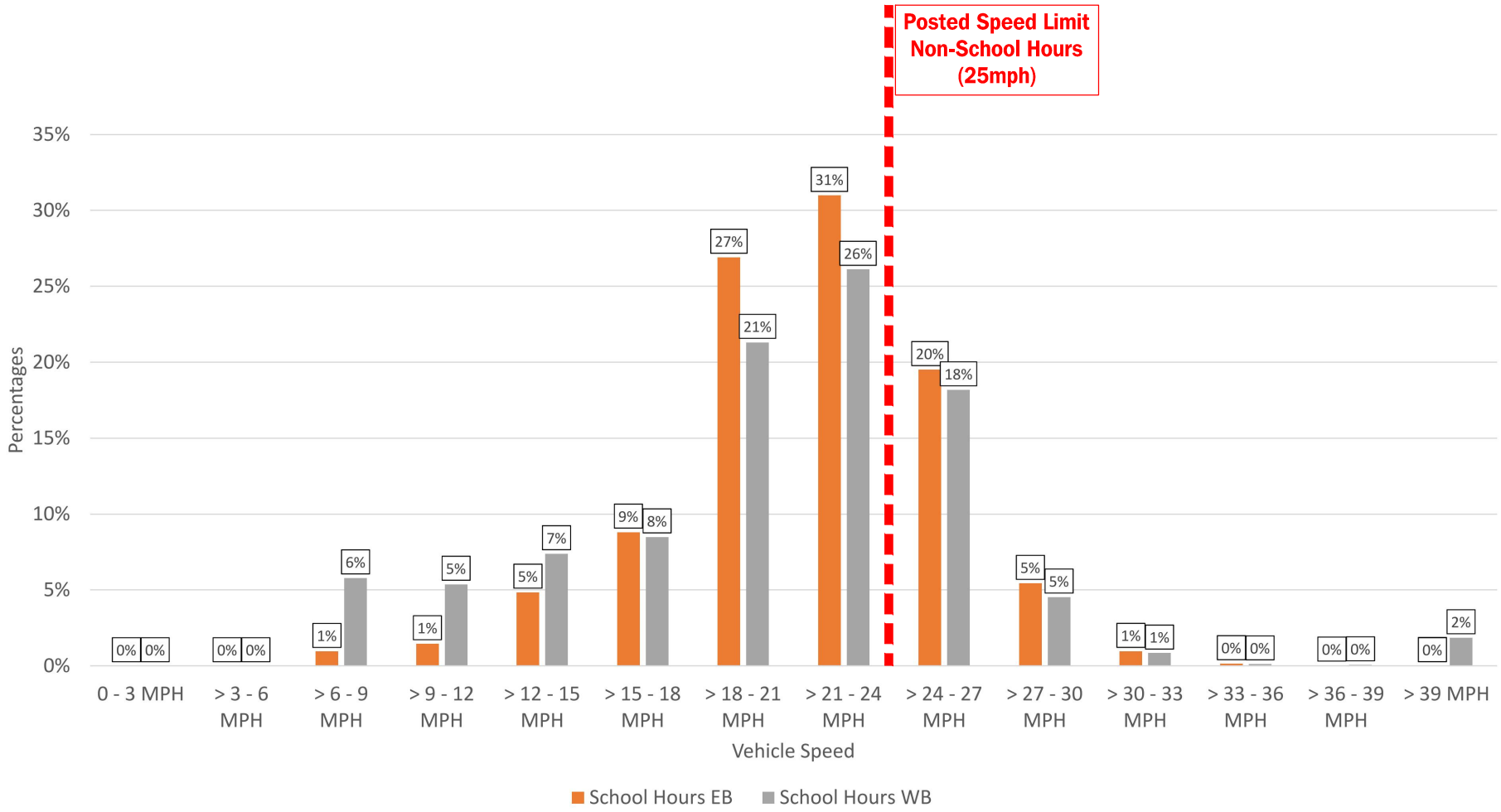
As can be seen in Table 6, the mean (average) vehicle travel speed along School Street near the school driveways was found to be approximately 21 mph in the westbound direction and approximately 22 mph in the eastbound direction. The measured 85th percentile vehicle travel speed, or the speed at which 85 percent of the observed vehicles traveled at or below, was found to be approximately 25 mph in both directions. Based on these readings, the average speed is slightly above the posted speed for school hours, while the 85th percentile speeds are 5 mph above the regulated speed limit for school hours. Speeds are generally compliant with the non-school hour speed limit.

The above metrics were calculated based on speeds collected over a seven-day period. A total of 61,425 data points were collected, and speed limits would be set based on the entirety of this data. However, also relevant are the maximum speeds observed, as these are notable to pedestrians and other users of the street and cause concern in general. To further refine the data, the maximum speeds observed during school hours (7:00 AM to 3:00 PM) were compiled. This data indicates that the maximum speeds observed ranged between (to be provided Tuesday) for the eastbound and westbound directions.

It is important to note that School Street is within a school zone and speed limit signs exist along both directions. While these hours are the peak hours of activity for most streets and motorists drive at the speeds they feel comfortable, the observed speeds indicate the need for action to address compliance with the posted speed limits set by the Town. There are ways to address compliance, including heightened enforcement, public awareness campaigns, and traffic calming measures. These will be discussed in a later section of this report.

Harvard Street Garage Access

The new School Street garage access to Harvard Street is proposed to be located in the general area of Homer Street, approximately 160 feet south of the School Street/Aspinwall Avenue intersection.



Source: Automatic Traffic Recorder conducted 1/31/2022 to 02/04/2022.

Figure 13

School Street Existing Speed Measurements

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In order to accommodate this curb cut, approximately 2 to 4 on-street parking spaces would need to be removed. It is expected that left turns and right turns into the driveway can be accommodated, as the right turn movement can occur with relatively minor delays and gaps created by the School Street/Aspinwall Avenue traffic signal should permit left turns, expected to be under single digits for the various peak-hour conditions. However, it is recommended that exiting movements at this driveway be restricted to right-turn out only.

Sight Distance Evaluation

Sight distance measurements were performed at the existing Pierce School loading driveway intersection with School Street and the location of the proposed garage driveway intersection with Harvard Street in accordance with MassDOT and American Association of State Highway and Transportation Officials (AASHTO)[5] requirements. In brief, stopping sight distance (SSD) is the distance required by a vehicle traveling at the design speed of a roadway, on wet pavement, to stop prior to striking an object in its travel path. Intersection sight distance (ISD) is the sight distance required by a driver entering or crossing an intersecting roadway to perceive an on-coming vehicle and safely complete a turning or crossing maneuver with on-coming traffic. Table 7 presents the measured SSD and ISD at the subject intersections.

Table 7
SIGHT DISTANCE MEASUREMENTS[a]

Intersection/Sight Distance Measurement	Recommended Distances (Feet)	Field Measured Distances (Feet)
Harvard Street at Proposed Garage Driveway[c]		
Stopping Sight Distance:		
Harvard Street approaching from the north	155	500+
Harvard Street approaching from the south	155	410
Intersection Sight Distance:		
Left turn into proposed garage driveway (looking north)	205	500+
Right turn from proposed garage driveway (looking north)	240	500+
School Street at New School Loading Driveway		
Stopping Sight Distance:		
School Street approaching from the east	169	500+
School Street approaching from the west	169	335
Intersection Sight Distance:		
Left turn from School loading drive (looking east)	377	500+
Left turn from School loading drive (looking west)	377	490

[a]Recommended values obtained from *A Policy on Geometric Design of Highways and Streets,* 7th Edition; American Association of State Highway and Transportation Officials (AASHTO); 2018.
[b]Values shown are the intersection sight distance for a vehicle turning right or left exiting a roadway under STOP control such that motorists approaching the intersection on the major street should not need to adjust their travel speed to less than 70 percent of their initial approach speed.
[c]Based on speed limit of 25 mph on Harvard Street.
[d]Based on observed 85th percentile speed of 27 mph on School Street.

[5]*A Policy on Geometric Design of Highway and Streets,* 7th Edition; American Association of State Highway and Transportation Officials (AASHTO); Washington D.C.; 2018.

As can be seen in Table 7, the sight distances at each driveway location were found to exceed the recommended values for SSDs in both directions. This is based on the town-wide speed limit of 25 mph applied to Harvard Street and the observed 85th percentile vehicle travel speed of 27 mph on School Street. Harvard Street does not have a posted speed limit; therefore, the town-wide speed limit of 25 mph was applied to the sight distance calculation.

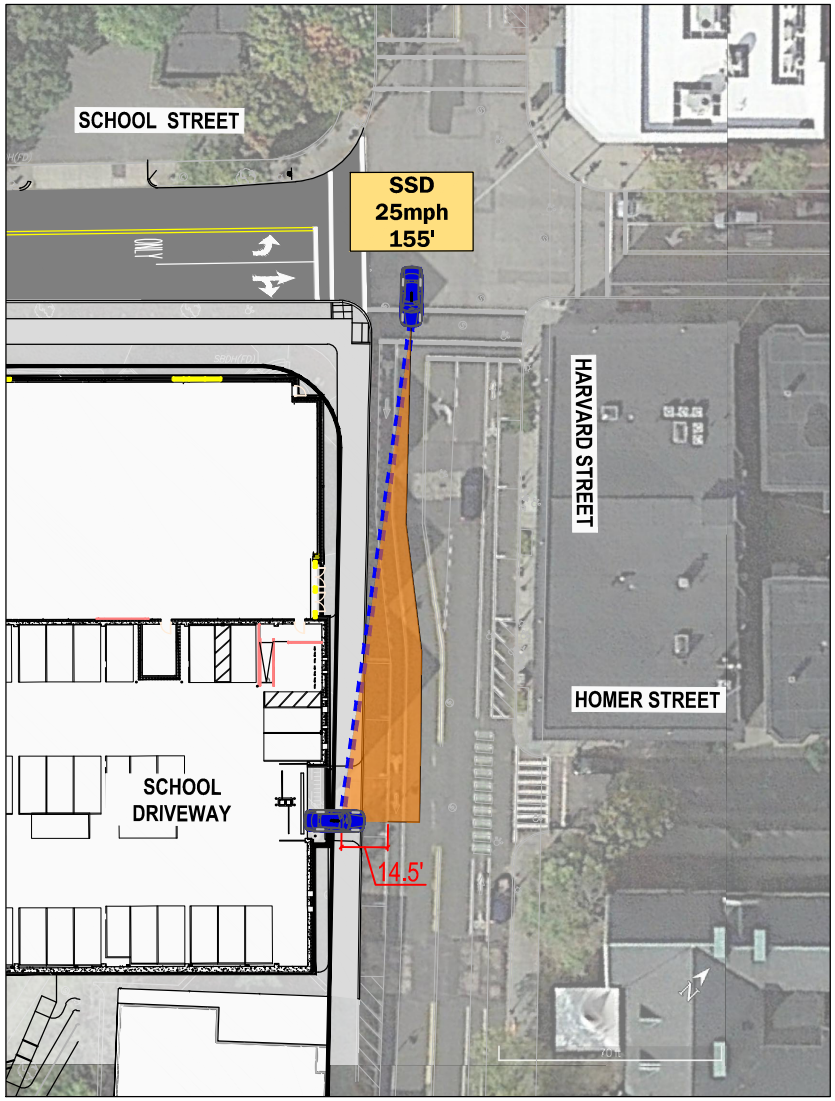
Pedestrian Sight Distance (Cone of Vision)

In order to evaluate pedestrian conflicts at the existing school loading driveway and the proposed Harvard Street garage driveway, an analysis of the cone of vision for a driver exiting from each location was conducted, pursuant to Sec. 6.04.4.f.1 of the Brookline Zoning Bylaw. The cone of vision was delineated on the plan 6 feet behind the property line and 5 feet to either side of the centerline of the driveway in question.

