ALTERNATIVES ANALYSIS

Bus Rapid Transit

PVTA Bus Rapid Transit Alternative Analysis

BUS LANE

Final Report—Draft

Pioneer Valley Transit Authority

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Chapter 1: Purpose and Need

1.1 Introduction

The Pioneer Valley Transit Authority (PVTA), in collaboration with the Massachusetts Department of Transportation (MassDOT) and the City of Springfield, has prepared a Bus Rapid Transit Alternatives Analysis to determine the feasibility of implementing Bus Rapid Transit (BRT) service along the State Street and Boston Road Corridor in Springfield, MA.In 2014, PVTA completed a Comprehensive Service Analysis (CSA) which developed a preferred alternative to improve transit service in the region. Implementing BRT service following PVTA's B7 (State Street Route) was a top recommendation for improving service.

There are many widely accepted definitions of BRT. For the purposes of this report and established by the project's Oversight Committee, BRT is defined[1] by transportation planners internationally as "a high-quality bus-based transit system that delivers fast, comfortable, and cost- effective services..." To make this definition more accessible to the public, we have modified it to be more easily understood by non-planning professionals as follows: "BRT is a cost-effective approach to transit service which blends the positive features of rail with the flexibility of bus transit to make riding the bus a higher-end transit service alternative."

Recommendations for implementing the BRT service in this report will be guided by how well PVTA can implement the seven key BRT elements defined by the FTA as follows:

[1] BRT definition from the Institute for Transportation and Development Policy (ITDP), in *The Bus Rapid Transit Standard.* ITDP works with cities worldwide to bring about transport solutions that cut greenhouse gas emissions, reduce poverty and improve the quality of urban life. Use of the ITDP standard for Bus Rapid Transit for the PVTA BRT Analysis was established by Mass DOT and PVTA jointly at the beginning of the project.

1.2 Purpose and Need

The purpose of this study is to develop an alternative to implement BRT service along State Street and Boston Road to reduce traffic delays, improve connectivity to Union Station, improve pedestrian and cyclist safety, support economic development and support Massachusetts' Statewide Healthy Transportation Policy Directive. MassDOT has identified a need for BRT service outside the City of Boston and believes the implementation of such a service will set the standard for future BRT corridors in the state.

PVTA's bus route, the B7, which currently provides fixed-route service to the State Street corridor, carries the largest number of passengers annually in the PVTA system, an average of more than 5,100 passengers per day. This is almost 20% of the PVTA ridership in Springfield carried by one route. Developments in the city, such as the MGM Springfield casino complex, the new Union Station Intermodal Transportation Center, and PVTA's proposed new bus operations and maintenance complex on Cottage Street, will allow for and add further demand for transit service. An influx of new riders could overwhelm the existing service and without capital improvements the level-of-service may not meet the needs of potential transit riders. Implementing a BRT service, as an addition to the existing local routes, will vastly improve mobility and safety along the corridor and provide better transit connectivity to the surrounding region.

Figure 1: Photos of Corridor

This analysis will evaluate factors such as ridership patterns, existing traffic conditions and future traffic impact, as well as environmental impacts. The alternatives presented in this study will be based on 10 year projections to the year 2025. The Study Corridor presents some unique conditions and challenges which must be considered in the development of the alternatives. Each alternative will be thoroughly vetted during the alternatives analysis to select a Preferred Alternative for the corridor.

1.2.1 Project Location

The Study Corridor is located in Springfield and originates from the future location of Union Station on Main Street and continues along State Street and Boston Road and ends at the Eastfield Mall (Figure 2).

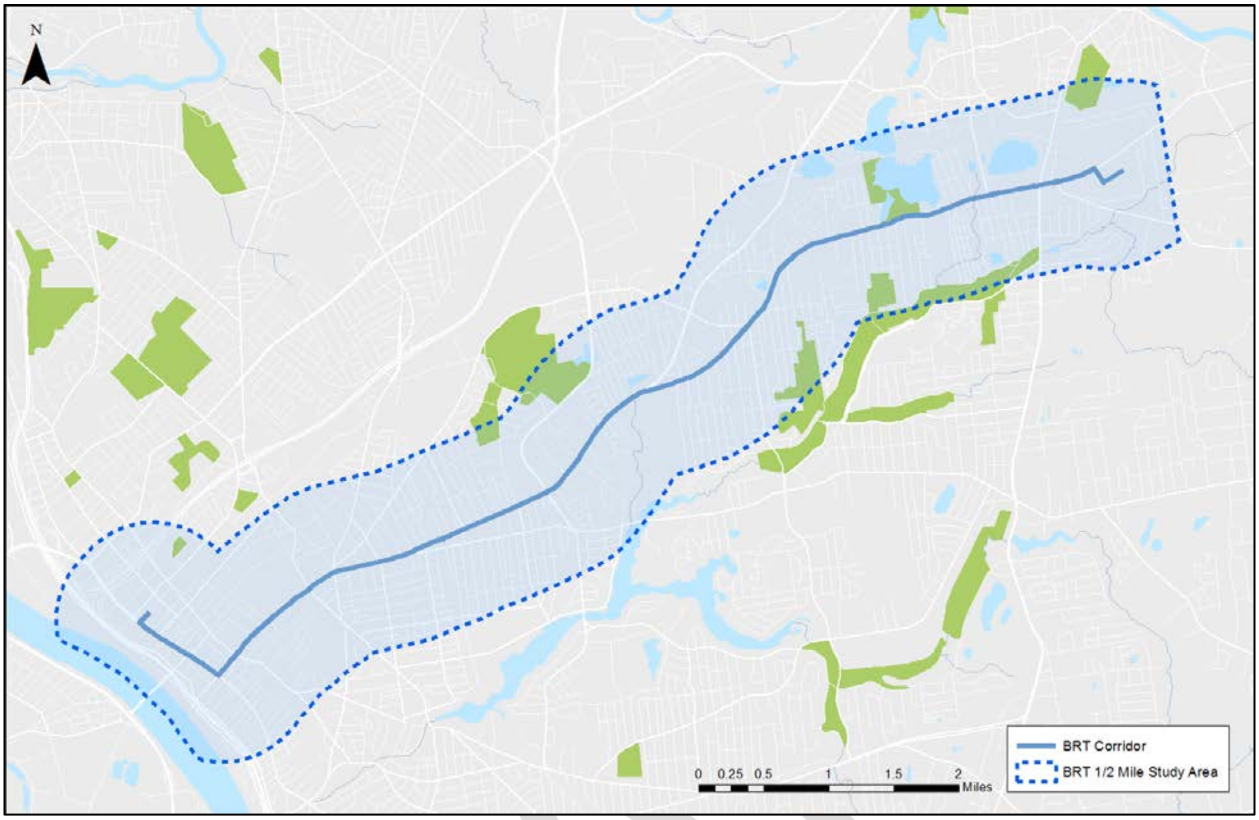

Figure 2: BRT Study Corridor

Existing Corridor

The Study Corridor spans 7.1 miles between Union Station and the Eastfield Mall. A majority of the corridor follows Boston Road and State Street. Known as the "Gateway to Springfield" due to its proximity to the entrance and exit ramps for I-90, the Boston Road/State Street corridor recently underwent a reconstruction and beautification project. The entire corridor operates as two-way traffic, and a majority of the corridor has two travelling lanes in each direction with turning bays at intersections. There are 36 signalized intersections along the corridor and some sections are as wide as 88 feet.

On-street parking is limited along most of the corridor. Parking spaces are available along Main Street, on State Street between the intersections of Main Street and Dwight Street, and on the eastbound lanes near the Walnut Street intersection and in front of American International College (AIC); after this point on-street parking is restricted.

The western end of the Study Corridor is located in the heart of downtown Springfield while the Eastfield Mall serves as the anchor at the eastern end. Prominent institutions in the downtown area include the downtown Springfield Central Business District, MassMutual Center, Springfield Library and Museums, Federal Court House, and the Springfield Armory National Historic Site. In addition to several Springfield public schools, Springfield Technical Community College (STCC) and AIC are located along the corridor; approximately 10,500 students are enrolled between the two colleges. Other major activity centers along the corridor include MassMutual and Walmart.

At the eastern terminus is the Eastfield Mall, which has undergone significant change since it first opened as the region's first shopping mall nearly 50 years ago. Activity at the mall has declined in recent years as retailers have closed shop including J.C. Penney, a major anchor at the mall, in 2011 and the recent announcement of the closing of Macy's in 2016. Redevelopment plans for the mall include demolition of the J.C. Penney space which will create a clean slate to help attract a new tenant. Should a major retailer, such as Target, fill this vacancy, the corridor would likely face additional vehicular traffic and increased transit demand.

Travel Market

For the purpose of this study, the Study Corridor is defined by the existing PVTA route B7 which travels along State Street and Boston Road as well as on Main Street to Union Station. An additional ½ mile buffer surrounding the corridor has been defined as the Study Area. This 1/2 mile buffer reflects the area of Springfield, both commercial and residential, that is a potential market for BRT service.

The Study Corridor is an important travel corridor for a variety of trip purposes. There are 42,074 residents living in 18,169 households within the Study Area.[2] In 2013, there were 26,504 jobs along the study corridor and 38,743 jobs within the ½ mile study corridor area[3].

27% of residents live in the study area

Future developments to the area, such as the MGM Springfield casino complex, will likely increase the number of people who live and work in the Study Area.

Existing Transit Service

The Study Corridor is currently served by several PVTA local bus routes. The B7 is the only route that travels the entire length of the corridor. Twelve other routes, such as the G3, B6, B17, R27, and X92, operate on sections of the corridor while the X90 only bi-sects the corridor at the intersection of Federal Street and Walnut Street. Union Station, which is located at the beginning of the corridor just off of Main Street, also provides transit service to the greater Springfield region. The rail station serves as a connection point along Amtrak's Northeast Corridor and is currently being renovated. Slated for completion in the fall of 2016, the station will become Springfield's transportation hub housing the city's rail and bus services together under one roof. The Peter Pan bus terminal is also located in the study corridor on Main Street and provides intercity and interstate bus service to riders.

1.2.2 Problem Definition

State Street and Boston Road are at the core of Springfield's business, commercial, and residential activity. While PVTA's B7 route provides consistent service along this corridor, increasing traffic congestion will likely impede the route's ability to provide efficient service to its riders.

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[2] 2010 Census population and household data – census blocks with their centroid within the ½ mile Study Area buffer. There are 806 census blocks. (Data accessed July 2015)

[3] Aggregated data from Metropolitan Area Planning Council (MAPC)

The existing service provided by the B7 route operates at slow speeds due to delays caused by traffic congestion on the corridor, signalized intersections and closely spaced bus stops. These delays result in long travel times for passengers, increased operating costs for PVTA, wasted fuel, and negative environmental effects. Increasing ridership on this route will only exacerbate these issues.

Planned developments, such as MGM Springfield, will generate significant increases in both pedestrian and traffic volumes. These attractions will drive the demand for a higher level-of-service than what can be offered by existing local routes. To meet this demand, capital improvements to the corridor are highly desirable. Implementing a BRT system will meet the needs of potential riders and also help alleviate existing and future traffic congestion by removing cars from the corridor.

PVTA Bus Operations (B7)

The B7 operates along the length of the corridor from Union Station to the Eastfield Mall for 7.1 miles. The service operates throughout the week, from 5:00 AM to approximately 11:00 PM during the week, 5:00 AM to approximately 10:00 PM on Saturday, and 9:00 AM and approximately 8:00 PM on Sunday. The B7 passes through 34 signalized intersections, services 93 bus stops, operates an average speed of 9.2 mph, and has a cycle time of 98 minutes. On Saturdays the B7 operates seven express trips originating from the Springfield Bus Terminal (SBT) and servicing Walmart and the Eastfield Mall before returning to the SBT via I-291. There are several deviations on the normal route which service Independence Hill, Price-Rite, and Walmart.

Among the PVTA bus routes, the B7 is the strongest performing route and has the highest ridership with over 5,000 daily weekday passenger trips (Table 1). Popular stops along the corridor with high ridership on the B7 include Springfield Bus Terminal (994 boardings), Sci. Tech High School (332 boardings), and Springfield Walmart (265 boardings).

Table 1: B7 Route Statistics

	Weekday	*Saturday*	*Sunday*
Trips per day	*121*	*106*	*37*
Ridership	*5,142*	*3,823*	*1,103*
Hours of Service	*5:00 AM – 10:50 PM*	*5:00 AM – 9:58 PM*	*9:00 AM – 8:08 PM*

Sources: Pioneer Valley Transit Authority (2015)

Although the B7 is a high performing route, it does face its share of challenges. Travel times vary throughout the day as the corridor experiences changing traffic volumes and congestion. Although the average outbound trip is 50 minutes, the B7 takes 20% longer (60 minutes) to travel outbound between 1:00 PM and 5:00 PM. This delay is likely attributed to school dismissal which results in ridership increases, increased vehicular traffic and higher pedestrian activity on the corridor. The route also experiences delays due to closely spaced bus stops. With 93 bus stops, there is a stop nearly every 0.15 miles along the corridor. The B7 stops at most of these for boarding and alighting passengers and each stop can create delays upwards of 30 seconds to accommodate deceleration, dwell time, reentry delay and reacceleration. Each additional passenger boarding can also add 5 extra seconds to the overall delay time. While these individual delays may seem minimal, they result in an increase of several minutes to the route's travel time due to the large number of stops and high ridership along the corridor.

In the entire PVTA system, the B7 has the 5th slowest operating speed and is the slowest among the Tier 1 routes. Although the corridor's posted speed limit is 30 mph, the B7 operates an average speed of only 9.2 mph. The route experiences slower delays along particular segments of State Street, especially between Maple Street and Main Street where average operating speeds are as low as 2.3 mph during evening peak hours. In comparison, the B7 operates at average speeds consistent with crosstown routes and the R44 in Northampton.

Each of the 34 signalized intersections the bus passes through also adds to the route travel time. Along the corridor, an analysis at ten intersections revealed signals create a delay of 5 minutes and 13 seconds on the route. The delay caused by all 34 signalized intersections is likely to be considerably higher and contributes to the low operating speeds and increased travel times exhibited on the B7.

Pedestrian Activity

As one of the busiest corridors in Springfield, pedestrians travel State Street and Boston Road for a variety of purposes. The highest activity is generally concentrated in the downtown area near Main Street. During the evening peak hour, 260 pedestrians cross the intersections at Main Street and State Street.

In the peak hour 260 pedestrians cross at Main & State

Although activity on the corridor is high, infrastructure and amenities on State Street and Boston Road are not conducive to a pedestrian-friendly environment. Many of the corridor's crosswalks are located far away from bus stops. This creates an environment that unintentionally encourages safety hazards, such as jaywalking, because crosswalks are inconveniently spaced. In an analysis at ten key intersections along the corridor, 24 accidents occurred between 2008 and 2012 which involved pedestrians or cyclists. These accidents, two of which resulted in fatalities, have contributed to an apprehensive public regarding future changes to the corridor. In light of this, pedestrian and cyclist safety is a top priority in the development and evaluation of the study's alternatives. BRT service could address these issues by implementing features to improve the pedestrian experience and safety along the corridor.

There is an average of 5 accidents a year along the corridor which involve pedestrians or cyclists

Future Development

Springfield has experienced a surge in development recently and $2.48 billion will be invested in the city through various construction and economic development projects over the coming years[4]. These projects, which include entertainment venues, residential housing, and upgrades to municipal and community buildings, are expected to attract new residents and visitors to Springfield. Along the corridor, two large-scale developments in particular will have a direct impact on the demand for increased transit in the city.

[4] Springfield Mayor Sarno presented a list of city projects totaling $2.48 billion in development at a forum hosted by the Affiliated Chambers of Commerce of Greater Springfield and the Western Massachusetts Economic Development Council in March 2014.

MGM Springfield, located a few blocks from the proposed BRT corridor, is currently under construction and is expected to open in 2018. This casino is expected to become a popular attraction for Springfield residents and visitors from Massachusetts and its neighboring states. Once completed, MGM Springfield has projected it will create 3,000 jobs, 2,200 of which will be full-time. An influx of permanent jobs will likely result in a higher demand for transit service to and from the casino by employees in the region.

Union Station, from which the BRT corridor originates, is undergoing a major reconstruction and is slated for completion in the Fall of 2016. The new station will house both the city's rail and transit services and will offer space for commercial use. Investments in the city's transportation hub will improve the level of mobility in Springfield and will complement the proposed BRT service.

Figure 3: New MGM Casino

Large developments like MGM Springfield and Union Station are intended to be a catalyst for future economic activity and growth in the city. This growth will result in more vehicular traffic and burden the corridor which already experiences congestion issues during peak travel times. Transit investments can relieve some of this traffic by removing vehicles from the road. Implementing a BRT system, which can accommodate a larger volume of riders than regular local routes, can effectively reduce the level of congestion along the corridor while providing a safe, fast, and reliable level-of-service to its passengers.

1.3 PROJECT GOALS AND OBJECTIVES

Based on the problems identified above, PVTA, in collaboration with MassDOT and the City of Springfield, has developed a list of goals and objectives for the study. Each goal has a specific performance measure which will be used to help guide the alternatives screening process. Alternatives will be evaluated against these measures to identify which alternative best meets the needs of the corridor. The preferred alternative will improve the route travel time, reduce delay at intersections, improve connectivity to Union Station and Springfield destinations and improve pedestrian and cyclist safety.

Table 2: Proposed Goals, Objectives, and Screening Criteria for Alternatives

Proposed Goals, Objectives, & Screening Criteria	
Objective	**Measurement Criteria**
GOAL 1: IMPROVE MOBILITY ALONG STATE STREET/BOSTON ROAD CORRIDOR	
Improve transit travel time for trips along the corridor	End-to-end travel time
Improve transit reliability	Remove conflicts with non-transit modes Remove traffic signal delay
Provide connections to existing and future transit service	Identify transit connections
Improve accessibility to existing and planned economic development areas	Travel time to the economic development sites
Improve passenger amenities and experience	Availability and quality of passenger amenities and experience
Increase transit demand	Estimated transit ridership
Accommodate future demand	Peak period capacity
GOAL 2: MINIMIZE CAPITAL AND OPERATING CONCERNS	
Implement within a reasonable construction timeframe	Construction duration
Implement within a reasonable construction cost	Estimated construction cost
Be consistent with PVTA operating procedures	Does mode integrate with PVTA operations and infrastructure?
Avoid conflicts with existing and proposed infrastructure	Potential infrastructure conflicts
Maintain delivery access to local businesses	Restricted or unrestricted truck access
Maintain access for emergency vehicles	Restricted or unrestricted emergency vehicle access
GOAL 3: ENHANCE COMMUNITY CHARACTER AND ENCOURAGE ECONOMIC DEVELOPMENT	
Infrastructure improvements support existing and proposed development	Transit travel time Construction Improvements Estimated infrastructure investments Restricted or unrestricted vehicular access Restricted or unrestricted truck access
Improve connections between residential and commercial destinations	Transit travel time Transit capacity
Improve pedestrian safety	Increase or reduction in pedestrian space Increase or reduction in vehicular traffic on State Street/Boston Road Increase or reduction in street crossing time Improved or degraded lines-of-sight
GOAL 4:MINIMIZE ADVERSE IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT	
Avoid, minimize, or mitigate impacts on historic resources	Historic properties to be acquired Potential visual effects on historic resources
Maximize improvements for underdeveloped streetscapes	Potential to beautify underdeveloped sections of corridors
Maintain access to existing and future uses on State Street and Boston Road	Access constraints Parking supply changes Delivery access
Avoid property acquisition to the maximum extent feasible	Identify property requirements
Reduce vehicular congestion, emissions, and noise	Transit ridership Noise emission of transit mode Vehicle emission of transit mode Number of vehicular travel lanes
Minimize construction impacts to the extent feasible	Construction duration Excavation requirements and requirements for spoils removal

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Chapter 2: Study Alternatives

2.1 Introduction

The development and evaluation of alternatives is central to the National Environmental Policy Act (NEPA) process. This chapter presents the methodology for determining the preferred alternatives including the long list of alternatives.

2.2 Long list of Alternatives

Nine alternatives were developed for the long list. Optimizing stationing, introducing new vehicle design, intelligent transportation systems (ITS), and a high frequency and reliable service, paired with distinct marketing can be applied to the alternatives under consideration and would advance the service overall.

2.2.1 No Build 2025

The No Build 2025 Alternative assumes that no action is taken in regards to implementing BRT service along the State Street/Boston Road corridor. It does, however, look at projected traffic volumes for 2025 and how that may impact the corridor. Under this alternative, all right-of-way alignments and lane configurations remain the same as under Existing Conditions (Figure 4). The current bus routes serving the corridor will continue to run similar to their current operating status, with no addition of BRT features to enhance the service, though PVTA could adjust bus service levels based on ridership changes.

Currently, traffic volumes are projected to increase one percent each year over the next 10 years, consistent with recent traffic growth. As a result, there will likely be greater congestion along the study corridor if there are no infrastructure changes. This could lead to slower bus service as transit vehicles get caught in the heavier traffic, making current service levels harder to maintain.

Alternatively, increased traffic congestion, and potentially higher vehicular operating costs, may lead to greater demand for improved transit service as motorists look for other modes of transport. However, this possible increase in demand could be difficult to accommodate in a no-build scenario. Without adding any BRT features, it could be difficult to improve bus service amid rising congestion.

The short-term benefit of not implementing any new bus infrastructure would be no financial outlays for new capital costs and associated operating costs. The long-term consequences, however, would be potentially greater cost and complexity to implement transit enhancements once traffic volumes are higher and there is increased demand for scarce road space.

Figure 4: Existing Conditions Typical Cross Section on State Street

2.2.2 TSM 2025

The TSM (Transportation System Management) 2025 Alternative contains no alterations to the corridor right-of-way, but does introduce elements from the standard set of BRT features. This alternative could perhaps be called BRT Light as it does not include a key BRT element – dedicated running ways for the BRT vehicles. However, it does allow for many other service improvements that could make riding the bus in this corridor slightly faster and more enjoyable. Possible enhancements could include all-door boarding and off-board fare collection to speed up the boarding and alighting process, more visible and comfortable bus stations with platform level boarding, technology elements such as transit signal prioritization and real-time arrival information for transit riders, increased headways, and enhanced branding to call out the service as something separate from the traditional bus service. This alternative also includes options such as a right lane queue jump and restrictions on turning vehicles at congested intersections. The right lane queue jump could be shared with vehicles in a right turn bay that would get a leading phase from the traffic signal, allowing buses and right-turning vehicles to get a jump start on the traffic queue and speed up service. Turn restrictions could also be employed at congested intersections that would reduce vehicular backups that might prevent a bus from moving through the intersection.

The BRT features in this alternative are typically easier to implement as they do not require a reduction in travel or parking lanes or property acquisition for possible right-of-way expansion. Costs can vary considerably depending upon the number and level of features implemented, allowing for financial flexibility. However, service gains are limited, particularly bus travel speeds, since there would not be a dedicated running way for the BRT service. Full BRT service includes exclusive travel lanes, and the alternatives below explore those options.

2.2.3 Alternative 1A – Median Running Guideway, Maintain Existing Lane Configuration

Alternative 1A would introduce a median running guideway to the corridor while maintaining the existing lane configuration. Alternative 1A is only workable with the acquisition of additional property to extend the existing right-of-way. This would preserve all existing travel and parking lanes while also providing dedicated lanes for the BRT vehicles to operate (Figure 5). Left turns would have to either be restricted or accommodated with signal phasing reconfiguration. The bus lanes would be solely utilized by the BRT buses, with local buses continuing to run in mixed-flow traffic with stops on the outside curbs.

BRT stations would be accommodated via center median platforms located at each BRT stop. These stations would require buses with doors opening on the left-hand, or driver's side, of the vehicle. It would also require that all riders cross part of the roadway to move to and from the stations, necessitating safe, clearly marked cross-walks for pedestrian safety. It is possible to use traditional buses that have boarding on the right side but this would require additional right-of-way to accommodate stations.

The benefit of this alternative is that it provides BRT service its own exclusive travel lane not shared with any other vehicles, except emergency vehicles, allowing significantly faster service along the corridor. It also allows existing traffic to travel the corridor without any impacts to road space for vehicular traffic or parking spaces. This would ensure that new BRT infrastructure would not significantly interfere with how motorists use the corridor.

The drawback to this alternative is that it would entail the acquisition of property along the corridor to maintain the existing lane configuration and add the new BRT infrastructure. As can be seen in the example in Figure 5, this would require considerable space, roughly 10 feet on each side of the right-of-way. The cost and complexity of acquiring the property would likely be high, given the length of the corridor and number of property owners. It would also likely result in challenges from property owners and neighbors, and may well involve the use of eminent domain if owners refuse to sell. These challenges could lead to a lengthier implementation process, with harder to forecast project delays and costs.

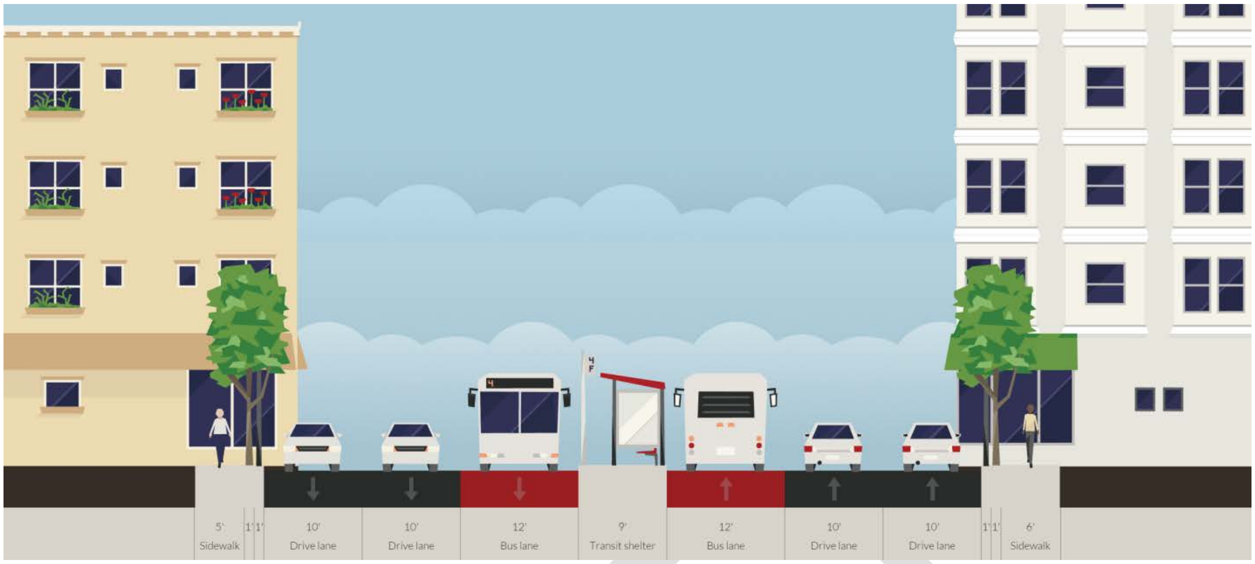

Figure 5: Alternative 1A: Median Guideway & Existing Lane Configuration

2.2.4 Alternative 1B – Median Running Guideway, Maintain Existing Right-of-Way

Alternative 1B also adds a median running guideway, but maintains the existing right-of-way rather than the existing lane configuration. This alternative would convert the left-most travel lane in each direction into a dedicated bus lane that would serve the BRT service. In some locations a minimal amount of right-of-way will be needed to be obtained to meet current design standards. As in Alternative 1A, it would require restricting or altering left turns and the addition of center median platform stations.

Alternative 1B provides the same BRT benefits as 1A in addition to not requiring the costly, lengthy, and challenging process of property acquisition. This would save considerable time, allowing the service to be up and running sooner, and money that could instead go towards enhanced BRT features or a lower cost project.

The challenge for this option is accommodating the new BRT service alongside the existing travel and parking uses of the roadway. Adding dedicated bus lanes necessitates converting existing space from automobile use to transit use. Depending upon the particular location along the corridor, this could mean either a reduction in a travel lane in each direction or a reduction in on-street parking. The feasibility of this will largely be governed by the ability of the remaining lanes to accommodate existing and projected vehicle volumes within an acceptable level-of-service.

Using the State Street example of two travel lanes in each direction, Figure 6 through Figure 8 illustrate how the different options could work. In Figure 6, the right-of-way accommodates the median lanes by converting the interior vehicle lanes to exclusive bus lanes, leaving one travel lane in each direction. The lane widths exceed the minimum preferred width by one foot, based on the City of Springfield's guidelines, but this does not include space to mark sharrows for bicycles. It also does not include space for a station, only showing what it would look like between stops.

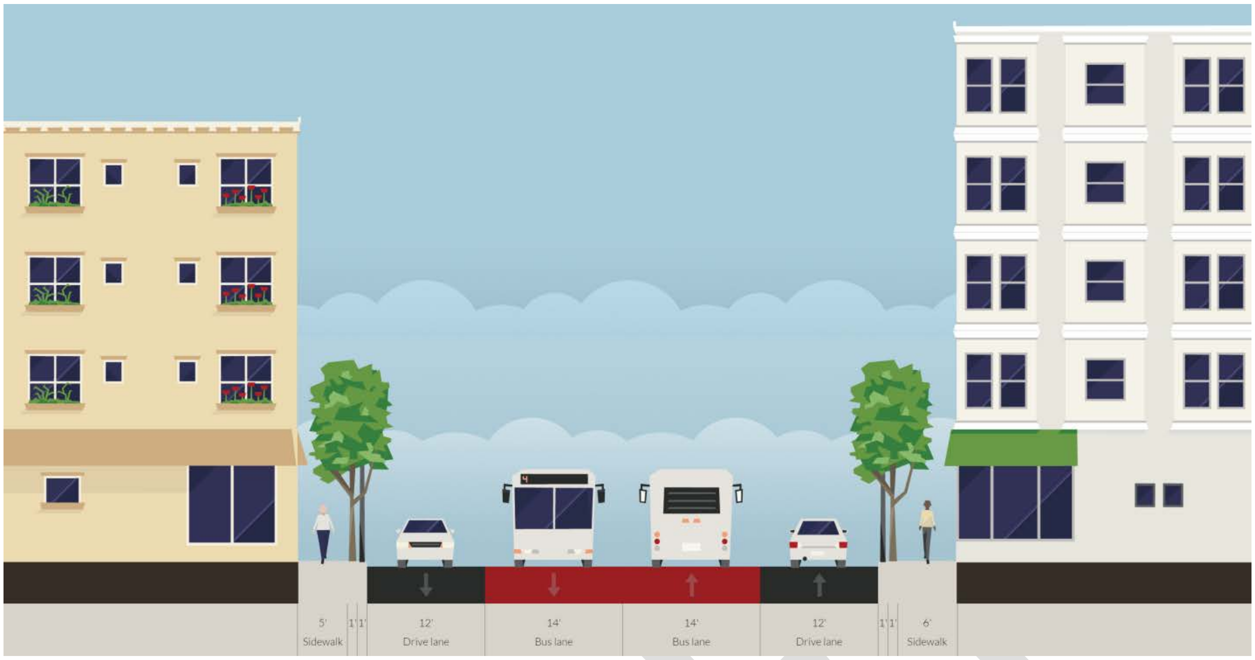

Figure 6: Alternative 1B: Median Guideway & Existing ROW with Two Travel Lanes

Figure 7 shows how a parking lane could possibly be included when there is not a station present. Given the right-of-way available in this particular location, this results in a standard parking lane and narrower travel lanes for buses and automobiles, though they still meet the City's preferred minimum width. Like the previous example, this configuration reduces the travel lanes from two in each direction to one in each direction.

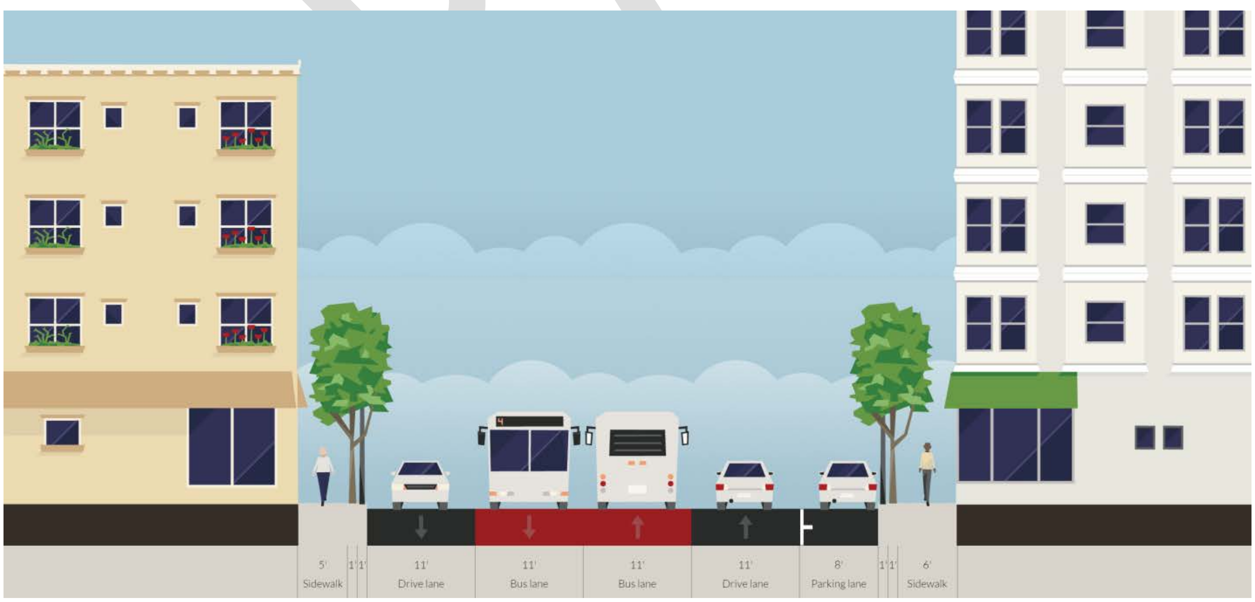

Figure 7: Alternative 1B: Median Guideway & Existing ROW with Two Travel Lanes and Parking

Figure 8 shows how this alternative might look when a station is present. There is enough room to accommodate standard BRT lanes, but the vehicular travel lanes are 6 inches narrower than is preferred.

However, these narrow lanes would only be alongside the station platforms, not necessarily for the whole corridor, so it would be feasible to accommodate them for short sections. This is especially true at station locations because the operator is already decelerating the vehicle and a wider lane is not necessary for safety reasons.

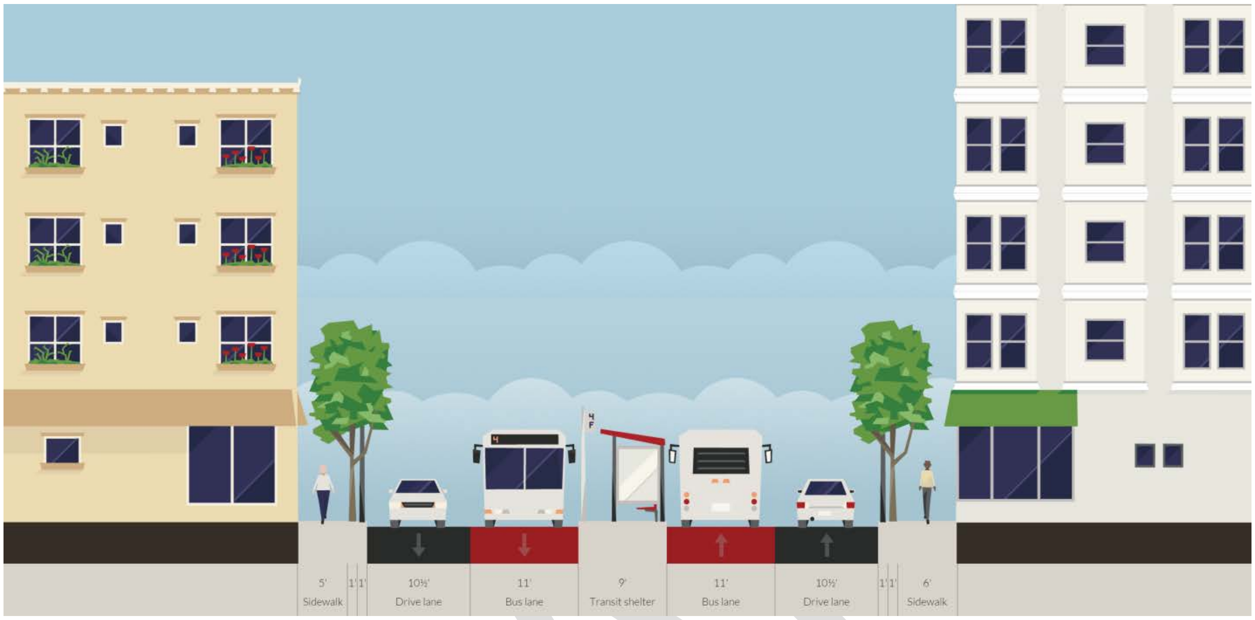

Figure 8: Alternative 1B: Median Guideway & Existing ROW with Two Travel Lanes and Station

2.2.5 Alternative 2A – Offset/Curbside Bus Lanes, Maintain Existing Lane Configuration

Alternative 2A would introduce offset and/or curbside bus lanes while maintaining the existing lane configuration. This alternative would preserve all existing travel and parking lanes while also providing dedicated lanes for the BRT vehicles to operate (Figure 9). Left-turn bays could also potentially be maintained. The bus lanes could be utilized by the BRT buses and local buses, though bus stops for local service should be separate from BRT stations.

Where there is no parking present, the buses would run adjacent to the curb and BRT stations would be located on the existing sidewalk space. Where parking is present, buses would run in offset lanes between a curbside parking lane and the mixed-flow traffic lanes. Here, BRT stations would be located on bus bulbs extending from the sidewalk to meet the bus lane, allowing the BRT buses to remain in the exclusive lane while picking up and dropping off passengers. With this station placement, BRT vehicles would need to have doors that opened up on the right-hand side of the vehicle.

The benefits to Alternative 2A are similar to those discussed under 1A, providing exclusive travel space for the buses while maintaining existing road space for motorists, not impacting traffic flow, and only minimally reducing parking capacity where bus bulbs are located. Additionally, since stations can be located on the sidewalk or bus bulbs, there is no need to construct center median platforms, saving road space for other uses such as left-turn bays.

The primary drawback to Alternative 2A is also the same as that in 1A, the need to acquire adjacent property so as to maintain the existing lane configurations while adding dedicated bus lanes. As seen in Figure 9, this entails about 8 feet of space on either side of the right-of-way, for a total of 16 feet, for the State Street example. Given that the stations can be placed on existing sidewalk space, this is a few feet less than Alternative 1A, but it still requires a potentially significant acquisition of property along the corridor. As mentioned earlier, this can be a lengthy, complex, and costly process that has the potential to delay BRT implementation.

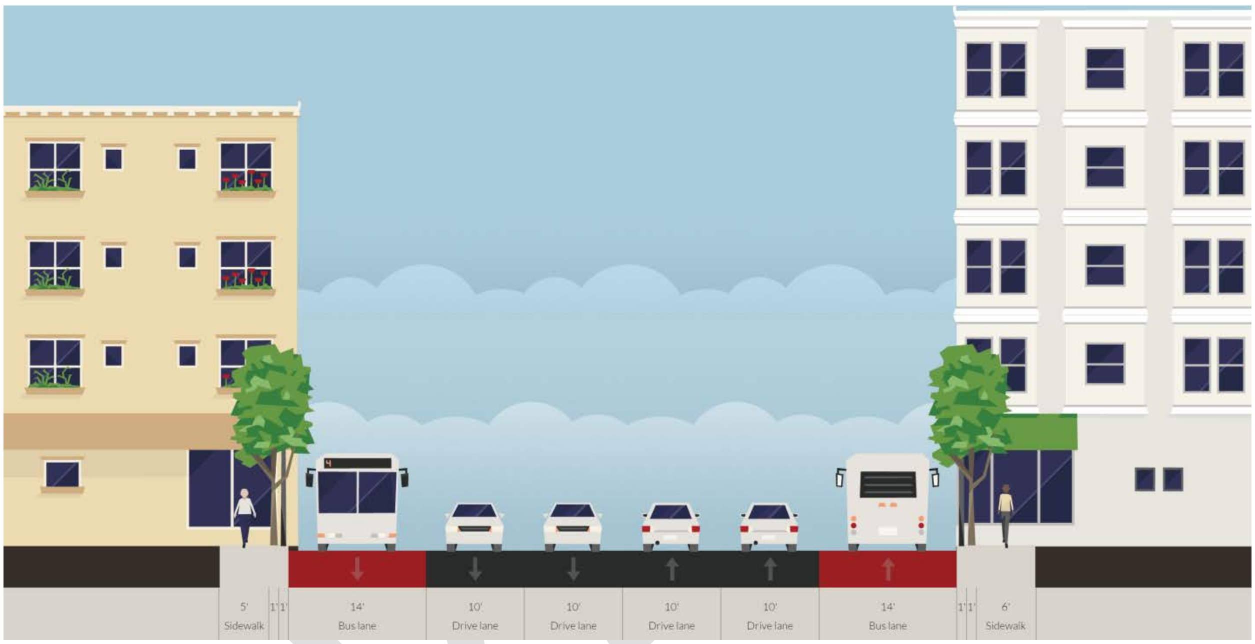

Figure 9: Alternative 2A: Curbside Bus Lanes & Existing Lane Configuration

2.2.6 Alternative 2B – Offset/Curbside Bus Lanes, Maintain Existing Right-of-Way

Alternative 2B also adds curbside and/or offset bus lanes, but maintains the existing right-of-way rather than the existing lane configuration. This alternative would convert the right-most travel lane or parking lane in each direction into a dedicated bus lane that would serve BRT buses as well as local buses. As in Alternative 2A, BRT stations would be placed on existing sidewalk space or on newly built bus bulbs where the bus lanes are offset.

Depending upon the particular location along the corridor, the bus lanes could be placed either adjacent to the curb or offset with a parking lane between the curb and the bus lane. Figure 10 illustrates what curbside lanes would look line in the State Street cross-section example. The outside travel lanes in each direction are converted to exclusive bus lanes, with enough space to have lanes about one foot over the City's preferred width. Figure 11 shows an example of what an offset lane could look like within the existing right-of-way, with an 8' parking lane on one side of the road. This narrows the travel lanes, but still leaves them with enough room to function.

Figure 10: Alternative 2B: Curbside Bus Lanes & Existing ROW

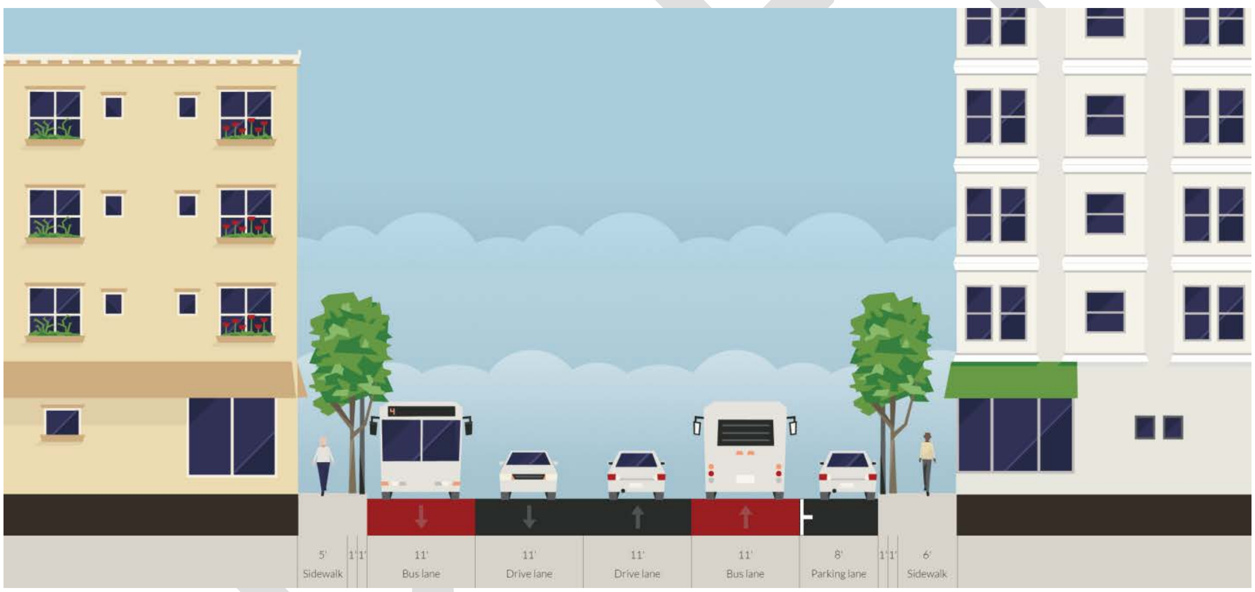

Figure 11: Alternative 2B: Offset and Curbside Bus Lanes & Existing ROW

The benefits of this alternative include dedicated bus lanes that can be shared with local service buses and being able to operate in the existing right-of-way without requiring any physical changes to the curb (except where bus bulbs are used with offset lanes). This would allow for a relatively quicker implementation process since physical construction would be minimized, but it would result in high-level transit service with exclusive bus lanes.

The challenges with Alternative 2B are similar to those discussed in 1B, with the need to convert existing road space from a travel or parking lane to a dedicated transit lane. This may have traffic impacts and analysis will be required to ensure remaining travel lanes can accommodate existing and projected traffic levels. Further, left-turn bays may need to be removed at intersections where they are present to allow for enough travel space to ensure through-put for the mixed-flow lanes. It may also require turn restrictions entirely at particularly tight or congested intersections to keep traffic flowing.

2.2.7 Alternative 3A – Combine Median Running Guideway & Offset/Curbside Bus Lanes, Maintain Existing Lane Configuration

Alternative 3A would introduce a combination of median running guideway and offset/curbside bus lanes, while maintaining the existing lane configuration of the road. This would be a combination of Alternatives 1A and 2A, with many of the same benefits and challenges, including property acquisition, that are discussed in those sections above.

Taking a combination approach allows for the BRT alignment to adapt to the changing corridor configuration and alternate between center running dedicated lanes and outside dedicated lanes. This can provide a more context-sensitive solution and additional flexibility when implementing the new service. However, it could also present challenges where there is a transition between center running and curbside/offset lanes as it would require navigating the mixed-traffic lanes. This could result in driver confusion and/or traffic delays, slowing down the service at these locations.

As this option would likely lead to BRT stations being located on both the sidewalk and center median platforms, Alternative 3A would require specific vehicles that have doors on both sides of the vehicle to service the different station setups. There is one manufacturer for this vehicle type that meets federal Buy America standards, but without multiple vendors to choose from this could result in potentially higher costs and decreased procurement flexibility.

2.2.8 Alternative 3B – Combine Median Running Guideway & Offset/Curbside Bus Lanes, Maintain Existing Right-of-Way

Alternative 3B would also introduce a combination of median running guideway and offset/curbside lanes, but would maintain the existing right-of-way rather than the existing lane configuration. This alternative brings many of the same benefits and challenges of Alternatives 1B and 2B, including converting existing travel or parking lanes to BRT service, that are discussed in those sections above.

Alternative 3B also faces the same pros and cons as 3A, with greater flexibility to adapt to the existing corridor configuration but requiring a more specialized bus to service stations located on either side of the vehicle. Arguably, this flexibility is of greater importance for Alternative 3B as the right-of-way would not expand and fitting the dedicated BRT lanes in could potentially be more challenging as the width and lane configuration of the corridor changes along its route.

2.2.9 Hybrid

The Hybrid alternative is a combination of the TSM and Alternatives 2A/2B. Between the Western terminus and the intersection of State Street and Berkshire Avenue TSM would be implemented and then again from the intersection of Pasco Road on Boston Road to the eastern terminus (Eastfield Mall) on Boston Road. From State Street/ Berkshire Avenue to Boston Road/ Pasco Road a curb side bus lane would be implemented.

2.3 Methodology

The evaluation of alternatives consists of a process designed to assess how well the proposed alternatives address the Proposed Project's goals and objectives. This write-up outlines the methodology, describes the performance measures, and presents the results of screenings for each BRT alternative and the proposed 12 BRT stations for the corridor. This reflects a stops spacing between 0.2 to 0.5 miles.

PERFORMANCE MEASURES

Performance measures have been developed to evaluate alternatives consistent with the goals and objectives. These measures are generally qualitative and allow for a comparison of the order of magnitude benefits and detriments of each Alternative. In certain cases, one performance measure correlates to multiple project objectives, and certain objectives have been defined by more than one performance measure.

SCREENING METHODOLOGY

The proposed alternatives were qualitatively evaluated in regards to the primary and secondary goals and objectives, established through a joint process with PVTA and found in Section 1.3 Project Goals and Objects of this report, using a scale that ranged from high-performing to low-performing:

● 20	◕ 15	◑ 10	◔ 5	○ 0

High-Performing **Low-Performing**

The screening considers a baseline (No Build 2025) condition against which the benefits and adverse effects of each alternative are to be weighed. Some alternatives could be implemented more quickly than others, but the evaluation must use a consistent baseline. Therefore for purposes of this study, the baseline condition reflects current land use, social and demographic conditions, and transportation services in 2025, by which time it is reasonable to assume that any of the alternatives could be implemented.

Utilizing the above approach, the following maximum scores can be assigned:

- Primary Goals: 280
- Secondary Score: 400
- Total Score: 680

All objectives and corresponding performance measures are equally weighted. The results from the alternative evaluation matrix can be found in Table 3.

