Everett-Boston BRT

APPENDICES

ITDP

APPENDIX

A

THE STATE OF TRANSIT IN EVERETT: EXISTING CONDITIONS AND FUTURE NEEDS

HISTORY OF TRANSIT IN EVERETT

Boston's transit system was originally designed with a series of surface–rapid transit transfer stations. Horsecars and then streetcars wound through narrow downtown streets, but the roads were quickly overcome by congestion, so the city built the first subway in the nation in 1897. However, this subway—now the Green Line—was relatively low-capacity, with a parade of short trolley cars running through narrow passages. As higher-capacity rapid transit lines were built, passengers would board surface vehicles (mostly trolleys) that fed into higher-capacity rapid transit lines at major transfer stations to continue trips downtown. Even as the network has changed, this general function has remained to this day.

In the case of Everett, bus routes only serve the bordering towns of Medford, Malden, Revere, and Chelsea; nearly all other destinations require a transfer. For most trips, the transfer point is at Sullivan station, but buses also provide connections to the Orange Line at Wellington and Malden, as well as the Blue Line at Wood Island and Wonderland. This has not always been the case: Before the Orange Line was extended to Oak Grove in the 1970s, the line terminated in Everett, south of Revere Beach Parkway and the main population of the city. When the extension was opened, the routes serving Everett had their termini moved, with some extended from the old Everett station to Sullivan and others rerouted to Malden and Wellington stations. The 112 bus, which used to cross the Mystic River Bridge to terminate at City Square, was rerouted to Wood Island on the Blue Line. Notably, the 111 bus from Chelsea, which also crossed the Mystic to City Square, was instead rerouted to downtown Boston to terminate at Haymarket, allowing a one-seat ride for commuters from Chelsea.

EVERETT HAS NO DIRECT TRANSIT LINK TO DOWNTOWN BOSTON

Since 1975, Everett has been without any rail transit and without a direct link to downtown Boston, making it unique amongst the most densely populated cities in the state (see **Figure 1**). Boston, Cambridge, and Somerville all have rapid transit lines, and Chelsea has a Commuter Rail station as well as a direct connection to downtown Boston on the 111 bus. Chelsea has a number of bus lines, but to get to downtown Boston, all require a transfer at Sullivan Square, Wellington, or another rapid transit station. Other than small sections of bus lanes recently installed, there is only a minimal benefit for bus riders, even though they make up a large proportion of the people going from Everett to Boston. A BRT corridor from Everett to Boston would allow a faster, more frequent, more reliable connection to downtown Boston.

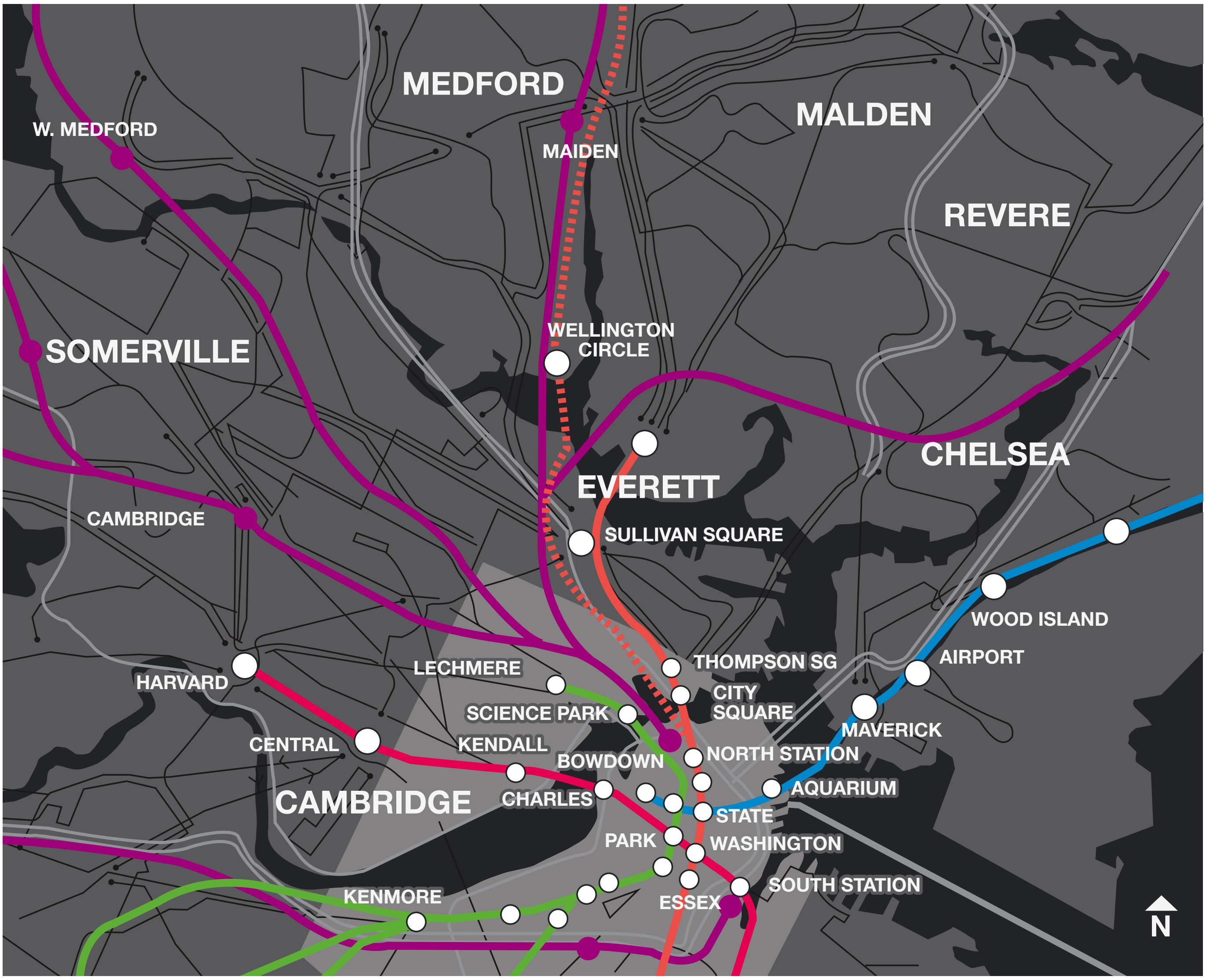
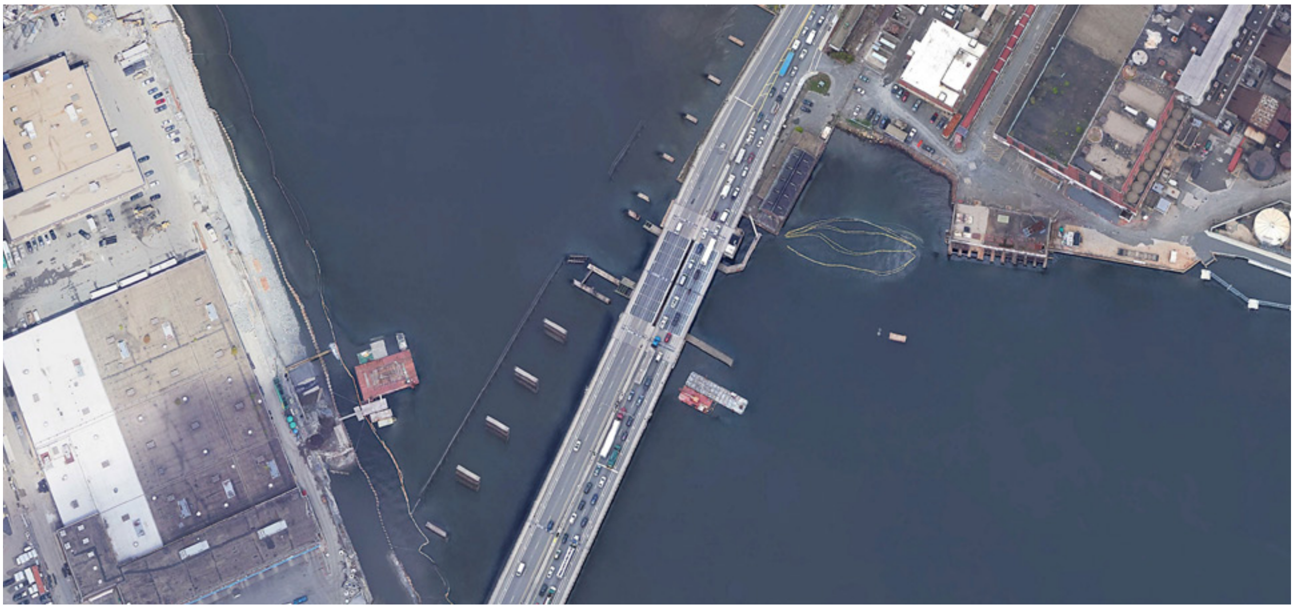


Figure 1
The 1974 MBTA system map, showing the Orange Line to Everett as well as the under-construction extension to Malden and Oak Grove. This was the last time that Everett had direct service to Boston beyond Sullivan Square, via the 112 bus through Chelsea.
SOURCE: MBTAgifts 2021

REPLACING RAIL SERVICE WITH BRT

BRT provides high-capacity transit, carrying far more people in a single lane of traffic than automobiles and, in some cases, approaching or even exceeding the throughput of a rail or subway line. In the case of Everett, BRT would be replacing the rail line that once ran to the southern part of the city across the Mystic River adjacent to the Alford Street Bridge (see **Figure 2**). This would allow a one-for-one replacement of rail service with BRT service between Everett and Sullivan Square, albeit with a 45-year gap during which the buses have operated in mixed traffic.

Figure 2
An aerial photograph of the Alford Street Bridge, showing the footings of the former elevated rail bridge.
SOURCE: Google Earth



EVERETT USED TO HAVE CENTER-RUNNING TRANSIT

Figure 3
A Boston Elevated Railway Birney Safety Car in Everett. A Type 5 car turns in the background.

Streetcars, like the ones shown here (**Figure 3**) in Everett in the early 1900s, operated in the center of the street, albeit not on an exclusive right-of-way. When traffic worsened, the streetcars were susceptible to traffic delays. A benefit of center-running operations, though, was that they didn't have to pull out of traffic as modern buses do to board passengers; instead, in most cases people boarded from the street itself.

EVERETT'S EXISTING TRANSIT SERVICE

Everett has no high-capacity transit service. The Newburyport/Rockport (Eastern Route) Commuter Rail line passes through the southern part of the city but does not stop in Everett. The Orange Line once terminated in Everett at an at-grade terminal that's now occupied by an auto dealership—this station was removed when the Main Line Elevated railroad was replaced with the current Orange Line alignment to Malden and Oak Grove. The Everett bus routes that terminated at Everett's station were extended across the Alford Street Bridge (the extension of Broadway) into Boston in 1975. The MBTA's Silver Line 3 busway terminates in Chelsea, not far from the Everett border. The closest transit station to Everett is Wellington, which is located only a quarter mile from the municipal boundary, although it is an unpleasant walk to the station along Revere Beach Parkway and a significantly longer trip to where most residents live.

Everett lacks a single "key" bus route, which the MBTA defines as a route that has high ridership and higher frequency standards. It is currently served by nine routes with confusing, infrequent service that prioritizes coverage over frequency. At peak hour, there are approximately 25 buses per hour from Everett to Sullivan and Wellington across eight routes sering the Broadway/Main Street corridor; however, none of the existing bus routes provides a fast connection to the job centers of downtown Boston, Cambridge, or Somerville.

Existing bus routes on Broadway include the 104, 105, and 109, all of which terminate at Sullivan Station (**Figure 4**). MBTA's Better Bus Project has identified the 104 and 109 as important routes that are frequently crowded and need more service.[1] Additional routes serve parts of Broadway and then run to Wellington station and provide a similar connection to Boston. While there is a bus leaving Everett on average every four or five minutes toward Boston at peak times, the routes are not well-coordinated, and northbound passengers have to choose a transfer point, each of which has less service. From Sullivan Square, the 92 and 93 continue to Haymarket in downtown Boston via local service in Charlestown. From Sullivan Square, passengers can currently transfer to several routes to access areas in Somerville and Cambridge.

Additional buses run through Everett to other rapid transit stations. The 97, 99, and 106 buses run from Malden through Everett to Wellington Station. The 97 and 99 directly serve the Malden center T station, and the 106 runs east of the center of Malden. The 99 and 106 follow Main Street from Malden to Sweetser Circle; the 97 follows Hancock Street and Broadway; and all three use Revere Beach Parkway to get to Wellington.

The 110 runs from Wellington to Wonderland through Everett and Revere. The 112 runs from Wellington to Wood Island via Chelsea. The Woodlawn terminal of the 111 bus, a "key" bus route and one of the MBTA's busiest, is located a few feet into Everett across the Chelsea border and is served by every other trip of the 111, although this still provides service at least every 15 minutes.

1 MBTA 2018.

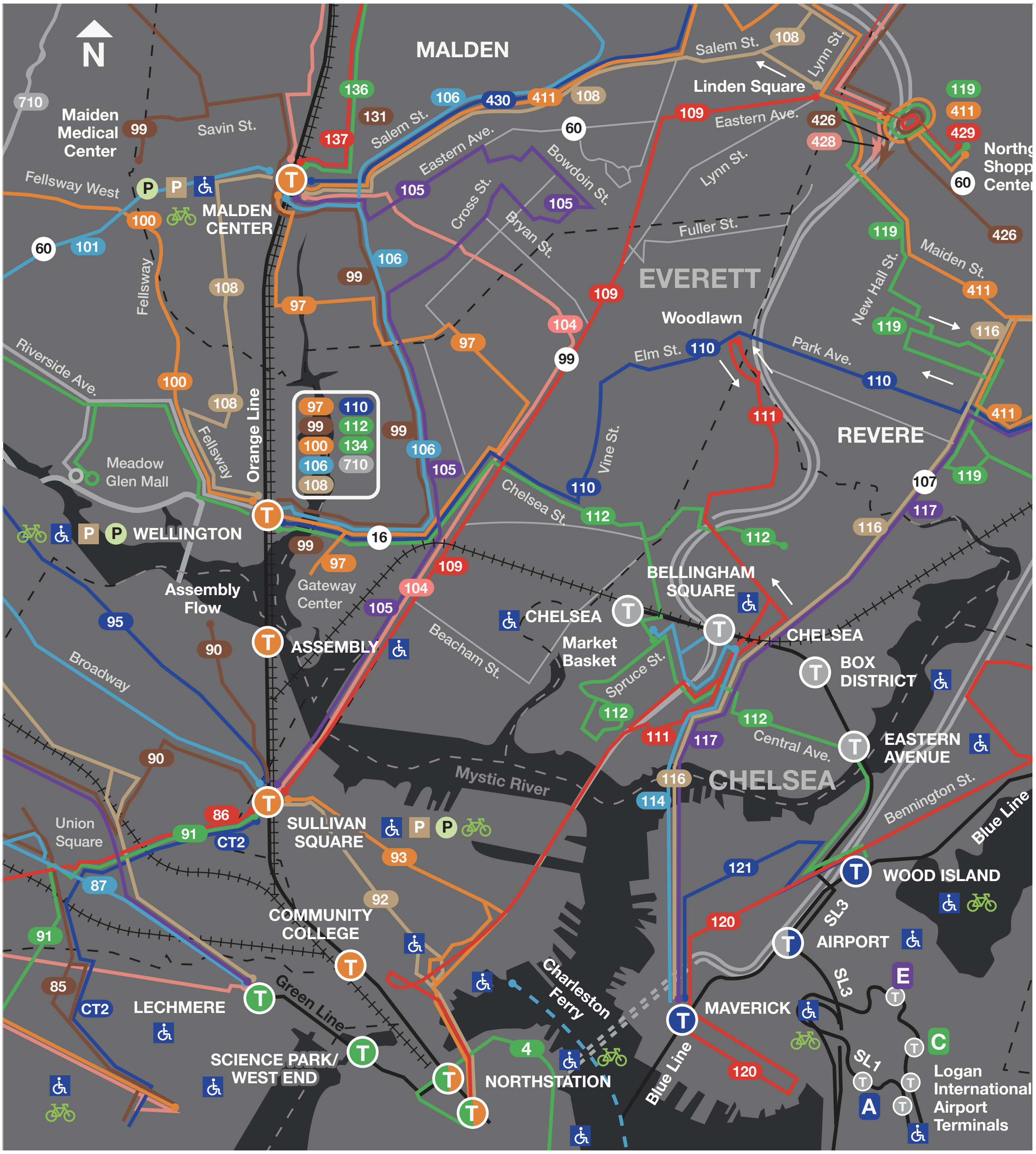
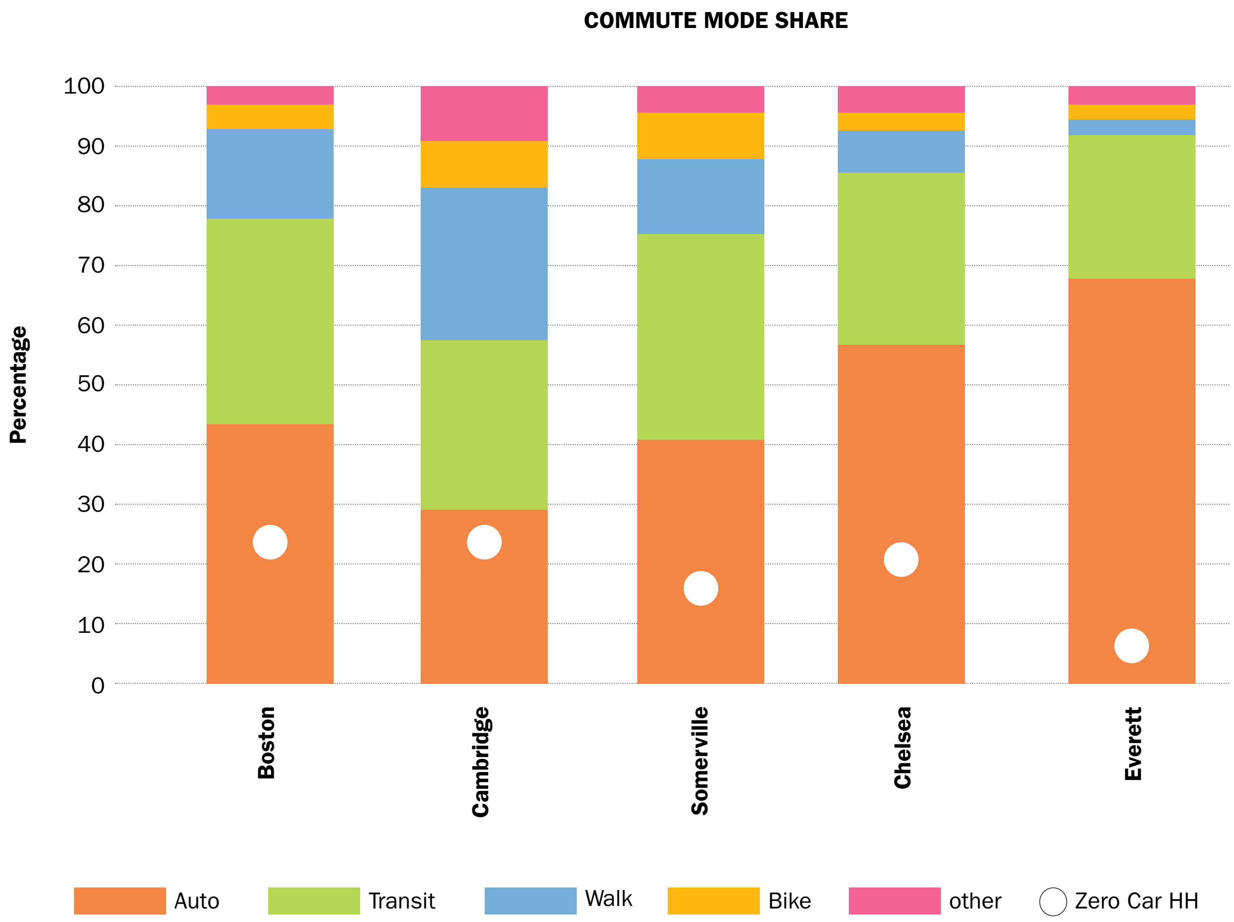


Figure 4
A portion of the MBTA system map showing Everett and bus routes serving Everett.
SOURCE:
MBTA 2020

MODE SHARE

While Everett is as dense as several nearby cities, it is more auto-dependent. In Boston, Cambridge, and Chelsea, more than 20% of households do not have access to a car; in Everett, that number is just 8%. Nearly two-thirds of Everett commuters drive to work (with about 14% carpooling, which is significantly higher than statewide) (**see Figure 5**). Everett has relatively few walk- and bike-to-work residents, and one quarter of Everett residents take transit to work. Everett's mode share is much closer to that of Chelsea than to Boston, Cambridge, or Somerville, even though they all have similarly dense populations. This suggests that Everett commuters fall into two camps. Some are "choice" riders—residents who have access to a vehicle but take the bus instead. Others are in households with a vehicle, but since the vehicle is in use by another household member, they use transit, walking, and biking to get around. While Everett's zero-car-household percentage is lower than that of any nearby community, its zero-or one-car-household proportion is higher than in both Malden and Revere.

Figure 5: Commute Mode Share for Everett and the Inner-Core Cities
Source: MHP 2019



The MBTA bus routes operating along Broadway in Everett collectively carry more than 1,500 weekday passengers per direction, including to both Sullivan and Wellington stations. At the south end of Rutherford Ave, North Washington Street from Charlestown to Haymarket Square also carries at least 1,500 bus passengers per direction each weekday. CTPS used this threshold of 1,500 passengers per direction to screen corridors for prioritization of dedicated bus lanes.[2] Total Everett employment in the City of Boston is approximately 5,900, of whom about 3,300 work downtown (**see Table 1**). This is not the full universe of transit trips, but it implies that many Everett-based employees going to downtown Boston (and elsewhere in the city) already take transit, likely because of both congestion between Everett and Boston at peak hour (the marginal cost of time to take transit is minimal) and the cost of driving and parking in Boston. This suggests that while BRT will benefit all current travelers, the potential for additional mode shift is relatively small, since most of the riders in the best transit market are already taking transit.

Table 1: Everett residents' location of employment, 2014
Source: BRA Research Division 2016

	Everett Residents Employed		Additional Transit Travel Time[3]
	In Neighborhood	Running Total	
Beacon Hill	50	50	0
Charlestown	284	334	0
North End	64	398	0
West End	565	963	0
Downtown	1,525	2,488	3
Back Bay	545	3,033	7
South End	310	3,343	9
East Boston	516	3,859	11
Mission Hill	319	4,178	12
Jamaica Plain	122	4,300	16
Fenway	147	4,447	17
SB Waterfront	316	4,763	20
Longwood	103	4,866	22
Roxbury	240	5,106	22
South Boston	174	5,280	24
Dorchester	219	5,499	29
Roslindale	16	5,515	29
Allston	135	5,650	35
Hyde Park	36	5,686	35
West Roxbury	26	5,712	39
Mattapan	10	5,722	41
Brighton	223	5,945	44

2 CTPS 2018a
3 Transit travel time calculated based on GTFS trip routing data from Haymarket, not including walk access time.

TRANSIT USER DEMOGRAPHICS

Everett's overall public transit mode share (origins and destinations, all trip purposes) is only 3% to 4%,[4] whereas public transit is used more heavily for commute trips. This includes many local trips, such as those made by walking and bicycling, which would not be easily replaced by transit. However, workers residing in Everett rely on public transit for 23% of their commute to work trips[5], even though many of these trips are to areas without good transit service. While Everett has a relatively high rate of households with access to vehicles, it also has a relatively high rate of households with only one car, similar to the number for other nearby communities. During the COVID-19 outbreak, transit use on bus routes in the region and in Everett fell less than overall transit use.

Table 2: Population Demographics and Household Commute Characteristics for Everett and Inner Core Cities
Source: U.S. Census Bureau 2018a

TOWN	Population		Racial Demographics (%)					Commute	Households	
	Population	Per sq mi	White	Black	Asian	Latinx	Other	60+ min	0 cars	1 car
Somerville	81,562	19,562	70%	6%	10%	11%	4%	10%	16%	43%
Chelsea	40,160	18,254	22%	6%	0%	67%	5%	16%	21%	39%
Cambridge	118,977	18,503	61%	10%	16%	9%	4%	5%	23%	49%
Boston	694,583	14,344	45%	23%	9%	20%	4%	12%	23%	41%
Everett	46,880	13,788	45%	18%	7%	27%	4%	21%	8%	38%
Malden	61,036	11,967	47%	16%	23%	9%	4%	17%	11%	35%
Lawrence	80,376	11,649	14%	2%	2%	80%	1%	6%	12%	38%
Revere	53,821	9,010	55%	5%	5%	33%	3%	16%	11%	33%

4 For trips originating in Everett, public transit represents 3.47%; it represents 3.81% for trips ending in Everett. Source: MAPC 2018.
5 U.S. Census Bureau 2018a.

Table 3: Commute Mode Share and Existing Transit Service for Everett and Inner Core Cities
Source: U.S. Census Bureau 2018a

	Commute Mode					Rapid Transit Stations	Comm Rail Stations	BRT Lines	Proposed Rapid Transit	Key Bus Routes
TOWN	**Drive**	**Carpool**	**Transit**	**Walk**	**Other**					
Somerville	36%	5%	35%	12%	8%	1	0	0	5	0
Chelsea	44%	14%	29%	7%	3%	0	1	1	0	0
Cambridge	27%	3%	29%	25%	16%	6	1	0	0	5
Boston	39%	6%	33%	15%	7%	43	19	5	0	12
Everett	54%	14%	24%	3%	5%	0	0	0	0	0
Malden	53%	8%	31%	3%	5%	1	1	0	0	0
Lawrence	66%	16%	4%	5%	9%	0	1	0	0	0
Revere	57%	9%	26%	4%	3%	3	0	0	0	2

Among residents of Everett, public transit trips to work are disproportionately made by women, African Americans, and nonwhites.[6] Women comprise 48% of Everett's resident workers and make 55% of public transit trips to work. Likewise, African American and nonwhite residents disproportionately rely on public transit to get to work. Black residents comprise 21% of Everett's workers and make 28% of the work trips on public transit, and 9% of Everett's workers are nonwhite and they make 15% of the public transit trips to work.[7]

6 U.S. Census Bureau 2018.
7 CTPS 2018b.

APPENDIX

B

WHAT IS BRT?

According to the *BRT Standard*, BRT is a bus-based rapid transit system that can achieve high capacity, speed, and service quality at relatively low cost by combining segregated bus lanes that are typically median-aligned with off-board fare collection, level boarding, bus priority at intersections, and other quality-of-service elements (such as information technology and strong branding).[8]

BRT is sometimes misunderstood in the U.S. because stakeholder institutions have defined the mode more broadly or vaguely. The Federal Transit Administration (FTA), for example, defines BRT as "a high-quality bus-based transit system that delivers fast and efficient service that may include dedicated lanes, busways, traffic signal priority, off-board fare collection, elevated platforms, and enhanced stations."[9] As a result, many projects that would otherwise be labeled as bus improvements or bus priority under international standards have become branded in American cities as BRT. This leads to confusion among decision-makers and the public at large about what to expect from a proposed BRT project.

BRT BASICS

The five BRT basics are the essential ingredients for ensuring that BRT is truly "rapid" transit (**see Table 3**). These BRT design elements are effective at reducing the main sources of delay for bus passengers, including boarding and alighting, and curbside and intersection delays. By reducing these sources of delay, BRT can increase bus transit speeds, reliability, and operational efficiencies. Faster buses with more riders are more cost-effective than slower, emptier buses. In addition to spending less time on the road, buses that operate at a higher speed can complete more trips, especially as layover and schedule recovery time can be decreased given higher reliability and lower variability of trip times. This provides a more effective and cost-efficient service for the operator.