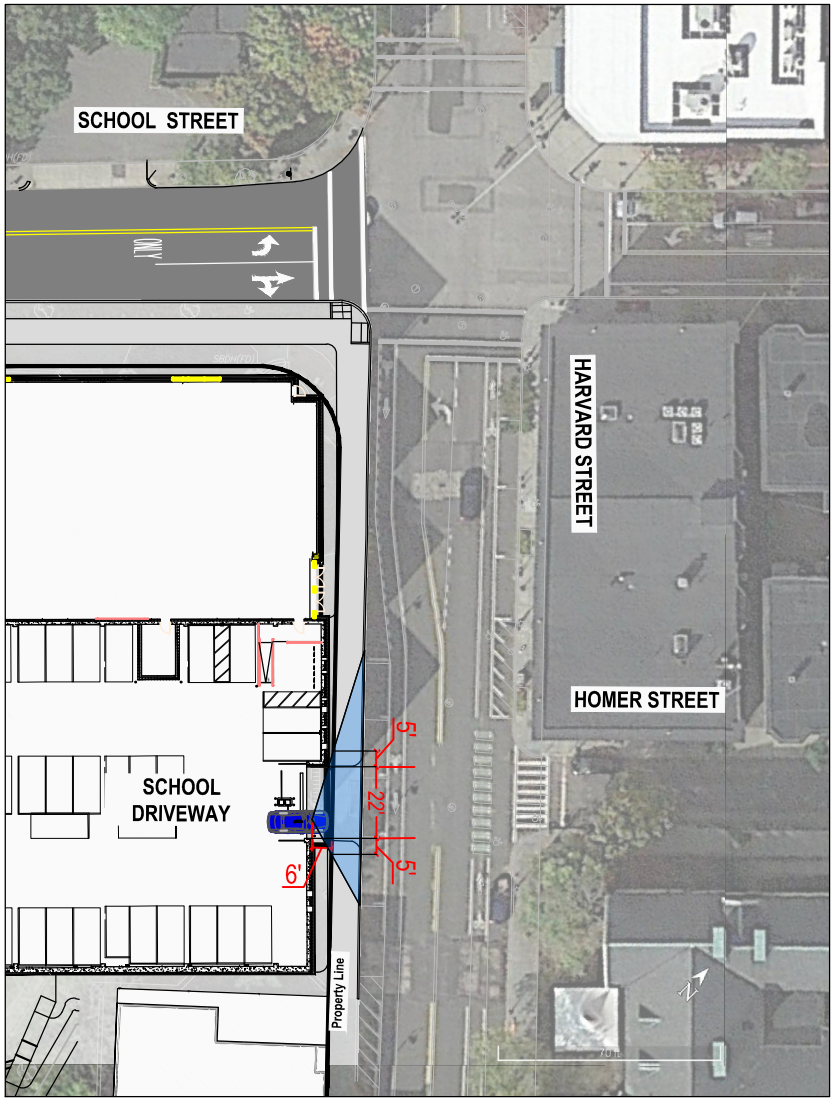
Figures 14 and 15 graphically depict sight triangle lines for vehicles and pedestrians at both driveway locations. As is graphically depicted, both driveway locations provide adequate and clear view of pedestrians on the sidewalk within the minimum 5 feet to either side of the driveway as well as a clear view of vehicles approaching either driveway.

Safety Assessment

Motor vehicle crash data was acquired from the Town of Brookline Police Department for the most recent six-year period available (2017 through 2022) in order to examine motor vehicle crash trends occurring along School Street. The data is summarized by intersection, year, and location and is presented in Table 8. Collision Diagram figures are illustrated on Figure 16 and 17.



VEHICLE SIGHT DISTANCE - VEHICLE CONFLICT



VEHICLE SIGHT DISTANCE - PEDESTRIAN CONFLICT

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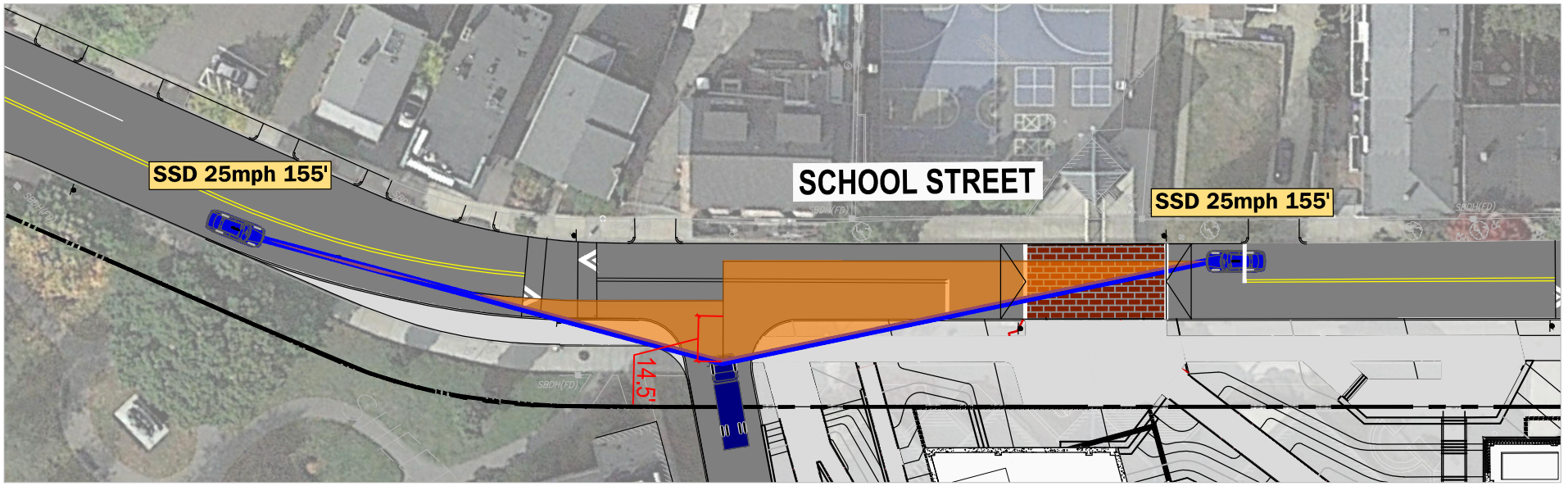
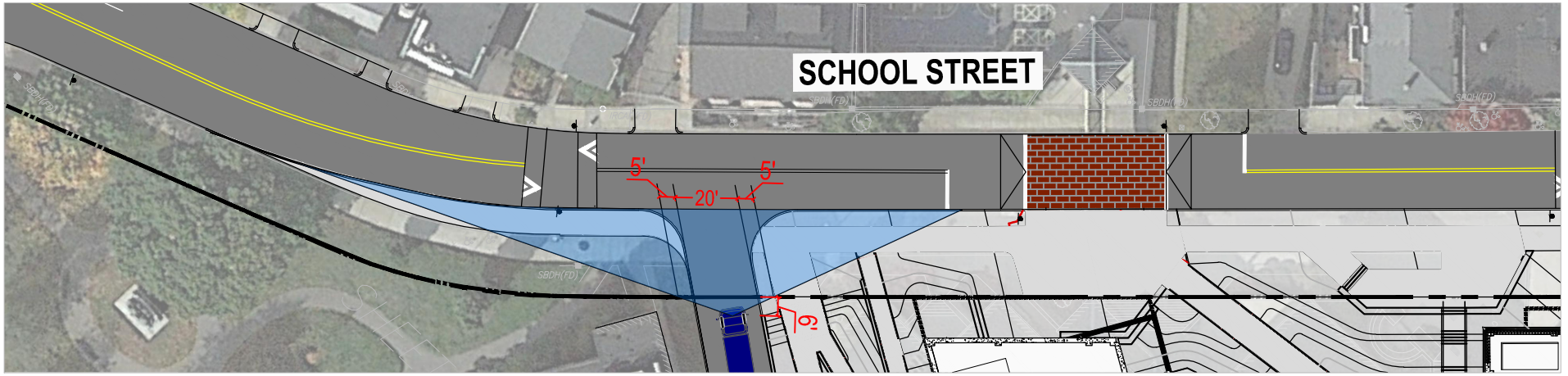
Figure 14

Vehicle Sight Distances
Proposed Harvard Street
Garage Driveway

R:\8791.1\Rev 1\12 - 8791.1-SSD.dwg, 5/13/2022 4:53:32 PM



VEHICLE SIGHT DISTANCE - VEHICLE CONFLICT



VEHICLE SIGHT DISTANCE - PEDESTRIAN CONFLICT

Figure 15

Vehicle Sight Distances
Proposed School Street
Loading Driveway

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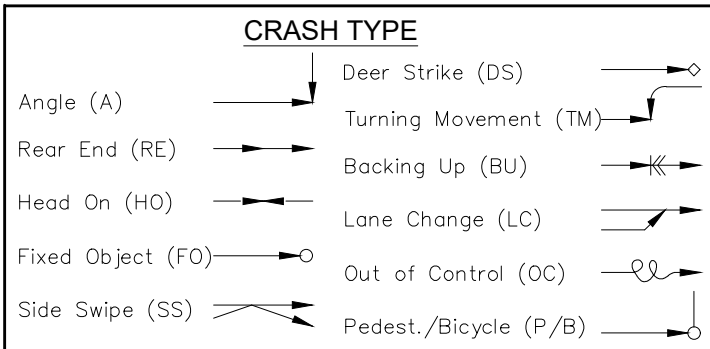


Severity

PD = Property Damage Only
PI = Personal Injury
F = Fatality
U = Uknown

Road Surface (R/S)

1 = Dry
2 = Wet
3 = Snowy
4 = Icy
5 = Unknown
6 = Slush

Weather (W)

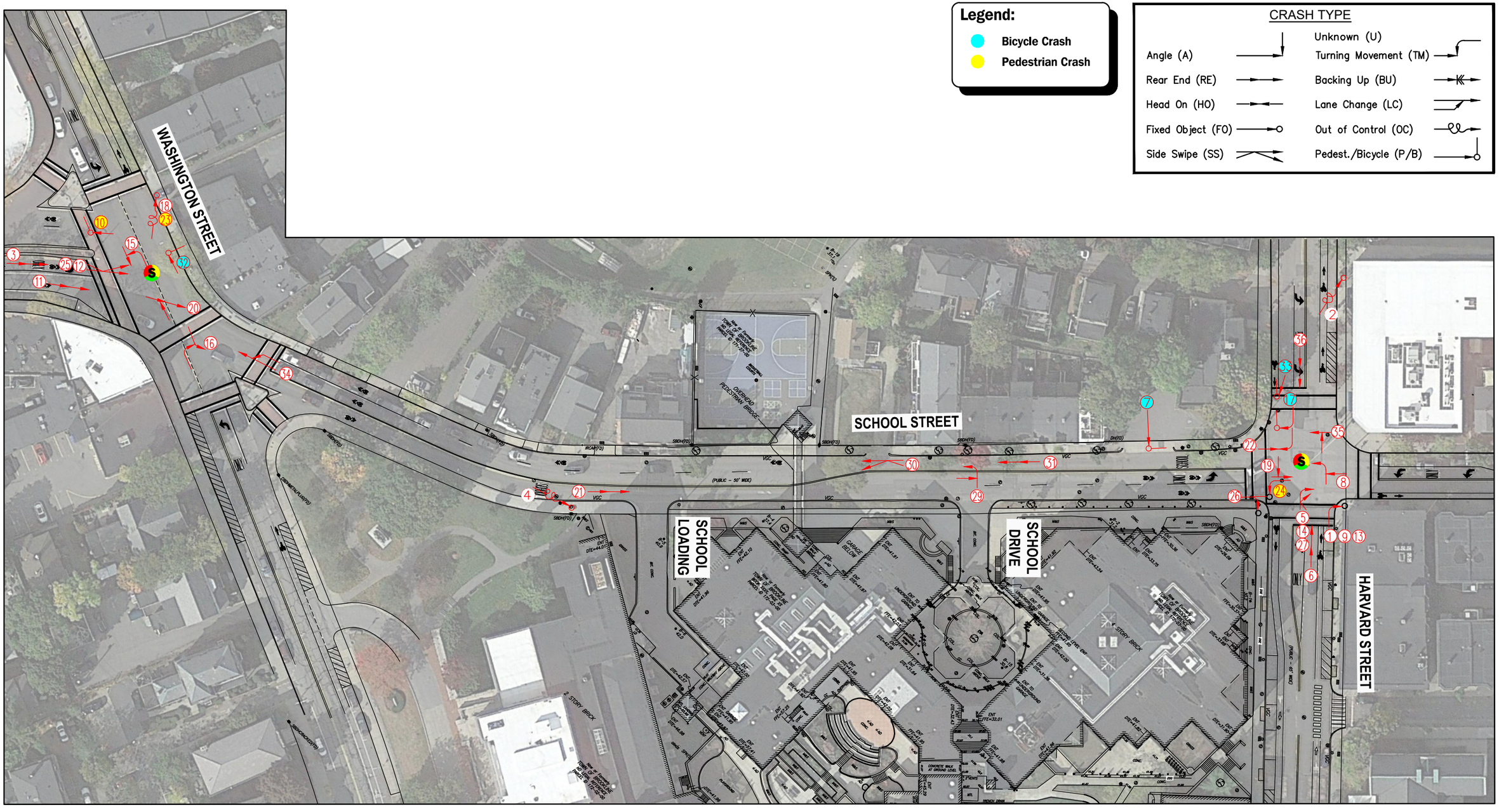
1 = Clear
2 = Cloudy
3 = Rain
4 = Snow
5 = Other
6 = Unknown