Table 3: Alternative Evaluation Matrix

(1 of 4)

PRIMARY GOALS	OBJECTIVES	PERFORMANCE MEASURES	No Build 2025		TSM 2025		Alternative 1A – Median Running Guideway, Maintain Existing Lane Configuration		Alternative 1B – Median Running Guideway, Maintain Existing Right-of-Way	
IMPROVE MOBILITY ALONG STATE STREET/BOSTON ROAD CORRIDOR	Improve transit travel time for trips along the corridor	End-to-end travel time	0	No improvements. Travel time may increase with expected increase in traffic volumes	5	Improvements are minimal without a dedicated bus lane	20	Provides dedicated lane with minimal chance of traffic interference	20	Provides dedicated lane with minimal chance of traffic interference
	Improve transit reliability	Remove conflicts with non-transit modes	0	No improvements	5	Improvements are minimal without a dedicated bus lane	20	Provides fewest points of conflict	20	Provides fewest points of conflict
		Remove traffic signal delay	0	No improvements	5	TSP improvements	5	TSP improvements	5	TSP improvements
	Provide connections to existing and future transit service	Identify transit connections	0	No new transit connections	0	No new transit connections	0	No new transit connections	0	No new transit connections
	Improve accessibility to existing and planned economic development areas	Travel time to economic development areas	0	No improvements	5	Improvements are minimal without a dedicated bus lane	20	Provides dedicated lane with minimal traffic interference	20	Provides dedicated lane with minimal traffic interference
	Improve passenger amenities and experience	Availability and quality of passenger amenities and experience	0	No improvements	10	Includes many improvements, such as off-board fare collection, all-door boarding, real-time arrival info, but not dedicated lanes	20	Includes all TSM improvements, plus dedicated stations and lanes	20	Includes all TSM improvements, plus dedicated stations and lanes
	Increase transit demand	Estimated transit ridership	0	No increase expected	5	Ridership will increase slightly due to small reduction in transit travel time	20	Ridership will increase most, partially due to the greatest reduction in transit travel time	20	Ridership will increase most, partially due to the greatest reduction in transit travel time
	Accommodate future demand	Peak period capacity	0	No increase in capacity	5	Adds some features to slightly increase capacity, but no dedicated lanes	20	Highest level of dedicated lane provides space for more BRT buses	20	Highest level of dedicated lane provides space for more BRT buses
MINIMIZE CAPITAL AND OPERATING CONCERNS	Implement within a reasonable construction timeframe	Construction duration	20	No construction required	15	Minimal construction time necessary for TSM improvements	0	Significant construction time due to ROW acquisition, road expansion, and constructing center medians	5	Construction of median station platforms will take longer than curbside stations
	Implement within a reasonable construction cost	Estimated construction cost	20	No construction required	15	Minimal construction costs for TSM improvements	0	Significant construction costs due to ROW acquisition, road expansion, and constructing center medians	5	Construction of median station platforms will cost more than curbside stations
	Be consistent with PVTA operating procedures	Does mode integrate with PVTA operations and infrastructure?	20	No change	15	Current procedures and vehicles can be used, but off-board fare collection would require checking passengers for valid fare	15	Current procedures and vehicles can be used, but off board fare collection would require checking passengers for valid fare	15	Current procedures and vehicles can be used, but off-board fare collection would require checking passengers for valid fare
	Avoid conflicts with existing and proposed infrastructure	Potential infrastructure conflicts	20	No new conflicts	15	Minimal conflicts with possible turn lane reconfiguration and queue jump lanes	0	Requires significant property acquisition	10	Requires construction of median station platforms, but would not interfere with sidewalk infrastructure
	Maintain delivery access to local businesses	Restricted or unrestricted truck access	20	No change in access	20	No change in access	20	No change in access	15	Possible minimal access restrictions depending on lane restrictions due to lane reduction
	Maintain access for emergency vehicles	Restricted or unrestricted emergency vehicle access	0	No change in access	5	Improvements such as signal control could possibly be used by emergency vehicles	20	Emergency vehicles will have access to dedicated lane	15	Emergency vehicles will have access to dedicated lane, but may see traffic interference due to lane reduction
RESULTS OF PRIMARY GOALS SCREENING			100		125		180		190	
		Primary Goal 1 total	0		40		125		125	
		Primary Goal 2 total	100		85		55		65	
		Primary Goals Total Relative Score	36%		45%		64%		68%	

Table 3 Alternative Evaluation Matrix (2 of 4)

PRIMARY GOALS	OBJECTIVES	PERFORMANCE MEASURES	Alternative 2A – Offset/Curbside Bus Lanes, Maintain Existing Lane Configuration		Alternative 2B – Offset/Curbside Bus Lanes, Maintain Existing Right-of-Way		Alternative 3A – Combine Median Running Guideway & Offset/Curbside Bus Lanes, Maintain Existing Lane Configuration		Alternative 3B – Combine Median Running Guideway & Offset/Curbside Bus Lanes, Maintain Existing Right-of-Way		HYBRID - Combination of alternatives: TSM (Western Terminus to Boston Road at Pasco Road) and Alternatives 2A/2B (Boston Road at Pasco Road and the Eastern Terminus)	
IMPROVE MOBILITY ALONG STATE STREET/BOSTON ROAD CORRIDOR	Improve transit travel time for trips along the corridor	End-to-end travel time	15	Provides dedicated lane with some chance of traffic interference (double parking or right-turning vehicles)	10	Provides dedicated lane with slightly greater chance of traffic interference due to lane reduction	15	Provides dedicated lane, with possible traffic interference during transition from curbside to median configurations	10	Provides dedicated lane with higher chance of traffic interference due to lane reduction	10	Provides dedicated lane only along a portion of the corridor
	Improve transit reliability	Remove conflicts with non-transit modes	15	Could see conflict with parking or right-turning vehicles	10	Could see conflict with parking or right-turning vehicles exacerbated by lane reduction	15	Can avoid most conflicts by placing lanes in the best location along the corridor	10	Could see conflict with parking or right-turning vehicles exacerbated by lane reduction where lane is curbside/offset	10	Would only avoid conflicts along portion of corridor with dedicated lane
		Remove traffic signal delay	5	TSP improvements	5	TSP improvements	5	TSP improvements	5	TSP improvements	5	TSP improvements
	Provide connections to existing and future transit service	Identify transit connections	0	No new transit connections	0	No new transit connections	0	No new transit connections	0	No new transit connections	0	No new transit connections
	Improve accessibility to existing and planned economic development areas	Travel time to economic development areas	15	Provides dedicated lane with some chance of traffic interference (double parking or right-turning vehicles)	10	Provides dedicated lane with chance of traffic interference due to lane reduction	15	Provides dedicated lane, with possible traffic interference during transition from curbside to median configurations	10	Provides dedicated lane with higher chance of traffic interference due to lane reduction	10	Provides dedicated lane only along portion of the corridor furthest from Downtown area
	Improve passenger amenities and experience	Availability and quality of passenger amenities and experience	20	Includes all TSM improvements, plus dedicated stations and lanes	20	Includes all TSM improvements, plus dedicated stations and lanes	20	Includes all TSM improvements, plus dedicated stations and lanes	20	Includes all TSM improvements, plus dedicated stations and lanes	15	Includes all TSM improvements, and dedicated lane for portion of corridor
	Increase transit demand	Estimated transit ridership	10	Ridership will increase due to dedicated lanes, resulting in travel time reductions	10	Ridership will increase due to dedicated lanes, resulting in travel time reductions	15	Ridership will increase due to effective mix of dedicated lanes, resulting in travel time reductions	15	Ridership will increase due to effective mix of dedicated lanes, resulting in travel time reductions	10	Ridership will increase due to dedicated lanes along a portion of the route, resulting in travel time reductions
	Accommodate future demand	Peak period capacity	10	Curbside/Offset lanes may not have as much capacity due to sharing with local buses and possible traffic interference	10	Curbside/Offset lanes may not have as much capacity due to sharing with local buses and possible traffic interference	15	Capacity will increase some due to effective mix of dedicated lanes	15	Capacity will increase some due to effective mix of dedicated lanes	5	Capacity increase is limited without dedicated lanes on much of the corridor
MINIMIZE CAPITAL AND OPERATING CONCERNS	Implement within a reasonable construction timeframe	Construction duration	0	Significant construction time due to ROW acquisition and road expansion	10	No median platforms or ROW acquisition, but may need to build bus bulbs	0	Significant construction time due to ROW acquisition, road expansion, and possible center medians	10	No ROW acquisition, but may need to build bus bulbs or median platforms	15	Portion of corridor with lane may require ROW acquisition or bus bulbs or median platforms
	Implement within a reasonable construction cost	Estimated construction cost	0	Significant construction costs due to ROW acquisition and road expansion	10	No median platforms or ROW acquisition, but may need to build bus bulbs	0	Significant construction costs due to ROW acquisition, road expansion, and possible center medians	10	No ROW acquisition, but may need to build bus bulbs or median platforms	15	Portion of corridor with lane may require ROW acquisition or bus bulbs or median platforms
	Be consistent with PVTA operating procedures	Does mode integrate with PVTA operations and infrastructure?	15	Current procedures and vehicles can be used, but off-board fare collection would require checking passengers for valid fare	15	Current procedures and vehicles can be used, but off-board fare collection would require checking passengers for valid fare	15	Current procedures and vehicles can be used, but off-board fare collection would require checking passengers for valid fare	15	Current procedures and vehicles can be used, but off-board fare collection would require checking passengers for valid fare	15	Current procedures and vehicles can be used, but off-board fare collection would require checking passengers for valid fare
	Avoid conflicts with existing and proposed infrastructure	Potential infrastructure conflicts	0	Requires significant property acquisition	15	Possible minimal interference with sidewalk infrastructure or drainage if bus bulbs are built	0	Requires significant property acquisition	15	Could place lanes to achieve minimal conflicts	15	Lane only added where conflicts are minimized, TSM has little conflict
	Maintain delivery access to local businesses	Restricted or unrestricted truck access	15	Possible minimal access restrictions depending on station locations near curb access points	15	Possible minimal access restrictions depending on lane restrictions due to lane reduction	15	Possible minimal access restrictions depending on station locations near curb access points	15	Possible minimal access restrictions depending on lane restrictions due to lane reduction	20	Likely no impact to access with limited portion of corridor would have a dedicated lane
	Maintain access for emergency vehicles	Restricted or unrestricted emergency vehicle access	20	Emergency vehicles will have access to dedicated lane	15	Emergency vehicles will have access to dedicated lane, but may see traffic interference due to lane reduction	20	Emergency vehicles will have access to dedicated lane	15	Emergency vehicles will have access to dedicated lane, but may see traffic interference due to lane reduction	10	Emergency vehicles will have access to dedicated lane on that portion of the corridor
RESULTS OF PRIMARY GOALS SCREENING			140		155		150		165		155	
		Primary Goal 1 total	90		75		100		85		65	
		Primary Goal 2 total	50		80		50		80		90	
		Primary Goals Total Relative Score	50%		55%		54%		59%		55%	

Table 3 Alternative Evaluation Matrix (3 of 4)

SECONDARY GOALS	OBJECTIVES	PERFORMANCE MEASURES	No Build 2025		TSM 2025		Alternative 1A – Median Running Guideway, Maintain Existing Lane Configuration		Alternative 1B – Median Running Guideway, Maintain Existing Right-of-Way	
ENHANCE COMMUNITY CHARACTER AND ENCOURAGE ECONOMIC DEVELOPMENT	Infrastructure improvements support existing and proposed development	Construction improvements	0	No improvements	5	Minimal improvements for bus stations	20	Significant improvements along the corridor, with fully reconstructed roadway	15	Significant improvements along the corridor, including center medians
		Estimated infrastructure investment	0	No investment	5	Minimal improvements for bus stations	20	Significant improvements along the corridor, with fully reconstructed roadway	15	Significant improvements along the corridor, including center medians
	Improve connections between residential and commercial destinations	Transit travel time	0	No improvements. Travel time may increase with expected increase in traffic volumes	5	Improvements are minimal without a dedicated bus lane	20	Provides dedicated lane with minimal chance of traffic interference	20	Provides dedicated lane with minimal chance of traffic interference
		Transit capacity	0	No increase in capacity	5	Adds some features to slightly increase capacity, but no dedicated lanes	20	Highest level of dedicated lane provides space for more BRT buses	20	Highest level of dedicated lane provides space for more BRT buses
	Improve pedestrian safety	Increase or reduction in pedestrian space	5	No change	0	Shelter may obstruct sidewalk space	10	Median platforms include pedestrian refuge at crosswalks	10	Median platforms include pedestrian refuge at crosswalks
		Increase or reduction in vehicular traffic on State Street/Boston Road	0	Traffic projected to increase	0	TSM improvements not likely to result in shift from vehicles to transit	10	Significant service improvements could lead to greater mode shift	15	Significant service improvements plus vehicle lane reduction could lead to greater mode shift
		Increase or reduction in curb-to-curb crossing distance/time across State St/Boston Rd	0	No change	5	Adjusting TSP could result in minor improvements	0	Wider road would lengthen times, but pedestrian refuge islands would compensate where stations are present	10	No change in time, but pedestrian refuge islands provide safe space to wait if needed
		Lines-of-sight	0	No change	0	No change	5	Slight visibility improvement at median platforms	5	Slight visibility improvement at median platforms
MINIMIZE ADVERSE IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT	Avoid, minimize, or mitigate impacts on historic resources	Historic properties to be acquired	20	No historic properties to be acquired	20	No historic properties to be acquired	0	Extensive property acquisition required	20	No historic properties to be acquired
		Potential visual effects on historic resources	20	No visual effects	15	Minimal effect (signage, shelters, fare collection equipment)	15	Minimal effect with station amenities in median (signage, shelters, fare collection equipment)	15	Minimal effect with station amenities in median (signage, shelters, fare collection equipment)
	Maximize improvements for underdeveloped streetscapes	Potential to beautify underdeveloped sections of the corridor	0	No change	5	Bus stop location allow for minor additional greening	20	Medians allow for additional greening; ROW acquisitions allow for additional streetscape improvements	10	Medians allow for additional greening
	Maintain access to existing and future uses on State Street and Boston Road	Access constraints	20	No change in access	15	Could see small reduction in access if any turn bans are included	5	Could see reduction in access if any turn bans are included	5	Could see reduction in access if any turn bans are included
		Parking supply changes	20	No change in parking supply	20	No change in parking supply	10	Could maintain current on-street parking at stations but may lose some off-street parking due to property acquisition and at station areas	5	Possible decrease in supply to accommodate a bus only lane and stations
		Delivery access	20	No change in access	20	No change in access	20	No change in access	15	Possible minimal access restrictions depending on lane restrictions due to lane reduction
	Avoid property acquisition to the maximum extent feasible	Identify property requirements	20	None	20	None	0	Extensive property acquisition required	5	Possible property impacts to accommodate turn lanes and stations at some intersections
	Reduce vehicular congestion, emissions, and noise	Transit ridership	0	No increase	5	Ridership will increase slightly due to small reduction in transit travel time	20	Ridership will increase most, partially due to the greatest reduction in transit travel time	20	Ridership will increase most, partially due to the greatest reduction in transit travel time
		Noise emission of transit mode	10	Increase in emissions due to buses stuck in increased congestion	5	Minimal increase if the bus runs more frequently, but still idles in traffic	15	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	15	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic
		Vehicle emission of transit mode	10	Increase in emissions due to buses stuck in increased congestion	5	Minimal increase if the bus runs more frequently, but still idles in traffic	15	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	15	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic
		Number of vehicular travel lanes	20	No change	20	No change	10	May see lane adjustments at intersections and station areas	0	Reduction in travel lanes
	Minimize construction impacts to the extent feasible	Construction duration	20	No construction required	15	Minimal construction time necessary for TSM improvements	0	Significant construction time due to ROW acquisition, road expansion, and constructing center medians	5	Construction of median station platforms will take longer than curbside stations
		Excavation requirements	20	No excavation required	20	No excavation required	0	Moderate excavation required to rebuild road with increased ROW	10	Minimal excavation for median platform construction
RESULTS OF SECONDARY GOALS SCREENING			205		210		235		250	
		Secondary Goal 1	5		25		105		110	
		Secondary Goal 2	200		185		130		140	
		Secondary Goals Total Relative Score	51%		53%		59%		63%	
		Total	305		335		415		440	
		Primary and Secondary Goals Total Relative Score	45%		49%		61%		65%	

Table 3 Alternative Evaluation Matrix (4 of 4)

SECONDARY GOALS	OBJECTIVES	PERFORMANCE MEASURES	Alternative 2A – Offset/Curbside Bus Lanes, Maintain Existing Lane Configuration		Alternative 2B – Offset/Curbside Bus Lanes, Maintain Existing Right-of-Way		Alternative 3A – Combine Median Running Guideway & Offset/Curbside Bus Lanes, Maintain Existing Lane Configuration		Alternative 3B – Combine Median Running Guideway & Offset/Curbside Bus Lanes, Maintain Existing Right-of-Way		HYBRID	
ENHANCE COMMUNITY CHARACTER AND ENCOURAGE ECONOMIC DEVELOPMENT	Infrastructure improvements support existing and proposed development	Construction improvements	20	Significant improvements along the corridor, with fully reconstructed roadway	15	Significant improvements along the corridor, possibly including bus bulbs	20	Significant improvements along the corridor, with fully reconstructed roadway	15	Significant improvements along the corridor, possibly including bus bulbs or medians	10	Improvements along a portion of the corridor, possibly including bus bulbs or medians
		Estimated infrastructure investment	20	Significant improvements along the corridor, with fully reconstructed roadway	15	Significant improvements along the corridor, possibly including bus bulbs	20	Significant improvements along the corridor, with fully reconstructed roadway	15	Significant improvements along the corridor, possibly including bus bulbs or medians	10	Improvements along a portion of the corridor, possibly including bus bulbs or medians
	Improve connections between residential and commercial destinations	Transit travel time	15	Provides dedicated lane with some chance of traffic interference (double parking or right-turning vehicles)	10	Provides dedicated lane with slightly greater chance of traffic interference due to lane reduction	15	Provides dedicated lane, with possible traffic interference during transition from curbside to median configurations	10	Provides dedicated lane with higher chance of traffic interference due to lane reduction	10	Provides dedicated lane only along a portion of the corridor
		Transit capacity	10	Curbside/Offset lanes may not have as much capacity due to sharing with local buses and possible traffic interference	10	Curbside/Offset lanes may not have as much capacity due to sharing with local buses and possible traffic interference	15	Capacity will increase some due to effective mix of dedicated lanes	15	Capacity will increase some due to effective mix of dedicated lanes	5	Capacity increase is limited without dedicated lanes on much of the corridor
	Improve pedestrian safety	Increase or reduction in pedestrian space	15	Addition of bus bulbs if offset lanes are used	15	Addition of bus bulbs if offset lanes are used	10	Addition of bus bulbs or pedestrian refuges at median platforms	10	Addition of bus bulbs or pedestrian refuges at median platforms	10	Possible addition of bus bulbs along portion of corridor with bus lane
		Increase or reduction in vehicular traffic on State Street/Boston Road	10	Significant service improvements could lead to greater mode shift	15	Significant service improvements plus vehicle lane reduction could lead to greater mode shift	10	Significant service improvements could lead to greater mode shift	15	Significant service improvements plus vehicle lane reduction could lead to greater mode shift	5	TSM plus segment of bus could lead to small reduction in vehicle traffic
		Increase or reduction in curb-to-curb crossing distance/time across State St/Boston Rd	0	Wider road would lengthen times, except where bus bulbs added	10	Bus bulbs would shorten distance at intersections with stations	0	Wider road would lengthen times	10	Added bus bulbs would shorten time where present	5	Added bus bulbs would shorten time where present
		Lines-of-sight	10	Improved visibility from bus bulbs	10	Improved visibility from bus bulbs	10	Improved visibility from bus bulbs and median platforms	10	Improved visibility from bus bulbs and median platforms	5	Slight visibility improvement from bus bulbs and median platforms
MINIMIZE ADVERSE IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT	Avoid, minimize, or mitigate impacts on historic resources	Historic properties to be acquired	0	Extensive property acquisition required	20	No historic properties to be acquired	0	Extensive property acquisition required	20	No historic properties to be acquired	15	Minimal property acquisition may be required
		Potential visual effects on historic resources	10	Moderate effect with station amenities on sidewalk (signage, shelters, fare collection equipment)	10	Moderate effect with station amenities on sidewalk (signage, shelters, fare collection equipment)	10	Moderate effect with station amenities on sidewalk in some places (signage, shelters, fare collection equipment)	10	Moderate effect with station amenities on sidewalk in some places (signage, shelters, fare collection equipment)	15	Minimal effect (signage, shelters, fare collection equipment)
	Maximize improvements for underdeveloped streetscapes	Potential to beautify underdeveloped sections of the corridor	15	ROW acquisitions allow for streetscape improvements	5	Bus stop location allow for minor additional greening	10	Medians allow for additional greening; ROW acquisitions allow for additional streetscape improvements	5	Medians allow for additional greening; Bus stop location allow for minor additional greening	5	Bus stop location allow for minor additional greening
	Maintain access to existing and future uses on State Street and Boston Road	Access constraints	10	Possible minimal access restrictions depending on station locations near curb access points	10	Possible minimal access restrictions depending on lane restrictions due to lane reduction	10	Possible minimal access restrictions depending on station locations near curb access points	10	Possible minimal access restrictions depending on lane restrictions due to lane reduction	15	Likely no impact to access as limited portion of corridor would have a dedicated lane
		Parking supply changes	10	Maintains most on-street parking but may lose some private off-street parking due to property acquisition and at station areas	0	Likely decrease in supply to accommodate a bus only lane and stations	10	Maintains current on-street parking but may lose some private off-street parking due to property acquisition and at station areas	0	Likely decrease in supply to accommodate a bus only lane and stations	15	Likely decrease in supply to accommodate a bus only lane and stations
		Delivery access	15	Possible minimal access restrictions depending on station locations near curb access points	15	Possible minimal access restrictions depending on lane restrictions due to lane reduction	15	Possible minimal access restrictions depending on station locations near curb access points	15	Possible minimal access restrictions depending on lane restrictions due to lane reduction	15	Likely no impact to access with limited portion of corridor would have a dedicated lane
	Avoid property acquisition to the maximum extent feasible	Identify property requirements	0	Extensive property acquisition required	5	Possible property impacts to accommodate turn lanes and stations at some intersections	0	Extensive property acquisition required	5	Possible property impacts to accommodate turn lanes and stations at some intersections	15	Possible property impacts on portion of corridor where it's most feasible
	Reduce vehicular congestion, emissions, and noise	Transit ridership	10	Ridership will increase due to dedicated lanes, resulting in travel time reductions	10	Ridership will increase due to dedicated lanes, resulting in travel time reductions	15	Ridership will increase due to effective mix of dedicated lanes, resulting in travel time reductions	15	Ridership will increase due to effective mix of dedicated lanes, resulting in travel time reductions	10	Ridership will increase due to dedicated lanes along a portion of the route, resulting in travel time reductions
		Noise emission of transit mode	10	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	10	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	10	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	10	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	5	Minimal increase if the bus runs more frequently, but offset via partial dedicated lanes to avoid idling in traffic
		Vehicle emission of transit mode	10	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	10	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	10	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	10	Minimal increase if the bus runs more frequently, but offset via dedicated lanes to avoid idling in traffic	5	Minimal increase if the bus runs more frequently, but offset via partial dedicated lanes to avoid idling in traffic
		Number of vehicular travel lanes	10	May see lane adjustments at intersections and station areas	0	Reduction in travel lanes	10	May see lane adjustments at intersections and station areas	0	Reduction in travel lanes	15	Travel lane reduction only along portion of the corridor
	Minimize construction impacts to the extent feasible	Construction duration	0	Significant construction time due to ROW acquisition and road expansion	10	No median platforms or ROW acquisition, but may need to build bus bulbs	0	Significant construction time due to ROW acquisition, road expansion, and possible center medians	10	No ROW acquisition, but may need to build bus bulbs or median platforms	15	Portion of corridor with lane may require ROW acquisition or bus bulbs or median platforms
		Excavation requirements	0	Moderate excavation required to rebuild road with increased ROW	10	Minimal excavation for bus bulb construction	0	Moderate excavation required to rebuild road with increased ROW	10	Minimal excavation for median platform and/or bus bulb construction	15	Minimal excavation for only a portion of the route
RESULTS OF SECONDARY GOALS SCREENING			200		215		200		220		220	
		Secondary Goal 1	100		100		100		100		60	
		Secondary Goal 2	100		115		100		120		160	
		Secondary Goals Total Relative Score	50%		54%		50%		55%		55%	
		Total	340		370		350		385		375	
		Primary and Secondary Goals Total Relative Score	50%		54%		51%		57%		55%	

The analysis of the matrix results show that the 1B Alternative best achieves the primary goal of improving mobility along the corridor and secondary goal of enhancing community character (Table 4). The No Build Alternative would have the least cost and impacts to the environment, this is not surprising. When considering only build alternatives the Hybrid Alternative scored highest in achieving the primary goal to minimize cost and secondary goal to minimize impact to the environment (Table 5).

Table 4: Best Achieving Alternative by Goal

Best Achieving Alternative by Goal	Tier 1 Stops Only	Score	Relative Score
Primary Goals			
IMPROVE MOBILITY ALONG STATE STREET/BOSTON ROAD CORRIDOR	Alternative 1A – Median Running Guideway, Maintain Existing Lane Configuration Alternative 1B – Median Running Guideway, Maintain Existing Right-of-Way	125	78%
MINIMIZE CAPITAL AND OPERATING CONCERNS	No Build 2025	100	83%
Secondary Goals			
ENHANCE COMMUNITY CHARACTER	Alternative 1B – Median Running Guideway, Maintain Existing Right-of-Way	110	69%
MINIMIZE ADVERSE IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT	No Build 2025	200	83%

Table 5: Best Achieving Alternative by Goal Without No Build and TSM

Best Achieving Alternative (without No Build & TSM 2025) by Goal	Tier 1 Stops Only	Score	Relative Score
Primary Goals			
IMPROVE MOBILITY ALONG STATE STREET/BOSTON ROAD CORRIDOR	Alternative 1A – Median Running Guideway, Maintain Existing Lane Configuration Alternative 1B – Median Running Guideway, Maintain Existing Right-of-Way	125	78%
MINIMIZE CAPITAL AND OPERATING CONCERNS	HYBRID - Combination of alternatives: TSM (Western Terminus to Boston Road at Pasco Road) and Alternatives 2A/2B (Boston Road at Pasco	90	75%
Secondary Goals			
ENHANCE COMMUNITY CHARACTER	Alternative 1B – Median Running Guideway, Maintain Existing Right-of-Way	110	69%
MINIMIZE ADVERSE IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT	HYBRID - Combination of alternatives: TSM (Western Terminus to Boston Road at Pasco Road) and Alternatives 2A/2B (Boston Road at Pasco	160	67%

Overall the 1B Alternative scored the highest with 440 points out of a possible 680 that could be achieved. The No Build Alternative scored the lowest. In general the median running guideway alternatives scored higher than the curbside bus lanes because they will have greater reductions in travel times and greater ridership gains. The Hybrid Alternative which scored highly in achieving two of the four goals is ranked 4th amongst the alternatives. It is the highest ranking curbside bus lane alternative.

Table 6: Matrix Score Ranking of Alternatives

Rank	Alternatives - Tier 1 Stops Only	Primary Goals	Secondary Goals	Overall
1	Alternative 1B – Median Running Guideway, Maintain Existing Right-of-Way	190	250	440
2	Alternative 1A – Median Running Guideway, Maintain Existing Lane Configuration	180	235	415
3	Alternative 3B – Combine Median Running Guideway & Offset/Curbside Bus Lanes, Maintain Existing Right-of-Way	165	220	385
4	HYBRID - Combination of alternatives: TSM (Western Terminus to Boston Road at Pasco Road) and Alternatives 2A/2B (Boston Road at Pasco Road and the Eastern Terminus)	155	220	375
5	Alternative 2B – Offset/Curbside Bus Lanes, Maintain Existing Right-of-Way	155	215	370
6	Alternative 3A – Combine Median Running Guideway & Offset/Curbside Bus Lanes, Maintain Existing Lane Configuration	150	200	350
8	Alternative 2A – Offset/Curbside Bus Lanes, Maintain Existing Lane Configuration	140	200	340
7	TSM 2025	125	210	335
9	No Build 2025	100	205	305
	Max Score	**280**	**400**	**680**

The Alternative 1B and Hybrid alternative were selected to move into further evaluation as they were the best build alternatives to achieve the project goals. Alternative 1B was also selected because it was the highest ranking alternative. The Hybrid Alternative was also selected because it was the highest curbside running lane alternative.

2.4 PROPOSED ALTERNATIVES

The Hybrid Alternative is defined as mixed traffic operation (buses share lanes with cars) from Union Station to the intersections of Berkshire Avenue on State Street, and then from the intersection of Pasco Road on Boston Road to the eastern terminus (Eastfield Mall) on Boston Road. From State Street/ Berkshire Avenue to Boston Road/ Pasco Road a curb side bus lane would be implemented. With the Hybrid Alternative change to the roadway would only be implemented along areas of the corridor that have not been recently reconstructed within the last 5 to 8 years. There would be 1.4 miles of dedicated running way without taking significant right-of-way (i.e. businesses/ buildings). If businesses were acquired, or if a through lane is eliminated, there could be up to 2.4 miles of a dedicated running way; which would meet the ITDP minimum requirement of 1.9 miles. The hybrid curbside bus lane, would provide a dedicated bus lane in the right-most travel lane in each direction; which would serve BRT buses as well as local buses. It is noted that the through traffic capacity along Boston Road will be maintained (i.e. no through lane reductions). The Two Way Left Turn Lane (TWLTL) along Boston Road will be eliminated to minimize the right-of-way needs.

Figure 12: Curb Side BRT

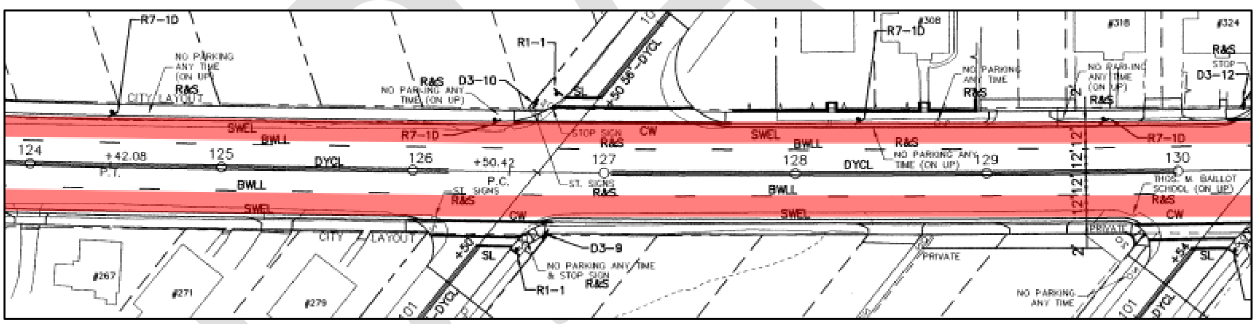

Figure 13: Curb Side Alignment

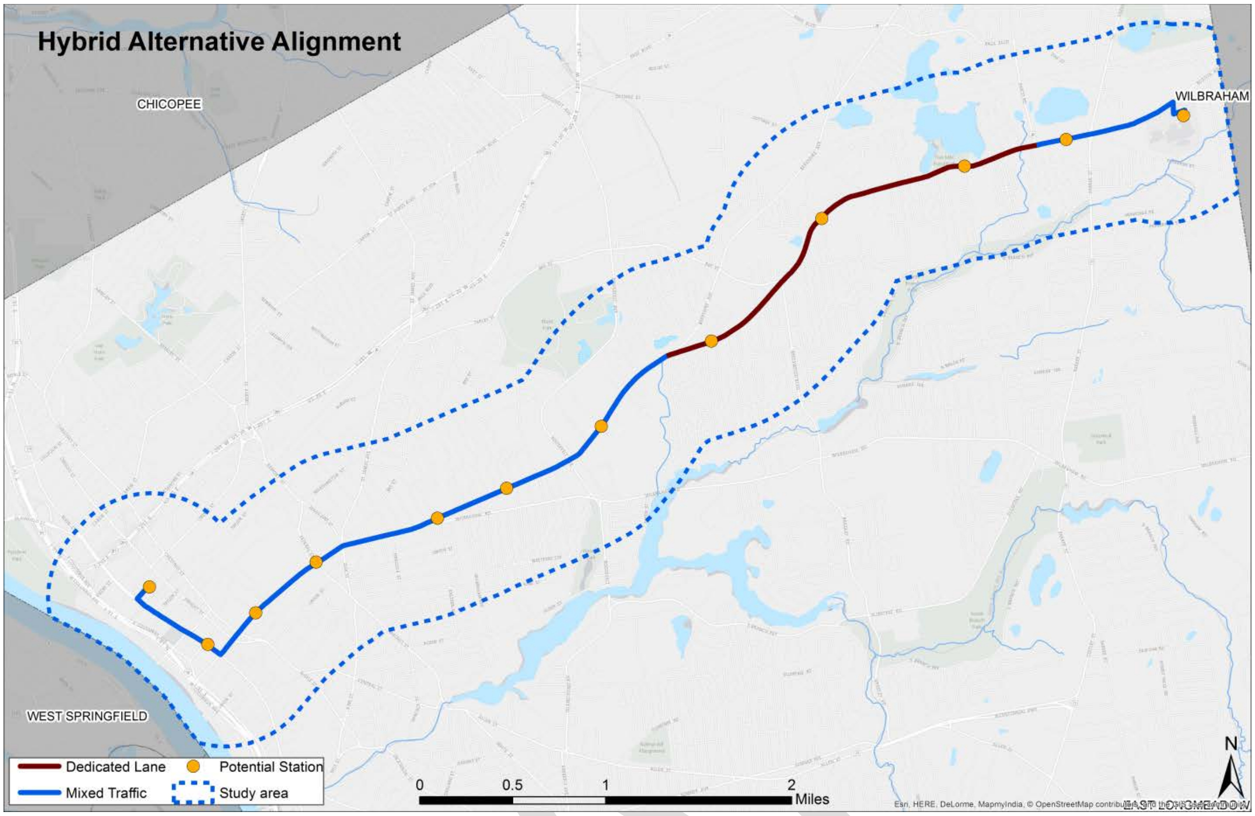

Figure 14: Hybrid Alternative

Figure 15: Median BRT

Alternative 1B is defined as having a median running guideway along the entire corridor of State Street and Boston Road. Alternative 1B would convert the left-most through travel lane in each direction into a dedicated bus lane that would serve the BRT service only. This will result in a decrease in traffic capacity along the majority of the corridor. Right-of-way for this option appears to be needed at locations where stations are proposed. For both th Hybrid and 1B alternatives the route would no longer deviate into Walmart, Price Rite, or Independence House. Both would no longer use Harrison Ave and Dwight/Chestnut but instead would turn at the intersection of Main and State.

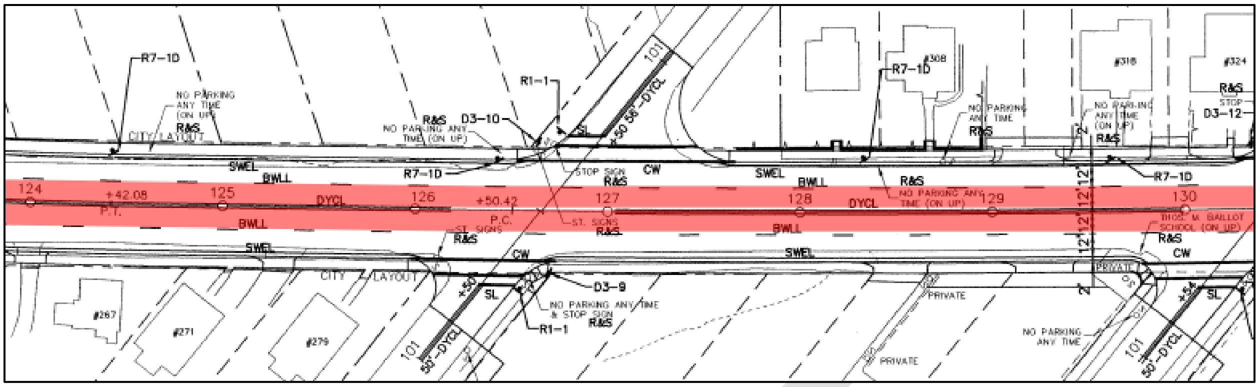

Figure 16: Centrally Aligned

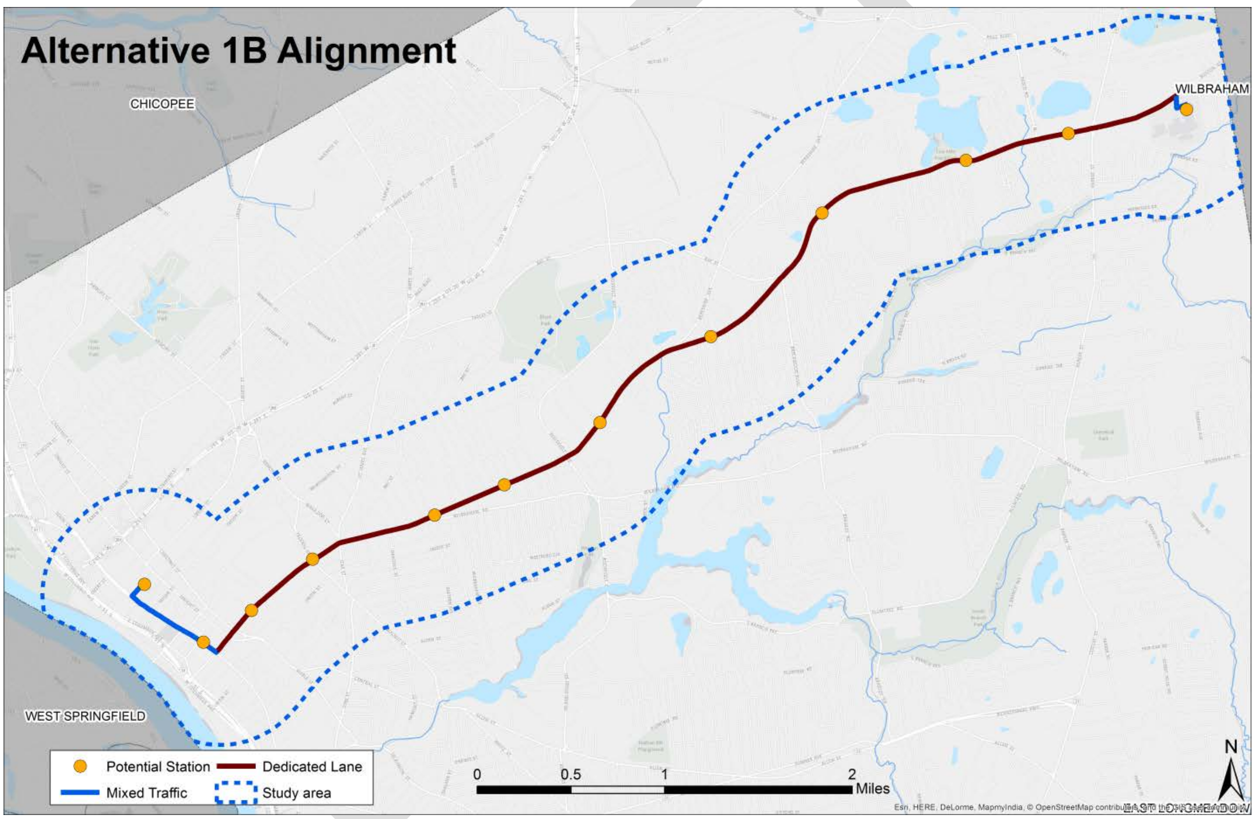

Figure 17: Alternative 1B

2.4.1 Common BRT Elements in Both Alternatives

Whether the Hybrid Alternative or Alternative 1B is selected, the following BRT elements are common to both:

- Off-Board Fare Collection
- Transit Signal Priority
- Modern BRT vehicles
- Real time passenger information
- Re-branding of the route

Figure 19: Example of Off-Board Fare Collection, Cleveland Health Line

Both alternatives would include off-board fare collection. Off-board fare collection is the preferred methodology as it reduces the dwell time of vehicles at a station so passengers are able to load faster and use all vehicle doors. Fare collection includes the collection process, payment options, media types and fare structure. This increases the speed along the corridor and improves the passenger experience. Proof-of-payment systems would be implemented, passengers pay at a kiosk prior to boarding and carry the ticket on-board where they may be asked by an inspector to show proof of payment. Two kiosks would be installed at each station and would be integrated with the PVTA Fast Break Smart Card.[5] PVTA could also consider fare payment through cellular telephone. The cellular telephone operates as the SmartCard with the ability to store multiple pass options and fare types. The riders downloads an application onto their cell phone and payment is processed through the app and a transit pass is produced on the person's phone. This system is used by TriMet in Portland, OR. The user simply selects their rider and mode type to purchase a ticket, then when they want to use it they select the ticket which generates a QR code that the fare inspector can scan.

Figure 18: TriMet Mobile Ticketing

Transit Signal Priority (TSP) would be installed at all intersections along the corridor regardless of the alternative. Along the proposed corridor there are 36 signalized intersections and 26 of them already have TSP pre-emption. The one segment of road without TSP currently installed is the 2.4 mile stretch between Berkshire and Pasco Road. On the remaining nine signal priority or preemption would be installed at all. The technology needed on board the vehicles currently exists but would need to be programed to interface with the signals.

Vehicles servicing the stations should be modern, attractive, and branded. At a minimum, 40' vehicles should be used, but during certain times of the day it warrants 60' articulated buses because capacity exceeds the current load factor bench marks. When 60' articulated vehicles are purchased in FY19 they

[5] PVTA's Fast Break Smart Card is a reloadable fare payment card which can store cash value and PVTA passes for passenger convenience and boarding ease. This technology is currently being explored by PVTA.

should be placed on the BRT corridor. The recent trend is to operate environmentally-friendly vehicles such as hybrids, electric, ultra-low sulfur, CNG, and others as part of an overall marketing and branding effort. The current 60' articulated buses owned by PVTA are diesel-hybrid, PVTA shold continue to purchase these. Vehicles should allow for boarding at all doors to speed up boarding and alighting, have low floors, bike racks, audio and visual announcements to aid riders in identifying stops, closed circuit cameras for safety and a host of ITS technology to inform riders of schedules, monitor performance and speed up the travel time.

PVTA currently has real time information at key stations to inform passengers of vehicle arrival times, automatic vehicle location (AVL) for dispatch and operational controls, automatic passenger counters (APC), in-vehicle automatic annunciation of stops and a phone app has been developed so passengers can know exactly when a vehicle will arrive. AVL, APC, and in-vehicle annunciation should be installed in all new vehicles purchased. All BRT stations should be equipped with real time information to provide the most up to date information for passengers

Need image from PVTA

Figure 20: PVTA Real Time Information Kiosk

PVTA should rebrand the BRT route as a new route to distinguish it from the rest of the system and introduce it as a new route. The current B7 route will become the local route and the name will remain as is. Passengers are familiar with the B7, therefore its name should stay the same since it will be servicing all stops. Branding the BRT service will not only clearly differentiate it but can enhance outreach efforts, increase customer loyalty, attract development and increase the brand value through marketing revenues. The service should have a distinct color scheme, graphics, and logos which are reflected on the vehicles, stations, signage and printed material. The route should have a unique name which sticks out. PVTA should work with the community to generate ideas and vote on a name for the new route. This will help with recognition and promoting the system within the community.

Figure 21: Branding of the Emerald Express - Lane Transit District, Eugene, OR

Public outreach events should be scheduled throughout the project planning and construction phases, and should be heavily promoted during the months leading up the launch of service. Events should be hosted across the service area in areas with high concentrations of people such as large employers, medical centers, higher education institutions, and shopping centers. The goal of these events is to reach a variety of potential riders – residents, employees, students, or visitors. Promotional materials, such as brochures, provide concise information and can easily be transported to events and displayed at information tables. To meet the needs of residents in the service area, materials should be printed in additional languages as needed.

2.5 Stations

BRT stations help develop the brand, are typically attractive, and provide a safe and comfortable place to wait. They will have a sheltered waiting area, be well lit, clearly delineate which routes utilize it if multiple routes service it, be fully accessible, have passenger amenities, multimodal access, and have security through the use of cameras, guards, or other safety enhancing technologies. The proposed guidelines for stations meet the following criteria:

1. Placed in locations that do not compromise the safety of pedestrians, bicyclists, vehicles or riders
2. Spacing that maximizes the efficient operations of transit services while not requiring passengers to walk more than one half mile to the nearest stop on the corridor
3. Context sensitive design that is consistently identifiable; involve neighborhood communities early in design process to gain input to reflect community identity
4. Have appropriate amenities based on the usage of the stop and surrounding land use
5. Be compliant with the Americans with Disabilities Act (ADA) for design and siting

The station, along with the vehicle, will also allow for platform-level boarding. Platform-level boarding is where the station platform and bus floors are level. This reduces the time needed to board and disembark the vehicles and improve accessibility. By reducing the platform gap, typically to less than two inches, safety is also increased. Multiple techniques such as alignment markers, guided docking, and Kassel curbs (a beveled curb) can be used to reduce the gap. It is important, however, to ensure that it is possible to board the vehicle without the presence of a platform. Routes often leave the BRT corridor and must be able to service stops without a platform. Typical low floor vehicles would need a curb height of approximately 14” for level boarding to occur.

2.5.1 Station Dimensions

For planning purposes, stations are assumed to be 140’ long to accommodate two articulated buses at once. However, a 90’ platform should be sufficient for PVTA and was included in the cost estimate (Several locations have been identified where a 90-100 foot platform may be preferable). Therefore, the difference between the 90’ and 140’ platform will enable the final design team to have flexibility in the exact placement of the station platforms. Median stations should be located near crosswalks; otherwise a midblock crossing may need to be installed. All median stations should have right side boarding. Median Stations should be at minimum a 10’ wide with at least 3’ at the front of the shelter for sidewalk clearance. The rear of the shelter must have 18” clearance from the edge of the station pad, shelters must be at least 4’ deep and the station must have an unobstructed 5’x8’ landing pad to meet ADA guidelines. Figure 22 represents tympical median station layout.

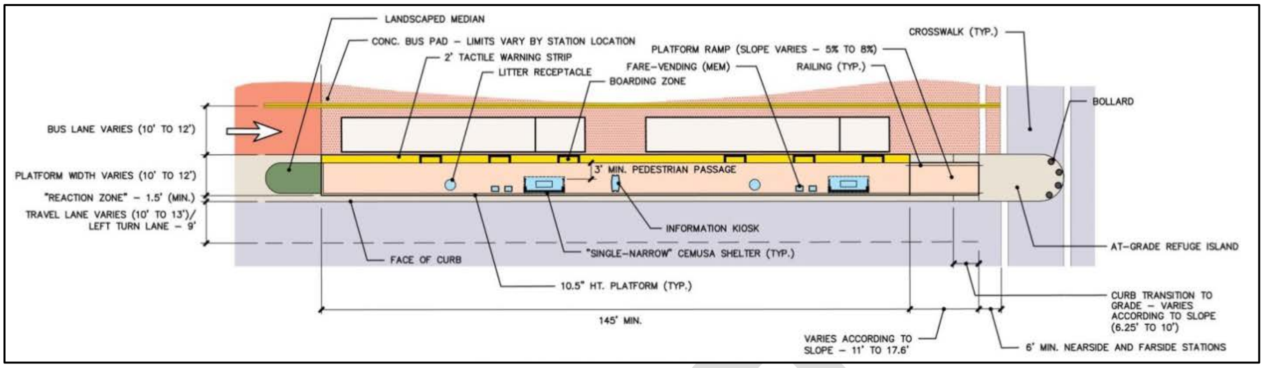

Figure 22: Typical Median Platform Station

Curbside stations should be placed by sidewalks where possible, but this is not as critical as it is for median stations. Curb side stations typically require 12’; 4’ for shelters with an 8’ deep ADA landing pad in front. The width can be shortened to 8’ if the landing pad is adjacent to the shelter and a clear path exists. A minimum of 3’, 5’ preferred, is required for sidewalk clearance at either the front or back of the shelter (this can include sections of the landing pad). In instances where there is insufficient sidewalk clearance shelters may be placed facing away from traffic in order to still meet the ADA requirements for sidewalk clearance and landing pads. All shelters which abut a building must have at least 12” between the back of the shelter and the building. To meet ADA guidelines all stations must be at least 4’ deep with entrance ways at least 2’-8” wide. Figure 23 represents minimum clearance requirements and Figure 24 represents typical minimum dimensions to meet ADA requirements. Figure 25 represents tympical median station layout.

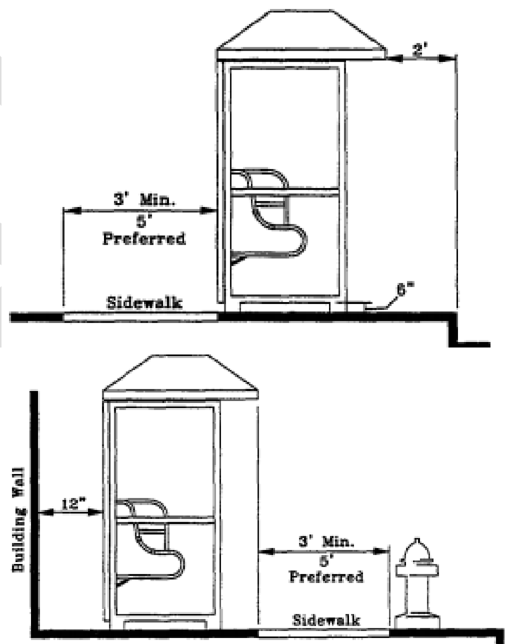

Figure 23: Curbside Bus Shelter Setback Requirements

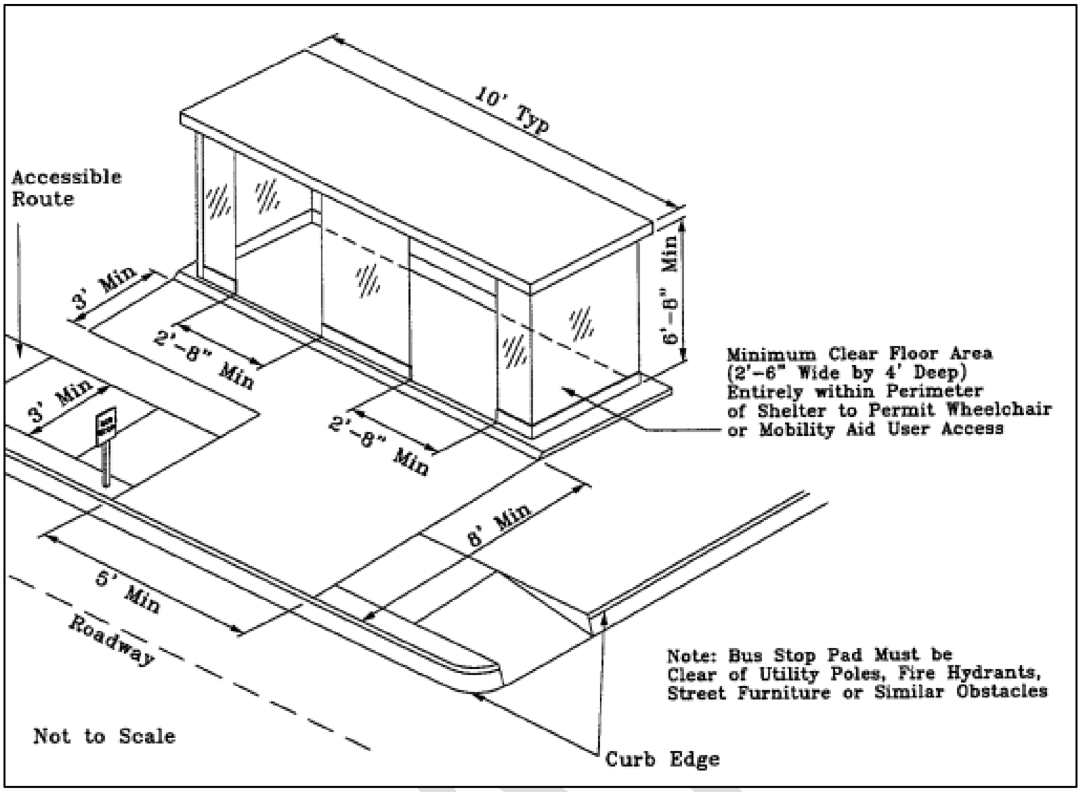

Figure 24: Accessible Bus Stop Pad and Shelter Minimum Dimensions

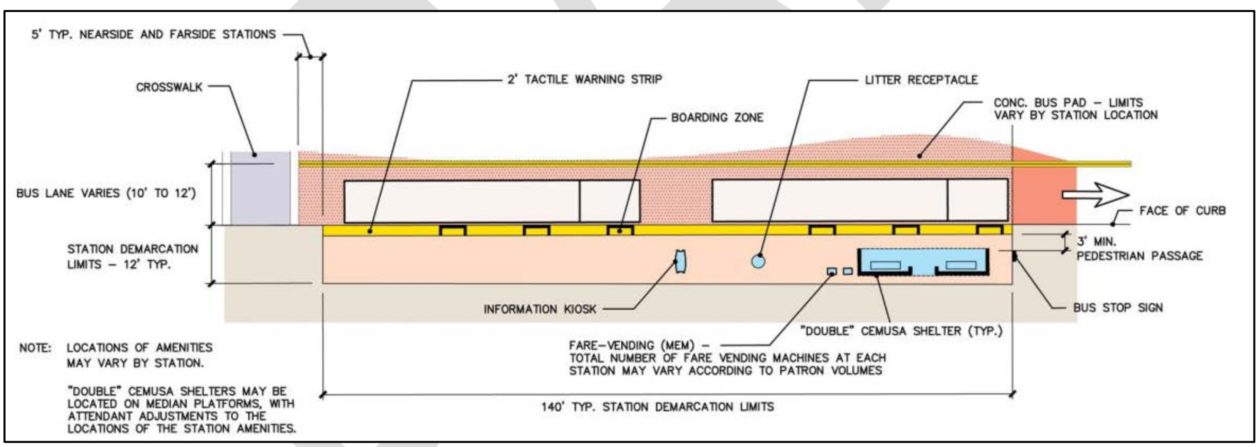

Figure 25: Typical Curbside Platform Station

2.5.2 Station Locations

Stations can be located either far side (after the intersection), near side (before the intersection) or mid-block (not near an intersection). Ideally, BRT stations should be located on the far side of intersections to minimize delay and conflicts, improve crossing safety, and to take full advantage of transit signal prioritization (TSP) and queue jumps. Far side stops allow the vehicle to pass through the intersection using the priority measures to minimize delay.

Far Side Station Advantages

- Minimizes conflicts with right turning vehicles and buses
- Allows for utilization of TSP
- Encourages pedestrians to cross behind the bus
- Minimizes potential sight distance problems on the approach of the intersection
- Creates shorter deceleration distances for buses
- Allows operators to take advantage of gaps in traffic created by signals

For each alternative 22 stations have been developed including the terminal stations at Union Station and the Eastfield Mall and 10 stations in each direction. This creates 12 locations for stations, Table 7 summarizes the stations and Figure 26 maps them. The Union Station, Main Street, and Eastfield Mall stations would be the same for either alternative, the remaining nine would differ. Station location was developed based on existing ridership, points of interest, a minimum[6] and maximum spacing, and roadway constraints. For a more precise location of each station along with the pros and cons of each see pages 2-28 – 2-38.

[6] Minimum of 0.3 miles in the dense urban area south of American International College and 0.5 miles north. The maximum station spacing used was 1 mile.

Table 7: Station Location Description by Alternative

Station	Alternative 1B		Hybrid Alternative	
	Inbound Stop	Outbound Stop	Inbound Stop	Outbound Stop
Union Station	Row 2 Bus Bay	Row 2 Bus Bay	Row 2 Bus Bay	Row 2 Bus Bay
Main St.	In front of the Mass Mutual Center on Main St.	In front of Court Square	In front of the Mass Mutual Center on Main St.	In front of Court Square
Elliot St.	Far-side at Main St./Elliot St. intersection	Far-side at Main St./Elliot St. intersection	In front of Saint Michaels Cathedral	In front of Classical High Condominiums
Federal St.	In front of STCC	In front of Burger King	In front of STCC	Just north of Burger King
Catharine St.	In front of McDonalds	In front of Dream Décor	In front of McDonalds on State St.	By the Memorial Park
College St.	Adjacent to AIC by the on-street parking	Adjacent to AIC by the on-street parking	In front of parking lot between Mapledell St. and Oak Grove Ave.	In front of AIC
Blunt Park Rd	In front of Putnam High School	Just north of the State St. and Insurance Rd intersection	In front of Putnam High School	Just north of the State St. and Insurance Rd intersection
Preston St.	In front of Salemi Appliance	Far-side (in front of apartments at the corner of Boston Rd./Coleman St.)	In front of Salemi Appliance	In front of the vacant parking lot at the Boston Rd/Ambrose St intersection
Arnold Ave.	In front of Five Star Cleaners	Near the main entrance at Price Rite	On the curve south of Kwik pik store	Near the main entrance at Price Rite
Shumway St.	Near the entrance to Five Mile Pond Park	In front of the Walmart plaza	Near the entrance to Five Mile Pond Park	In front of the Walmart plaza
Lucerne St.	Near the Olive Garden Plaza	In front of Sunoco Gas Station	Near the Olive Garden Plaza	In front of Webster Bank
Eastfield Mall	At the former JC Penny Entrance	At the former JC Penny Entrance	At the former JC Penny Entrance	At the former JC Penny Entrance

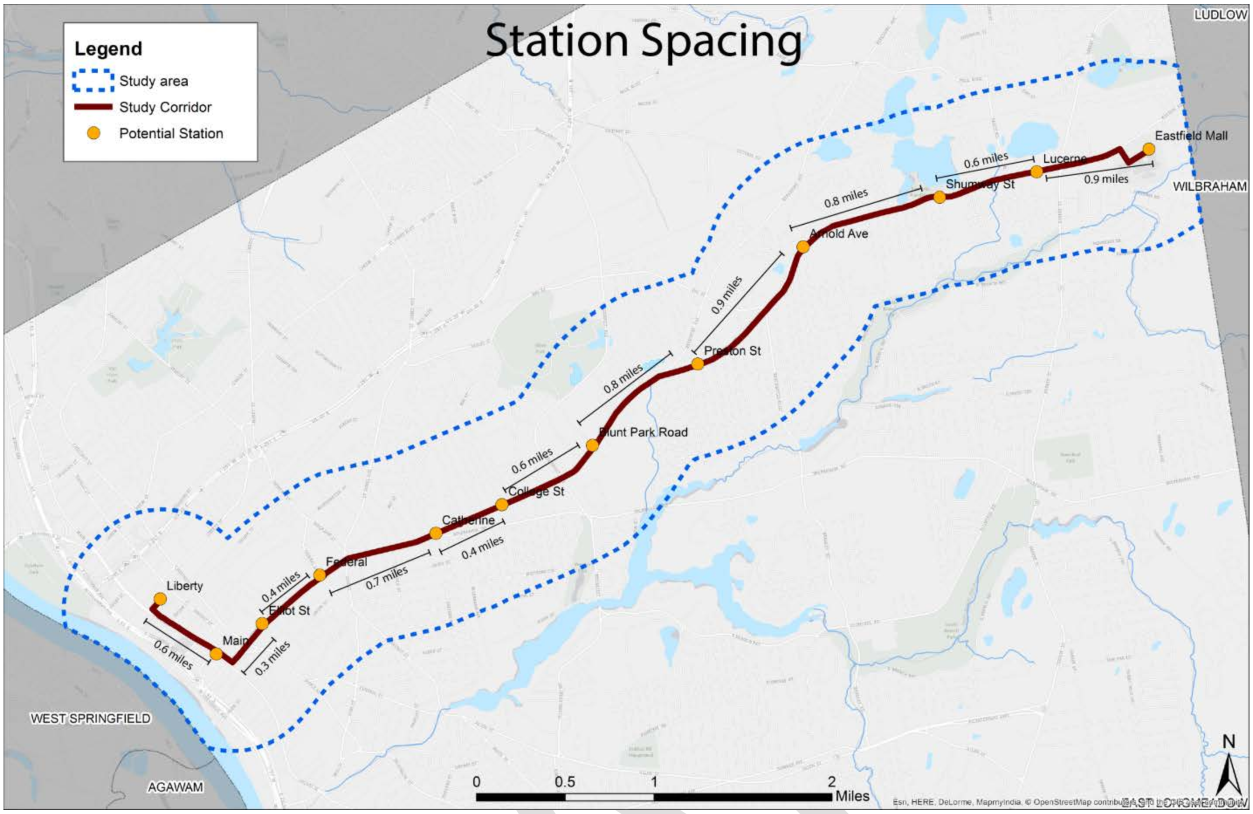

Figure 26: Station Spacing

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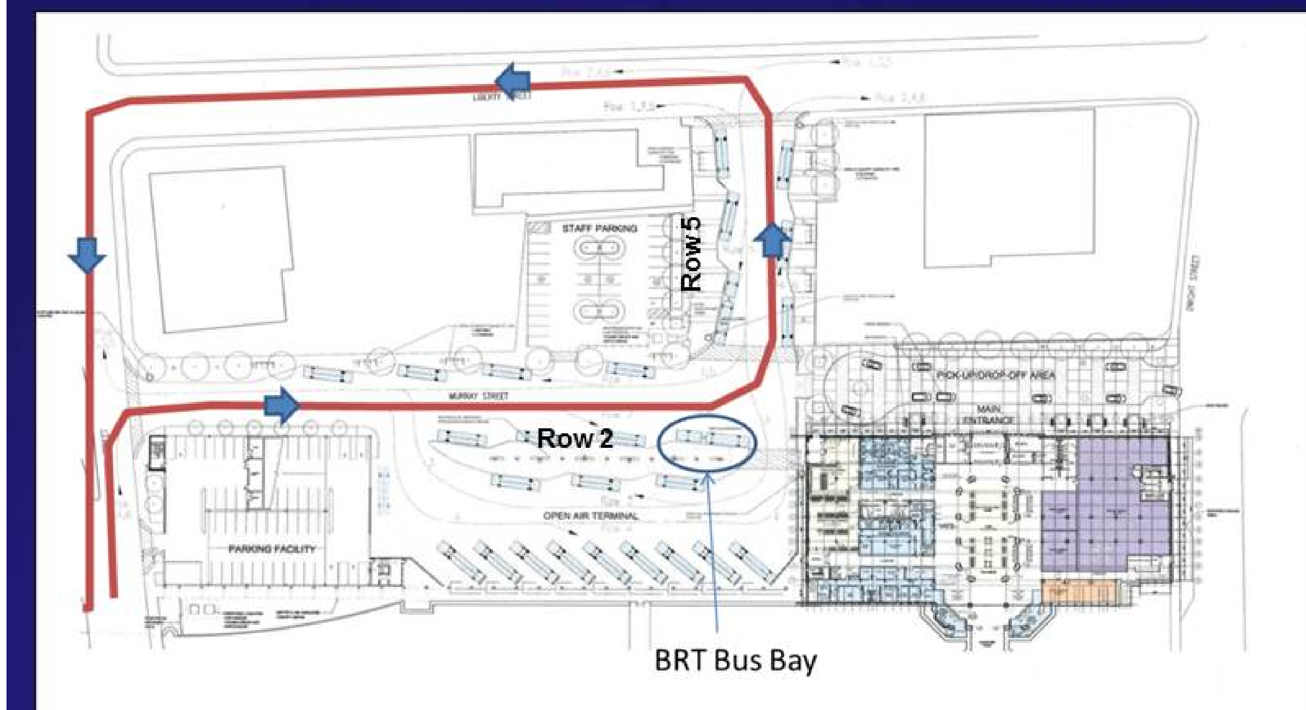
Hybrid and 1B Alternative

Union Station



- Must use Row 2 bus bay since there are only two articulated bus bays and since there is no traffic signal it would be difficult for buses to turn left onto Main St. from the Row 5 bus bay.
- Signal operations at the intersection of Liberty St. and Main St. would need to be evaluated to determine if modifications to the timing or geometry at the intersection are warranted. A similar evaluation should be conducted at the proposed access drive from Union Station to Liberty St. and Main St.

Hybrid Alternative

Main St.