8 ITDP 2016.
9 FTA 2017a.

Table 3: Five Basic Features of BRT

BRT BASIC FEATURE	DESCRIPTION
Dedicated right-of-way	Bus-only lanes make for faster travel and ensure that buses are never delayed due to mixed traffic congestion. Physically separated, dedicated lanes earn the maximum points in the *BRT Standard*.
Busway alignment	A center-of-the-roadway or bus-only corridor keeps buses away from the busy curbside where cars are parking, standing, and tunning. A two-way, center-aligned busway in the central verge of a two-way road earns the maximum points in the *BRT Standard*.
Off-board fare collection	Fare payment at the station, instead of on the bus, eliminates delays caused by passengers waiting to pay on board.
Intersection treatments	Traffic turning across bus lanes causes delays. Prohibiting such turns is the most important measure for moving buses through intersections—more important even than signal priority.
Platform-level boarding	The station should be level with the bus floor for quick and easy boarding. This also makes it fully accessible for wheelchairs, passengers with disabilities, and strollers with minimal delays.

Adapted from ITDP 2016

For the Everett–Boston corridor, ITDP is recommending true BRT, not simply bus service improvements. The *BRT Standard* definition of BRT guides our recommendations: Namely, the proposed corridor design includes the five elements of Basic BRT. By reducing common sources of delay for bus passengers, the Everett-to-Boston BRT corridor will be more reliable, more convenient, and quicker than existing MBTA bus service. This differs, in several respects, from the existing Silver Line corridors, which do not meet the *BRT Standard*'s definition of BRT (see **Appendix C**).

BRT CORRIDOR VERSUS BRT ROUTES

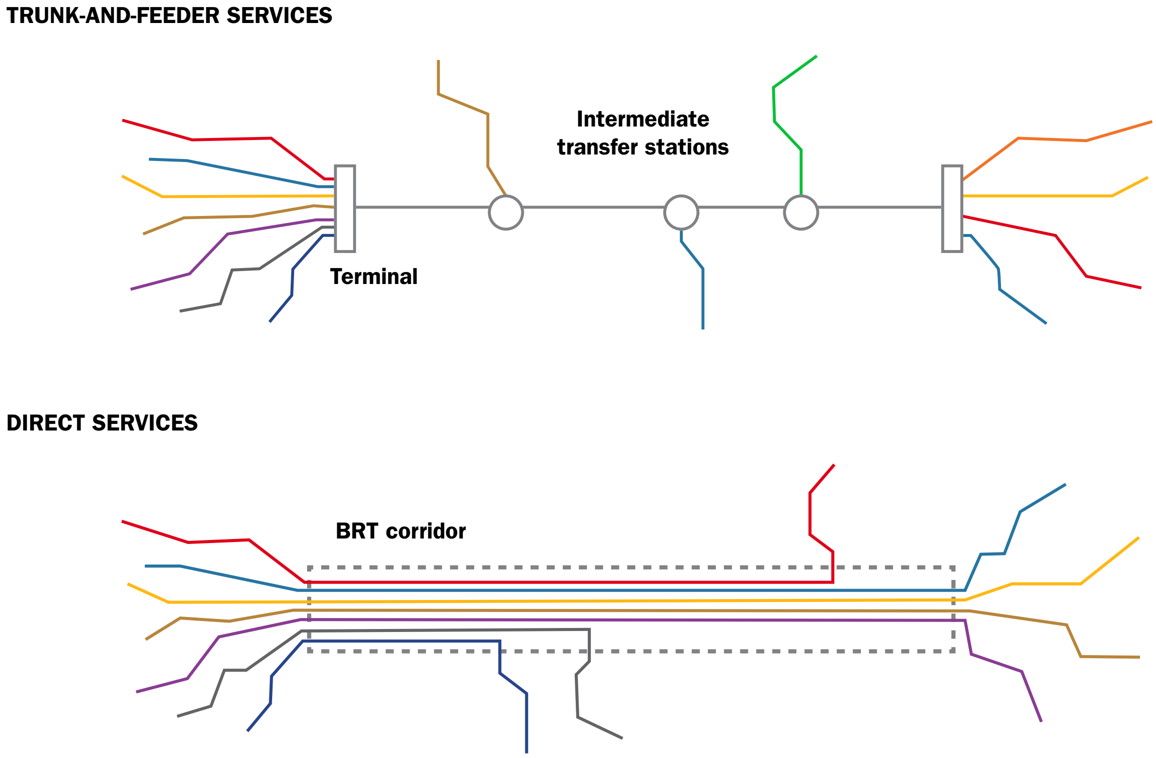
There is an important distinction between the BRT corridor infrastructure and the BRT services or routes operating in that corridor. Two approaches to BRT service delivery can utilize the corridor infrastructure: trunk-and-feeder or direct services (**see Figure 6**):

- **Trunk-and-feeder**
  High-capacity buses operate exclusively in the “trunk” corridor, and feeder buses may bring passengers from outlying areas to the corridor

via terminals or transfer stations. This service model increases the number of transfers required for passengers.

- **Direct service**
  With a direct-service model, on the other hand, buses operate in mixed traffic before entering the BRT corridor and taking advantage of the dedicated bus lane. Buses may exit the corridor and continue in curbside bus lanes or even mixed traffic. This configuration connects passengers directly to their destination without requiring them to transfer. This is the service model ITDP recommends on the Everett–Boston corridor.

Figure 6: Schematics of BRT Service Delivery Options
Source: ITDP 2021.



EARLY POLITICAL SUPPORT FOR BRT ON THIS CORRIDOR

Early support from the mayor of Everett and his staff for improving bus service and implementing BRT on Broadway elevates the priority of this corridor as much as the actual public transit demand that exists to warrant it. While Broadway is not the corridor with the highest demand in the region or the one with the most congestion, the political support is there, at least on the Everett side, to implement not just dedicated bus lanes but full-scale BRT. Successfully implementing BRT on this corridor can help catalyze other potential corridors, especially those in the City of Boston.

APPENDIX

C

LESSONS FROM THE SILVER LINE FOR AN EVERETT-BOSTON BRT CORRIDOR

The Silver Line Gateway (SL3) opened on April 21, 2018, with the intention to improve connections from Chelsea to East Boston, the Seaport District, and downtown Boston. For the first 1.2-mile segment starting at Chelsea Station, the SL3 operates in a dedicated busway built in a decommissioned freight rail right-of-way.

While SL3 includes infrastructure and service improvements over typical MBTA bus service, it does not meet the definition of Basic BRT, according to the *BRT Standard*. The Chelsea busway has dedicated bus lanes in both directions with four new stations, but other Basic BRT infrastructure elements are lacking, including:

- a minimum 1.9 miles of continuous dedicated bus-only lanes within the corridor. While the SL3 does connect to the SL1 corridor, the multiple miles of mixed-traffic congestion in between disqualifies the corridor.
- off-board fare collection
- platform-level boarding

SLOWED BY CONGESTION WITHOUT DEDICATED BUS LANES

Beyond the new dedicated busway and existing Silver Line Busway tunnel—currently also used by the SL1 and SL2—the SL3 runs for significant portions of the route in mixed traffic and is affected by congestion. Given increased traffic in the Ted Williams Tunnel, the bus is often delayed by severe congestion during rush hour as it doesn't get any priority treatment. Without a continuous dedicated bus-only lane with physical separation and enforcement for the entirety of the corridor, mixed traffic will cause unpredictable service and poor on-time performance.

The raising of the Chelsea Street Bridge to allow passing marine traffic further reduces reliability and speeds. Coordination with the local shipping authorities will be required to ensure that the buses continue to meet on-time performance standards despite this contextually unique infrastructure element. In theory this would be achieved by opening the bridges only during off-peak hours, when ridership on buses is lower and the alternate route is generally traffic-free (this is the case for the Alford Street Bridge, which does not open during peak hours). However, these barges are generally carrying liquefied natural gas and can only pass the bridge at high tide, so several days per month, the bridge requires rush-hour operation, which stymies the on-time performance of the bus.

INEFFICIENT FLEET MAINTENANCE AND OPERATION

There are other salient issues with the operation of the Silver Line 3 that are relatively unique to the route but provide insight for further development of improved bus operation in the region and an Everett–Boston BRT corridor. One regards the fleet. Since 2004, the Silver Line has used a dual-mode diesel-electric trolleybus fleet, operating using electric power on the surface and using trolley wires in the tunnel, which is not properly ventilated for diesel exhaust. This fleet has proved to be troublesome, particularly as operated by the MBTA. Unlike most operators of similar buses in other cities, the MBTA has not maintained the buses in a manner that allows the automatic raising and lowering of trolley poles, so every bus driver must exit the bus and walk to the back to adjust the poles at each power changeover, increasing travel time and operational complexity.

The Silver Line offers insights into fleet electrification choices and trade-offs that are pertinent to fleet selection for the Everett–Boston corridor as well. A future fleet for the SL3 route will likely use either battery-electric buses or in-motion-charging (IMC) buses, which use the existing trolleybus infrastructure. Battery buses are a promising technology but may not be particularly well-suited to a route like the Silver Line. The line provides relatively even headways during the day (especially the SL1, which actually provides more service on Sunday than on weekdays) given the route profile outside of the Piers Transitway tunnel. This means that buses typically operate 20 hours per day and average 12 to 14 miles of travel per hour of operation, putting their range beyond the comfortable daily range of a battery-electric bus and leaving minimal time overnight to recharge. This means that converting the fleet to battery buses would require additional fleet and the requisite storage to keep the buses sufficiently charged to serve the entire route, especially given the limited capacity for charging at the MBTA's current bus maintenance facilities.

In-motion-charging buses, which would use the existing trolley wire to charge when on the wired network and then operate off-wire in the tunnel (and beyond), are somewhat more promising. Some buses of this type have been able to operate with just 20% of their operation time on trolley wire,[10] which would allow the conversion of the Silver Line buses to IMC buses without any additional infrastructure or fleet requirements. (See Section 4.4.4 for more discussion about IMC buses.) Any BRT corridor should consider the propulsion type that best balances passenger demands, existing infrastructure, route profile, and the limited capacity of the MBTA's current bus yards.

10 Knorr-Bremse 2019.

LACK OF TRANSIT SIGNAL PRIORITY

Transit signal priority (TSP) is an additional blind spot for the Silver Line. Most notably, there is limited TSP where the Silver Line crosses D Street at-grade, and multiple buses with up to 100 passengers aboard wait for long intervals during which the crossing street may see few if any passing vehicles. Without TSP on the corridor, SL3 passengers are given no travel time advantage over other vehicles.[11] This is emblematic of the struggle to install TSP in Boston: There have been few implementations of TSP in the region, and most are only activated when a bus is already behind schedule and do not provide priority over vehicles to allow a faster trip.

LIMITED CAPACITY AND THROUGHPUT

Finally, the Silver Line tunnel has been a victim of its own success. While it does have some elements of BRT, notably full grade separation and fare prepayment, the limited capacity of the vehicles causes extreme crowding at rush hour, despite frequent headways and 60-foot vehicles. The tunnel geometry also precludes higher-speed operations, and buses are limited to 15 to 20 mph. This would be a difficult problem to solve without converting to a mode with a higher per-vehicle capacity as well as higher-speed tunnel-based operations with an improved guideway. As BRT grows, especially in space-constrained corridors, it must be planned so that successful implementation and high ridership do not cause a reduction in the level of service provided. In the Everett corridor, care should be taken to make sure that infrastructure is not built that precludes future speed or capacity.

11 There has been a longstanding effort by transit advocacy groups to allow the SL3 use of a restricted vehicle ramp that would let buses bypass some of the worst congestion on the highway. But this has been continually stymied by the State Police, who use the ramp for nonemergency purposes, frequently disregarding "one way" signs to access the barracks. Allowing buses to use the ramp was tested in 2019, and the state is currently collecting data on its eventual permanent use. Any further implementation of BRT in the region must learn from such mistakes and make sure that the preferences of a small few do not block implementation of major improvements for regional transit (Gaffin 2019).

APPENDIX

D

TRAFFIC COUNT DATA

To inform our recommendations about BRT service and infrastructure between Everett and Boston, ITDP directed a study undertaken by AECOM that looked at travel patterns between Everett and Boston, and specifically at travel patterns along Rutherford Avenue. This included three weeklong traffic counts along the corridor, as well as zone data from Streetlight, which tracks cell phone data along the corridor. The study was particularly focused on traffic on Rutherford Avenue and to and from the casino, but it can also inform how the BRT corridor will function between Everett and Boston.

Approximately 95% of daily trips from Everett are made in passenger vehicles, but these trips have destinations across the region—only a relatively small portion are to destinations in Boston and Cambridge that would be served by BRT. Of vehicles starting in Everett and crossing the Alford Street Bridge to Charlestown (10,370), slightly more are headed to Cambridge/Somerville (4,600) than to downtown Boston (3,600). Expanding bus service to provide convenient and efficient connections between Everett and Cambridge/Somerville, Charlestown, and downtown Boston could encourage more transit use to these areas. In addition, providing transit from Everett to other transit connections would provide more flexibility to travel to other areas that were not previously accessible.

TRAFFIC COUNT VOLUME

These volumes were collected over seven days in January 2020 during which there were no holidays or adverse weather events and which was two months before any impact from COVID-19. Data here represent an average for traffic volumes from Monday to Thursday. Data is shown in 15-minute intervals.

Figure 7: Rutherford Avenue Traffic Volume
Source: ITDP.

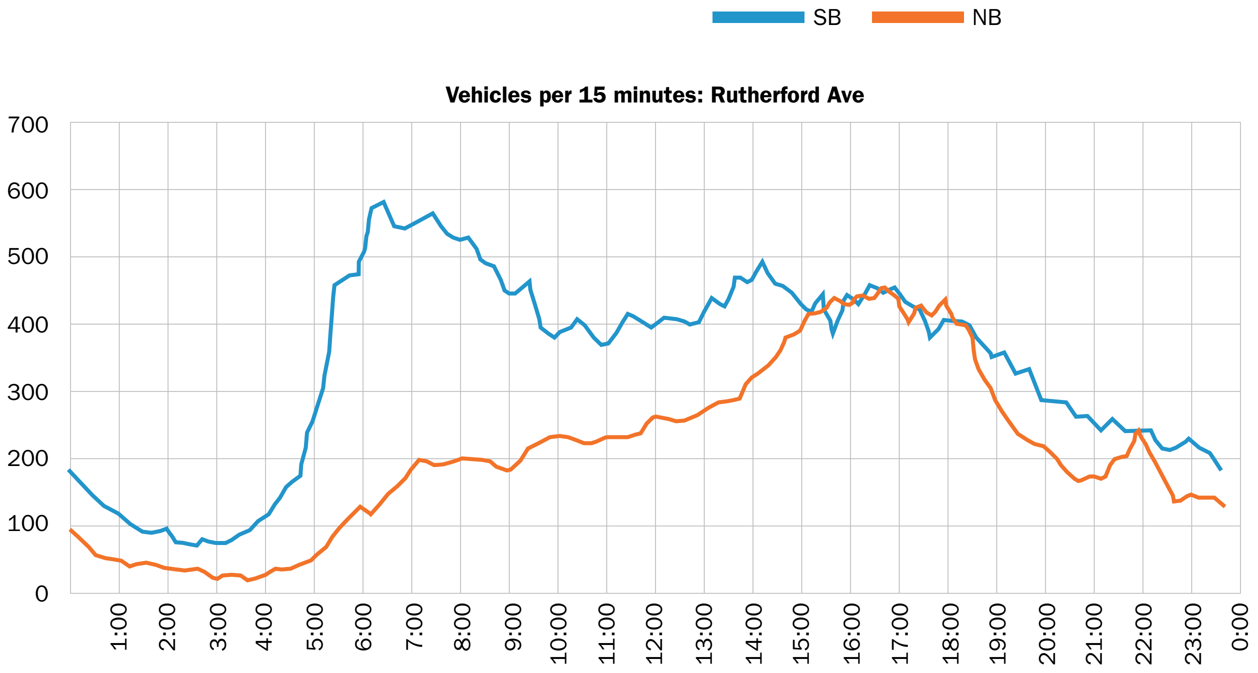
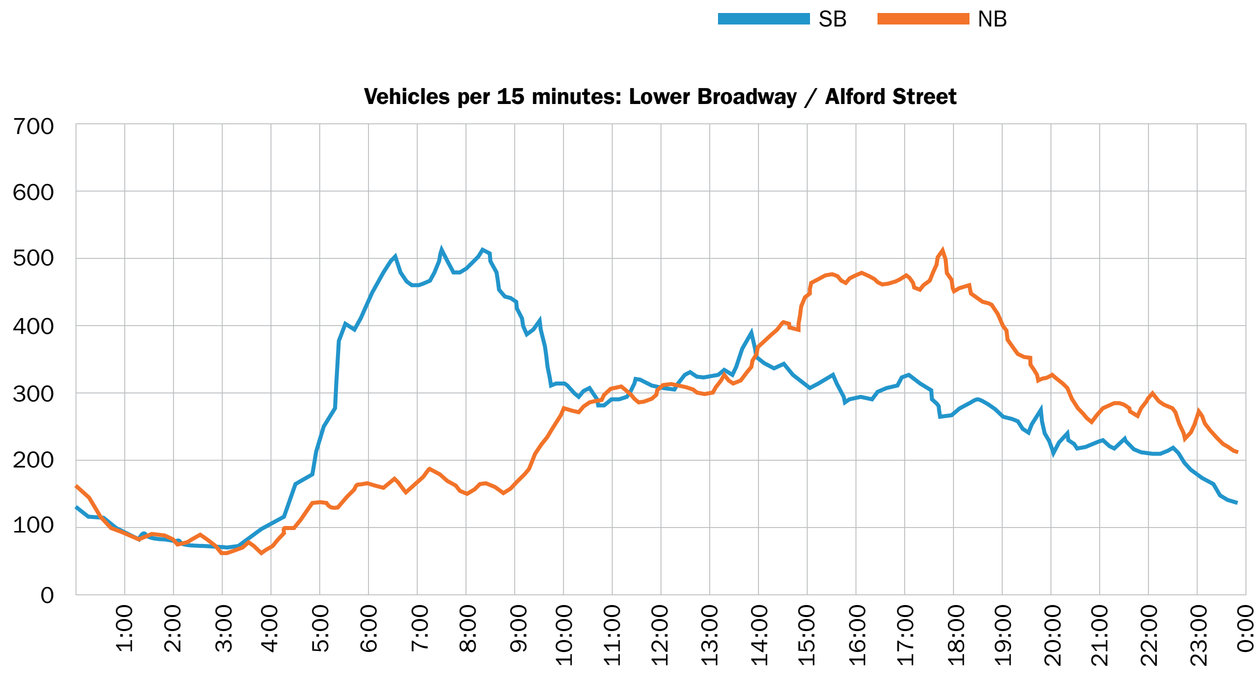


Figure 7 shows traffic on Rutherford Avenue in the vicinity of the North Washington Bridge. Traffic shows distinct rush-hour peaks, with the **highest volumes observed during the morning rush hour between 6 a.m. and 8 a.m.**, then dropping during the later part of the morning commute—likely due to throughput issues stemming from downstream congestion, possibly combined with upstream bottlenecks that reduce traffic generation. During the peak hour, volumes of over 2,200 vehicles per hour are observed. Northbound volumes are quite low during the morning rush hour, however, with observed volumes of no more than 800 vehicles per hour. **This underscores the need for a southbound bus lane on the North Washington Bridge and suggests that a northbound bus lane may be reasonable as well.**

Southbound traffic remains relatively steady throughout the day and exceeds northbound traffic at all times except during the evening rush hour, when they are approximately even (**Figure 7**). This is likely due to the layout of the roadway into and out of the narrow Boston street grid, where there is only limited traffic generation due to upstream bottlenecking. Even more so, the availability of an off-ramp into Sullivan Square at Cambridge Street, which was installed as part of the Big Dig, gives northbound traffic a direct path of travel to Charlestown, parts of Somerville, and Everett, while there is no corresponding southbound ramp south for the McGrath Highway near Assembly Square. (Instead of entering I-93 near Sullivan Square, southbound traffic continues down Rutherford Avenue and enters near City Square. This is the corresponding southbound movement but is located approximately a mile away.) Overall, **this leads to a 3-to-2 difference between southbound and northbound traffic**. Northbound traffic, during the evening rush hour, peaks at only about 1,700 vehicles per hour. These data suggest that **with no more than 1,100 vehicles per lane per mile (and at most times, significantly less than that), no more than two lanes are required for vehicular throughput anywhere along the Rutherford Avenue corridor**.

Figure 8: Alford Street Bridge Traffic Counts
Source: ITDP.

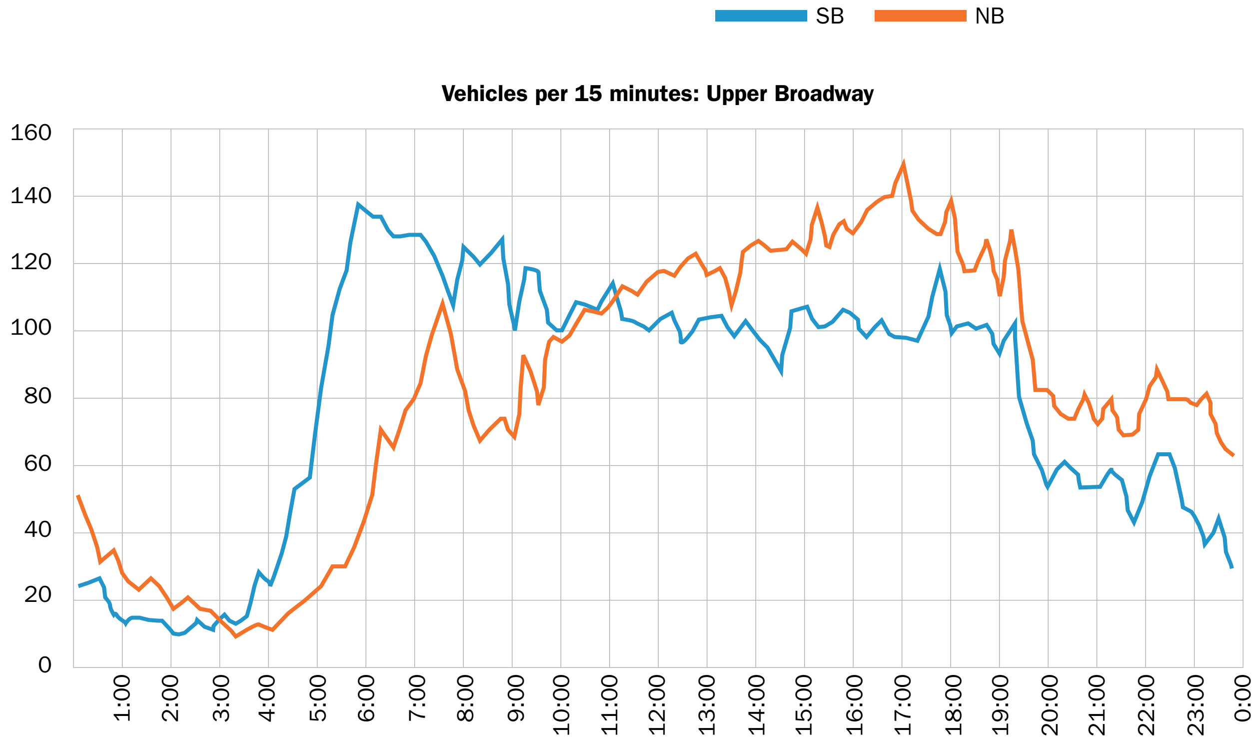


North of Sullivan Square, traffic volume between northbound and southbound traffic is more evenly split (**Figure 8**). The peak volumes are similar to those farther south on Rutherford Avenue, with about 2,000 vehicles per hour at peak periods. During the morning peak, northbound traffic is quite low—in the range of 600 to 700 vehicles per hour. Volumes then increase to about 900 vehicles per hour during midday. This suggests **that traffic volumes there are quite low, and "borrowing" a lane from northbound traffic at rush hour to run southbound buses in a contraflow/center-running lane would work**. Evening reverse-peak traffic volumes are higher, and that would make it more difficult to have a contraflow lane during the evening commute.

These traffic counts are within 5% of daily traffic counts obtained before the opening of the Encore Casino.

Bicycle volumes were generally in the range of 100 to 200 per day, although that may have been artificially low because of the time of year. These counts do suggest that a bus/bike lane to bypass traffic on the Alford Street Bridge for buses leaving Sullivan Square would have only a minimal impact on both bicyclists (who would have the potential to be trailed across the bridge by a bus) and buses (which might have to follow cyclists on the bridge, although this would still be faster than nearby traffic). A pathway connection adjacent to the Eastern Route railroad bridge between the Encore Casino and Assembly Row would probably reduce some of the demand for bicycles on the roadway.

Figure 9: Upper Broadway Traffic Counts
Source: ITDP.



Traffic on Upper Broadway in Everett is significantly lower than south of Revere Beach Parkway (Figure 9). There are small peaks during the morning and evening rush hour periods, which are small compared with those observed in other parts of the corridor. Morning traffic actually peaks before 6 a.m., with a reverse-peak observed at 7:30 that may be related to school activities. Traffic volume ranges between 400 and 600 vehicles per hour in each direction between 10 a.m. and 8 p.m. The relative uniformity of these data show that there is minimal commuting traffic, with the exception of the early-morning inbound peak between 5 a.m. and 7 a.m. **These data suggest that much of the traffic on Upper Broadway is local traffic, not pass-through traffic between other communities.**

While the 2020 traffic counts did not take place in the same locations as previous counts on Rutherford Avenue itself, a count along the Alford Street Bridge just north of Sullivan Square shows the rate of growth of traffic was slower from 2015 to 2020 compared with 2008 to 2015:

- 2008: 48,480 (City of Boston)
- 2015: 50,195, 0.5% growth per year (City of Boston)
- 2020: 51,248, 0.4% growth per year (ITDP/AECOM)

TRAFFIC COUNT NOTES

The casino has now been open for more than one year, with minimal impacts on traffic. A recent traffic analysis undertaken by ITDP—conducted using Automated Traffic Recorders (ATRs) placed at Rutherford Avenue near Bunker Hill College from January 9, 2020 to January 15, 2020—shows traffic volumes mostly unchanged from 2015 pre-casino counts from the City of Boston.[12] The Alford Street Bridge, which had been reduced in lane number for construction, was fully reopened by this time.[13]

These traffic counts were conducted in 15-minute intervals, and this level of detail shows how traffic varies during the day. The highest volume per lane per hour is 1,100, which is well below the threshold where congestion occurs because of volume alone. The highest single traffic volume (about 2,200 per hour) occurs between 6 a.m. and 7 a.m. inbound, when casino activity is at its low point. Afternoon traffic (1,600 per hour in each direction, or 800 per lane) is significantly lower, and there is very little difference between afternoon peak traffic and traffic during the midday, suggesting that while the casino might increase overall traffic, it is spread out over the course of the day and that people may actually avoid driving to the casino when the roadways are otherwise congested. There is less northbound traffic than southbound as well, since a good deal of northbound traffic uses I-93 and the Cambridge Street/Sullivan Square exit ramp, for which there is no southbound equivalent.

12 City of Boston 2016.
13 Jessen 2018.

While the 2020 traffic counts did not take place in the same locations as previous counts on Rutherford Avenue itself, a count along the Alford Street Bridge just north of Sullivan Square shows that the rate of growth of traffic per year was actually slower from 2015 to 2020 (.4% growth/year) than it was from 2008 to 2015 (0.5% growth/year).

APPENDIX

E

STREETLIGHT DATA

ORIGIN-DESTINATION ESTIMATES FROM CELL PHONE DATA

Additional data was obtained from Streetlight, which uses cell phone data to estimate travel between user-defined zones. For the purposes of this study, 10 zones were defined around the Everett–-Boston corridor to estimate travel demands. The data were collected during the second half of 2019, after the casino had opened. The zones were defined as follows:

1. Everett north of Revere Beach Parkway
2. Everett south of Revere Beach Parkway
3. Charlestown (including Sullivan Square)
4. Downtown Boston
5. Seaport
6. Back Bay, Fenway, Longwood Medical Area
7. East Boston and Winthrop (including Logan Airport)
8. The balance of Boston and Brookline
9. Cambridge and Somerville
10. Cities and towns immediately surrounding Everett to the north (Medford, Chelsea, Malden, Revere, Melrose, Saugus)

These data do not show traffic flows along any particular corridor, but do help us to understand the general traffic flow in the corridor. They also do not show travel to and from particular locations, like the Encore Casino, which would require additional data collection and purchase. These data are mostly focused on flows from Everett to Boston given the scope of this project.