Crash Diagram Reference	Crash Date	Crash Day	Crash Time	Sev	R/S	W	Crash Type	No. of Vehicles
1	1/9/2017	Monday	4:45 PM	PD	1	1	FO	1
2	03/16/2017	Thursday	1:37 AM	PI	1	1	OC/FO	1
3	6/23/2017	Friday	1:15 PM	PD	1	2	RE	2
4	9/2/2017	Saturday	11:35 PM	PD	1	2	OC/FO	1
5	10/26/2017	Thursday	11:30 AM	PD	2	3	SS	2
6	1/5/2018	Friday	1:45 PM	PD	3	4	RE	2
7	03/07/2018	Wednesday	8:38 AM	PI	2	1	B	1
8	6/24/2018	Sunday	11:43 AM	PI	1	1	TM	2
9	7/7/2018	Saturday	12:15 AM	PD	1	1	FO	1
10	9/5/2018	Wednesday	5:45 PM	PD	1	1	P	1
11	9/28/2018	Friday	7:01 PM	PD	1	1	RE	2
12	11/8/2018	Thursday	9:15 PM	PD	1	1	SS	2
13	11/14/2018	Wednesday	11:30 AM	PD	1	1	FO	1
14	11/21/2018	Wednesday	7:22 AM	PD	1	2	SS	2
15	11/26/2018	Monday	8:00 AM	PD	2	3	TM	2
16	12/5/2018	Wednesday	8:56 AM	PI	1	1	TM	2
17	2/10/2019	Sunday	10:04 PM	PI	1	1	B	1
18	2/27/2019	Wednesday	10:05 PM	PD	3	4	OC/FO	1
19	3/6/2019	Wednesday	10:58 AM	PD	1	1	A	2
20	6/10/2019	Monday	7:00 PM	PI	1	1	A	2
21	7/15/2019	Monday	1:58 PM	PD	1	1	RE	2
22	9/4/2019	Wednesday	4:00 PM	PD	1	1	HO	2
23	11/20/2019	Wednesday	6:40 PM	PI	2	4	P	1
24	11/29/2019	Friday	5:00 PM	PI	1	1	P	1
25	3/6/2020	Friday	4:00 PM	PD	1	1	SS	2
26	6/10/2020	Wednesday	10:21 AM	PD	1	1	FO	1
27	7/6/2020	Monday	11:27 AM	PD	1	1	SS	2
28	11/25/2020	Wednesday	2:20 PM	PD	1	1	SS	3
29	9/22/2021	Wednesday	2:48 PM	PD	2	3	TM	2
30	9/29/2021	Wednesday	2:05 PM	PD	1	1	SS	2
31	10/9/2021	Saturday	3:30 PM	PD	2	3	RE	2
32	10/15/2021	Friday	8:51 AM	PI	1	1	B	1
33	11/3/2021	Wednesday	1:05 PM	PI	1	1	B	1
34	11/7/2021	Sunday	9:49 PM	PD	1	1	SS	2
35	12/24/2021	Friday	10:38 PM	PD	1	1	A	2
36	3/14/2022	Monday	10:07 AM	PD	1	1	RE	2

Figure 16

Vanasse & Associates inc

School Street Collision Diagram Data Summary



Legend:

- Bicycle Crash
- Pedestrian Crash

CRASH TYPE

Angle (A)	Unknown (U)
Rear End (RE)	Turning Movement (TM)
Head On (HO)	Backing Up (BU)
Fixed Object (FO)	Lane Change (LC)
Side Swipe (SS)	Out of Control (OC)
	Pedest./Bicycle (P/B)

0 45 70 Scale in Feet

Figure 17

School Street Collision Diagram

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Table 8
MOTOR VEHICLE CRASH DATA SUMMARY

Scenario	Washington St at Brookline Ave	Washington St/ Boylston St at High St/ Washington St	Harvard St at Kent St	Washington St at Davis Ave	Harvard St at Pierce St	Harvard St at Linden St
Year:						
2017	3	2	0	0	0	0
2018	4	4	1	0	1	0
2019	2	2	0	2	0	0
2020	0	1	0	0	0	1
2021	0	0	0	0	1	0
2022	1	0	0	0	0	0
Total	10	9	1	2	2	1
Average[a]	1.8	1.8	0.2	0.4	0.4	0.2
Crash Rate[b]	0.31	0.31	0.31	0.67	0.45	0.45
Significant[c]	No	No	No	No	No	No
Type:						
Angle	2	5	0	0	0	0
Rear-End	4	2	0	0	0	0
Head-On	1	0	0	0	0	0
Sideswipe	1	1	0	2	1	0
Fixed Object	0	0	0	0	0	0
Pedestrian	2	1	1	0	1	1
Bicyclist	0	0	0	0	0	0
Unknown/Other	0	0	0	0	0	0
Total	10	9	1	2	2	1
Weather Conditions:						
Clear	6	7	1	1	1	1
Cloudy	2	1	0	0	0	0
Rain	2	0	0	0	1	0
Snow/Ice	0	0	0	1	0	0
Fog	0	0	0	0	0	0
Unknown/Other	0	1	0	0	0	0
Total	10	9	1	2	2	1
Lighting Conditions:						
Daylight	7	4	1	1	1	1
Dawn	0	1	0	0	0	0
Dusk	0	0	0	0	0	0
Dark (lit)	3	3	0	1	1	0
Dark (unlit)	0	0	0	0	0	0
Unknown/Other	0	1	0	0	0	0
Total	10	9	1	2	2	1
Pavement Conditions :						
Dry	6	6	1	1	1	1
Wet	4	1	0	1	1	0
Snow/Ice	0	1	0	0	0	0
Unknown/Other	0	1	0	0	0	0
Total	10	9	1	2	2	1
Severity:						
Property Damage Only	7	6	1	2	1	0
Personal Injury	3	3	0	0	1	1
Fatality	0	0	0	0	0	0
Unknown/Other	0	0	0	0	0	0
Total	10	9	1	2	2	1

See notes at end of table.

Table 8 (Continued)
MOTOR VEHICLE CRASH DATA SUMMARY

Scenario	Harvard St at School St/ Aspinwall Ave	St Paul St at Aspinwall Ave	Harvard St at Harvard Ave	Harvard Ave at Park Street	Washington St at Park St	School St
Year:						
2017	2	1	1	1	2	1
2018	5	1	1	0	1	1
2019	4	1	0	0	1	1
2020	2	1	0	0	2	0
2021	2	0	1	0	1	3
2022	1	0	0	0	0	0
Total	16	4	3	1	7	6
Average[a]	3.0	0.8	0.6	0.2	1.4	1.2
Crash Rate[b]	0.31	0.31	0.31	0.67	0.45	0.45
Significant[c]	No	No	No	No	No	No
Type:						
Angle	3	1	1	0	0	1
Rear-End	2	0	0	0	2	2
Head-On	1	0	0	0	0	0
Sideswipe	3	1	0	0	4	1
Fixed Object	4	0	1	1	0	1
Pedestrian	1	0	1	0	1	0
Bicyclist	2	2	0	0	0	1
Unknown/Other	0	0	0	0	0	0
Total	16	4	3	1	7	6
Weather Conditions:						
Clear	13	3	3	0	6	2
Cloudy	1	0	0	0	0	1
Rain	1	0	0	1	0	3
Snow/Ice	1	0	0	0	0	0
Fog	0	0	0	0	0	0
Unknown/Other	0	1	0	0	1	0
Total	16	4	3	1	7	6
Lighting Conditions:						
Daylight	12	3	3	0	6	5
Dawn	0	0	0	0	0	0
Dusk	0	0	0	0	0	0
Dark (lit)	4	0	0	1	0	1
Dark (unlit)	0	0	0	0	0	0
Unknown/Other	0	1	0	0	1	0
Total	16	4	3	1	7	6
Pavement Conditions :						
Dry	14	3	3	0	6	3
Wet	1	0	0	1	0	3
Snow/Ice	1	0	0	0	0	0
Unknown/Other	0	1	0	0	1	0
Total	16	4	3	1	7	6
Severity:						
Property Damage Only	12	4	2	1	5	5
Personal Injury	4	0	1	0	2	1
Fatality	0	0	0	0	0	0
Unknown/Other	0	0	0	0	0	0
Total	16	4	3	1	7	6

See notes at end of table.

Table 8 (Continued)
MOTOR VEHICLE CRASH DATA SUMMARY

Scenario	Washington St at School St/ Cypress St	Washington St at Thayer St	Washington St at Holden St	Cypress St at Davis St	Boylston St at Cypress St
Year:					
2017	2	0	1	2	3
2018	5	0	0	2	2
2019	3	2	0	1	2
2020	2	1	0	0	5
2021	2	0	0	1	3
2022	0	0	0	0	0
Total	14	3	1	6	15
Average[a]	2.8	0.6	0.2	1.2	3.0
Crash Rate[b]	0.31	0.31	0.31	0.67	0.45
Significant[c]	No	No	No	No	No
Type:					
Angle	3	1	1	0	3
Rear-End	2	2	0	1	4
Head-On	0	0	0	1	0
Sideswipe	4	0	0	0	2
Fixed Object	2	0	0	2	4
Pedestrian	2	0	0	1	0
Bicyclist	1	0	0	1[d]	2
Unknown/Other	0	0	0	0	0
Total	14	3	1	6	15
Weather Conditions:					
Clear	10	1	1	3	10
Cloudy	1	1	0	1	3
Rain	1	0	0	0	1
Snow/Ice	2	1	0	2	0
Fog	0	0	0	0	0
Unknown/Other	0	0	0	0	1
Total	14	3	1	6	15
Lighting Conditions:					
Daylight	9	3	1	4	10
Dawn	0	0	0	0	0
Dusk	0	0	0	0	0
Dark (lit)	5	0	0	2	3
Dark (unlit)	0	0	0	0	0
Unknown/Other	0	0	0	0	2
Total	14	3	1	6	15
Pavement Conditions :					
Dry	11	1	1	3	8
Wet	2	1	0	1	4
Snow/Ice	1	1	0	2	0
Unknown/Other	0	0	0	0	3
Total	14	3	1	6	15
Severity:					
Property Damage Only	9	2	1	2	10
Personal Injury	5	1	0	4	5
Fatality	0	0	0	0	0
Unknown/Other	0	0	0	0	0
Total	14	3	1	6	15

[a]Average number of crashes over five-year period. Only includes crashes from 2017-2021
[b]Crash rate per million entering vehicles (mev). Only includes crashes from 2017-2021
[c]Significant if crash rate > 0.73 for signalized intersections or > 0.57 for unsignalized intersections (MassDOT District 4 rates).
[d]Crash involved a bicyclist hitting a pedestrian.

As summarized in Table 8 and depicted on Figures 16 and 17, a total of 6 crashes were identified along School Street in the past six years, averaging 1 accident per year. No vehicle-pedestrian crashes along School Street were identified. Within the School Street study area, the majority of crashes were vehicle-vehicle crashes, with the exception of 3 crashes that occurred between vehicle and bicycle. No fatalities were reported at any of the study area intersections over the five-year period reviewed.

In addition, the Highway Safety Improvement Program (HSIP) database was reviewed. The purpose of the HSIP is a federal program intended "to reduce the number of fatal and serious injury crashes by targeting high crash locations and causes on all public roads."[6] The HSIP program identifies "clusters" of high crash locations involving various vehicle and pedestrian crash types over successive three-year periods. The intersection of Harvard Street with School Street/Aspinwall Avenue is listed as a HSIP bicycle cluster in the most recent (2010 through 2019) HSIP bicycle cluster listing.

Public Transportation

Public transportation services are provided within the study area by the Massachusetts Bay Transportation Authority (MBTA) for subway and bus service. ***However, School Street is not used by any of the bus lines available in this area***. Within the study area, the MBTA operates the following bus and subway services:

- ***Route 65 - Brighton Center - Kenmore Station*** - Within the study area, this bus travels along Washington Street with a bus stop at the intersection of Washington Street at School Street/Cypress Street.

- ***Route 66 - Harvard Square - Nubian Station*** - Within the study area, this bus travels along Harvard Street with a bus stop at the intersection of Harvard Street at School Street/Aspinwall Avenue.

PEDESTRIAN AND BICYCLE FACILITIES

A comprehensive field inventory of pedestrian and bicycle facilities within the study area was also conducted for the Project. The field inventory consisted of a review of the location of sidewalks and pedestrian crossing locations along the study area roadways and at the study area intersections, as well as the location of existing and planned future bicycle facilities. A detailed review was conducted for School Street, with review of facilities located throughout the study area also included.

School Street

A Student Travel Choice[7] survey conducted by MassDOT in 2019 for Pierce School indicate that approximately 81 percent of the Pierce School students walk to the school. As a majority of school trips are walking trips, an assessment of the pedestrian infrastructure along School Street and the general study area was conducted.

Sidewalks of between 7 and 9 feet in width are provided along both sides of the street. A buffer of approximately 6 feet in width is provided between the sidewalk and roadway along the south side

[6] *HSIP Criteria Updated*; MassDOT; July 7, 2020.