Inbound

Pros

- Farside
- Wide sidewalk
- Existing stop
- Would also service G1, G2, X92
- 140' long
- Near crosswalk

Cons

- Approval from state required

Other

- Evaluate traffic signal at location to determine if queue clearing strategies can be employed in the left turn / through lane

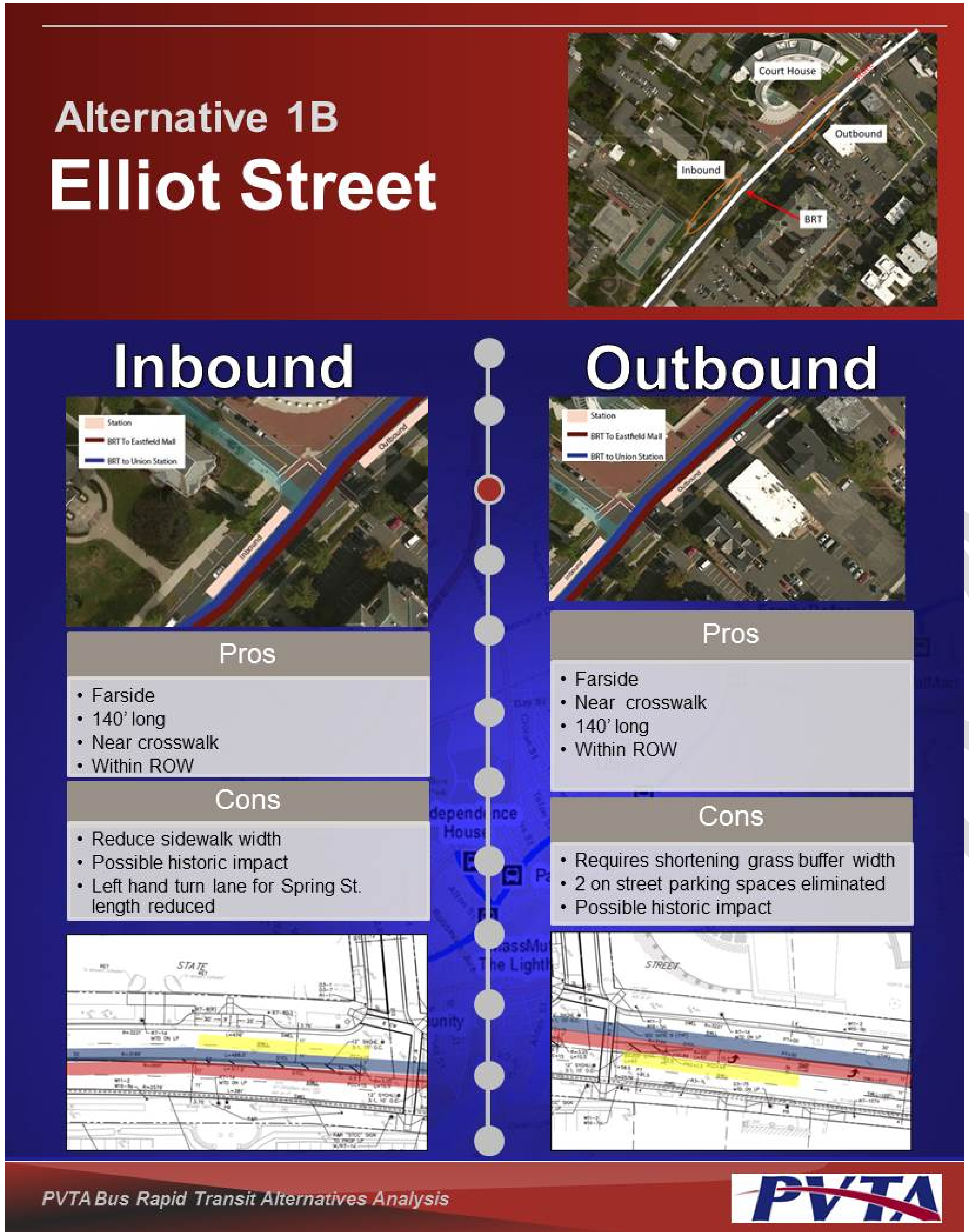
Outbound

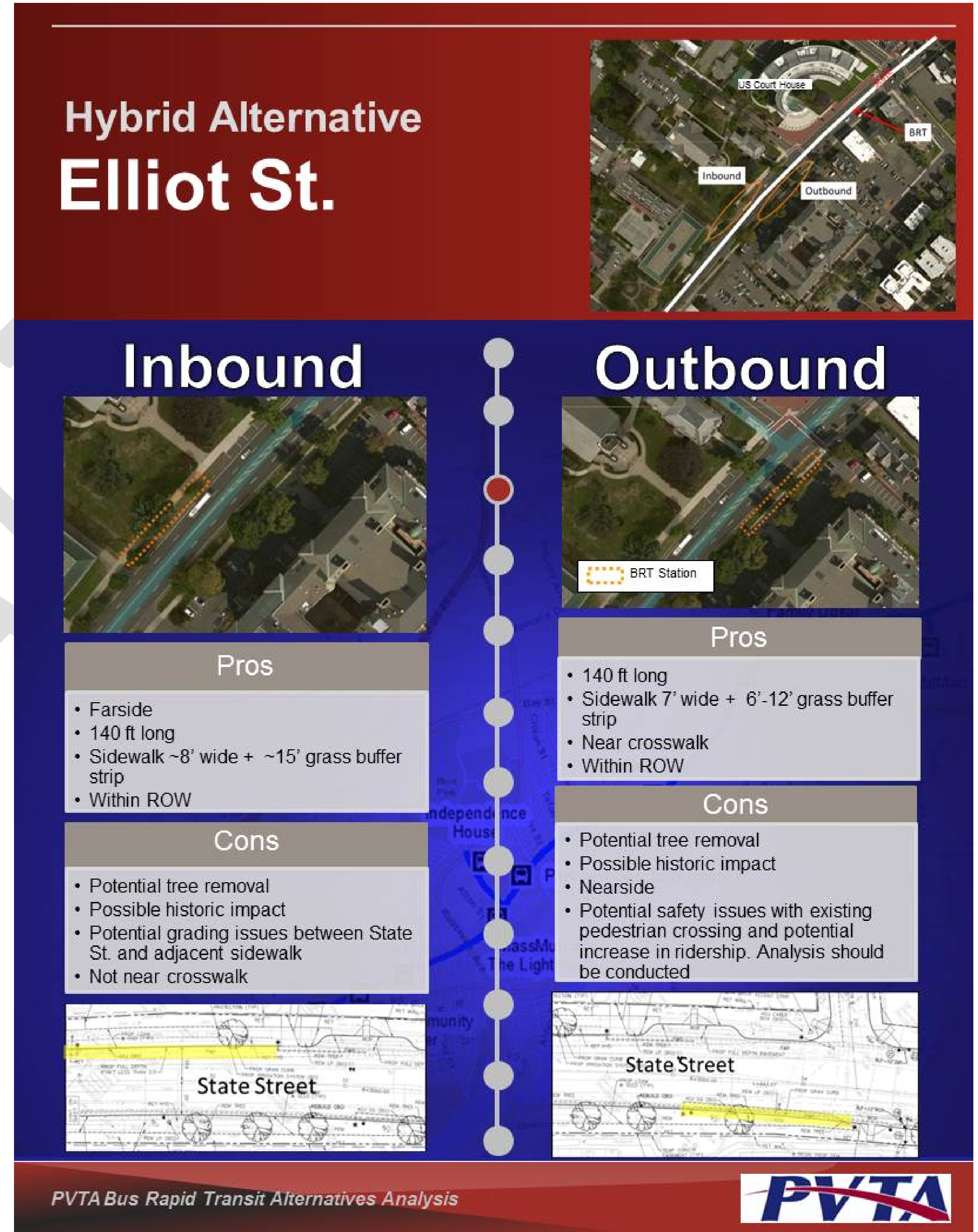
Pros

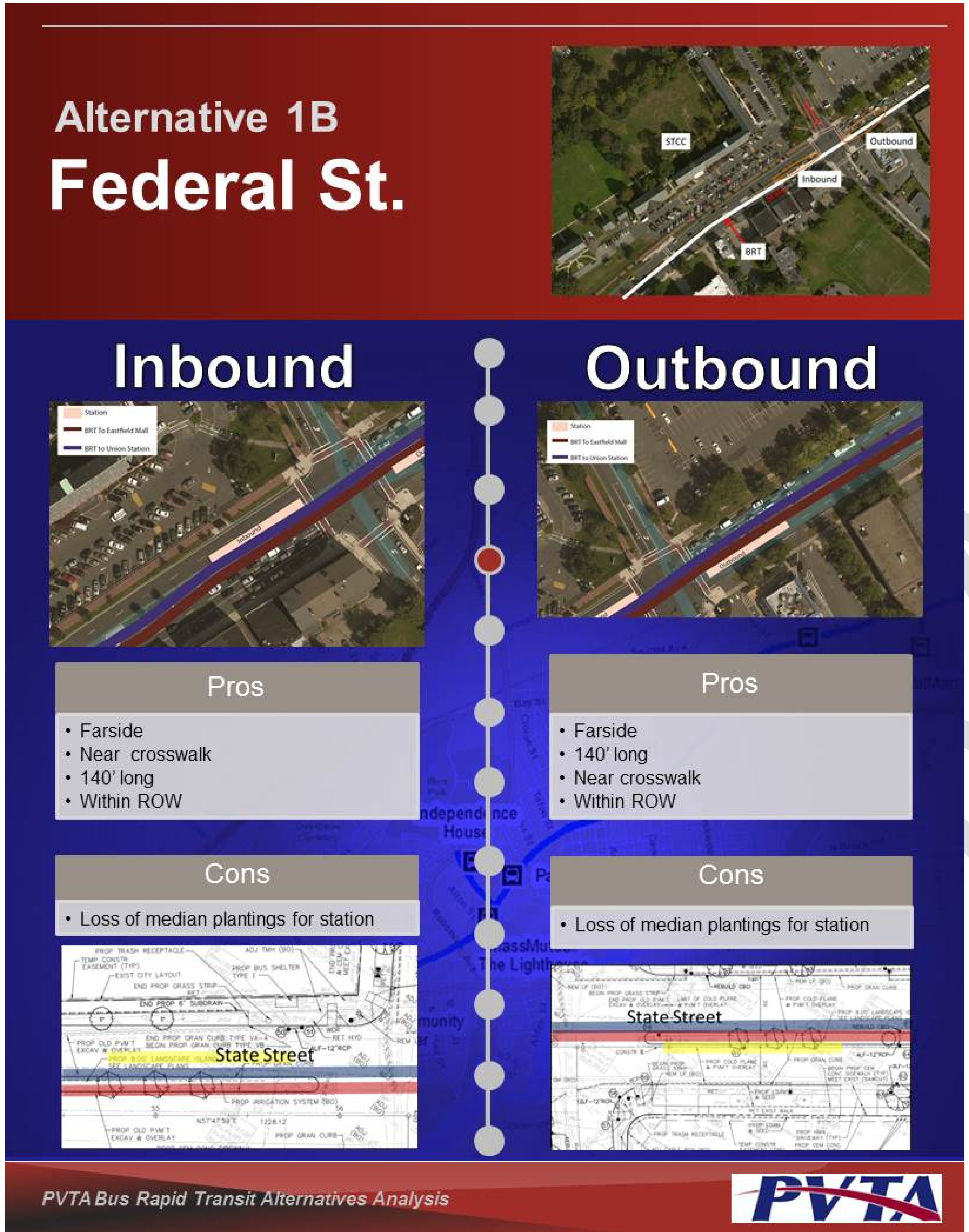
- Wide sidewalk
- Existing stop
- Would also service G1, G2, X92
- 140' long
- Expansive width of pavement
- Near crosswalk

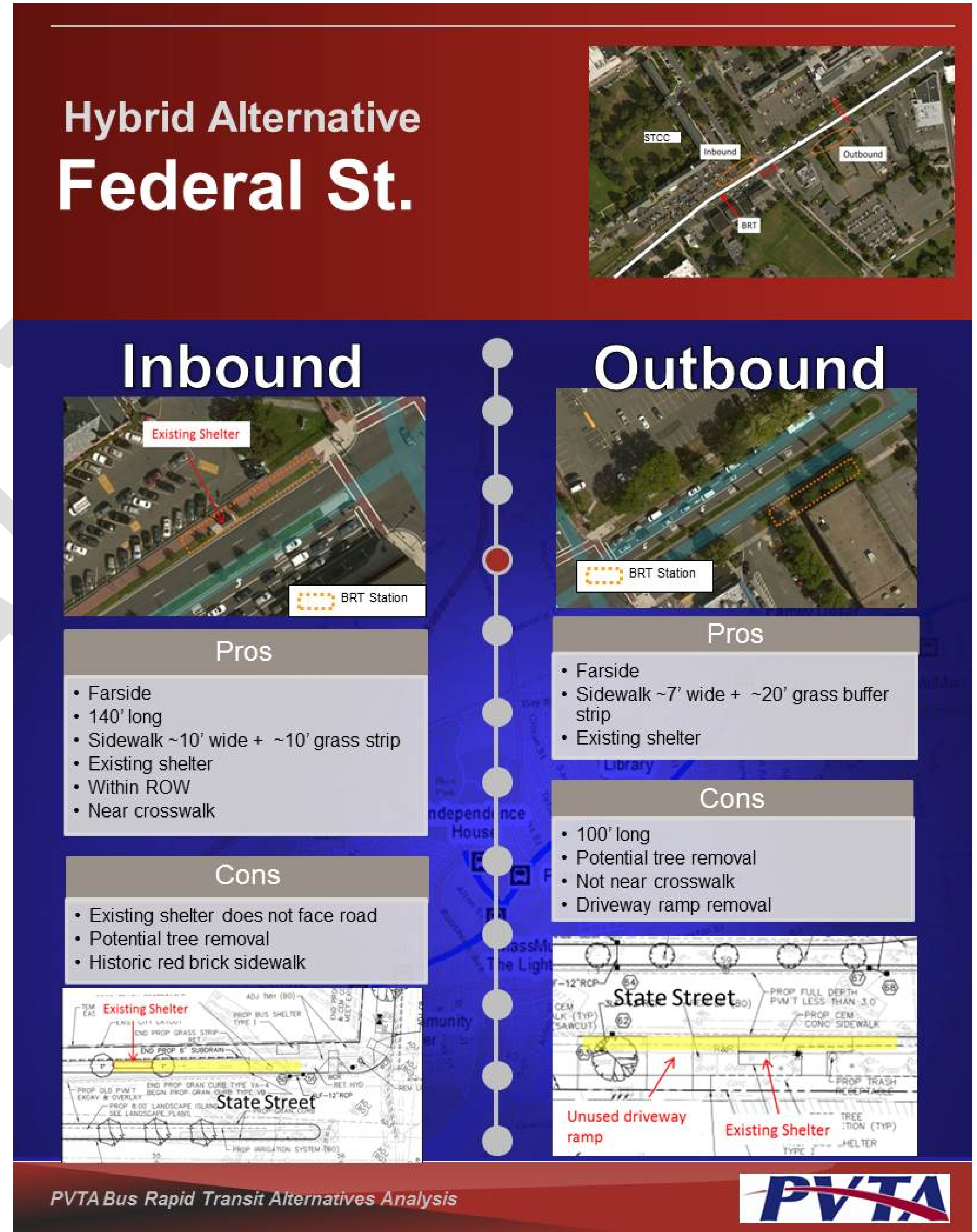
Cons

- Near side
- Historic impact
- Possible midblock pedestrian crossings


Alternative 1B
Elliot Street
Court House
Outbound
Inbound
BRT
Inbound
Outbound
Station
BRT To Eastfield Mall
BRT to Union Station
Pros
• Farside
• 140' long
• Near crosswalk
• Within ROW
Cons
• Reduce sidewalk width
• Possible historic impact
• Left hand turn lane for Spring St. length reduced
Pros
• Farside
• Near crosswalk
• 140' long
• Within ROW
Cons
• Requires shortening grass buffer width
• 2 on street parking spaces eliminated
• Possible historic impact
PVTA Bus Rapid Transit Alternatives Analysis
PVTA


Hybrid Alternative
Elliot St.
US Court House
BRT
Inbound
Outbound
Inbound
Outbound
BRT Station
Pros
• Farside
• 140 ft long
• Sidewalk ~8' wide + ~15' grass buffer strip
• Within ROW
Cons
• Potential tree removal
• Possible historic impact
• Potential grading issues between State St. and adjacent sidewalk
• Not near crosswalk
State Street
Pros
• 140 ft long
• Sidewalk 7' wide + 6'-12' grass buffer strip
• Near crosswalk
• Within ROW
Cons
• Potential tree removal
• Possible historic impact
• Nearside
• Potential safety issues with existing pedestrian crossing and potential increase in ridership. Analysis should be conducted
State Street
PVTA Bus Rapid Transit Alternatives Analysis
PVTA


Alternative 1B
Federal St.
STCC
Outbound
Inbound
BRT
Inbound
Outbound
Station
BRT To Eastfield Mall
BRT to Union Station
Pros
• Farside
• Near crosswalk
• 140' long
• Within ROW
Cons
• Loss of median plantings for station
State Street
Pros
• Farside
• 140' long
• Near crosswalk
• Within ROW
Cons
• Loss of median plantings for station
State Street
PVTA Bus Rapid Transit Alternatives Analysis
PVTA

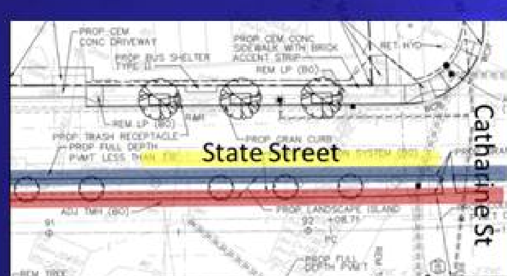

Hybrid Alternative
Federal St.
STCC
Inbound
Outbound
BRT
Inbound
Outbound
Existing Shelter
BRT Station
Pros
• Farside
• 140' long
• Sidewalk ~10' wide + ~10' grass strip
• Existing shelter
• Within ROW
• Near crosswalk
Cons
• Existing shelter does not face road
• Potential tree removal
• Historic red brick sidewalk
Existing Shelter
State Street
BRT Station
Pros
• Farside
• Sidewalk ~7' wide + ~20' grass buffer strip
• Existing shelter
Cons
• 100' long
• Potential tree removal
• Not near crosswalk
• Driveway ramp removal
State Street
Unused driveway ramp
Existing Shelter
PVTA Bus Rapid Transit Alternatives Analysis
PVTA

Alternative 1B
Catharine St.

Inbound

Pros
- Farside
- Near crosswalk
- 140' long
- Within ROW

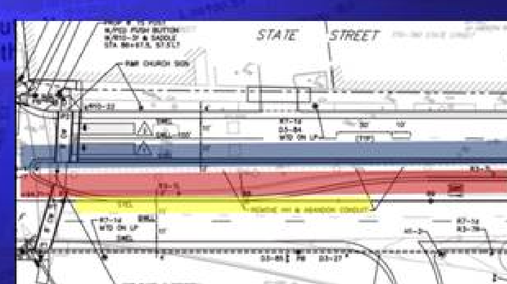
Cons
- Loss of median plantings for station



Outbound

Pros
- 140' long
- Near crosswalk
- Within ROW

Cons
- Nearside of Catharine but farside of Buckingham St.
- Loss of median plantings for station

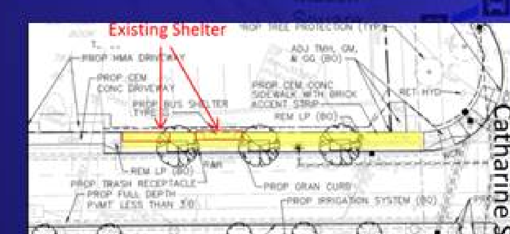


Hybrid Alternative
Catharine St.

Inbound

Pros
- Farside
- 10' wide sidewalk
- Could expand depth with takings
- Existing shelters
- Would also service R27 and B17
- Near crosswalk

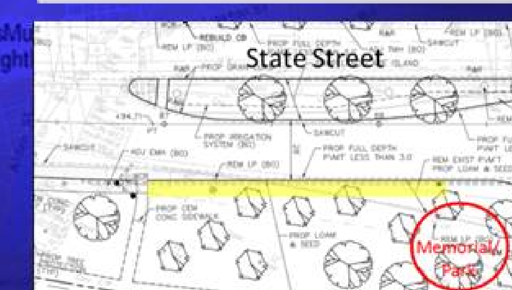
Cons
- 110' long
- Potential tree removal
- Parking impacts
- Possible easement/takings



Outbound

Pros
- 140' long
- Plenty of room for station
- Would also service R27 and B17
- Near crosswalk
- Within ROW

Cons
- Nearside
- Potential tree removal
- Taking from green space



Alternative 1B

College St.

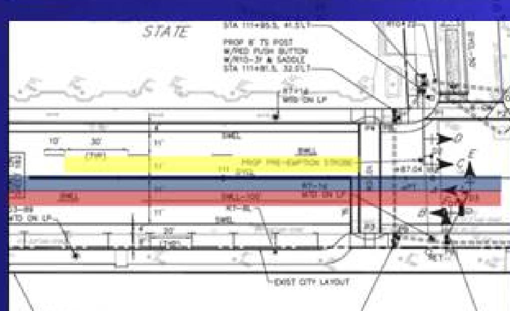
Inbound

Pros

- Farside
- Near crosswalk
- 140' long

Cons

- Loss of on street parking by AIC
- Will not fit within existing ROW, roadway must shift



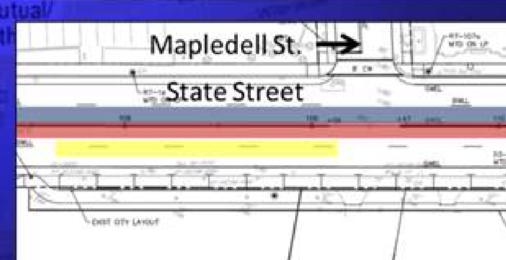
Outbound

Pros

- 140' long

Cons

- Loss of on street parking by AIC
- Nearside
- Not near crosswalk
- Will not fit within existing ROW, roadway must shift



Hybrid Alternative

College St.

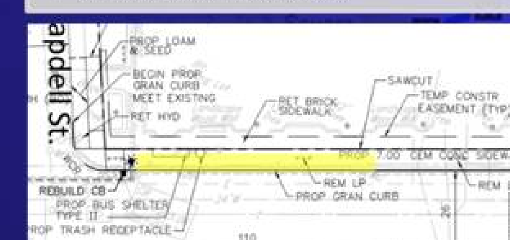
Inbound

Pros

- Existing shelter
- 140' long
- Farside
- 7' sidewalk with varying red brick paved spaced behind
- Near crosswalk

Cons

- 7' sidewalk
- Farther from College St.
- Takings/easement for larger shelter
- Impacts to landscaping
- Potential parking impacts



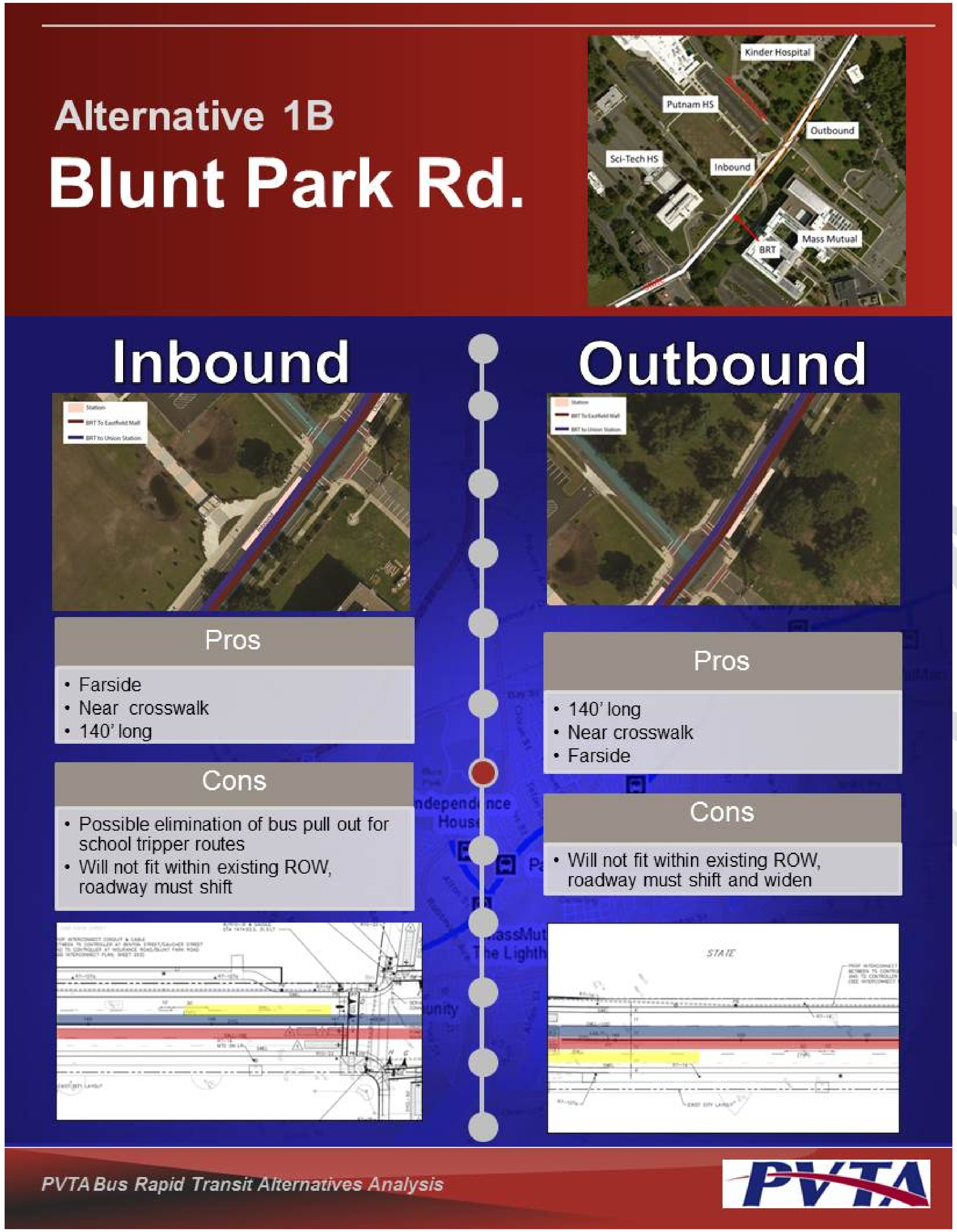
Outbound

Pros

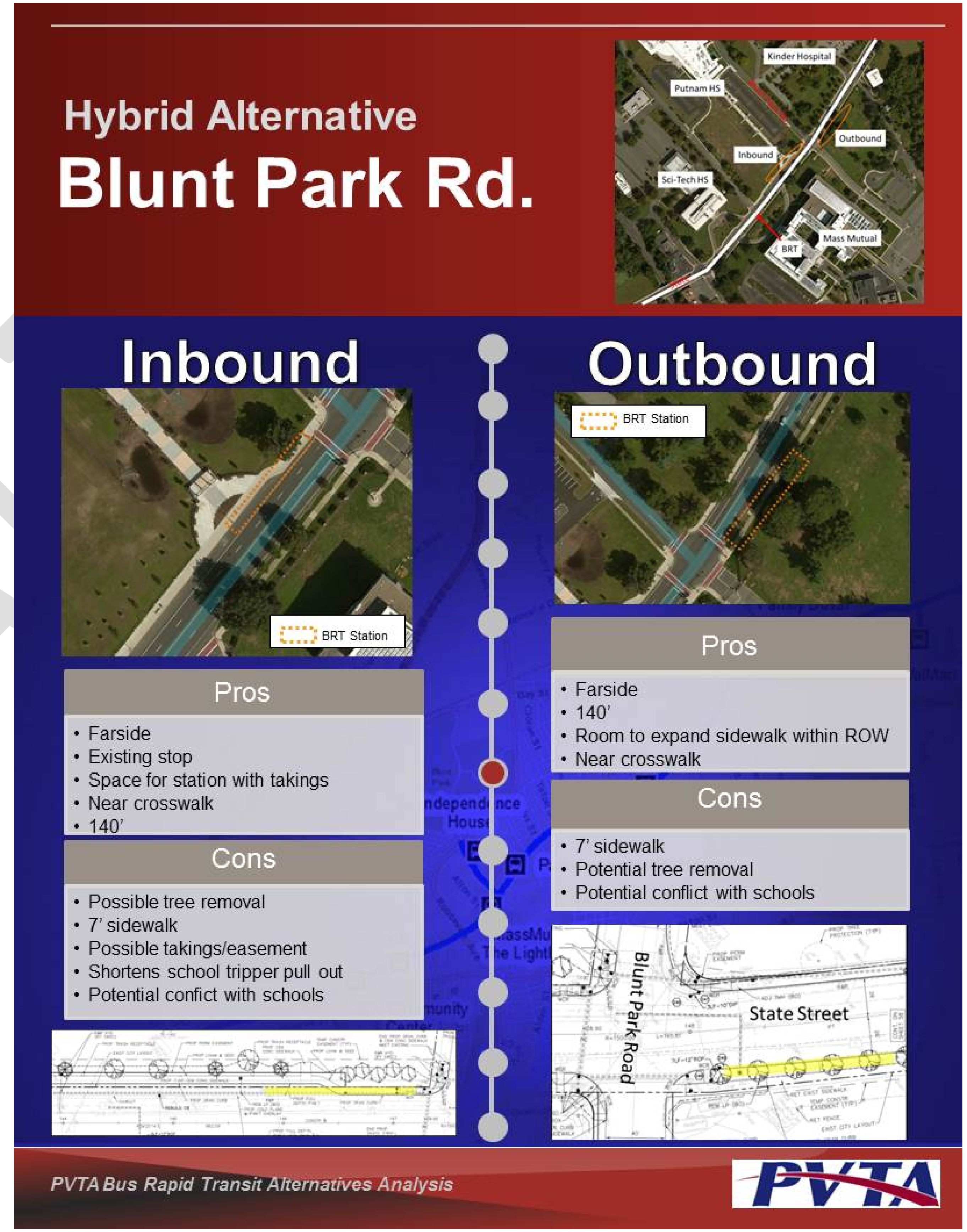
- No ROW impacts

Cons

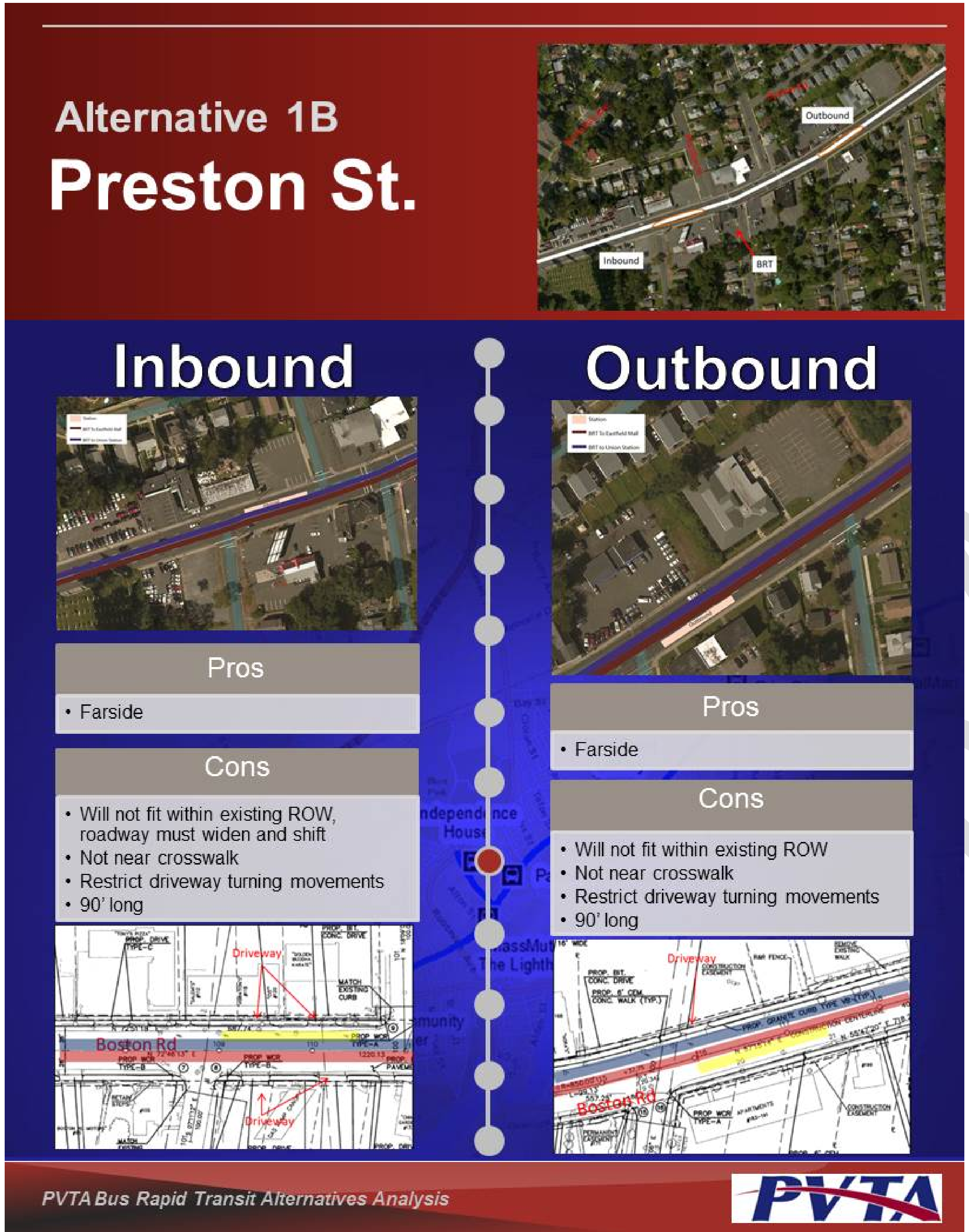
- 100' long
- Bus bay pullout eliminated
- 6' sidewalk
- Crosswalk must be added

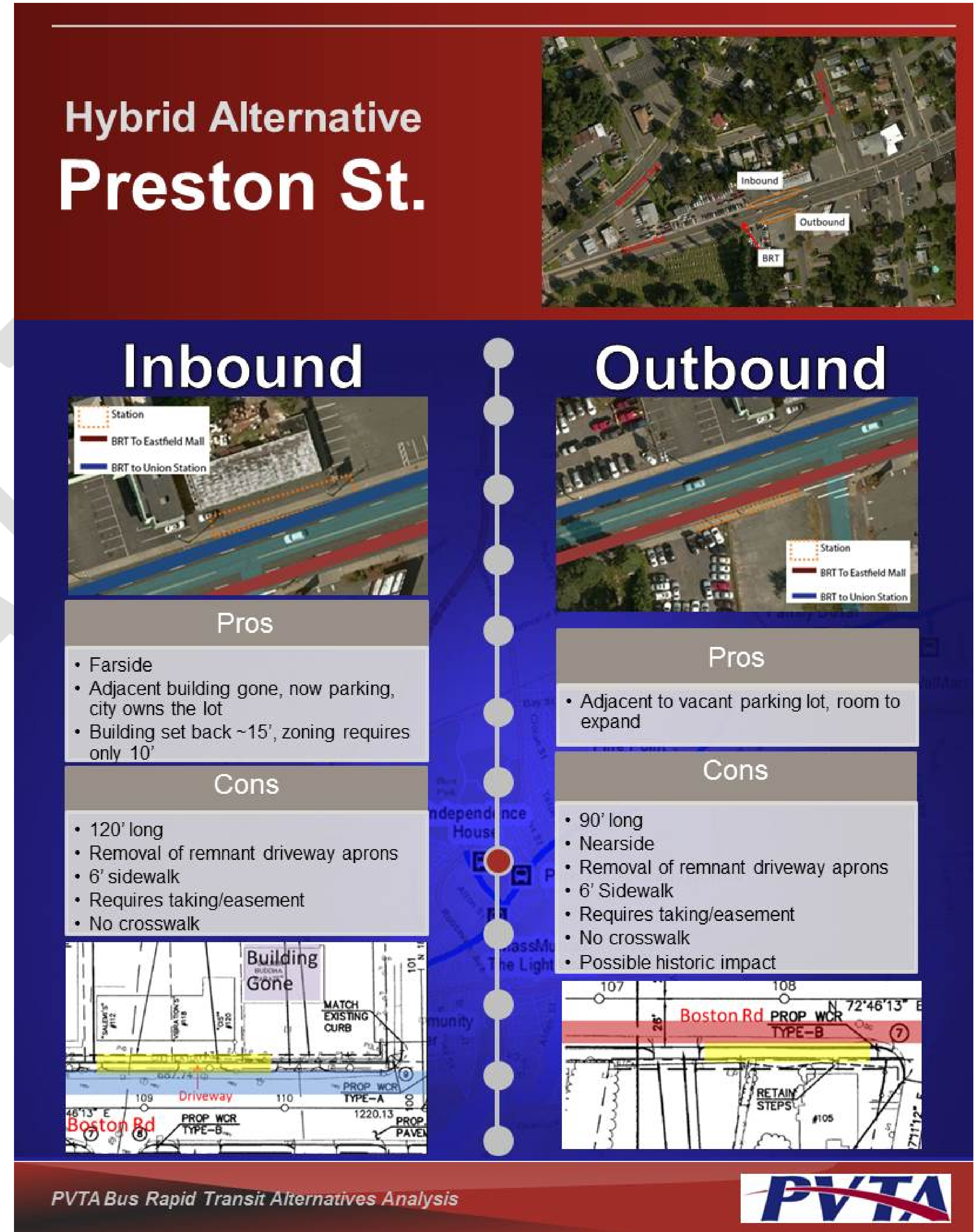


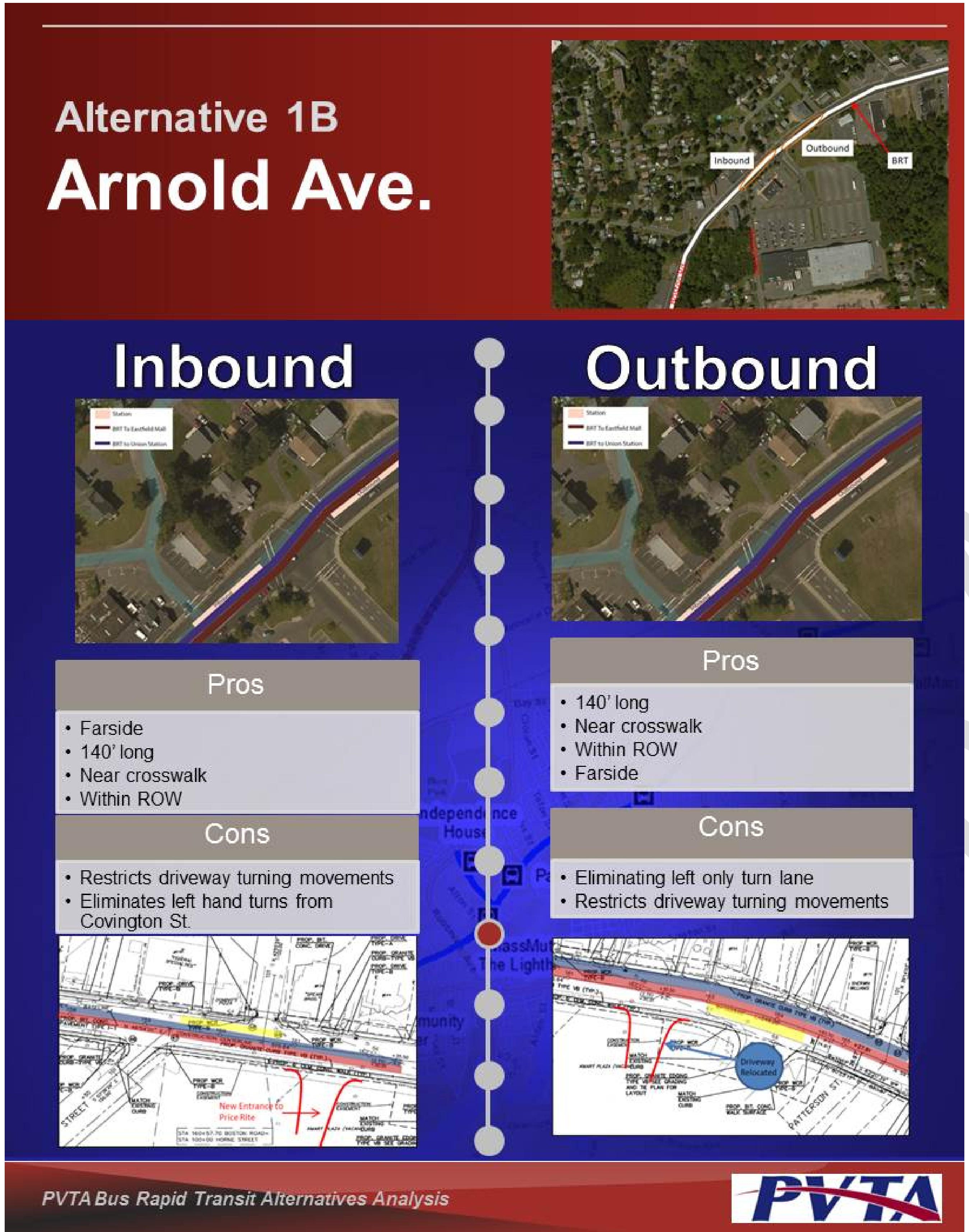
Alternative 1B
Blunt Park Rd.
Kinder Hospital
Putnam HS
Outbound
Sci-Tech HS
Inbound
Mass Mutual
BRT
Inbound
Outbound
Pros
• Farside
• Near crosswalk
• 140' long
Cons
• Possible elimination of bus pull out for school tripper routes
• Will not fit within existing ROW, roadway must shift
Pros
• 140' long
• Near crosswalk
• Farside
Cons
• Will not fit within existing ROW, roadway must shift and widen
PVTA Bus Rapid Transit Alternatives Analysis
PVTA



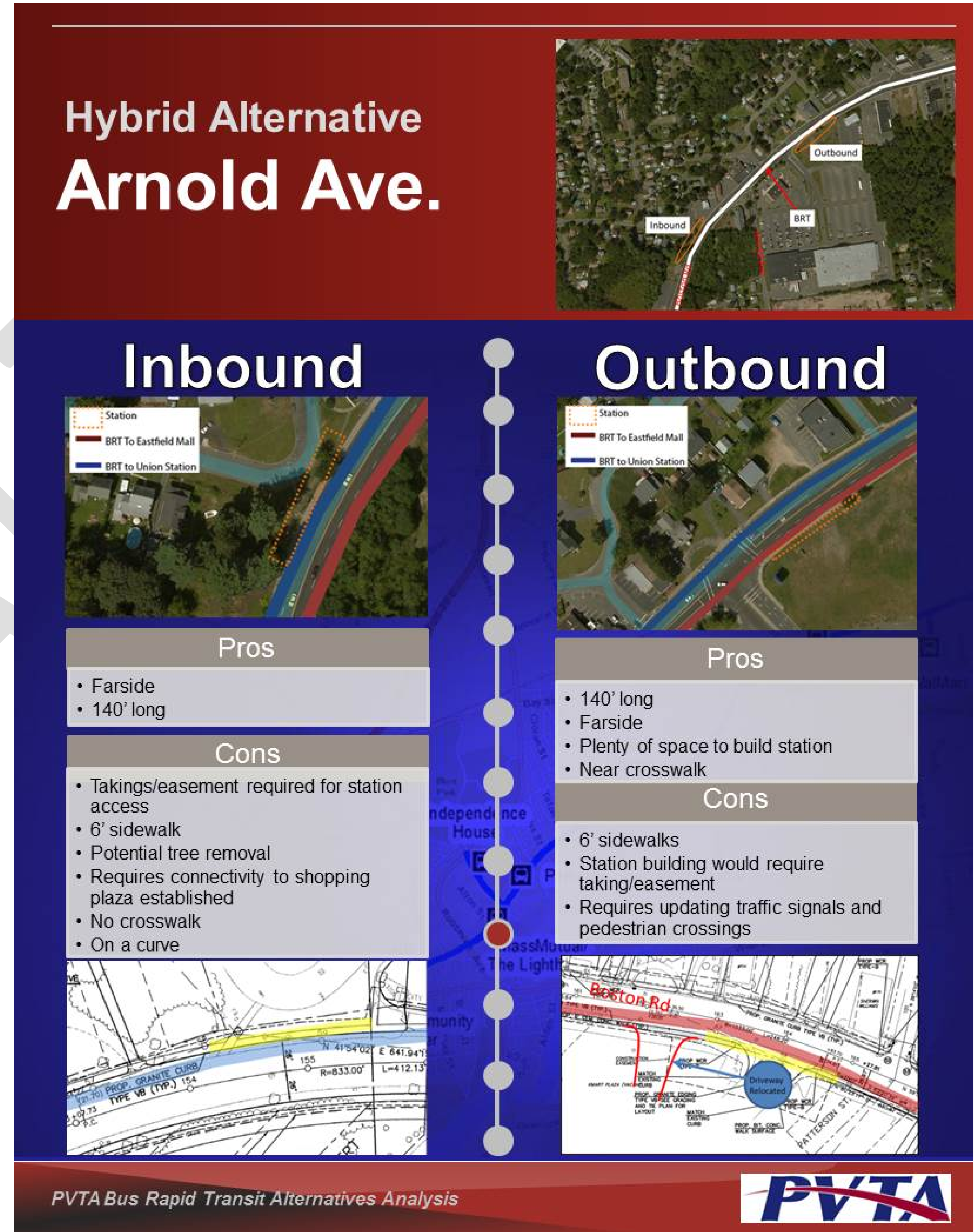
Hybrid Alternative
Blunt Park Rd.
Kinder Hospital
Putnam HS
Outbound
Inbound
Sci-Tech HS
Mass Mutual
BRT
Inbound
Outbound
BRT Station
BRT Station
Pros
• Farside
• Existing stop
• Space for station with takings
• Near crosswalk
• 140'
Cons
• Possible tree removal
• 7' sidewalk
• Possible takings/easement
• Shortens school tripper pull out
• Potential conflict with schools
Pros
• Farside
• 140'
• Room to expand sidewalk within ROW
• Near crosswalk
Cons
• 7' sidewalk
• Potential tree removal
• Potential conflict with schools
Blunt Park Road
State Street
PVTA Bus Rapid Transit Alternatives Analysis
PVTA


Alternative 1B
Preston St.
Outbound
Inbound
BRT
Inbound
Outbound
Pros
• Farside
Cons
• Will not fit within existing ROW, roadway must widen and shift
• Not near crosswalk
• Restrict driveway turning movements
• 90' long
Driveway
Boston Rd
Driveway
Pros
• Farside
Cons
• Will not fit within existing ROW
• Not near crosswalk
• Restrict driveway turning movements
• 90' long
Driveway
Boston Rd
PVTA Bus Rapid Transit Alternatives Analysis
PVTA

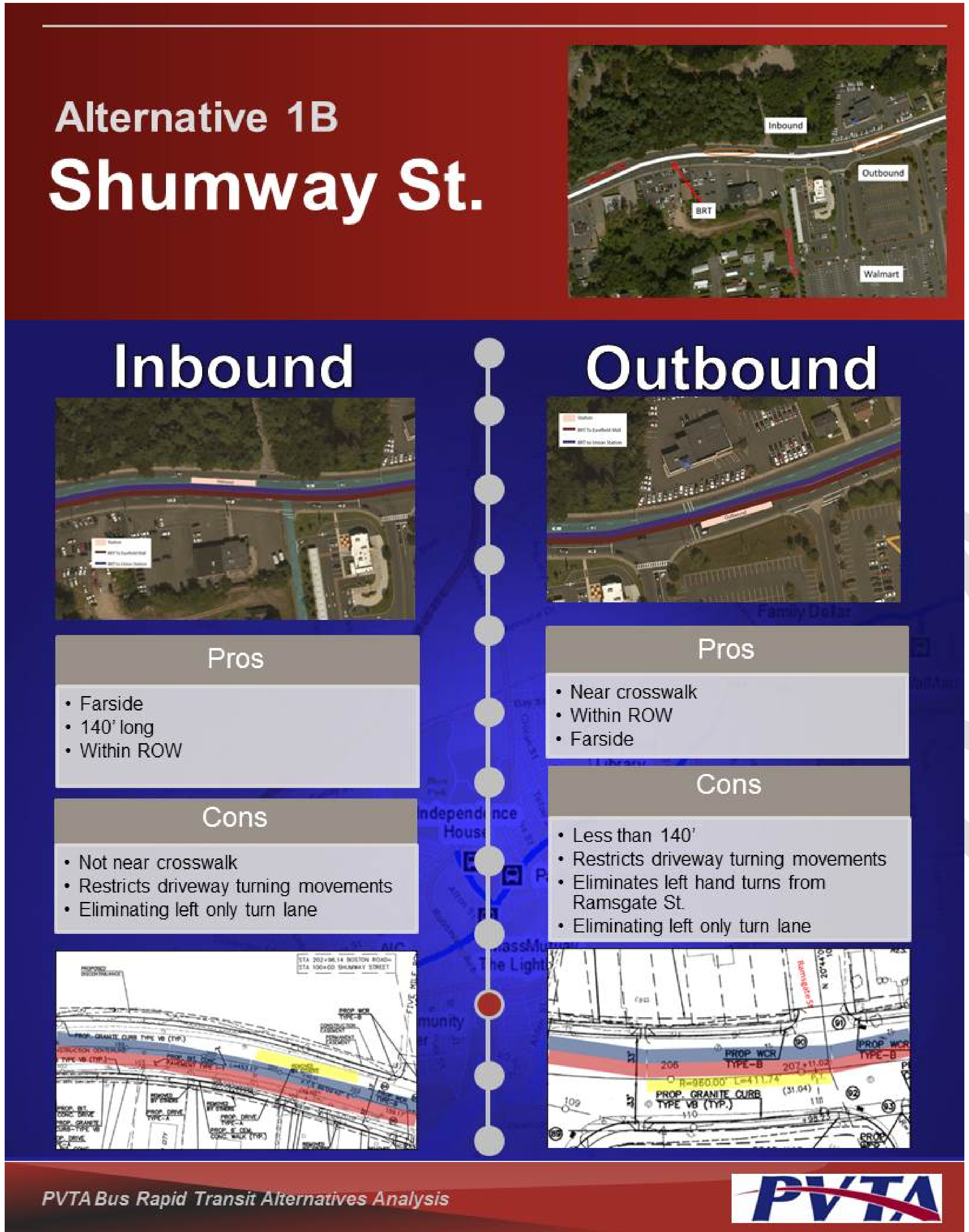

Hybrid Alternative
Preston St.
Inbound
Outbound
BRT
Inbound
Outbound
Station
BRT To Eastfield Mall
BRT to Union Station
Pros
• Farside
• Adjacent building gone, now parking, city owns the lot
• Building set back ~15', zoning requires only 10'
Cons
• 120' long
• Removal of remnant driveway aprons
• 6' sidewalk
• Requires taking/easement
• No crosswalk
Building Gone
Driveway
Boston Rd
Station
BRT To Eastfield Mall
BRT to Union Station
Pros
• Adjacent to vacant parking lot, room to expand
Cons
• 90' long
• Nearside
• Removal of remnant driveway aprons
• 6' Sidewalk
• Requires taking/easement
• No crosswalk
• Possible historic impact
Boston Rd
PVTA Bus Rapid Transit Alternatives Analysis
PVTA



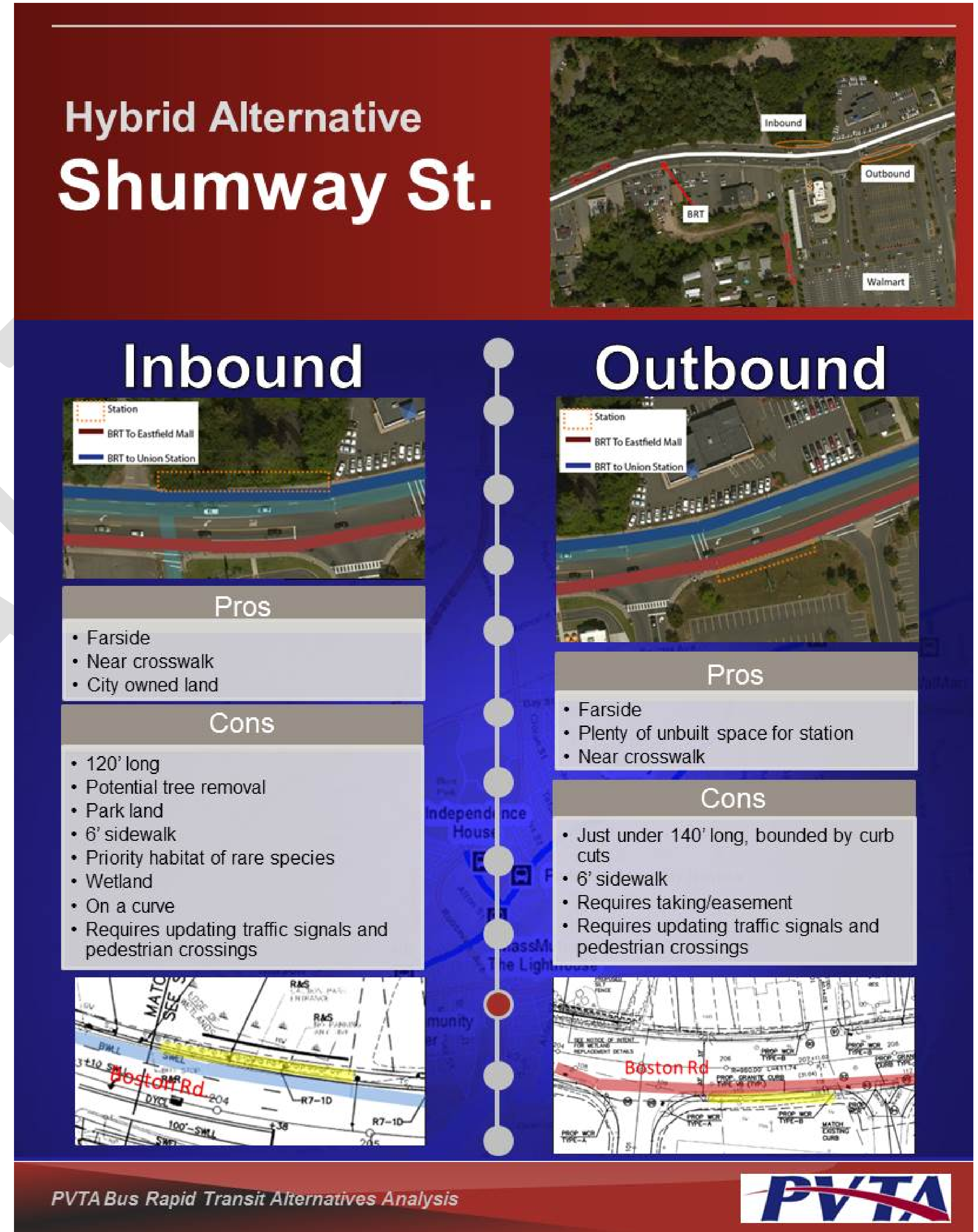
Alternative 1B
Arnold Ave.
Inbound
Outbound
BRT
Inbound
Station
BRT To Eastfield Mall
BRT to Union Station
Outbound
Station
BRT To Eastfield Mall
BRT to Union Station
Pros
• Farside
• 140' long
• Near crosswalk
• Within ROW
Cons
• Restricts driveway turning movements
• Eliminates left hand turns from Covington St.
New Entrance to Price Rite
Pros
• 140' long
• Near crosswalk
• Within ROW
• Farside
Cons
• Eliminating left only turn lane
• Restricts driveway turning movements
Driveway Relocated
PATTERSON ST.
PVTA Bus Rapid Transit Alternatives Analysis
PVTA



Hybrid Alternative
Arnold Ave.
Outbound
BRT
Inbound
Inbound
Station
BRT To Eastfield Mall
BRT to Union Station
Pros
• Farside
• 140' long
Cons
• Takings/easement required for station access
• 6' sidewalk
• Potential tree removal
• Requires connectivity to shopping plaza established
• No crosswalk
• On a curve
Outbound
Station
BRT To Eastfield Mall
BRT to Union Station
Pros
• 140' long
• Farside
• Plenty of space to build station
• Near crosswalk
Cons
• 6' sidewalks
• Station building would require taking/easement
• Requires updating traffic signals and pedestrian crossings
Boston Rd
Driveway Relocated
PATTERSON ST.
PVTA Bus Rapid Transit Alternatives Analysis
PVTA



Alternative 1B
Shumway St.
Inbound
Outbound
Walmart
BRT
Inbound
Pros
• Farside
• 140' long
• Within ROW
Cons
• Not near crosswalk
• Restricts driveway turning movements
• Eliminating left only turn lane
Outbound
Pros
• Near crosswalk
• Within ROW
• Farside
Cons
• Less than 140'
• Restricts driveway turning movements
• Eliminates left hand turns from Ramsgate St.
• Eliminating left only turn lane
PVTA Bus Rapid Transit Alternatives Analysis
PVTA



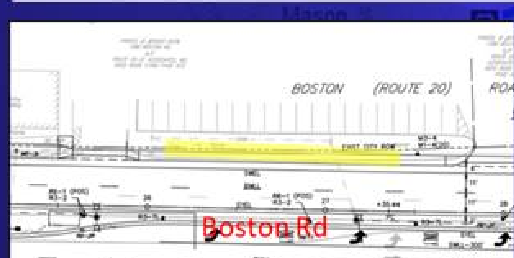
Hybrid Alternative
Shumway St.
Inbound
Outbound
BRT
Walmart
Inbound
Station
BRT To Eastfield Mall
BRT to Union Station
Pros
• Farside
• Near crosswalk
• City owned land
Cons
• 120' long
• Potential tree removal
• Park land
• 6' sidewalk
• Priority habitat of rare species
• Wetland
• On a curve
• Requires updating traffic signals and pedestrian crossings
Boston Rd
Outbound
Station
BRT To Eastfield Mall
BRT to Union Station
Pros
• Farside
• Plenty of unbuilt space for station
• Near crosswalk
Cons
• Just under 140' long, bounded by curb cuts
• 6' sidewalk
• Requires taking/easement
• Requires updating traffic signals and pedestrian crossings
Boston Rd
PVTA Bus Rapid Transit Alternatives Analysis
PVTA

Hybrid Alternative
Lucerne St.