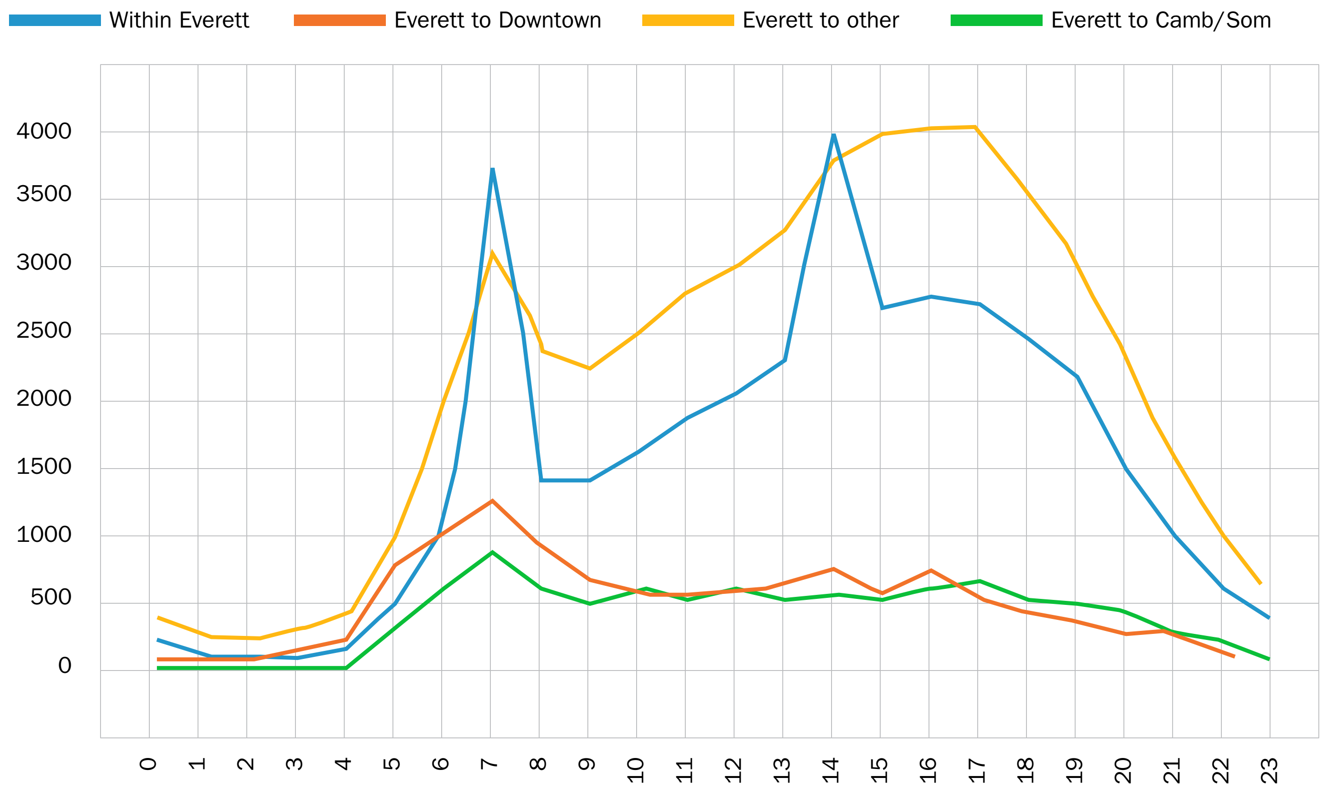
Some notes on the Streetlight data. Streetlight allows data to be disaggregated on an hourly basis and day types of :

- Weekday (Monday to Thursday)
- Weekend (Saturday to Sunday)
- All days

This allows us to look at changes in traffic by time of day, which we can then compare to the traffic counts on nearby roadways. Most traffic originating within Everett is not traveling to downtown Boston but rather within Everett or from Everett to the geographically larger zones defined in the study area.

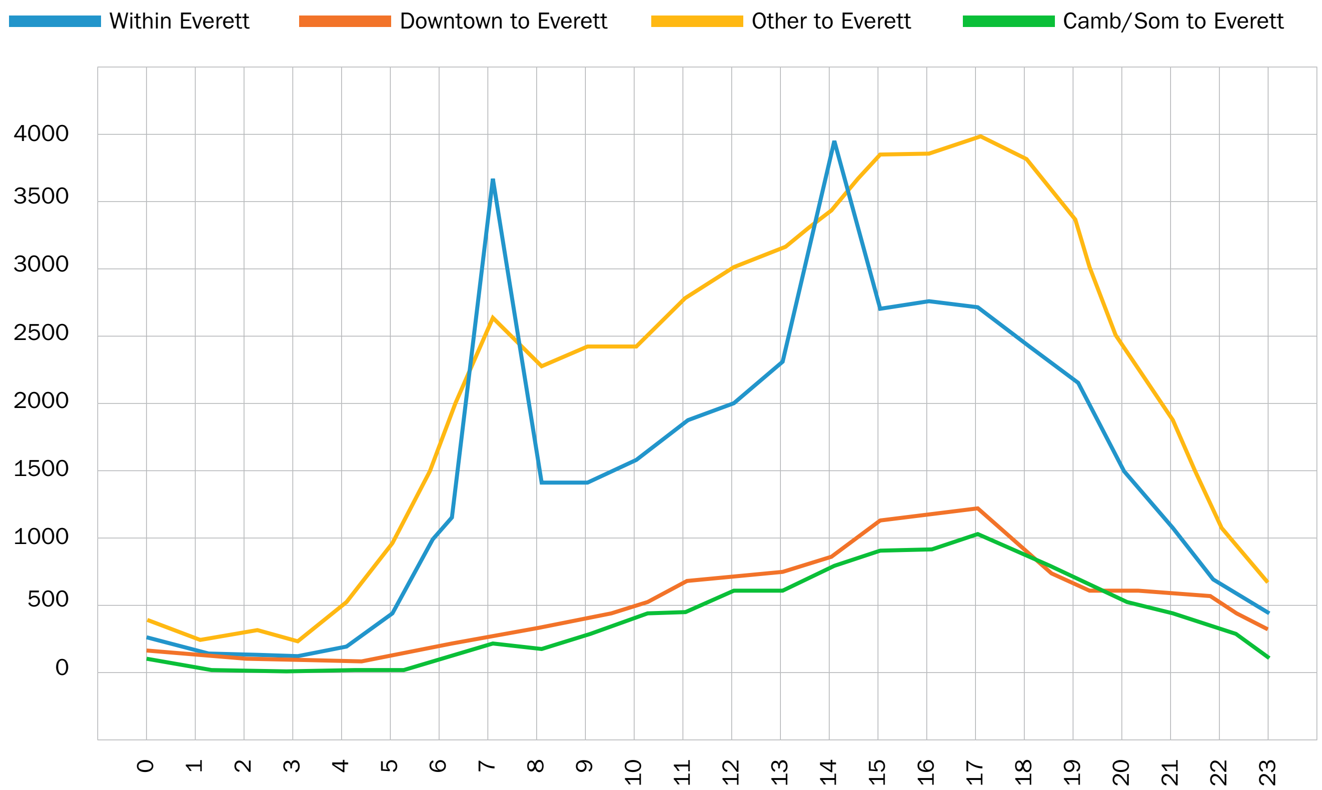
Figure 10 shows trips originating in Everett (note that for these charts, the axis shows hours of the day).

Figure 10: Number of Trips Originating in Everett by Destination
Source: ITDP.



And Figure 11 shows travel to Everett:

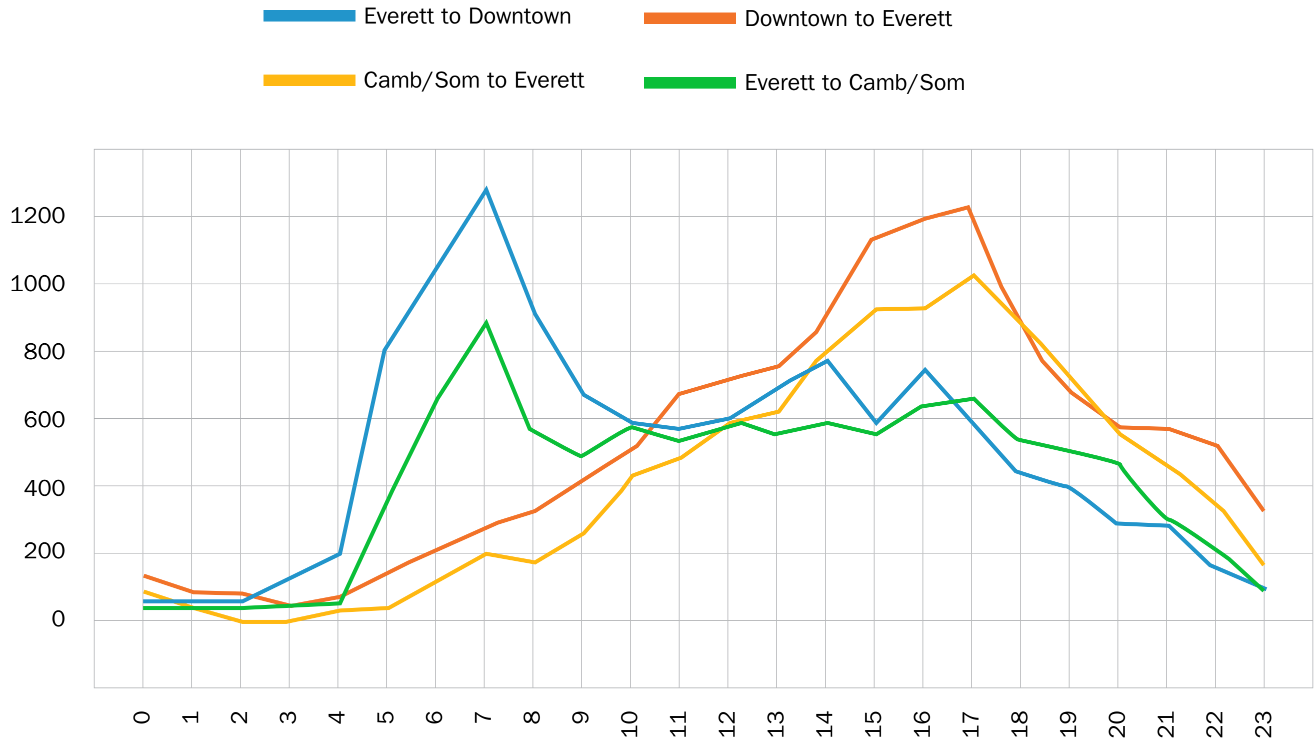
Figure 11: Number of Trips Destined for Everett by Origin
Source: ITDP.



During the peak travel periods, about one in four trips in the peak direction to and from Everett are going to downtown Boston, Cambridge, or Somerville, which are transit-accessible areas where transit trips would make use of the BRT corridor on Broadway. *It must be noted that this is only pertinent to travel between Everett and adjacent towns and does not include trips from Everett to communities further from the study area like Lynn, Waltham, or Quincy.*

We can look more closely at those trips as follows (**Figure 12**).

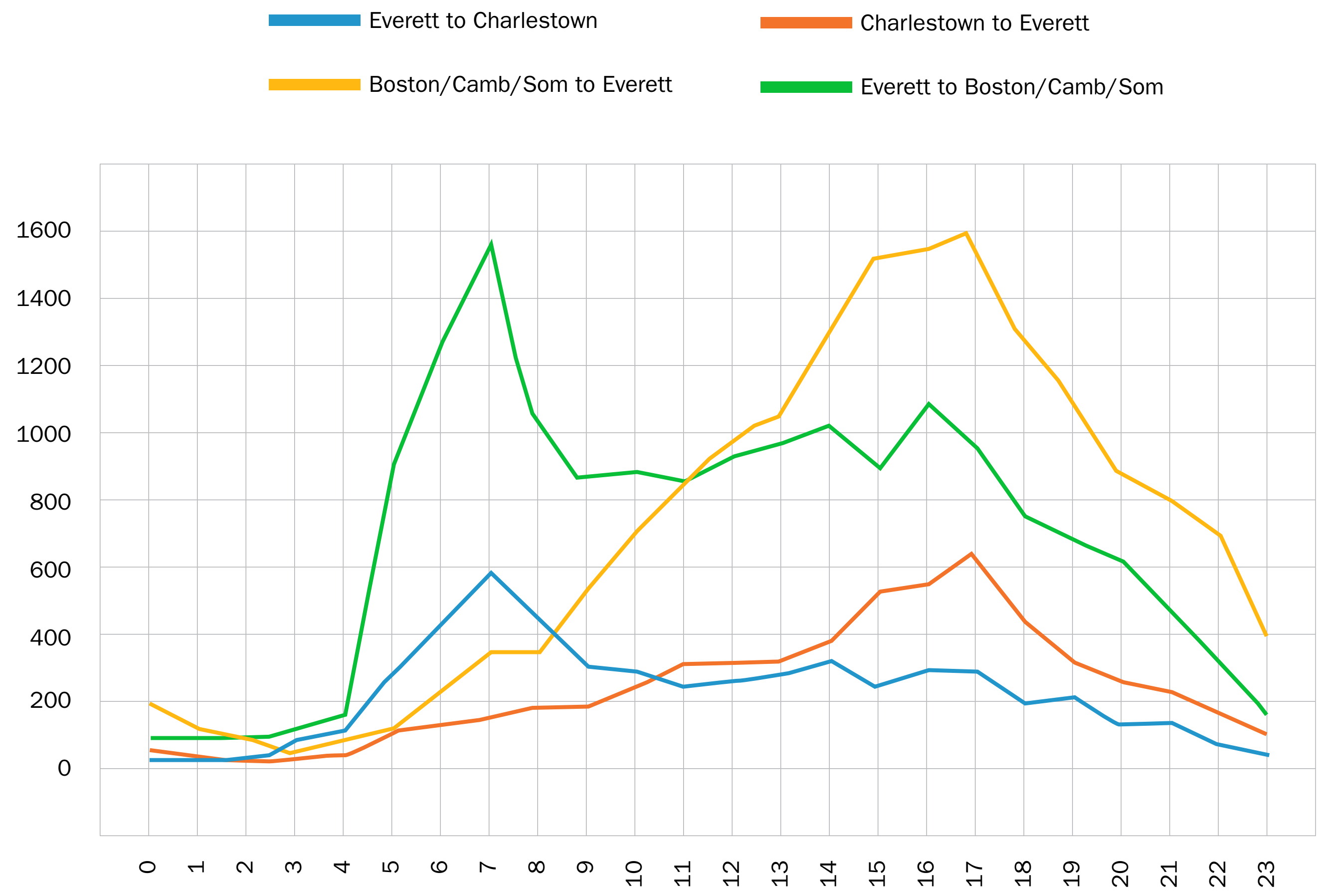
Figure 12: Number of Peak-hour Trips To and From Everett
Source: ITDP.



It is particularly interesting to note how unbalanced the traffic flows are between Everett and Boston/Back Bay and Cambridge/Somerville. In those cases, there is nearly four times as much traffic in the evening as the morning for Everett-bound trips, suggesting a high proportion of commuting. This is observed less in other traffic patterns, whether it is within Everett or to and from other areas. In those cases, there is much less of a ratio, suggesting more balanced flows during the day. This affirms the traffic counts on Upper Broadway, which show relatively even traffic flows during the day.

One note is that Streetlight does not allow us to break out data between driving trips and transit trips. A trip from Everett to Boston, Cambridge, or Somerville may be coded as a single trip or as two trips, depending on the amount of time spent transferring at Sullivan Square. Figure 13 shows the number of trips between Everett and Charlestown, many of which are likely legs of transit trips between Everett and other communities.

Figure 13: Number of Trips Between Everett and Charlestown
Source: ITDP.



COMPARING STREETLIGHT DATA AND TRAFFIC COUNTS, AND INTEGRATING TRANSIT DATA

By comparing Streetlight and Traffic Count data, we can estimate the proportion of users on these roadways (particularly south of Revere Beach Parkway) who are traveling to transit-accessible locations from Everett. During peak commuting times, there are approximately 2,000 trips per hour from Everett to Charlestown/Downtown Boston and Cambridge/Somerville, with about an even split between these two destinations. Most of these trips would be made using the Alford Street Bridge. There are another 400 trips from Everett to the portion of Boston south of downtown/Back Bay, and additional trips to areas outside of the study area. This suggests a demand of 1,800 trips per hour from Everett to Boston excluding East Boston (most of which would use the Alford Street Bridge) with an additional demand of about 1,000 trips to Cambridge and Somerville. Most of these trips could conceivably be served by transit, and, in fact, there are currently about 1,000 trips per hour from Everett to Sullivan during the A.M. peak.

This gives us a ceiling for the current demand for travel between Everett and areas to the south. The City of Everett has approximately 40,000 people; 1,000 trips represents 5% of all residents and about 20% of people traveling at peak hour. During this peak hour, there are approximately 20 buses, and we have inferred, from ODX data discussed later, that approximately 75% of people on these buses are transferring on to the Orange Line. Given ridership analysis, there are approximately 800 passengers on these buses, of whom about 600 are going to the Orange Line (or a bus transfer at Sullivan). Not all take the Alford Street Bridge; some take a bus to Wellington.

Currently approximately 1,600 people from Everett have a desire path on the Alford Street Bridge, and today about 40% are using transit (some of these vehicular trips are longer-distance traffic for trips where transit would be more difficult). There are few transit or car trips that begin to the north of Everett and come through the city: Automobile traffic feeds onto routes 1 and 93, which bypass the city, and transit lines from the north feed into Malden to transfer to the Orange Line. Furthermore, directly north of Everett there is little catchment for transit: The area is dominated by parkland and cemeteries and auto-oriented uses along Route 1, which would take a major redesign of the region to be more transit-friendly.

A faster trip by transit, however, could be appealing for many Everett residents who are not currently taking transit. Of the 1,000 Everett trips that use this corridor and go to downtown Boston, a mode shift of 50% would account for 25% of the peak traffic on the Alford Street Bridge feeding into Sullivan station. This would be a high mode shift and may not be possible with current infrastructure, but as there is more development in Everett, there may be more demand for transit service, as the roadway network is at or near capacity, and the city plans for minimal parking in new transit-oriented areas.

STREETLIGHT DATA NOTES

These counts took place when Route 1 and the Tobin Bridge were limited to two lanes in each direction, so there may have been some spillover traffic onto other roadways, although this is difficult to quantify. A further analysis of AET toll data might suggest how Route 1/Tobin Bridge traffic has fallen, but it would be more difficult to trace these travel patterns to other roadways (although a more in-depth Streetlight analysis may work toward this end).

APPENDIX

F

MIT MBTA ODX MODEL

TRANSIT ORIGIN-DESTINATION-TRANSFER (ODX) DATA

It is important to investigate the destinations of Everett transit passengers, since where passengers from Everett are going will impact the efficacy of the BRT, especially if routes are extended beyond Sullivan. Today many passengers trying to get to the Orange Line may simply take whatever bus comes first: For instance, a passenger at Everett Square can choose between the 104 and 109, which provide service to Sullivan Square, and the 97, 110, and 112, which provide service to Wellington, combining a slightly shorter bus ride with a slightly longer train ride.[14] (**See Appendix A** for a more detailed description of how passengers utilize bus–rail transfers in Everett.)

For passengers going to downtown Boston, a BRT providing direct service would provide a one-seat ride with—depending on the downtown route—an equal or even faster overall travel time. It would also reduce the “friction” encountered by less able-bodied passengers, who currently transfer at Sullivan. However, passengers destined for other areas, particularly those farther into the core of downtown, in Back Bay, the Longwood Medical Area, or elsewhere requiring a transfer, may still wish to make these transfers farther upstream—at Wellington or Sullivan—since even with the most aggressive transit priority, the grade-separated rapid transit service will still be faster than a parallel surface route. This allows analysis of which passengers will be most affected by BRT service and how extensions of BRT beyond the North Station–Haymarket area can increase the proportion of passengers who can use a one-seat ride instead of making a transfer.

To answer these questions, ITDP used data from the MBTA’s Origin–Destination–Transfer (ODX) data set, developed by MIT.[15] We used a typical time of year and looked at the relative prevalence of destinations and transfers for people with origins in Everett. ODX works by inferring the destination of a passenger based on their next transit interaction, so it does not measure every passenger—those using cash to pay or whose travel patterns include another nontransit trip in between cannot be detected by the system. However, this is not a tool to calculate the exact number of boardings; rather, it shows the relative destinations. We can then use actual boarding counts to scale the ODX data to the full set.

14 Originally all Everett routes were planned to terminate in Wellington, but they were relocated to Sullivan after complaints about the lack of transit service to Lower Broadway following the closure of the transfer station there (Belcher 2021).

15 Vanderwaart 2016.

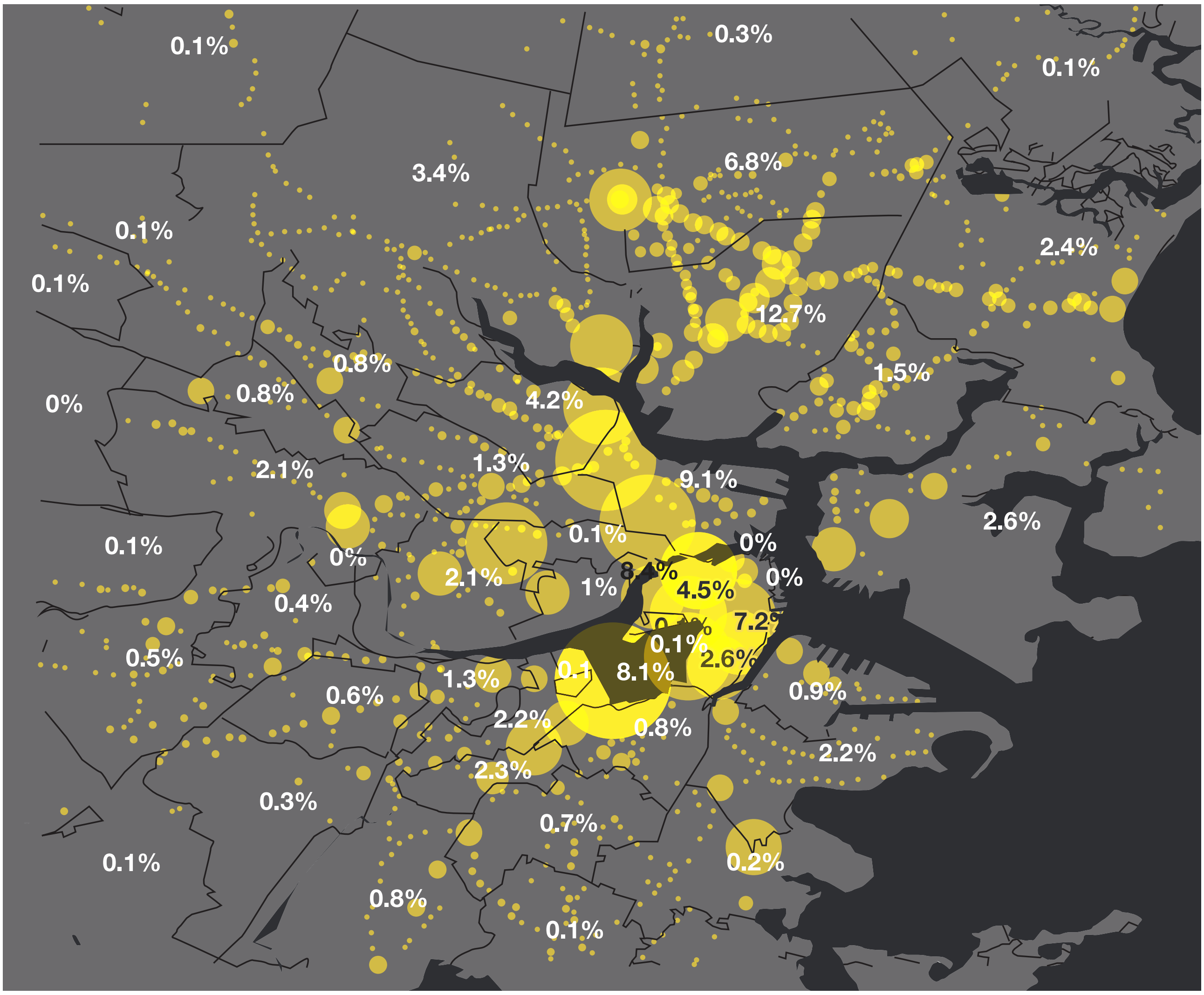


Figure 14: Destination bus stop/station of passengers boarding in Everett. ZIP codes are overlaid, showing the percent of total trips ending in each ZIP code. **SOURCE:** ITDP with MIT ODX Data

Based on these data, the following trends are observed:

- **Approximately one in four passengers boarding a bus in Everett has a destination in downtown Boston**, for which they currently have to make a transfer at Sullivan, but where a direct bus would create a one-seat ride.
- However, the transfer at Sullivan is important, because **there are an additional one in three passengers going beyond downtown Boston on the Orange Line or going to Cambridge and Somerville** who would likely make use of the transfer points there. Ridership in Cambridge and Somerville is quite distributed; there is no single destination point or bus route that has significantly more ridership than any other, so it is difficult to recommend a specific destination that would be logical to extend as a bus route from Everett. Such a route would be used by additional travelers transferring from the Orange Line, however, which may suggest a specific desire pathway.

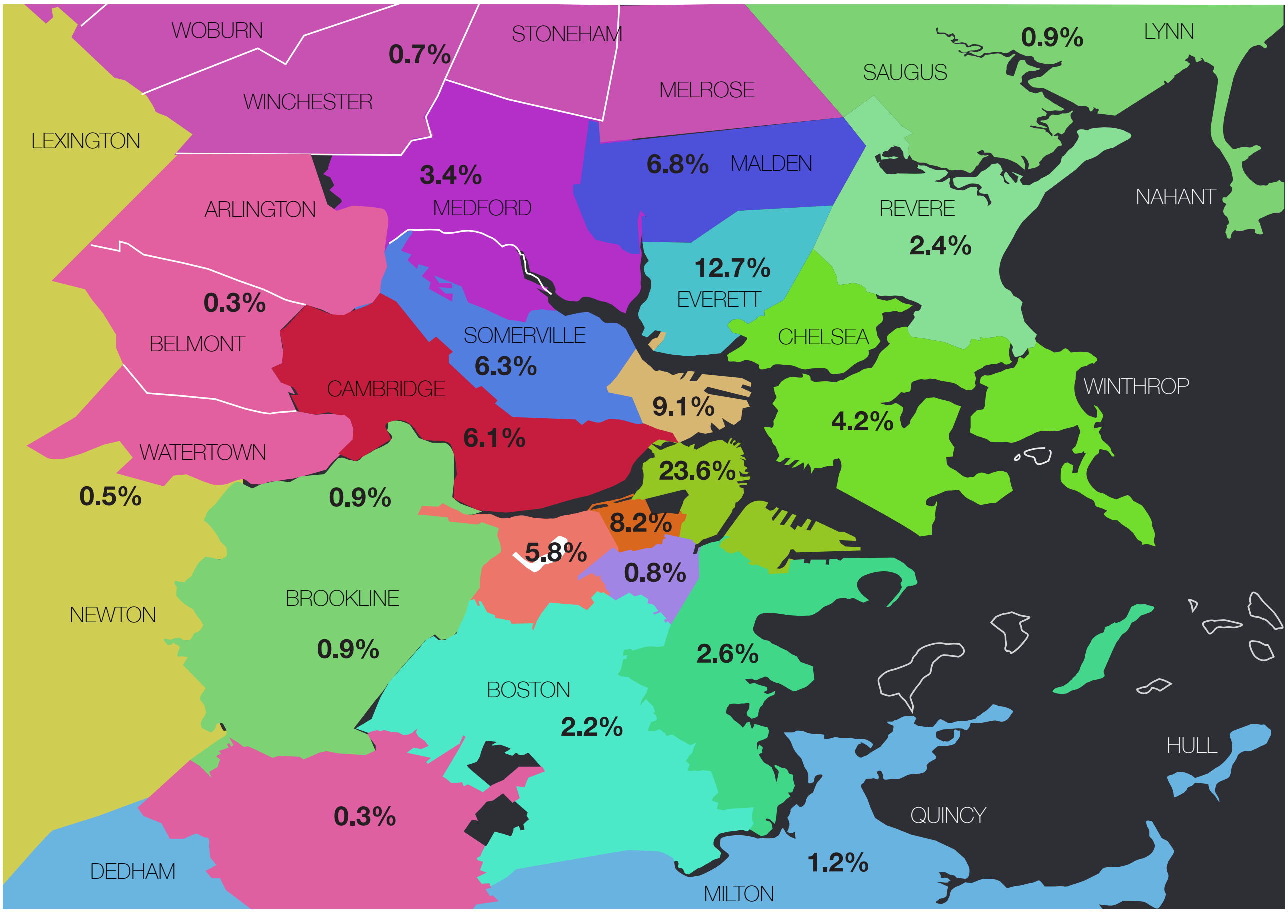


Figure 15: Destinations for Everett-based commuters by groups of Zip Codes (colors)
SOURCE: ITDP with MIT ODX Data

ODX MODEL TRANSFER ANALYSIS

Everett is the most densely populated municipality in Massachusetts that lacks any rapid transit service or a "key" bus route as defined by the MBTA. However, it has relatively frequent bus service to connect to rapid transit, chiefly the Orange Line. From Everett Square, there are five bus routes to the Orange Line—the 97, 110, and 112 to Wellington Station and the 104 and 109 to Sullivan Square. The schedules for these routes are not particularly well-coordinated, but combined, they provide service to an Orange Line transfer point every three to four minutes at rush hour. This begets the question of whether travelers at this stop wait for a specific bus route (or a bus to a specific transfer point) or simply take the first bus which arrives, since the total travel time to their destination on the bus and Orange Line varies little whether they transfer at Wellington or Sullivan Square (and, depending on the weather or other conditions, they may be willing to take a slightly longer route to avoid time waiting at the stop, which is usually perceived as longer than time on the transit vehicle). For instance, a passenger at Everett Square can choose between the 104 and 109, which provide service to Sullivan Square, and the 97, 110 and 112, which provide service to Wellington, combining a slightly shorter bus ride with a slightly longer train ride.[16]

16 Originally, all Everett routes were planned to terminate in Wellington, but relocated to Sullivan after complaints about the lack of transit service to Lower Broadway following the closure of the transfer station there (Belcher 2021).