[7] Massachusetts Safe Routes to School; Survey Report: Brookline – Pierce; MassDOT; Boston, MA; 2019.

of School Street. These sidewalks were noted to be in good condition. During field observations, it was identified that some pedestrians crossed School Street in the vicinity of the pedestrian bridge, but instead crossed at street-level as these did not appear to be students or staff of the school, and therefore did not have access to the bridge. As part of the traffic counts, a pedestrian count was performed at the existing School Street driveways (discussion follows). The traffic count indicated that a total of 66 pedestrians crossed School Street during the weekday morning peak hour.

Remainder of Study Area

As detailed on Figure 2, sidewalks are provided on both sides of the study roadways with marked crosswalks and pedestrian traffic signal equipment provided at the signalized study intersections. The intersection of School Street with Cypress Street and Washington Street was observed to have countdown signal heads identifying the amount of time left in the WALK and flashing DON'T WALK signal indications. The intersection of School Street with Aspinwall Avenue and Harvard Street was observed to have standard pedestrian signal head indications. All pedestrian signal heads and pushbutton equipment was observed to be in operating condition with no malfunctioning equipment observed at any of the signalized intersections that were part of this review. Bicycle lanes are installed on both sides of Harvard Street and the east side of Washington Street within the study area. Crossing guards are stationed at most major locations surrounding the Pierce School.

Bicycle and pedestrian movement counts were completed in conjunction with vehicle counts during the weekday morning, weekday afternoon, weekday evening, and Saturday midday peak periods at each study area intersection.

It should be noted that in general, the weekday morning and weekday afternoon peak hours were observed to have the highest numbers of pedestrians observed along the Harvard Street, Washington Street, Park Street, and Cypress Street corridors. This is assumed to correlate with Pierce School student traffic and indicates these time periods are critical for the review of impacts associated with the proposed School Street modifications. The pedestrian and bicycle volumes occurring during the peak hours of analysis are provided in the Appendix.