Inbound

Pros
- Farside
- 140' long

Cons
- No sidewalk
- Requires taking/easement
- Not near crosswalk
- Close proximety to driveway, potential conflicts



Outbound

Pros
- Farside
- 140' Long
- Plenty of unbuilt space for station
- Within ROW

Cons
- Potential tree removal
- 5.5' sidewalk
- Not near crosswalk
- Close proximity to driveway, potential conflicts

PVTA Bus Rapid Transit Alternatives Analysis

PVTA

Alternative 1B
Lucerne St.

Inbound

Pros
- Farside
- 140' long
- Within ROW
- Near crosswalk

Cons
- Restricts driveway turning movements
- Eliminating left only turn lane

Outbound

Pros
- Farside
- 140' Long
- Within ROW

Cons
- Not near crosswalk
- Restricts driveway turning movements
- Eliminating left only turn lane

PVTA Bus Rapid Transit Alternatives Analysis

PVTA


Hybrid Alternative
Eastfield Mall
Potential Park & Ride
Station
BRT
PVTA Bus Rapid Transit Alternatives Analysis
PVTA

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2.5.3 Station Design and Amenities

For shelter design it is recommended that the shelters are similar to those used by the Central Ohio Transit Authority (COTA) and that PVTA works with the community to incorporate local artwork which reflects the neighborhoods along the route. This is an opportunity for each neighborhood to take ownership of the station and will benefit the relationship between PVTA and its constituents.

All stations should include a 2’ tactile warning strip along the edge of the platform, two ticket vending machines, one information kiosk, an enclosed shelter, two seating areas, proper lighting, security cameras and a trash receptacle.

Figure 27: Example of Shelter Design

2.6 RIDERSHIP

Ridership has been estimated in the proposed BRT corridor of Springfield that could be expected as a result of the conversion of the existing B7 conventional fixed route bus service to a full-featured BRT system. Methodology was derived from the TCRP Report 118 Bus Rapid Transit Practitioner’s Guide (2007), which is based on observed changes ridership patterns following the upgrading of conventional bus service to BRT on three routes: Boston (Silver Line), Los Angeles (Rapid Bus Wilshire/Whittier Line), and Vancouver BC (98B Line). Differences in Springfield’s population and employment projections from these other systems, transit rider characteristics, as well as differences in Year 1-Opening and Year 5-Mature System ridership observed on other systems were also accounted for.

2.6.1 Defining BRT Scenarios

Ridership is estimated for two BRT scenarios. Both assume a “full featured” BRT system that includes:

- Transit signal priority (TSP) at signalized intersections
- Level boarding
- Real-time “next vehicle” signs
- Shelters that are the distinctive “COTA” shelter design
- Simple schedule

- 10 min headways during peak; 15 min headways during off peak
- Direct service pattern (Union Station to Eastfield Mall via State Street and Boston Road)
- Rapid fare payment (onboard proof of purchase)
- Aggressive branding with integrated smart phone app

Scenario variations are:

- **Hybrid Alternative:** Curbside Running Ways and Stations
    - Assumes 3.1 mi dedicated running ways on eastern end of Boston Rd; mixed traffic running on State Street and Main Street
    - 60 min total run time reduced to 48 min (12 min travel time savings)

- **Alternative 1B:** Center Running Ways and Stations
    - Assumes 8 mi dedicated running ways on Boston Road and State Street; mixed traffic running on .5 mi on Main Street
    - 60 min total run time reduced to 36 min (24 min travel time savings)

2.6.2 Ridership Estimation

This section presents the initial ridership estimate using the BRT ridership estimation method presented in *TCRP Report 118 – Bus Rapid Transit Practitioner's Guide (2007)*; adjustments to the initial ridership estimates based on local conditions and other relevant information for Year 1 (opening), and Year 5 (mature system); and additional factors that should be considered in the use of the estimate provided and making future adjustments.

The midpoint arc elasticity uses the midpoint for the base of change rather than the initial point

The *midpoint arc elasticity* method in the above referenced publication was used to generate an initial estimate of future BRT ridership. This method takes into account travel time and service frequency changes, as well as the components that distinguish BRT service from conventional bus service, specifically dedicated running ways, stations, unique vehicles, high-frequency service, and ITS for operations and customer information. The proportional benefit to existing convention ridership from each of these components for the "mature system" of BRT operation (assumed to be Year 5), the elasticity factors and proportional impacts for this method can be found in Appendix A.

Initial estimates for ridership, without accounting for local market conditions, on a mature full-featured bus rapid transit system in Springfield serving the State Street/ Boston Road corridor from the future Union Station to the Eastfield Mall can be expected to be approximately 30% to 49% greater than that of the existing B7 conventional bus service depending on the Alternative. Using the B7 annual ridership from 2015 of 1,280,507 trips as the basis for estimation there would be an initial estimate of 1,790,837 trips annually for the Hybrid alternative and 2,039,682 for the 1B alternative.

The Springfield travel market differs from those of the three BRT systems upon which the ridership elasticity estimation method in TCRP Report 118 – Bus Rapid Transit Practitioner's Guide (2007) is derived in terms of population, employment and transit customer characteristics. Because the elasticity method used in Section 3.1 does not account for these factors (all of which affect BRT ridership), adjustments have been made to the initial estimates generated by the elasticity method.

Population growth in Springfield from 2010 to 2040 is forecast to be 9.8%, exceeding the average 7.0% population growth that is forecast for all PVTA communities in Hampshire County (see Appendix A). However, employment growth for Springfield from 2010 to 2040 is expected to lag more than 2% behind population growth, at just 7.7%. Further, all of Springfield's employment is expected to occur by 2020 (up 8% likely due to the opening of MGM Springfield and CRRC transit rail car plant developments) and then actually fall 1% by 2030 (the decade in which it is likely that the Springfield BRT system would begin operating). Beyond the MGM and CRRC developments, there are no other major projects currently known that would influence employment beyond the 2020 horizon. Even by 2040, there are expected to be fewer jobs in Springfield (80,668) than there will be in 2020 (80,882). This general employment trend is also expected to occur in the other Hampshire County communities served by PVTA.

This trend is in contrast to the strong workforce growth in Boston in the Silver Line Service area of the South Boston waterfront, where 40% growth in population and 20% growth in employment were forecast by 2025 (A Better City 2009). Development on the Euclid Avenue corridor of the Cleveland HealthLine since its opening in 2009 has included $5 billion of new public and private development, 7.9 million square feet in commercial development and 13,000 new jobs. Public and private investment in current and upcoming public and private projects in Springfield is currently estimated at approximately $2.7 billion (though not all of this will be in the BRT corridor).

A 5% adjustment for weaker employment markets than major metropolitan cities

Development and employment increases in Springfield of the scale experienced in Boston and Cleveland are certainly possible, but are not currently foreseen. Therefore, a best estimate of the impact of local population and employment forecasts has been made. The estimate adjustment for weaker employment market conditions is 5%.

A 5% adjustment for weaker travel markets than major metropolitan cities

Current transit customer characteristics for the anticipated Springfield BRT market differ from those of the BRT systems upon which the estimation method is based. The majority of current B7 riders are transit dependent, as measured by income (62% of report annual income of $20,000 or less) and low auto ownership/accessibility (46% report no car available). Direct comparisons to rider characteristics of other BRT systems were not available. Current B7 rider characteristics appear to differ from general Massachusetts Bay Transportation Authority (MBTA) bus ridership, where a majority of riders report having at least one car available (MBTA Transit Rider Diary Demographics 6/9/15). Also, MBTA Silver Line users have less transit dependence than riders of conventional MBTA buses (Central Transportation Planning Staff (CTPS) MBTA Passenger Survey: Bus Rapid Transit 2006). A best estimate of the impact on future BRT ridership is a reduction of approximately 5% to account for travel market demographic factors.

The methods above estimate ridership for a mature system but it is important to estimate ridership at the one year mark as it tends to be lower than year 5 due to the growth period. It is likely that the Year 1 to Year 5 difference for the proposed Springfield BRT line would be somewhere between the 26% difference experienced by the Silver Line, and the 12% difference experienced by the Health Line. Therefore, this report uses the midpoint of 19% as the reduction for Springfield's Year 1 ridership from the Year 5 mature system estimates.

Alternative 1B = 29.9% growth in ridership

Hybrid Alternative = 49.3% growth in ridership

Using the initial estimate produced and adjustments made the following adjusted estimates are obtained. The Hybrid Alternative will experience a 10.9% increase in ridership in year one and within five years almost a 30% increase in ridership over 2015 numbers. That is an additional 383,000 passenger trips a year or an increase in a little over 1,000 passenger trips per day. The 1B Alternative is expected to have even greater gains in ridership with a 30% increase in year one and almost 50% increase within 5 years. Under this alternative there would be an additional 1,700 passenger trips per day.

Table 8: Adjusted Ridership Estimates

Operating Year	Baseline: B7 Service	Scenario 1: Curbside Running							
		Initial Estimates		Market Conditions Adjustments (-10%)		Year 1 Adjustment (-19%)		Adjusted Estimates	
	Trips	Trips/Yr	% Change	Trips/Yr	% Change	Trips/Yr	% Change	Trips/Yr	% Change
2015	1,280,507	-	-	-	-	-	-	-	-
Year 1 (System Opens)	-	1,790,837	39.9%	1,663,379	29.9%	1,420,082	10.9%	1,420,082	10.9%
Year 5 (Mature System)	-	1,790,837	39.9%	1,663,379	29.9%	-	-	1,663,379	29.9%

Operating Year	Baseline: B7 Service	Scenario 2: Center Median Running							
		Initial Estimates		Market Conditions Adjustments (-10%)		Year 1 Adjustment (-19%)		Adjusted Estimates	
	Trips	Trips/Yr	% Change	Trips/Yr	% Change	Trips/Yr	% Change	Trips/Yr	% Change
2015	1,280,507	-	-	-	-	-	-	-	-
Year 1 (System Opens)	-	2,039,682	59.3%	1,911,797	49.3%	1,668,501	30.3%	1,668,501	30.3%
Year 5 (Mature System)	-	2,039,682	59.3%	1,911,797	49.3%	-	-	1,911,797	49.3%

2.6.3 Additional Considerations for Future Adjustments

- Additional walk times from some existing B7 stops to respective new BRT station(s)
- Ridership gains from transfers from new cross-town routes X90, X92
- Union Station improvements: more convenient transfer, improved facilities, safety improvements, parking facility, direct passenger rail connection, addition of 12-15 commuter rail trips per day to Hartford/New Haven in 2018

2.6.4 Ridership Distribution Among Proposed BRT Stations

To better understand the likely distribution of future BRT ridership among the 12 proposed stations, the current B7 ridership for each of the 93 B7 stops plus 17 other stops which are in the study area but are serviced by other routes were assigned to the closest of the 12 proposed BRT stations. The Hybris and 1B alternatives 2 ridership estimates were then divided proportionally among them based on existing stop usage.

These assignments are shown in Appendix A. Ridership allocations to future BRT stations is shown below for both annual and typical weekday trip totals.

Table 9: BRT Ridership Estimates by Station Based on Existing B7 Stop Use

	Existing B7 Ridership			Hybrid		1B	
Future BRT Station	Trips/Yr (2015)	Typical Weekday*	% of Total	Trips/Yr	Typical Weekday	Trips/Yr	Typical Weekday
1. Union Station	287,501	1,301	22.8%	366,864	1,690	417,841	1,943
2. Main Street	73,797	334	5.8%	94,168	434	107,254	499
3. Elliot Street	93,603	424	7.4%	119,442	550	136,039	632
4. Federal Street	140,174	634	11.1%	178,868	824	203,723	947
5. Catharine Street	105,014	475	8.3%	134,002	617	152,622	710
6. College Street	99,132	449	7.8%	126,497	583	144,074	670
7. Blunt Park Road	131,174	594	10.4%	167,384	771	190,643	886
8. Preston Street	42,588	193	3.4%	54,344	250	61,895	288
9. Arnold Ave	59,516	269	4.7%	75,945	350	86,498	402
10. Shumway St	114,184	517	9.0%	145,704	671	165,950	772
11. Lucerne Street	42,093	191	3.3%	53,712	247	61,176	284
12. Eastfield Mall	74,310	336	5.9%	94,822	437	107,998	502
Totals	1,263,084	5,717	100.0%	1,611,753	7,424	1,835,713	8,535

*Daily average from week of September 14-18, 2015

2.7 BUS OPERATIONS

This document describes the potential operating plans for the proposed BRT service along the State Street corridor. Operating plans for the Hybrid and 1B alternatives have been advanced for further refinement following the alternative analysis screening process and an examination of the existing operations (Appendix B). In addition this report describes various potential modifications to the PVTA system for routes that may operate along segments of the corridor as well as provides service guidelines to monitor the new BRT service.

A number of assumptions have been made in order to facilitate the development of the operating plan for the chosen alternatives. Additional information on these alternatives can be found in the Alternative Analysis Report. These assumptions include the following:

- Turn restrictions could be employed for both alternatives; however, this would have an impact at major intersections for both alternatives. Restrictions would be best placed at non-congested intersections, or between signalized intersections. This would reduce vehicular backups that might prevent a bus from moving along the corridor. This approach is the most effective at reducing bus delay along the corridor. It is noted that restricting turning movements at midblock may require raised medians to be effective and U-turns permitted at nearby intersections; both could have additional right-of-way impacts.

- The intersections where left-turn lanes currently exist warrant the need to maintain left-turn movements (and lanes). The remainder of the intersections would need to be evaluated in greater detail to assess traffic operations, traffic diversions, and alternate traveled routes when and if restricting left-turn movements.

- Queue bypass (also called queue jumps) lanes can be used for the hybrid alternative on the mixed use stretches. Queue jumps can be implemented where the vehicle is operating in mixed traffic by converting right-turn lanes into a shared right-turn queue jump lane. Inbound the right-turn lanes at Main St., Federal St., St. James St, and Parker St. could have queue jumps. Outbound there are only three signals which could accommodate right-turn lanes: Wilbraham Rd, Eastfield Mall and Parker St.

- Transit Signal Priority (TSP) would be installed at all intersections along the corridor regardless of the alternative. TSP will help advance the bus through the intersection and speed up the overall travel time on the corridor.

2.7.1 Service Characteristics

BRT Route B7

The BRT Route B7 would be designated as a BRT route. Under Alternative 1B the cycle time, including a layover at either end, would be 70 minutes. The vehicles running time would be range from 60-65 minutes depending on the time of day with an average of 62 minutes. This would allow for 8 minutes of layover time. The current vehicle running time ranges from 98 to 118 minutes depending on the time of day. The 1B BRT alternative will improve round trips travel time on the corridor by 38 to 53 minutes and improve the frequency to 10 minutes.

The Hybrid Alternative will have a longer cycle time because two-thirds of the route will operate in mixed traffic. The cycle time, including a layover at either end, would be 80-100 minutes between the AM Peak and early evening and 70 minutes in the late evening. The vehicle running time for the Hybrid Alternative would be 74-93 minutes with an average of 83 minutes, this would lead 7 minutes available for layover time on average. This equates to an improved round trip travel time of up to 18 minutes while improving the headway to 10 minutes.

For both alternatives the hours of service would be the same, roughly what the B7 currently has.

HEADWAY (min)	
AM Peak	10
Mid-Day	10
PM Peak	10
Early Evening	20
Late Evening	20
Saturday	20 before 7 PM, 30 after
Sunday	30
Hours of Service	
Weekday	5:00 AM – 11:00 PM
Saturday	5:00 AM – 10:00 PM
Sunday	9:00 AM – 8:00 PM

Table 10: BRT Operating Information

Table 11: 1B Travel Times

1B	Loop time (min)	Layover (min)	Cycle time (min)	Headway (min)	Vehicles	AVG MPH
AM Peak	60	10	70	10	7	14.2
Mid-Day	62	8	70	10	7	13.7
PM Peak	65	5	70	10	7	13.1
Early Evening	58	2	60	20	3	14.2
Late Evening	58	2	60	20	3	14.2
Saturday	58	2	60	20	3	14.2
Sunday	58	2	60	30	2	14.2

Table 12: Hybrid Travel Times

Hybrid	Loop time (min)	Layover (min)	Cycle time (min)	Headway (min)	Vehicles	AVG MPH
AM Peak	74	6	80	10	8	11.5
Mid-Day	83	7	90	10	9	10.3
PM Peak	93	7	100	10	10	9.2
Early Evening	78	2	80	20	4	10.7
Late Evening	70	10	80	20	4	12.2
Saturday	78	2	80	20	4	10.7
Sunday	78	12	90	30	3	10.7

Local B7

The current B7 local route would be designated a Tier II[7] route and would stop at all stops and stations along the BRT B7 corridor. PVTA should consider consolidating the stops along Boston Road and State Street as stops are often placed close together which slows down the route. The current stops do not meet PVTAs stop spacing guidelines. The B7 local would stop at all of the BRT stations in addition to the regularly spaced stops. On the segment of road for the Hybrid Alternative which would have dedicated curb bus lanes the Local B7 will use the bus lanes. To reduce confusion information should be placed at the local B7 stops to differentiate service from the BRT B7. Slight modifications to the alignment are proposed. The route would no longer use Harrison Avenue and Dwight Street/Chestnut Street but instead would turn at the intersection of Main Street and State Street. The B7 local will no longer deviate into Price Rite.

The cycle time would be 113 minutes, with 5 minutes of layover time with the Hybrid BRT implemented. This route would require 2.5 buses, to maximize efficiency this route should be interlined with another route that ends at Union Station. The decrease in running time is due to the elimination of Price Rite and Independence House, TSP,

OPERATING INFORMATION	LOCAL If Hybrid	LOCAL If 1B
Peak Vehicle Requirement	2.5	3.33
Operating Speed MPH	7.9 MPH	6.1 MPH
Cycle Time (min)	113	150
Vehicle running time (min)	108	140
HEADWAY (min)		
AM Peak	45	45
Mid-Day	45	45
PM Peak	45	45
Early Evening	45	45
Late Evening	60	60
Saturday	60	60
Sunday	60	60
Hours of service		
Weekday	6:00 AM – 9:00 PM	
Saturday	7:00 AM – 8:00 PM	
Sunday	10:00 AM - 5:00 PM	

Table 13: Local B7 Operating Information

[7] Tiers are defined per currently existing PVTA service guidelines

queue jumps and if the Hybrid Alternative is implemented the dedicated bus lanes the local could take advantage of.

If the 1B Alternative was implemented the cycle time for the local route, including a layover at either end, would be 150 minutes. The vehicle running time would be 140, with 5 minutes of layover time. The increase in running time is because the conversion of a travel lane into a bus lane will cause increased traffic and delay. The local route will be unable to utilize the centrally aligned bus lane in Alternative 1B because it will need to run in the mixed traffic lane in order to service all stops.

Annual Operational Characteristics

Currently the B7 operates 297,392 revenue vehicle hours (VH) and 31,421 revenue vehicle miles (VM) annually. Implementing either BRT alternative and local routes will increase revenue miles by 39,034. The increase in annual revenue hours under Alternative 1B for the combined B7 BRT and local would be 10,899; the Hybrid Alternative operates at lower speeds and requires additional vehicles resulting in a larger increase in revenue hours.

Table 14: Daily Operating Statistics For Hybrid Alternative

	BRT		Local	
	VH	VM	VH	VM
Weekday	132.0	1278.0	26.9	237.5
Saturday	68.0	724.2	24.5	195.0
Sunday	33.0	312.4	13.2	105.0

Table 15: Daily Operating Statistics for Alternative 1B

	BRT		Local	
	VH	VM	VH	VM
Weekday	102.0	1278.0	49.3	237.5
Saturday	51.0	724.2	28.2	195.0
Sunday	22.0	312.4	15.2	105.0

Table 16: Changes in Annual Operation Statistics - Alternative 1B

Alternative 1B	VH	VM
Proposed BRT	29,857	326,209
Proposed Local	14,883	10,217
New Total for Proposed BRT and Local	**47,740**	**336,426**
Current B7	31,421	297,392
Difference Between Proposed and Current	**13,319**	**39,034**

Table 17: Changes in Annual Operation Statistics - Hybrid Alternative

Hybrid Alternative	VH	VM
Proposed BRT	38,992	326,209
Proposed Local	8,914	10,217
New Total for Proposed BRT and Local	**47,906**	**336,426**
Current B7	31,421	297,392
Difference Between Proposed and Current	**16,486**	**39,034**

Other Service Recommendations

- Any route which passes by a BRT station shall service it if the Hybrid Alternative is implemented.
- Routes 3, 6, 27, 7 local will no longer use Harrison Avenue and Dwight Street/Chestnut Street but instead will turn at the intersection of Main Street and State Streetin order to serve the Main Street Station.

Potential Interfaces with Existing Transit Services

This section describes how the proposed BRT service might interact with the existing system (Figure 28). Thirteen routes, including the BRT will service all or part of the corridor. All routes will begin at Union Station and use some segment of Main Street between Liberty Street and State Street. The G1 and G2 will continue straight through the State Street intersection along Main Street. The G5 will exit the corridor at Maple Street. The R10 and R14 will head west on Boland Way to cross the Connecticut River and the P11 will through downtown Springfield via Main Street and Hancock Street and then heads north to Holyoke Community College (HCC). The G3 will leave the corridor at the intersection of State Street/Hancock Street and the B6 at State Street and St. James Avenue.

The B17, R27 and X92 will service the corridor in multiple locations. The B17 will service it from Union Station to Main Street/Harrison Avenue; it will then rejoin the corridor at State Street/Oak Street until State Street/Catherine Street/Wilbraham Road; lastly it will reenter the corridor at State Street/Parker Street (Rt. 20) until the Eastfield Mall. The R27 will leave the corridor at State Street/Catherine Street/Wilbraham Road but will rejoin it just east of the Eastfield Mall and head west to service the mall. The X92 will travel straight on Main Street through the State Street/Main Street intersection and then leave the corridor to rejoin it again at State Street and Berlin Street until the intersection of State Street and Blunt Park Road. One route, X90 Crosstown, will intersect but not operate on the corridor, it will cross the corridor at the intersection of Federal Street/Walnut Street.

The B7 local will run the entire length of the corridor and will stop at all stops and stations. It will also deviate into Walmart. The BRT B7 will only stop at the stations and will not deviate from the corridor except at the termini. Figure 29 provide the conceptual operational plan for the corridor for each alternative.

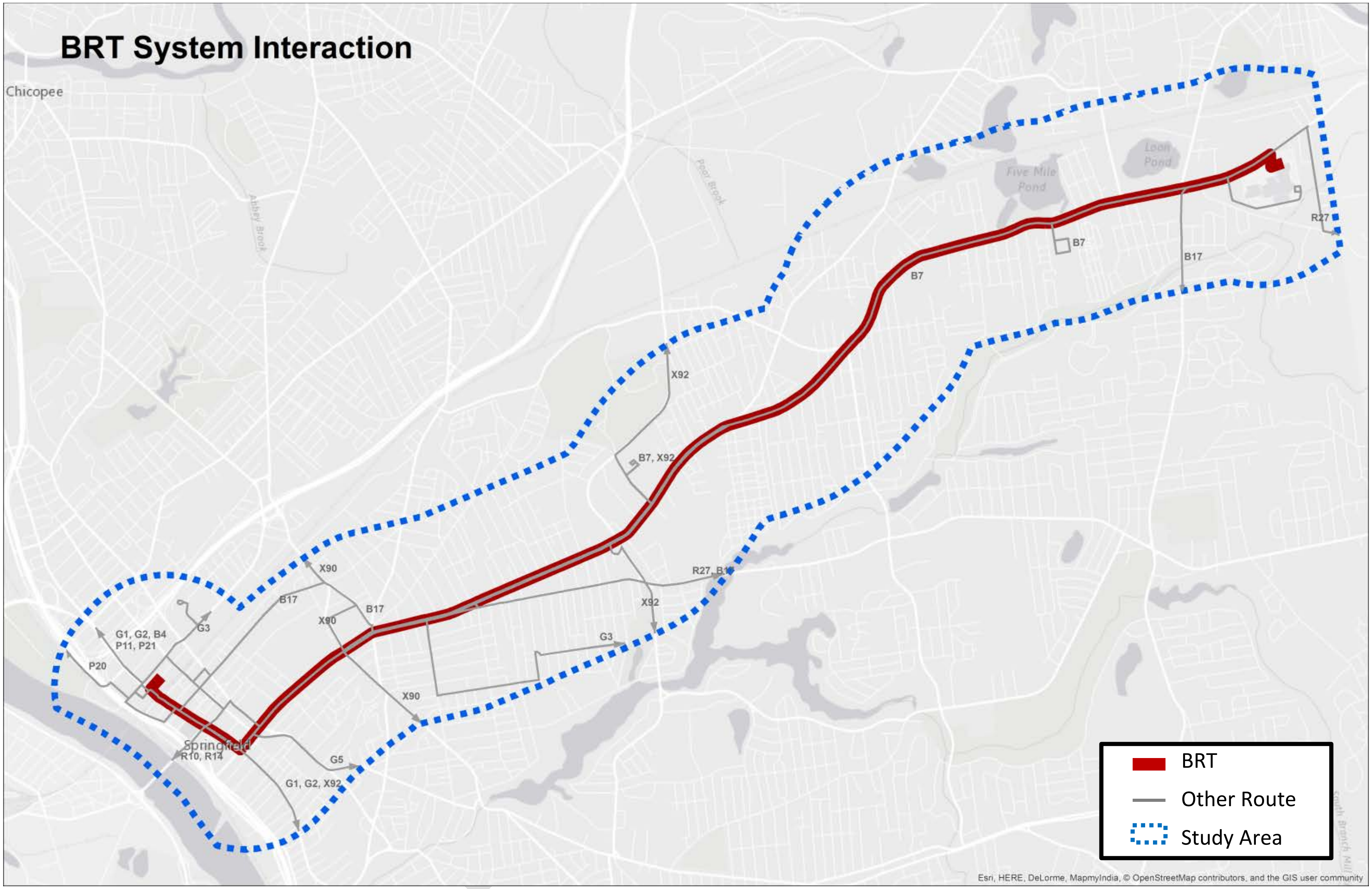

Figure 28: BRT and Local Routes Interaction

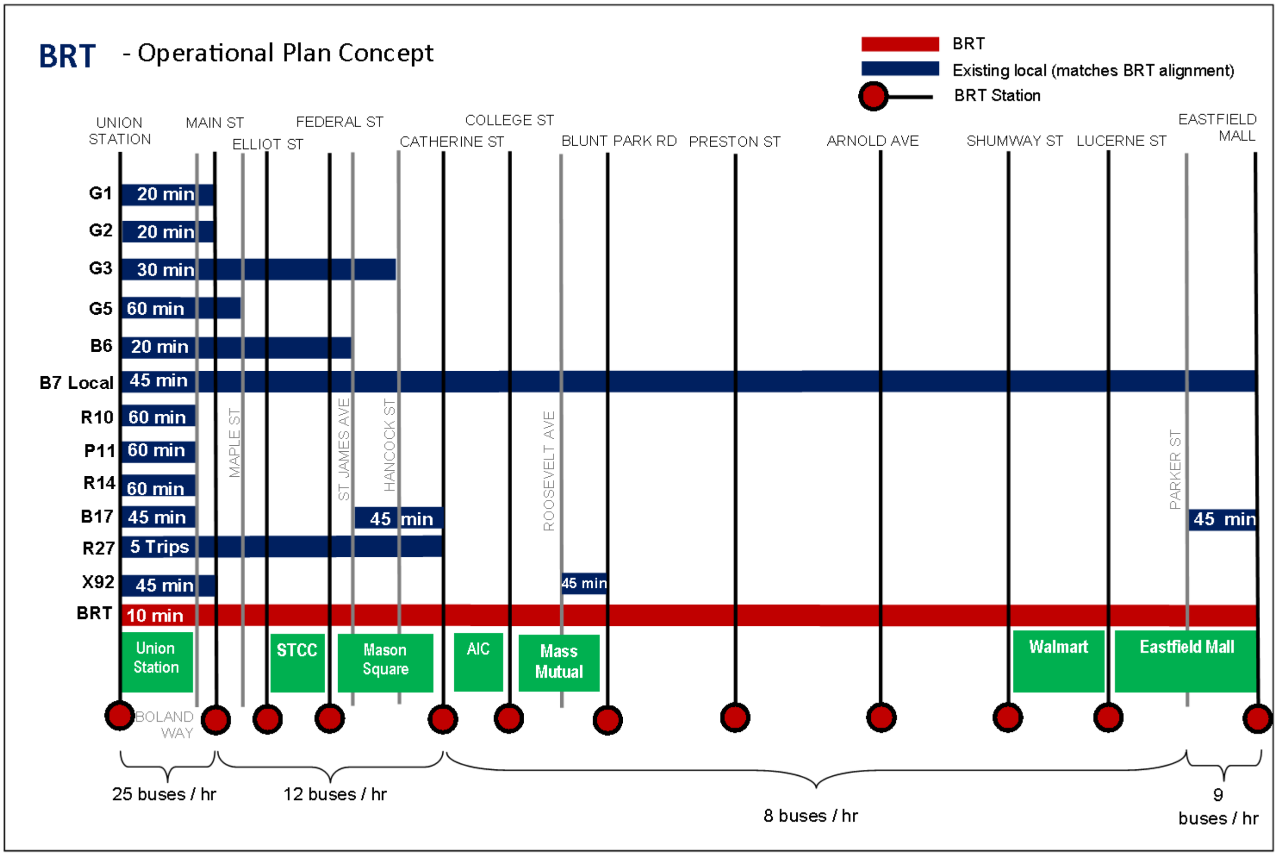

Figure 29: Corridor - Operational Plan Concept

2.7.2 O&M Cost Estimates

BRT and background bus service modifications described above will impact PVTA's annual operating and maintenance (O&M) costs for fixed route bus service. Changes to existing bus expenses have been estimated with a spreadsheet cost model developed with PVTA's FY 2014 National Transit Database (NTD). Costs for BRT operations are based on the existing bus O&M cost model but also include unit costs unique to BRT service.

BRT O&M Cost Methodology

For FY 2014, PVTA reported to the NTD $30,341,612 in annual O&M expenses for fixed route bus service (2014 dollars). O&M cost estimation defined by the Federal Transit Administration (FTA) was used to develop spreadsheet cost models to estimate cost impacts related to proposed service changes[8]. The annual O&M cost was divided by the annual revenue hours for PVTA (329,052) to get a cost per revenue hour of $92.21. Estimates for annual BRT O&M expenses build upon the cost per revenue hour for PVTA. Additional line items have been included for operations/maintenance features that will be unique to the proposed BRT service.

[8] FTA Procedures and Technical Methods for Transit Project Planning, Chapter 4. Operating and Maintenance Costs

The PVTA BRT vehicle is envisioned to be an articulated bus. The model applies a 25% increase to selected unit costs to account for line item costs that are likely to be higher for articulated vehicles compared with standard-sized buses. This assumption is consistent with other planning studies for agencies that operate articulated buses. Line items factored up for articulated buses include vehicle operation consumables such as fuel/lube and tires/tubes; and vehicle maintenance labor costs which include repair/maintenance parts and supplies.

The following seven items have been added as BRT-specific O&M costs with proposed unit costs derived from other BRT studies and projects and are presented in 2015 dollars.

BRT Security and Fare Enforcement. Additional security and fare enforcement is assumed for BRT operations beyond what is provided for background bus service to account for off-board fare collection. Fare inspectors are assumed to be deployed on BRT buses and platforms to randomly verify passenger fare payment and generally provide a security presence on vehicles and at passenger facilities. For purposes of these cost estimates, an annual 50% fringe benefit rate. An average 1,800 work hours per full-time employee was assumed, with a security presence of one work hour for every five BRT revenue bus-hours of service. This results in a unit cost of $8.33 ($2014) per BRT revenue bus-hour for BRT security and fare enforcement. The model inflates this unit cost to $8.34, representing 2015 dollars.

BRT Platform Maintenance. It is assumed that the majority of BRT stops for this project will be facilities without extensive furnishings serving moderate passenger activity. Based on data from MetroTransit in Minneapolis/St. Paul, which experiences winter weather similar to Springfield, for use in that agency's BRT project planning, an average annual labor cost is $1,665 per platform for periodic cleaning and maintenance. The model rounds the unit cost up to $2,000 to account for materials and supplies as well. This unit cost will not be applied to stations already in existence or construction (Union Station).

TVM Equipment Maintenance. On-going maintenance will be required for ticket vending machines to stock, clean and repair them. Data provided by MetroTransit in Minneapolis/St. Paul have identified a rate of $6,000 per TVM for non-complex ("light") equipment for use in that agency's BRT project planning. This is the unit cost assumed for PVTA.

ITS Equipment/Signage Maintenance. BRT passenger facilities are also assumed to have real time information signage (e.g., next bus arrival times). Cost information collected from MetroTransit in Minneapolis/St. Paul have been adjusted for the ratio of ITS equipment assumed for PVTA BRT platforms, which yields a per platform unit cost of $4,071 for this project.

Exclusive Lane-Mile Routine Maintenance. No additional lane maintenance costs are anticipated if BRT lanes are to be created by converting existing general traffic lanes to exclusive BRT lanes.

Vehicle Maintenance The PVTA BRT vehicle is envisioned to be an articulated bus. The model applies a 25% cost increase per revenue mile for maintenance costs that are likely to be higher for articulated vehicles compared with standard-sized buses. This assumption is consistent with other planning studies for agencies that operate articulated buses. In 2014 PVTA spent $5,193,290 on maintenance for a cost per mile of $1.11. Using the 25% cost increase the additional cost per revenue mile is $0.28.

Transit Signal Priority (TSP) Maintenance. Repair and maintenance information collected from MetroTransit in Minneapolis/St. Paul has identified an average cost of $2,850 per signalized intersection equipped with TSP for use in other BRT projects.

BRT-specific unit costs applicable to the project, along with standard PVTA bus unit costs, have been applied to service and facility requirements in the BRT O&M cost mode summarizes unit costs specific to BRT service utilized in the BRT cost model.

Table 18: Summary of BRT Unit Costs

BRT - Specific Line Item	Unit	Cost
Security and Fare Enforcement	Revenue hour	$ 8.34
BRT Platform Maintenance	Platform	$ 2,000
ITS Maintenance	Platform	$ 4,071
TVM Equipment Maintenance	per machine	$ 6,000
Vehicle Maintenance	Revenue mile	$ 0.28
TSP Maintenance	Signalized intersection	$ 2,850
BRT base operational cost	Revenue hour	$ 92.21

O&M Cost Estimates

Table 19 summarizes the cost estimate for each alternative under consideration, showing background bus and BRT system and service variables, cost or savings by variable and total estimated impact on PVTA's annual operating cost. For each alternative the cost savings associated with reduced operations on the local route is considered. All alternatives assume service will be operated with articulated buses. BRT's estimated annual O&M costs will increase in range from $4.5M (Hybrid) to $3.6M (1B). The B7 local annual cost will decrease from $2.9M to $0.8M for the Hybrid and $1.3M for 1B. This results in a net annual operating cost of $5.3M for the Hybrid and $4.9M for 1B, which is an increase of $2.0 to $2.4 million on top of the current $2.9M spent now on the B7, this includes reductions in cost on the local B7.

Table 19: O&M Annual Operating Cost by Alternative

BRT - Specific Line Item	Unit	Unit Cost	Quantity	Total cost
Alternative 1B				
Security and Fare Enforcement	Revenue hour	$8.34	29,857	$249,007
BRT Platform maintenance	Platform	$2,000	21	$42,000
ITS maintenance	Platform	$4,071	21	$85,491
TVM Equipment Maintenance	per machine	$6,000	42	$252,000
Vehicle maintenance	Revenue mile	$0.28	326,209	$91,339
TSP Maintenance	Signalized intersection	$2,850	34	$96,900
BRT base operational cost	Revenue hour	$92.21	29,857	$2,753,114
Local Route Operations savings	Revenue hour	$92.21	-16,538	($1,525,006)
Total Additional Cost to PVTA				**$2,044,845**
Hybrid Alternative				
Security and Fare Enforcement	Revenue hour	$8.34	38,992	$325,193
BRT Platform maintenance	Platform	$2,000	21	$42,000
ITS maintenance	Platform	$4,071	21	$85,491
TVM Equipment Maintenance	per machine	$6,000	42	$252,000
Vehicle maintenance	Revenue mile	$0.28	326,209	$91,339
TSP Maintenance	Signalized intersection	$2,850	34	$96,900
BRT base operational cost	Revenue hour	$92.21	38,992	$3,595,452
Local Route Operations savings	Revenue hour	$92.21	-22506	($2,075,320)
Total Additional Cost to PVTA				**$2,413,055**

2.7.3 BRT Service Guidelines

These recommendations for service guidelines reflect the proposed changes to PVTA's current service guidelines in order to incorporate BRT. If no guideline is proposed then the current guideline stands. To establish BRT specific guidelines the BRT/Key Regional Tier I category of routes has been broken into two categories; BRT and Key Regional Tier I. They can be defined as follows:

> **BRT:** routes with increased investment for corridor improvements such as transit signal priority, queue jumps, level boarding, and dedicated bus lanes. These routes play an important role by connecting major urban centers and other major activities centers in the greater Springfield area. These routes should offer frequent and consistent weekday

service, as well as weekend service. 60’ articulated buses should be used on these routes.

Tier 1: Routes which operate primarily along primary arterials and offer direct service between Springfield, Amherst, Northampton, and Holyoke. These routes play an important role by connecting major urban centers and other major activities centers in the greater Springfield area. These routes should offer frequent and consistent weekday service, as well as weekend service.

Table 20: Stop Spacing

	BRT	Tier 1
Minimum Stop Spacing		
Moderate to High Density Areas	0.40 miles	900 ft
Low Density Areas	1 mile	1,100 ft
Maximum Stops per Mile		
Moderate to High Density Areas	2	6
Low Density Areas	0.5	4

Table 21: Minimum Span of Service Guidelines

	BRT	Tier 1
Weekdays		
Begin	5:30 AM	6:00 AM
End	11:00 PM	10:00 PM
Saturdays		
Begin	6:00 AM	6:00 AM
End	10:00 PM	9:00 PM
Sunday		
Begin	9:00 AM	9:00 AM
End	7:00 PM	5:00 PM

Table 22: Minimum Service Frequency Guidelines (minutes)

	BRT	Tier 1
Weekdays		
AM/PM peak	15	20
Mid-Day	15	20
Early Evening	20	30
Late evening	30	30
Saturdays		
All day	30	30
Sunday		
All day	30	60

Table 23: Average Vehicle Loading Maximum

Vehicle Loading	BRT	Tier 1
Peak	120%	120%
Off-Peak	100%	100%

Table 24: Minimum Productivity Levels

	BRT	Tier 1
Weekdays		
All Day	30	20
Early morning	15	15
Late Night	20	15
Saturdays		
All Day	30	15
Early morning	15	15
Late Night	15	15
Sunday		
All Day	20	15
Early morning	15	15
Late Night	15	15

Table 25: Minimum Farebox Recovery

	BRT	Tier 1
Weekday	20%	20%
Saturday	20%	15%
Sunday	20%	15%

2.8 Fleet Analysis

PVTA's revenue vehicle fleet consists of three main types of vehicles – 60' articulated buses, 40' standard buses, and 35' standard buses. The 35' and 40' vehicles are used in regularly scheduled service on local routes and the 60' articulated vehicles provide service on the high volume university operation. At present, the Springfield operating/maintenance facility is operating at capacity and does not have the capability of servicing the 60' articulated buses or additional vehicles. The following table presents a fleet plan based on the size and composition of PVTA's fleet as of 2015. It should be noted that some of the 35' and 40' standard buses will be replaced by 60'articulated buses to provide expanded capacity for the PVTA fleet and that the current plan is to procure these vehicles in 2019, 2020, and 2021.

Table 26: PVTA Fleet Plan

Capital Project Description	Qty	2017	Qty	2018	Qty	2019	Qty	2020	Qty	2021	5 Yr Total
Buses - Articulated - Replacement					4	4,271,344	8	8,798,968			13,070,311
Buses- Articulated - Expansion											
Buses 40' Replacement					15	8,349,299	5	2,866,593	21	12,400,881	23,616,773
Buses 40' Expansion					6	3,339,720	6	3,439,911			6,779,631
Buses 35' Replacement					11	6,060,917			14	8,183,670	14,244,587
Buses 35' Expansion											
Buses 30' Replacement											
Buses 30' Expansion											

The current fleet plan, completed in 2014, assumes a stable fleet size for the subsequent 5 years though expansion may be accommodated with the implementation of BRT. Appendix C contains a complete vehicle inventory for PVTA as of 2015.

The current local service operating on the Main Street/State Street/Boston Road corridor between Union Station and Eastfield Mall via Route B7, and described more fully in the Operations Plan, has a peak vehicle requirement of 9 40’ vehicles. The operating plan for both alternatives requires that some local service continue to operate on the B7 route, at a reduced level-of-service, in addition to the Bus Rapid Transit (BRT) line on the corridor.

The purpose of continuing local service is to ensure continuity and accessibility of service for the areas in between the BRT stations, which are spaced at much greater distances than the local stops on the B7Further, it will help provide service to the major activity centers located off of the corridor, such as Walmart and others.

Consequently, the operating plan results in an increase in overall fleet size under both alternatives. There are currently 9 40’ buses used in peak service on the B7, under both alternatives the new BRT route would operate 60’ articulated vehicles and the local route would have 40’ buses. PVTA currently has 12 60’ articulated buses programed into their five year fleet plan, it is assumed that they will replace 40’ vehicles and the priority will be to use these on the proposed BRT service and not the university service which currently has articulated buses. As can be seen in Figure 30, the Hybrid Alternative will have a net increase in six buses to the fleet. It will require 12 (including spares) articulated 60' buses, therefor no additional 60' articulated buses will need to be programmed[9] but six 40's will need to be (3 for the local service and three for other routes which were previously scheduled to have the articulated vehicles)[10].

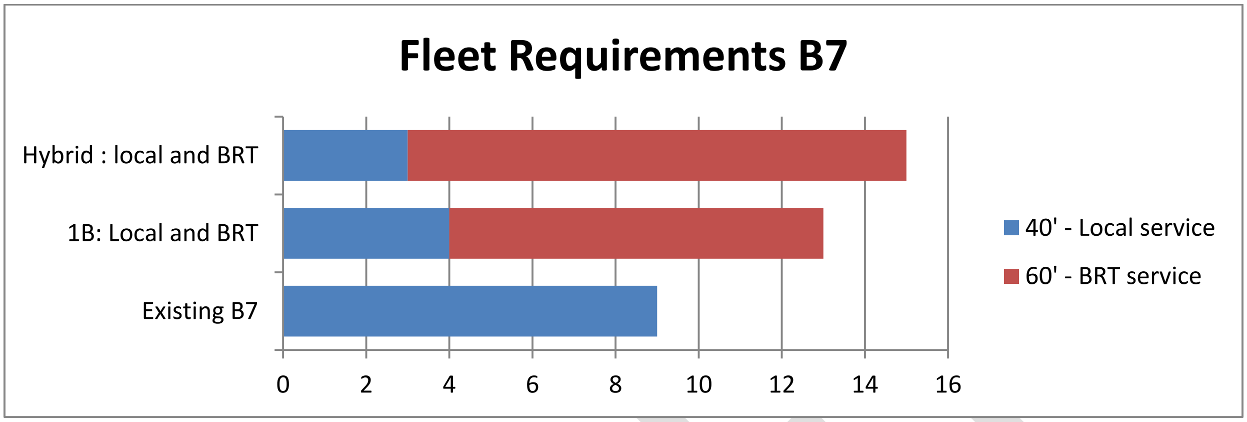

Figure 30: Fleet Requirements for BRT and Local B7

The 1B Alternative will have a net increase in four buses to the fleet. It will require 9 (including spares) articulated 60' buses, therefor no additional 60' articulated buses will need to be programmed but four 40's will need to be to operate the local service. Since PVTA has 12 articulated buses programmed but only 9 are needed to operate the BRT service under the 1B Alternative there would be three available for use on other routes. All vehicles must be procured a year in advance of the BRT route's debut to ensure their delivery coincides with the commencement of BRT service in the corridor and there is sufficient fleet size to operate the local service.

2.8.1 Further Vehicle Considerations

The new vehicles servicing the BRT stations should be modern, attractive, and branded. The recent trend is to operate environmentally-friendly vehicles such as hybrids, electric, ultra-low sulfur, CNG, and other efficient vehicles as part of an overall sustainability and branding effort. As such, PVTA should purchase alternative fuel or hybrid vehicles for its new BRT service. BRT vehicles should have low floors and allow for boarding at all doors to speed up the boarding and alighting process. Added enhancements should include bike racks, audio and visual announcements to aid riders in identifying stops, closed circuit cameras for safety, as well as a host of ITS technology to inform riders of schedules, monitor performance, and speed up travel time. Wi-Fi service is also an option (currently is in use on Connecticut's CT*fastrak* buses). Additionally, the vehicles should have a distinct color scheme, graphics, and logos which reflect and enhance the BRT service's overall branding. All vehicles should have the

[9] If PVTA wishes to use the 60' articulated vehicles on other routes additional 60' will need to be programmed in the future to replace current 40'

[10] This assumes that the 12 40' buses PVTA has planned for expansion are for other services and not related to the BRT

current TSP, APC, Fare collection system and security features that are installed on all existing PVTA vehicles.

2.9 Easements and Acquisitions

In order to construct the stations and dedicated bus lanes easements will be required in order to maintain sidewalks, roadway widths, shoulders and parking. To determine if an easement is required traffic plan maps were consulted to determine the roadway, sidewalk and shoulder widths as well as current property lines. Easements were determined for each alternative for the stations, intersection upgrades and corridor widening to meet MassDOT standards.

2.9.1 Station Easements

In Alternative 1B, where stations are centrally aligned and right-of-way (ROW) is required the amount I s split on both sides of the road in order to reduce the taper needed for traffic approaching the station. A minimum of 100 feet on either end of the station will be require to reroute the general purpose lanes around the stations and provide adequate site distance. For the 1B Alternative three station sets (inbound and outbound, six stations in total) will require permanent easements be obtained (Figure 31). Temporary construction easements will be needed around all permanent easements. For Alternative 1B approximately 40,500 square feet, almost 1 acre, of right-of-way will need to be obtained to accommodate the stations (Table 27).

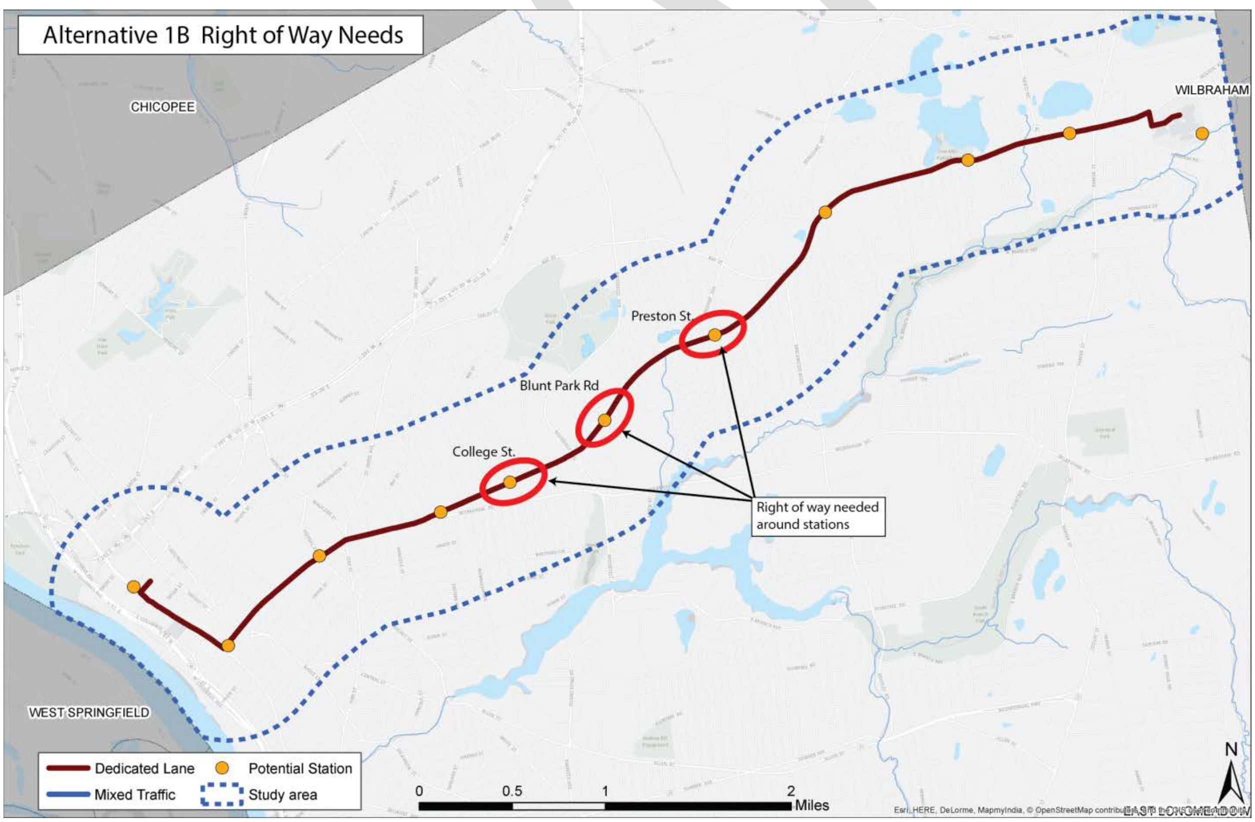

Figure 31: 1B Station Easement Requirements

Table 27: Alternative 1B Station ROW Needs

Station	ROW needs
College St	25,000 s.f.
Blunt Park Rd	9,000 s.f.
Preston St	6,500 s.f.
Total	**40,500 s.f.**

The College Street stations will require takings along State Street between the intersection with Hunter Place and Homer Street (Figure 32). The easement will be needed to shift the side walk on the north side of the road. On the south side of the road the easement will be needed to maintain American International College on-street parking on State Street and to shift the side walk to accommodate sidewalk adjustments.

The Blunt Park Road stations will require takings along State Street between 450 south of Blunt Park Rd and 100 feet south of Clarence St (Figure 33). On the west side of the easement will be needed to shift the side walk and maintain the 350' long bus pull out for the tripper routes which queue there for the schools. On the east side of the road the easement will be needed to maintain sidewalk access.

The Preston St. stations will require takings along Boston Road between 125 feet west of Ambrose St and the intersection of Denver St. (Figure 34). On both sides of the road the easements will be needed to maintain travel lane widths, improve the shoulder width to meet state standards and adjust sidewalk locations.

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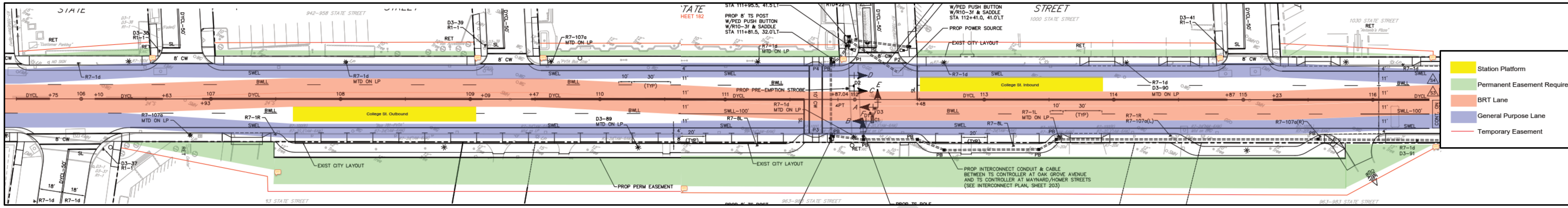

Figure 32: 1B College Street Easement Needs

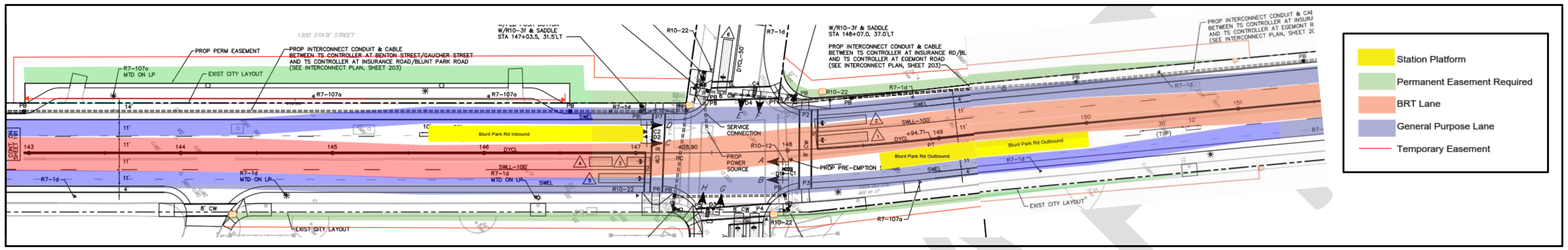

Figure 33: 1B Blunt Park Road Easement Needs

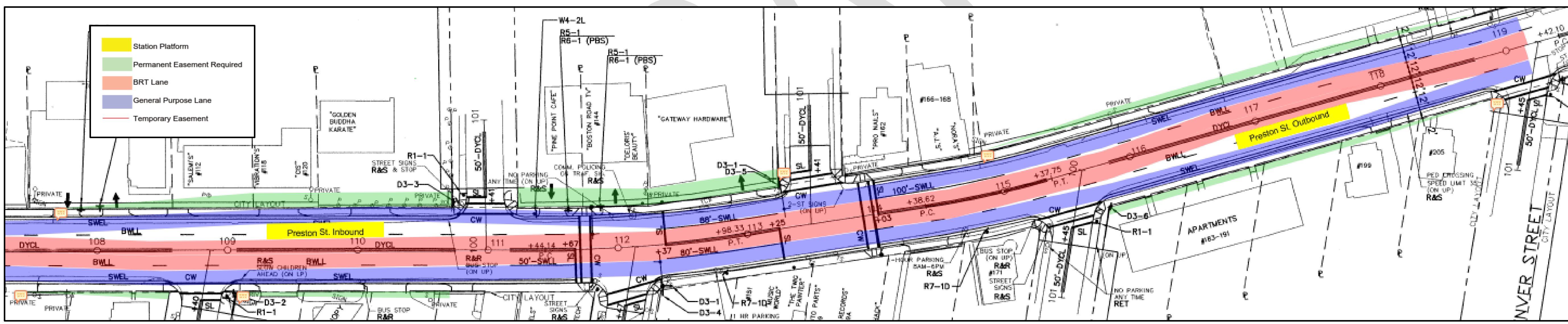

Figure 34: 1B Preston Street Easement Needs

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For the Hybrid Alternative takings is required to build nine of the 24 stations at six different locations. In all instances except the Blunt Park Road Inbound station, the takings is required to fit the 12' wide station. Since the Blunt Park Road inbound station is close to the intersection and near the existing bus pull out the takings will need to extend to the intersection in order to adjust the sidewalk and provide safe access. Temporary construction easements will be needed around all permanent easements. For the Hybrid Alternative approximately 7,000 square feet, less than ¼ of an acre, of right-of-way will need to be obtained to accommodate the stations (Table 27).