The ODX data can be used to examine these behaviors. Based on these data, it is clear that while some passengers may wait for a bus to a specific transfer point, most board whichever bus comes first. If we look at frequent transit users,[17] we find that, aside from a few users who make at least two-thirds of their trips on a single route, most people make less than half of their trips on any single route.

Furthermore, if we split these data by just looking at trips that end at either Sullivan or Wellington, we find that some people (about 17% of the data set) use a specific transfer point, probably because they are transferring to a bus specific to that point or have a destination nearby. However, the majority of people seem to use the two transfer points interchangeably, or close to it.

This presents a problem for the reverse trip where travelers must choose a transfer point between the two. Some savvy travelers may look at real-time bus departure information on mobile devices before choosing whether or not to exit the train at Sullivan or Wellington; others may rely on schedules or past experiences. For all intents and purposes, however, **the average wait time at a transfer point for an outbound trip is double that of an inbound trip.** Concentrating service at a single point, or making it more frequent, would help reduce some of this wait time. Providing connecting bus information on heads-up displays onboard trains arriving at each station—which may be possible with the new Orange Line rolling stock—would also aid this integration.

Of the 700 inbound travel cards analyzed, approximately 400 also have at least 20 outbound trips that use the Orange Line and a bus headed to Everett. Significantly different patterns are observed for outbound trips, and it appears quite clear that outbound transit riders generally choose one specific transfer point. Some of this difference may have to do with the eventual destination of a bus—it might make sense for a passenger to go to a high-frequency stop for inbound traffic even if it is slightly farther from their origin, while for outbound travel, they may choose whichever bus gets them closest to their destination, even if it means choosing a bus with lower frequency. Still, this results in significantly longer wait times: Since bus frequencies are generally split evenly between Sullivan and Wellington, passengers would have to wait approximately twice as long for a bus no matter which transfer point they choose.

17 People who had at least 20 boardings over a 90-day study period are considered frequent transit users. See Appendix A for more discussion.

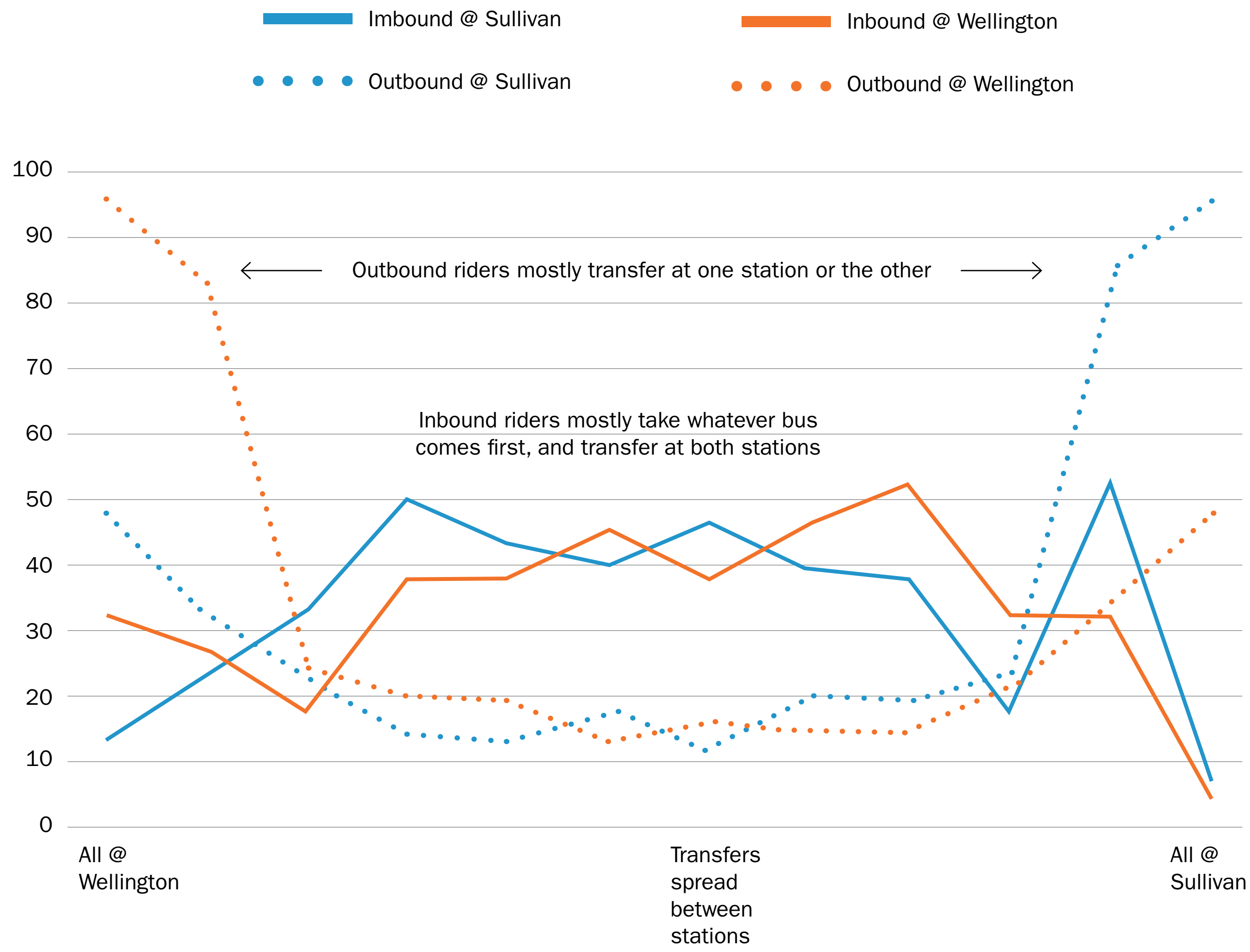


Figure 15: Transfer behavior for frequent Everett travelers at Sullivan and Wellington. Inbound passengers generally show a pattern where they use a combination of stations, while outbound passengers tend to choose to transfer at one station or the other. **Source:** ITDP with MIT ODX Data

APPENDIX

G

EVERETT PARKING STUDIES

EVERETT PARKING OVERVIEW: UPPER BROADWAY

SUMMARY/KEY FINDINGS:
SOURCES:
MAPC 2016a and 2016b, Stantec 2019.

Overall, parking is most utilized *on-street* and during the late-morning and early-afternoon hours. Off-street parking opportunities are extremely underutilized and present the biggest opportunity for shared parking programs that can help move cars from Broadway to create room for BRT.

BROADWAY ON-STREET UTILIZATION

- 46 on-street spaces from Sweetser Circle to Second Street (MAPC, May 2016)
- 61 on-street spaces from Whittier School to City Hall (MAPC, July 2016)
- Peak weekday: 11 a.m., with **76% occupancy**
- Peak weekend: 11 a.m., with **80% occupancy**
- The average parking duration for on-street spaces was 96 minutes during weekdays and 102 minutes on Saturday. (MAPC, July 2016)

OFF-STREET UTILIZATION

- 228 off-street public spaces, Everett Square (MAPC, July 2016)
    - Peak weekday: 12 p.m., with **69% occupancy**
    - Peak weekend: 12 p.m., with **57% occupancy**
- Municipal parking lots are the most underutilized. Every municipal lot had at least **30% parking availability** even during peak times. (MAPC, July 2016)

EVERETT SQUARE
(ON- AND OFF-STREET TOGETHER) (MAPC, JULY 2016)

- Peak weekday: 11 a.m., with **71% occupancy**
- Peak weekend: 11 a.m., with **68% occupancy**
- Busiest parking areas are on-street, near Broadway and City Hall.

SHARED PARKING OPTIONS (STANTEC, 2019)

- Stantec estimates: 683 off-street private spaces
- Total off-street (public and private): ~900 spaces
- Notable owners
  - Roman Catholic Archbishop of Boston
    - 3 Lots, 77 spaces
  - New Creek, LLC (Glendale Square Shopping Area)
    - 2 lots, 175 spaces
  - Everett Broadway Retail, LLC
    - Rite Aid Parking Lot, 82 spaces
- Moving forward with shared parking
  - We need to understand the utilization of these lots by their current owners (Archbishop of Boston likely has peak utilization on Sundays/weekends, for example).
  - Zoning requirements need to be changed/amended. Currently, zoning requires almost as much square footage of parking as active use.
    - No shared parking provision
    - No reductions available
    - No Transportation Demand Management required

EVERETT SQUARE URBAN REVITALIZATION PLAN (2019)

- Four municipal surface parking lots within Urban Revitalization Area
- "The new overlay district will also establish reduced off-street parking requirements instead of relying more on shared public parking, public transportation, and lower vehicular trip generation rates associated with the walkable, mixed-use type of development envisioned."

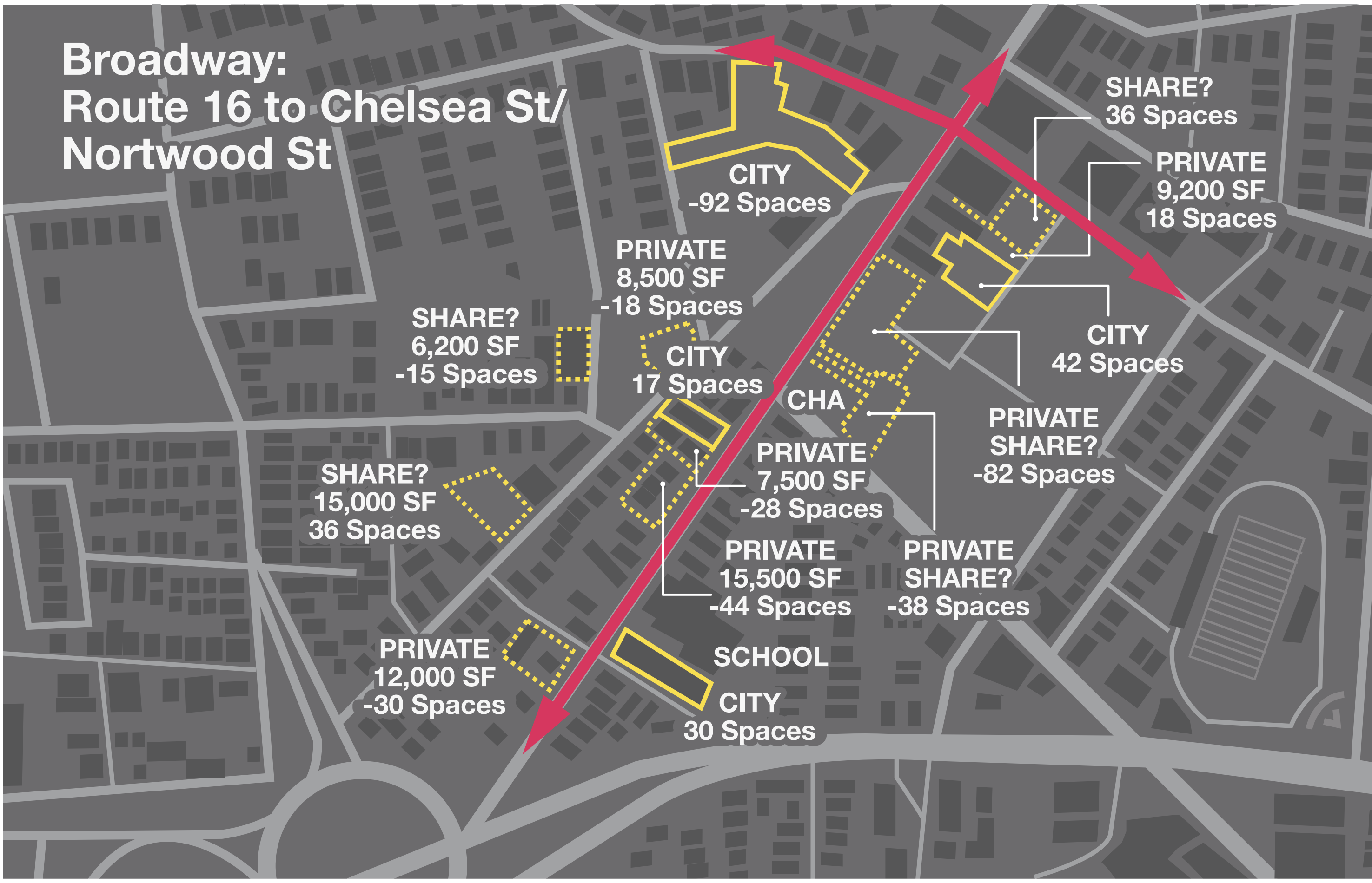
BROADWAY PARKING UTILIZATION (MAPC, 2016)

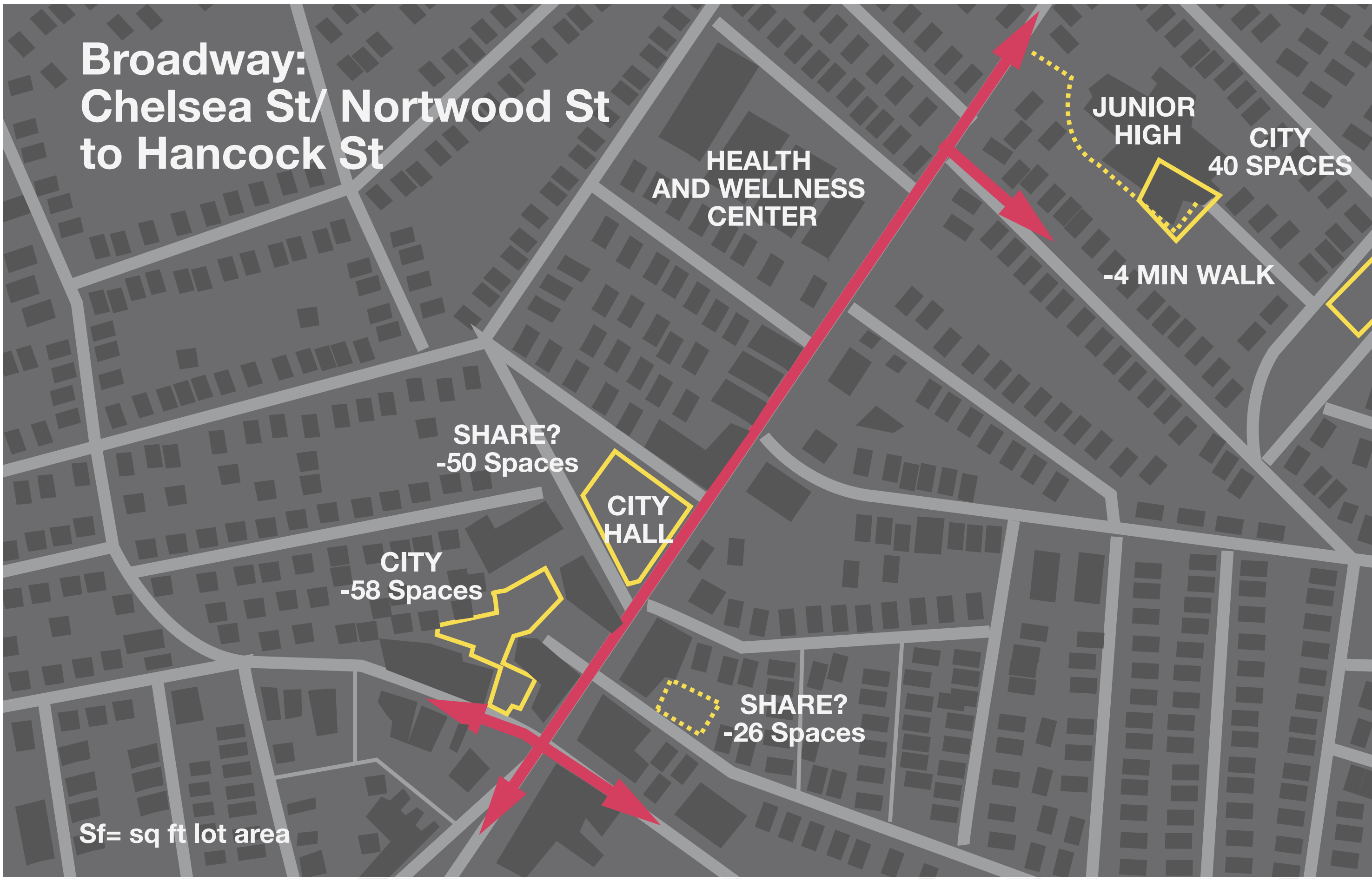
- 453 public parking spaces (on-street and surface lots)
- Peak weekday parking was 11 a.m., with 70% of all spaces being utilized.
  - Highest between 10 a.m. and 2 p.m., but occupancy never surpassed 71%.
- Saturday peak occupancy was 11 a.m., with the range as a whole from 11 a.m. to 1 p.m., with 68% of all spaces being utilized.

- Busiest parking areas are on-street, near Broadway and City Hall.
- Municipal parking lots are the most underutilized; they all had at least 30% parking availability on weekdays and Saturday, even during peak times.
- The average parking duration for on-street spaces was 96 minutes on weekdays and 102 minutes on Saturday.

EVERETT TRANSPORTATION STRATEGY (STANTEC, 2019)

- Main Street Parking Alternatives:
  - Through shared parking agreements, potential to access nearly 200 spaces for public use nearby
  - In some cases Everett's current zoning code requires almost as much square footage of parking as active use. Requirements include:
  - No shared parking provision
  - No reductions available
  - No bicycle parking requirements
  - No Transportation Demand Management required
  - Parking currently required by zoning: 23,000
  - Current parking shared demand: 14,000


Broadway:
Route 16 to Chelsea St/ Nortwood St
CITY
-92 Spaces
SHARE?
36 Spaces
PRIVATE
9,200 SF
18 Spaces
PRIVATE
8,500 SF
-18 Spaces
SHARE?
6,200 SF
-15 Spaces
CITY
17 Spaces
CITY
42 Spaces
CHA
PRIVATE
SHARE?
-82 Spaces
SHARE?
15,000 SF
36 Spaces
PRIVATE
7,500 SF
-28 Spaces
PRIVATE
15,500 SF
-44 Spaces
PRIVATE
SHARE?
-38 Spaces
PRIVATE
12,000 SF
-30 Spaces
SCHOOL
CITY
30 Spaces


Broadway:
Chelsea St/ Nortwood St to Hancock St
JUNIOR HIGH
CITY
40 SPACES
HEALTH AND WELLNESS CENTER
-4 MIN WALK
SHARE?
-50 Spaces
CITY HALL
CITY
-58 Spaces
SHARE?
-26 Spaces
Sf= sq ft lot area

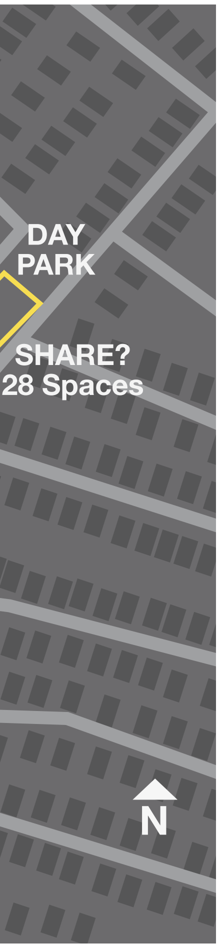


Figure 17: Existing Off-street Parking Could Support Shared Parking and Create Space for BRT Lanes Along Upper Broadway
SOURCE: ITDP

APPENDIX

H

ACCESS TO JOBS FROM EVERETT ANALYSIS

As a foundation for the BRT corridor planning, it is important to consider how an improved transit network could allow better access to more opportunity. For instance, there are relatively few people who live in Everett and commute to Kendall Square for work, possibly because it requires a bus transfer to a low-frequency route[18]. A direct trip to Kendall using a BRT route would make the jobs there more accessible to Everett residents by transit (and with bus priority, than car travel as well), although it also may make Everett a more attractive location for highly paid technology workers in Kendall.

ITDP's goal with this analysis was to measure the difference between the current transit route structure and several aspirational variants. This will not be a predictive ridership model, because the number of variables to input—including increased housing, changes in traffic patterns, as well as rider behavior regarding transfers and walking time—would create a model with a highly variable outcome and require resources beyond what is available for this project. ITDP plans to work with the regional MPO on a larger modeling study in coming months that will look at these routes and further inform how mode shift with a BRT may occur. In this initial analysis, we looked at the increased opportunity to travel to destinations—in the case of the tool we are using, to various employment opportunities—based on changes to the transit network.

HOW BUS IMPROVEMENT SCENARIOS CHANGE ACCESS TO JOBS

We used Conveyal and LODES[19] data (see next subsection) to show access to employment opportunities, which in many ways is a proxy for accessibility to other opportunities, such as medical, educational, cultural, and recreational opportunities.[20] We analyzed how different bus transit improvements in Everett change access to employment opportunities. The selected scenarios address the key issues with the existing transit service in Everett: low frequency, low speeds, and poor connections to downtown Boston and Cambridge/Somerville. The different modeled scenarios are discussed here and summarized in figures 18 and 19.

SCENARIO 1:
IMPROVING THE SPEED OF THE 104, 105, AND 109 BUSES.

Today the 104/105/109 bus runs in mixed traffic, covering its 4.25-mile route in a scheduled time of between 19 and 43 minutes, depending on the time of day. This equates to an average speed that ranges from a high of 13 miles per hour at off-peak times to as slow as 6 mph during the morning peak, although actual service times are generally a bit faster, averaging 7 mph.

18 The CT2 route runs only every 20 minutes at rush hour. While the trip is scheduled to take 18 to 25 minutes, it is susceptible to traffic and fewer than half of trips adhere to schedule. MBTA 2018.

19 LODES stands for LEHD (Longitudinal Employer-Household Dynamics) Origin-Destination Employment Statistics. LODES data combines census data with tax reporting data to match employees to employers to look at journey-to-work data.

20 For this report, we are examining the full "total jobs" data set, but we can also run similar analyses for other categories of jobs by sector, income, or education requirements.

However, this is the speed of a relatively slow jog! Improving the bus route's speed to an average of 10 mph to 13 mph allows passengers to reach their destination more quickly.[21] By allowing faster access to downtown Boston, this scenario increases employment accessible from Everett within a range of 30 to 40 minutes by approximately 50,000 jobs.

SCENARIO 2:
IMPROVING THE FREQUENCY OF BUSES ON BROADWAY.

Instead of increasing the speed of the bus, which reduces vehicle travel time, we can instead increase the frequency of the bus, which reduces wait time at stops. This alternative imagines a much more frequent 104 bus that would arrive every 10 minutes. This would increase service from Everett at rush hour by approximately 25% and service to Sullivan by approximately 50%. This would have a greater impact on the number of accessible jobs than increasing the speed of the bus. Furthermore, literature suggests that passengers perceive wait time as more burdensome than time in a vehicle; this is somewhat dependent on the amenities available at the transit stop and the overall experience of the wait.[22]

SCENARIO 3:
IMPROVING BOTH SPEED AND FREQUENCY.

This scenario simply combines scenarios 1 and 2. It obviously provides better access than either of the first scenarios on its own, especially for trips to downtown Boston, where significantly more jobs are accessible within 30 minutes.

SCENARIOS 4 AND 5:
EXTENDING THE 104/105/109 TO HAYMARKET.

Extending the 104, 105, and 109 to Haymarket provides only a minimal benefit to Everett-based ridership. There is a small gain in access to jobs that would be a 40-minute trip from Everett to jobs near Haymarket and Keany Square at the foot of the North Washington Bridge. However, for any trip that would not be accessed from Haymarket or nearby, such as the Financial District, Seaport, Back Bay, or beyond, it is faster to transfer to the Orange Line at Sullivan Square. Even increasing the speed of the bus route to 30 mph from Sullivan Square to Haymarket (on average, including stops, traffic lights, etc.) provides a relatively small benefit compared to other scenarios.

21 The bus speed was increased to 130% compared to baseline. The high scale rate is used because Conveyal uses the existing schedule, which overestimates actual trip times.

22 Fan et al. 2016.

SCENARIO 6, 7, 8:
ROUTES TO KENDALL SQUARE.

These three scenarios consist of a new BRT route to Kendall Square using the Prison Point/Gilmore Bridge and assuming that a bus lane on said bridge[23] would allow reasonably fast travel:

- Alternative 6 extends the Route 104 to Kendall.
- Alternative 7 creates a new route from Everett to Kendall via Sullivan.
- Alternative 8 creates a frequent shuttle service from Sullivan to Kendall (more frequent than the existing 104).

Alternatives 6 and 8 provide only marginally more access to jobs than the current system, which requires passengers to change downtown. Passengers in Everett to Kendall would have to choose between the less-frequent 104 direct trip and a more-frequent trip with transfers, with similar trip times, so by timing a trip for when the 104 runs they might be able to have a slightly faster trip (Conveyal does not assume passengers will wait for a specific bus, but take the fastest service based on their arrival at a bus stop). Alternative 8 allows passengers to take any bus to Sullivan, but then the time spent waiting to transfer to the every-10-minutes shuttle (similar to the current EZRide Shuttle) eats up any savings they may otherwise experience. Alternative 7 provides better access, mostly because it would add service to the Everett-to-Sullivan corridor. However, these calculations do not take into account passenger preferences to avoid transferring in the crowded stations in downtown Boston, and this shuttle service may attract passengers from the Orange Line wishing to go to Kendall Square as well.

It might also be possible to extend an existing route that terminates at Sullivan Square to Everett. The candidate routes for this sort of service would be the 86, 91, and CT2, which serve Harvard, Central, and Kendall squares, respectively. Each of these routes serves a congested area of Cambridge (and elsewhere) and experiences reliability issues far worse than systemwide averages and goals.[24] The CT2 and 86 are already long routes, with run times in the 50- to 60-minute range at rush hour; an extension to Everett, even with BRT, would extend these longer, and reliability issues anywhere on the route would result in reliability issues in Everett. The 91 route only requires 20 minutes (and less at off-peak times) and would be a more reasonable interlined route without other bus network redesign changes.

23 The Gilmore Bridge is a major feeder route to Kendall Square and is frequently congested at rush hour, especially approaching Lechmere, where the signal at O'Brien Highway creates a bottleneck. Bus lanes would be required to make this route reliable for a BRT, as it is one of the more congested portions of the regional roadway network. Portions of the bridge would be wide enough to add bus lanes, while others would require additional right-of-way to be built (the bridge also contains a very narrow, substandard shared-use bike/walk path that should be widened). However, a BRT from Sullivan Square to Kendall would not only serve residents of resident of Everett but also Orange Line riders at Sullivan and potentially a future Commuter Rail stop at Sullivan. Existing bus routes through Cambridge and Somerville could be considered, but they would require significant additional bus priority on narrow, congested streets through the area.