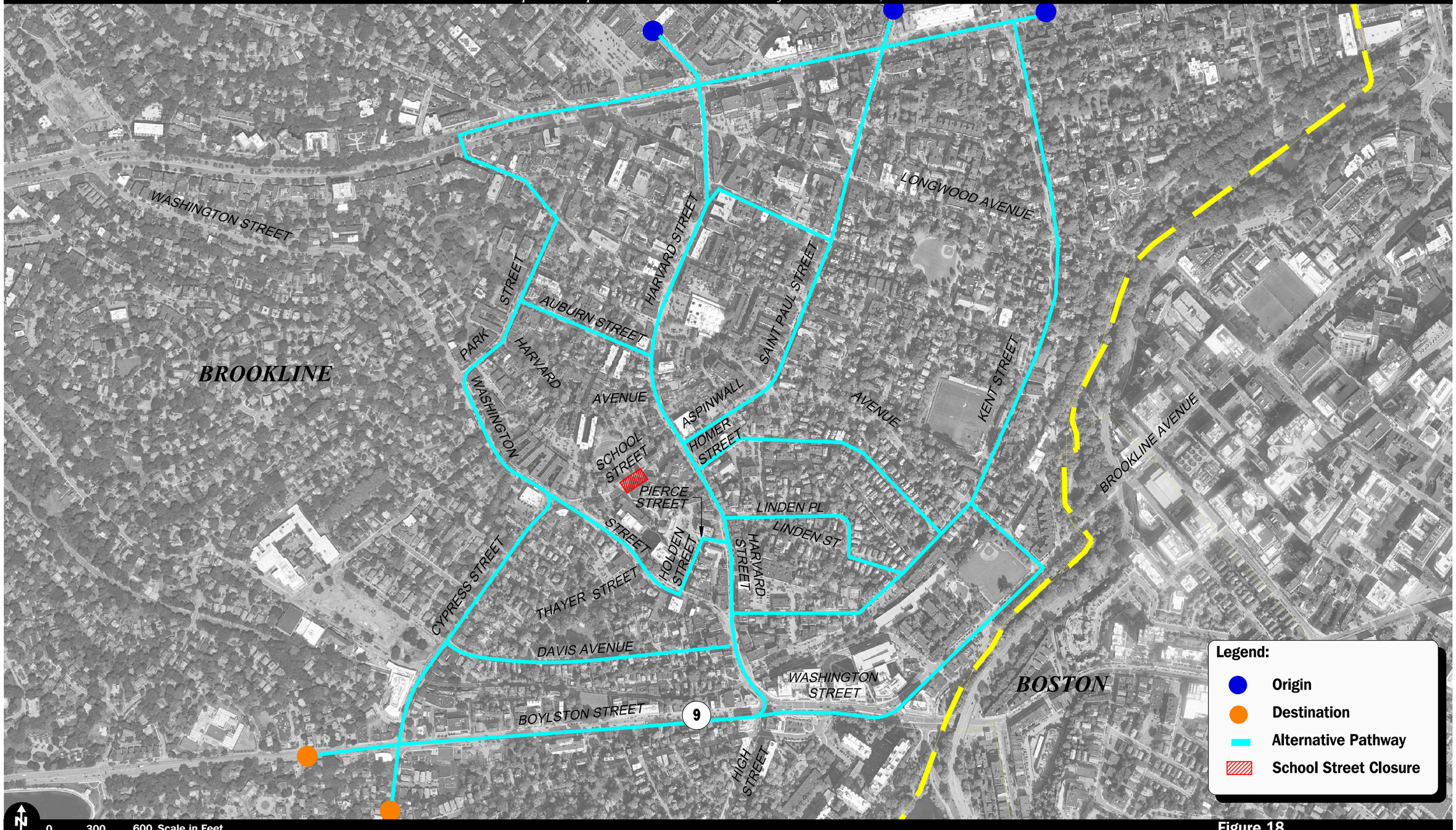


Figure 18

Alternative Pathways with School Street Closure from North to South

Vanasse & Associates inc

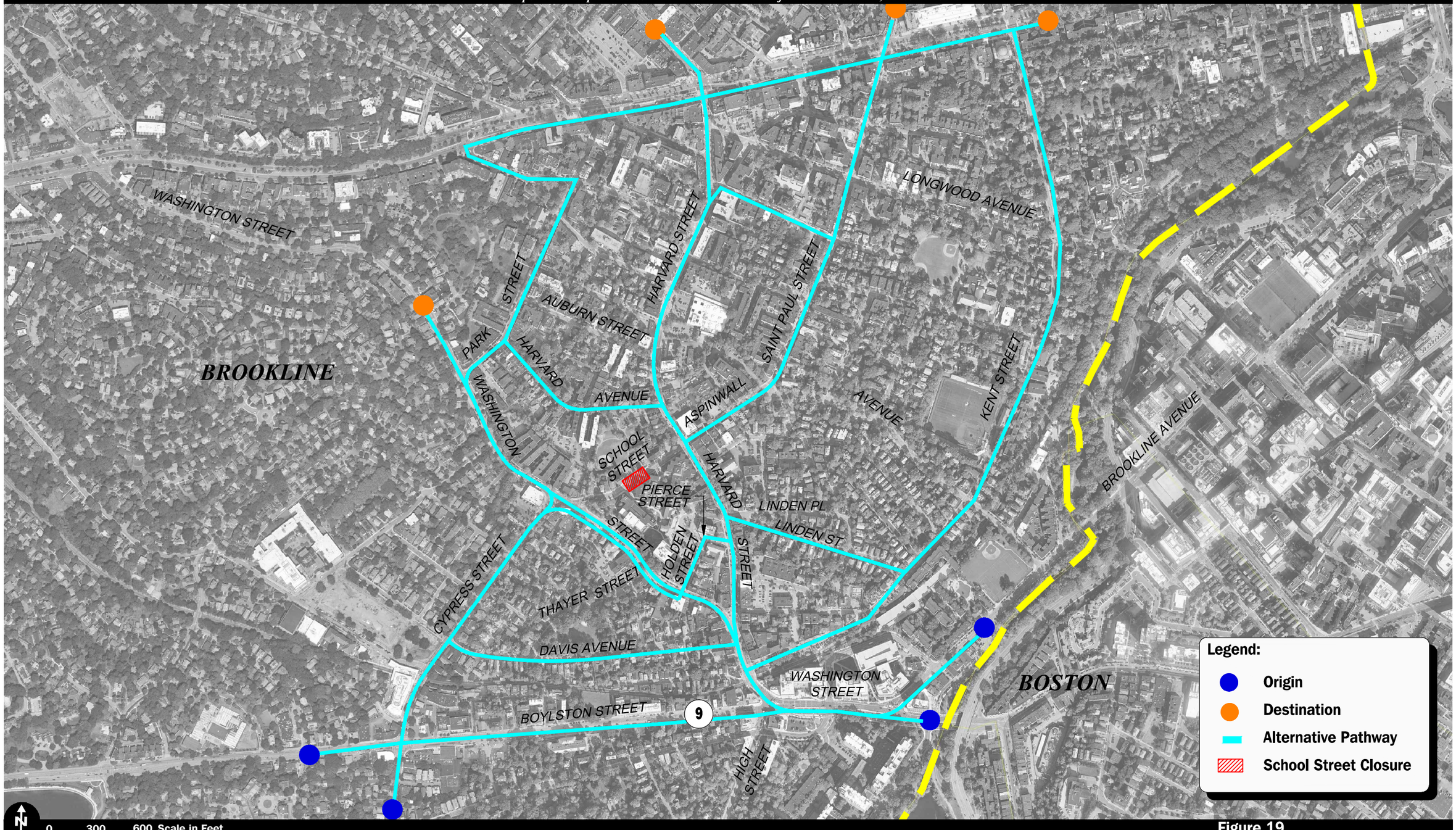


Figure 19

Alternative Pathways with School Street Closure from South to North

Vanasse & Associates inc

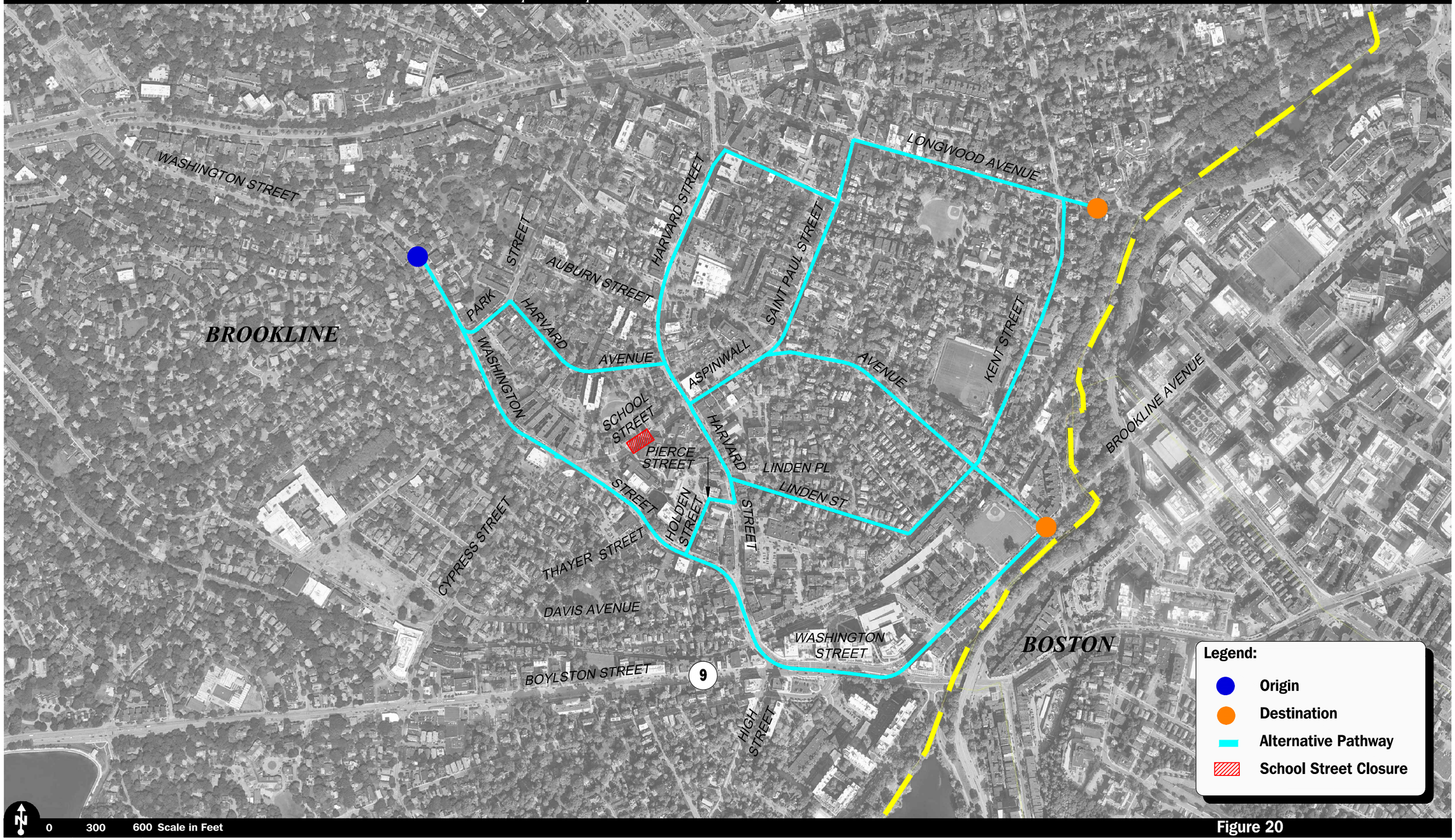


Figure 20

Alternative Pathways with School Street Closure from West to East

Vanasse & Associates inc

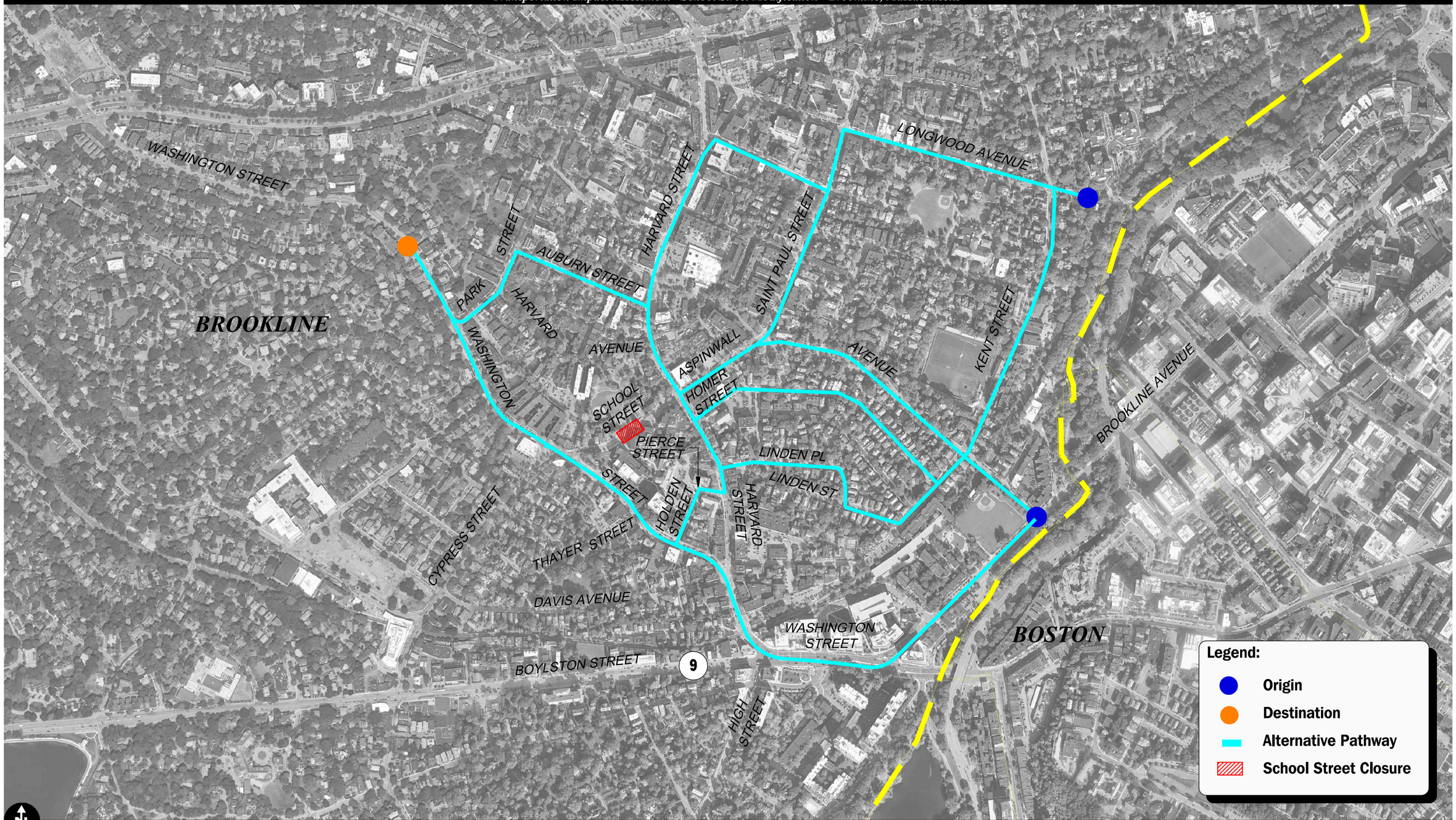


Figure 21

Alternative Pathways with School Street Closure from East to West

Vanasse & Associates inc

FUTURE CONDITIONS

Traffic volumes in the study area were projected to the year 2027, which reflects a five-year planning horizon. Independent of the school street modification, traffic volumes on the roadway network in the year 2027 under No-Build conditions include all existing traffic and new traffic resulting from background traffic growth.

FUTURE TRAFFIC GROWTH

Future traffic growth is a function of the expected land development in the immediate area and the surrounding region. Several methods can be used to estimate this growth. A procedure frequently employed estimates an annual percentage increase in traffic growth and applies that percentage to all traffic volumes under study. The drawback to such a procedure is that some turning volumes may actually grow at either a higher or a lower rate at particular intersections.

An alternative procedure identifies the location and type of planned development, estimates the traffic to be generated, and assigns it to the area roadway network. This procedure produces a more realistic estimate of growth for local traffic. However, the drawback of this procedure is that the potential growth in population and development external to the study area would not be accounted for in the traffic projections.

To provide a conservative analysis framework, both procedures were used, the salient components of which are described below.

GENERAL BACKGROUND TRAFFIC GROWTH

Based on the future traffic forecast presented in the corridor study for Route 9 in Brookline prepared by Central Transportation Planning Staff (CTPS)[8] in January 2020. Traffic in the Brookline area is expected to increase by 0.25 percent annually in the morning peak period and by 0.3 percent annually in the evening peak. Based on this information, a conservative 0.5 percent per year compounded annual background traffic growth rate was used to account for future traffic growth and presently unforeseen development within the study area. This rate was applied to the existing traffic volumes to develop the 2025 design year traffic volumes.

[8] *Route 9 Corridor Study in Brookline;* Central Transportation Planning Staff; Boston, MA; January 2020.

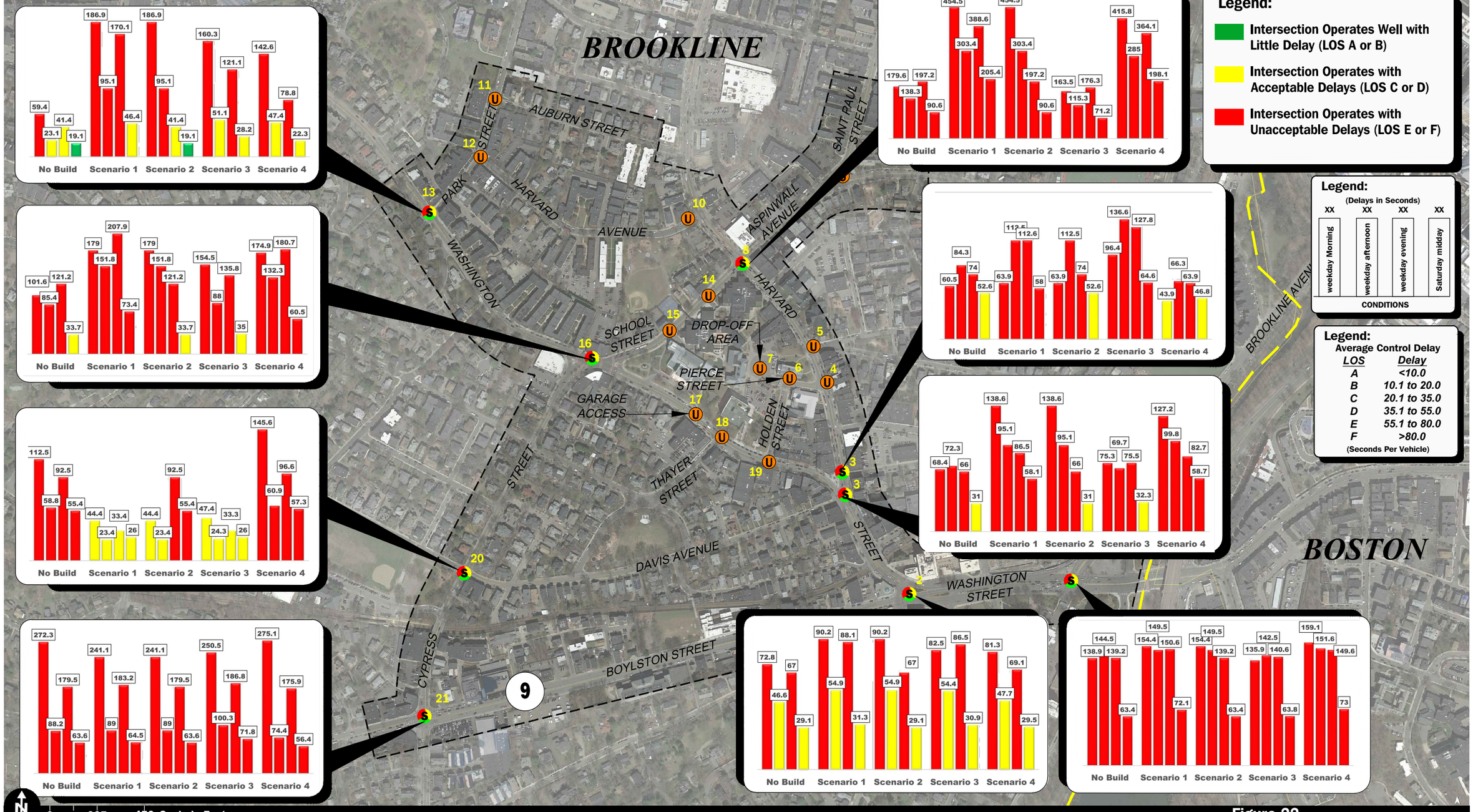


Figure 22

Signalized Intersection
Overall Future Delays Comparison
Peak Hour Traffic Conditions

Vanasse & Associates inc

SPECIFIC DEVELOPMENT BY OTHERS

The Planning Department of the Town of Brookline was contacted in order to determine if there were any projects planned within the study area that would have an impact on future traffic volumes at the study intersections. Based on these discussions, the following projects were identified:

1. High School expansion – Brookline High School
2. Residential development – 107-111 Cypress Street
3. Audi Brookline renovation – 308 Boylston Street (Route 9)
4. NETA delivery traffic
5. Walnut Crossing residential
6. One Brookline Place – Boston Children's Hospital expansion
7. Two Brookline Place – Boston Children's Hospital
8. Hilton Garden Inn – 700 Brookline Avenue
9. Kent/Station Street affordable senior housing
10. Residential development – 217 Kent Street
11. Residential development – 54 Auburn Street
12. Colonel Eugene B. Floyd Apartments redevelopment – 32 Marion Street
13. Residential development – 209 Harvard Street
14. Residential/retail development – 1299 Beacon Street
15. Hampton Court – 1223 Beacon Street
16. Center for Partnership in Early Education
17. Residential development – 83 Longwood Avenue

Traffic volumes associated with the aforementioned specific development projects by others were obtained from the respective traffic studies or using trip-generation information available from the Institute of Transportation Engineers (ITE)[9] for the appropriate land use and were assigned onto the study area roadway network based on existing traffic patterns where no other information was available. No other developments were identified at this time that are expected to result in an increase in traffic within the study area beyond the general background traffic growth rate.

ROADWAY IMPROVEMENT PROJECTS

The Town of Brookline Planning Department was contacted in order to determine if there were any planned roadway improvement projects expected to be completed within the study area. Based on these discussions, no improvements are planned beyond general maintenance.

NO-BUILD TRAFFIC VOLUMES

The 2027 No-Build peak-hour traffic-volume networks were developed by applying the 0.5 percent per year compounded annual background traffic growth rate to the 2022 Existing peak-hour traffic volumes plus the identified background developments. The resulting 2027 No-Build weekday morning, weekday afternoon, weekday evening and Saturday midday peak-hour traffic-volume networks are shown in the Appendix.

[9] *Trip Generation,* 11th Edition; Institute of Transportation Engineers; Washington, DC; 2021.