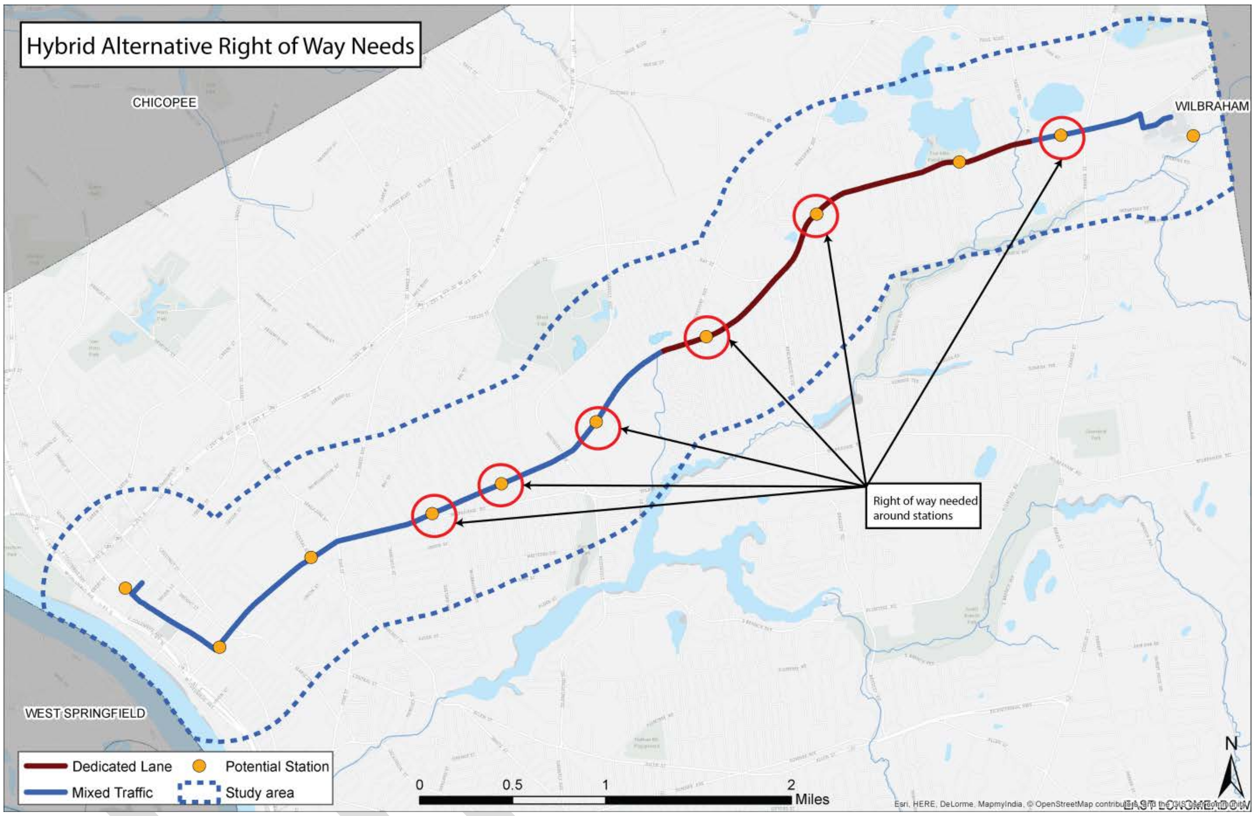

Figure 35: Hybrid Easement Requirements

Table 28: Hybrid Alternative Station ROW Needs

Station	ROW needs
Catharine St.	500 s.f.
College St	700 s.f.
Blunt Park Rd	1,300 s.f.
Preston St	1,000 s.f.
Arnold St	600 s.f.
Shumway St	1,000 s.f.
Lucerne St	1,900 s.f.
Total	**7,000 s.f.**

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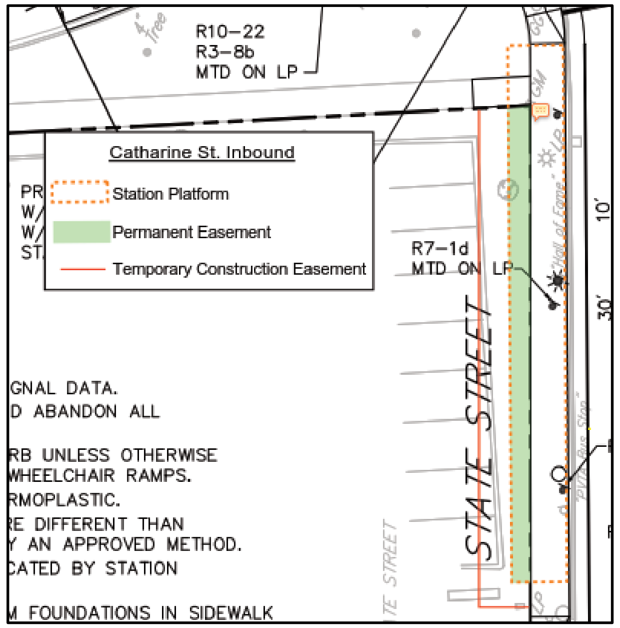

Figure 36: Catharine Street Inbound Easement Map

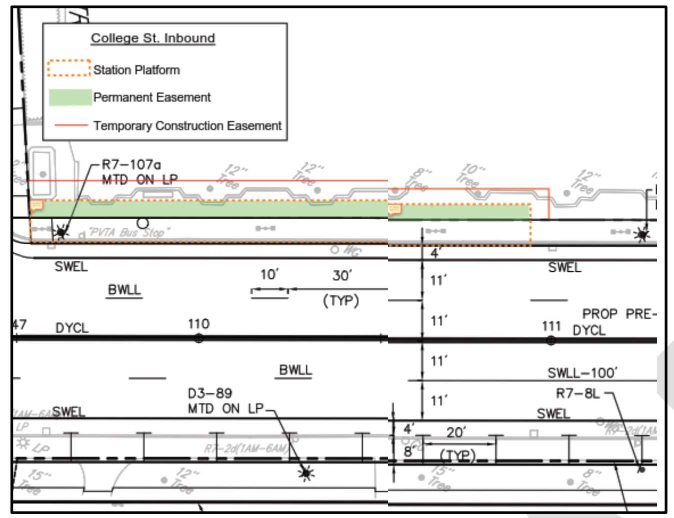

Figure 37: College Street Inbound Easement Map

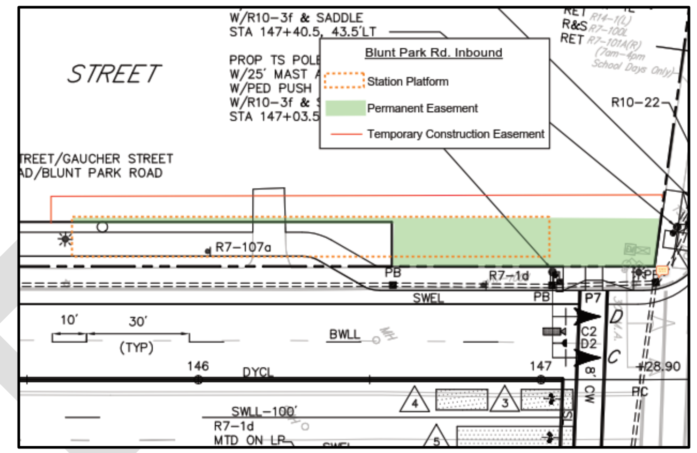

Figure 38: Blunt Park Road Inbound Easement Map

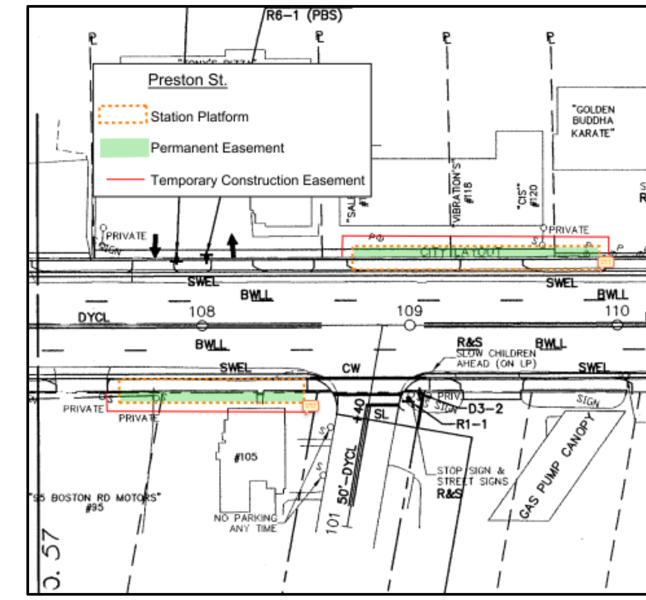

Figure 39: Preston Street Inbound and Outbound Easement Map

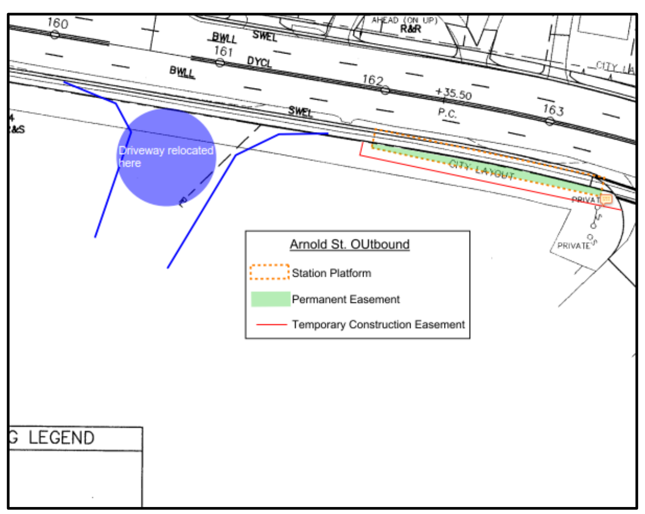

Figure 40: Arnold Street Outbound Easement Map

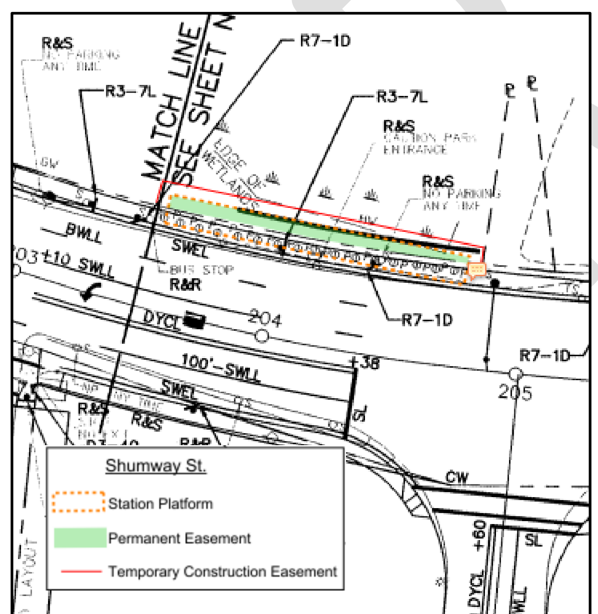

Figure 41: Shumway Street Inbound Easement Map

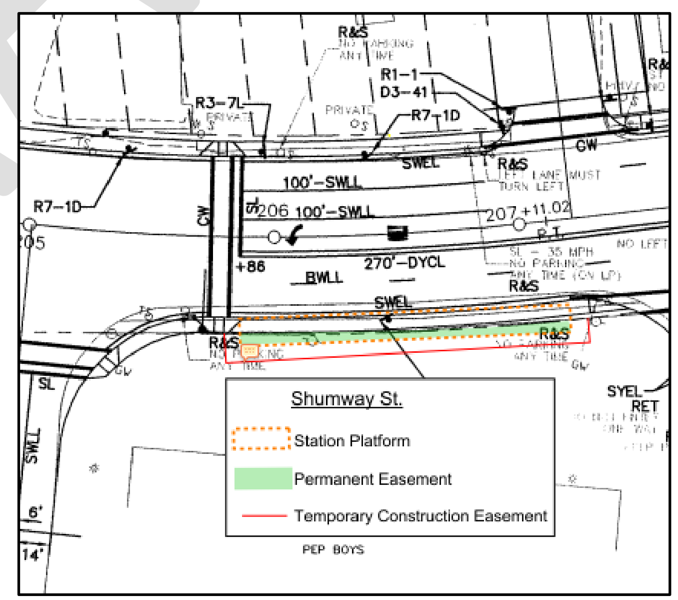

Figure 42: Shumway Street Outbound Easement Map

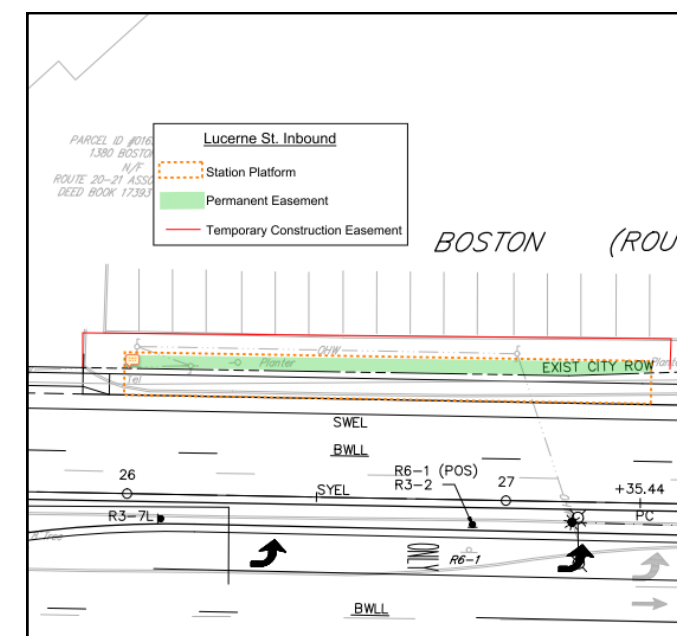

Figure 43: Lucerne Street Inbound Easement Map

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2.9.2 Intersection Easements

In Alternative 1B, nine of the ten intersections analyzed will require the acquisition of right-of-way (Figure 31). At the State Street and Main Street intersection buildings are built up to the sidewalk and there is likely no opportunity acquire right-of-way to widen without impacting buildings, therefor at this intersection a reduction of lanes would occur as opposed to right-of-way acquisition. In many instances the need for right-of-way is for reconstructing the traffic signal layout, adjusting sidewalks, bringing the shoulders up to the current standards, maintaining parking, and maintaining landscaping. Temporary construction easements will be needed around all permanent easements. For Alternative 1B approximately 41,400 square feet, almost 1 acre, of right-of-way will need to be obtained to accommodate intersection improvements (Table 29).

Table 29: Alternative 1B Intersection ROW Needs

Station	ROW Needs (SF)
State St. at Main St.	-
State St. at Dwight St.	1,200
State St. at Maple St.	3,200
State St. at Federal St.	4,400
State St. at St. James Ave	3,200
State St. at Catharine St	6,400
State St. at Gaucher St.	3,200
Boston Rd.at Bay St.	7,000
Boston Rd. at Pasco Rd.	5,200
Boston Rd. at Parker St.	7,600
Total	**41,400**

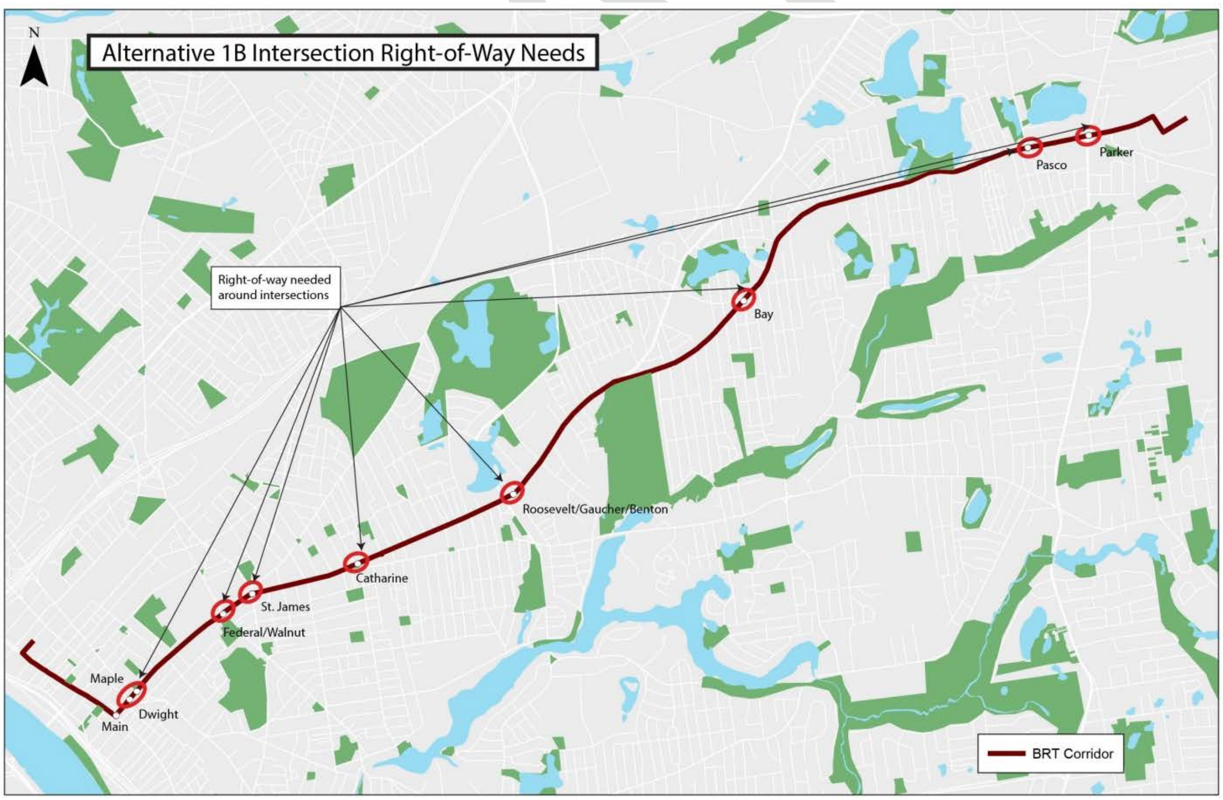

Figure 44: 1B Intersection Easement Requirements

Table 30: Hybrid Alternative Intersection ROW Needs

Station	ROW Needs (SF)
State St. at Main St.	-
State St. at Dwight St.	-
State St. at Maple St.	-
State St. at Federal St.	-
State St. at St. James Ave	500
State St. at Catharine St	1,000
State St. at Gaucher St.	-
Boston Rd.at Bay St.	5,600
Boston Rd. at Pasco Rd.	-
Boston Rd. at Parker St.	1,100
Total	**8,200**

In the Hybrid Alternative, only four of the ten intersections analyzed will require the acquisition of right-of-way (Figure 31) since many of the intersections will not require physical improvements since it will be operating in mixed traffic. Intersections where the vehicle will operate in the general purpose lanes only require TSP upgrades which can be implemented through modifications to the traffic control box. Where right-of-way is required it is needed to accommodate a queue jump, adjust sidewalks, or bring shoulders up to current standards. Temporary construction easements will be needed around all permanent easements. For the Hybrid Alternative approximately 8,200 square feet, almost 1/5 of an acre, of right-of-way will need to be obtained to accommodate intersection improvements (Figure 45).

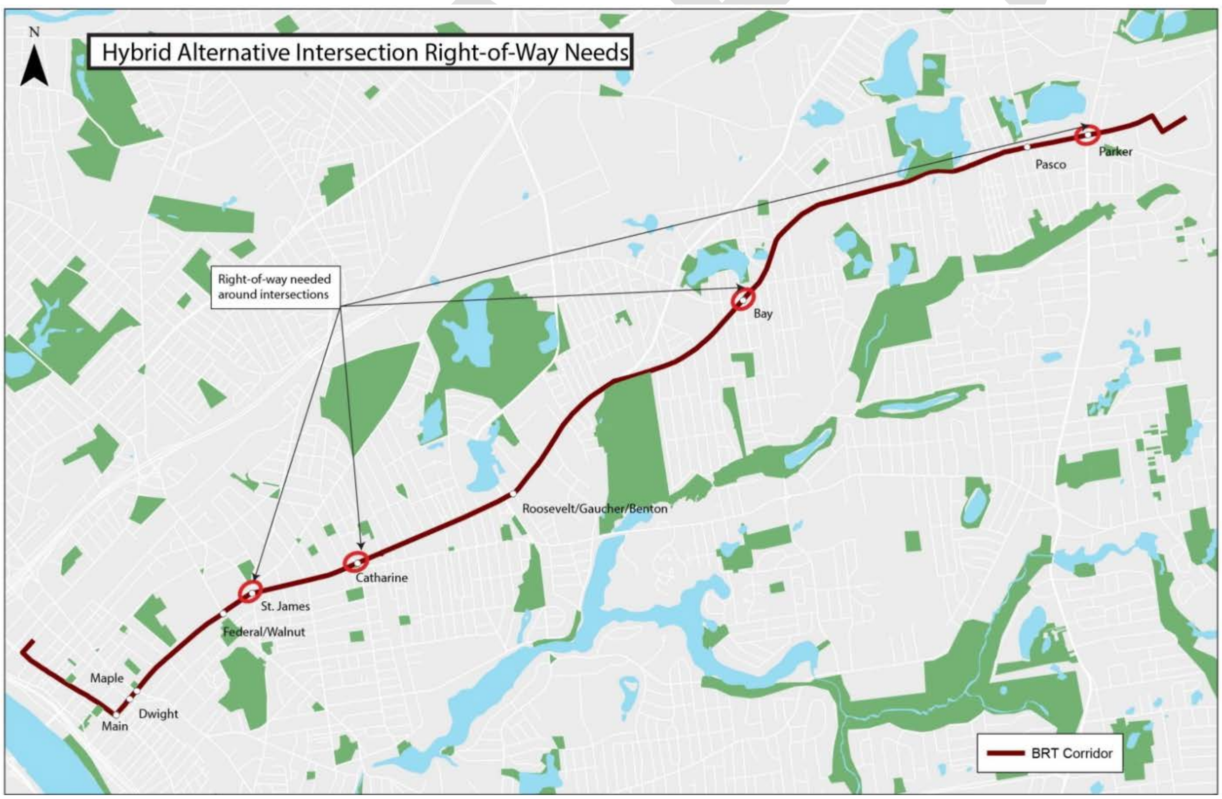

Figure 45: Hybrid Intersection Easement Requirements

2.9.3 Corridor Easements

For both alternatives overall widening of the corridor will be required along certain segments in order to meet current standards for lane and shoulder width. Alterative 1B requires 80,900 square feet (almost 2 acres) of right-away be acquired. The corridor will need to be widened by 2-4 feet to meet newer design standards for shoulder width to accommodate bicycles. The Hybrid Alternative requires 61,600 square feet (approximately 1.4 acres) of right-away be acquired. The right-of-way is needed where there is proposed dedicated bus lanes along Boston road and the two way left turn lanes (TWLTL) do not exist. In this section the road could require widening upwards of 20 feet.

2.9.4 Easement Summary

The Hybrid Alternative will require upwards of 76,800 square feet (1.76 acres) to accomodate the stations, intersection upgrades and corridor widening (Table 31). Most of the right-of way will be needed to widen the corridor. The 1B Alternative will need more than twice the amount of right-of-way acquisitions as compared to the Hybrid Alternative with 162,800 square feet (3.73 acres). For 1B half of the right-of-way will be needed to widen the corridor and a quarter each for intersection improvements and stations. There is greater need for station right-of-way with 1B because the stations are centrally aligned and would require diverting the roadway around the stations as compared to the curbside stations in the hybrid. More intersection upgrades will be needed for 1B than the hybrid due to the number of signals along the dedicated running way. While the 1B requires greater corridor widening, the majority of it will be needed along Boston Road between Pasco Road and Berkshire Avenue which is indicated in the high value associated with the Hybrid option

Table 31: Right-of-Way Requirements

Easement	1B (SF)	Hybrid (SF)
Stations	40,500	7,000
Intersection Upgrades	41,400	8,200
Corridor widening	80,900	61,600
Total	**162,800**	**76,800**

2.10 Construction Implementation

Construction Implementation is the project schedule from preliminary design through the first day of revenue service. Two sets of schedules have been developed for each alternative. The first set (1) assumes that federal and state funding is involved requiring MassDOT and the FHWA and/or FTA be involved with the design and that at each stage of design it will need to be reviewed by MassDOT, FHWA, FTA in addition to the city, PVTA and local stakeholders. The second set (2) of timelines assume that the project does not need to go through state and federal review process and can be reviewed by only PVTA and the City of Springfield. Both schedule sets assume that some level of environmental permitting will be required.

The schedule for each set and alternative has been broken up into three sections: Project Development; Construction; Revenue Operations/Closeout of Project. Project Development includes the processes of taking the project through engineering design to awarding a construction contract. It includes all design, cost estimation, reviews, environmental permitting, and issuing bids. A design review is required at 25%, 75%, 100% and for plans, specifications and estimates. These are standard design phases for MassDOT and engineering. The second stage is construction and includes acquiring any real estate/ right-of-way which may be needed, constructing stations, improving intersections, altering roadways, relocating utilities and all other elements as laid out in the final design. Acquiring real estate lasts through the design phase and should begin with the 25% design and be complete before bids are issued. Construction cannot begin until all real estate is acquired. During the construction phase is also when the procurement of vehicles should begin in order to acquire them in time to test on the corridor and train operators as the Springfield PVTA operations does not currently have articulated vehicles the recommended vehicle type. Once construction is complete and vehicles tests done revenue service can begin. If the project is funded by the FTA through New Starts a before and after study on ridership must be completed. The before study should occur a few months to beginning revenue operations and the after will need to occur two year after the start of revenue service.

2.10.1 Schedule Set 1

This schedule set for both alternatives assumes that MassDOT and federal design reviews will be required due to funding structures. These reviews add time.

Hybrid Schedule

It will take approximately seven years to design and construct the Hybrid Alternative, with service beginning in the first quarter of Year 8 (Figure 46). The Project Development phase will take four and a half years. Once a bid has been awarded construction of the physical infrastructure can begin and will take two construction seasons. The process for acquiring right-of-way should start during the design phase in order to finalize it before construction begins. Once construction is complete 6 months will be needed to test the vehicles on the corridor. Once the testing is complete operations will begin. It is unlikely that the Hybrid Alternative will meet the requirements for New Starts funding but if so a before and after study will need to be conducted.

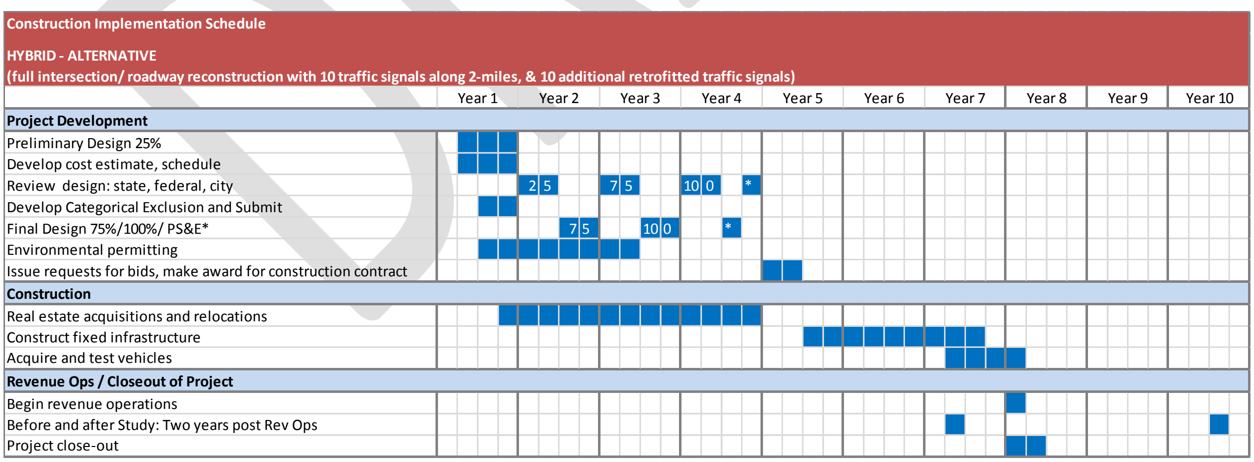

Figure 46: Implementation Schedule Set 1 - Hybrid Alternative

1B Schedule

It will take approximately 12 years to design and construct the 1B Alternative (Figure 47). The Project Development phase will take seven and a half years. Once a bid has been awarded construction of the physical infrastructure can begin and will take four construction seasons. The process for acquiring right-of-way should start during the design phase in order to finalize it before construction begins. Once construction is complete six months will be needed to test the vehicles on the corridor. Once the testing is complete operations will begin. It is possible that the 1B Alternative will meet the requirements for New Starts funding and if so a before and after study will need to be conducted

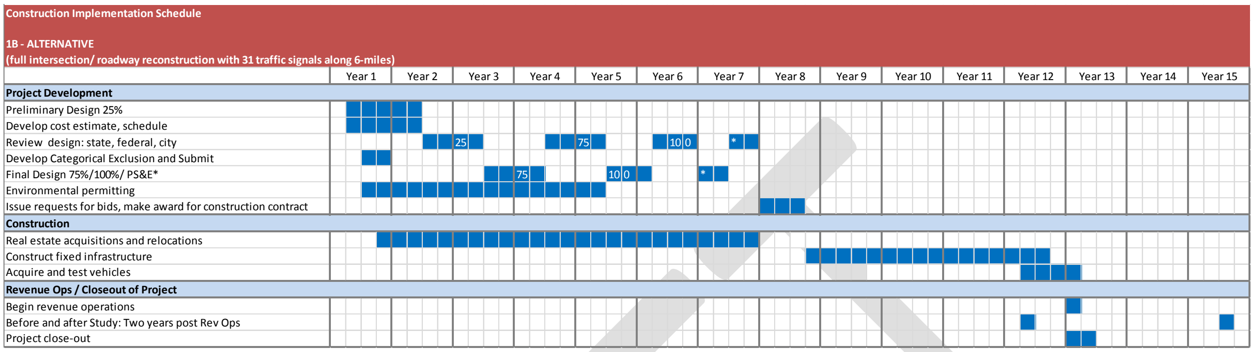

Figure 47: Implementation Schedule Set 1 - Alternative 1B

2.10.2 Schedule Set 2

This schedule set for both alternatives assumes that MassDOT and federal design review will not be required due to funding structures. In previous projects in Springfield, where the state and federal government was not involved, the design phases were condensed into preliminary and final design. These schedules follow this model.

Hybrid Schedule

It will take approximately 5 years to design and construct the Hybrid Alternative, with service beginning in the first quarter of Year 5 (Figure 48). The Project Development phase will take four and a half years. Once a bid has been awarded construction of the physical infrastructure can begin and will take a little over two construction seasons. The process for acquiring right-of-way should start during the design phase in order to finalize it before construction begins. Once construction is complete 6 months will be needed to test the vehicles on the corridor. Once the testing is complete operations will begin. It is unlikely that the Hybrid Alternative will meet the requirements for New Starts funding but if so a before and after study will need to be conducted.

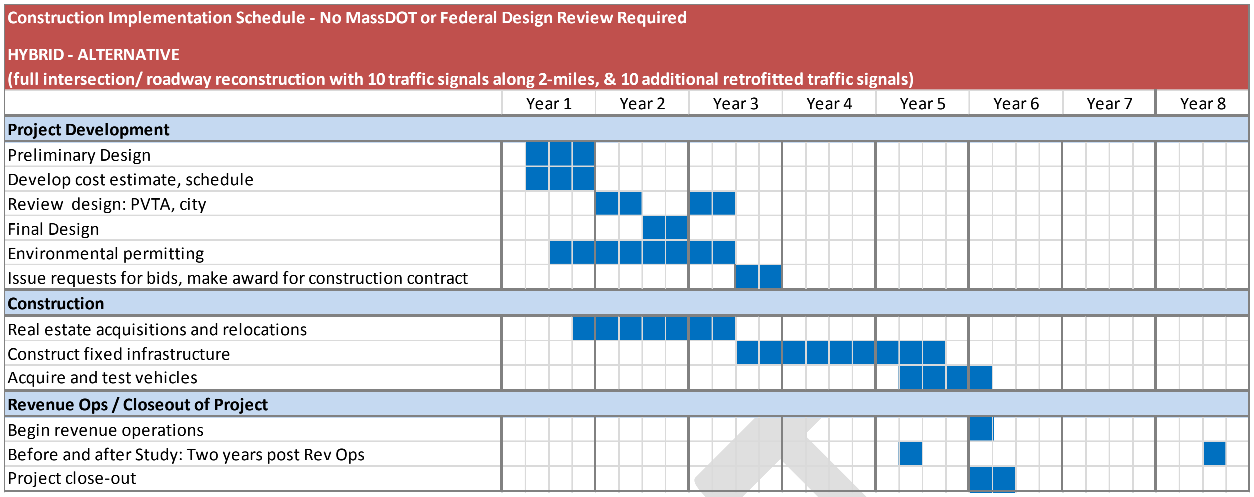

Figure 48: Implementation Schedule Set 2 - Hybrid Alternative

1B Schedule

It will take approximately 9 years to design and construct the 1B Alternative (Figure 49). The Project Development phase will take four and a half years. Once a bid has been awarded construction of the physical infrastructure can begin and will take four years. The process for acquiring right-of-way should start during the design phase in order to finalize it before construction begins. Once construction is complete six months will be needed to test the vehicles on the corridor. Once the testing is complete operations will begin. It is possible that the 1B Alternative will meet the requirements for New Starts funding and if so a before and after study will need to be conducted.

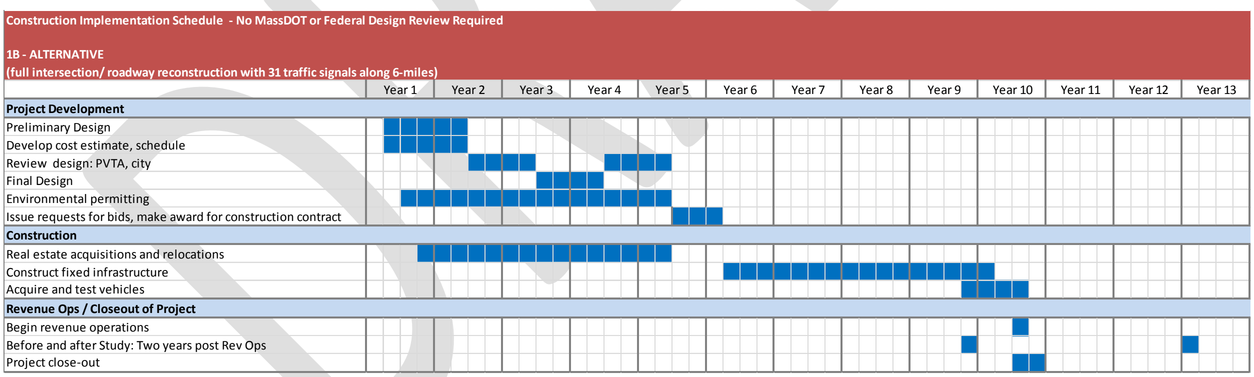

Figure 49: Implementation Schedule Set 2 - 1B Alternative

2.11 Capital Cost Estimation

The intent of the capital cost estimate is to provide an order of magnitude approximation of what it will cost to implement bus rapid transit along the State Street-Boston Road corridor. This estimate is not meant to provide detailed or specific numbers, and further cost analysis will be required once the locally preferred alternative has been selected and advanced through the project development process. The estimate spreadsheet shows high and low estimates for the Hybrid Alternative and Alternative 1B (see Table 32 for summary). Unit costs are listed for each of the cost estimate categories and the number of units and associated costs are shown for each of 4 segments of the corridor (see Table 33 - Table 36 for detailed estimates). The cost assumptions currently do not include estimates to integrate the BRT route/service into Union Station and Eastfield Mall. The numbers in the Standard Cost Category (SCC) column are based on the Federal Transit Administration's Standard Cost Categories. While most estimate categories have a SCC code, signalized intersections does not as it does not cleanly fit into an existing SCC.

Estimated roadway costs were informed by the team's local experience in the region. Costs are calculated per route mile, with an estimated unit cost of $7.4 million per route mile of designated busway for complete reconstruction and $500,000 for repainting/restriping only. A low and high estimate was developed for the Hybrid Alternative, with the low estimate only including paint for the dedicated lane and not reconstruction as in the high estimate.

Station estimates are based on the Webster Avenue Select Bus Service Final Design, recently completed for the New York City Department of Transportation. Estimates are based on a 90' station length, but this could be extended to 140' if operating conditions warrant at a cost of $10k-$30k per station. There is room for significant variation in the cost of station design, particularly with elements such as branding, signage, landscaping, and other amenities. These will vary depending upon the project goals, available budget, and available space at the station locations. High and low estimates were created based on larger or smaller station size and amenities.

Intersection estimates are also based on the Webster Avenue Select Bus Service Final Design. The estimate does not include full intersection reconstructions for the Hybrid Alternative. The low estimates use only 2 traffic signal mast arms and strain poles per intersection, while the high estimates use 4 per intersection. The vehicle cost estimates are based on unit costs provided by PVTA, with the change in the number of buses required coming from the project team's Operational Analysis. Since local B7 service would be reduced upon the implementation of BRT, fewer 40' buses would be needed in the fleet. These savings are incorporated into the final vehicle cost estimate.

Estimates for site work, transit signal prioritization, communication systems, expanding right-of-way, professional services (such as design, legal, insurance, and project management), and contingency funds were developed based the project team's experience with other BRT projects, such as the Webster Ave project and the Foothill Boulevard/5th Street Transit Corridor (for the San Bernardino Associated Governments).

Table 32: Summary of Capital Cost Estimates

Evaluation of Alternatives - Capital Cost Summary		Hybrid Alternative		Alternative 1B	
	Capital Item	**Low Estimate**	**High Estimate**	**Low Estimate**	**High Estimate**
10	**Lanes**	$2,140,000	$18,680,800	$48,168,000	$48,168,000
20	**Stations**	$2,295,673	$4,301,803	$2,295,673	$4,301,803
30	**Signalized Intersection Improvements**	$1,792,000	$3,072,000	$12,077,600	$14,061,600
40	**Sitework, utilities and Park-n-ride lots (25% of 10 thru 20)**	$1,108,918	$5,745,651	$29,168,003	$30,327,546
50	**TSP/Comm/Systems**	$7,810,000	$7,810,000	$7,810,000	$7,810,000
60	**ROW, Land, existing improvements (6.3% of 10)**	$134,820	$1,176,890	$3,034,584	$3,034,584
70	**Vehicles (incl. 20% for spare vehicles)**	$3,339,720	$3,339,720	$2,226,480	$2,226,480
80	**Prof. Services costs, design, legal, ins., PM/CM (35% of 10 thru 60)**	$5,348,494	$14,275,501	$47,995,207	$50,405,254
90	**Unallocated contingency (25% of items 10 thru 80)**	$5,157,476	$14,600,591	$37,637,267	$40,083,817
	Total	**$29,127,102**	**$73,002,956**	**$190,412,814**	**$200,419,084**
	Cost per mile	**$4,102,409**	**$10,282,106**	**$26,818,706**	**$28,228,040**

Table 33: Hybrid Alternative Low Estimate

Hybrid Alternative - CURBSIDE and Mixed Traffic -- Low Estimate			Downtown Main/Liberty - Main/State			Center West Main/State - State/Berkshire			Center East State/Berkshire - Boston/Pasco			East Boston/Pasco - Eastfield Mall			BRT - Hybrid Whole Corridor			
SCC	**Capital Item**	**per unit cost**		**units**	**Costs**		**units**	**costs**		**units**	**costs**		**units**	**costs**		**units**	**costs**	**cost per mile**
10.02	**Median Lanes (per route mile)**	**$7,392,000**	0	mile	$ -	0	mile	$ -	0	mile	$ -	0	mile	$ -	0	mile	$ -	
	Curbside Lanes (new construction, per route mile)	**$7,392,000**	0	mile	$ -	0		$ -	0		$ -	0		$ -	0	mile	$ -	
	Curbside Lanes (paint only, per route mile)	**$ 500,000**	0	mile	$ -	0		$ -	2.4		$ 1,200,000	0		$ -	2.4	mile	$ 1,200,000	
10.03	**Non-exclusive lane improvements (per route mile)**	**$ 200,000**	0.6	mile	$ 120,000	3	mile	$ 600,000	0	mile	$ -	1.1	mile	$ 220,000	4.7	mile	$ 940,000	
20	**BRT Stations**		2	stations		8	stations		6	stations		5	stations		21	stations		
	Concrete & Electrical Work	**$ 19,318**	2	stations	$ 38,636	8	stations	$ 154,542	6	stations	$ 115,907	5	stations	$ 96,589	21	stations	$ 405,673	
	Vending Machines	**$ 10,000**	4	machines	$ 40,000	16	machines	$ 160,000	12	machines	$ 120,000	10	machines	$ 100,000	42	machines	$ 420,000	
	Information Kiosks	**$ 20,000**	2	kiosks	$ 40,000	8	kiosks	$ 160,000	6	kiosks	$ 120,000	5	kiosks	$ 100,000	21	kiosks	$ 420,000	
	Shelters	**$ 50,000**	2	shelters	$ 100,000	8	shelters	$ 400,000	6	shelters	$ 300,000	5	shelters	$ 250,000	21	shelters	$ 1,050,000	
	Signage/Branding/Landscaping	**proj. specific**		n/a	$ -		n/a	$ -		n/a	$ -		n/a	$ -		n/a	$ -	
	Signalized Intersection Improvements	**$ 89,600**	0	ints.	$ -	10	ints.	$ 896,000	10	ints.	$ 896,000	0	ints.	$ -	20	ints.	$ 1,792,000	
40	**Sitework, utilities and Park-n-ride lots (25% of 10 thru 20)**				*$ 84,659*			*$ 368,636*			*$ 463,977*			*$ 191,647*			$ 1,108,918	
50	**TSP/Comm/Systems (per route mile)**	**$1,100,000**	0.6	mile	$ 660,000	3	mile	$ 3,300,000	2.4	mile	$ 2,640,000	1	mile	$ 1,210,000	7.1	mile	$ 7,810,000	
60	**ROW, Land, existing improvements (6.3% of 10)**				*$ 7,560*			*$ 37,800*			*$ 75,600*			*$ 13,860*			$ 134,820	
70	**Vehicles (incl. 20% for spare vehicles)**	**$556,620**		vehicles	$ -		vehicles	$ -		vehicles	$ -		vehicles	$ -	6	vehicles	$ 3,339,720	
80	**Prof. Services costs, design, legal, ins., PM/CM (35% of 10 thru 60)**				*$ 381,799*			*$ 2,126,942*			*$ 2,076,019*			*$ 763,734*			*$ 5,348,494*	
90	**Unallocated contingency (25% of items 10 thru 80)**				*$ 368,163*			*$ 2,050,980*			*$ 2,001,876*			*$ 736,457*			*$ 5,157,476*	
Hybrid Alternative - CURBSIDE and Mixed Traffic -- Low Estimate				**total**	**$ 1,840,817**		**total**	**$ 10,254,900**		**total**	**$ 10,009,378**		**total**	**$ 3,682,287**		**total**	**$ 29,127,102**	**$ 4,102,409**

Table 34: Alternative 1B Low Estimate

Alternative 1B - MEDIAN -- Low Estimate			Downtown Main/Liberty - Main/State			Center West Main/State - State/Berkshire			Center East State/Berkshire - Boston/Pasco			East Boston/Pasco - Eastfield Mall			BRT - 1B Whole Corridor			
SCC	**Capital Item**	**per unit cost**		**units**	**costs**		**units**	**costs**		**units**	**costs**		**units**	**costs**		**units**	**costs**	**cost per mile**
10.02	**Median Lanes (per route mile)**	**$7,392,000**	0	mile	$ -	3	mile	$ 22,176,000	2.4	mile	$ 17,740,800	1.1	mile	$ 7,392,000	6.5	mile	$48,048,000	
	Curbside Lanes (new construction, per route mile)	**$7,392,000**	0	mile	$ -	0		$ -	0		$ -	0		$ -	0	mile	$ -	
	Curbside Lanes (paint only, per route mile)	**$ 500,000**	0	mile	$ -	0		$ -	0		$ -	0		$ -	0	mile	$ -	
10.03	**Non-exclusive lane improvements (per route mile)**	**$ 200,000**	0.6	mile	$120,000	0	mile	$ -	0	mile	$ -	0	mile	$ -	0.6	mile	$120,000	
20	**BRT Stations**		2	stations	$ -	8	stations	$ -	6	stations	$ -	5	stations	$ -	21	stations		
	Concrete & Electrical Work	**$ 19,318**	2	stations	$ 38,636	8	stations	$ 154,542	6	stations	$ 115,907	5	stations	$96,589	21	stations	$405,673	
	Vending Machines	**$ 10,000**	4	machines	$ 40,000	16	machines	$ 160,000	12	machines	$ 120,000	10	machines	$100,000	42	machines	$420,000	
	Information Kiosks	**$ 20,000**	2	kiosks	$ 40,000	8	kiosks	$ 160,000	6	kiosks	$ 120,000	5	kiosks	$100,000	21	kiosks	$420,000	
	Shelters	**$ 50,000**	2	shelters	$ 100,000	8	shelters	$ 400,000	6	shelters	$ 300,000	5	shelters	$250,000	21	shelters	$1,050,000	
	Signage/Branding/Landscaping	**proj. specific**		n/a	$ -		n/a	$ -		n/a	$ -		n/a	$ -		n/a	$ -	
	Signalized Intersection Improvements	**$ 389,600**	0	ints.	$ -	18	ints.	$ 7,012,800	10	ints.	$ 3,896,000	3	ints.	$ 1,168,800	31	ints.	$12,077,600	
40	**Sitework, utilities and Park-n-ride lots (57.8% of 10 thru 20)**				*$ 195,731*			*$ 13,323,213*			*$ 10,633,296*			*$ 5,015,762*			$29,168,003	
50	**TSP/Comm/Systems (per route mile)**	**$1,100,000**	0.6	mile	$ 660,000	3	mile	$ 3,300,000	2.4	mile	$ 2,640,000	1.1	mile	$ 1,210,000	7.1	mile	$7,810,000	
60	**ROW, Land, existing improvements (6.3% of 10)**				*$ 7,560*			*$ 1,397,088*			*$ 1,117,670*			*$ 512,266*			$3,034,584	
70	**Vehicles (incl. 20% for spare vehicles)**	**$556,620**		vehicles	$ -		vehicles	$ -		vehicles	$ -		vehicles	$ -	4	vehicles	$2,226,480	
80	**Prof. Services costs, design, legal, ins., PM/CM (46.8% of 10 thru 60)**				*$ 562,502*			*$ 22,503,145*			*$ 17,167,959*			*$ 7,761,601*			*$47,995,207*	
90	**Unallocated contingency (25% of items 10 thru 80)**				*$ 441,107*			*$ 17,646,697*			*$ 13,462,908*			*$ 6,096,554*			*$37,637,267*	
Alternative 1B - MEDIAN -- Low Estimate				**total**	**$ 2,205,536**		**total**	**$ 88,233,486**		**total**	**$ 67,314,541**		**total**	**$ 30,432,771**		**total**	**$190,412,814**	**$190,412,814**

**Note: Alternative 1B would result in 7 fewer 40' buses needed, with a savings of $3,896,340, which is subtracted from the final vehicle cost estimate.*

Table 35: Hybrid Alternative High Estimate

Hybrid Alternative - CURBSIDE and Mixed Traffic -- High Estimate			Downtown Main/Liberty - Main/State			Center West Main/State - State/Berkshire			Center East State/Berkshire - Boston/Pasco			East Boston/Pasco - Eastfield Mall			BRT - Hybrid Whole Corridor			
SCC	**Capital Item**	**per unit cost**		**units**	**costs**		**units**	**costs**		**units**	**costs**		**units**	**costs**		**units**	**costs**	**cost per mile**
10.02	**Median Lanes (per route mile)**	**$7,392,000**	0	mile	$ -	0	mile	$ -	0	mile	$ -	0	mile	$ -	0	mile	$ -	
	Curbside Lanes (new construction, per route mile)	**$7,392,000**	0	mile	$ -	0		$ -	2.4		$ 17,740,800	0		$ -	2.4	mile	$ 17,740,800	
	Curbside Lanes (paint only, per route mile)	**$ 500,000**	0	mile	$ -	0		$ -	0		$ -	0		$ -	0	mile	$ -	
10.03	**Non-exclusive lane improvements (per route mile)**	**$ 200,000**	0.6	mile	$ 120,000	3	mile	$ 600,000	0	mile	$ -	1.1	mile	$ 220,000	4.6	mile	$ 920,000	
20	**BRT Stations**		2	stations	$ -	8	stations	$ -	6	stations	$ -	5	stations	$ -	21	stations		
	Concrete & Electrical Work	**$ 54,848**	2	stations	$ 109,696	8	stations	$ 438,782	6	stations	$ 329,087	5	stations	$ 219,391	21	stations	$ 1,151,803	
	Vending Machines	**$ 10,000**	6	machines	$ 60,000	24	machines	$ 240,000	18	machines	$ 180,000	15	machines	$ 150,000	63	machines	$ 630,000	
	Information Kiosks	**$ 20,000**	2	kiosks	$ 40,000	8	kiosks	$ 160,000	6	kiosks	$ 120,000	5	kiosks	$ 10,000	21	kiosks	$ 420,000	
	Shelters	**$ 100,000**	2	shelters	$ 200,000	8	shelters	$ 800,000	6	shelters	$ 600,000	5	shelters	$ 500,000	21	shelters	$ 2,100,000	
	Signage/Branding/Landscaping	**proj. specific**		n/a	$ -		n/a	$ -		n/a	$ -		n/a	$ -		n/a	$ -	
	Signalized Intersection Improvements	**$ 153,600**	0	ints.	$ -	10	ints.	$ 1,536,000	10	ints.	$ 1,536,000	0	ints.	$ -	20	ints.	$ 3,072,000	
40	**Sitework, utilities and Park-n-ride lots (25% of 10 thru 20)**				*$ 132,424*			*$ 559,696*			*$ 4,742,472*			*$ 311,060*			$ 5,745,651	
50	**TSP/Comm/Systems (per route mile)**	**$1,100,000**	0.6	mile	$ 660,000	3	mile	$ 3,300,000	2.4	mile	$ 2,640,000	1	mile	$ 1,210,000	7.1	mile	$ 7,810,000	
60	**ROW, Land, existing improvements (6.3% of 6 10)**				*$ 7,560*			*$ 37,800*			*$ 1,117,670*			*$ 13,860*			$ 1,175,630	
70	**Vehicles (incl. 20% for spare vehicles)**	**$556,620**		vehicles	$ -		vehicles	$ -		vehicles	$ -		vehicles	$ -	6	vehicles	$ 3,339,720	
80	**Prof. Services costs, design, legal, ins., PM/CM (35% of 10 thru 60)**				*$ 465,388*			*$ 2,685,297*			*$ 10,152,110*			*$ 972,706*			*$ 14,275,501*	
90	**Unallocated contingency (25% of items 10 thru 80)**				*$ 448,767*			*$ 2,589,394*			*$ 9,789,535*			*$ 937,966*			*$ 14,600,591*	
Hybrid Alternative - CURBSIDE and Mixed Traffic -- High Estimate				**total**	**$ 2,243,834**		**total**	**$ 12,946,969**		**total**	**$ 48,947,673**		**total**	**$ 4,027,791**		**total**	**$ 73,002,956**	**$ 10,282,106**

Table 36: Alternative 1B High Estimate

Alternative 1B - MEDIAN -- High Estimate				Downtown Main/Liberty - Main/State			Center West Main/State - State/Berkshire			Center East State/Berkshire - Boston/Pasco			East Boston/Pasco - Eastfield Mall			BRT - 1B Whole Corridor		
SCC	**Capital Item**	**per unit cost**		**units**	**costs**		**units**	**costs**		**units**	**costs**		**units**	**costs**		**units**	**costs**	**cost per mile**
10.02	**Median Lanes (per route mile)**	**$ 7,392,000**	0	mile	$ -	3	mile	$ 22,176,000	2.4	mile	$ 17,740,800	1.1	mile	$ 8,131,200	6.5	mile	$48,048,000	
	Curbside Lanes (new construction, per route mile)	**$ 7,392,000**	0	mile	$ -	0		$ -	0		$ -	0		$ -	0	mile	$ -	
	Curbside Lanes (paint only, per route mile)	**$ 500,000**	0	mile	$ -	0		$ -	0		$ -	0		$ -	0	mile	$ -	
10.03	**Non-exclusive lane improvements (per route mile)**	**$ 200,000**	0.6	mile	$120,000	0	mile	$ -	0	mile	$ -	0	mile	$ -	0.6	mile	$120,00	
20	**BRT Stations**		2	stations	$ -	8	stations	$ -	6	stations	$ -	5	stations	$ -	21	stations		
	Concrete & Electrical Work	**$ 54,848**	2	stations	$ 109,696	8	stations	$ 438,782	6	stations	$ 329,087	5	stations	$ 274,239	21	stations	$ 1,096,956	
	Vending Machines	**$ 10,000**	6	machines	$ 60,000	24	machines	$ 240,000	18	machines	$ 180,000	15	machines	$ 150,000	63	machines	$ 600,000	
	Information Kiosks	**$ 20,000**	2	kiosks	$ 40,000	8	kiosks	$ 160,000	6	kiosks	$ 120,000	5	kiosks	$ 100,000	21	kiosks	$ 400,000	
	Shelters	**$ 100,000**	2	shelters	$ 200,000	8	shelters	$ 800,000	6	shelters	$ 600,000	5	shelters	$ 500,000	21	shelters	$ 2,000,000	
	Signage/Branding/Landscaping	**proj. specific**		n/a	$ -		n/a	$ -		n/a	$ -		n/a	$ -		n/a	$ -	
	Signalized Intersection Improvements	**$ 453,600**	0	ints.	$ -	18	ints.	$ 8,164,800	10	ints.	$ 4,536,000	3	ints.	$ 1,360,800	31	ints.	$ 14,061,600	
40	**Sitework, utilities and Park-n-ride lots (57.8% of 10 thru 20)**				*$ 306,164*			*$ 13,764,944*			*$ 10,964,594*			*$ 5,291,844*			$ 30,372,546	
50	**TSP/Comm/Systems (per route mile)**	**$ 1,100,000**	0.6	mile	$ 660,000	3	mile	$ 3,300,000	2.4	mile	$ 2,640,000	1	mile	$ 1,210,000	7	mile	$ 7,810,000	
60	**ROW, Land, existing improvements (6.3% of 10)**				*$ 7,560*			*$ 1,397,088*			*$ 1,117,670*			*$ 512,266*			$ 3,034,584	
70	**Vehicles (incl. 20% for spare vehicles)**	**$556,620**		vehicles	$ -		vehicles	$ -		vehicles	$ -		vehicles	$ -	4	vehicles	$ 52,226,480	
80	**Prof. Services costs, design, legal, ins., PM/CM (46.8% of 10 thru 60)**				*$ 703,600*			*$ 23,606,676*			*$ 17,890,775*			*$ 8,204,203*			*$ 50,405,254*	
90	**Unallocated contingency (25% of items 10 thru 80)**				*$ 551,755*			*$ 18,512,072*			*$ 14,029,732*			*$ 6,433,638*			*$ 40,083,817*	
Alternative 1B - MEDIAN -- High Estimate				**total**	**$ 2,758,775**		**total**	**$ 92,560,362**		**total**	**$ 70,148,658**		**total**	**$ 29,147,271**		**total**	**$ 200,419,084**	**$ 28,228,040**

Table 37: Intersection Costs

Items	Unit Costs ($)	Unit	Low Estimate	High Estimate	per Intersection	per Intersection
Intersection Improvements- Alt. 1B					*Low*	*High*
Full Intersection Reconstruction	$300,000	per intersection	$300,000	$300,000	1	1
Pedestrian Signal Post w/ Head	$3,000	per signal post	$12,000	$12,000	4	4
Traffic Signal Post	$1,000	per signal post	$4,000	$4,000	4	4
Traffic Signal Mast Arm (45-feet)	$17,000	per mast arm	$34,000	$68,000	2	4
Traffic Signal Strain Pole	$15,000	per pole	$30,000	$60,000	2	4
Traffic Signal Head	$1,200	per signal head	$9,600	$9,600	8	8
		Total per Intersection:	**$389,600**	**$453,600**		
Intersection Improvements- Hybrid Alt.					*Low*	*High*
Pedestrian Signal Post w/ Head	$3,000	per signal post	$12,000	$12,000	4	4
Traffic Signal Post	$1,000	per signal post	$4,000	$4,000	4	4
Traffic Signal Mast Arm (45-feet)	$17,000	per mast arm	$34,000	$68,000	2	4
Traffic Signal Strain Pole	$15,000	per pole	$30,000	$60,000	2	4
Traffic Signal Head	$1,200	per signal head	$9,600	$9,600	8	8
		Total per Intersection:	**$89,600**	**$153,600**		

Table 38: Station Calculations

Description	Unit	Unit PRICE	Station COST - High	Station COST - Low
Asphaltic Concrete Wearing Course, 2" Thick	S.Y.	$20.00	$2,400.00	$800.00
High-Early Strength Reinforced Concrete Pavement (Bus Stops)	C.Y.	$500.00	$15,277.78	$15,277.78
New Granite Curb, Straight	L.F.	$140.00	$12,600.00	-
Straight Steel Faced Concrete Curb (27" Deep)	L.F.	$85.00	$7,650.00	-
Depressed Steel Faced Concrete Curb (27" Deep)	L.F.	$80.00	$7,200.00	-
4" Concrete Sidewalk (Unpigmented)	S.F.	$9.00	$9,720.00	$3,240.00
			$54,847.78	**$19,317.78**

2.12 Funding Evaluation

In this section both federal and state funding sources for capital improvements and construction were evaluated. The FTA appropriates roughly $2 billion each year to fund new rail and BRT projects as part of the FAST-Act legislation. The primary program through which funding is awarded is the 5309 "Fixed Guideway Capital Investment Grants". The 5309 program awards discretionary Capital Investment Grants (CIG) under the following four categories:

New Starts	•New fixed guideway projects where the totalcapital cost is greater than $300M, or New Starts funding sought equals or exceeds $100M
Small Starts	•New fixed guideway projects where the total cost is less than $300M and Small Starts funding sought equals or is less than $100M
Core Capacity	•Substantial corridor-based capital investment in an existing fixed guideway system that increases the capacity of a corridor by not less than 10 percent
Programs of Inrerlated Projects	•Any Combination of two or more New Starts, Small Starts, or Core Capacity projects. Projects must have locical connectivity and begin construction within a reasonable timeframe

2.12.1 New Starts

New Start funding can be used for the design and construction of new fixed-guideways or extensions of existing fixed guideways. To apply for a New Starts project the total capital cost must be greater than $300M or the applicant must be seeking $100M or more in funding. New Start programs under Section 5309 CIG will fund up to 60% of the capital cost therefore a project must have at least $167M in capital costs to apply for the program. Collectively all federal funding for the project cannot exceed 80% of the capital cost. The funding can be used for acquiring or property and/or right-of-way, rolling stock, and construction

New Starts BRT Requirement Facts

- Capital Cost > $300M or seeking $100M+
- 5309 will fund up to 60%
- 20% local share
- 50%+ or project is fixed guideway
- Defined Stations
- TSP
- Short headways
- Bidirectional service
- Service operates 7 days a week

New Start Projects for BRT must be a fixed guideway project where during the peak periods the majority of the project operates in a separated right-of-way dedicated for public transportation. It must also include features that emulate rail fixed guideway. These features include defined stations, transit signal priority, short headways, bi-directional service and weekday and weekend service. The 1B Alternative meets all of the operating and capital costs requirements to apply for New Starts funding, the Hybrid does not meet the cost requirements.