24 MBTA 2018.

SCENARIO 9:
EXTENDING THE 105/105/109 TO DOWNTOWN BOSTON.

This scenario extends scenario 5 to South Station, increasing the number of jobs accessible via a one-seat ride. However, because we assume a slow travel speed of 9 mph on downtown streets (and even this might be generous), it is no faster than transferring to the Orange Line at Sullivan, even if it then requires an additional transfer or walk farther downtown, because of the advantage of grade separation below narrow, congested streets with frequent cross streets downtown.

SCENARIO 10:
COMBINE SPEED AND FREQUENCY WITH THE DOWNTOWN EXTENSION.

This scenario combines scenario 3 with scenario 9 to bring faster service from Everett to downtown. By doing so, it makes all of downtown Boston accessible within 30 minutes from Everett, opening up access to significantly more jobs than the current service.

SCENARIO 11:
EVERETT TO BOSTON VIA CHELSEA AND A TOBIN BRIDGE BUS LANE.

Recent discussions have been floated regarding a Tobin Bridge bus lane, which would allow buses to bypass chronic congestion on the Tobin Bridge. This iteration imagines a new service from Everett to Boston via Chelsea and the Tobin Bridge. Even without BRT corridor infrastructure between Broadway in Everett and the Tobin, this route would improve access because of the limited-access bridge and lack of any signals between Chelsea and Boston and speed of the trip on the bridge. This is preferable to a route via the Ted Williams Tunnel and the SL3. Because of congestion in the tunnel, the SL3's trip time from the current terminus in Chelsea to South Station is 35 minutes, so a conceptual route from Everett to South Station would be 45 minutes, which is no faster than the current transit network[25]. Because the tunnel only has two lanes (compared with three lanes on the bridge, despite similar traffic volumes), there is not enough capacity for a bus lane to bypass this congestion.

25 The Seaport is slightly closer via the Silver Line, although many of the jobs near the Silver Line are only a short walk from South Station or a busway on Summer Street.

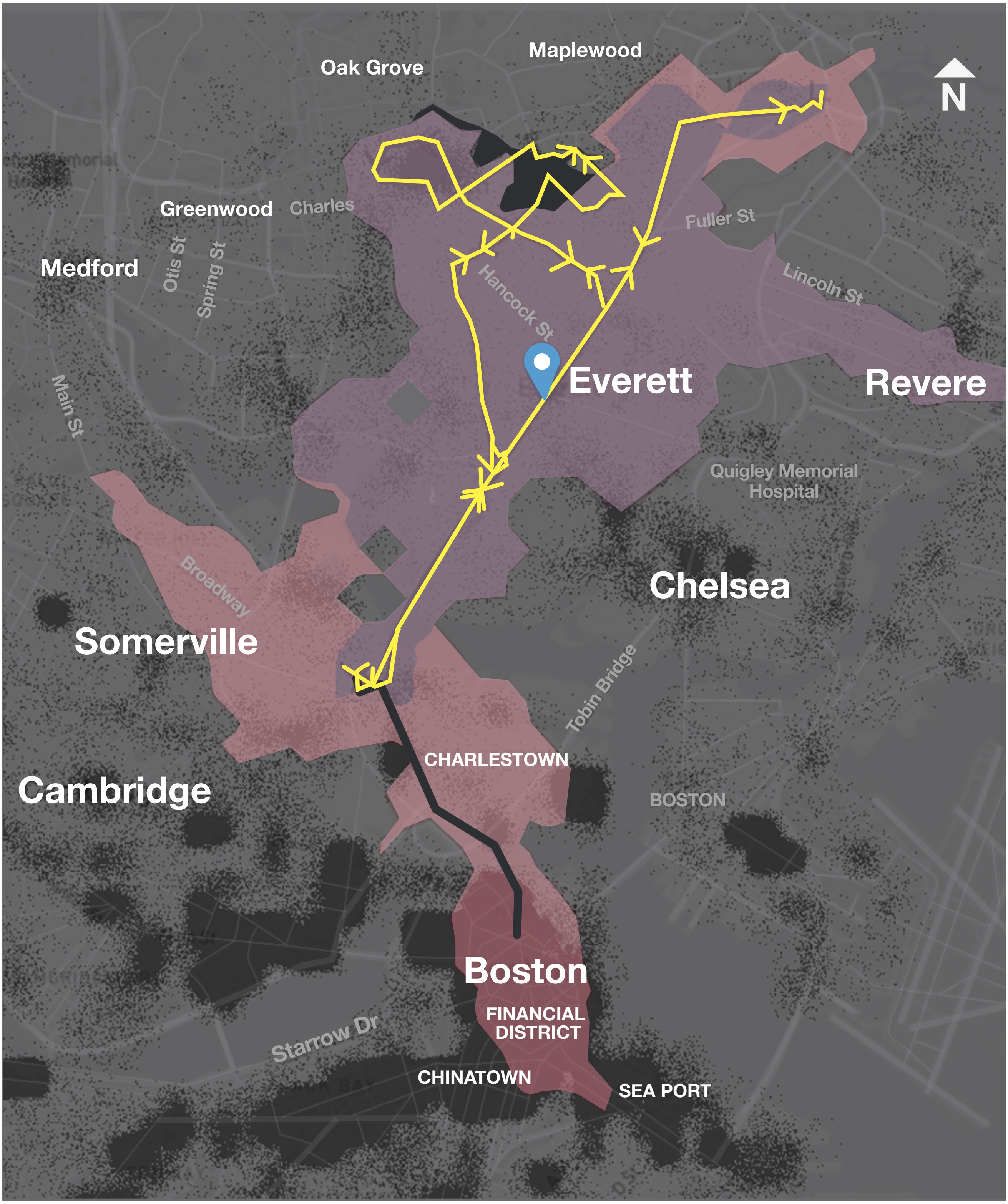
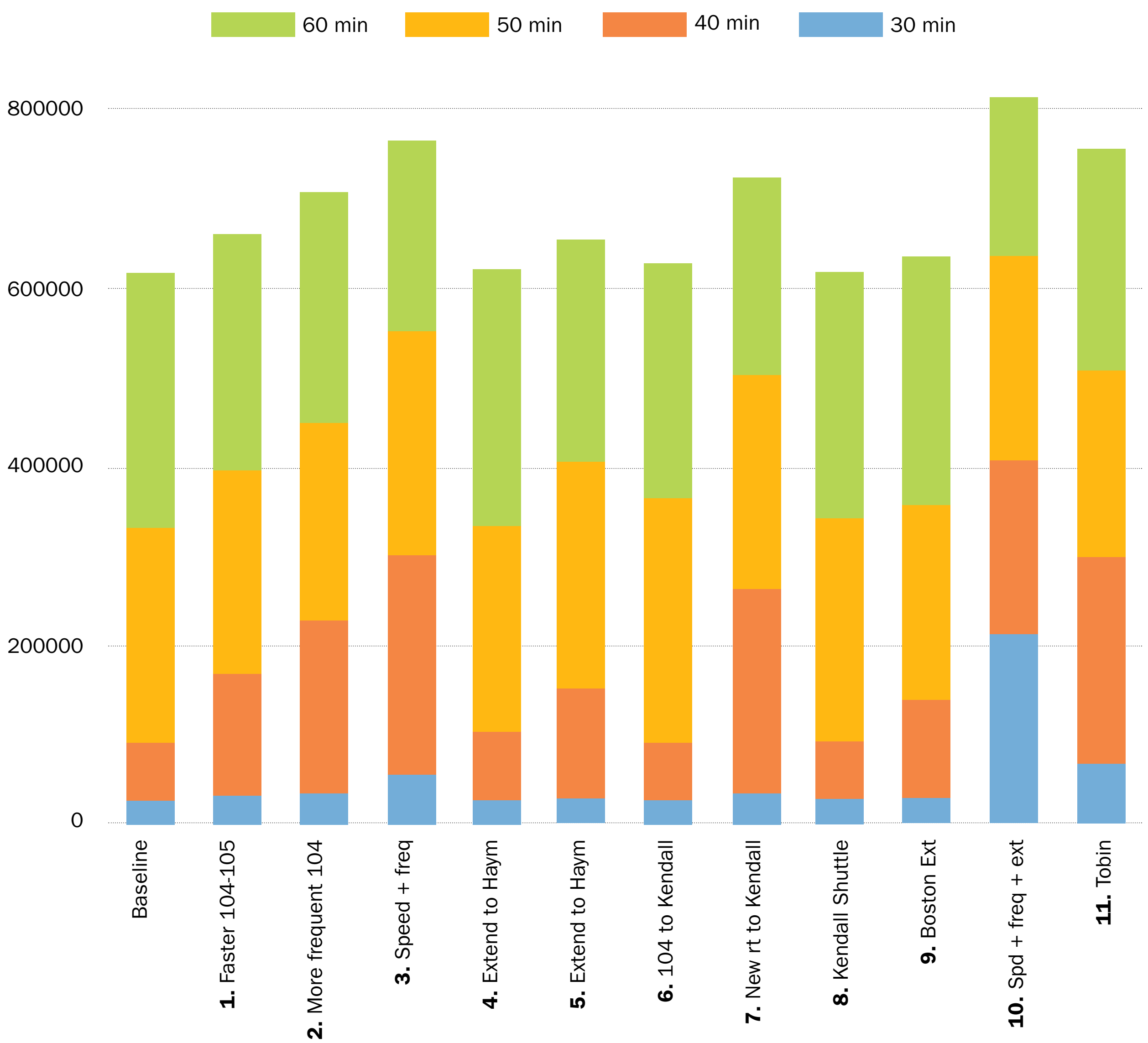


Figure 18: Jobs accessible within 30 minutes from Everett. Baseline shown in blue (underneath), scenario 10 shown in red. **SOURCE:** ITDP using Conveyal

Figure 19: Number of Jobs Accessible from Everett by Transit by Scenario



The total number of jobs is shown in each time bucket. It is additive, so the top of the red (40-minute) bar shows the total number of jobs accessible up to 40 minutes, including the 30-minute sum.

DESCRIPTION OF CONVEYAL IMPACT ANALYSIS

To estimate jobs accessibility from Everett under different scenarios, ITDP used Conveyal Impact Analysis to establish differences in accessibility to opportunity based on changes to the transit network, looking at various scenarios and how they change the accessibility to jobs in the region by transit. These can be shown in two ways. First, we can look at isochrone maps showing new areas that are accessible at the same travel time. (An isochrone map is like a topographical map for time—each line on an isochrone map represents somewhere that can be reached in the same amount of time. A frequent example would be a map showing mail shipping times from a location.

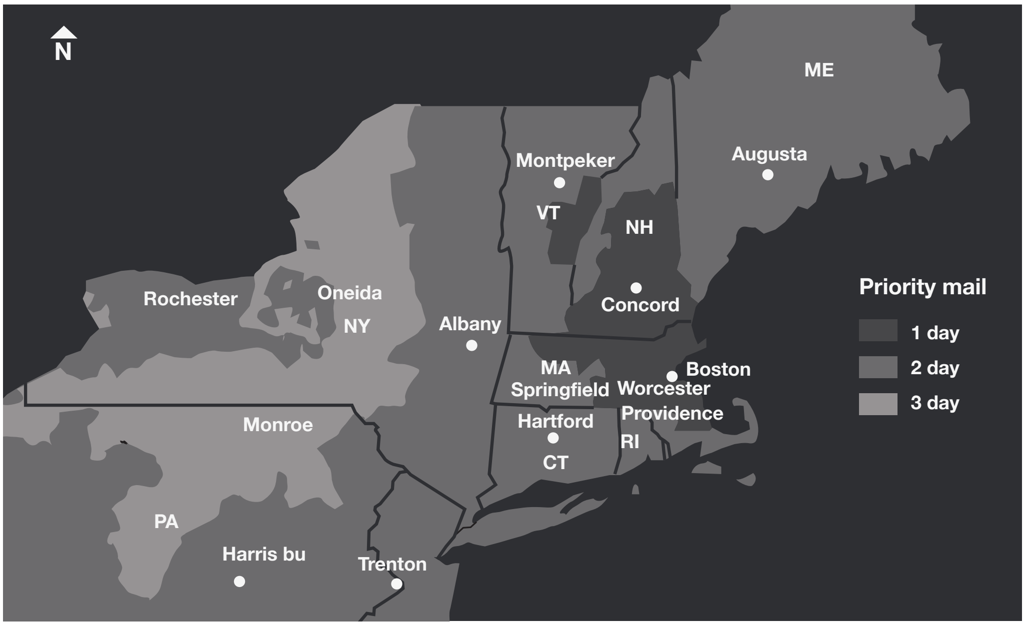


Figure 20: Example of an Isochrone Map: USPS Shipping Times from Everett

While these maps don't necessarily show major differences in geographic reach, the maps can show many new jobs that would be accessible via BRT. Quite frequently a small change in the network can create accessibility to much more opportunity.

- Several variables are available for this analysis. These include:
- The specific isochrone time buffers analyzed
- Changes to existing bus routes
- Changes to the speed of existing bus routes (whether by decreasing travel time or dwell time at stations)
- Extensions of existing routes
- New routes

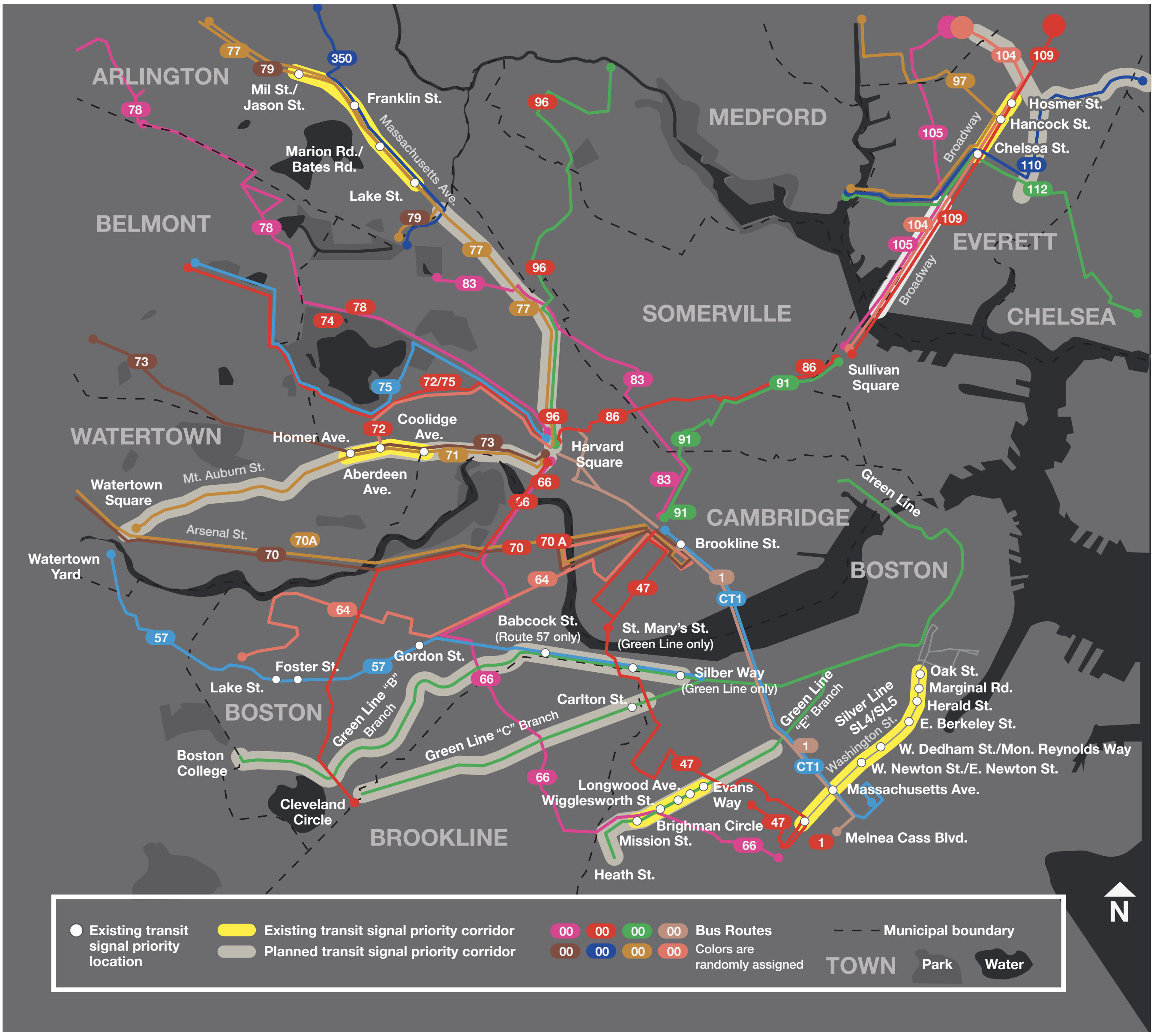
The 11 bus improvement scenarios were analyzed by combining these variables.

APPENDIX

I

COMPLETED AND PLANNED TRAFFIC SIGNAL PRIORITY IN THE BOSTON REGION

Figure 21: Completed and Planned Traffic Signal Priority in the Boston Region
Source: CTPS 2018c

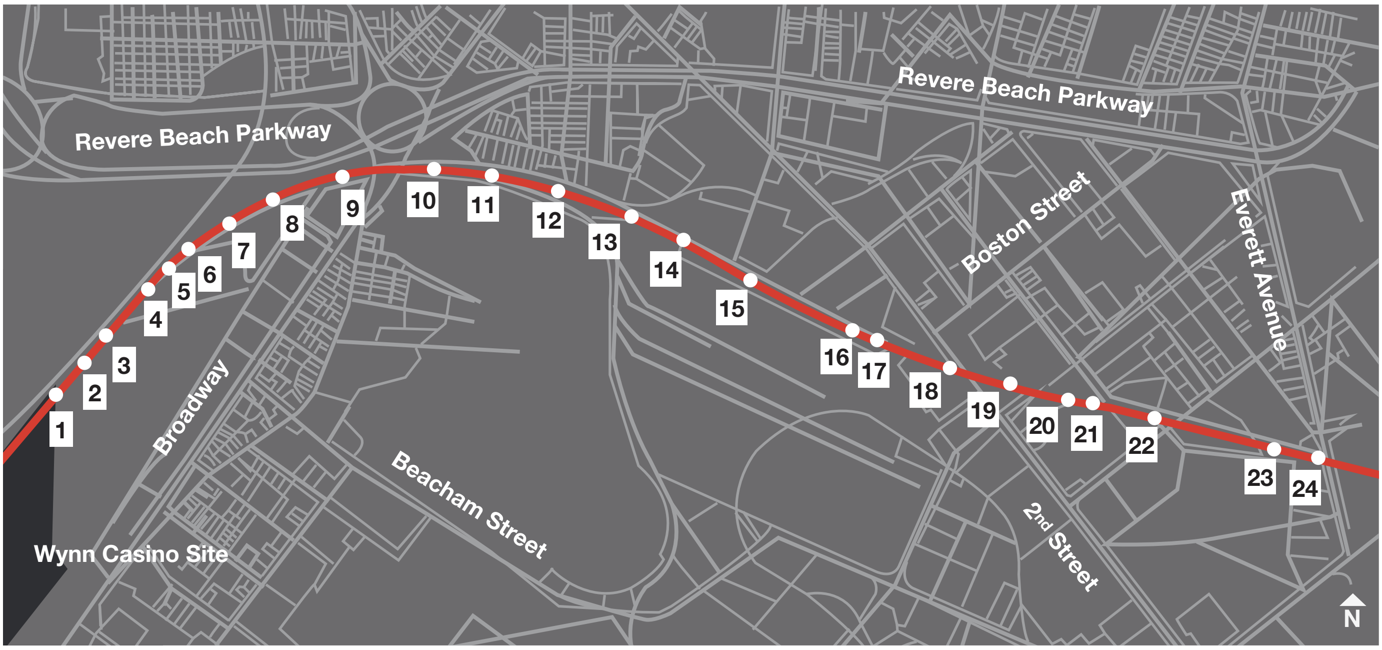


APPENDIX

J

CTPS ANALYSIS OF MBTA NEWBURY/ ROCKPORT COMMUTER RAIL ROW WIDTH FOR SILVER LINE EXTENSION

Figure 22: MBTA Newbury/Rockport Commuter Rail RoW Width
Source MAPC and CTPS 2019.



Reference Point	Total Row for All Rail Lines (feet)	Distance Between Southern Parcel Edge and Closest CR Track (feet)	Distance Between Southern Parcel Edge and 12 Foot Offset of Closest CR Track (feet)
1	72	39.1	27.1
2	60.9	32.6	20.6
3	73.2	32.7	20.7
4	83.0	42.2	30.2
5	101	48.2	36.2
6	127	52.3	43.2
7	221.8	55	43
8	UNL	55.2	43.2
9	UNL	58.6	46.6
10	UNL	57	45
11	85.6	60	48
12	90.7	65.1	53.1
13	99.3	69.7	57.7
14	110.3	69.2	57.2
15	160.1	119.9	107.9
16	153.2	117.9	105.9
17	84	59.1	47.1
18	87.8	43.1	37.1
19	83.4	43.5	31.5
20	80.7	42.1	30.7
21	72.1	33.2	21.2
22	68.6	30.3	18.9
23	67.2	30.5	18.5
24	86.7	46	34

APPENDIX

K

ROADWAY DESIGN OPTIONS BY SEGMENT

The complexity of incorporating BRT depends on the geometry of the roadway involved. In a greenfield development, the roadway can be designed with BRT in mind to allow ample space for transit, vehicular access, and safe passage for pedestrians and bicyclists. In some roadway redevelopments, historically wide rights-of-way can relatively easily accommodate BRT infrastructure (for example, the proposed BRT on Blue Hill Avenue in Boston takes advantage of that street's width, which is 110 feet between property lines at a minimum). As an older city with narrow streets, Everett's task is more difficult. North of Revere Beach Parkway, Broadway is only 65 feet wide between property lines and just 42 feet to 44 feet wide between curbs.

In considering how to accommodate BRT lanes on the Everett corridor, ITDP has made several assumptions: **(1)** changing the curbs is not feasible, since it would require a full-depth reconstruction of the roadway and associated drainage and **(2)** widening the road is unacceptable, since it would encroach upon street trees and the pedestrian environment. This roadway width of 42 feet to 44 feet requires significant compromises to prioritize transit and accommodate other users, especially since there are no nearby parallel roadways in the corridor. The subsequent sections will examine the roadway geometry for each segment of the proposed corridor.

UPPER BROADWAY

UPPER BROADWAY EXISTING CONDITIONS

Upper Broadway, the portion of Broadway north of Sweetser Circle, can be characterized as a suburban prewar main street. It is a 42- to 44-foot-wide street in a 66-foot right-of-way, with little variation. Traffic on the street is consistent during the day, without significant rush hour peaks, although traffic in the surrounding area sees peaks at 7 a.m. and 2 p.m. for school arrival and dismissal times. The road generally has between 500 and 700 vehicles per hour in each direction, and most areas not occupied by bus stops or turning lanes or interrupted by driveways are used as on-street parking. Sidewalks are generally 10 feet to 12 feet wide on the east side of the street and 12 feet wide on the west side, with street trees and street furniture in places. Moving curbs to widen the roadway to better accommodate transit would require the removal of trees, the reduction of space for pedestrians, and a general reduction in the vibrancy of the street for people, which is considered to be anathema for this project.

The street itself is generally two travel lanes, bicycle lanes, and parking lanes, with the parking and bike lanes striped for temporal conversion to bus lanes. There are frequent crosswalks and at least one pedestrian "bulb" to reduce crossing distances. Side streets are generally narrow and staggered, few continuing directly across Broadway. Main roadway intersections include Chelsea, Ferry, and Hancock streets. The corridor is mixed use, with mostly small businesses, some municipal uses (including the library, City Hall, and schools), and mostly two- and three-unit houses. Most of these houses and some businesses have driveways leading off the street.

Figure 23: Current conditions on Upper Broadway (66-foot right-of-way) during morning rush, looking north

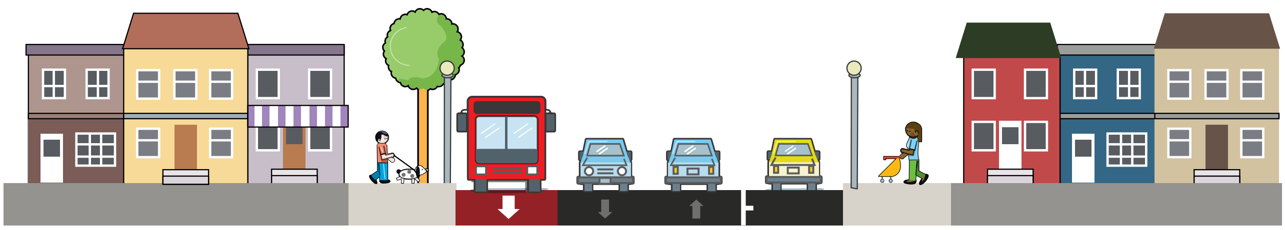


Figure 23 shows the current configuration of Broadway during the morning rush hour. The southbound on-street parking is converted to a bus- and bike-only lane during the morning peak. The northbound curb lane is used for parking, so outbound buses share the travel lane with mixed traffic. There is not enough room to accommodate bicycles on the street; southbound bicycles can use the bus lane, and for northbound bicycles, there is a de facto "door zone" bicycle lane between the parked cars and the northbound travel lane.

The current configuration of Upper Broadway has very limited transit prioritization—only the southbound morning peak curbside lane. Elements of the current street design that degrade the bus passenger experience include:

- The painted bus lane provides no physical separation to prevent mixed traffic from moving into the lane;
- Curbside bus lanes expose buses to delays from vehicle activity at the curb or right turns at intersections;
- The bus-only lanes are available during specific times of day only;
- And there is no transit prioritization off-peak or in the northbound direction.

ITDP explored how feasible it is to enhance transit prioritization with segregated bus lanes and reduce curbside bus–vehicle conflicts with median-aligned lanes within the existing narrow right-of-way. Described below are four design configurations for BRT lanes beginning on Upper Broadway, at the intersection with Ferry Street, near Glendale Square, and continuing to Sweetser Circle.

BRT LANES ON UPPER BROADWAY

NORTHBOUND CURBSIDE PEAK-HOUR BUS LANE.

In the current configuration (**see Figure 23**), the southbound on-street parking lane is converted to a bus- and bike-only lane during the morning rush. The northbound lane has not yet been used in this manner, but road-striping work in 2019 moved the lane edge line to accommodate a similar time-of-day treatment to provide prioritization for bus passengers in the evening. While there is more utilization of parking in the evening than the morning, removing on-street parking from this segment of the corridor should allow A.M. and P.M. peak-hour curbside bus lanes to operate without detriment to vehicular access to businesses and amenities by continuing to allow some parking at all times of day. In the future these lanes could be converted to full-time BRT lanes as conditions permitted, although given the current use of the street, some short-term parking/pull-out lanes may still be required.