SCHOOL STREET MODIFICATIONS

SCHOOL STREET MODIFICATION SCENARIOS

Discussions regarding modifications to School Street circulation began in November 2021 at a Pierce School Traffic Calming Meeting. At that time there were a number of options that were discussed including a potential road diet on School Street, closure of School Street, closure of School Street in either the eastbound or the westbound direction, and also temporary closure of School Street between the hours of 7:00 AM and 3:00 PM. The intent of the review was to identify the ramifications of such a change since School Street is a major east-west route and serves as a cut-through between Route 9 and Beacon Street. Accordingly, any study of closure of School Street, even for a temporary period, would have to review collateral impacts at locations not near School Street.

At subsequent Pierce School building committee meetings, additional points of concern were raised. These involved access to other potential driveway locations if the existing school driveways were relocated, traffic calming measures for School Street if it were to remain open, and measures to provide alternatives to the existing pedestrian crossing via the pedestrian bridge. It was noted by school officials that the existing bridge crossing is only available during school hours and only available to school occupants. Outside of school hours, pedestrians crossing School Street to get to the Pierce School Playground would have to walk to either the Washington Street or Harvard Street intersections to cross at a protected crosswalk or cross the street at an unprotected location.

Included in these alternatives were revisions to teacher and staff parking within the Town garage with access onto Washington Street, as well as the relocation of garage access to Harvard Street in the vicinity of Homer Street.

Accordingly, the following School Street modification alternatives were assessed:

- Scenario 1 - Closing School Street in both directions
- Scenario 2 - Temporary closure of School Street 7:00 AM – 3:00 PM
- Scenario 3 - School Street one-way eastbound
- Scenario 4 - School Street one-way westbound

Scenario 1-2 – School Street Closure

Scenario 1 and Scenario 2 involve the complete closure of School Street in both directions. In this case, access would be limited to the current users that are on School Street, which include six driveways located west of the school pedestrian bridge and two driveways located east of the pedestrian bridge. These driveways provide access to a number of businesses, residences, and library service with no other practical alternative for access other than from School Street. Therefore, access would have to be maintained to these properties, likely taking the form of terminating School Street from either direction in the vicinity of the pedestrian bridge and providing turnaround areas for vehicles to reverse direction. Thus, it would be impossible to close School Street at the Harvard Street and Aspinwall Avenue intersection on the east side, and on the Cypress Street and Washington Street intersection on the west side, so the intersections and traffic signal equipment would remain as they currently exist. While through traffic could be theoretically restricted on School Street with signage, this would be difficult to enforce and as a practical matter not likely to be effective.

Scenario 3 – School Street One-Way Eastbound Direction

Scenario 3 involves the closure of School Street traffic in the westbound direction, which would allow traffic movement to continue from Cypress Street and Washington Street eastbound on School Street to Harvard Street.

Scenario 4– School Street One-Way Westbound Direction

Scenario 4 involves the closure of School Street traffic in the eastbound direction, which would allow traffic movement to continue from Harvard Street and Aspinwall Avenue westbound on School Street to Cypress Street and Washington Street.

Discussion

In order to reassign traffic for the various scenarios, the StreetLight data showing origins and destinations was utilized. A number of data points were utilized; specifically, the top routes to and from School Street as graphically depicted on Figures 11 and 12, respectively. These graphics indicate the varying percentages of traffic utilizing the routes to School Street such as: Harvard Street, St. Paul Street, Cypress Street, Washington Street, Boylston Street, and Park Street. In some cases, the traffic routes vary considerably between the various time periods with Boylston Street representing 24 percent of the traffic flow to School Street in that morning time. However, traffic from School Street to Boylston Street represents only 16 percent of the overall traffic during this time period.

As shown on Figure 8, users of School Street fall into three types according to the StreetLight data. These include Home-Based-Work trips, Non-Home-Based trips, and Home-Based-Other trips. The StreetLight data indicates that Home-Based-Work trips do not represent a significant percentage of the overall users on School Street during any of the time periods analyzed. The maximum usage for School Street and Home-Based-Work trips is 21 percent during the peak-morning time period between 6:00 and 10:00 AM.

The majority of users of School Street are Non-Home-Based trips with percentages between 41 and 56 percent depending on the time period. Home-Based-Other trips account for a medium range between the two other user groups with the midday time period on Saturday representing the highest portion of users of School Street at 52 percent. This could be the effect of non-local traffic circu-

lating through School Street in this area of Brookline.

Reassignment

Traffic at the two ends of School Street was reassigned depending on scenario. Scenario 3 (one-way eastbound) involved the reassignment of traffic otherwise entering School Street in the westbound direction at the School Street intersection with Harvard Street and Aspinwall Avenue. Similarly, Scenario 4 (one-way westbound) involved the reassignment of traffic otherwise entering School Street in the eastbound direction at the School Street intersection with Cypress Street and Washington Street. Scenarios 1 and 2 included the reassignment of both directions of School Street traffic for the weekday morning and weekday afternoon time period while only Scenario 1 included the reassignment for the other two time periods.

StreetLight data informed the redistribution of the traffic volumes by indicating the constituent percentages of origin and destination revisions to turning movements for the overall volumes to be reassigned at the restricted section of School Street. The redistribution percentages for the weekday morning, weekday midday, weekday evening, and Saturday midday time periods are shown in the Appendix. Further, the StreetLight data was used to reassign these turning movements to alternative pathways available for this traffic. The alternative pathways used are shown on Figure 18 for the diversions from north to south; Figure 19 for diversions from south to north; Figure 20 for diversions from east to west; and Figure 21 for diversions from west to east.

2027 Build Condition Traffic Volume Networks

Following redistribution of the traffic diverted from the various School Street closure scenarios, the 2027 Build condition traffic-volume networks were developed. Traffic-volume networks for the various Build (School Street restriction) scenarios are provided in the Appendix, including 2027 Build Scenario 1-2 volumes for the weekday morning, weekday afternoon, weekday evening, and Saturday midday time periods, 2027 Build Scenario 3 traffic volumes for the weekday morning, weekday afternoon, weekday evening, and Saturday midday time periods, and 2027 Build Scenario 4 traffic volumes for the weekday morning, weekday afternoon, weekday evening, and Saturday midday time periods.

TRAFFIC OPERATIONS ANALYSIS

Measuring traffic volumes quantifies traffic flow within the study area. To assess quality of flow, roadway capacity and vehicle queue analyses were conducted under all traffic-volume conditions. Capacity analyses provide an indication of how well the roadway facilities serve the traffic demands placed upon them, with vehicle queue analyses providing a secondary measure of the operational characteristics of an intersection or section of roadway under study.

ANALYSIS RESULTS

Level-of-service and vehicle queue analyses were conducted for 2022 Existing, 2027 No-Build, and 2027 Scenario 1-2, 2027 Scenario 3, and 2027 Scenario 4 Build conditions for the intersections within the study area. For presentation purposes, the summaries of the traffic analyses as well as the detailed analysis worksheets are presented in the Appendix. Figure 22 provides a comparison of the future overall delays at signalized intersections between the various scenarios.

Discussion

Due to the traffic-volume conditions under the No-Build scenario by 2027 at the majority of the study area intersections, most intersections are found to be operating above theoretical capacity with high levels of delay associated. This includes the intersections of Cypress Street and Boylston Street, High Street and Boylston Street at Washington Street, Cypress Street and School Street at Washington Street, and School Street/Aspinwall Avenue at Harvard Street, among others. However, results of the analysis on the redistribution indicate that some scenarios make operations at these intersections worse. The delays at some intersections are shown to decrease with redistributed traffic volumes under some scenarios as compared with the No-Build condition due to shifting of traffic volumes from some movements to others, but with other scenarios at other locations, the redistribution can result in higher delays.

Scenario 1-2

Scenario 1 and Scenario 2 are combined in most discussions as they are the same during the weekday morning and weekday afternoon analysis periods. Scenario 2 has School Street returning to the No-Build condition after the school day has ended, so the weekday evening and Saturday midday time period would be the same as the No-Build condition. In terms of overall impacts, Scenario 1-2 result in increased delays at seven of nine signalized intersections. Delays decreased in only the

southwest section of the study area, along the Cypress Street corridor.

In terms of volume increases, locations to the north, south, east, and west would be expected to see double-digit percentage increases with Scenario 1 during all time periods reviewed, and with Scenario 2 during the weekday morning and weekday afternoon peak hours. Auburn Street at Park Street and Harvard Avenue at Park Street would see traffic volumes increase by 35 to 70 percent over the No-Build conditions. These locations also had some of the highest pedestrian volumes observed during the weekday morning and weekday afternoon periods, which would be expected to be negatively impacted by the projected traffic-volume increases.

Double digit percentage increases in traffic volumes are also expected along the Harvard Street and Washington Street corridors, which also have high levels of pedestrian activity. In particular, the increase in traffic volume expected at Washington Street and Thayer Street of approximately 20 percent conflicts with the pedestrian volumes of between 93 and 120 pedestrians crossing Washington Street at this location during the weekday morning and weekday afternoon peak hours.

On Harvard Street at the Kent Street intersection, a 19 to 20 percent increase in traffic volume is projected, with volumes on the Kent Street approach increasing by 39 to 51 percent. This increase would conflict with the 231 to 261 pedestrians crossing Kent Street during the weekday morning and weekday afternoon peak hours, respectively. Delays also increase substantially at this location during the weekday afternoon and weekday evening peak hours.

Removal of the School Street approach to the Harvard Street/Aspinwall Avenue intersection and the Cypress Street/Washington Street intersection did not improve operations and in fact made conditions worse, even with a 27 to 31 percent decrease in traffic volumes. This is due to a portion of the redistributed School Street traffic still traveling to these intersections to return to Aspinwall Avenue or Cypress Street and overloading the respective movements at the intersections. It should be noted that the Brookline Police Department crash data reviewed at these two locations indicate they have the highest number of crashes of the 21 locations studied. Pedestrian volumes are also significant, with between 416 and 393 pedestrians per hour observed during the weekday morning and weekday afternoon peak hours. Increasing delay at these two locations by closing School Street may have negative effects for safety given the crash history and pedestrian volumes recorded.

Scenario 3 (School Street one-way eastbound)

In terms of overall impacts, Scenario 3 results in increased delays at five of nine signalized intersections. Delays decreased in the southwest section of the study area along the Cypress Street corridor and to a minor degree at the School Street/Aspinwall Avenue/Harvard Street intersection and along Davis Avenue.

In terms of volume increases, locations to the north along Park Street and east along Harvard Street would be expected to see double-digit percentage increases with Scenario 3 during all time periods reviewed. Similar to Scenario 1-2, Auburn Street at Park Street and Harvard Avenue at Park Street would see traffic volumes increase by 31 to 50 percent over the No-Build conditions. The same considerations for pedestrian volumes as those under Scenario 1-2 apply to Scenario 3, as the high pedestrian crossing volumes would be expected to be negatively impacted by the projected traffic-volume increases.

As it relates to the Harvard Street and Washington Street corridors, percentage volume increases due to this partial closure are less severe, although still in double digits on Washington Street at Thayer Street and on Harvard Street at Kent Street, Pierce Street, and Linden Place.

At the Harvard Street/Aspinwall Avenue intersection delay improved and volumes decreased by between 15 and 18 percent. At the Cypress Street/Washington Street intersection with School Street, delay increased even with a decrease in overall traffic volume of between 12 and 15 percent. This is due to diverted traffic increasing volume on Washington Street turning movements, which overload capacity for these movements.

Scenario 4 (School Street one-way westbound)

In terms of overall impacts, Scenario 4 results in increased delays at seven of nine signalized intersections. Delays increase during the weekday morning peak hour at the Cypress Street intersection with Boylston Street but decrease slightly during the other time periods. The only location where delays decreased was at the Harvard Street and Kent Street intersection.

In terms of volume increases, again locations to the north along Park Street and east along Harvard Street would be expected to see single- to double-digit percentage increases with Scenario 4 during all time periods reviewed. However, the increases with Scenario 4 are less than the other scenarios, although Harvard Avenue at Park Street would again see traffic volumes increase by 32 to 38 percent over the No-Build conditions. The same considerations for pedestrian volumes as those under Scenario 1-2 and Scenario 3 apply to Scenario 4, as the high pedestrian crossing volumes would be expected to be negatively impacted by the projected traffic-volume increases.

As it relates to the Harvard Street and Washington Street corridors, percentage volume increases due to this partial closure are less severe, but still in single digits on Washington Street at Thayer Street and Harvard Street at Kent Street, and in double digits at Harvard Street at Pierce Street and at Linden Place.

At the Harvard Street/Aspinwall Avenue intersection delay more than doubled during all time periods even though volumes decreased by between 11 and 16 percent. As with Scenario 1-2, a portion of the redistributed School Street traffic travels to this location to return to Aspinwall Avenue which overloads the southbound left-turning traffic from Harvard Street and other movements. At the Cypress Street/Washington Street intersection with School Street, delay increased even with a decrease in overall traffic volume of between 10 and 15 percent. This is due to diverted traffic increasing volume on Washington Street turning movements, which overload capacity for these movements.