The process to be eligible for funding is multi-step and multi-year, requiring FTA evaluation and rating at various points in the process. The first step in the process is Project Development, the second Engineering, and the third a Full Funding Grant Agreement for Construction. To enter the project development phase the applicant must submit a letter to the Secretary describing the project and requesting entry. They must also initiate the National Environmental Policy Process. During the project development phase an environmental review is completed, alternatives reviewed and evaluated, the locally preferred alternative selected and adopting it into the Long Range Transportation Plan. Within two years the development phase must be completed. In the engineering phase design must be completed and non-New Starts funding commitments must be obtained. In the last stage construction takes place.

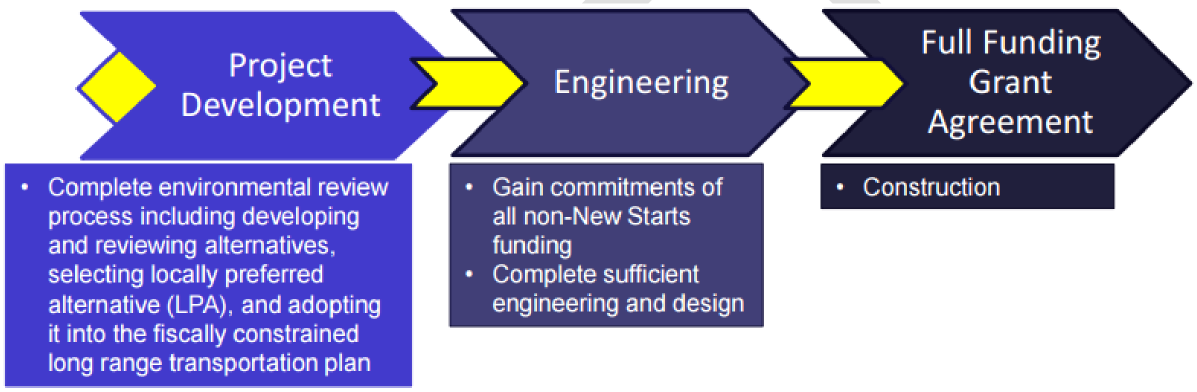

Figure 50: New Starts Funding Process

2.12.2 Small Starts

Small Start funding can be used for the design and construction of corridor-based BRT projects operating in mixed traffic in addition to new fixed-guideways or extensions of existing fixed guideways. To apply for a Small Starts project the total capital cost must not exceed $300M and the applicant must be seeking less than $100M in funding. Small Start programs under Section 5309 CIG will fund up to 80% of the capital cost. Collectively all federal funding for the project cannot exceed 80% of the capital cost.

Small Starts BRT Requirement Facts

- Capital Cost < $300M and seeking < $100M
- 5309 will fund up to 80%
- Corridor-based or fixed guideway
- Defined Stations
- TSP
- Short headways
- Bidirectional service
- Substantial weekday service

Small Start Projects for BRT can be on a fixed-guideway or corridor-based. Corridor-based projects must have a substantial investment in the corridor but do not operate in a separate right-of-way dedicated for public transportation. Substantial investment include defined stations; traffic signal priority for public transportation vehicles; short headway; bidirectional services for a substantial part of weekdays;

and any other features the Secretary may determine support a long-term corridor investment. Both alternatives meet the requirements for Small Starts funding.

The eligibility process for Small Starts is a two-step process; Step one is Project Development and step two the Expedited Grant Agreement. While this is a multi-year process it is typically shorter than the New Starts process. The Project Development phase includes both the Project Development phase and Engineering phase of New Starts. To enter the project development phase the applicant must submit a letter to the Secretary describing the project and requesting entry. They must also initiate the National Environmental Policy Process. If the Secretary determines that the project has a locally preferred alternative that is in the MPO LRTP, is supported by local financial commitments and has gone through a suitable evaluation process it may become eligible for funding. The application is then evaluated and rated. If selected it will move onto phase two Grants and Expedited Grants.

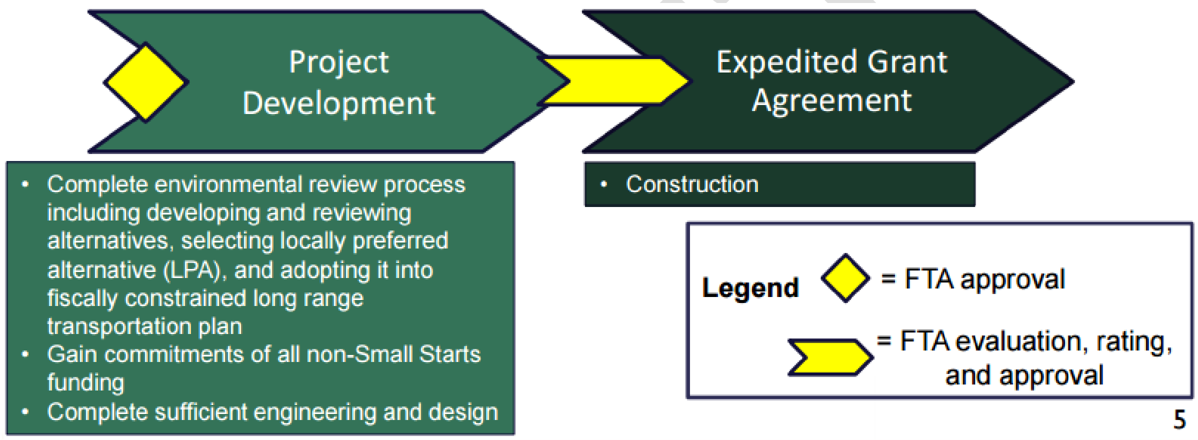

Figure 51: Small Starts Funding Process

2.12.3 Core Capacity

Core Capacity funding is for the design and construction of a corridor-based investment in an existing fixed guideway system that will improve the capacity by 10% or more within five years. Typically funding is used for acquiring property and/or right-of-way, signalization improvements, electrification, expanding platforms/stations, double tracking, procuring rolling stock associated with increased service or adding stations. It cannot include project elements designed to maintain a state of good repair. Core Capacity programs under Section 5309 CIG will fund up to 80% of the capital cost. Collectively all federal funding for the project cannot exceed 80% of the capital cost. The process to be eligible for funding is the same as New Starts (Figure 50). Neither Alternative meets the requirements for Core Capacity since they are both new systems.

2.12.4 Programs of Interrelated Projects

The Program of Interrelated Projects is for the design and construction of two or more connected projects. Projects may include new fixed-guideway, corridor based BRT core capacity projects. Programs of Interrelated Projects under Section 5309 CIG will fund up to 80% of the capital cost.

2.12.5 State Funding

There are several funding sources that could potentially be available through MassDOT if the project is placed on the PVPC Transportation Improvement Program (TIP) list. These funding sources have been used in Springfield for previous projects. Funding sources include:

- **Congestion Mitigation and Air Quality Improvement Program (CMAQ)**: Funding to reduce transportation related emissions through transit amenities, bicycle amenities, pedestrian accommodations, and major intersection improvements if reducing congestion.
- **National Highway Performance Program/ National Highway System (NHPP/ NHS):** Funding for improving infrastructure conditions, safety, or mobility movement on the National Highway System (NHS) roadway. State Street and Boston Road are on the NHS Network.
- **Surface Transportation Program (STP):** Funding for projects to preserve and improve the conditions and performance of pedestrian and bicycle infrastructure, and transit capital projects, including intercity bus terminals.
- **Highway Safety Improvement Program (HSIP):** Funding for safety improvements in crash cluster areas to achieve a significant reduction in traffic fatalities and serious injuries. Boston Road and State Street have crash clusters throughout the corridor. A Road Safety Audit is needed in order to be considered for this funding source.
- **Transportation Alternatives Program (TAP):** Funding for transportation alternatives, including on- and off-road pedestrian and bicycle facilities, infrastructure projects for improving non-driver access to public transportation and enhanced mobility.
- **Complete Streets Program (CS):** Funding for bicycle, pedestrian and transit improvements.

It is important that a variety of funding sources are pursued, instead of relying on a single source. A variety of funding will lessen the cost on the city and or PVTA, improve awareness of the project, and creating for a better financial foundation. It should be noted that many or the state and federal funding sources do require milestone reporting and may require additional design reviews.

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Chapter 3: Environmental Analysis

3.1 Introduction

A key component of the alternatives analysis examines each alignment's impact on environmental resources. For the purpose of this report, the study area is defined as 500 feet measured on each side of the proposed alternative's alignment where there was dedicated right-of-way and 250 feet around all proposed stations and intersections which would have major improvements. Within this area, environmental resources were identified for the 1B and Hybrid Alternatives. Resources analyzed included water resources, parks and designated open spaces, rare species/wildlife, areas of critical environmental concerns, and historic sites/structures. The study's goals include objectives which seek to minimize any negative impacts to the area. Detailed maps depicting the locations of all identified resources can be viewed in Appendix D an overall map of environmental conditions can be seen in Figure 52.

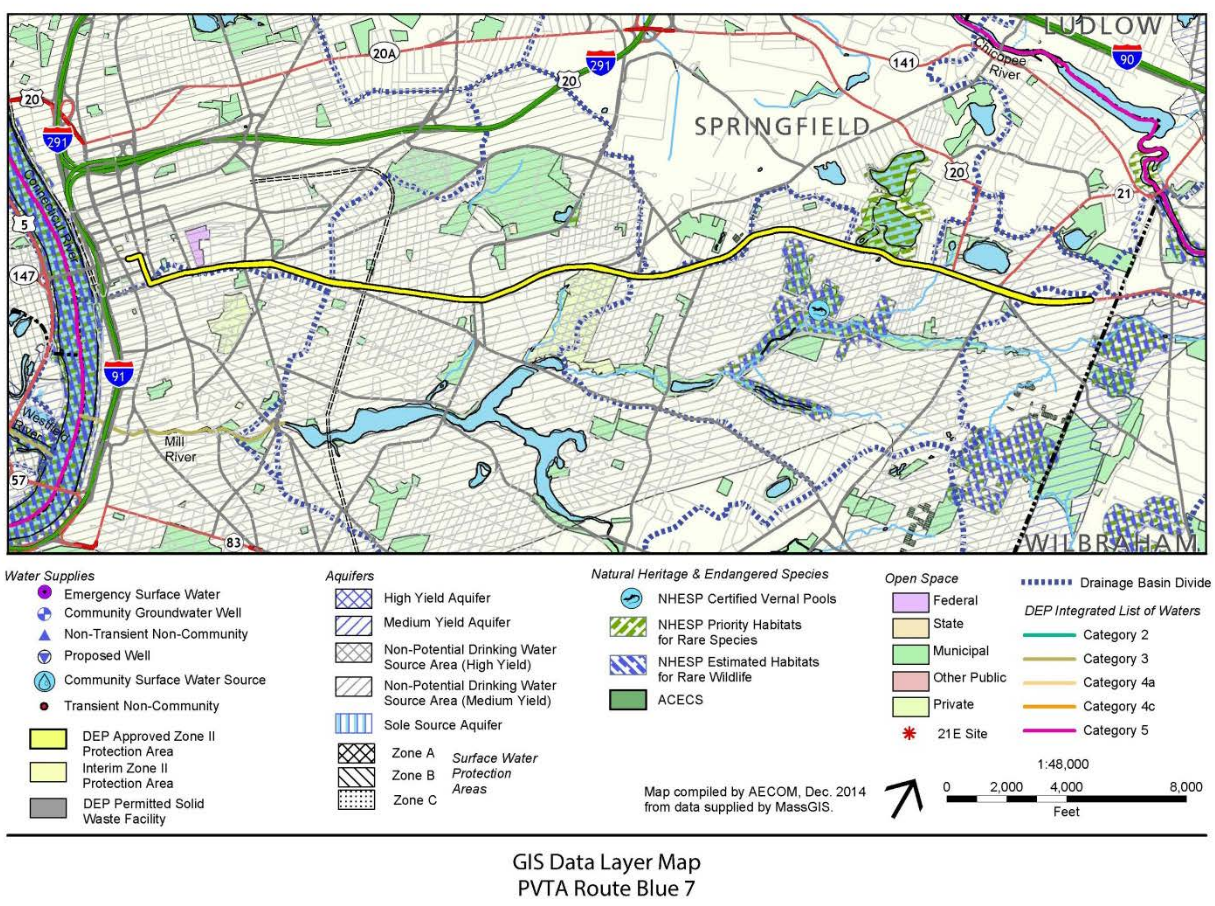


Figure 52: Environmental Conditions Along the Corridor

3.2 Water Resources

Water resources identified include wetlands, rivers and streams, reservoirs, Federal Emergency Management Agency (FEMA) floodplains, Class A public water supplies, and surface water supply protection areas. These are waterways governed under Chapter 91 Waterways permitting, the Wetlands Protection Act or the Rivers Protection Act. A Chapter 91 permit is required for any construction, alteration, fill placement, or dredging in any publically owned waterway including; tidelands, great ponds and navigable rivers and streams. The Connecticut River is considered a navigable waterway but does not fall within 500 feet of the study corridor. Great ponds are any pond or lake greater than 10 acres. There are two great ponds in Springfield, Five Mile Pond and Loon Pond, both are within the eastern end of the study area, there for a Chapter 91 permit may be required. The Wetlands Protection Act and Rivers Protection Act apply to any body of water, riverfront areas, tidal zones, beaches and a 100-foot buffer zone around set waterways. All projects within these boundaries must obtain an Order of Conditions (OC) from the municipal Conservation Commission. This project, either alternative, will most likely require an Order of Conditions from the Springfield Conservation Commission per the Springfield Wetlands Protection Ordinance.

> A Chapter 91 permit is required for any construction, alteration, fill placement, or dredging in any publically owned waterway including; tidelands, great ponds and navigable rivers and streams.

If a project will alter 10 or more acres of wetland an Environmental Notification Form (ENF) and Environmental Impact Report (EIR) are required; however if only 0.5 – 10 acres of a wetland are altered then only an ENF is required. The 1B alternative could impact up to 18.92 acres, although it is unlikely that all wetlands would be impacted. Most of the wetlands within the corridor are greater than ½ an acre, therefore the likelihood of triggering an ENF is high. The Hybrid alternative could impact up to 17.34 acres of wetland and likely trigger an ENF.

> Projects with over 10 acres of impact require an Environmental Impact Report

When a permit is required for altering 500 or more linear feet of an inland waterway bank then an ENF is also required. There are three streams/rivers in the corridor, which would impact the alternatives equally. One requires a culvert on Boston Road in the vicinity of Fieldston Court, the other two are minor in size. Construction around the culvert may require an ENF.

> Environmental Notification Forms are required if 500’ of a waterway are impacted

Reservoirs are considered Outstanding Resource Waters (ORW) and include active, inactive and emergency ones that are approved by the Massachusetts Department of Environmental Protection (MassDEP). If a reservoir is within 0.5 miles of the project site it may require an ENF or EIR. There are no reservoirs (active, inactive or emergency) within the study area or the City of Springfield.

The FEMA areas depict zones/floodplains which would be inundated with water in the event of a 100 year flood. If a proposed project is in a floodplain they must be reviewed in conjunction with the Massachusetts Environmental Policy Act (MEPA), and the Massachusetts Wetlands Protection Act and

Projects within FEMA floodplains must go through a MEPA review

may require filing a Notice of Intent per the Order of Conditions as outlined in the Massachusetts Wetlands Protection Act. There is one 100 year floodplain located on Boston Road by Fieldston Court which would impact both alternatives equally.

If a public water supply, or within 200 feet of a tributary of a public water supply, is impacted by 10,000+ gallons per day of new storm water or wastewater discharge then it is subject to an ENF. Public water supplies are considered ORWs and if they are within 0.5 miles of the project site but do not meet the aforementioned criteria they may still require an ENF. There are no public water supplies for either alternative within the study area, 0.5 miles of the corridor, or within 200 feet of a tributary that feeds a public water supply.

The surface water supply protection areas delineate zones which are protected under the Massachusetts Drinking Water Regulations (MDWR). Similar to public water supplies, if a project will cause an increase in discharge of wastewater into a protected zone then it may require an ENF and EIR. The requirement for an ENF and/or EIR is dependent on the amount of new discharge. There are no surface water supply protection areas along the corridor.

Project sites wholly or partially within a federal or state designated scenic river may also be required to complete an ENF and EIR but there are no such designations in Springfield.

Table 39: Water Resource Impact Analysis

Water Resource	1B	Hybrid
Wetlands (Acre)	18.92	17.34
River/Stream (L.F.)	1,403	1,403
FEMA Floodplain (Acre)	4.28	4.28
Reservoirs (Acre)	0	0
Class A public water supplies (Each)	0	0
Surface Water Protection Supply (Acre)	0	0
Scenic and Wild River	No	No

3.3 Open Space

Although there are designated open space parcels within 500 feet of each alternative, none intersect the proposed alignment and about three quarters are along the corridor. The 1B Alternative has 14 different open space properties totaling 41.4 acres. The open spaces vary from playgrounds, to historical parks to bogs. The Hybrid Alternative has the least potential impact on open space property with only 10 different areas covering 29.8 acres identified within 500 feet of the corridor segment with a dedicated bus lane or 250 feet of a station or an intersection that would require major improvements (Table 40).

Table 40: Open Space Impact Analysis

Alternative	Open Space	Locations
1B	40.0 acres	Court Square Park, Merrick Park, Quadrangle Park, Armory National Historical Park, Commerce Playground, Magazine Playground, Winchester Square, Rebecca Johnson Park, Saint Michaels cemetery, White Cedar Bog, Five Mile Pond Park, Fanti Bog, Warner Pond
Hybrid	29.8 acres	Court Square Park, Quadrangle Park, Commerce Playground, Magazine Playground, Winchester Square, Saint Michaels cemetery, White Cedar Bog, Five Mile Pond Park, Fanti Bog

3.4 Endangered Species

To examine the impact of each alternative on endangered species, the areas of critical environmental concern (ACEC), priority habitats of rare species, estimated habitats of rare wildlife, vernal pools and natural communities were explored. ACECs are places that are specially recognized due to their quality, uniqueness and significance of their natural/cultural resources. Any project partially or fully within an ACEC requires an ENF and potentially other MEPA reviews if required so by the secretary. If the project is within 0.5 miles of an ACEC it may require an ENF at the discretion of the secretary. ACECs are nominated by a community and then designated by the state's Energy and Environmental Affairs Secretary. Springfield has no ACECs, and there are none within 0.50 miles of the study area.

Priority Habitats of Rare Species (PHRS) are the state-listed rare species in the Natural Heritage & Endangered Species Program (NHESP); the estimated habitats of rare wildlife (EHRW) are a subset of the PHRS for non-wetland species. Altering significantly endangered or threatened species listed by NHESP are subject to the Massachusetts Endangered Species Act and require permitting. If the species are regulated by the federal endangered species act an Incidental Take Permit must be obtained. If a significant habitat is being altered or two or more acres of PHRS are being disturbed then an ENF is mandatory and a MEPA review may be required. Both alternatives could potentially impact more than 2 acres of PHRS. There are two areas with PHRS, one of which has an EHRW subset. The area with the EHRW has a species of conservation concern, Eastern Worm Snake, which is listed as threatened by the state. The other area has the two plants (Dwarf Bulrush and Terete Arrowhead), one is listed as threatened and the other as a special concern. None of these species are regulated by the federal endangered species act. Both of these areas would be impacted by either alternative.

Altering habitats of species listed by NHESP require permitting

A vernal pool is a small, shallow temporary body of water which provides habitats for distinctive plants and animals and is marked by periods of dryness. In Massachusetts certified vernal pools are protected under the Massachusetts Wetlands Protection Act. Altering wetlands that are protected under the Wetlands Protection Act require ENF and a mandatory EIR. Vernal pools are considered ORWs and if they are located within 0.5 miles of the project site they may trigger an ENF. There are no vernal pools within 500 feet of the corridor but there is one within 0.5 miles along the section proposed for a dedicated right-of-way for both alternatives.

Natural communities are areas of biodiversity conservation interest and are protected under the NHESP. Natural Communities are not protected or regulated under the Massachusetts Endangered Species Act but are tracked for potential conservation interest. Under *BioMap2*, a regulatory document to guide conservation in Massachusetts, natural communities have conservation priority. There is one natural community within the corridor located around Hobson St. and both alternatives would impact it. It is a moderate-sized Atlantic White Cedar Bog, classified as "Imperiled in Massachusetts"[11]. This bog has been degraded by human disturbance, and is not well buffered to the effects of surrounding development.

Table 41: Endangered Species Impact Analysis

Impact	Alt 1B	Hybrid
Areas of Critical Environmental Concern	0	0
Priority Habitats Rare Species	22.96 acres	22.96 acres
Estimated Habitats of Rare Wildlife	3.48 acres	3.48 acres
Vernal Pool	1	1
Natural Community	3.45 acres	3.45 acres

3.5 Historical Sites/Structures

Historic sites and structures are sites and districts listed in the State Register of Historic Places or under the Historic and Archaeological Assets of the Commonwealth. Any project that may impact historically listed properties must file a Project Notification Form (PNF) with the Massachusetts Historic Commission (MHC) who will render an opinion on the proposed projects impact. If a project will alter the exterior part of an historic site or any art of an archeological site it is also required to complete an ENF. The majority of the historic sites/districts and structures are located in the western end of the corridor. Alternative 1B has 22 different historic districts/areas and 168 historic structures. The largest impacted sites would be the Springfield Armory, Prospect Park/Dorman School Area and the Ambrose Street Area. There are more than 10 acres within the 500 foot boundaries for each of these sites that may be potentially impacted. Many of the structures and sites are listed on the National Register and include such notable ones as Court Square, Springfield Armory, and Union Station.

Projects that impact historical properties must file a PNF with the MHC

The Hybrid Alternative has 15 different historic districts/areas and 26 historic structures. The largest impacted site would be the Ambrose Street Area, there are more than 10 acres within the impact boundaries for this site that may be potentially impacted. Over half of the structures and sites are listed

[11] Imperiled is defined as rare, typically 6-20 occurrences state wide, with a restricted range and few remaining acres which make it vulnerable to extirpation.

on the National Register and include such notable ones as Court Square, Springfield Armory, and Union Station.

Table 42. Summary of Historic Impacts

Alternative	Historic Structures	Historic District	Locations of Historic Districts
1B	118	119.8 acres	Upper Lyman Warehouse District, Downtown Springfield Railroad District, Court Square Historic District, Quadrangle – Matton Street Historic District, Gunn and Hubbard Blocks, Lower Maple Street Historic District, Springfield Armory National Historic Site, McKnight Historic District, Benton Street Area, College – Cortland Streets Area, Byers Street Area, Lower Oak Grove Avenue Area, Mapledell- Montrose Streets Area, Andrew-Dawes-Cambridge Streets Areas, Winchester Square Historic District, Edgemont-Ionia Streets Area, Prospect Park – Dorman School Area, Ambrose Street Area, Wilton Street Area, Marsden Street Area
Hybrid	26	39.7 acres	Upper Lyman Warehouse District, Downtown Springfield Railroad District, Court Square Historic District, Quadrangle – Matton Street Historic District, Gunn and Hubbard Blocks, Lower Maple Street Historic District, Springfield Armory National Historic Site, College – Cortland Streets Area, Lower Oak Grove Avenue Area, Mapledell- Montrose Streets Area, Winchester Square Historic District, Prospect Park – Dorman School Area, Ambrose Street Area, Wilton Street Area, Marsden Street Area

3.6 AIR QUALITY

A screening-level analysis of air quality impacts associated with the project was conducted. Given the limited available data at this stage, ridership data and average transit trip length were used to calculate potential reductions in CO_2 emissions associated with the shift from passenger vehicles to the proposed BRT system.

Preliminary annual ridership projections for the proposed service are shown below in Table 43.

Table 43: Ridership Projections

Operating Year	Baseline: B7 Service	Scenario 1: Curbside Running		Scenario 2: Center Median Running	
	Trips/Yr	Trips/Yr	% Change	Trips/Yr	% Change
2015	1,280,507	-	-	-	-
Year 1 (System Opens)	-	1,420,082	10.9%	1,668,501	30.3%
Year 5 (Mature System)	-	1,663,379	29.9%	1,911,797	49.3%

The net change in ridership over the baseline is as follows:

- Hybrid: year 1, 139,575 new riders; year 5, 382,872 new riders;
- 1B: year 1, 387,994 new riders; year 5, 631,290 new riders.

The proposed BRT route is estimated to be 7.1 miles in length. If the average trip length per new rider is 3.55 miles (half of the route, to account for station-to-station trips vs. end-to-end trips), the passenger miles traveled are as follows:

- Hybrid, year 1: 495,491 miles; year 5: 1,359,196 miles;
- 1B 2, year 1: 1,377,379 miles; year 5: 2,241,080 miles.

For purposes of this analysis, these trips are considered to replace passenger vehicle trips of the same length.

EPA guidelines on converting vehicle miles traveled to greenhouse gas emissions[12] (in this case CO_2) indicate that the average vehicle has tailpipe CO_2 emissions of 411 grams per mile. Using this value provides the following results:

- Hybrid, year 1: 203.6 metric tons; year 5: 558.6 metric tons;
- 1B, year 1: 566.1 metric tons; year 5: 921.1 metric tons.

BRT service calculations indicate that the annual net increase in bus mileage associated with the BRT project is 39,034 miles. Using the same emissions rate of 411 grams/mile[13] yields a calculation of 16.1 metric tons/year associated with the additional BRT service. By subtracting this value from the various scenario results provided above, the annual net benefit of reduced CO_2 emissions from the proposed BRT project is as follows:

- Hybrid, year 1: 187.5 metric tons reduced ; year 5: 542.5 metric tons reduced;
- 1B 2, year 1: 550.0 metric tons reduced; year 5: 905.0 metric tons reduced.

[12] EPA-420-F-14-040a, Office of Transportation and Air Quality, May, 2014.
[13] Ibid: ("Diesel creates about 15% more CO_2 per gallon. However, many vehicles that use diesel fuel achieve higher fuel economy than similar vehicles that use gasoline, which generally offsets the higher carbon content of diesel fuel."

3.7 Noise and Vibration

As is mentioned in Section 4.1.1 (Land Use), there are many noise- and vibration-sensitive uses in the study area, including schools, churches, libraries, cemeteries, and thousands of residences. Therefore, the potential for noise and vibration impacts resulting from the project must be investigated. The noise and vibration analyses for this project are being performed in accordance with the latest version of the Federal Transit Administration's (FTA's) noise and vibration assessment guidelines,[14] as is typically required for proposed BRT projects. The noise impact criteria in the FTA guidelines are based on three levels of impact – no impact, moderate impact (with noticeable changes but not sufficient to cause adverse reactions), and severe impact (sufficient to cause adverse reactions) – with regard to three land use categories – highly sensitive (Category 1), residential (Category 2), and institutional (Category 3). Severe impact is typically the only category warranting noise mitigation consideration.

The noise impact limits are in terms of A-weighted sound pressure levels (dBA) and vary with existing background sound levels, so the determination of the existing background level at each noise-sensitive location is critical for identifying potential noise impacts. These background levels can be determined through calculations or measurements at representative locations. Background levels were calculated for this feasibility study but, due to the complex nature of land uses within the study area, these levels should be verified through measurements in later phases of the project. The calculation methods of background sound levels are prescribed in the FTA guidelines, based on either population density (in people per square mile) or existing surface vehicle traffic volumes and speeds.

As is mentioned in Section 4.2.1 (Population), population densities are consistently above 1,000 people per square mile in the study area and are above 10,000 people per square mile in much of the corridor. Any areas having less than 1,000 people per square mile in the study area are commercial/business areas or protected open space. Commercial areas are typically not considered to be noise- or vibration-sensitive and protected open space areas are typically not considered to be vibration-sensitive, although some of these areas may be noise-sensitive (such as parks and cemeteries). There are no interstate highways or rail lines within 500 feet of the project alignment, and only local roadways influence the background sound levels, so background levels in the project study area are estimated to average between 55 and 60 dBA based on population density estimates using the FTA calculation guidelines. The calculation of background levels based on traffic volumes (using FTA guideline methods) on State Street and Boston Road yields AM and PM peak hour levels of 59 dBA and 57 dBA at 50 feet, respectively, which agree with the 55 to 60 dBA estimate determined using the population density data.

The FTA severe noise impact criteria for background levels in the 55 to 60 dBA range translate to increases in sound levels of 3 to 6 dBA by the introduction of the proposed project (with a required increase of 3 dBA for background levels of 60 dBA and a required increase of 6 dBA for background levels of 55 dBA). The permitted magnitude of increase in sound levels decreases with increasing background levels. Limits in residential areas are in terms of 24-hour averaged sound levels (Ldn or day-night average levels, which add 10 dBA to levels occurring between 10 PM and 7 AM to account for the

[14] Hanson, C.E., Towers, D.A., and Meister, L.D. *Transit Noise and Vibration Impact Assessment*. Report Number FTA-VA-1003-06. Washington, DC: Federal Transit Administration, May 2006.

added sensitivity to sounds generated during normal sleeping hours) and limits in institutional areas are in terms of maximum hourly averaged values.

In the No Build condition, general traffic growth in the area is expected to occur at a rate of 1% per year through 2025, plus a new school and casino are planned to be opening in the study area. Traffic increases associated with these changes are calculated to increase average background levels by up to 1 dBA in the study area, which would not qualify as a noise impact at any noise-sensitive location. Therefore, no noise impacts are anticipated under the No Build Alternative.

Future project alternatives evaluated for this study were the 1B and Hybrid Alternatives. The 1B Alternative locates new buses in the median of the corridor and the Hybrid Alternative locates the buses in the outmost lanes closest to the curbs. These lane locations would only make a difference to noise levels within 50 feet of the project alignment, as their sounds would blend into a common level at farther distances. Alternative 1B would introduce a maximum of 7 new bus operations per hour, resulting in a maximum hourly energy-averaged (Leq) sound level of 48 dBA 50 feet from the bus lanes. The Hybrid Alternative introduces a maximum of 10 new bus operations per hour, also resulting in an hourly Leq of 48 dBA at 50 feet. Adding these to the No Build levels results in up to a 1 dBA increase over the existing levels in the study area, which will not yield any severe noise impacts for any uses more than 50 feet from the roadway. Although there are noise-sensitive uses within 50 feet of the roadway, impacts at specific locations would depend on the distances from the buses to each receptor, which will be evaluated at a later phase of this project.

There will be a minimal increase in noise for any use within 50 feet of the roadway and no impact beyond

Vibration impacts according to the FTA guidelines are in terms of absolute limits independent of existing levels. There are two levels of vibration impacts – one for the potential for structural damage and another for the potential for generating annoyance. Structural damage criteria are typically limited to heavy construction activities, such as blasting and pile driving, and vary depending on the types of building construction materials. Blasting and pile driving are not expected with this project and, even though there are historic structures close to the project alignment, the types of excavation activities expected for the construction of the project would not generate vibration levels approaching structural damage limits for any nearby buildings.

Vibration-related annoyance criteria use similar land use categories to those used for noise. Depending on the locations of excavation activities during the construction process, these types of limits may be exceeded at the closest vibration-sensitive locations but these impacts will be short in duration and temporary. Construction activities will also comply with the City of Springfield's noise ordinance (Title 7, Chapter 7.20, Section 259 of the City Code, amended 5-24-2007), which limits construction activities to weekday hours between 7 AM and 7 PM.

Vibration levels generated by the operations of the buses will not approach any annoyance or structural damage limits at any location in the study area.

3.8 Environmental Summary Findings

Table 44 summarizes the existing environmental resources within the study area for each of the alternatives. It should be noted that the presence of identified resources only indicates potential impacts. Final impacts will depend on which alternative is selected and the design for implementing the improvements. For example, improvements limited to the existing right-of-way would have minimal environmental impacts as the land is already disturbed. Before proceeding with any work within the corridor, it will be necessary to analyze each alternative more thoroughly to determine the specific level of impact the improvements would have.

Table 44: Summary of Environmental Impacts

	1 B		Hybrid	
	Quantity	Permitting	Quantity	Permitting
Open Space (Acre)	40.0	No	29.8	No
Natural Community (Acre)	3.5	No	3.5	No
Rare Wildlife Habitat (Acre)	3.48	Possible ENF	3.48	Possible ENF
Priority Habitats Rare Species (Acre)	22.96	Possible ENF	22.96	Possible ENF
Areas of Critical Environmental Concern (Acre)	0	No	0	No
Vernal Pools (Count)	1	Possible ENF	1	Possible ENF
Historic Structures (Count)	118	PNF, possible ENF	26	PNF, possible ENF
Historic Sites (Acre)	119.8	PNF, possible ENF	39.7	PNF, possible ENF
Wetlands (Acre)	18.92	ENF, Chapter 91 permit, OC	17.34	ENF, Chapter 91 permit, OC
River/Stream (L.F.)	1,403	ENF	1,403	ENF
FEMA Floodplain (Acre)	4.28	OC[15]	4.28	OC
Surface Water Protection Supply (Acre)	0	No	0	No
Reservoirs (Acre)	0	No	0	No
Class A public water supplies (Acres)	0	No	0	No
Scenic and Wild River	No	No	No	No

[15] Order of Conditions as outlined in the Massachusetts Wetlands Protection Act

Chapter 4: Social Conditions

This chapter examines the potential impacts on social conditions in the study area. It examines physical effects on the built environment and identifies potential benefits and impacts on population, employment, and business operations. Specifically, this chapter includes the following sections of analysis:

- Land Use, Zoning, Public Policy
- Socioeconomic Conditions
- Historic Characteristics

4.1 Land Use, Zoning and Public Policy

4.1.1 Land Use

Land use data was obtained from the accessor's data for all parcels within ½ mile of the corridor, and coded into 8 categories based on the attributes available. Overall, the land use study area is composed of a variety of uses. The largest use (not including roadways) is residential (39%) and is located throughout the corridor but concentrated in the eastern end of the study area on connecting streets (Figure 54). Along the main corridor the main uses are commercial and civic, which includes schools, churches, libraries and community buildings. The largest node of commercial is at the eastern end by the Eastfield Mall and several big box stores. Downtown (Main Street) is predominantly a mix of commercial and civic.

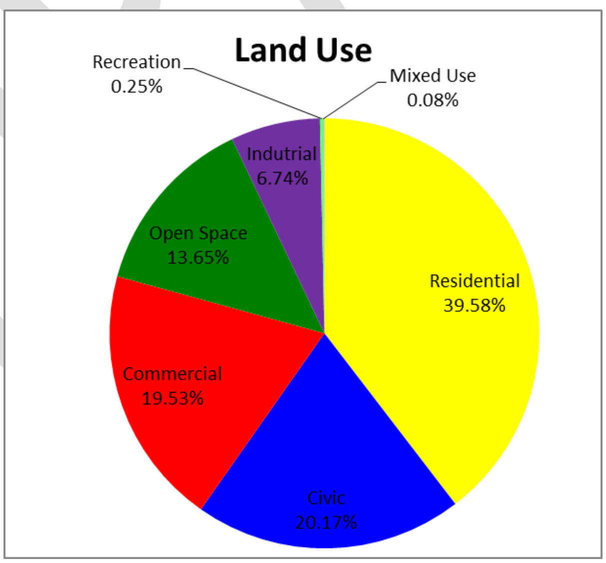


Figure 53: Percentage of Land Use Along the Corridor

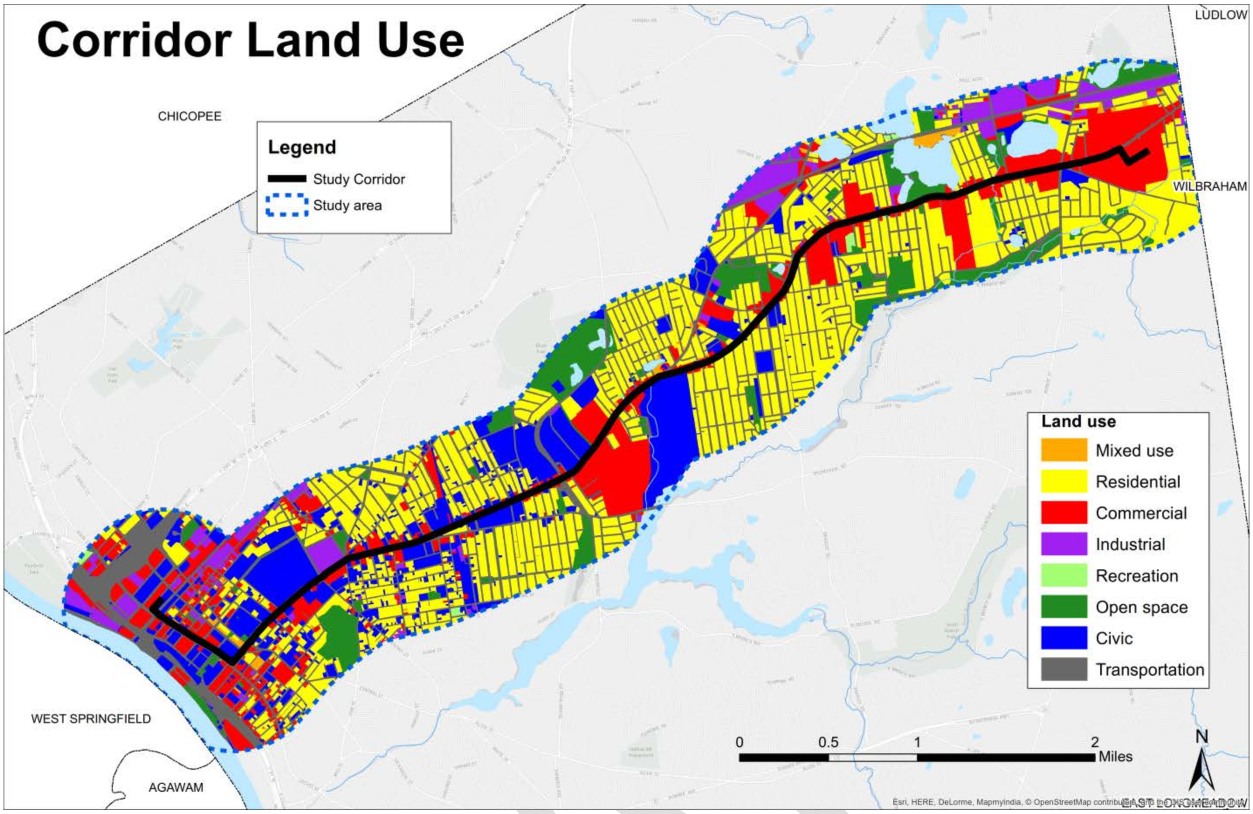


Figure 54: Corridor Land Use

4.1.2 Zoning

There are a number of zoning districts within the land use study area, most of which allow for high density residential and commercial development. Overall the zoning matches the land use along the corridor. The majority of the corridor is zoned as business with a small segment along State Street between Walnut and Chestnut Streets zoned as Neighborhood Commercial (Com A). Downtown is zoned as Central Business (Bus C) while the remainder of the corridor zoned as business is General Business (Bus A). Both business districts are pedestrian oriented shopping districts with the main difference being Bus C does not require setbacks and encourages high intensity uses where are Bus A is for neighborhood shopping along major roads. Residential areas closer to downtown are zoned as Urban Residential (Res B), which is a mix of single and two-family dwellings. The eastern end is zoned Low Density Residential (Res A) and are primarily single-family detached dwellings.

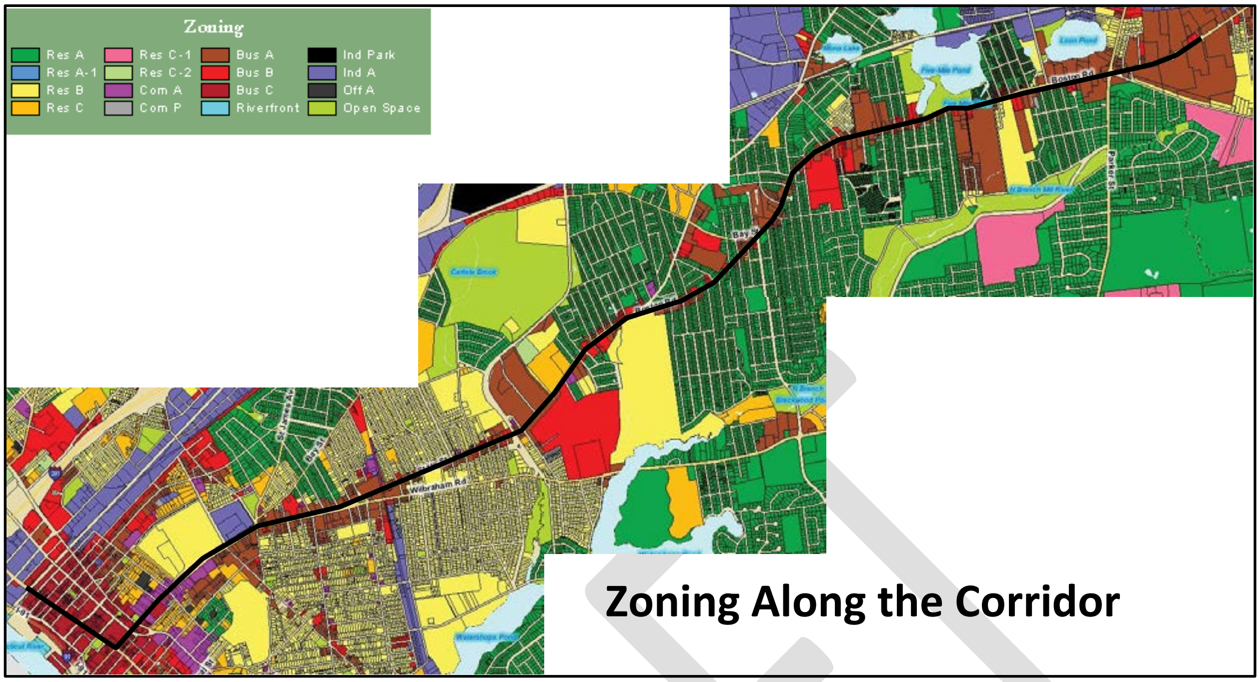


Figure 55: Zoning Map of Study Corridor

4.1.3 Public Policy

There are a number of public policy initiatives that apply to the land use study area or to the transit-nature of the proposed project. Some policies are citywide initiatives while others are more localized undertakings. The following are the policies that are specific to the corridor or relevant to the Proposed Project as well as general citywide initiatives that apply to either:

Comprehensive Service Analysis (CSA) - Implementing BRT service following PVTA's B7 (State Street Route) was a top recommendation for improving service.

Springfield Complete Streets Implementation Guide – Recommends a transit corridor with dedicated bus way along State Street and Boston Road. The transit corridor includes a proposed BRT line.

Figure 56: Springfield Complete Street Transit Corridor with BRT

4.2 Socioeconomic Conditions

4.2.1 Population

Population statistics were gathered for the land use study area[16], which was defined as 1/2 mile on either side of the study corridor. There are 42,074 residents living in 18,169 households within the Study Area. The density varies along the corridor but is consistently above 1,000 people per square mile (Figure 57). Examination of areas with less than 1,000 people per square mile indicates these are commercial/business areas or protected open space.

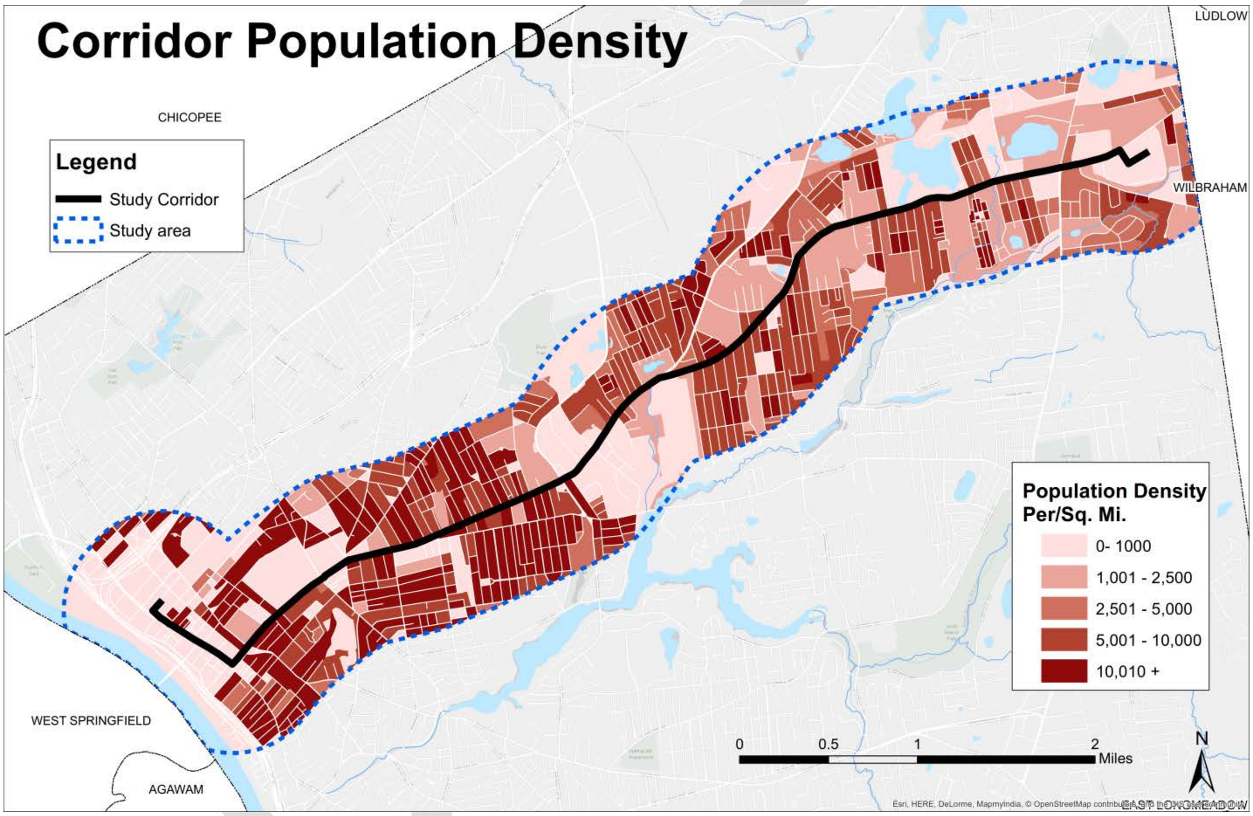
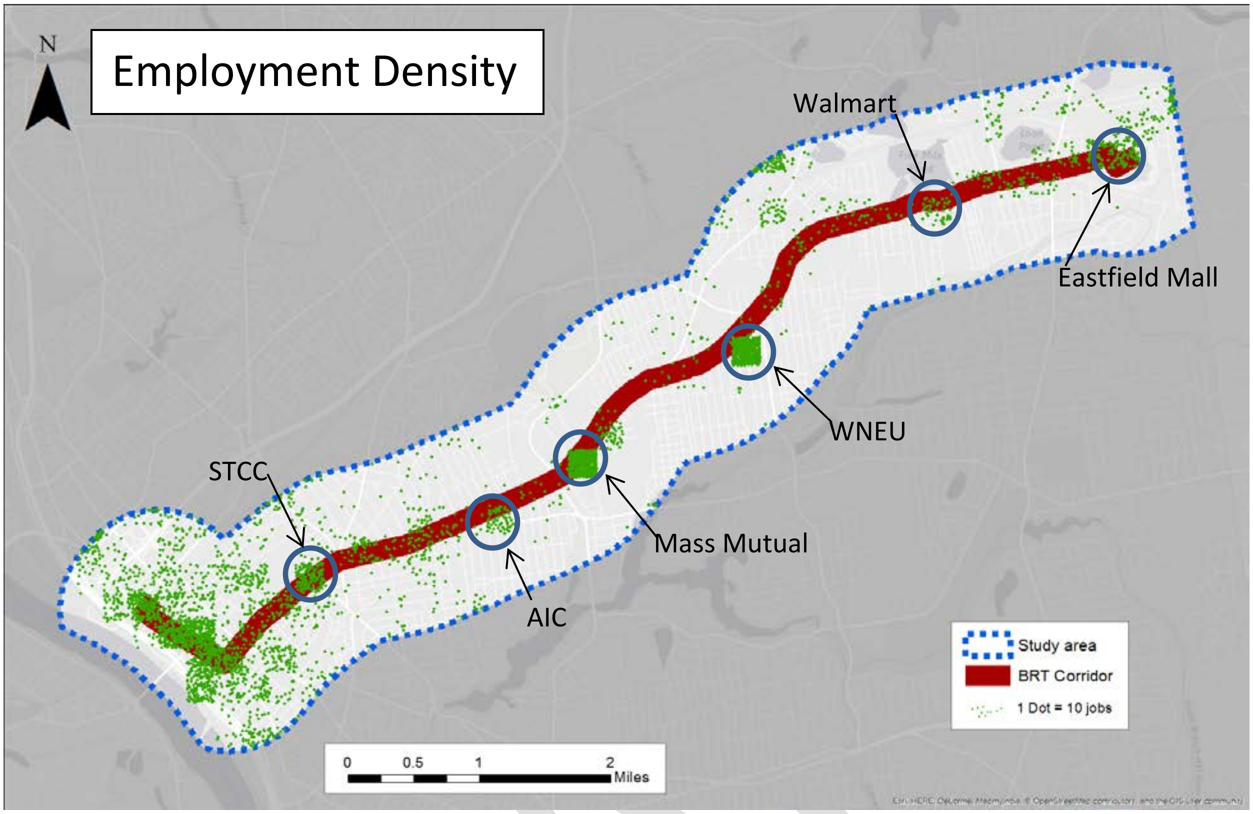


Figure 57: Corridor Population Density

4.2.2 Employment

Employment data shows that within the study area there are 38,743 jobs. The majority of the jobs, 68.4% or 26,504, are located on the corridor. The highest concentration of jobs are downtown. There are also large clusters at Springfield Technical Community College, American International College, Mass Mutual and the Eastfield Mall. Due to the constraints of the data a cluster also shows up along Breckwood Boulevard which incorporates employment from Western New England University.

[16] Data was obtained from the 2010 Census



4.2.3 Environmental Justice

A screening was undertaken to identify the potential environmental justice impacts of the Proposed Project as required by Executive Order 12898, Federal Actions, to address Environmental Justice in Minority Populations and Low-Income Populations (*Federal Register* 59, February 11, 1994) and in accordance with the Council on Environmental Quality (CEQ) and U.S. Department of Transportation (USDOT) guidance. An environmental justice study area was defined as ½ -mile around the corridor. Based on the CEQ and USDOT guidance, low-income and minority (collectively, "environmental justice") communities were identified in the environmental justice study area based on the following criteria:

- Minority communities: USDOT Order 5610.2 defines minorities to include American Indians or Alaskan Natives, Asian and Pacific Islanders, African Americans, and Hispanic persons. This environmental justice analysis also considers minority populations to include persons who identified themselves as being either "some other race" or "two or more races" in the Census 2010. Minority populations were identified where the minority population of the affected area exceeds 25 percent.

- Low-income communities: USDOT Order 6640.23 defines low-income as "a household income at or below the Department of Health and Human Services (HHS) poverty guidelines." The percent of individuals below poverty level in each census block group, available in the 2010 U.S. Census was used to identify low-income communities. To determine whether a block group is a low-income community, the percentage of its population below the poverty level was compared to the average for Massachusetts as a whole. Block groups in the study area that have a population below the poverty level of $40,673 were considered low-income communities.

The environmental justice study area is comprised of 52 Census block groups, all block groups meet the criteria for environmental justice populations. The corridor has 77% of the population which meets both the minority and income thresholds for environmental justice, 19% meets just the minority and 4% just the income (Figure 58). The proposed BRT project will improve transit access along the corridor, benefiting the population within the environmental justice study area. Therefore, the proposed project would not result in any significant adverse effects on minority and low-income populations or any disproportionate adverse effects on environmental justice communities.

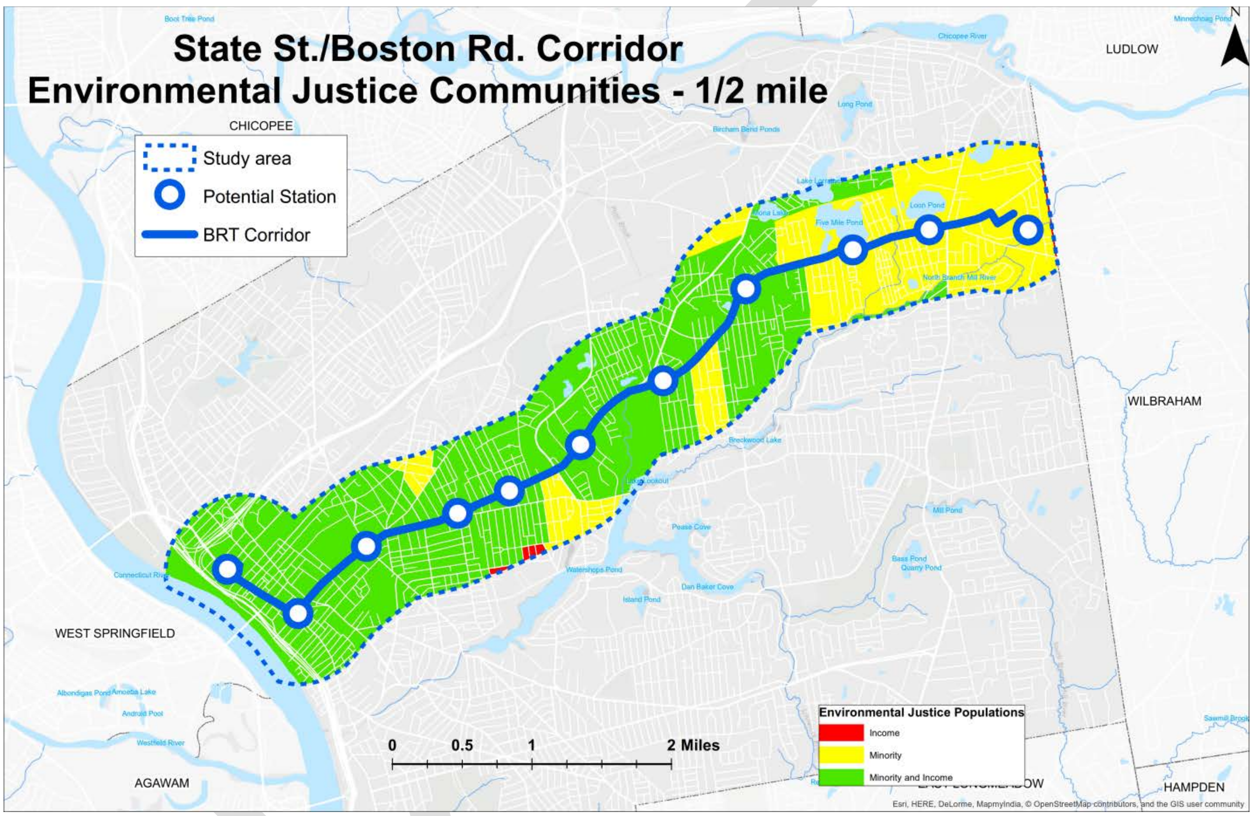


Figure 58: Environmental Justice Communities

4.3 Historical Characteristics

There are 443 properties along the corridor of which 51 are listed on the State Register of Historical Places and 22 of these are listed on the National Register according to accessor's data. Historical structures data show that there are over 120 historic structures in the study area. The majority of the historic sites and structures are located in the western corridor.

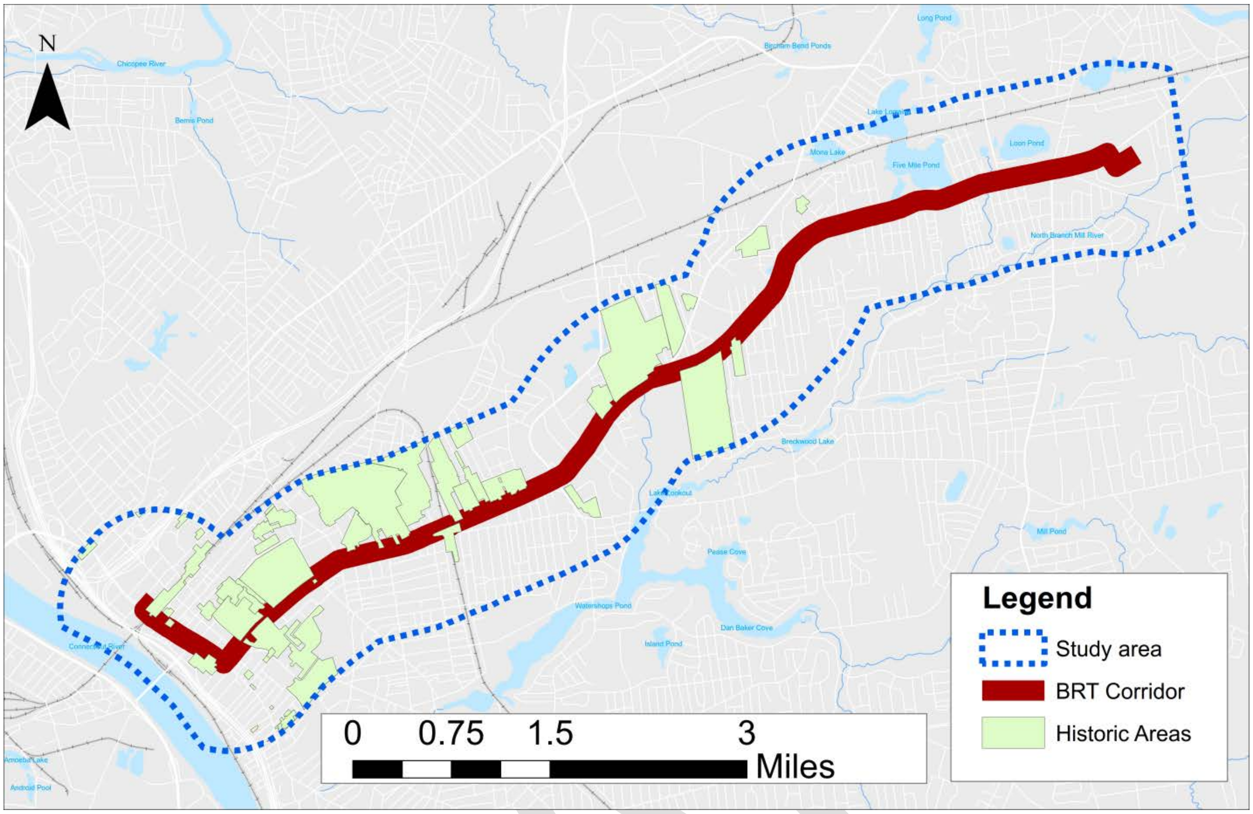


Figure 59: Historic Properties Along the Corridor

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Chapter 5: Traffic Analysis

This chapter focuses on a review of the existing and future traffic conditions for the Study Area and the potential traffic impacts associated with the two preferred BRT alternatives. Field visits were performed, field observations made, traffic data collection coordinated, existing bus operations observed, data available from the City, MassDOT, and the Pioneer Valley Planning Commission (PVPC) was reviewed, and past design efforts were reviewed. Using this data, and in collaboration with information from other chapters in this report, an assessment of the traffic was performed of the Study Area intersections and corridor as a whole. The result of this effort are described in greater detail below. This chapter will also provide a more detailed review of the Multi-Modal Level-of-Service (MMLOS) analysis. This assessment was performed of the Study Area intersections and the corridor as a whole.