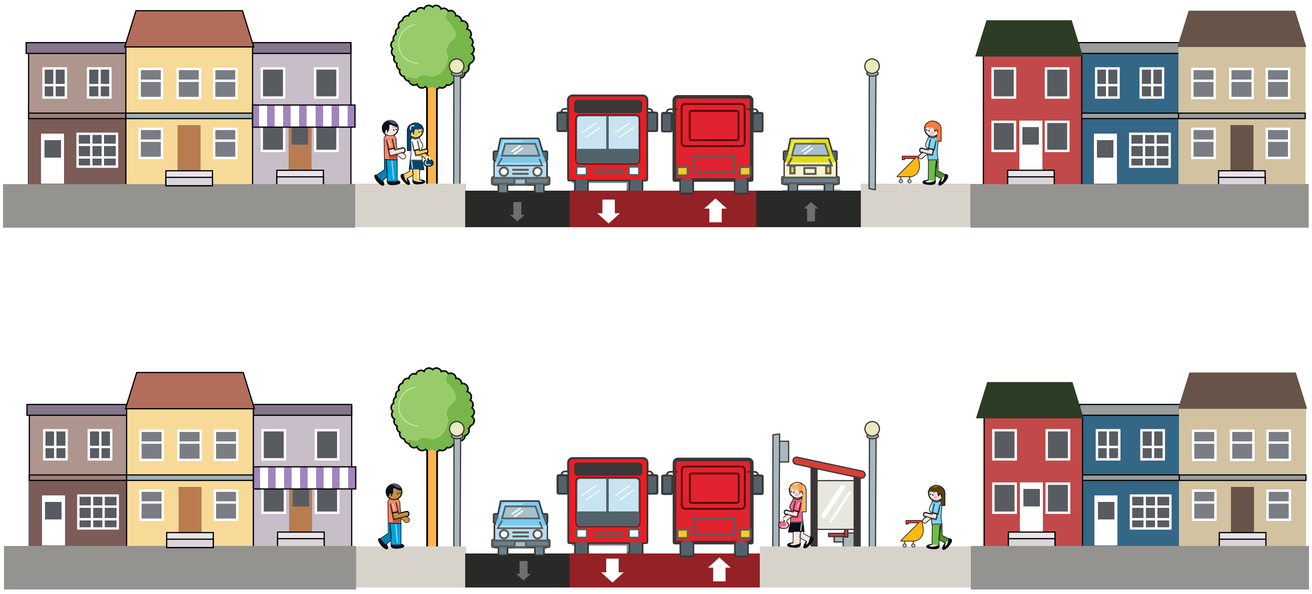
Given the narrow width of Upper Broadway, significant compromises would need to be made to incorporate transit priority lanes beyond the side-running lanes that are currently implemented and proposed. We explore the feasibility of and trade-offs associated with three configurations of BRT lanes on Upper Broadway:

- Two bus-only lanes aligned to the center of the roadway
- One center-aligned shared bus-only lane
- A transitway

With side-running bus lanes, portions of the sidewalk can be repurposed as bus stops, allowing four lanes of traffic to be fitted into the current street width. Shifting the BRT lanes to the center of the road reduces conflicts for the buses at the curb and intersections. However, because the roadway is only 42 feet to 44 feet wide, there is not enough space to accommodate transit and vehicle lanes in both directions while also allowing a center BRT island station. The cross-sections here show the width of the street and the ability to accommodate these features. All sections are shown looking north.

Figure 24: Configuration A: Upper Broadway with Center BRT lanes, between stations (top) and at station (bottom)

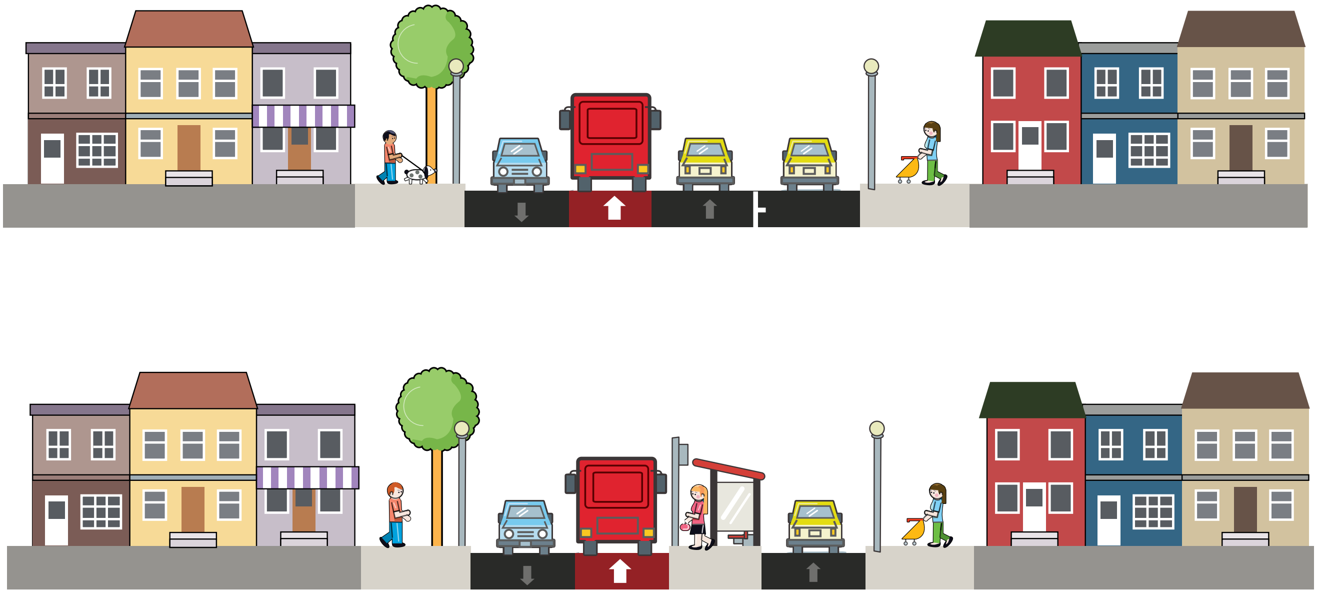
CONFIGURATION A



Our first potential reconfiguration of Upper Broadway (**Configuration A**) is shown in Figure 24 (top), with center-running lanes and bidirectional automobile traffic. It would preclude any accommodations for bicycles. At BRT station locations, a boarding platform would displace one of the travel lanes, as shown in Figure 23 (bottom). This design is theoretically possible, but it is detrimental to vehicular access to Upper Broadway.

Figure 25: Configuration B: Upper Broadway with a single center-aligned reversible BRT lane, between stations (top) and at station (bottom)

CONFIGURATION B



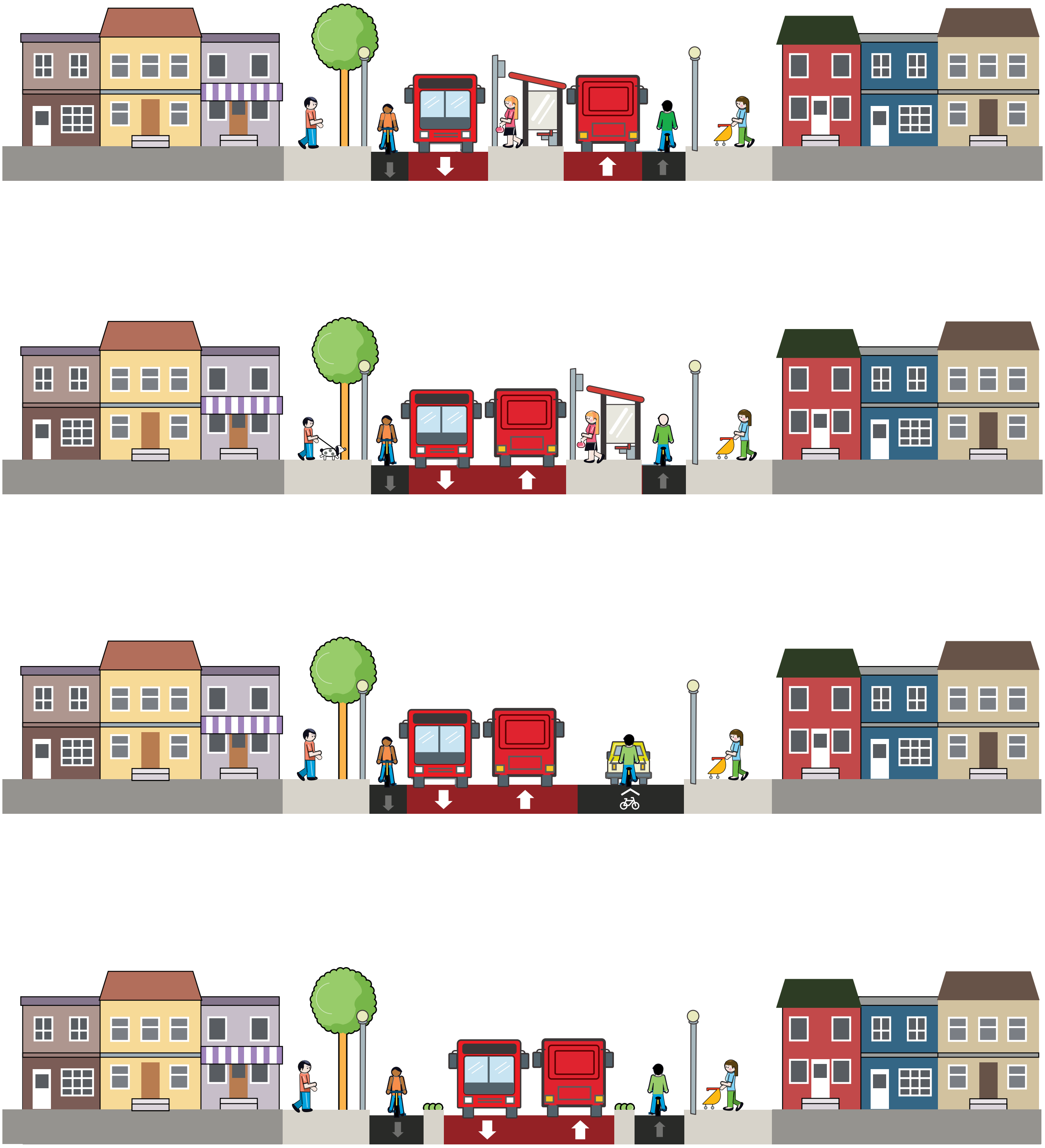
A single, reversible bus lane (**Configuration B, see Figure 25**) would be feasible, but it introduces a lot of complexity to the corridor design and operations. It could be center-running, but it would only allow bus priority in one direction at any given time. Buses traveling in the opposite direction would share the travel lane with mixed traffic.[26] The road-safety implications of reversible BRT lanes is uncertain and should be examined carefully.[27] One center boarding platform requires buses with left- and right-handed doors. There would be room for parking between stations. This design would also preclude accommodations for bicycles.

26 Albuquerque's ART corridor includes a short section of reversible lane. In the A.M. peak, the inbound buses use the BRT lane and the outbound buses travel in the mixed travel lane and use curbside bus stops (Carrigan, Wallerce, and Kodransky 2019). This is reversed in the P.M. peak. At 105 feet, this corridor is significantly wider than Upper Broadway, however.

27 The potential for crashes may be higher, since the reversible lane acts as a counterflow bus lane. Pedestrians and drivers alike may not expect a bus to be traveling in the opposite direction. Albuquerque's ART corridor includes a short reversible lane section. Road-safety data after its first year of operations may help clarify the road-safety implications of the unusual lane configuration.

Figure 26: Configuration C: Upper Broadway transitway. Single shared center platform (top) or split station platforms (second); two possible configurations between station locations (bottom two).

CONFIGURATION C



If rebuilt as a transitway or “transit mall” (**Configuration C**), Broadway could prioritize transit, bicycles, and pedestrians, but it would not be able to accommodate any through travel of vehicles. In places without parallel travel on another street, this would require significant detours for all of the local traffic using Upper Broadway. The 42-foot cross-section would be repurposed as two 10-foot transit lanes, protected bicycle lanes, and a 10-foot-wide station. The BRT station could be a center platform shared by buses traveling in both directions (**see Figure 26, top**). This option requires buses to make a crossing movement to approach the platform from the left side, or introducing a new fleet with left-side doors. Alternatively, the boarding platform could be split into two, one for each direction, and aligned with the inside of the BRT lane (**see Figure 26, second**).

Between stations there would be more flexibility, which would allow for separated bicycle lanes or minimal vehicle access to one side of the roadway shared with bicycles between stations, but not for any through traffic (**see Figure 26, bottom two**).

Figure 27: Rendering of “transit mall” concept on Upper Broadway at Chelsea Street shown with uniform level for roadway and bollards separating bicycle and bus lanes. There would be only very limited private vehicular access.
Source: Utile

North of Chelsea Street, Upper Broadway does not have any parallel major streets, so using it as a transitway would require significant detours for other users. Any potential parallel routes use narrow residential streets that are not well-suited to high traffic volumes, and even Ferry Street, which is the closest-to-parallel street, requires the use of narrow one-way streets to reach Revere Beach Parkway.

South of Chelsea Street, however, there is the potential to divert southbound traffic vehicles to the roughly parallel School Street, which would provide enough room for a two-way busway on Broadway itself. While this is a short section—only about one quarter of a mile—it is the section approaching or departing Sweetser Circle, the most congested portion of the roadway. Bus passengers would benefit from transit priority offered by dedicated bus lanes through this congested section, but diverting other traffic to secondary routes will worsen congestion on other roads.

To test this during a short period of time would require some minor detours, particularly for trucks, which could not easily use a detour route on School Street or School and Oak streets to reach Main Street, although our analysis shows only 11 large trucks (semi-trailer trucks) use the roadway per day. For a longer-term project, the intersection of School and Main streets could be reconfigured to allow through traffic from School Street to Sweetser Circle, precluding the turn onto Oak Street, which would require difficult maneuvers for truckers, although increasing traffic on those residential streets would be very politically difficult and would require significant reconfiguration of traffic patterns with the potential of property takings and structure demolition.

This would create a scenario where the left two lanes of Broadway would be used for bus travel. Southbound bus traffic, which makes up the majority of boardings on Broadway, would board at the curb as they do today, but in an exclusive bus lane. Northbound bus traffic would use one or more boarding platforms in what is today the northbound travel lane of Broadway, where regular traffic would be shifted into what is now the parking lane. In other areas, the northbound side of the street would be maintained with a single traffic lane adjacent to the parking lanes. Bicycle traffic could either be routed via School Street (potentially with a contraflow lane on the street) or on Broadway in spaces shared with cars or buses.

Table 4: Trade-offs between transit priority and accommodating vehicles and bicycles in Upper Broadway BRT lane configurations

CONFIG	Physically segregated BRT lines	Transit priority SB & NB	More than time-of-day lanes	Reduce bus delays at curb & intersections	Veh. Traffic	Bike Lanes	Bus Door Position
Existing Conditions: 2x curbside bus lanes	×	✓	×	×	✓	–	Right
A: 2 Center BRT Lanes	✓	✓	✓	✓	–	×	Right
B: 1 shared Center BRT Lane	✓	×	–	–	✓	–	Both sides
C: Transitway	✓	✓	✓	✓	×	✓	Right or Both sides

ITDP developed three conceptual redesigns of Upper Broadway that prioritize moving more people via transit by reducing conflict between buses and other vehicles. Given how narrow Upper Broadway is, reallocating street space to prioritize transit requires reducing space for parked cars, vehicles, or bicycles. Certain design configurations also have implications for the bus door position on the BRT fleet. To summarize the main trade-offs between each design (**see Table 4**):

- Each of the design options (**Configurations A, B, and C)** provides more transit priority than the existing conditions.
- Two center BRT lanes (**Config. A**) reduces the most transit delay. but does not accommodate bicycles or vehicular traffic well;
- One shared center BRT lane (**Config B.**) provides the least transit priority of the options considered, has the least impact on vehicular traffic, and requires new buses with left-side doors;
- The transitway (**Config. C**) maximizes the benefits for transit passengers and bicyclists and is the most disruptive to vehicles.

SWEETSER CIRCLE

SWEETSER CIRCLE EXISTING CONDITIONS ANCHOR25

Figure 18: Aerial image of Sweetser Circle
SOURCE: Google Earth

Sweetser Circle is the intersection of Broadway, which runs southwest to northeast; Main Street, which runs to the northwest; and Revere Beach Parkway, which runs east to west. Revere Beach Parkway dates to the 1930s and originally crossed the two streets at-grade. It was rebuilt as a grade-separated highway in the mid-1950s, with the circle built above, partially necessitated by the presence of the Boston and Maine Railroad's Eastern Route Main Line (now the Newburyport/Rockport Commuter Rail) just to the south. Sweetser Circle is being studied for redesign, and it is the most congested portion of the corridor: Traffic routinely backs up for five to 10 minutes to traverse the circle. This is a critical pinch point for buses.

This 60-year-old nine-leg rotary, owned by DCR, carries 53,107 AADT vehicles and is heavily congested in the morning and evening peak hours. Between 2014 and 2016, 81 crashes occurred here[28], partly due to the outdated rotary design and geometry. This geometry currently precludes transit prioritization, and so redesigning Sweetser Circle is critical to the success of an Everett–Boston BRT corridor.[29] The rotary itself is elevated, so building a busway through the center, or even widening the roadway itself, would involve a major bridge project. Furthermore, the area to the south of the rotary cannot be overbuilt without bridges over the adjacent railroad.

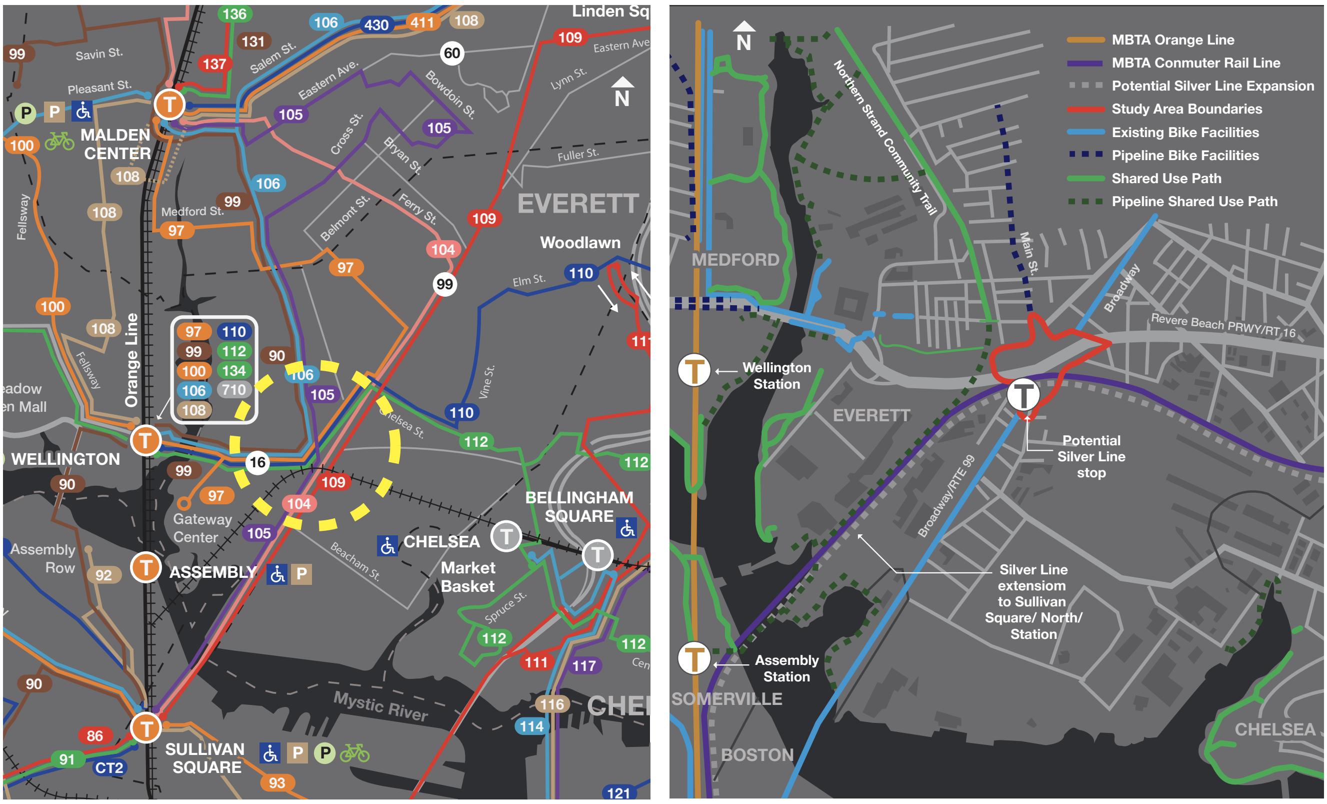
28 CTPS 2019.
29 City of Everett 2019.

Sweetser Circle is a major transit node in Everett, serving all of its eight MBTA bus routes (Figure 29). More than 11,400 bus passengers move through the congested circle each day. A future extension of the Chelsea Busway to Everett (see "Connecting Chelsea Busway to Broadway" below) could introduce a Silver Line station close to the Circle. Everett's bus-only lanes currently operate on Upper Broadway, and the Everett–Boston BRT corridor would need to traverse the Circle, connecting Upper and Lower Broadway.

BRT LANES THROUGH SWEETSER CIRCLE

Sweetser Circle is a top candidate for transit priority. While it will not specifically fit within the guidelines for BRT standards, establishing transit priority through the circle will save each peak-hour bus passenger using the corridor several minutes in travel time. In addition, it will also establish that it is possible to give buses an advantage through congested rotaries, something that occurs at several other such choke points in the region, none of which has any transit priority.

Figure 29: Current transit services (left) and current and future nonmotorized transportation facilities (right) at Sweetser Circle



SOURCE:
City of Everett 2019.

MassDOT proposes[30] replacing four bridge decks in Sweetser Circle (two over Route 16 and two over the MBTA Newburyport/Rockport Commuter Rail line) at a cost of $16 million, and the City of Everett would like to leverage this opportunity to transform the rotary into a more functional, safer node. Modernizing and redesigning Sweetser Circle could lead to the addition of transit priority and access, safer bicycle and pedestrian facilities and connection to regional trails, and reduced maintenance costs.
Everett has allocated $100,000 in city funds to explore the feasibility of three design alternatives for a modernized Sweetser Circle, including:

- Rebuild and upgrade existing circle as modern rotary;
- Rebuild and upgrade existing circle as a signalized intersection;
- At-grade junction alternative.

The scope and schedule of this potential redesign of Sweetser Circle will impact the phasing of the BRT corridor implementation and will need to be monitored. Each alternative under consideration would allow a transit priority bypass route for buses to leapfrog the congestion that regularly occurs at the circle.

While there are no examples of BRT lanes through rotaries in the U.S., international precedents exist. If BRT lanes on Upper Broadway and Lower Broadway are center-running, a dedicated bus-only lane on the inside of the rotary can bridge the two segments. Buses entering the rotary lanes could be given signal priority.[31] Mexico City's heavily used Metrobus Line 1 has an area at Glorieta de los Insurgentes where the buses navigate a circle.[32]

30 City of Everett 2019.
31 Section 24.8 of the *BRT Planning Guide* describes several ways to accommodate BRT through rotaries (ITDP 2021).
32 Wikipedia (2021) has images of BRT buses operating through this roundabout along Mexico City's Avenida de los Insurgentes here.

CONNECTING CHELSEA BUSWAY TO BROADWAY

Figure 30: Extending Chelsea Busway from Chelsea Station west to Everett
SOURCE: ITDP

Extending the Chelsea Busway west to Everett would make it possible to add at least one Silver Line station in Everett. Connecting the Chelsea Busway Extension with the proposed Everett–Boston BRT corridor has two additional BRT service benefits:

1. **BRT route flexibility.** BRT routes could more easily turn from one corridor to another, allowing more service options. For instance, a BRT route could begin on Upper Broadway in the Everett–Boston BRT corridor and then enter the Chelsea Busway extension and continue to South Station. Or, an SL3 from South Station could continue from the Chelsea Busway into the Everett–Boston BRT corridor and continue to Sullivan Square and downtown Boston. Fleet compatibility would be required.

2. **Transfer station.** A BRT station that is shared by BRT routes using both the Chelsea Busway extension and the Everett–Boston BRT corridor would allow passengers to transfer to other BRT routes.

Extending the Chelsea Busway west and connecting it to Broadway in Everett poses several geometric challenges:

- The rail right-of-way and Broadway are at different grades/heights.
- The rail right-of-way is narrow in places, making it difficult to accommodate a busway.

- There are tracks serving freight uses south of the rail line that would have to be crossed at-grade.

- Sweetser Circle has a complex design, even for rotaries, and designing an interchange with the Revere Beach Parkway and the complex geometry of Sweetser Circle will be difficult.

- Revere Beach Parkway is defined as a park, so any changes may be subject to section 4(f) oversight and require coordination with DCR.

Furthermore, significant freight truck traffic moves through the vicinity. The MPO designated Broadway (Route 99), Revere Beach Parkway (Route 16), and Second Street in Everett as Critical Urban Freight Corridors (CUFC) (Figure 31). These freight corridors have been incorporated into both the statewide freight plan and the National Highway Freight Network (NHFN).[33]

Figure 31: Boston MPO-designated Critical Urban Freight Corridors in Everett (red)

Source: CTPS 2017.

33 CTPS 2019.

Possible alignments for a Chelsea Busway extension from its current terminus at Chelsea Station to Broadway in Everett include (see **Figure 30**):

1. Continuing along the **rail right-of-way** and meeting Broadway just south of Sweetser Circle.[34]
2. Diverting from the rail right-of-way and routing along **surface streets** to Broadway, probably via 2nd Street.
3. A combination of these dependent on the direction of travel.

RAIL RIGHT-OF-WAY ALIGNMENT

Extending the Chelsea busway west to Everett along the MBTA Commuter Rail right-of-way may require easements from adjacent property owners to allow adequate space for the busway.[35] The busway will have to include two signalized at-grade crossings at 3rd and 2nd streets. Pedestrian access to a BRT station along this segment of the busway extension would be limited by the large blocks and industrial uses. A complex interchange design will be needed at Broadway to contend with the Revere Beach Parkway and Sweetser Circle.

SURFACE STREET ALIGNMENT

The BRT corridor could depart the rail right-of-way at Second Street (at grade) and then intersect Broadway north of Sweeter Circle. This route currently experiences significant truck traffic due to surrounding industrial uses, such as the New England Produce Center, and it is a designated Critical Urban Freight Corridor (**see Figure 31)**. Alternatively, departing the rail right-of-way at grade at Everett Avenue and then continuing along Chelsea Street to the Broadway BRT corridor may also be an option. Narrow road widths and adjacent single-family property owners as well as the Chelsea High School would need to be convinced. This alignment may be conducive to a more pedestrian-accessible station, but it will also be more disruptive to trucks and local traffic.

34 Connecting from the rail right-of-way to Broadway in the Sweetser Circle area would be difficult, however, and CTPS found several narrow sections that may preclude a busway (See Appendix J).

35 As part of the Lower Mystic Regional Working Group's study (MAPC and CTPS 2019), CTPS staff conducted a GIS-based analysis of the width of the available rail right-of-way and whether it was sufficient for a busway. This analysis assumed the Commuter Rail alignment would remain unchanged and that 30-foot width is needed for a bidirectional dedicated busway (two 12-foot bus lanes plus two three-foot shoulders). It also assumed a 12-foot buffer was needed between the active Commuter Rail tracks and the edge of a busway. The CTPS GIS analysis found that between Everett Avenue and 3rd Street there is insufficient width to accommodate both a 30-foot busway and a 12-foot buffer between the Commuter Rail corridor and adjacent parcels; at the narrowest location, there is only 18.5 feet for the busway. See Appendix J for CTPS analysis findings.

LOWER BROADWAY

LOWER BROADWAY EXISTING CONDITIONS

Below Sweetser Circle, Lower Broadway widens to between 55 feet and 62 feet. The lane configuration also varies on this segment. There are two travel lanes plus a bike lane in each direction the whole length of Lower Broadway. Between Barlett and Thorndike streets, there is also on-street parking on the northbound side.

Between Dexter Street and Sweetser Circle, Broadway was extensively rebuilt with the construction of the casino. This portion of the right-of-way is 76 feet between lot lines and features elevated, protected cycle tracks. The roadway is 51 feet wide, laid out with two 10-foot lanes in each direction and a 10-foot-wide median, but with minimal provision for bus priority. Left-turn lanes are provided where needed. There are two driveways on the southbound side of the roadway, but both access parking lots that could be accessed from other roadways.

Most left turns going northbound, other than for traffic wishing to access the casino, could be accommodated by rerouting turning traffic via Robin and Beacham streets, creating a long “jug handle” type movement to remove the need for a left turn. Traffic volumes are high enough several times of day that two lanes are required for throughput, although this is not the case for northbound traffic in the morning. While the corridor is mostly large commercial and industrial institutions, there are some residences on the roadway nearer Sweetser Circle.

The main objective for incorporating BRT lanes on Lower Broadway is to continue the transit prioritization from Upper Broadway through to Sullivan Square by offering some travel time advantage for bus passengers.