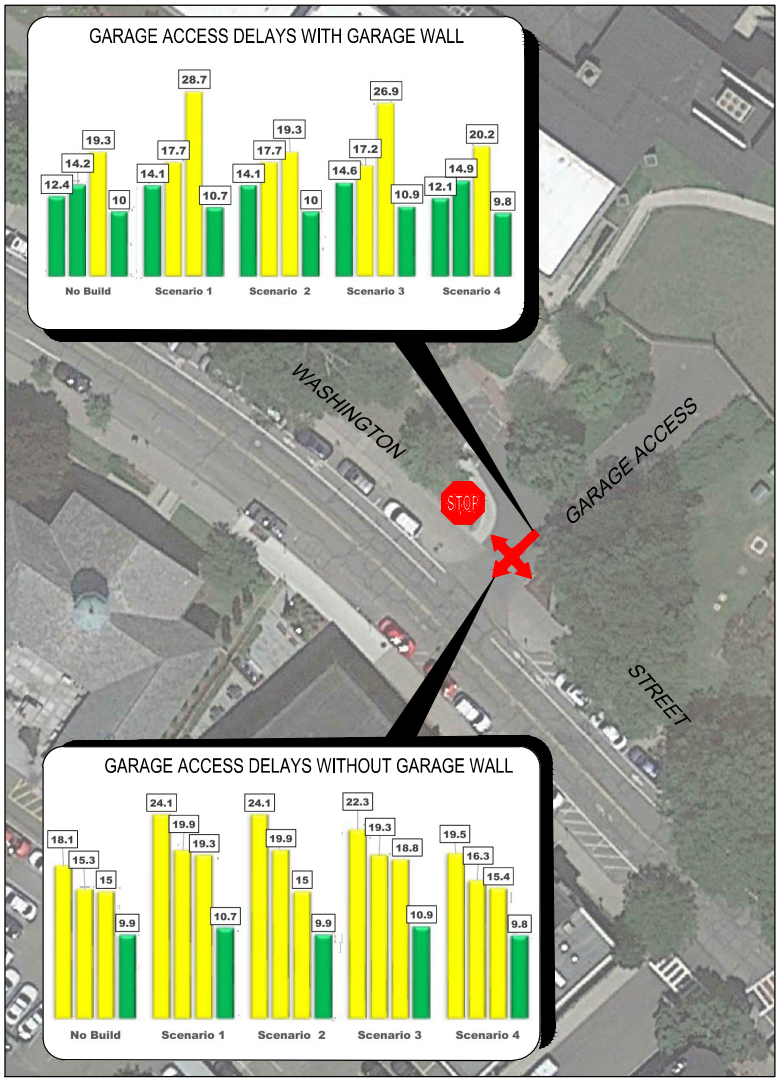
Connected Garage Access

An alternative for school access involves internal modifications to link the school, library, and Town Hall garages to allow access between the school garage and the Town Hall parking garage accessed via Washington Street. This was viewed as an option to improve operations at each access point. Currently the traffic intending to use the Town Hall upper and lower garages enter via Washington Street and exit via School Street. Traffic using the Pierce School garage enters and exits via School Street, while traffic using the library garage enters and exits via Washington Street. Due to anticipated increases in parking supply, it is anticipated that additional trips may use the access points. Traffic data by garage user type that would allow a detailed adjustment and reassignment based on changes to specific garage increases was not available. However, assumptions were developed based on available information. Based on DPW comments, there are currently 192 spaces available between the various garages, which will be increased to 217 spaces, an increase of approximately 13 percent. Therefore, garage traffic volumes were increased by 13 percent for this analysis. For the traffic volumes associated with both the garage access to Harvard

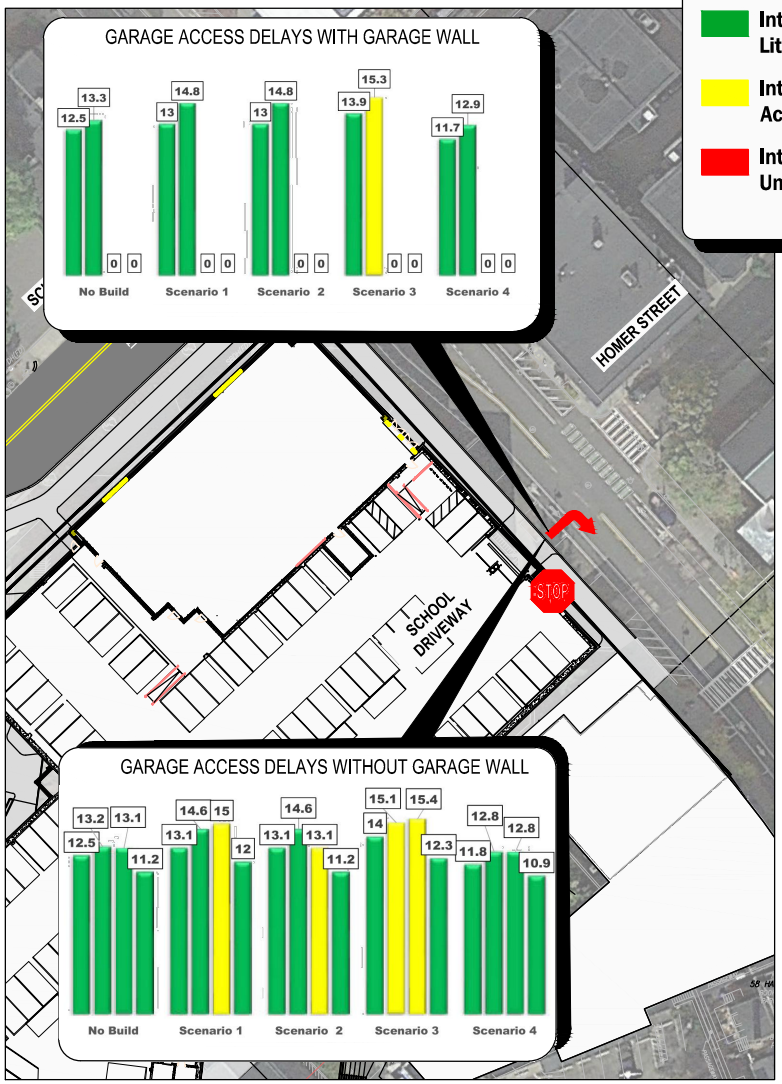
Street and the garage access to Washington Street, these adjustments are reasonable since the volumes are not high and operations indicate minor delays associated with these movements under all non-linked conditions reviewed.

When the garage access points are linked and traffic is able to pass between the two driveways, there is only a minor effect on delays during the various time periods. The main difference is that the school garage driveway to Harvard Street would recognize activity during the weekday evening and Saturday midday peak hour periods under the linked-garage condition and not under the non-linked condition. A summary of the analysis results is shown on Figure 23, which provides a comparison between the delays associated with the various scenarios and time periods reviewed.

As shown on Figure 23, operations at the Harvard Street garage driveway are shown to operate with slightly more delay with the connection to the Town Hall garage than without. However, operations at the Washington Street garage driveway would operate with nearly double the delay than without the connection. This is due to trips from the School portion of the garage expected to use the Town Hall access to turn left to eventually reverse direction to Harvard Street north. The operations at the Town Hall garage access would improve during the weekday evening peak hour with access to the Harvard Street garage driveway.



GARAGE ACCESS OFF WASHINGTON STREET



GARAGE ACCESS OFF HARVARD STREET

Legend:

- Intersection Operates Well with Little Delay (LOS A or B)
- Intersection Operates with Acceptable Delays (LOS C or D)
- Intersection Operates with Unacceptable Delays (LOS E or F)

Legend:

(Delays in Seconds)

XX	XX	XX	XX
Weekday Morning	Weekday Afternoon	Weekday Evening	Saturday Midday

CONDITIONS

Average Control Delay

LOS	Delay
A	≤10.0
B	10.1 to 15.0
C	15.1 to 25.0
D	25.1 to 35.0
E	35.1 to 50.0
F	>50.0

(Seconds Per Vehicle)

Figure 23

Delay Comparison
Potential Linked Garage
Between Harvard Street
and Washington Street

Vanasse & Associates inc

RECOMMENDATIONS AND CONCLUSIONS

The intent of this TIA was to identify the effects that full or partial closure of School Street is likely to have on area intersections that would be expected to be impacted by traffic avoiding the School Street area. Closure of School Street is an option to address traffic conditions associated with pedestrian crossings between the Pierce School and the Pierce School Playground. However, another option exists to address these conditions, which is identified in following sections.

The review of the various closure scenarios indicated that there were substantial trade-offs involved with any restriction of traffic flow on School Street. Looking at the relative differences in delays between the various scenarios, locations in and around the Village area would deteriorate with any restriction on School Street traffic flow. Not considering the actual delays calculated with some alternatives, the magnitude of the difference between the No-Build condition and some Scenarios indicates a doubling or greater increment of delay would be expected.

However, there are other strategies that can be used to address concerns of the effects of traffic on School Street. Included in these measures are relocation of the Pierce School driveways from School Street to other potential locations such as Harvard Street or Washington Street. An analysis of the potential operations of these driveways is included in this section.

In addition, traffic calming measures on School Street can also address concerns with traffic flow. It should be noted that the speed measurements conducted on School Street do not indicate a problem with speeding, as the 85th percentile speed was recorded at 25 mph. Nor do the crash statistics indicate an excessive crash history, as 6 crashes were recorded on School Street over a five-plus-year period and only 2 of these crashes were related to movements from either of the driveways. Based on these findings, traffic calming measures can effectively reduce negative effects of traffic flow on School Street while providing safe and efficient street crossings for school occupants during school hours and for others during off-school hours. Our findings are provided below.

Traffic Calming Measures

A series of potential traffic calming measures have been identified for School Street. Traffic calming measures are intended to encourage a more orderly flow of vehicle traffic along street segments and have been installed at numerous locations across the Town of Brookline. Typical installations include vertical deflection devices such as raised crosswalks or speed humps, as well as horizontal deflections such as neckdowns (narrowing of the road section) or chicanes.

In this case, traffic calming measures are proposed that include speed humps, a raised cross-walk/speed table, a neckdown/narrowing of the street section, a pushbutton-activated Pedestrian Hybrid Beacon traffic signal device, and supplementary signage. All of these are proven traffic calming measures that have been utilized with success over the last 10-20 years, with the performance ratings as noted.

Speed Humps

- Reduction in speeds and volumes of up to 22 percent with speed humps based on WMU study
- Reduction in crashes of 13 to 45 percent
- Elton Avenue in Watertown pictured
- Specified by VAI, installed in 2016
- Speeds on street reduced to 16 mph on average and 12 mph at speed hump location

Raised Crosswalks

- Crosswalk used in conjunction with vertical deflection, similar to speed hump
- Can reduce pedestrian crashes by 45 percent based on FHWA study
- Several installations in Brookline including Walnut Street (pictured)

Speed Table

- Larger area than raised crosswalk or speed hump
- Can be used at intersection or midblock crossing
- Nichols Avenue at Elton Avenue in Watertown pictured
- Specified by VAI, installed in 2016
- Reduction in crashes of 38 percent and 85th percentile speeds of 24 percent based on NACTO study

Pedestrian Hybrid Beacon

- More robust installation than Rectangular Rapid Flashing Beacon (RRFB)
- Red signal displayed to vehicles while crossing is in use
- Driver yielding averaged 96 percent in studies of 4-lane 40-45 mph crossings based on FHWA study
- Route 3 in Meredith, NH installed by VAI (pictured)

A conceptual improvement plan has been developed which retains the existing lane assignments and geometry at both ends of School Street but includes the aforementioned changes.

Figure 24 depicts the overall School Street traffic calming measures. Figure 25 depicts a detail for a Pedestrian Hybrid Beacon. Figure26 includes details on speed humps and the speed table design. These measures have a high degree of success associated with them in lowering vehicle speeds both nationally and in the town of Brookline, and it is anticipated that they will be successful on School Street as well.

CONCLUSION

A review of the reassigned traffic volumes for the scenarios listed indicated that most alternate routes utilized by the reassigned traffic from School Street increased delay at intersections substantially over the No Build conditions. None of the scenarios reviewed improved delay at all locations. Some scenarios did result in reductions in delay and traffic volumes at one or two intersections. However, due to the resultant effects on high pedestrian routes and high crash locations, as well as the overall increased vehicle volume and delay to operations, none of the scenarios were attractive enough to recommend their adoption. Any of the proposed changes to School Street would affect the travel and movement patterns of residents and businesses in close proximity to School Street that have to use the road daily.