5.1 Existing Conditions

The following section provides a description of the existing traffic conditions within the study area, including descriptions of the corridors and intersection geometry, safety analysis and traffic operations.

5.1.1 Study Area Intersections

The Project Study Area consists of the major intersections along the State Street and Boston Road corridors. In general, the traffic analysis for this Project extends from Main Street in Downtown to the Eastfield Mall. Ten (10) of the busier or more congested intersections are included in this Study; however, it is noted that there are 26 additional signalized intersections along the corridor(s) that were not assessed as part of this Project.

Figure 60 shows the intersection geometry of all of the study area intersections; in addition, the intersections that were not studied are shown.

The study area intersections are listed in Table 45 below. Each of these intersections have a traffic signal; however, the following is noted for two of the locations:

- The signalized intersection at Eastern Avenue/ Wilbraham Road (location 6b in the table below) was included as part of this assessment since it is located very close to the intersection of State Street at Eastern Avenue (location 6a in the table below), and they are coordinated.

- The unsignalized intersection of Saint James Avenue at Magazine Street (location 5b in the table below) was included as part of this assessment since it is located very close to the intersection of State Street/ Saint James Avenue (location 5a in the table below).

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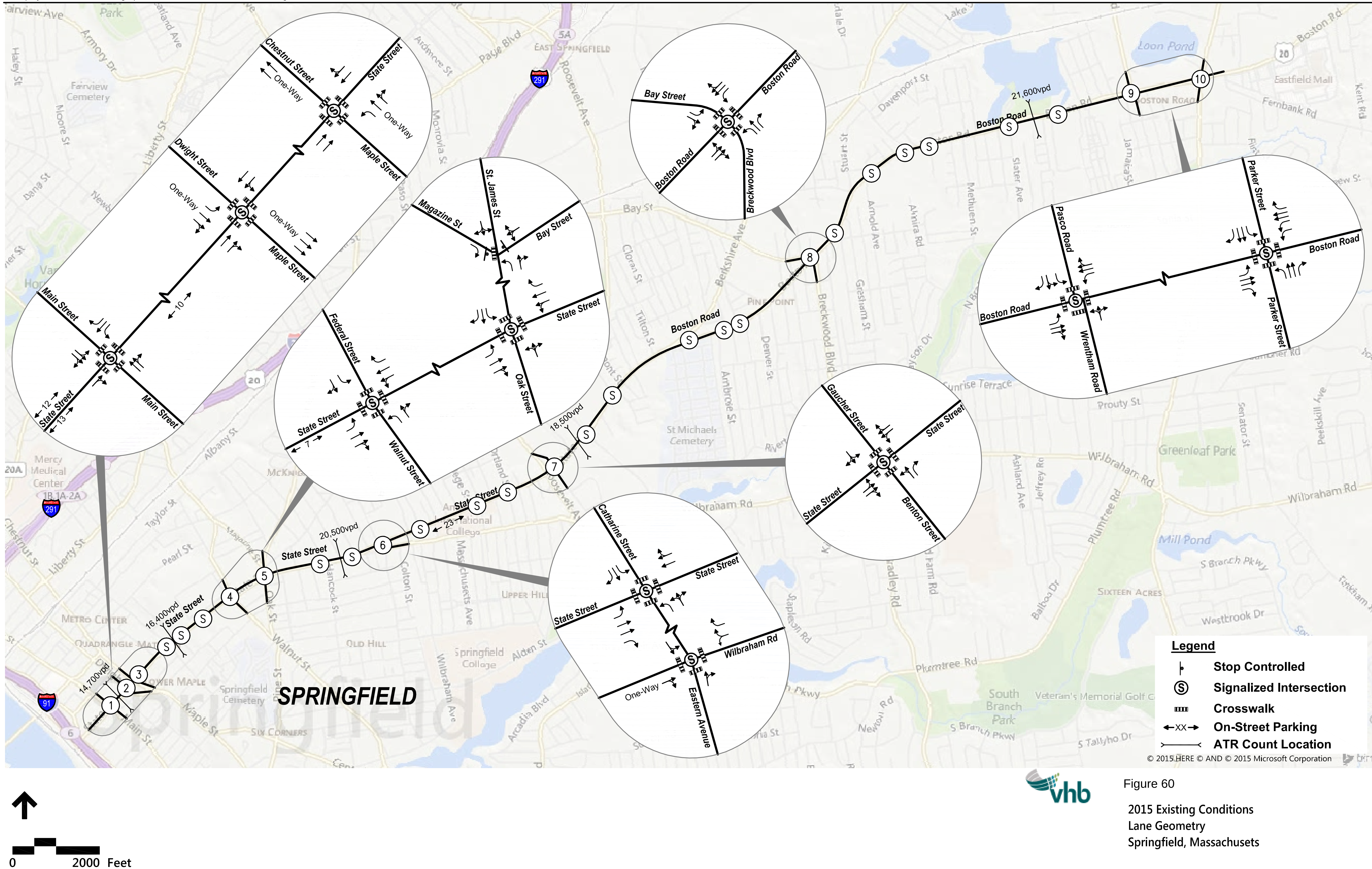

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Figure 60

2015 Existing Conditions
Lane Geometry
Springfield, Massachusets

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Table 45: Study Area Intersections

	Intersection Name
1.	State Street at Main Street (signalized)
2.	State Street at Dwight Street and Maple Street (signalized)
3.	State Street at Chestnut Street and Maple Street (signalized)
4.	State Street at Federal Street (signalized)
5a.	State Street at Saint James Avenue and Oak Street (signalized)
5b.	Saint James Avenue at Magazine Street and Bay Street (unsignalized)
6a.	State Street at Catharine Street and Eastern Avenue (signalized)
6b.	Eastern Avenue at Wilbraham Road (signalized)
7.	State Street at Gaucher Street and Benton Street (signalized)
8.	Boston Road at Bay Street and Breckwood Avenue (signalized)
9.	Boston Road at Pasco Street (signalized)
10.	Boston Road at Parker Street (signalized)

Note: locations are denoted by a letter "a" or "b" following the intersection number to indicate close proximity.

5.1.2 Existing Traffic Signal Conditions

A review of the existing traffic signal equipment at the 10 Study Area intersections along State Street and Boston Road was conducted to evaluate existing operations. During this review traffic signal timing, phasing, lane geometry, etc. was obtained. The following provides a brief summary of some of these findings.

State Street

The intersections along State Street were re-constructed in 2009. Over the last six years, adjustments to the traffic signals have been made to accommodate the change in traffic flow, new development, increase in demand, etc. The following provides a summary of some of our findings from field reviews/ investigations:

- The traffic signal cycle lengths range from 90 to 183 seconds.
- Pedestrian phases are protected.
- All but two of the study area intersections are running free (i.e. not part of a coordinated system).
- Transit Signal Priority (TSP) is currently incorporated within the signal infrastructure for all of the Study Area intersections. It is noted that TSP is different from an emergency pre-emption system in that it uses a different frequency. To enable the current TSP, the software in each signalized controller would need to be reviewed to determine if it is compatible with systems in the PVTA buses. Some calibration between the signal controller and buses could be needed.
- The existing signal equipment is in good condition overall.
- Vehicle operating speeds were observed along the corridor and range from 13 to 40 mph. The posted speed limit is between 30 mph and 35 mph.

Boston Road

Boston Road will often be referenced in this report as two separate corridors since the most easterly section of the corridor (east of Pasco Road) was reconstructed in 2015. The section from Pasco Road to Berkshire Avenue (at State Street) was reconstructed in the 1990's, and has the greatest opportunity for change. The following provides a summary of some of our findings from field reviews/ investigations for each section:

Boston Road: Pasco Road to Eastfield Mall

- The traffic signal cycle lengths on this segment are 110 seconds.
- Pedestrian phases are protected.
- All signals are currently running as part of a coordinated system.
- TSP is currently incorporated in all of the Study Area intersections.
- The signal equipment along this segment is new, having been installed in 2015.
- Vehicle operating speeds were observed along the corridor and range from 25 to 45 mph. The posted speed limit is between 30 mph and 35 mph.

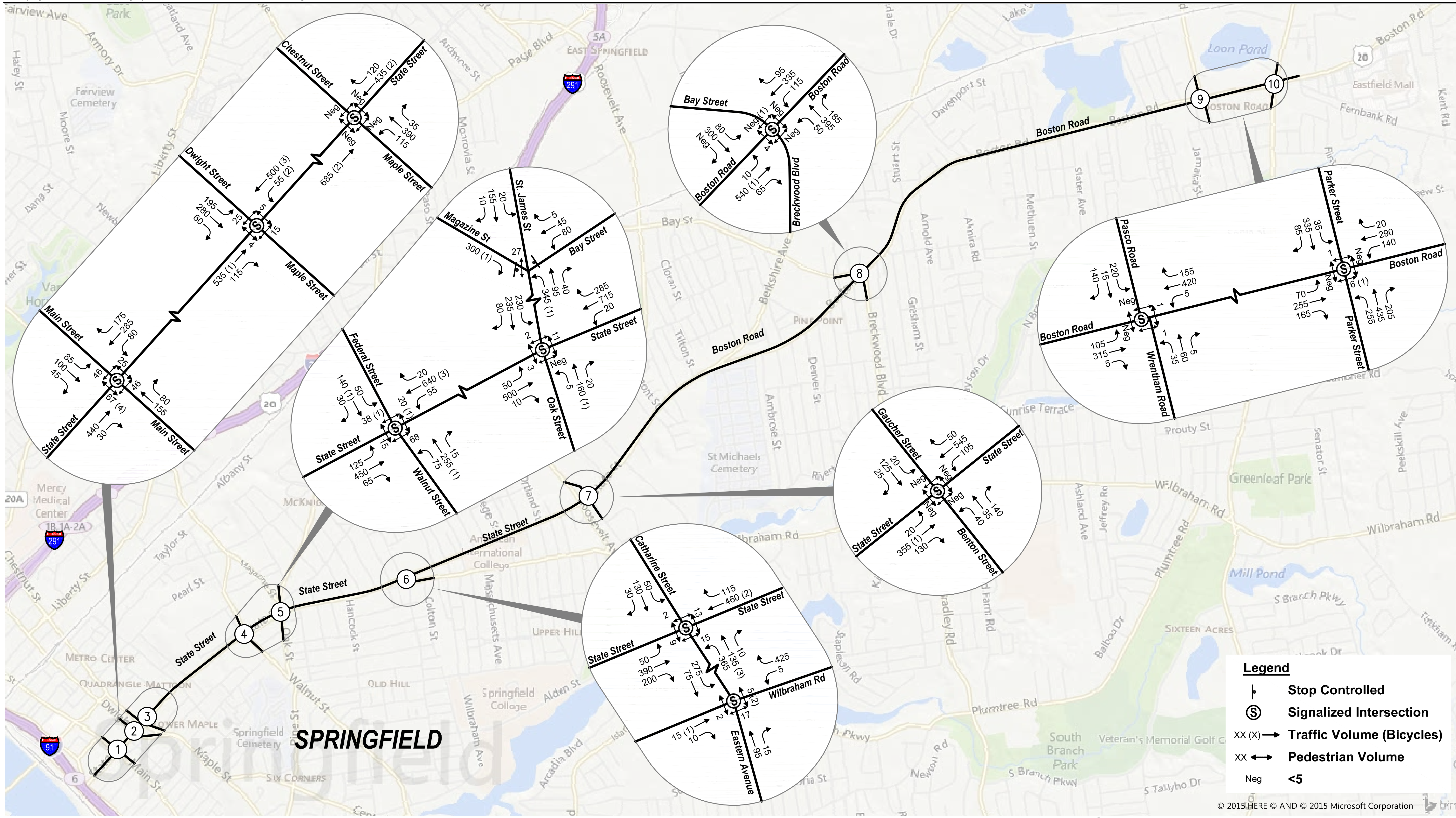
Boston Road: Berkshire Avenue (at State Street) to Pasco Road

- The traffic signal cycle length for Bay Street at Boston Road is 90 seconds.
- Pedestrian phases are protected.
- All other intersections appear to be running free (i.e. not part of a coordinated system).
- TSP is not incorporated in any of the Study Area intersections.
- The signal equipment along this segment is in fair condition, with equipment at some locations having been installed more recently than in others.
- Vehicle operating speeds were observed along the corridor and range from 20 to 40 mph. The posted speed limit is between 30 mph and 35 mph.

5.1.3 Observed Traffic Volumes (Year 2015)

Manual turning movement and classification (TMC) counts were collected at the study area intersections during a typical weekday morning (7:00 AM – 10:00 AM) and evening (3:00 PM – 6:00 PM) peak period. These count periods were selected based on historic traffic counts collected along the corridor for other projects. The counts were conducted on June 17th and June 18th in 2015. The morning and evening peak hours for the study area intersections vary by location. The network peak hours were determined to be from 7:45 AM to 8:45 AM in the weekday morning and from 4:30 PM to 5:30 PM in the weekday evening. The raw traffic count data for each intersection is included in Appendix E. The 2015 weekday morning and 2015 evening peak hour traffic volumes are illustrated in Figure 61 and Figure 62, respectively.

In addition to peak hour traffic period traffic counts, daily automatic traffic recorder (ATR) counts were collected along State Street and Boston Road on June 16th and 17th. The results of these ATR counts are displayed in Figure 60 and summarized in Table 46.



0 2000 Feet

NOTES:
1. VOLUMES REFLECT NETWORK PEAK 7:45AM TO 8:45AM.
2. COUNTS WERE PERFORMED BY INNOVATIVE DATA, LLC. IN JUNE OF 2015 ON THE 17TH AND 18TH.

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Figure 61

2015 Existing Conditions
Weekday Morning Peak Hour
Traffic Volumes
Springfield, Massachusets

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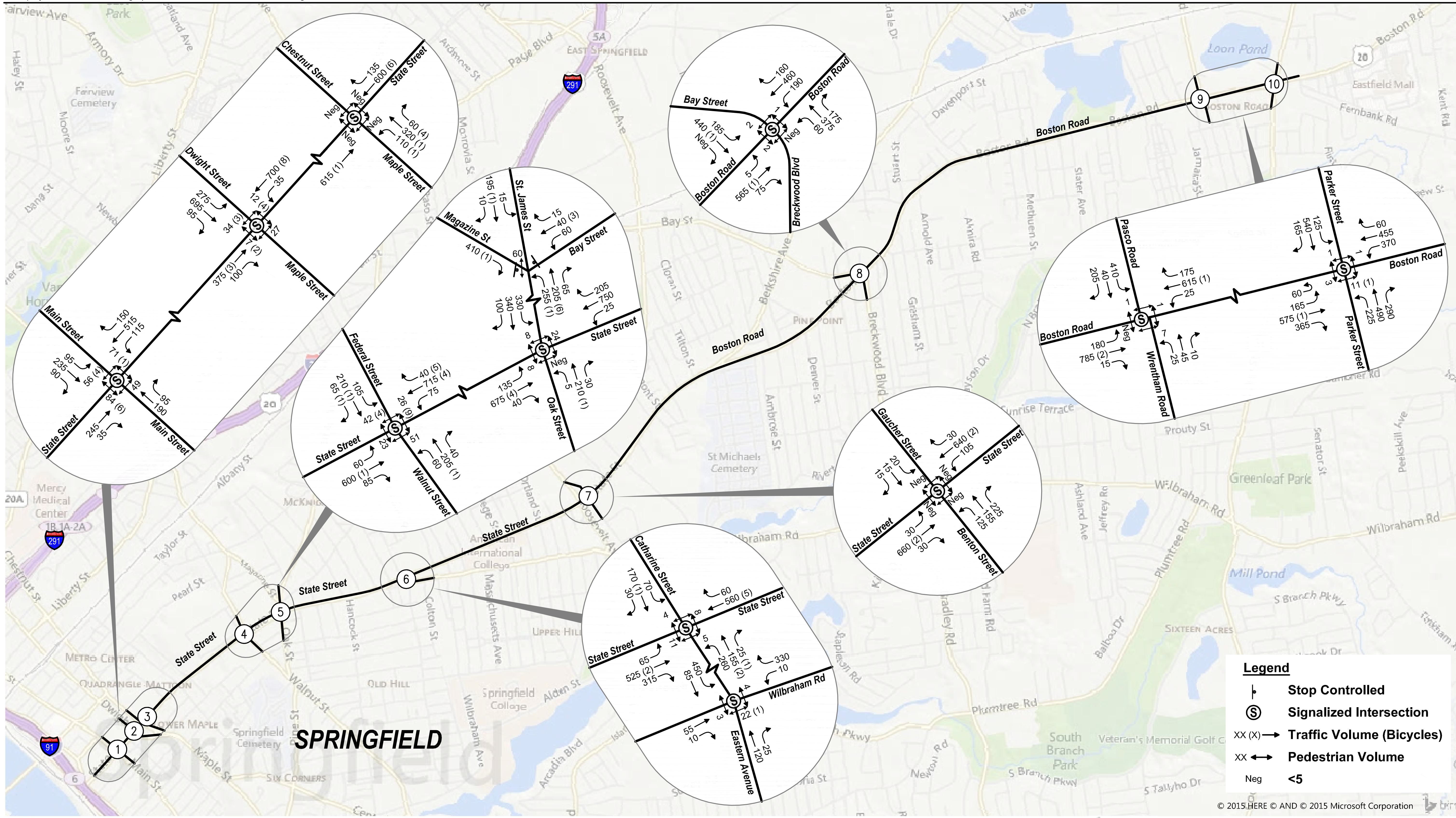

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NOTES:

1. VOLUMES REFLECT NETWORK PEAK 4:30PM TO 5:30PM.
2. COUNTS WERE PERFORMED BY INNOVATIVE DATA, LLC. IN JUNE OF 2015 ON THE 17TH AND 18TH.

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Figure 62

2015 Existing Conditions
Weekday Evening Peak Hour
Traffic Volumes
Springfield, Massachusets

Table 46: ATR Summary

Location	Daily [a] Weekday	Weekday Morning Peak Hour Volume	K Factor	Dir. Dist.	Weekday Evening Peak Hour Volume	K Factor	Dir. Dist.
Boston Road West of Shumway Street	21,600	1,135	5.2%	EB 52%	1,600	7.4%	EB 51%
State Street West of Byers Street	16,400	1,130	6.9%	EB 52%	1,340	8.2%	EB 54%
State Street East of Main Street	14,700	1,140	7.8%	EB 51%	1,190	8.1%	EB 64%
State Street East of Westminster Street	20,500	1,355	6.6%	EB 52%	1,460	7.1%	EB 57%
State Street At MassMutual	18,500	1,140	6.2%	WB 58%	1,475	8.0%	EB 56%

Source: Innovative Data, LLC. Based on automatic traffic recorder (ATR) counts conducted in June 2015

a average daily traffic (ADT) volume expressed in vehicles per day

b peak period traffic volumes expressed in vehicles per hour

c percent of daily traffic that occurs during the peak period

d directional distribution of peak period traffic

Note: peak hours do not necessarily coincide with the peak hours of the individual intersection turning movement counts

5.1.4 Safety Assessment

To identify crash trends and/or roadway deficiencies in the study area, crash data for the Study Area intersections were obtained from MassDOT's database for the most recently available three-year period (2011-2013) and are summarized in Table 47. Historically, the MassDOT database did not always capture all of the crashes occurring at local intersections or private driveways. So it is likely that additional crashes may have occurred during this time period but were not reported or otherwise not included in the MassDOT database. MassDOT reports vehicle crashes with damage greater than $1,000 or personal injury occurrences, which can give a good indication of safety along the study corridor. Overall, the information presented in Table 47 should provide a fair representation of the current incident experience for the Study Area intersections.

Table 47: Crash Summary

Intersection	2011-2013 Total Crashes	Crash Rate	HSIP Cluster
1. State Street at Main Street (signalized)	41	1.70	Yes
2. State Street at Dwight Street and Maple Street (signalized)	29	0.93	Yes
3. State Street at Chestnut Street and Maple Street (signalized)	50	1.99	Yes
4. State Street at Federal Street (signalized)	47	1.71	Yes
5a. State Street at Saint James Avenue and Oak Street (signalized)	74	1.90	Yes (Top 200)
5b. Saint James Avenue at Magazine Street and Bay Street (unsignalized)	27	1.55	Yes
6a. State Street at Catharine Street and Eastern Avenue (signalized)	40	1.31	Yes
6b. Eastern Avenue at Wilbraham Road (signalized)	11	0.74	No
7. State Street at Gaucher Street and Benton Street (signalized)	42	1.50	No
8. Boston Road at Bay Street and Breckwood Avenue (signalized)	58	1.57	Yes (Top 200)
9. Boston Road at Pasco Street (signalized)	62	1.94	Yes
10. Boston Road at Parker Street (signalized)	65	1.22	Yes (Top 200)

Source: MassDOT

The MassDOT average crash rates for signalized and unsignalized intersections for District 2 (the MassDOT district designation for Springfield) are 0.82 and 0.68, respectively. The crash rates represent the number of reported crashes for every million vehicles that pass through an intersection, the higher the crash rate, the more crashes have been experienced at a particular intersection. In Table 47 above, it can be seen that all of the study area intersections have a crash rate higher or equal to the state average, with the exception of the intersection of Eastern Avenue at Wilbraham Road (location 6b).

In addition, ten of the twelve study area intersections are classified by MassDOT as Highway Safety Improvement Program (HSIP) Clusters, of which three rank on the top 200. Locations identified as HSIP clusters are eligible to receive HSIP funds for the construction of safety-related improvements.

5.1.5 Travel Time Runs

Vehicle Travel Time Runs

To help assess existing traffic operations at the study area intersections, and to identify areas of traffic congestion, travel time data for all vehicles (buses are discussed in the next section) traveling the corridor was collected along a portion of the State Street and Boston Road corridors. Travel time observations were made on typical weekday morning and typical weekday evening peak periods in June

2015; in coordination with the count periods where traffic volumes were collected. The following provides a summary of the travel run limits:

Corridor Segment 1: State Street from the intersection of Main Street to the intersection of Benton Street at Gaucher Street.

Corridor Segment 2: State Street and Boston Road from the intersection of Benton Street and Gaucher Street (at State Street) to the intersection of the Eastfield Mall driveway across from Lowes (at Boston Road).

The corridor was driven at the speed of existing traffic or at the posted speed limit. A GPS device was used to record the time, speed, and position along the corridor. The overall results of these travel times are presented in Table 48.

Table 48: Existing Conditions Vehicle Peak Commute Period Travel Times

	Corridor Distance (Miles)	Average Travel Time (Minutes)[1]		Average Speed (MPH)	
Corridor		AM Peak	PM Peak	AM Peak	PM Peak
Corridor Segment 1					
Outbound – Via State Street	2.2	7.7	9.9	17.1	13.3
Inbound – Via State Street	2.2	8.4	7.4	15.7	17.8
Corridor Segment 2					
Outbound – Via Boston Road	3.9	8.0	10.3	29.3	22.7
Inbound – Via Boston Road	3.9	9.7	10.1	24.1	23.2

Source: Compiled by VHB based on travel time runs performed by VHB in June 2015
1 Average travel time along the corridor, including delays caused by traffic signals.

The running speeds observed during the travel time runs provide an idea of the congestion present along the various segments of the corridor. As would be expected, speeds decreased the closer the vehicle got to the central business district, which also reflects the higher density of signalized intersections along State Street compared to Boston Road. In addition, the speeds were lowest along both segments during the PM peak hour, which sees higher overall traffic volumes.

PVTA Bus Travel Time Runs

To provide a better understanding of the travel times for the existing buses, PVTA provided GPS data for the running times along route B7. The average weekday peak hour travel times for the PVTA buses along State Street and Boston Road, as defined in the previous section, are presented in Table 49.

As is shown in Table 48, the average speeds of the PVTA buses are slower than general traffic which is to be expected, due to the numerous stops each bus makes. It should be noted that the bus speeds are substantially slower in the inbound direction on State Street than Boston Road. A cross reference with ridership by stop data shows that these stops have a higher activity, in particular boarding, which increases dwell time at stops resulting in lower operating speeds.

Table 49: Existing Conditions Bus Peak Commute Period Travel Times

Corridor	Corridor Distance (Miles)	Average Travel Time (Min)[1]		Average Speed (MPH)	
		AM Peak	PM Peak	AM Peak	PM Peak
Corridor Segment 1					
Route B7 Outbound – Via State Street	2.2	12.4	17.2	10.6	7.7
Route B7 Inbound – Via State Street	2.2	17.5	17.8	7.5	7.4
Corridor Segment 2					
Route B7 Outbound – Via Boston Road	3.9	28.0	35.2	8.4	6.7
Route B7 Inbound – Via Boston Road	3.9	17.9	24.3	13.1	9.6

Source: PVTA GPS Data for Route B7

1 Average travel time along the corridor, including delays caused by traffic signals and bus operations.

5.2 Future Traffic Volumes (Year 2025)

The next step in understanding impacts associated with any project is to evaluate how the existing transportation system will function in the future. Therefore, future transportation conditions, including recommended traffic signal and roadway geometry improvements, and there impacts to overall transportation operations are discussed and evaluated in this section.

Traffic growth on area roadways is a function of the expected land development, economic activity, and changes in demographics. A frequently used procedure is to estimate traffic that could be generated by a planned new major development that potentially affects the Study Area roadways. An alternative procedure is to estimate an overall area annual percentage increase and apply that increase to the study area traffic volumes. For the purpose of this assessment both methods were used.

To estimate future traffic volumes, an annual growth rate of one percent per year was used (compounded over a 10-year period) along with adding the site specific traffic for the MGM Casino and a proposed Charter School located at One Federal Street. The annual growth rate, which was selected to be consistent with recent traffic studies conducted in the area, accounts for any additional development sites that were unknown or not planned at the time of this study. More details on the site specific growth is summarized in the next section.

5.2.1 Site Specific Growth

The MGM Casino is anticipated to have a significant traffic impact in the Springfield area. As part of the Final Environmental Impact Report (FEIR) for the MGM Springfield (EEA#15033), traffic volumes were projected along the State Street corridor.

In general, it was anticipated in the FEIR that approximately 200 trips (90 eastbound and 110 westbound) would be added to the State Street corridor during the weekday evening peak hour. For the morning peak hour trips, it was considered that many of the traffic generating uses of the casino would not be in use and therefore this study estimated (using the FEIR report) that morning peak hour volumes would only be around 17-percent of the evening peak hour volumes (or 34 trips).

The Charter School development is the rehabilitation of an existing building within the STCC Technology Park at One Federal Street. This project is anticipated to add 110 trips during the morning peak hour and 35 trips during the evening peak hour.

The trips associated with these developments were distributed to the existing traffic network either based on the distribution assumptions summarized in the FEIR or proportionally based on the existing traffic volumes collected as part of this study.

5.2.2 Future Traffic Volumes

The one percent per year annual growth rate and the trips for the known developments were added to the 2015 Existing traffic volumes to develop the projected 2025 Future weekday morning and evening peak hour traffic volumes, which can be seen in Figure 63 and Figure 64, respectively.

5.3 Traffic Operations: No Build

5.3.1 Traffic Signal Capacity Analysis

Level-of-Service Criteria

Level-of-service (LOS) is the term used to denote the different operating conditions which occur on a given roadway segment under various traffic volume loads. It is a qualitative measure of the effect of a number of factors including roadway geometrics, speed, travel delay, freedom to maneuver, and safety. Level-of-service provides an index to the operational qualities of a roadway segment or an intersection. Level-of-service designations range from A to F, with LOS A representing the best operating conditions with little or no delay and LOS F representing the worst operating conditions with highly congested operations and long delays. The evaluation criteria used to analyze area intersections are based on the 2000 Highway Capacity Manual.

Capacity Analysis Results

Capacity analyses were conducted for the signalized intersections included in this study area for existing conditions and for future traffic conditions with no improvements to the corridor for BRT, referred to as “No Build”. The traffic signal timings used for the existing and no build analysis were based on extracted traffic signal controller data obtained by VHB in June of 2015. Summaries of the 2015 Existing and 2025 No Build signalized intersection capacity analyses results are presented for the weekday morning peak hour and the weekday evening peak hour in Tables 6 and 7.

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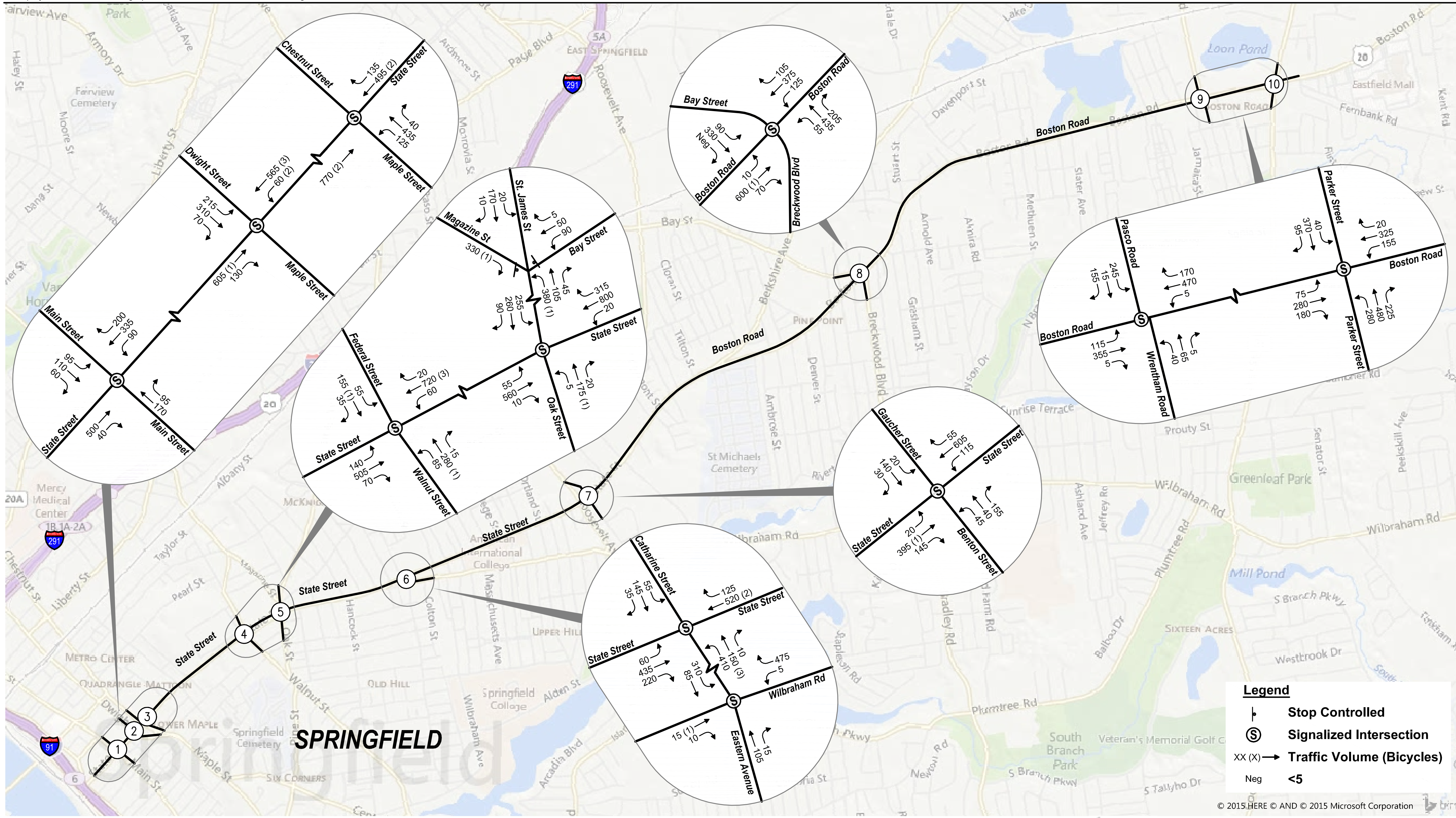

0 2000 Feet

NOTES:

1. VOLUMES REFLECT NETWORK PEAK 7:45AM TO 8:45AM.
2. 1% ANNUAL GROWTH OVER 10-YEARS WAS APPLIED TO DEVELOP THE FUTURE CONDITIONS NETWORK.
3. MGM TRIPS AND CHARTER SCHOOL TRIPS WERE BOTH APPLIED TO THE ROADWAY NETWORK.

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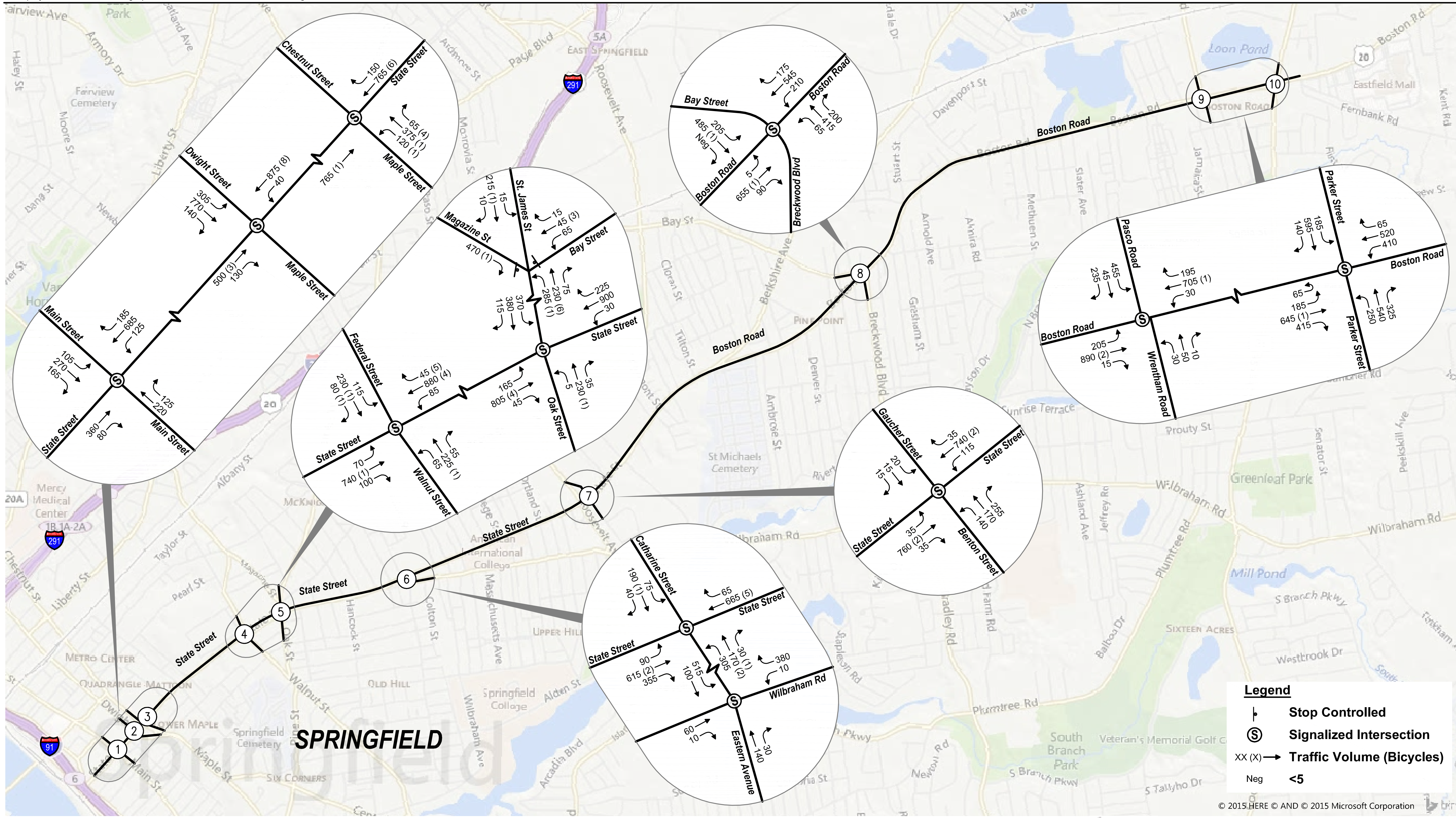
Figure 63

2025 Future Conditions
Weekday Morning Peak Hour
Traffic Volumes
Springfield, Massachusets



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NOTES:
1. VOLUMES REFLECT NETWORK PEAK 4:30PM TO 5:30PM.
2. 1% ANNUAL GROWTH OVER 10-YEARS WAS APPLIED TO DEVELOP THE FUTURE CONDITIONS NETWORK.
3. MGM TRIPS AND CHARTER SCHOOL TRIPS WERE BOTH APPLIED TO THE ROADWAY NETWORK.

Figure 64

2025 Future Conditions
Weekday Evening Peak Hour
Traffic Volumes
Springfield, Massachusets

Table 50: Capacity Analysis Weekday Morning

(1 of 3)

		2015 Existing Conditions			2025 No Build Conditions		
Intersection	Lane Group	V/C[1]	Delay[2]	LOS[3]	V/C	Delay	LOS
State Street at Main Street							
State Street	EB TH-RT	0.70	27.4	C	0.81	36.2	D
State Street	WB LT	0.48	41.5	D	0.56	50.2	D
State Street	WB TH	0.35	11.3	B	0.39	14.3	B
State Street	WB RT	0.24	10.4	B	0.26	13.1	B
Main Street	NB TH-RT	0.45	35.6	D	0.42	40.1	D
Main Street	SB LT-TH-RT	0.60	38.4	D	0.71	47.4	D
	Overall	**0.57**	**26.0**	**C**	**0.63**	**32.2**	**C**
State Street at Dwight Street and Maple Street							
State Street	EB TH-RT	0.40	13.7	B	0.46	14.8	A
State Street	WB LT-TH	0.43	5.8	A	0.47	4.7	B
Dwight Street	SB LT	0.68	37.8	D	0.69	38.1	D
Dwight Street	SB TH-RT	0.57	33.5	C	0.59	33.4	C
	Overall	**0.47**	**17.8**	**B**	**0.51**	**17.8**	**B**
State Street at Chestnut Street and Maple Street							
State Street	EB TH	0.44	6.6	A	0.5	7.5	A
State Street	WB TH-RT	0.36	15.0	B	0.42	16.1	B
Maple Street	NB LT	0.36	31.5	C	0.36	30.9	C
Maple Street	NB TH-RT	0.69	36.0	D	0.71	35.8	D
	Overall	**0.43**	**17.9**	**B**	**0.47**	**18.4**	**B**
State Street at Federal Street and Walnut Street							
State Street	EB LT	0.61	55.3	E	0.65	63.0	E
State Street	EB TH-RT	0.49	36.0	D	0.51	34.9	C
State Street	WB LT	0.52	60.1	D	0.56	65.4	E
State Street	WB TH-RT	0.76	44.7	D	0.79	48.4	D
Walnut Street	NB LT	0.31	37.9	D	0.32	43.2	D
Walnut Street	NB TH-RT	0.68	42.8	D	0.67	51.7	D
Federal Street	SB LT	0.24	28.9	C	0.26	31.7	C
Federal Street	SB TH-RT	0.27	28.7	C	0.32	32.3	C
	Overall	**0.6**	**43.6**	**D**	**0.62**	**44.6**	**D**

Source: VHB, Inc. using Synchro 8 software.

1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 50: Capacity Analysis Weekday Morning (2 of 3)

Intersection	Lane Group	2015 Existing Conditions V/C[1]	Delay[2]	LOS[3]	2025 No Build Conditions V/C	Delay	LOS
State Street at Saint James Avenue and Oak Street							
State Street	EB LT	0.36	59.9	D	0.36	52.5	D
State Street	EB TH-RT	0.40	22.1	C	0.40	22.3	C
State Street	WB LT-TH	0.88	48.3	D	0.87	47.5	D
State Street	WB RT	0.26	20.6	C	0.25	20.6	C
Oak Street	NB LT-TH-RT	0.94	94.4	F	0.85	78.4	E
Saint James Avenue	SB LT	0.92	66.2	E	0.90	60.2	E
Saint James Avenue	SB TH	0.47	33.1	C	0.46	32.6	C
Saint James Avenue	SB RT	0.06	20.9	C	0.06	20.6	C
	Overall	**0.75**	**42.4**	**D**	**0.74**	**39.9**	**D**
State Street at Eastern Avenue and Catherine Street							
State Street	EB LT	0.28	57.4	E	0.33	57.4	E
State Street	EB TH	0.28	25.5	C	0.30	25.0	C
State Street	EB RT	0.14	24.5	C	0.16	23.9	C
State Street	WB LT-TH-RT	0.65	44.2	D	0.66	43.4	D
Eastern Avenue	NB LT	0.57	1.9	A	0.61	2.5	A
Eastern Avenue	NB TH-RT	0.51	1.2	A	0.53	1.4	A
Catharine Street	SB LT	0.30	53.7	D	0.26	54.6	D
Catharine Street	SB TH	0.74	67.4	E	0.65	63.2	E
Catharine Street	SB RT	0.03	34.7	C	0.02	35.7	D
	Overall	**0.66**	**30.6**	**C**	**0.66**	**28.7**	**C**
State Street at Gaucher Street and Benton Street							
State Street	EB LT-TH-RT	0.38	6.9	A	0.38	7.8	A
State Street	WB LT-TH-RT	0.57	8.2	A	0.62	9.8	A
Benton Street	NB LT-TH	0.20	12.6	B	0.21	13.2	B
Benton Street	NB RT	0.10	12.1	B	0.11	12.7	B
Gaucher Street	SB LT-TH-RT	0.38	13.2	B	0.37	13.9	B
	Overall	**0.49**	**8.8**	**A**	**0.73**	**10.0**	**B**

Source: VHB, Inc. using Synchro 8 software.
1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 50: Capacity Analysis Weekday Morning (3 of 3)

Intersection	Lane Group	2015 Existing Conditions V/C[1]	Delay[2]	Intersection	2025 No Build Conditions Lane Group	V/C[1]	Delay[2]
Boston Road at Bay Street and Breckwood Boulevard							
Boston Road	EB LT-TH-RT	0.63	22.9	C	0.7	25.8	C
Boston Road	WB LT	0.43	14	B	0.53	16.5	B
Boston Road	WB TH-RT	0.29	13.6	B	0.34	15.3	B
Breckwood Blvd	NB LT	0.18	21.5	C	0.18	21.2	C
Breckwood Blvd	NB TH	0.81	35	D	0.83	36	D
Breckwood Blvd	NB RT	0.12	17.6	B	0.13	17.3	B
Bay Street	SB LT	0.33	16.1	B	0.38	16.3	B
Bay Street	SB TH-RT	0.46	16.8	B	0.48	16.6	B
	Overall	**0.71**	**21.2**	**C**	**0.76**	**22.6**	**C**
Boston Road at Pasco Street and Wrentham Street							
Boston Road	EB LT	0.29	13.5	B	0.29	13.5	B
Boston Road	EB TH-RT	0.19	15.0	B	0.19	15.0	B
Boston Road	WB LT	0.19	76.8	E	0.19	78.8	E
Boston Road	WB TH-RT	0.46	19.5	B	0.46	18.7	B
Wrentham Road	NB LT-TH-RT	0.49	45.7	D	0.49	45.7	D
Pasco Road	SB LT-TH	0.58	47.7	D	0.58	47.7	D
Pasco Road	SB RT	0.34	32.4	C	0.34	32.4	C
	Overall	**0.49**	**26.0**	**C**	**0.50**	**25.7**	**C**
Boston Road at Parker Street							
Boston Road	EB LT	0.50	47.8	D	0.50	46.4	D
Boston Road	EB TH	0.39	46.6	D	0.39	35.8	D
Boston Road	EB RT	0.13	0.2	A	0.13	0.0	A
Boston Road	WB LT	0.42	46.3	D	0.42	45.3	D
Boston Road	WB TH	0.39	35.6	D	0.39	35.2	D
Boston Road	WB RT	0.02	0.0	A	0.02	0.0	A
Parker Street	NB LT	0.70	46.2	D	0.70	39.7	D
Parker Street	NB TH	0.35	22.8	C	0.35	22.6	C
Parker Street	NB RT	0.15	0.2	A	0.15	0.0	A
Parker Street	SB LT	0.38	52.5	D	0.38	49.2	D
Parker Street	SB TH	0.42	34.7	C	0.42	34.2	C
Parker Street	SB RT	0.06	0.1	A	0.06	0.0	A
	Overall	**0.52**	**29.2**	**C**	**0.52**	**29.2**	**C**

Source: VHB, Inc. using Synchro 8 software.

1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 51: Capacity Analysis Weekday Evening

(1 of 3)

Intersection	Lane Group	2015 Existing Conditions V/C[1]	Delay[2]	LOS[3]	2025 No Build Conditions V/C	Delay	LOS
State Street at Main Street							
State Street	EB TH-RT	0.61	33.1	C	0.86	55.2	E
State Street	WB LT	0.52	40.9	D	0.70	64.8	E
State Street	WB TH	0.68	22.6	C	0.91	45.8	D
State Street	WB RT	0.23	15.9	B	0.28	21.5	C
Main Street	NB TH-RT	0.31	26.4	C	0.33	33.5	C
Main Street	SB LT-TH-RT	0.62	31.0	C	0.77	44.4	D
	Overall	**0.64**	**27.5**	**C**	**0.79**	**44.3**	**D**
State Street at Dwight Street and Maple Street							
State Street	EB TH-RT	0.44	21.2	C	0.53	22.4	C
State Street	WB LT-TH	0.78	27.9	C	0.85	31.5	C
Dwight Street	SB LT	0.48	20.3	C	0.54	23.7	C
Dwight Street	SB TH-RT	0.69	23.4	C	0.8	30.0	C
	Overall	**0.72**	**24.1**	**C**	**0.8**	**28.1**	**C**
State Street at Chestnut Street and Maple Street							
State Street	EB TH	0.56	17.1	B	0.6	17.8	B
State Street	WB TH-RT	0.71	19.7	B	0.75	20.9	C
Maple Street	NB LT	0.26	18.8	B	0.29	21.4	C
Maple Street	NB TH-RT	0.47	19.8	B	0.54	23.2	C
	Overall	**0.49**	**18.8**	**B**	**0.56**	**20.3**	**C**
State Street at Federal Street and Walnut Street							
State Street	EB LT	0.50	85.3	F	0.54	86.0	F
State Street	EB TH-RT	0.49	39.8	D	0.63	45.6	D
State Street	WB LT	0.60	87.1	F	0.63	88.3	F
State Street	WB TH-RT	0.53	40.4	D	0.67	46.7	D
Walnut Street	NB LT	0.48	68.2	E	0.41	64.9	E
Walnut Street	NB TH-RT	0.83	87.1	F	0.84	85.9	F
Federal Street	SB LT	0.64	56.4	E	0.6	53.9	D
Federal Street	SB TH-RT	0.68	60.2	E	0.61	56.1	E
	Overall	**0.56**	**52.5**	**D**	**0.63**	**54.7**	**D**

Source: VHB, Inc. using Synchro 8 software.

1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 51: Capacity Analysis Weekday Evening (2 of 3)

		2015 Existing Conditions			2025 No Build Conditions		
Intersection	Lane Group	V/C[1]	Delay[2]	Intersection	Lane Group	V/C[1]	Delay[2]
State Street at Saint James Avenue and Oak Street							
State Street	EB LT	0.68	61.3	E	0.82	79.2	E
State Street	EB TH-RT	0.48	22.8	C	0.51	22.1	C
State Street	WB LT-TH	0.88	50.5	D	0.92	53.5	D
State Street	WB RT	0.16	21.1	C	0.19	20.7	C
Oak Street	NB LT-TH-RT	1.06	126.2	F	1.30	223.3	F
Saint James Avenue	SB LT	1.17	143.7	F	1.44	259.3	F
Saint James Avenue	SB TH	0.62	38.0	D	0.77	49.5	D
Saint James Avenue	SB RT	0.06	20.4	C	0.07	24.3	C
	Overall	0.87	56.1	E	0.98	79.5	E
State Street at Eastern Avenue and Catherine Street							
State Street	EB LT	0.34	59.2	E	0.49	64.6	E
State Street	EB TH	0.35	26.3	C	0.41	28.5	C
State Street	EB RT	0.21	25.0	C	0.23	26.6	C
State Street	WB LT-TH-RT	0.63	43.4	D	0.71	47.1	D
Eastern Avenue	NB LT	0.38	2.4	A	0.43	3.1	A
Eastern Avenue	NB TH-RT	0.49	2.1	A	0.54	3.0	A
Catharine Street	SB LT	0.29	55.1	E	0.32	58.2	E
Catharine Street	SB TH	0.68	64.8	E	0.77	74.2	E
Catharine Street	SB RT	0.02	35.9	D	0.03	38.6	D
	Overall	0.62	31.2	C	0.69	34.2	C
State Street at Gaucher Street and Benton Street							
State Street	EB LT-TH-RT	0.50	9.0	A	0.51	8.1	A
State Street	WB LT-TH-RT	0.63	10.4	B	0.65	9.8	A
Benton Street	NB LT-TH	0.65	17.9	B	0.79	30.5	C
Benton Street	NB RT	0.16	12.5	B	0.18	17.0	B
Gaucher Street	SB LT-TH-RT	0.19	12.6	B	0.11	16.5	B
	Overall	0.87	11.3	B	0.89	12.9	B

Source: VHB, Inc. using Synchro 8 software.
1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 51: Capacity Analysis Weekday Evening (3 of 3)

		2015 Existing Conditions			2025 No Build Conditions		
Intersection	Lane Group	V/C[1]	Delay[2]	Intersection	Lane Group	V/C[1]	Delay[2]
Boston Road at Bay Street and Breckwood Boulevard							
Boston Road	EB LT-TH-RT	0.71	34.0	C	0.83	39.2	D
Boston Road	WB LT	0.75	30.1	C	0.92	56.7	E
Boston Road	WB TH-RT	0.47	21.0	C	0.53	21.8	C
Breckwood Blvd	NB LT	0.27	29.2	C	0.27	28.0	C
Breckwood Blvd	NB TH	0.81	43.7	D	0.84	44.3	D
Breckwood Blvd	NB RT	0.11	21.6	C	0.14	20.7	C
Bay Street	SB LT	0.72	45.7	D	0.61	21.2	C
Bay Street	SB TH-RT	0.57	19.6	B	0.59	19.9	B
	Overall	0.82	29.4	C	0.90	31.2	C
Boston Road at Pasco Street and Wrentham Street							
Boston Road	EB LT	0.66	24.2	C	0.76	37.6	D
Boston Road	EB TH-RT	0.55	25.0	C	0.61	26.7	C
Boston Road	WB LT	0.35	84.5	F	0.45	89.8	F
Boston Road	WB TH-RT	0.63	23.9	C	0.77	23.0	C
Wrentham Road	NB LT-TH-RT	0.48	51.9	D	0.47	51.6	D
Pasco Road	SB LT-TH	0.74	52.9	D	0.76	52.5	D
Pasco Road	SB RT	0.39	29.7	C	0.39	27.4	C
	Overall	0.69	31.5	C	0.76	32.4	C
Boston Road at Parker Street							
Boston Road	EB LT	0.79	59.0	E	0.87	63.1	E
Boston Road	EB TH	0.75	53.4	D	0.79	49.6	D
Boston Road	EB RT	0.25	0.3	A	0.29	0.4	A
Boston Road	WB LT	0.86	53.1	D	1.03	90.0	F
Boston Road	WB TH	0.61	31.0	C	0.68	33.3	C
Boston Road	WB RT	0.04	0.0	A	0.40	0.0	A
Parker Street	NB LT	0.77	51.2	D	0.74	51.8	D
Parker Street	NB TH	0.50	34.6	C	0.65	41.2	D
Parker Street	NB RT	0.16	0.2	A	0.24	0.4	A
Parker Street	SB LT	0.59	52.4	D	0.63	49.5	D
Parker Street	SB TH	0.86	56.1	E	0.81	49.7	D
Parker Street	SB RT	0.11	0.0	A	0.09	0.1	A
	Overall	0.82	37.5	D	0.84	40.3	D

Source: VHB, Inc. using Synchro 8 software.

1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

As shown in Table 50 and Table 51 the majority of the Study Area signalized intersections operate at an acceptable overall level-of-service (LOS) of C or better during the 2015 Existing weekday morning and evening peak hours. Only three of the intersections operate lower than LOS C. The intersection of State Street at Federal Street operates at a LOS D during both morning and evening peak periods. The intersection of State Street at Saint James Avenue operates at a LOC D during the weekday morning peak hour and a LOS E during the weekday evening peak hour. The intersection of Boston Road at Parker Street operates at a LOS D during the weekday evening peak hour.

In the 2015 Existing conditions, some of the intersections experience excessive vehicle queues during the weekday evening and morning peak hours including. The following 95th percentile queues were calculated, and it is noted that each number references the Study Area intersection number.

1. State Street at Main Street: Long queues (>500-feet) on the State Street eastbound approach during morning peak hour and on State Street westbound approach during the evening peak hour.

5. State Street at Saint James Avenue: Long queues (>500-feet) on the Saint James Avenue southbound approach and the Oak Street northbound approach during the evening peak hour.

As shown in Table 50, comparing the 2015 Existing conditions to the 2025 No Build conditions several of the intersections had a decrease in performance during the weekday evening peak hour. The largest impacts were along State Street during the weekday evening which is mostly attributed to the added casino trips. In the weekday evening the flowing intersection had a decrease in level-of-service from the existing conditions:

1. State Street and Main Street: 2015 Existing LOS C to 2025 No Build LOS D

3. State Street at Chestnut Street and Maple Street: 2015 Existing LOS B to 2025 No Build LOS C

In the 2025 No Build conditions, some of the intersections experience excessive calculated vehicle queues during the weekday evening and morning peak hours including:

1. State Street at Main Street: Long queues (>500-feet) on the State Street eastbound approach during morning and evening peak periods and on State Street westbound approach during the evening peak hour.

2. State Street at Dwight Street: Long queues (>500-feet) on Dwight Street southbound during the evening peak hour.

4. State Street at Federal Street: Long queues (>500-feet) on State Street westbound during the morning and evening peak hours and on State Street eastbound during the evening peak hour.

5. State Street at Saint James Avenue: Long queues (>500-feet) on the Saint James Avenue southbound approach and the Oak Street northbound approach during the evening peak period. Long queues (>500 feet) on the State Street westbound approach during both weekday and evening and morning peak hours.

When comparing the Existing 2015 and Future No Build 2025 conditions shown in Table 50 and Table 51, a slight decrease in overall performance can be seen during both weekday peak periods, which is to be expected given the anticipated traffic growth.

If no improvements are made 5.6 seconds of delay in the AM and 58 seconds in the PM will be added

5.3.2 Multi-Modal Assessment

In addition to the intersection capacity analysis discussed in the previous section, a multi-modal assessment was conducted to provide an analysis of existing and future operations for pedestrians, bicyclists and transit users. This section provides a discussion on the methodology used for the multi-modal assessment and the results for the 2015 Existing and 2025 No Build conditions. As part of this assessment vehicular capacity analysis is considered along pedestrian, bicycle and transit performances; which is also known as a Multimodal Level-of-Service (MMLOS) Assessment

The motivation of the proposed bus rapid transit project is to improve the experience for non-motorists including Pedestrians, Bicyclists and Transit riders. In order to quantify this experience a MMLOS review was conducted utilizing methods outlined in the 2010 Highway Capacity Manual. This manual provided means to quantitatively assess the performance of each mode of travel (automobile, pedestrian, bicycle and transit). For the purposes of this review the automobile performances were reviewed in the previous section using the more commonly accepted methods of the capacity analysis of the 2000 Highway Capacity Manual.