BRT LANES ON LOWER BROADWAY

Figure 32: Lower Broadway with center-running BRT and center stations (not compatible with current fleet)
Source: Utile

There are several options for BRT in this corridor given its width, but most would require major infrastructure changes to the roadway (Figure 32). A center-running BRT would be feasible with these changes, but it would still face several hurdles, including requiring significant changes to the north and south to allow buses to transition in and out of a center-running configuration, since the current plans call for bus lanes on the outside of Sweetser Circle and would likely require outside lanes to access Sullivan Square. Stations would also have to be sited to minimize conflicts with current traffic movements, especially at the left-turn to access the casino.

There is the possibility of utilizing the southbound lane of the roadway for a morning-peak bus lane to test the feasibility of median-aligned bus operations and left-turn restrictions. Such a pilot will be operationally difficult to do safely, and it would also require a reconfiguration of the current median to serve as an ADA-compliant boarding area. It would be feasible between Sweetser Circle and the Alford Street Bridge with some roadway modifications. Because of the level of additional infrastructure this would require and the potential safety issues involved, this was not included in the current pilot projects.

ALFORD STREET BRIDGE

ALFORD STREET BRIDGE EXISTING CONDITIONS

Broadway enters the City of Everett just north of the Alford Street Bridge in Boston[36] and runs 2.4 miles to the Malden border. The Alford Street Bridge is a drawbridge that is opened irregularly and chiefly for pleasure boat traffic; by policy, it is not opened during rush hour and is rarely opened between October and May.[37]

The dual carriageway was extensively rebuilt between 2014 and 2019. The bridge deck is 44 feet wide on each side, with a curb-to-curb width of approximately 38 feet. The bridge incorporates two travel lanes, shoulders, and a bike lane in each direction. This is the only bicycle connection between Everett and Boston, and despite poor connectivity farther south, it receives reasonably heavy bicycle traffic. There is no on-street parking and no signalized intersections on the bridge.

BRT LANES ON ALFORD STREET BRIDGE

Alignment of the bus-only lanes on the Alford Street Bridge—whether center or curbside—can help to position the BRT for an efficient approach to Sullivan Circle. Since there is no curbside activity on the bridge, curbside bus lanes may provide as much transit priority as median-aligned lanes. Congestion on the bridge is variable, with northbound bus lanes needed most. Given the need for BRT to serve Sullivan Station, curbside lanes are likely preferable for the corridor. To accommodate bicyclists, a combined bicycle/bus lane may be used in this corridor, as there is not enough room for two travel lanes, a bus lane, and a bike lane.

Adding a signalized intersection before or after the Alford Street Bridge could provide an opportunity to shift the BRT lane alignment from center to curbside, depending on the lane alignment on Lower Broadway and Sullivan Circle.

SULLIVAN SQUARE/CIRCLE

SULLIVAN SQUARE/CIRCLE EXISTING CONDITIONS

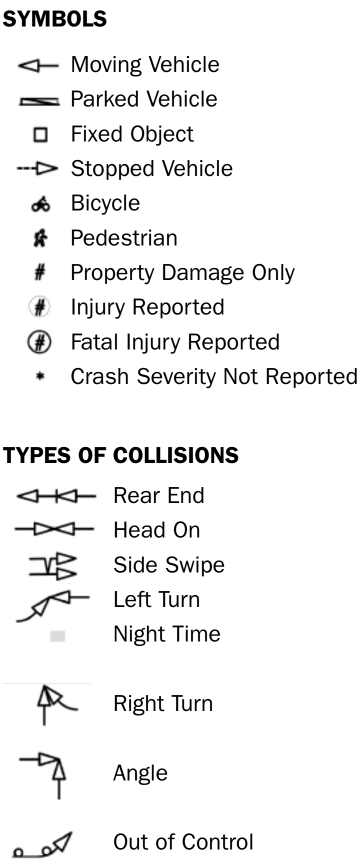
Sullivan Square is a large traffic circle connecting Rutherford Avenue, Alford Street, Main Street, Cambridge Street, and Maffa Way, all under the City of Boston's jurisdiction. Rutherford Avenue, Alford Street, Maffa Way, and Main Street west of Sullivan Square are all classified as Urban Principal Arterials. Main Street east of Sullivan Square is an Urban Minor Arterial. The intersection was home to the original Sullivan Station on the Main Line El, which was replaced by the Orange Line in 1975 and was located just to the northwest of the current traffic circle, between West and Gardner streets. Before the completion of Interstate 93 from Medford to Boston in 1973

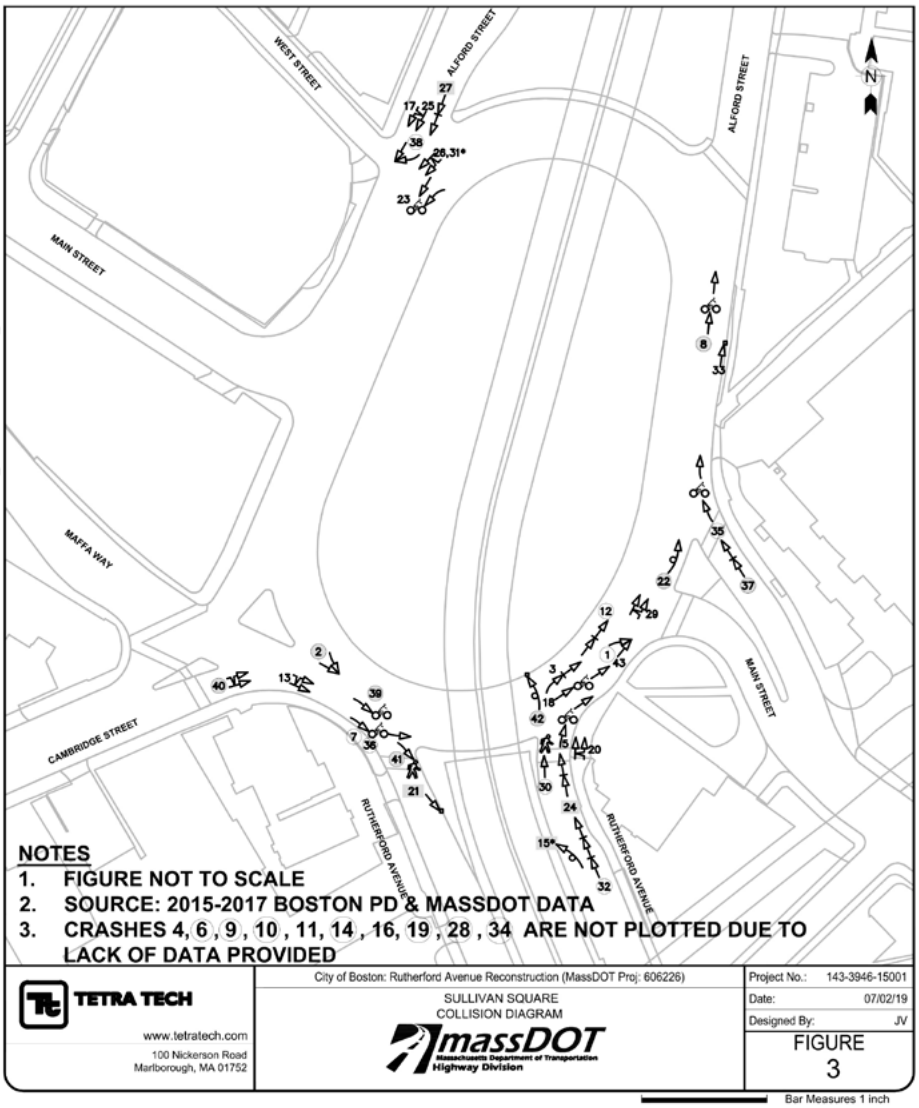
36 The Boston/Everett boundary is past the shoreline of the Mystic River at Dexter Street.
37 Waterway Guide 2021.

(the last major new highway construction inside of 128), Sullivan Square was a more important regional connection, and in addition to the current underpass, an elevated roadway passed over Sullivan Square, allowing traffic from Broadway and Mystic Avenue to access Rutherford Avenue without passing through the Square itself.

Today Sullivan Square traffic circle does not function well for any road user; in fact, it has been called the “Rotary of Death”[38] and featured in local media as a major choke point[39]. Drivers and bus passengers experience significant morning and evening peak congestion. Pedestrians and bicyclists trying to navigate the circle face long and circuitous paths, little protection from motor vehicles, and frequent accidents. Despite the lack of infrastructure, bicycle counts undertaken by ITDP found hundreds of cyclists per day in the corridor, even during inclement weather. Between 2015 and 2017, there were 43 reported traffic crashes in Sullivan Square.[40] As Figure 33 shows, these occurred primarily at the southbound approach to the circle on Alford Street and between the circle and Rutherford Avenue. This crash data predates Spring 2019 roadway and pedestrian upgrades at Sullivan Circle, so the impact of those improvements is unknown.

Figure 33: 2015–2017 Crash Locations at Sullivan Square





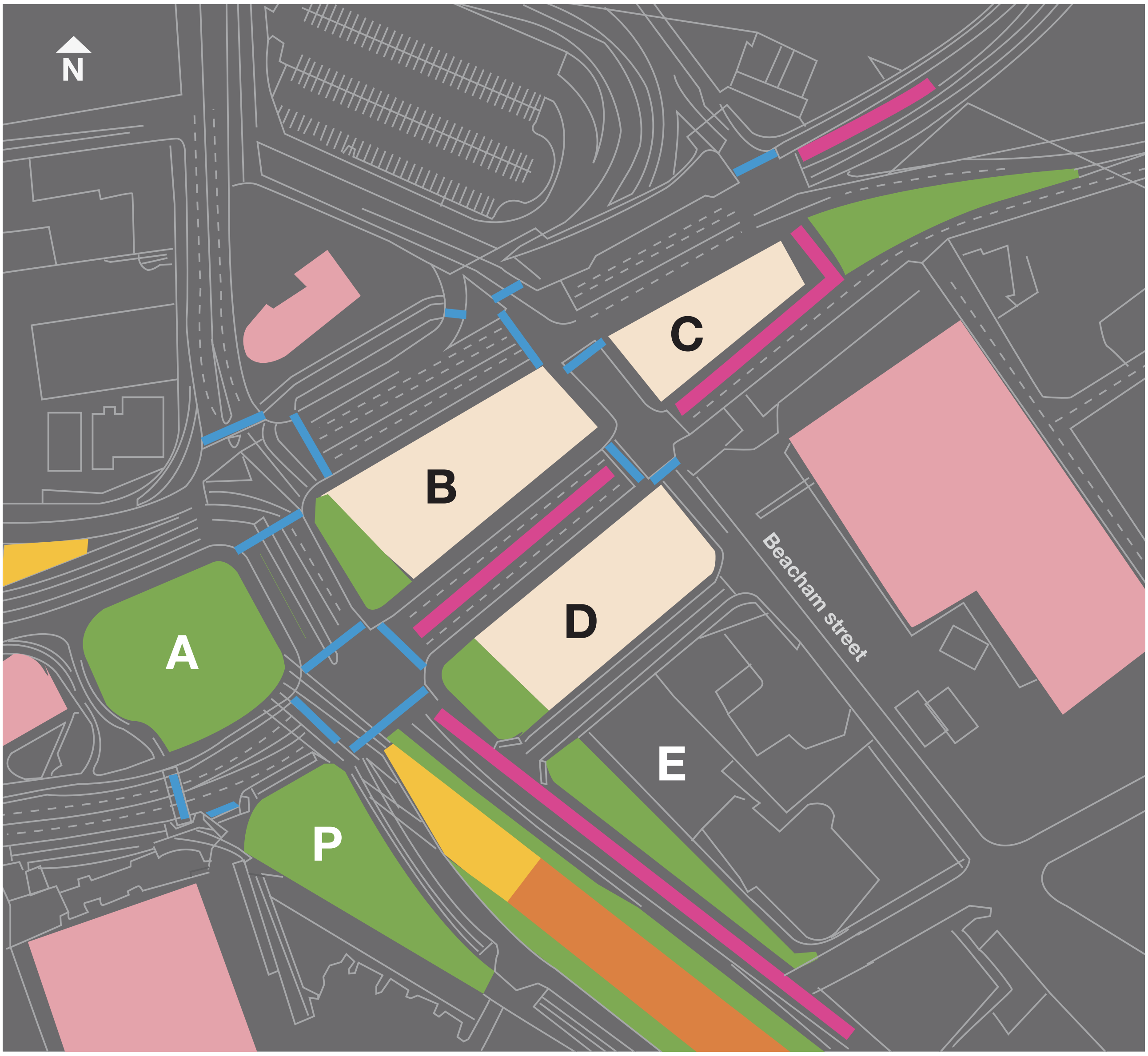
SOURCE: MassDOT 2019. Note, 10 of the 43 crashes had insufficient data to include in the map.

38 Scanlon 2017.
39 Faraone 2018.
40 MassDOT 2019.

REDESIGN PLANS

Plans to redesign Sullivan Circle and Sullivan Square MBTA station are underway. In October 2019, the City of Boston's proposed design calls for replacing the circle with two signalized intersections (Figure 34). It will be more feasible to include dedicated BRT lanes through two intersections than through the current circle, and traffic signal prioritization (TSP) here will help reduce delay for bus passengers, although the number of transferring passengers at Sullivan Square may preclude any travel path that bypasses the station itself.

Figure 34: City of Boston Proposes Replacing Sullivan Square Traffic Circle with Two Signalized Intersections.



SOURCE City of Boston 2019.

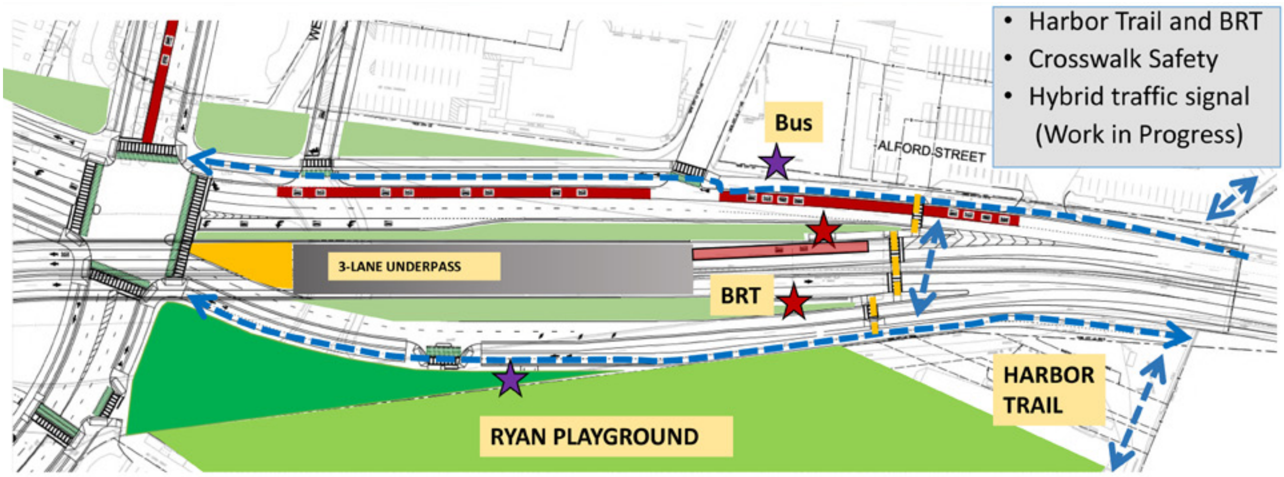
BRT LANES THROUGH SULLIVAN SQUARE/CIRCLE

The October 2019 City of Boston proposal for a redesigned Sullivan Square only includes a dedicated bus lane southbound on Alford Street. Including northbound dedicated lanes would help reduce delays from congestion and turning vehicles for P.M. peak bus passengers as well. Integrating TSP into the new signalized intersections will advantage buses over vehicular traffic through this congested area.

ITDP recommends including a BRT station at Sullivan Square to allow transfers to the Orange Line and several MBTA bus routes. Approximately one in four Everett bus passengers makes trips that require transferring at Sullivan to the Orange Line or a bus to Cambridge or Somerville. This station could also serve adjacent properties, including Schrafft's City Center, Springfield College, The Graphic Lofts, and parts of the new Hood Park development.

The City of Boston's latest plans for a redesigned Sullivan Square propose a BRT station at the entrance/exit of a three-lane underpass. This configuration introduces significant pedestrian safety concerns. The roadway is at its widest here, making for very long pedestrian crossings. Vehicles passing through the (unsignalized) three-lane underpass will be traveling at relatively high speeds at its entrance/exit, making this an unsafe location for a pedestrian crossing. The proposed station location is partially below-grade, so passengers will have to wait in a microenvironment with poor air circulation and a high concentration of air pollutants from vehicle exhaust.[41] An alternative location for a BRT station should be considered, including at the proposed new signalized intersection of Main Street and Alford Street, or at Sullivan Square Station.

Figure 35: City of Boston's proposal for a BRT station at the entrance to the Rutherford Avenue underpass poses significant safety concerns



SOURCE City of Boston 2019.

41 Betancourt et al. 2017.

It would not be feasible to build a below-grade BRT station at Sullivan Station, because of the vertical circulation elements (it would require a wider tunnel and significant elevator and egress elements at a station 20 feet below grade) as well as horizontal alignment issues, since such a station would be an 800-foot walk from the existing Orange Line station and bus transfer node. This would add a walk of several minutes for transferring passengers, more than negating any time savings from BRT. In order to access an at-grade station at Sullivan Station, BRT buses would need to remain at-grade through the circle or new intersections. BRT lanes through the Rutherford Avenue underpasses would be unable to access Sullivan Station, and likewise, once BRT buses stop at Sullivan, they could not subsequently enter the Rutherford Avenue underpasses. Therefore, a Sullivan Square BRT station favors at-grade bus-only lanes along the redesigned Rutherford Avenue rather than below-grade BRT lanes.

SULLIVAN SQUARE/CIRCLE SUPERSTATION

MBTA's Focus40 report notes that plans are underway to redevelop Sullivan Square Station. Depending on "the form and intensity" of the station-area development, a Superstation with commuter rail, Orange Line, and BRT connections may be warranted, and that is identified in the plan as a "Big Idea" to consider in the future.[42] Physical integration of a BRT station with the rail modes at such a Superstation would help facilitate more seamless multimodal transfers. There is significant right-of-way available adjacent to the Orange Line, but any track realignment will have to contend with the presence of structural steel for the elevated highway above. There are also groups advocating for using some of the right-of-way to build a bicycle and pedestrian link between Assembly Square and Kendall Square in this area.

RUTHERFORD AVENUE

RUTHERFORD AVENUE EXISTING CONDITIONS

The Rutherford Avenue underpass is 56 feet to 65 feet wide, which could accommodate two travel lanes in each direction. However, due to structural issues with the retaining walls, concrete barriers block off one lane, leaving only one operational lane in each direction. Parallel to the underpass, there is a one-way service road on either side. These service roads vary in width from 35 feet to 40 feet, with two or three lanes.

Rutherford Avenue is also a designated Critical Urban Freight Corridor and currently experiences significant daily heavy-duty vehicle traffic, especially trucks accessing the Boston Sand & Gravel (see Figure 31 above). Any redesign of the corridor needs to take into account accommodating or rerouting heavy-duty vehicles.

Because it has been impacted by so many local infrastructure changes over the years (see Box A), the Rutherford Avenue corridor is characterized by a

42 MBTA and MassDOT 2019.

few pinch points and bottlenecks and long stretches of roadways with far more capacity than the roadways will ever need. The locations of various grade separations are generally not where they are required for efficient traffic flow, and it is one of the most overbuilt highways in the region.

There are two major bottlenecks on the roadway:

- Prison Point Bridge to Rutherford Avenue northbound. Traffic from Kendall Square and environs heading to I-93, Everett, and elsewhere uses this bridge to get to Rutherford Avenue and then further north. This bridge was originally planned to have a free-flowing highway ramp in the 1960s, but full grade separation was built instead. Given how little northbound traffic is present on Rutherford Avenue, there is no need for bidirectional throughput in the tunnel, and northbound traffic could be routed on the surface, allowing a busway to use the underpass if desired. The entirety of Rutherford Avenue, originally planned for 78,000 vehicles in 1980 (a number that, based on volume increases, would be more than 100,000 today), carries only 50,000, with most of the traffic southbound.

- A travel path through Sullivan Square, from I-93 via Cambridge Street, the traffic circle, and then north toward Everett, Medford, and Somerville, with additional crossing traffic from Charlestown and Rutherford going west, all interacting in the circle. The only grade-separated movement is that from Rutherford Avenue toward Everett, which currently is handled with a single lane and is not the proximate cause of congestion, which is caused by backups approaching the Alford Street Bridge and within the rotary itself. Given that most of this traffic is already handled on the inefficient surface rotary, an underpass remains unneeded and, because of the merging situation to the north of Sullivan Square, may exacerbate traffic congestion. If any underpass were retained, a direct link from I-93 under Sullivan Square to Alford Street would be the most reasonable pathway, but this would require significant capital outlay.

Otherwise, roadways are generally built far wider than necessary. Rutherford Avenue was built in the 1960s with five through lanes in each direction—three more than I-93, despite carrying just a quarter of the traffic. Initial data has shown that the opening of the nearby casino has not materially changed these numbers, as casino traffic has no incentive to travel at the most congested times of day. Traffic from the south likely avoids Rutherford Avenue by using the Cambridge Street ramp. Traffic from the north likely exits I-93 or Route 1 farther north, avoiding Rutherford Avenue entirely.

Just because Rutherford Avenue has the cross-section present today does not mean that it needs to retain that cross-section in the future. The roadway carries no more traffic today than it did in 1962—six decades ago! Its use has been stagnant for that time, and there is no reason to think that it will need additional capacity in the future. In the 1960s, in fact, it carried as many cars as it does today with a cross-section that, at the Prison Point

Bridge, was a four-lane city street, not a 10-lane expressway. **Rutherford Avenue should be used as a minor arterial roadway at most, and it should be better integrated into the neighborhood rather than serving as a high-speed, low-traffic barrier with a bottleneck at either end.**

Rutherford Avenue's excess vehicle capacity can be reallocated to improve transit priority and safe pedestrian and bicycle connections. BRT lanes along Rutherford will connect bus-only lanes on Broadway with proposed lanes on North Washington Bridge, providing continuous transit priority between Everett and Boston. BRT stations on Rutherford will make it more feasible to access Community College or the new Hood Park development without a car.

BOX A: Brief History of Rutherford Avenue

Rutherford Avenue runs parallel to the original route from Charlestown (originally a neck) toward Cambridge and Medford, which was in fact the route taken by Paul Revere in 1775. Rutherford Avenue was one of the streets radiating from what is now City Square, running a few blocks to the tidal flats of the Millers River, and often called Richmond Street. Charlestown grew quickly after Independence and was annexed to Boston in 1874. The Prison Point Bridge was first built in the early 1800s, when the state prison was constructed where Bunker Hill Community College is today.

By the late 1800s, Rutherford Avenue was laid out running along its current alignment from Sullivan Square south-southeastward toward the state prison, and then along the earlier Richmond Street toward City Square, generally demarcating the transition between residential parts of Charlestown and the industrial and railroad yards farther west. The roadway remained at this width until after World War II.

In 1952, Rutherford was widened along the northern, more-industrial portion of the corridor, eating about 100 feet into the eastern Charlestown side of the corridor. This included the construction of both the underpass present today connecting to the Alford Street corridor toward Everett and the now-demolished overpass northwest toward Medford and Somerville. This created the rotary at Sullivan Square and was built to mostly avoid the Main Line El, which wasn't relocated and extended toward Oak Grove until 1975. With these changes, Sullivan Square had throughput for four through lanes of traffic on the overpass and underpass, as well as traffic through the rotary, although the roadway still narrowed considerably approaching Charlestown and running on city streets to City Square and the North Washington Street bridge.

The state prison was decommissioned in the late 1950s and the site lay fallow until the Community College was built in the early 1970s. Notably, one of the last portions of the metropolitan highway system to be completed in Boston was the extension of I-93 from Medford to Boston. During this time, most Boston-bound traffic from the north exited the highway in Medford and then used the McGrath-O'Brien highway to get to Boston. Rutherford Avenue also handled this traffic, with the flyover near Sullivan Square allowing traffic to bypass the rotary there, but there was still no connection to Boston other than the narrow older segment of Rutherford Avenue.

The1962 North Area Terminal Study[43] looked at this area. Some facts from the report:

- Rutherford Avenue at that time had 45,000 vehicles per day, despite the narrow cross-section approaching the Prison Point Bridge: This is approximately the same number of vehicles that use this bridge today. It was designed to carry 78,000 vehicles in 1980, far more than today; the Alford Street Bridge was planned to carry 35,000.
- At the time, North Station and the Lechmere Viaduct were seen as inconsequential and deemed for demolition, which would also allow the extension of the Mystic River Bridge to tie directly into Storrow Drive.
- Rutherford Avenue at the Prison Point Bridge was planned with a single flyover ramp from the Prison Point Bridge to Rutherford Avenue. (This is likely why the current Prison Point Bridge widens approaching Rutherford.) This was never built; instead, a full grade separation was built at this intersection.
- Rutherford Avenue was originally planned to cross over a pair of bridges, Warren Street (the location of the new Charles River Dam and locks today) and the existing North Washington Bridge.
- Land Boulevard and O'Brien Highway were planned to have a grade separation. An irony of the report is that it spends considerable time bemoaning the blighting effects of the Lechmere trolley viaduct but spares no cost building new, adjacent road viaducts.
- Community College station was originally planned on the Boston Redevelopment Authority (now Boston Planning and Development Agency) owned land to the southeast of the station but was moved below the highway to allow more land for development.

The early 1970s brought many changes to the roadway network. I-93 was completed between Medford and Boston as a compromise: It would have been subjected to Governor Sargent's moratorium on highway construction, but the contracts would have cost more to cancel than complete, so it was placed into service in 1973. Rutherford Avenue was completed in parallel and was originally striped with five lanes in each direction, although these converged to the City Square rotary, so much of this capacity went unused, especially with the parallel interstate highway. Combined, these two roadways added 16 to 18 lanes of traffic to the corridor in the course of a few years, mostly due to a lack of coordination between the Mass DPW and the City of Boston and BRA.

Just 20 years later, the Central Artery North Area (CANA) project rerouted the Tobin Bridge ramps into a tunnel below City Square, which finally allowed the alignment of Rutherford Avenue onto the North Washington Bridge, although this bridge still runs to narrow roads in Boston and frequently results in congestion because of this downstream pinch point. Still, it was more than 40 years from when the underpass and overpass were built at Sullivan Square to when the roadway was widened into Boston. This was one of the first portions of the Central Artery put into service.

Rutherford Avenue was not part of the Central Artery but was affected by two major pieces of it. First, the Central Artery project added an off-ramp from I-93 northbound to Cambridge Street near Sullivan Square, but no corresponding on-ramp. This ramp was originally supposed to match the on-ramp to I-93 near City Square but was relocated as part of the long saga building the "Scheme Z" ramps between City Square and the Artery. Thus, traffic from Everett and nearby parts of Charlestown, Medford, and Somerville logically uses Rutherford southbound but I-93 northbound. This has led to dramatic differences in traffic volumes on the two directions of Rutherford Avenue, as well as significant congestion in the rotary at Sullivan Square, since all northbound traffic is required to turn through at least 180 degrees of the rotary to access the Alford Street Bridge or Broadway and Mystic avenues.

The second change was the decommissioning of the overpass above Sullivan Square in the early 2000s. With the opening of I-93 three decades before, this link had not filled any major desire path—it carried little traffic, so its removal has not drastically changed traffic patterns in the region.

43 https://archive.org/details/northterminalare00bart/mode/2up

REDESIGNING RUTHERFORD AVENUE

The City of Boston is currently redesigning Rutherford Avenue with the goals of improving pedestrian and bicycle connections, reducing congestion, protecting Main Street from cut-through traffic, creating public and open space, and unlocking opportunities for new development.[44] The design and construction is funded by the Massachusetts Gaming Commission, Encore Boston Harbor, and the federal government. **BTD had planned to present 25% designs to the public in the fall of 2020, but this date has already been pushed back several times.**

BRT LANES ON RUTHERFORD AVENUE

As the Lower Mystic Regional Working Group study concluded, redesigning Rutherford Avenue may "help liberate capacity" for improved bus and BRT service.[45] Dedicated bus lanes and BRT service connecting Everett and downtown Boston along Rutherford could help transform the corridor from a motor vehicle–dominated throughway to a more human-scale corridor that prioritizes transit and pedestrians.