Instead of drastic modifications such as restriction of School Street traffic flow, a revised approach for installation of significant traffic calming measures are proposed. This approach provides a more manageable solution with fewer detriments for the area neighborhood than the potential restriction of School Street would create, with its numerous ancillary impacts to pedestrian, bicycle, and vehicular traffic flow. The increase in vehicle-pedestrian conflict at multiple area intersections is an undesirable condition and one that would be experienced on a 24 hours per day/7 days per week schedule, even though the majority of school-related pedestrian crossings of School Street would only occur between the hours of 10:00 AM to 3:00 PM, and only during the weekdays during the school year. It is anticipated that adoption of these measures will address the school's and neighborhood's concerns regarding School Street and improve conditions and safety for all users of this important link in Brookline.

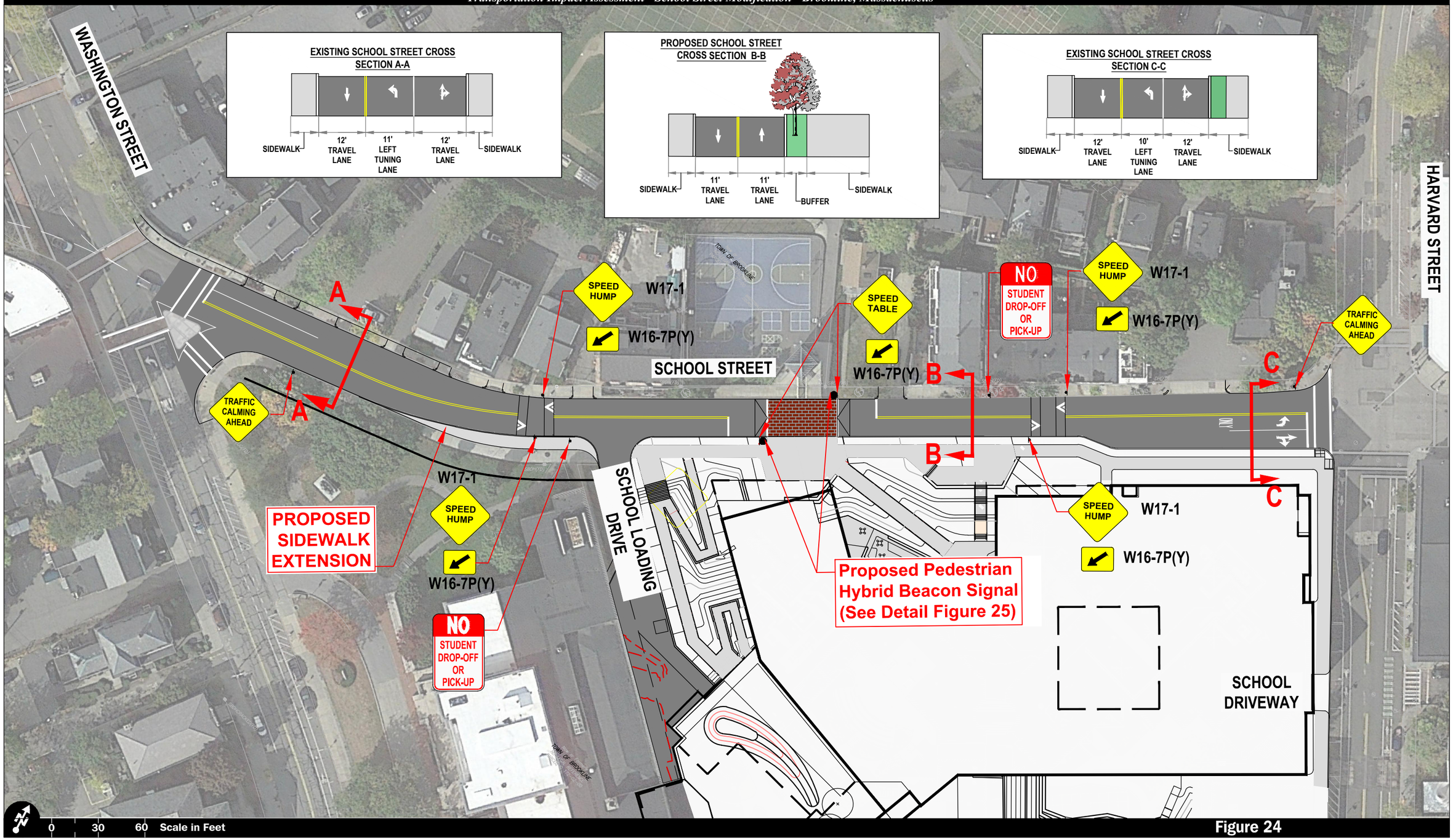


Figure 24

Conceptual Improvement Plan
School Street
Traffic Calming Measures

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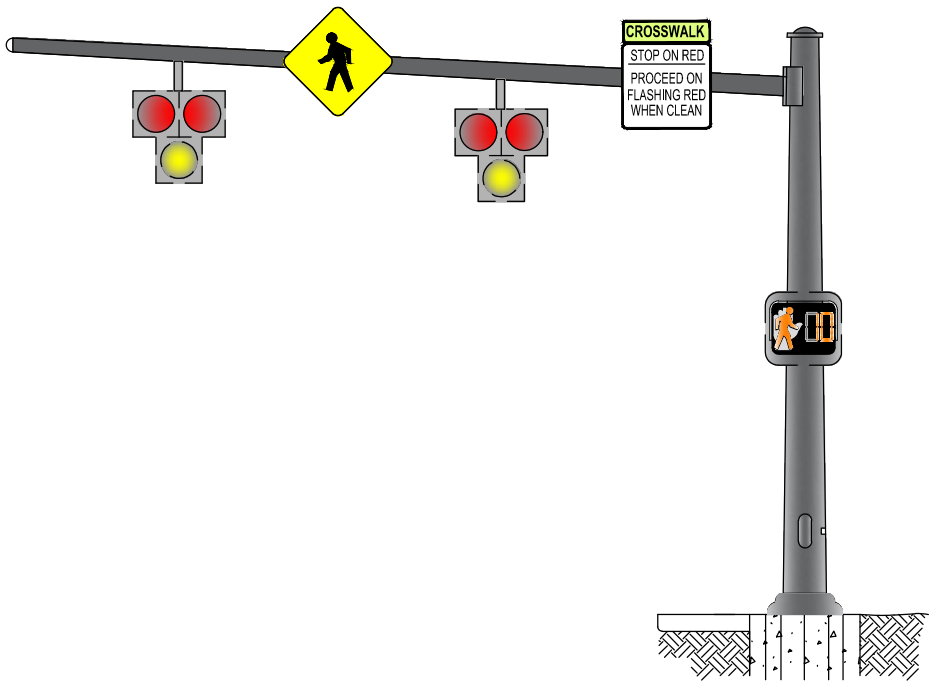
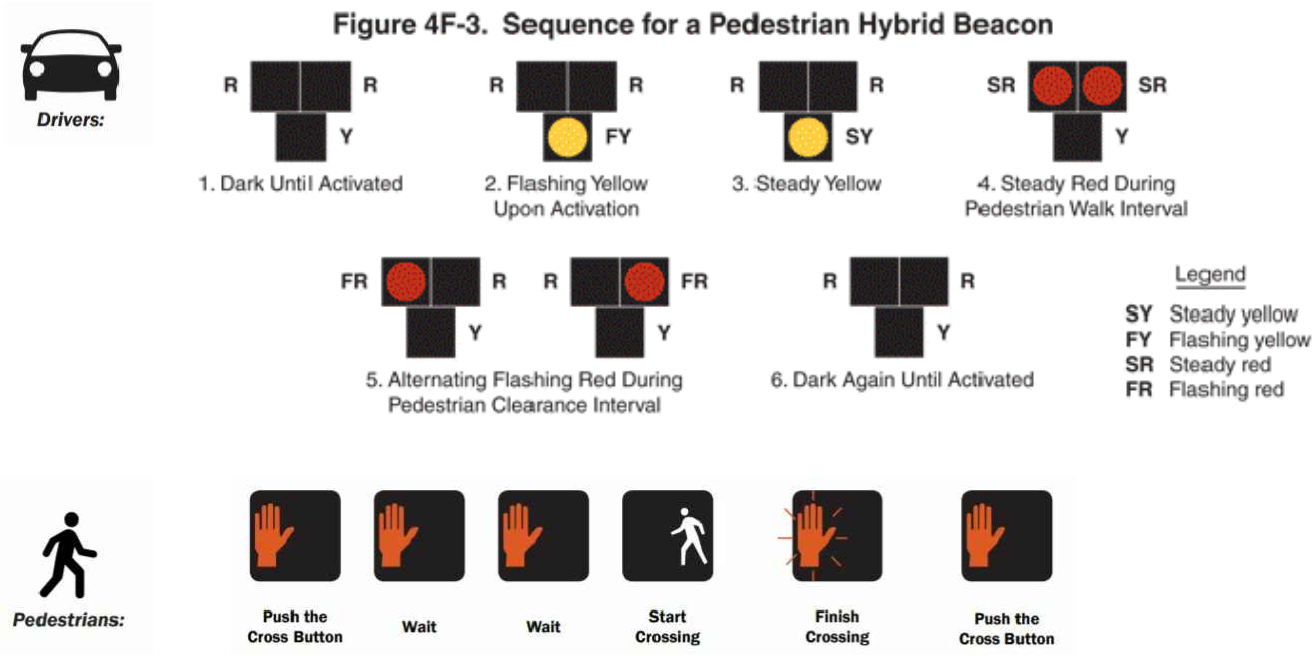


HAWK SIGNAL
Not to scale



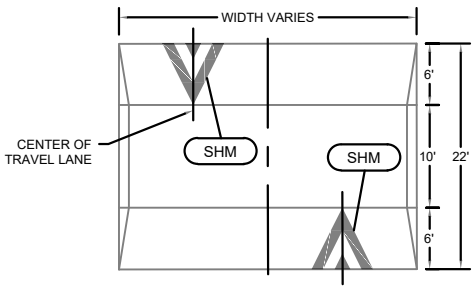
Source: MUTCD

Figure 25

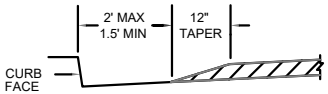
Proposed Pedestrian Hybrid Beacon Signal Detail

Vanasse & Associates inc

SPEED HUMP DETAIL

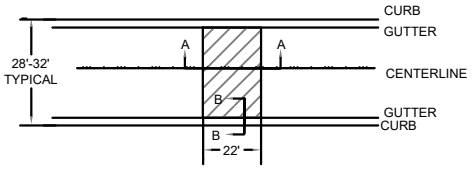


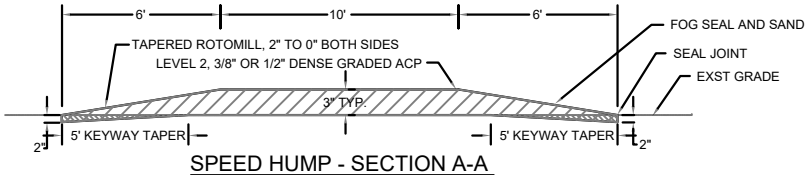
SPEED HUMP LAYOUT



SECTION B-B CURB DETAIL

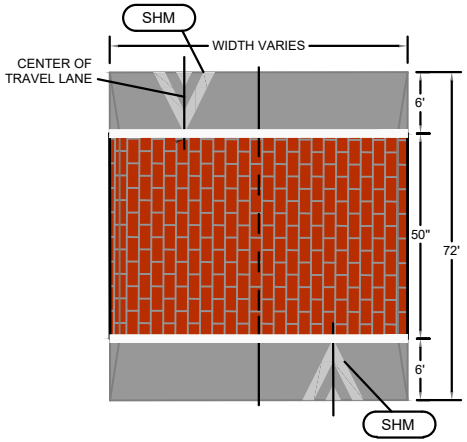
TYPICAL TRANSITION TO GUTTER DETAIL





SPEED HUMP - SECTION A-A

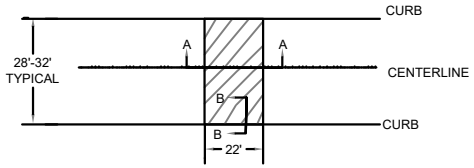
PEDESTRIAN CROSSING/ SPEED TABLE DETAIL

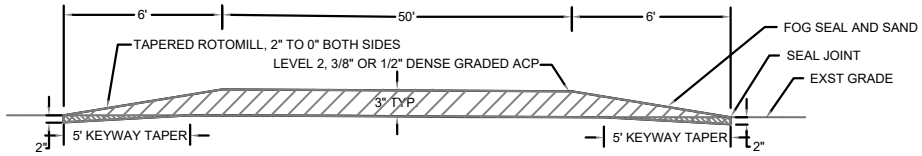


SPEED TABLE

SECTION B-B CURB DETAIL

TYPICAL TRANSITION TO GUTTER DETAIL





SPEED TABLE - SECTION A-A

Figure 26

Speed Hump and Pedestrian Crossing/ Speed Table Detail

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