A BRT corridor along Rutherford Avenue does not require preserving the underpasses; in fact, it benefits from their removal. BRT buses would be unlikely to use the Rutherford underpasses since they need to remain at-grade to access Sullivan Square Station. Travel time on the corridor would not suffer from removing the underpasses as there is a negligible difference in travel time between the underpass and surface road design options.[46]

If the Rutherford underpasses are removed, they could give way to an at-grade boulevard designed to meet regional transit, equity, and climate-change goals. An improved, at-grade Rutherford Avenue could prioritize transit, improve pedestrian and bicycle connections between adjacent neighborhoods, replace excessive hardscape with green infrastructure, and ultimately move more people safely and more efficiently.

The final configuration of Rutherford Avenue, vis-à-vis the underpasses and prioritization of right-of-way, impacts how BRT could be incorporated along the corridor.

- **Underpasses removed.**
  If an entirely at-grade Rutherford Avenue is proposed, center-running BRT lanes could be considered (Figure 36). The addition of new cross streets and signalized intersections along Rutherford may introduce convenient locations for BRT stations. The new mixed-use development along the southside of Rutherford Avenue (e.g., The Graphic Lofts, Hood Park) would benefit from improved transit service and may even consider reducing the amount of parking built on site as a result. These developers are important stakeholders in the redesign of Rutherford and should be engaged early about the benefits of transit service, transit priority, and BRT.

44 BTD 2021.
45 MAPC and CTPS 2019.
46 The Lower Mystic Regional Working Group (MAPC and CTPS 2019) found that there was a negligible difference in travel times between the underpass and surface road design options. The travel time from Sullivan Square to the North Washington Street Bridge will only be 3.2 minutes longer with the Surface Option in the morning and 2.7 minutes in the afternoon peak hours in 2040 (RCIC 2017). This is a negligible difference given the modeling and forecasting uncertainty.

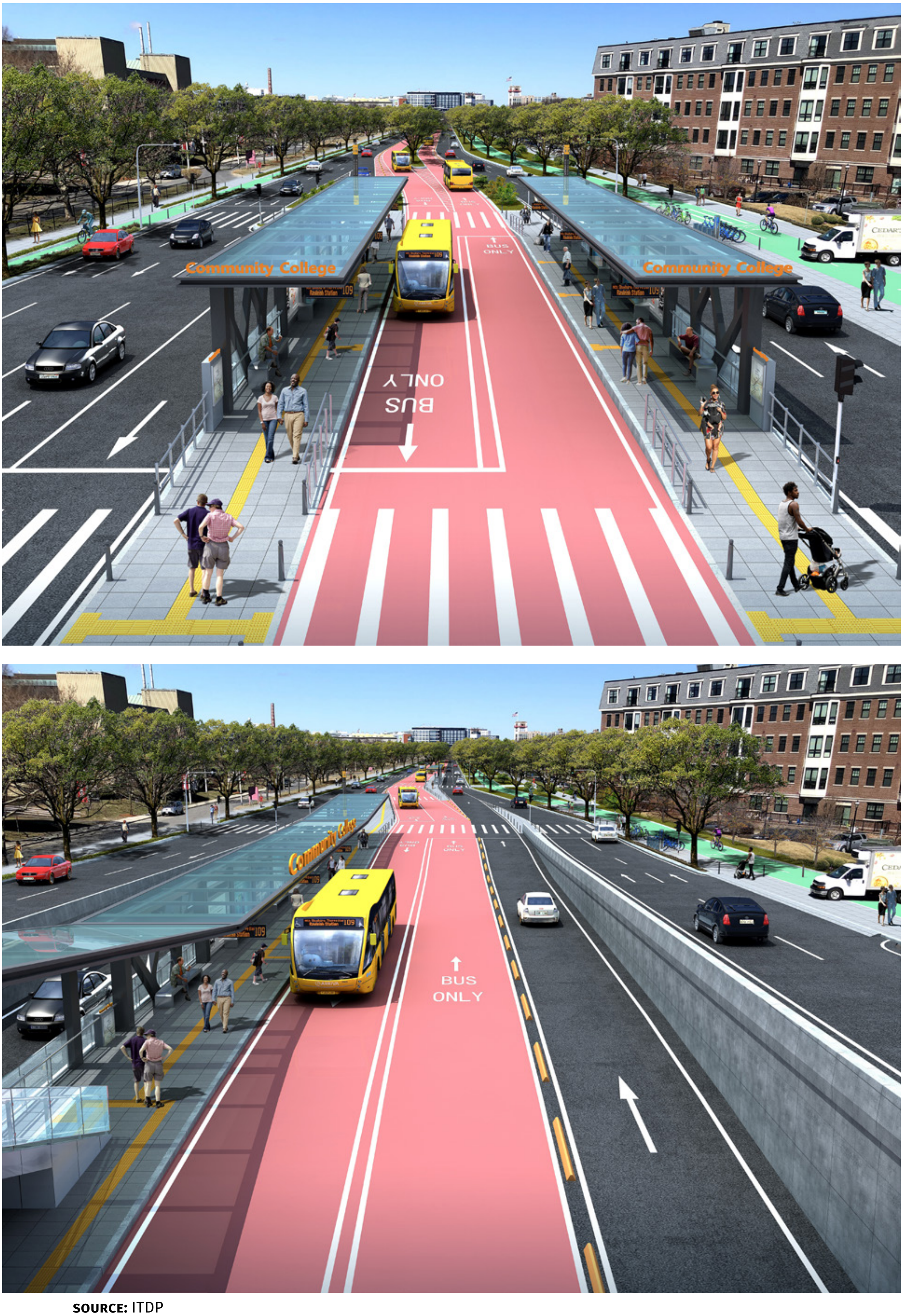
- **Underpasses retained.**
  If the Rutherford Avenue underpasses are preserved, it would likely be preferable to keep the BRT lanes and stations aligned to the at-grade service lanes between Sullivan Square and Chelsea Street. This would require one-way BRT lanes in each direction and split-platform stations. The bus-only lanes could be aligned to the outer curb of the service lane or the inner curb of the central roadway.

Figure 36: Rutherford Avenue rendering, typical cross-section with BRT lanes.

SOURCE: ITDP

As of October 2019, the City of Boston's preliminary plans for the corridor preserve the underpasses. An in-bound BRT lane is proposed both through the Sullivan Square underpass and along the surface lanes. It is unclear if BTD plans to include a bus-only lane along Rutherford Avenue between Sullivan Square and Chelsea Street. Omitting a BRT lane from Rutherford Avenue would miss a significant opportunity to connect bus-only lanes on either side of the Rutherford corridor—on Broadway in Everett and North Washington Street Bridge—providing continuous bus priority from Everett to downtown Boston. As ITDP's transit job-access modeling showed, fast bus service connecting Sullivan Square and downtown Boston opens up access to significantly more jobs than the current service.

Figure 37: Rutherford Avenue rendering at Community College, without an underpass (top) and with underpass (bottom).



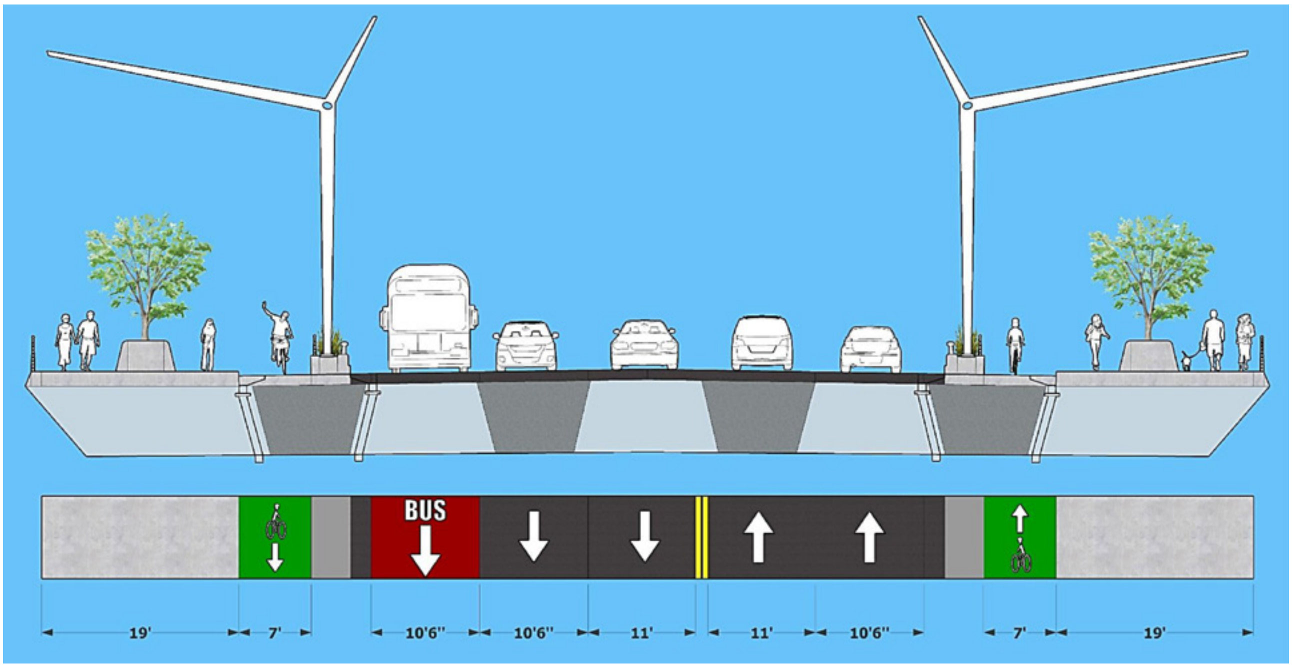
SOURCE: ITDP

The intersection of Rutherford and Austin Street is an important connection to Bunker Hill Community College and the MBTA Orange Line Community College Station to the south. This is recommended as a preliminary BRT station location (Figure 37). The Rutherford Avenue service lanes narrow here, so the design and configuration of curbside BRT lanes and the station will need to be carefully studied.

NORTH WASHINGTON STREET BRIDGE

MassDOT and the City of Boston are constructing a new North Washington Street Bridge to replace the 100-year-old structure. The final design includes a dedicated bus lane in the inbound direction only, plus two travel lanes in each direction (**see Figure 38**). Construction is currently in progress and is expected to continue until Spring 2023. The construction is phased and includes a temporary bridge structure that also includes two inbound lanes and one outbound lane. This temporary bridge is scheduled to be operational throughout the second stage of the project, from November 2019 to October 2021. The final alignment could be restriped to swap a northbound general-purpose travel lane for a northbound bus lane, given the limited upstream throughput for traffic originating from narrow streets in Boston. ITDP has discussed data collection with the City of Boston during the time when a single lane outbound lane is being provided to determine whether this could be carried forth for the final configuration. If an outbound dedicated bus lane can be accommodated, both bus lanes could be moved to the center of the bridge.

Figure 38: Final design configuration of the New North Washington Street Bridge includes a dedicated inbound bus lane.



SOURCE: MassDOT and City of Boston.

APPENDIX

L

FLEET SELECTION

ITDP recommends electric BRT buses for the Everett–Boston corridor to reduce harmful local air pollution for surrounding communities and to contribute to reductions in greenhouse-gas emissions. The MBTA buses that currently connect Everett to Sullivan Square (routes 104, 105, 109) are diesel-powered, so shifting this corridor to electric-powered transit would result in a net reduction in emissions of local air pollutants and greenhouse gases (GHG), resulting in positive public health and equity outcomes.

ITDP considered the trade-offs between two types of electric buses for this BRT corridor: battery-electric buses (BEBs) and electric trolleybuses, described here.

BATTERY-ELECTRIC BUSES (BEB)

In 2019, MBTA purchased five 60-foot New Flyer Xcelsior XE60 low-floor, articulated battery-electric busses for service on the Silver Line as part of a two-year pilot.[47] These BEBs may prove suitable for the Everett–Boston BRT corridor.

Inadequate battery range is the biggest weakness of BEBs. In its BEB pilot, MBTA found the battery range of the buses was less than the distance a typical Silver Line bus operates each day, and that the range was halved on cold days.[48] Other U.S. cities have had similar experiences with battery range of electric BRT buses. Albuquerque returned its electric BRT buses when their performance did not meet the city's range specification and launched its ART service with articulated clean-diesel buses instead.[49] Indianapolis has tried to extend the battery range of the electric buses operating on its Red Line bus corridor with in-route charging, but it continues to have problems.

There are also some concerns that battery-electric buses have insufficient **power to adequately heat** the interior during winter. Two typical work-arounds include:

- Incorporating a secondary diesel-powered heater if the batteries are insufficient. This cuts the emissions-reduction benefits of electric buses.
- The five BEBs MBTA is piloting include auxiliary electric on-board heaters. These are expected to improve emissions compared to diesel-powered heaters but will also deplete the battery.[50] On a high-mileage corridor, this negates the advantages of a battery-operated fleet.

The New Flyer BEB being tested in Silver Line operations has two driven axles, which provide a benefit on hills during inclement weather. The rear and center axles are powered by electric motors. On-road testing during Boston's winter will reveal whether this improves traction compared to MBTA's existing 60-foot articulated buses. This is important in the Everett corridor, given the relatively steep grades on portions of Broadway in Everett.

47 AASHTO 2019.
48 Vaccaro 2020
49 Carrigan, Wallerce, and Kodransky 2019.
50 AASHTO 2019.

As the BRT draft service plan is refined, the total expected daily vehicle miles for the fleet can be calculated. In turn, this can inform a battery range specification for battery-electric buses operating on the BRT routes. Buses may be able to serve the route with only overnight charging, but if the battery range is less than anticipated, buses may require auxiliary cabin heat and/or additional fleet to maintain operating frequency.

ELECTRIC TROLLEY BUSES (ETBS)

Another BRT vehicle to consider is electric trolleybuses, a familiar technology in Boston. The MBTA currently operates about 22 electric trolleybuses along almost 22 route miles (routes 71, 72, 73, 77A). These buses rely on connections to overhead catenary wires for their electricity, and the addition of small on-board batteries and inline charging provide more operational flexibility, since the buses could go off wire for up to five miles, or farther depending on the length of the route and the proportion of the route spent operating on-wire[51]. This in-motion charging is discussed further below. Trolleybuses are used on the Silver-rated BRT in Quito, Ecuador, as well as a BRT in Beijing.[52]

COMPARISON OF BEB AND ELECTRIC TROLLEY BUSES

The performance and cost trade-offs between battery-electric and electric trolleybuses in the operational context of the Everett–Boston BRT corridor needs to be considered further (see **Table 5**). Battery electric BRT buses are a nascent technology and their range may be inadequate for the Everett–Boston BRT corridor operations. BEBs have lower maintenance costs than other BRT bus technologies. Electric trolleybuses are mature technologies, and very familiar to MBTA. Their overhead catenary lines, while a visual nuisance, eliminate battery range anxiety, and with in-motion charging, ETB can even travel off-wire for several miles. A drawback is higher maintenance costs.

51 Knorr-Bremse 2019.
52 ITDP 2021.

Table 5: BEB and electric trolleybus performance metrics

	Battery-Electric Buses	Electric Trolleybuses
Operational battery range (miles/charge)	Varies widely by weather, terrain. Recent U.S. tests have revealed ranges between 60 and 177.[55]	With in-motion charging, up to 15 miles off-wire.
Rated power	220 kW peak (295 hp)	240kW
HVAC power source	Aux diesel or electric	Electric
Powered 2nd axle	Either rear only, or rear and center axle	Electric
Fuel cost per mile[53]	$0.50	
Total maintenance cost per mile[54]	$0.26	$0.46

RECHARGING OPTIONS FOR EACH VEHICLE TECHNOLOGY

WHERE TO RECHARGE ELECTRIC BRT BUSES?

While the MBTA's five pilot New Flyer battery-electric buses do include a 450 kW on-route rapid charger, which allows the buses to partially recharge during service, they will need to be fully recharged overnight. Depending on the battery and charging method, it can take three to fivehours at a high charging rate to fully recharge a BEB.[55] This is a significant operational difference compared to conventional buses, which can be refueled in several minutes.

Battery-electric buses on a new Everett–Boston BRT corridor would likely need to be charged at a garage overnight. As part of its $10m federal grant, MBTA installed five charging stations at the Southampton Garage for overnight recharging of the new Silver Line BEBs.[56] In its BEB pilot, MBTA found it took six hours to recharge the batteries, which would introduce significant operational challenges.[57]

53 Assuming electricity cost of $0.50 per mile based on study of King County Metro's battery-electric bus demonstration (FTA 2017b).
54 These maintenance costs per mile are from an NREL study of buses in King County Metro (FTA 2017b). Hybrid buses had a maintenance cost of $0.32/mile and diesel buses $0.46/mile. The BEBs were still under warranty at the time, and the maintenance costs were expected to increase once the warranty ended and King County Metro staff assumed responsibility for the maintenance. The route profiles of the buses were such that the BEB fleet was used on suburban routes with speeds more than 50% faster than ETB routes.
55 MassTransit 2018.
56 MBTA 2019.
57 Vaccaro 2020.

Using the Southampton Garage for buses operating on the Everett–Boston corridor would introduce significant deadheading, whereas recharging BEB buses at a garage closer to the BRT corridor would reduce nonrevenue service hours and operating costs. Other options closer to the Everett-Boston BRT corridor to explore include:

- MBTA Everett Main Repair Facility, 80 Broadway, Everett
- MBTA Charlestown Garage, 21 Arlington Avenue, at the south landing of the Malden Bridge

Many of MBTA's existing bus garages are over capacity and outdated, and therefore no longer able to service the existing diesel and hybrid fleet. So in addition to upgrading a garage for electric vehicle charging and maintenance, there's a backlog of bus garage maintenance. An estimated $1 billion is needed (and currently unfunded) over the next 13 years to rebuild or replace all of the bus maintenance facilities.[58] The MBTA may also consider new locations, especially on highway surplus land, for bus storage facilities. However, running ample power for mass charging stations will require significant upgrades to any existing or future facility.

IN-ROUTE CHARGING FOR BEBS

In-route charging allows battery electric buses to charge at certain points along their route to maintain a state of charge. For instance, a bus traveling between two terminals might charge for a few minutes at each and then charge along the route. Indianapolis is experimenting with in-route chargers to extend the battery range of the BEBs on its Red Line bus corridor. This might be useful for some buses in the Everett corridor, especially the 104, which runs from Sullivan to Malden, since there is ample traction power available at each layover.

The disadvantage of this is that it requires built-in charging time at the end of the route beyond normal schedule recovery time (although it may be possible for a bus to charge while a driver takes a break). This reduces the overall efficiency of the vehicle, because it is required to spend some time stopped to charge. While buses generally do spend time stopped at route termini, during times of heavy ridership or congestion, this time may be reduced if the bus runs behind schedule. However, with an adequate fleet, there would be plenty of room to charge buses between runs at Sullivan Station, at least in its current layout.

IN-MOTION-CHARGING (IMC) BUSES

In between fully battery-electric buses and static trolleybuses are in-motion- or in-route-charging buses. These buses can charge along the route and then run for significant distances off the wire. They require much smaller battery packs and less charging infrastructure, and they are able to heat and cool the cabin while on the wire to minimize battery depletion due

58 Lisinski 2019.

to climate control. These buses are common in Europe, where many cities have trolleybus networks and have used these buses to gain flexibility or to increase the range of their zero-emissions networks. In the United States, they are in use in other cities with ETB networks. In most cases they provide a range of a few extra miles in case of wire problems or construction, but they are, in some cases, used to extend routes beyond existing wires. Dayton, Ohio, the smallest city with electrified mass transit, replaced its fleet of trolleybuses with a fleet of in-motion-charging buses after the IMC buses compared favorably to dual-mode diesel-electric trolleybuses that were also tested.

Dayton, which has an existing trolleybus network, tested two types of buses for system, diesel-electric hybrids similar to the MBTA's existing Silver Line fleet and in-motion charging buses and found the latter far superior. It is now upgrading its entire fleet to IMC buses.[59] Quito, Ecuador's Silver-ranked BRT system uses electric trolleybuses.

There are two specific uses in which these types of buses would be favorable: in a network with existing electrification or on a heavily used trunk where the investment in electrification would allow many buses to charge. In Boston, a good example of the first case would be to electrify all the buses that currently use the Harvard Busway Tunnel.

Where there is existing electric catenary infrastructure, IMC buses have significant advantages over BEBs. First, they require no additional charging infrastructure: They charge the batteries when they are running on the wired portion of the route and then use the stored power when operating off-wire. BEBs would require either end-of-route power stations, high-voltage charging facilities at garages, or both. While the range for an IMC bus is lower than that of a BEB, they can be deployed on routes with partial or full coverage of existing wires, so they only need to travel a few miles off-wire at a time. This allows the buses to carry much smaller batteries, reducing the weight of the on-board power source and the power required to carry this bulk around.

There are several challenges to implementing in-motion charging on the route in Everett. The first is that there is no existing trolleybus infrastructure in this area (although Everett did have an extensive trolleybus network, it was abandoned in 1963[60]). Traction power would be available from the existing Orange Line substations. The length of the BRT corridor infrastructure along Broadway and Rutherford Avenue (and where the electric catenary would be installed) dictates how far IMC buses could operate off-wire. There are further issues with the geometry of the roadway network, particularly crossing the movable bridge at Alford Street and navigating Sweetser Circle. **IMC buses would be difficult to implement on this route**, although there are examples of movable bridges with overhead electric power, such as the Montlake Bridge in Seattle.

59 Hulsey 2017.
60 Belcher 2021.

BOX B: MBTA's Electric Trolleybuses

The two portions of the MBTA that currently run ETBs (or in the case of the Silver Line, combination diesel-ETBs) are almost perfectly designed for IMC technology. In the case of the Silver Line, the distance from the end of the wire at Silver Line Way to the Airport and back is about six miles—well within the range of the buses (the SL2 is shorter still). The distance covered by the SL3 to Chelsea is slightly longer, clocking in at 11 miles. This is still within the range of an IMC bus, but adding a short segment of wires to the Chelsea portion of the route would allow the buses to operate even more reliably.

For the buses serving the Harvard Busway Tunnel, the calculus is even more favorable. Today, buses entering the Harvard Busway Tunnel from the west—the 71 and 73 on Mount Auburn Street—operate on electric power, while buses coming from the north (other than yard pullouts for the ETB routes and the 72) use diesel propulsion. This means that each set of buses empties out in the tunnel and then requires a significant "deadhead" trip without passengers to turn around and begin its trip in the other direction. For the 71 and 73, this means a lap of Cambridge Common, traveling nearly a mile before picking up their next load.

With an IMC fleet, the diesel routes from the north and electric routes from the south could be interlined, meaning that buses would no longer have to run through the tunnel, loop around empty, and run back. At peak rush, there are 20 buses running through the tunnel in each direction each hour: from the west, the 71 and 73, and from the north, the 72, 74, 75, 77, 78, and 96. These routes could be interlined: A bus from Watertown Square could run through the tunnel at Harvard and continue on to Arlington Heights or Medford Square, while the next bus, from Waverly, could run through the tunnel and proceed to Belmont or Arlmont Village. This would increase the efficiency of the current routes through the Harvard Busway Tunnel, allowing the T to provide more service for passengers with the same number of vehicles by eliminating the time needed by the bus to travel without passengers to turn around outside of the tunnel.

FLEET PROCUREMENT

The recent cost of 60-foot articulated buses can guide the capital cost estimates for the Everett–Boston BRT fleet. Table 6 shows recent costs of BEB, diesel-electric hybrids, clean-diesel, and electric trolleybuses.

Table 6: Recent procurement costs of 60-foot articulated buses

Fuel/ Propulsion	Mfg & Model	Length	Door Location	Unit Cost	Year	Agency	Source
BEB	New Flyer Xcelsior CHARGE	60-foot articulated	Right	$1.3m	2020	King County Metro	MassTransit 2020a and 2020b
BEB	New Flyer XE60	60-foot articulated	Right	$2m each, Part of $10m FTA LoNo grant	2019	MBTA	AASHTO 2019
BEB	BYD K11M	60-foot articulated	Left and right	$1.2m	2017	IndyGo	Carrigan, Wallerce, and Kodransky 2019
Diesel-electric hybrid	NFI DE60LFA	60-foot articulated	Left and right	$989k	2007	GRCTA & LTD	Carrigan, Wallerce, and Kodransky 2019
Diesel-electric hybrid	New Flyer XDE40 & Nova Bus LFX	60-foot articulated	Left and right	Unknown	2014	CTDOT	Carrigan, Wallerce, and Kodransky 2019; CPTDB 2020.
Clean-diesel	New Flyer XD60	60-foot articulated	Left and right	$870k	2018	ABQ RIDE	Carrigan, Wallerce, and Kodransky 2019
Electric trolleybus	NFI XT60	60-foot articulated	Right		2015	King Country Metro	2020

APPENDIX

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AFFORDABLE HOUSING FUND PRECEDENTS

Table 7 summarizes recent equitable TOD and affordable housing funds in U.S. cities that could be used as models for the Everett–Boston BRT corridor.

Table 7: Examples of equitable TOD and affordable housing funds in U.S. cities

Where	Name	Amount	Sucess	Goal	Source
Denver (2010)	Denver Regional Transit-Orientated Development Fund	$24m	$32.8m invested to create or preserve more than 1,300 affordable housing units		Enterprise 2021
Bay Area (2011, relaunched in 2017)	Bay Area Transit-Orientated Affordable Housing (TOAH2)	$40m	TOAH2 so far has created or preserved 900 units	"Development of affordable housing, community services, fresh food markets, and other neighborhood assets near transit lines throughout the Bay Area"	MTC 2018
Boston (2014)	LISC Equitable TOD Accelerator Fund		$18m invested to create or preserve more than 22 properties, including more than 1,500 affordable housing units		LISC Boston 2021
Seattle Region (2016)	Regional Equitable Development Initiative (REDI) Fund	$21m		"Acquire sites to preserve affordable housing or to develop new affordable and mixed-income housing."	Alvarado 2018
Indianapolis (2019)	Equitable Transit-Orientated Development Fund	$15m	N/A	"Preserve or create 1,000 housing units of affordable housing options."	Carlstedt and Washburn 2019
Dallas	eTOD			1,300 housing units within 5 years	buildingcommunityWorkshop 2016

APPENDIX

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EXISTING AND CONCURRENT PLANNING PROJECTS

The plans to engage with include:

- Silver Line 3 Extension Feasibility Study (MassDOT)
- Rutherford Avenue redesign
- Sullivan Square redesign
- Sweetser Circle redesign
- MBTA 5-year Capital Investment Plan
- MBTA Bus Network Redesign
- MBTA Focus40
- MBTA Bus Service Delivery Plan
- MBTA Rail Vision
- Tobin Bridge bus lane pilot (launched December 2020)
- MetroCommon2050 (MAPC's new regional planning process)
- Municipal planning efforts
- Lower Mystic Working Group
- Adjacent BRT corridors and bus lanes in nearby communities (especially Somerville and Cambridge as destination cities)

Several of the MBTA's current and planned priority investments relate to or will affect the Everett-Boston BRT planning and implementation. These represent opportunities to collaborate and integrate BRT into MBTA's plans:

Table 8: MBTA Current and Planned Priority Investments Related to Everett-Boston BRT Corridor

	Current or Near-Term MBTA Commitments Through 2023	Next MBTA Priorities Through 2040	Big Ideas MBTA Is Exploring
Silver Line	• New Silver Line fleet planning. Testing hybrid and ZEB options eliminating power changeover delays. • In-service testing 5 60-foot BEB on the Silver Line • Transit priority improvements to SL2, SL3 and in Seaport	• Expanded Southampton Garage or other storage location • BRT to Everett • Silver Line extension beyond Chelsea	
Orange Line	New cars increase capacity and reduced headways to 4.5-mins (by early 2022)	• Additional capacity and 3-min headways	• Sullivan Square Superstation with new Commuter Rail connections and Silver Line extension • Orange Line extension to Everett. Lower-cost speed and reliability improvements to Broadway should be exhausted before costly rail pursued

SOURCE: MBTA and MassDOT 2019

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Grill
LOUNGE
SCHOOL STREET
THE DISTANCE OF CARE
BUS ONLY

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