Multimodal Level-of-Service Criteria

The Multimodal Level-of-Service (MMLOS) provides an individual ranking from LOS A to LOS F to each mode of travel (pedestrian, bicycle and transit). The letter "A" represents the "best" quality and the letter "F" represents the "worst" quality. This LOS ranking is determined based on the LOS Score which is mathematically calculated considering a variety of factors for each mode of travel. The LOS Score and corresponding LOS ranking are outlined in Table 52.

Table 52: MMLOS Ranking (2010 Highway Capacity Manual, Exhibit 17-4)

LOS	LOS Score
A	≤2.00
B	>2.00-2.75
C	>2.75-3.50
D	>3.50-4.25
E	>4.25-5.00
F	>5.00

The following outlines the parameters used to evaluate the MMLOS:

- Traffic characteristics data
  - Dwell time, Excess wait time, Passenger trip length, Transit frequency, Passenger load factor, Mid-segment flow rate, Percent heavy vehicles, Pedestrian flow rate, Proportion of on-street parking occupied, Permitted left-turn flow rate, and Mid-segment 85th percentile speed.

- Geometric design data
  - Downstream intersection width, Width of outside through lane, bicycle lane, and paved outside shoulder, Median type and curb presence, Presence of a sidewalk, Total walkway width, crosswalk width and length, and corner radius, Effective width of fixed objects (in walkway), Buffer width and spacing of objects in buffer, and Street Width.

- Traffic Signal Control Data
  - Rest in walk, Cycle Length, Pedestrian signal head presence, Duration of phase serving pedestrians and bicycles, and Effective green-to-cycle-length ration.

- Other Data
  - Area type (Central Business District), Pavement condition rating, Distance to nearest signal-control crossing, Legality of mid-segment pedestrian crossing, Proportion of sidewalk adjacent to window, building, or fence, Transit stop location, Transit stop position, Proportion of stops with shelters and with benches, Performance measures, Motorized vehicle running speed, Reentry delay, Pedestrian delay and Bicycle delay.

The 2010 Highway Capacity manual details methods for calculating the level-of-service for a Link, Intersection and a segment. A link is the area between intersections and a segment considers the intersection and the downstream intersection. For the purposed of this review each intersection on a segment level in both eastbound and westbound directions along State Street and Boston Road was reviewed.

Multi-Modal Level-of-Service Results

The level-of-service for each mode of travel was calculated in both the eastbound and westbound directions for each of the Study Area intersections for both the 2015 Existing and 2025 No Build. The results of the existing weekday morning and weekday evening peak hours are presented graphically in the following chapter. The results are presented in this way to provide an easier way to compare the existing conditions to the future conditions (with no improvements) and the two BRT alternatives. However, the following provides a summary of the results of the existing MMLOS analysis:

- The pedestrian level-of-service was at a LOS D or better for every segment between the Study Area intersections.
- The bicycle level-of-service ranged from LOS C to LOS E, and the segments with a poor level-of-service had more driveways that could create more conflict.

- The transit mode level-of-service ranked from LOS C to LOS E.

Overall the level-of-service did not change significantly for pedestrians, bicycles or transit riders when assessing the 2025 future conditions (with no improvements). A handful of segments did experience a slight decrease in level-of-service due to the expected increase in traffic volumes due to other developments and background growth. The only segment that decreased to a LOS E was the eastbound segment of Boston Road between Pasco Road and Parker Street (LOS D to LOS E) during the weekday morning peak hour for both bicycle and transit.

5.4 Corridor Issues

Within the study area corridor, there are several existing safety concerns, existing capacity restrictions, future traffic demands, and right of way restrictions. Figure 65 illustrates the issues throughout the corridor. The following provides a summary of some of the key issues that could impact traffic operations:

- The majority of the intersections along the corridor are classified as MassDOT HSIP Clusters with a handful among the top 200. Typically if an intersection (or area along the corridor) is on this list, a project could be eligible for safety funding through the State's Transportation Improvement Program (TIP).

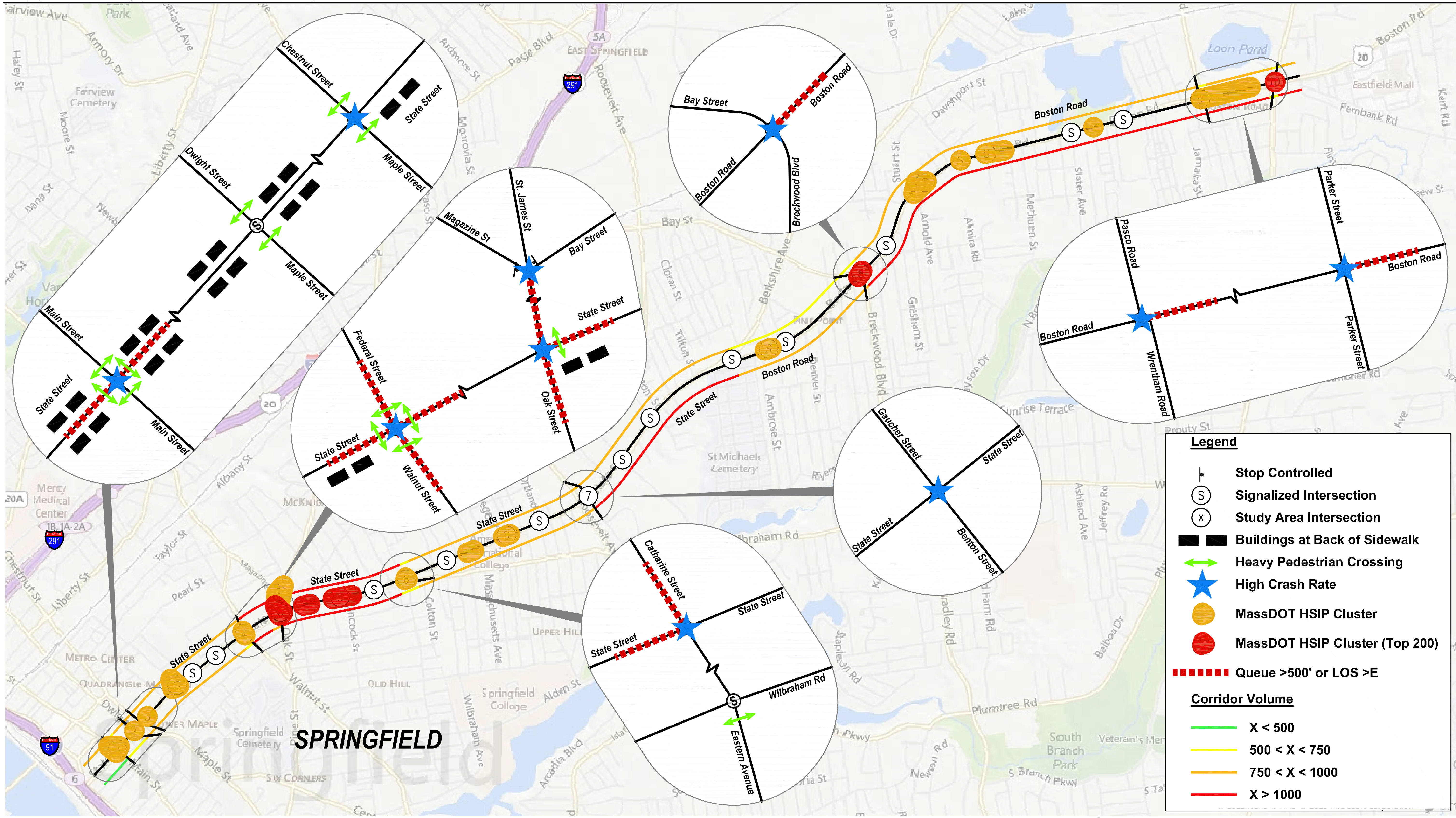
- Throughout the corridor the traffic demand inbound versus outbound is at or above 750 vehicles an hour. This amount of traffic typically means that multiple thru lanes are needed to process vehicles in a safer and more efficient manner. This is especially true at signalized intersections.

- Many of the Study Area intersections are anticipated to have approaches with queues over 500 feet and poor levels of service of E or F. This is generally a result traffic demand from side streets being high enough to cause delay in a number of directions. Typically the only way to resolve these issues is to add capacity at an intersection by way of improved signal timings and phases, or additional lanes.

- There are a number of areas where existing buildings are adjacent to the back of sidewalks. These areas create limited opportunities to widen the roadway without significant land takings. In general, most of this occurs within the downtown area (Saint James west); however, there are some areas east of Berkshire Avenue where buildings are located no too far off the sidewalk.

- The highest amount of pedestrian traffic was observed between Main Street and Federal Street, and steadily decreases to the east. Based on the conducted traffic counts, locations with major pedestrian crossings have been called out in Figure 64.

\\vhb\proj\Worcester\13152.00\graphics\FIGURES\Traffic\Issues Graphic.dwg



0 2000 Feet

Figure 65

Corridor Issues
Springfield, Massachusetts

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5.5 Traffic Operations: BRT Alternatives

This traffic assessment considers two design alternatives that have been described in greater detail in previous chapters. A brief description of each alternative is summarized below for quick reference when reviewing this chapter.

5.5.1 Alternative 1B

The Full Build Alternative 1B assessment considers the impacts to the roadway and Study Area intersections when removing one (of the two) through travel lane in both the eastbound and westbound directions. The removal of a travel lane would allow the construction of a dedicated bus lane (inbound and outbound) while minimizing the need to obtain right-of-way if two through travel lanes were maintained. In this alternative, traffic signal timings would be optimized to provide and improve signal coordination for better progression along the corridor. PVTA buses would also utilize a Transit Signal Priority (TSP) system. Many of the signalized intersections along the corridor have TSP; although some upgrades could be needed depending on whether the software is compatible with PVTA's system. It is noted that even with the removal of a through lane, it is anticipated that this alternative would significantly impact signal operations and the alignment of lanes at intersection that were reconstructed in 2009 and 2015.

5.5.2 Hybrid Alternative

The Hybrid Alternative analysis primarily considers optimizing traffic signal timings to improve signal coordination and TSP for portions of the corridor that were reconstructed in 2009 and 2015. However, some impacts would be realized where new bus station are to be located. For the corridor between Berkshire Avenue and Pasco Road, roadway and intersection improvements would be proposed to include a dedicated curb side bus lane. This would be proposed while maintaining roadway capacity; which includes providing two through travel lanes in the eastbound and westbound directions. This section of the corridor was reconstructed in the 1990's and is in need of intersection and roadway upgrades; making it a great candidate to implement BRT.

5.5.3 BRT Alternatives: Traffic Signal Capacity Analysis

Intersection capacity analyses were conducted for the ten (10) Study Area signalized intersections. It is noted that the 2015 Existing conditions and 2025 No Build conditions analyses were discussed in the previous chapter. The analyses presented in this section provides a comparison of all future conditions considered; including: the 2025 No Build condition, the 2025 Full Build Alternative 1B condition and the 2025 Hybrid Alternative condition. The 2025 No Build condition was added to provide a direct comparison of the potential impacts associated with each alternative.

Capacity Analysis Methodology

The following summarizes the conditions reviewed as part of this assessment:

- 2025 Build Analysis: The traffic signal timings used for the No Build analysis were based on extracted traffic signal controller data obtained by VHB in June of 2015. No signal timing or phasing adjustments were assumed for this scenario.

- 2025 Alternatives Analysis: For both the 2025 1B Alternative and 2025 Hybrid Alternatives the signal timings from the 2025 No Build Analysis were optimized to manage the overall intersection delay and vehicle-queuing. It was assumed that under each of these alternatives signal coordination (or an adaptive signal control system) would be provided. Most signals are currently running un-coordinated, as the City has made timing adjustments to address traffic fluctuations/ increases.

  While coordination is expected to be established throughout the project limits, and the following assessments model the Study Area intersections as such, it is again noted that only a portion of the signalized intersections along the entire corridor were evaluated as part of this study. As a result, the overall benefits stated in this chapter would need to be reviewed more closely with all signalized intersections in the assessment model.

- Coordinated Systems: For this assessment, the following three separate segments were analyzed for the Study Area intersections:

  1. State Street between Main Street and Chestnut Street
  2. State Street between Federal Street and St. James Avenue
  3. Boston Road between Pasco Road and Parker Street (existing)

  These three systems overlap with what was originally proposed for the previously completed State Street and Boston Road Corridor Improvement Projects. Additional non-Study Area intersections may need to be added to these three segments upon preparing a final assessment during design.

- Turn Restrictions: Turn restrictions are proposed where low volumes (range from 20 to 55 during the peak hours) seem to warrant eliminating movements. These restrictions would need to be coordinated with the City and any other local Stakeholders prior to implementation to ensure that there is an alternative route or U-turns can be accommodated at the next traffic signal. The following provides a summary of the areas that could be considered:

  1. State Street westbound onto Maple Street
  2. State Street westbound onto Oak Street
  3. Mid-block locations between traffic signals along State Street; such as at Orleans Street, etc. and where there are breaks in the median

- Signal Timing Refinements: There are several areas along the corridor where the traffic analysis and signal timings will need to be refined to accommodate the final alignment of each intersection. This can only be completed during a design phase where the layout of turn lanes, through lanes, bus lanes, stations, etc. can be confirmed and compared to the established design criteria by MassDOT, the City, etc.

For example, if left turning traffic and the thru-running bus lane were to weave prior to reaching a signalized intersection, the associated traffic phase (at the intersection) could run simultaneously. However, if the bus lane were to remain in the middle of the roadway, an extra phase may be needed at the signalized intersection to accommodate (or protect) the left-turn without bus conflict. This additional phase could result in higher overall delays, longer left-turning queues and potentially larger right-of-way needs to accommodate turn movements. Restricting left-turn movements at the Study Area intersections is not currently an option as there are no other alternative route or means to redirect traffic without a significant impact. For the purposes of this study, it is assumed that left-turning traffic will be able to run at the same time as a bus lane.

Capacity Analysis Results

Summaries of the 2025 No Build, 2025 1B Alternative and 2025 Hybrid Alternative signalized intersection capacity analyses results are presented for the weekday morning peak hour and the weekday evening peak hour in Table 53 and Table 54. At almost all intersections evaluated the LOS would worsen with the implementation of the 1B Alternative. In the AM peak delay per intersection increase between 1.2 seconds and 34.4 seconds. Delay in the PM is even greater with 13.9 to 110.7 seconds per intersection.

LOS worsens at all intersections under Alternative 1B

Table 53: Future Capacity Analysis Weekday Morning

(1 of 3)

Intersection	Lane Group	2025 No Build V/C[1]	Delay[2]	LOS[3]	2025 1B V/C	Delay	LOS	2025 Hybrid V/C	Delay	LOS
State Street at Main Street										
State Street	EB TH-RT	0.81	36.2	D	0.89	54.4	D	0.71	31.9	C
State Street	WB LT	0.56	50.2	D	0.89	74.2	E	0.68	48.4	D
State Street	WB TH	0.39	14.3	B	0.78	20.7	C	0.37	5.7	A
State Street	WB RT	0.26	13.1	B	N/A	N/A	N/A	0.24	5.2	A
Main Street	NB TH-RT	0.42	40.1	D	0.27	34.3	C	0.46	46.2	D
Main Street	SB LT-TH-RT	0.71	47.4	D	0.91	70.5	E	0.81	62	E
	Overall	**0.63**	**32.2**	**C**	**0.79**	**44**	**D**	**0.62**	**31.4**	**C**
State Street at Dwight Street and Maple Street										
State Street	EB TH-RT	0.46	14.8	A	0.74	13.6	B	0.39	8.3	A
State Street	WB LT-TH	0.47	4.7	B	0.94	27.5	C	0.41	4.7	A
Dwight Street	SB LT	0.69	38.1	D	0.81	62.2	E	0.75	55	D
Dwight Street	SB TH-RT	0.59	33.4	C	0.7	49.6	D	0.65	46.8	D
	Overall	**0.51**	**17.8**	**B**	**0.88**	**30.4**	**C**	**0.47**	**19.8**	**B**
State Street at Chestnut Street and Maple Street										
State Street	EB TH	0.5	7.5	A	0.81	17.6	B	0.44	8.8	A
State Street	WB TH-RT	0.42	16.1	B	0.68	22.5	C	0.37	16.5	B
Maple Street	NB LT	0.36	30.9	C	0.43	44.6	D	0.39	42.5	D
Maple Street	NB TH-RT	0.71	35.8	D	0.85	58.1	E	0.76	50.1	D
	Overall	**0.47**	**18.4**	**B**	**0.69**	**30.4**	**C**	**0.45**	**23.1**	**C**
State Street at Federal Street and Walnut Street										
State Street	EB LT	0.65	63	E	0.78	53.5	D	0.77	77.2	E
State Street	EB TH-RT	0.51	34.9	C	0.87	54.8	D	0.54	40.1	D
State Street	WB LT	0.56	65.4	E	0.28	5.7	A	0.34	16.1	B
State Street	WB TH-RT	0.79	48.4	D	1.04	28.4	C	0.63	10	A
Walnut Street	NB LT	0.32	43.2	D	0.6	57.6	E	0.4	51.7	D
Walnut Street	NB TH-RT	0.67	51.7	D	0.87	74.5	E	0.84	70.6	E
Federal Street	SB LT	0.26	31.7	C	0.39	58.9	E	0.43	40.2	D
Federal Street	SB TH-RT	0.32	32.3	C	0.42	43.8	D	0.4	40.6	D
	Overall	**0.62**	**44.6**	**D**	**0.85**	**45.8**	**D**	**0.61**	**36**	**D**

Source: VHB, Inc. using Synchro 8 software.
1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.
NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 53: Future Capacity Analysis Weekday Morning (2 of 3)

Intersection	Lane Group	2025 No Build V/C[1]	2025 No Build Delay[2]	2025 No Build LOS[3]	2025 1B V/C	2025 1B Delay	2025 1B LOS	2025 Hybrid V/C	2025 Hybrid Delay	2025 Hybrid LOS
State Street at Saint James Avenue and Oak Street										
State Street	EB LT	0.36	52.5	D	0.46	35.9	D	0.62	44.2	D
State Street	EB TH-RT	0.4	22.3	C	0.69	14.9	B	0.5	15.2	B
State Street	WB LT-TH[4]	0.87	47.5	D	1.16	127.8	F	0.94	67.5	E
State Street	WB RT	0.25	20.6	C	0.29	15.3	B	0.23	25.7	C
Oak Street	NB LT-TH-RT	0.85	78.4	E	1.25	215.3	F	0.51	51.2	D
Saint James Avenue	SB LT	0.9	60.2	E	0.79	53.1	D	0.6	30	C
Saint James Avenue	SB TH	0.46	32.6	C	0.5	41.7	D	0.35	26.9	C
Saint James Avenue	SB RT	0.06	20.6	C	0.06	31.2	C	0.06	19.1	B
	Overall	**0.74**	**39.9**	**D**	**0.93**	**74.2**	**E**	**0.65**	**39.4**	**D**
State Street at Eastern Avenue and Catherine Street										
State Street	EB LT	0.33	57.4	E	0.37	49.3	D	0.41	37.9	D
State Street	EB TH	0.3	25	C	0.5	18.7	B	0.32	17.1	B
State Street	EB RT	0.16	23.9	C	0.16	15.5	B	0.16	16.4	B
State Street	WB LT-TH-RT	0.66	43.4	D	1	69.1	E	0.7	29.6	C
Eastern Avenue	NB LT	0.61	2.5	A	0.92	11.9	B	0.59	5.2	A
Eastern Avenue	NB LT[5]-TH-RT	0.53	1.4	A	0.34	7	A	0.52	4.5	A
Catharine Street	SB LT	0.26	54.6	D	0.4	51.4	D	0.37	37.5	D
Catharine Street	SB TH	0.65	63.2	E	1	124.1	F	0.92	85.2	F
Catharine Street	SB RT	0.02	35.7	D	0.02	33.9	C	0.02	24.3	C
	Overall	**0.66**	**28.7**	**C**	**1.05**	**40.2**	**D**	**0.79**	**23.3**	**C**
State Street at Gaucher Street and Benton Street (Roosevelt Avenue)										
State Street	EB LT-TH-RT	0.38	7.8	A	0.47	5.4	A	0.34	5.3	A
State Street	WB LT-TH-RT	0.62	9.8	A	0.74	9.9	A	0.55	6.4	A
Benton Street	NB LT-TH	0.21	13.2	B	0.61	47.7	D	0.31	14.9	B
Benton Street	NB RT	0.11	12.7	B	0.11	37.7	D	0.11	13.9	B
Gaucher Street	SB LT-TH-RT	0.37	13.9	B	0.7	47.9	D	0.54	15.9	B
	Overall	**0.73**	**10**	**B**	**0.83**	**16.8**	**B**	**0.82**	**8.1**	**A**

Source: VHB, Inc. using Synchro 8 software.
1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.
4. Westbound left-turn removed for 2025 Full BRT and 2025 Hybrid Conditions at the intersection of State Street at Saint James Avenue and Oak Street
5. Northbound left-turn removed for 2025 Full BRT Condition at the Intersection of State Street at Eastern Avenue and Catherine Street

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 53: Future Capacity Analysis Weekday Morning (3 of 3)

		2025 No Build			2025 1B			2025 Hybrid		
Intersection	**Lane Group**	**V/C[1]**	**Delay[2]**	**LOS[3]**	**V/C**	**Delay**	**LOS**	**V/C**	**Delay**	**LOS**
Boston Road at Bay Street and Breckwood Boulevard										
Boston Road	EB LT-TH-RT	0.7	25.8	C	0.83	31.7	C	0.75	23.5	C
Boston Road	WB LT	0.53	16.5	B	0.43	16.5	B	0.55	14.3	B
Boston Road	WB TH-RT	0.34	15.3	B	0.51	16.2	B	0.34	12.7	B
Breckwood Blvd	NB LT	0.18	21.2	C	0.23	32.2	C	0.18	16.3	B
Breckwood Blvd	NB TH	0.83	36	D	0.88	55.6	E	0.79	27.2	C
Breckwood Blvd	NB RT	0.13	17.3	B	0.16	23.3	C	0.13	13.4	B
Bay Street	SB LT	0.38	16.3	B	0.72	46.9	D	0.48	14.4	B
Bay Street	SB TH-RT	0.48	16.6	B	0.59	31.7	C	0.5	14.4	B
	Overall	**0.76**	**22.6**	**C**	**0.87**	**31.9**	**C**	**0.81**	**18.9**	**B**
Boston Road at Pasco Street and Wrentham Street										
Boston Road	EB LT	0.33	14	B	0.55	21.1	C	0.41	14.5	B
Boston Road	EB TH-RT	0.21	15.5	B	0.39	15.8	B	0.26	16.2	B
Boston Road	WB LT	0.16	76	E	0.16	53.6	D	0.12	50.8	D
Boston Road	WB TH-RT	0.48	20.9	C	0.83	31.1	C	0.62	22.1	C
Wrentham Road	NB LT-TH-RT	0.49	45.7	D	0.87	88.9	F	0.5	34.2	C
Pasco Road	SB LT	0.59	48.1	D	0.85	60.9	E	0.52	32.6	C
Pasco Road	SB LT[4]-TH	0.59	47.8	D	0.05	36.2	D	0.52	32.5	C
Pasco Road	SB RT	0.36	32.3	C	0.34	30.1	C	0.3	20.4	C
	Overall	**0.52**	**26.5**	**C**	**0.86**	**35.6**	**D**	**0.61**	**22.7**	**C**
Boston Road at Parker Street										
Boston Road	EB LT	0.54	50.5	D	0.68	60.6	E	0.61	33.9	C
Boston Road	EB TH	0.49	51.7	D	0.72	41.8	D	0.59	30.8	C
Boston Road	EB RT	0.13	0.2	A	0.13	0.2	A	0.13	0.2	A
Boston Road	WB LT	0.44	46.3	D	0.41	41.5	D	0.49	35.2	D
Boston Road	WB TH	0.51	39.6	D	0.68	35.8	D	0.59	32.3	C
Boston Road	WB RT	0.02	0	A	0.02	0	A	0.02	0	A
Parker Street	NB LT	0.74	45.8	D	0.76	44.7	D	0.67	30.2	C
Parker Street	NB TH	0.34	19.9	C	0.39	22.5	C	0.38	17.1	B
Parker Street	NB RT	0.16	0.2	A	0.16	0.2	A	0.16	0.2	A
Parker Street	SB LT	0.41	52.7	D	0.6	61.8	E	0.33	36.2	D
Parker Street	SB TH	0.44	33.7	C	0.61	38.8	D	0.55	28.9	C
Parker Street	SB RT	0.06	0.1	A	0.06	0.1	A	0.06	0.1	A
	Overall	**0.59**	**29.8**	**C**	**0.75**	**29.5**	**C**	**0.67**	**22.2**	**C**

Source: VHB, Inc. using Synchro 8 software.
1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.
4. Pasco Street Southbound left-turn removed from Full BRT Condition at the intersection of Boston Road at Pasco Street and Wrentham Street

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 54: Future Capacity Analysis Weekday Evening

(1 of 3)

		2025 No Build			2025 1B			2025 Hybrid		
Intersection	Lane Group	V/C[1]	Delay[2]	LOS[3]	V/C	Delay	LOS	V/C	Delay	LOS
State Street at Main Street										
State Street	EB TH-RT	0.86	55.2	E	0.84	53.3	D	0.85	48.7	D
State Street	WB LT	0.7	64.8	E	1.02	75.5	C	0.77	38.3	D
State Street	WB TH	0.91	45.8	D	1.27	148.5	C	0.9	17.7	B
State Street	WB RT	0.28	21.5	C	N/A	N/A	N/A	0.28	4.2	A
Main Street	NB TH-RT	0.33	33.5	C	0.33	32.2	D	0.42	33.3	C
Main Street	SB LT-TH-RT	0.77	44.4	D	1.63	338.9	F	1.08	104.3	F
	Overall	**0.79**	**44.3**	**D**	**1.28**	**155**	**F**	**0.85**	**46.4**	**D**
State Street at Dwight Street and Maple Street										
State Street	EB TH-RT	0.53	22.4	C	0.74	19.5	B	0.46	21.6	C
State Street	WB LT-TH	0.85	31.5	C	1.39	198.2	F	0.73	18	B
Dwight Street	SB LT	0.54	23.7	C	0.71	43.6	D	0.62	31.1	C
Dwight Street	SB TH-RT	0.8	30	C	1.06	90.2	F	0.92	46.3	D
	Overall	**0.8**	**28.1**	**C**	**1.23**	**105.2**	**F**	**0.77**	**29.7**	**C**
State Street at Chestnut Street and Maple Street										
State Street	EB TH	0.6	17.8	B	0.75	13	B	0.43	8.7	A
State Street	WB TH-RT	0.75	20.9	C	0.92	36.8	D	0.54	15.6	B
Maple Street	NB LT	0.29	21.4	C	0.49	47.8	D	0.38	36	D
Maple Street	NB TH-RT	0.54	23.2	C	0.93	74.9	E	0.72	41.7	D
	Overall	**0.56**	**20.3**	**C**	**0.79**	**36.5**	**D**	**0.51**	**19.4**	**B**
State Street at Federal Street and Walnut Street										
State Street	EB LT	0.54	86	F	0.52	36.2	D	0.67	82.9	F
State Street	EB TH-RT	0.63	45.6	D	1.14	119.7	F	0.64	39.1	D
State Street	WB LT	0.63	88.3	F	0.86	77.3	E	0.74	36.2	D
State Street	WB TH-RT	0.67	46.7	D	1.23	115.3	F	0.65	17	B
Walnut Street	NB LT	0.41	64.9	E	0.43	52.1	D	0.44	55.3	E
Walnut Street	NB TH-RT	0.84	85.9	F	0.86	74.4	E	0.9	85.8	F
Federal Street	SB LT	0.6	53.9	D	0.68	48.7	D	0.69	52.2	D
Federal Street	SB TH-RT	0.61	56.1	E	0.64	46.7	D	0.65	49	D
	Overall	**0.63**	**54.7**	**D**	**0.94**	**96.2**	**F**	**0.65**	**39.8**	**D**

Source: VHB, Inc. using Synchro 8 software.
1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 54: Future Capacity Analysis Weekday Evening (2 of 3)

		2025 No Build			2025 1B			2025 Hybrid		
Intersection	Lane Group	V/C[1]	Delay[2]	LOS[3]	V/C	Delay	LOS	V/C	Delay	LOS
State Street at Saint James Avenue and Oak Street										
State Street	EB LT	0.82	79.2	E	1.29	211.7	F	1.07	128.5	F
State Street	EB TH-RT	0.51	22.1	C	1.04	84.3	F	0.68	23	C
State Street	WB LT-TH[4]	0.92	53.5	D	5.21	254.7	F	1.12	126.3	F
State Street	WB RT	0.19	20.7	C	0.23	15.5	B	0.2	21.9	C
Oak Street	NB LT-TH-RT	1.3	223.3	F	1.16	298	F	1.03	124.4	F
Saint James Avenue	SB LT	1.44	259.3	F	1.22	78	E	0.83	52.3	D
Saint James Avenue	SB TH	0.77	49.5	D	0.67	41.1	D	0.51	31.7	C
Saint James Avenue	SB RT	0.07	24.3	C	0.09	27.7	C	0.08	18.1	B
	Overall	**0.98**	**79.5**	**E**	**1.15**	**144.1**	**F**	**0.88**	**69.8**	**E**
State Street at Eastern Avenue and Catherine Street										
State Street	EB LT	0.49	64.6	E	0.44	48.3	D	0.43	43.9	D
State Street	EB TH	0.41	28.5	C	0.63	19.3	B	0.44	21..9	C
State Street	EB RT	0.23	26.6	C	0.29	14.6	B	0.23	20.4	C
State Street	WB LT-TH-RT	0.71	47.1	D	1.06	84.4	F	0.83	42.8	D
Eastern Avenue	NB LT	0.43	3.1	A	0.77	11.3	B	0.44	5.6	A
Eastern Avenue	NB LT[5]-TH-RT	0.54	3	A	0.49	9	A	0.55	5.6	A
Catharine Street	SB LT	0.32	58.2	E	0.48	51.4	D	0.34	42.2	D
Catharine Street	SB TH	0.77	74.2	E	1.14	161.8	F	0.82	62.5	E
Catharine Street	SB RT	0.03	38.6	D	0.03	31.7	C	0.03	25.6	C
	Overall	**0.69**	**34.2**	**C**	**1.08**	**48**	**D**	**0.78**	**28.9**	**C**
State Street at Gaucher Street and Benton Street (Roosevelt Avenue)										
State Street	EB LT-TH-RT	0.51	8.1	A	0.7	10.9	B	0.5	8.5	A
State Street	WB LT-TH-RT	0.65	9.8	A	0.85	18.8	B	0.64	10.3	B
Benton Street	NB LT-TH	0.79	30.5	C	1.1	131.9	F	0.78	30.2	C
Benton Street	NB RT	0.18	17	B	0.35	44.5	D	0.17	18	B
Gaucher Street	SB LT-TH-RT	0.11	16.5	B	0.3	43.7	D	0.11	17.6	B
	Overall	**0.89**	**12.9**	**B**	**1**	**34.7**	**C**	**0.86**	**13.4**	**B**

Source: VHB, Inc. using Synchro 8 software.
1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.
4. Westbound left-turn removed for 2025 Full BRT and 2025 Hybrid Conditions at the intersection of State Street at Saint James Avenue and Oak Street
5. Northbound left-turn removed for 2025 Full BRT Condition at the Intersection of State Street at Eastern Avenue and Catherine Street

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

Table 54: Future Capacity Analysis Weekday Evening (3 of 3)

		2025 No Build			2025 1B			2025 Hybrid		
Intersection	**Lane Group**	**V/C[1]**	**Delay[2]**	**LOS[3]**	**V/C**	**Delay**	**LOS**	**V/C**	**Delay**	**LOS**
Boston Road at Bay Street and Breckwood Boulevard										
Boston Road	EB LT-TH-RT	0.83	39.2	D	0.87	36.6	D	0.78	32.8	C
Boston Road	WB LT	0.92	56.7	E	0.77	38.5	D	0.82	34.7	C
Boston Road	WB TH-RT	0.53	21.8	C	0.76	24.2	C	0.49	18.3	B
Breckwood Blvd	NB LT	0.27	28	C	0.62	48.8	D	0.3	25.5	C
Breckwood Blvd	NB TH	0.84	44.3	D	0.95	74.3	E	0.8	37.9	D
Breckwood Blvd	NB RT	0.14	20.7	C	0.16	25.3	C	0.13	18.1	B
Bay Street	SB LT	0.61	21.2	C	1.19	159.3	F	0.77	30.2	C
Bay Street	SB TH-RT	0.59	19.9	B	0.79	42	D	0.64	21.6	C
	Overall	**0.9**	**31.2**	**C**	**1.05**	**47.5**	**D**	**0.89**	**27.1**	**C**
Boston Road at Pasco Street and Wrentham Street										
Boston Road	EB LT	0.76	37.6	D	1.15	161.9	F	0.79	37.5	D
Boston Road	EB TH-RT	0.61	26.7	C	0.97	55.2	E	0.6	26.5	C
Boston Road	WB LT	0.45	89.8	F	0.45	80.5	F	0.45	80.9	F
Boston Road	WB TH-RT	0.77	23	C	1.08	81.5	F	0.74	17.9	B
Wrentham Road	NB LT-TH-RT	0.47	51.6	D	0.44	62.7	E	0.49	52.2	D
Pasco Road	SB LT	0.76	52.2	D	1.8	437.7	F	0.75	52.5	D
Pasco Road	SB LT[4]-TH	0.75	52.5	D	0.17	55.6	E	0.74	52.1	D
Pasco Road	SB RT	0.39	27.4	C	0.54	47.9	D	0.4	28.2	C
	Overall	**0.76**	**32.4**	**C**	**1.21**	**131.8**	**F**	**0.77**	**30.6**	**C**
Boston Road at Parker Street										
Boston Road	EB LT	0.87	63.1	E	0.96	96.2	F	0.8	50.5	D
Boston Road	EB TH	0.79	49.6	D	1.06	78.4	E	0.83	41.3	D
Boston Road	EB RT	0.29	0.4	A	0.29	0.1	A	0.29	0.4	A
Boston Road	WB LT	1.03	90	F	1.1	140	F	0.9	58.6	E
Boston Road	WB TH	0.68	33.3	C	0.89	60.2	E	0.7	34.9	C
Boston Road	WB RT	0.4	0	A	0.04	0.1	A	0.04	0	A
Parker Street	NB LT	0.74	51.8	D	0.75	64.5	E	0.7	48.2	D
Parker Street	NB TH	0.65	41.2	D	0.83	65.3	E	0.65	41.1	D
Parker Street	NB RT	0.24	0.4	A	0.24	0.4	A	0.24	0.4	A
Parker Street	SB LT	0.63	49.5	D	0.66	62.7	E	0.65	51	D
Parker Street	SB TH	0.81	49.7	D	1.08	122.9	F	0.87	56.8	E
Parker Street	SB RT	0.09	0.1	A	0.09	0.1	A	0.09	0.1	A
	Overall	**0.84**	**40.3**	**D**	**1.02**	**68.7**	**E**	**0.84**	**36.5**	**D**

Source: VHB, Inc. using Synchro 8 software.
1. V/C – Volume-to-capacity ratio. V/C ratios range from 1.0 when demand equals capacity to 0 when demand is zero. Values over 1.0 indicate demand in excess of capacity.
2. Delay – Control delay per vehicle, expressed in seconds, includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.
3. LOS – Level-of-Service. LOS A indicates free flow conditions with minimal delays. LOS E and F indicate congested conditions.
4. Pasco Street Southbound left-turn removed from Full BRT Condition at the intersection of Boston Road at Pasco Street and Wrentham Street

NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound; LT = left-turn; TH = through; RT = right-turn; UT = u-turn

BRT Alternatives Condition Analyses Overview

As shown in the previous tables there are several intersections where signal operations are impacted by either BRT alternatives. Some intersections see minimal impact, some have significant impact, and some improve in operations as a result of optimizing signal timings. The following provides a summary of both alternatives, starting with the 2025 Hybrid Alternative.

Hybrid Alternative

All intersections, with the exception of the intersection of State Street at Chestnut Street/ Maple Street maintain or improve the overall level-of-service. This demonstrates that, from a vehicle capacity perspective, the 2025 Hybrid Alternative has the least operational impacts of the two alternatives. The following provides more details:

Delay will decrease by 24.2 seconds in the AM peak and 36.3 seconds in the PM peak

- During the weekday morning and evening peak hours, most intersections are expected to operation at the same level-of-service, or better, when compared to the 2025 No Build condition. Maintaining or improving level-of-service is attributed to the optimization of each signal timings at each intersection.

- State Street at Chestnut Street is expected to operate one letter grade level-of-service worse (LOS B to LOS C) when compared to the 2025 No Build scenario.

- When comparing the 2025 Hybrid Alternative to the 2025 Full Build Alternative, six (6) of the ten (10) Study Area intersections during the morning peak hour, and every intersection during the evening peak hour, operate at least one level-of-service (LOS) letter grade better. See summary on 2025 1B condition below.

- Two of the Study Area intersections are expected to continue to experience excessive calculated vehicle queues: State Street at Main Street and State Street at Saint James Avenue/ Oak Street.

1B Alternative

The following summarizes some of the findings for the 2025 1B Alternative condition and it can be expected that many of the Study Area intersections are expected to significantly worsen as a result of dropping a through travel lane in each direction under this BRT alternative.

Delay will increase by 109.7 seconds in the AM peak and 489.8 seconds in the PM peak

- During the weekday morning peak hour, six Study Area intersections are expected to worsen one level-of-service letter grade (ex. LOS C to LOS D) when compared to the 2025 No-Improvements condition.

- During the weekday evening peak hour, six Study Area intersections are expected to worsen one level-of-service letter grade, two intersections are expected to worsen two letter grades (ex. LOS C to LOS E), and two intersection are expected three letter grades (ex. LOS C to LOS F).

- The majority of the Study Area intersections experience excessive vehicle-queues during the weekday morning and weekday evening peak hours. This can be attributed to the fact that a through travel lane is being eliminated in the eastbound and westbound directions.

- During the weekday morning peak hour eight (8) of the ten (10) Study Area intersections (with the exception of State Street at Gaucher Street and Benton Street, and Boston Road at Parker Street), will have vehicle-queues that are greater than 500-feet along State Street and Boston Road.

5.5.4 Multi-Modal Assessment

This assessment includes the evaluation of pedestrian, bicycle and transit systems during the 2025 BRT Alternatives conditions. The previous section reviewed 2015 Existing and 2025 No Build baseline conditions.

As part of this assessment vehicular capacity analysis is considered along with pedestrian, bicycle and transit performances. The capacity analyses results, summarized in previous sections, was used for this assessment. This assessment is also known as a Multimodal Level-of-Service (MMLOS) Assessment; which was defined in greater detail in the previous chapter.

One of the goals of any bus rapid transit project is to improve the experience of traveling transit while not impacting other roadway users, including motorists, pedestrians and bicyclists. In order to quantify this experience, a multimodal level-of-service assessment was conducted utilizing methods outlined in the 2010 Highway Capacity Manual. This manual provides means to quantitatively assess the performance of each mode of travel (automobile, pedestrian, bicycle and transit). The MMLOS takes into account the impacts that certain variables have on a roadway user's experience. These variables include traffic volumes, available shoulder and sidewalk width, presence of street furniture and bus shelters, and many others features.

Multi-Modal Level-of-Service Results

The level-of-service of each mode of travel was calculated for each Study Area intersection and the adjacent roadway segments in both the eastbound and westbound directions. Figure 66 and Figure 67 show the results of the 2015 Existing, 2025 No Build, 2025 1B and 2025 Hybrid build conditions MMLOS for the weekday morning and evening peak hours, respectively. As shown, the level-of-service for pedestrian, bicycle and transit modes of travel during future conditions are expected to range widely throughout the project limits.

2025 1B Alternative

Based on the analyses, the implementation of a dedicated bus lane along the entire length of the corridor, when compared to the 2025 No Build condition, is expected to:

- Vehicle operations have been summarized in the previous section.

- The pedestrian level-of-service had a mix of increasing and decreasing performances, which is mostly a function of the traffic signal cycle length (shorter cycle length improves performance) and an increase in pedestrian crossing distance (longer crossings decrease performance).

- Some of the segments had an improved bicycle performance, which was a result of providing wider shoulders and creating lower vehicle travel speeds. Lower vehicle speeds are primarily caused by eliminating a through travel lane along the corridor (in each direction). When a through lane is eliminated, vehicle delays and queues are expected to get worse slowing traffic down.

- Result in improved overall transit performance during both the morning and evening peak hours. The majority of the segments realized a huge improvement of two letter grades or more (ex. LOS E to LOS A). This is primarily due to the dedicated bus lane and is enhanced by consolidating bus stop locations along with providing benches and shelters (or stations). Increasing bus frequency also improves this LOS.

2025 Hybrid Alternative

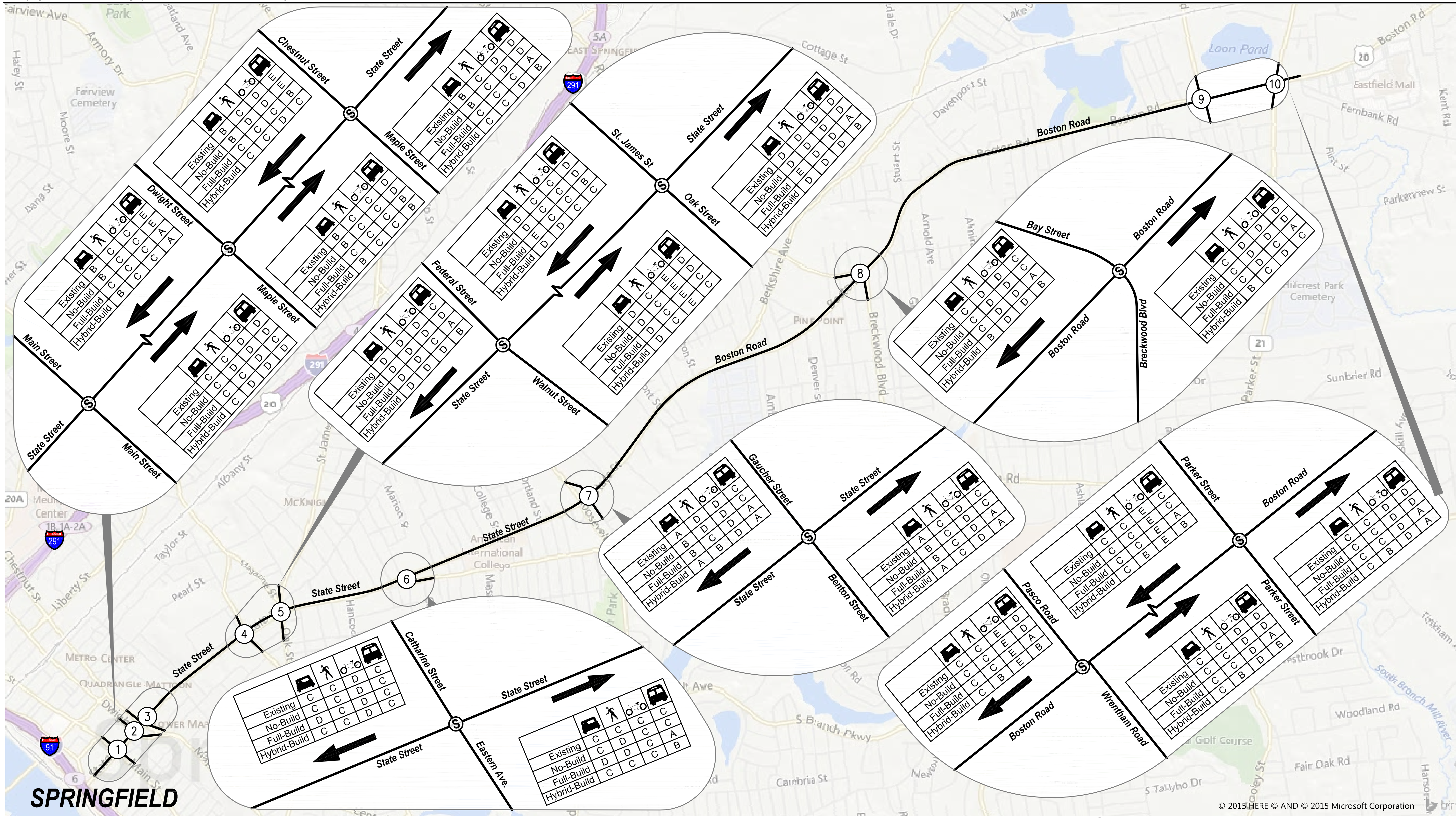
For the Hybrid Alternative the greatest improvement to most modes are likely to be realized at intersections on Boston Road between Bay Street and Pasco Road. This is because this section of Boston Road would be completely reconstructed as part of this alternative. Based on the analyses, the implementation of a curb side bus lane along a portion of the corridor, when compared to the 2025 No-Build condition, is expected to:

- Vehicle operations have been summarized in the previous section.

- In many areas of the corridor, improved pedestrian and bicycle accommodations are not proposed as part of this alternative. This doesn't change the performance for these categories along many sections of the corridor when compared to the 1B Alternative where improvements were proposed corridor wide.

- Transit performance for this alternative does not improve as significantly as discussed in the previous 1B Alternative. This is simply because the hybrid focuses on a curb side bus lane for a portion of the corridor and not the entire length as it was for the 1B Alternative. The transit performance does improve more in areas where bus stop locations are consolidated and as a result of implementing benches and shelters (or station).

\\vhb\proj\Worcester\13152.00\graphics\FIGURES\Traffic\MMLOS.dwg



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NOTES:
1. AUTO LEVEL OF SERVICE IS BASED ON THE HIGHWAY CAPACITY MANUAL 2000 METHODS WITHIN SYNCHRO.
2. PEDESTRIAN, BICYCLE, AND TRANSIT LEVEL OF SERVICE WAS CALCULATED UTILIZING THE HIGHWAY CAPACITY MANUAL 2010. THESE VALUES REPRESENT THE SEGMENT LEVEL OF SERVICE, WHICH IS CONSIDERS AN INTERSECTION WITH THE DOWNSTREAM ROADWAY LINK.

Legend

- Signalized Intersection
- Analysis Direction
- Vehicle Level of Service
- Pedestrian Level of Service
- Bicycle Level of Service
- Transit Level of Service

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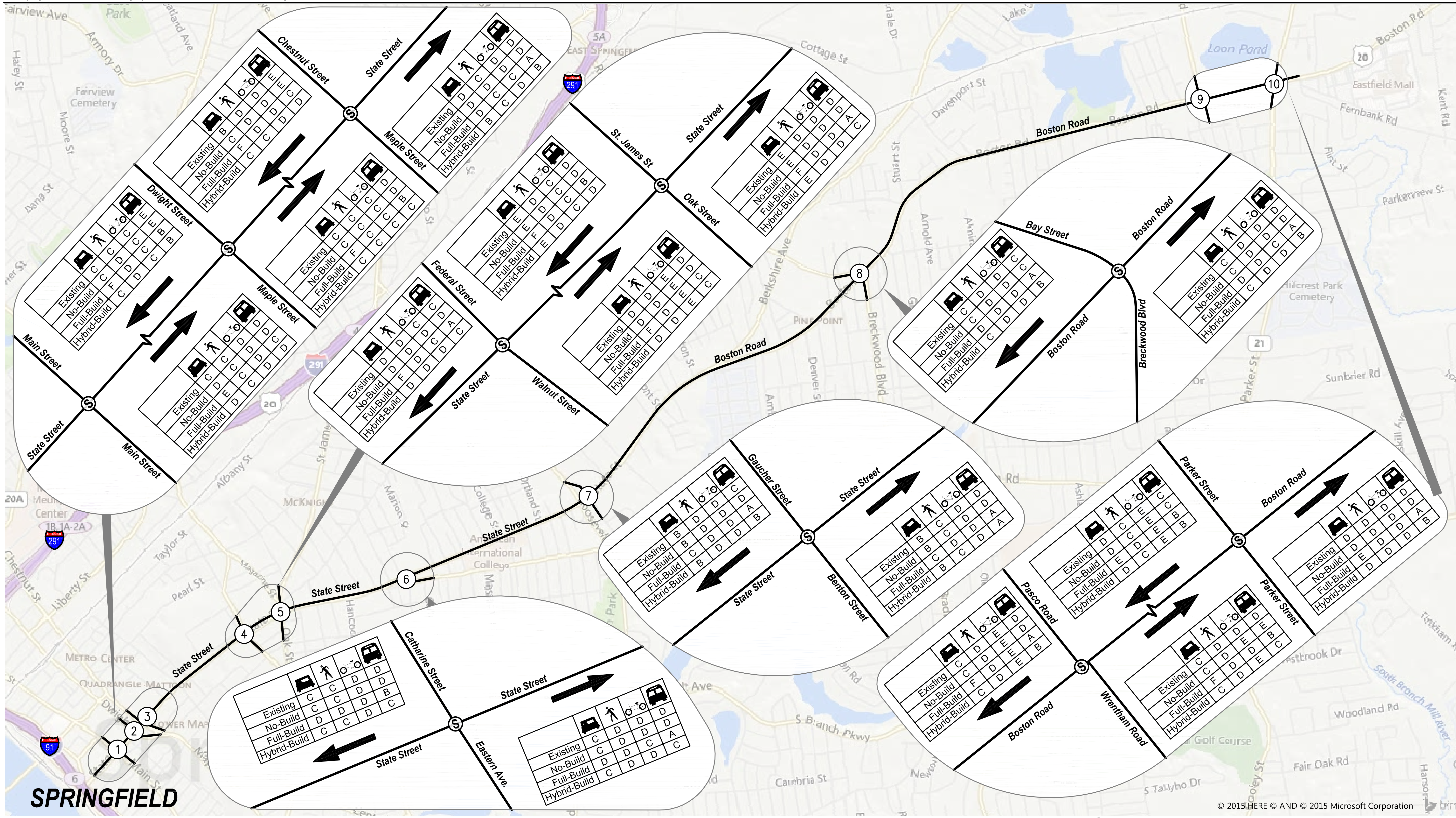
Figure 66

MMLOS Summary
Weekday Morning Peak Hour
Springfield, Massachusets



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NOTES:

1. AUTO LEVEL OF SERVICE IS BASED ON THE HIGHWAY CAPACITY MANUAL 2000 METHODS WITHIN SYNCHRO.
2. PEDESTRIAN, BICYCLE, AND TRANSIT LEVEL OF SERVICE WAS CALCULATED UTILIZING THE HIGHWAY CAPACITY MANUAL 2010. THESE VALUES REPRESENT THE SEGMENT LEVEL OF SERVICE, WHICH IS CONSIDERS AN INTERSECTION WITH THE DOWNSTREAM ROADWAY LINK.

Legend

- Ⓢ Signalized Intersection
- → Analysis Direction
- Vehicle Level of Service
- Pedestrian Level of Service
- Bicycle Level of Service
- Transit Level of Service

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Figure 67

MMLOS Summary
Weekday Evening Peak Hour
Springfield, Massachusets

5.6 Conclusions

This Chapter has provided a discussion on the existing conditions within the study area, including safety concerns and traffic operations, as well as the potential impacts to traffic operations of each of the preferred alternatives. The following provides a summary of the results discussed in the preceding sections:

- Eleven of the twelve intersections within the study area have crash rates higher than the MassDOT District 2 average, suggesting that there are potential safety concerns at these locations. In addition, ten of the twelve study area intersections are classified as High Crash Locations (HSIP clusters) by MassDOT.

- Observed vehicle speeds throughout the study area ranged from 13 mph in the vicinity of Main Street to 45 mph on Boston Road. Based on travel time runs conducted by VHB and information provided by PVTA, it was determined that a private vehicle can travel from the Eastfield Mall on Boston Road to Main Street and back in approximately 35 minutes during both the morning and evening peak hours. For a bus to make this same trip can take up to 95 minutes during the evening peak hour.

- The following provides a summary of some of the findings from the capacity analysis that was conducted:
    - The intersection of State Street at Federal Street operates at a LOS D during both morning and evening peak periods.

    - The intersection of State Street at Saint James Avenue operates at a LOC D during the weekday morning peak hour and a LOS E during the weekday evening peak hour.

    - The intersection of Boston Road at Parker Street operates at a LOS D during the weekday evening peak hour. All other study area intersections operate at LOS C or better under existing conditions.

    - Under the No-Improvements condition, one additional intersection (State Street at Main Street) has operations reduce to LOS D.

    - When comparing the 2025 Hybrid Alternative to the 2025 1B Alternative, six (6) of the ten (10) Study Area intersections during the morning peak hour, and every intersection during the evening peak hour, operate at least one level-of-service (LOS) letter grade better.

- The following provides a summary of some of the findings from the MMLOS analysis that was conducted:

- The pedestrian level-of-service was at a LOS D or better for every segment between the Study Area intersections.

- The bicycle level-of-service ranged from LOS C to LOS E, and the segments with a poor level-of-service had more driveways that could create more conflict.

- The transit mode level-of-service ranked from LOS C to LOS E.

- Under future conditions the only segment that decreased to a LOS E was the eastbound segment of Boston Road between Pasco Road and Parker Street (LOS D to LOS E) during the weekday morning peak hour for both bicycle and transit.

Chapter 6: Construction Impacts

This chapter focuses on a review of the potential construction impacts associated with two Bus Rapid Transit (BRT) improvement alternatives for the Study Area corridors and intersections. More specifically, this chapter will provide an overview of potential intersection, roadway and potential right-of-way impacts. Proposed BRT Bus Station impacts are discussed in a previous chapter. It is also noted that the operational analyses for the Study Area intersections is summarized in a previous chapter. The results presented in this chapter are based on preliminary information and should be considered conceptual in nature and used for planning purposes only until further engineering design is performed.

6.1 BRT Alternatives Roadway Cross Section

6.1.1 Alternative 1B Build

The 1B Alternative would remove a through travel lane in both eastbound (outbound) and westbound (inbound) directions along the State Street and Boston Road corridor(s). This would include elimination of a through lane at each of the ten (10) Study Area intersections, as well as at any non-study area intersection that has a cross section which has two through lanes in each direction. Transit Signal Priority (TSP) would be incorporated into all of the traffic signals as well as upgraded stations being placed at BRT stops that include BRT amenities such as off-board fare collection, etc. This alternative assumes that the project would construct a dedicated bus lane close to the center of right-of-way. The objective with this alternative is to reduce the need for additional right-of-way, while providing the most enhanced BRT system.

For this alternative, it is anticipated that the roadway cross section could consist of approximately 68-feet. This is based on current MassDOT design standards for the functional classification of Boston Road and State Street; which are major arterial roadways and part of the Federal Highway (FHWA) National Highway System (NHS) network. The 68-foot cross section could accommodate the following configuration: a 12-foot dedicated bus lane, an 11-foot travel lane, a 5-foot shoulder and a 6-foot sidewalk for each the inbound and outbound directions. For turn lanes, an additional 11-feet should be assumed, and should these lanes abut any medians, a 2-foot inside shoulder would also be required. It is anticipated that this cross section would be used for the entire length of the corridor from the Eastfield Mall to Main Street, although this cross section may need to be revised in certain areas where building locations make the available right-of-way constrained (especially near Main Street). It can also be anticipated that the cross section would need to shift away from the center of the roadway when a bus station or left-turn lane is proposed. It is noted that existing left-turn lanes are needed at many of the Study Area intersections to accommodate the existing and future traffic demands.

6.1.2 Hybrid Alternative Build

The Hybrid Alternative considers the implementation of a curb-side dedicated bus lane along the Boston Road corridor, specifically between the intersections of Pasco Road and Bay Street. From Bay Street to

Berkshire Avenue there are several constraints with buildings being located very close to the back of the existing sidewalk, making it difficult to widen the roadway without acquiring land, buildings and/ or businesses. The sections of State Street and Boston Road from Pasco Road east were reconstructed in 2010 and 2015. The corridor from Pasco Road to Berkshire Avenue was reconstructed around 1997, so the traffic signal equipment is reaching its expected life span and will soon need to be replaced. Along this section of Boston Road, there is a Two-Way-Left-Turn-Lane (TWLTL) that appears to be ineffective and unsafe. There have been an increase in crashes along this stretch of roadway, and are on MassDOT's Highway Safety Improvement Program (HSIP) crash list. For these reasons, this section of the corridor is a perfect area to incorporate BRT improvements along with traffic signal and roadway improvements.

For the corridor(s) west of Berkshire Avenue and east of Pasco Road, no major physical modifications other than the proposed bus stations would be proposed. For the limits between Pasco Road and Berkshire Avenue, the curb side bus lanes would be combined with Transit Signal Priority (TSP) and the use (or retrofit) of existing right-turn lanes for queue jumps at intersections. In addition, upgraded stations will be placed at BRT stops and will include BRT amenities such as off-board fare collection, etc. In this scenario, the roadway cross section (where curb-side bus lanes are proposed), would need to be widened to an 82-foot cross section. This cross section could accommodate two 11-foot travel lanes, a 13-foot shared dedicated bus lane/ shoulder (that would be shared with bicycles), and a 6-foot sidewalk in each direction. This is also based on current MassDOT design standards; however, it is noted that further discussions with MassDOT and the PVTA should occur regarding the feasibility of a shared bus/ bicycle lane. The reason that this cross section is wider than the 1B Alternative is that two through lanes are maintained. To reduce the impacts associated with keeping a through lane in each direction along the corridor, shared bus/ bike lanes are proposed to eliminate the need to construct 5-foot dedicated shoulders.

6.2 BRT Alternatives Impacts

This section will provide a general overview of the roadway impacts associated with the implementation of a BRT system. This review will break the corridor up into three segments, where each of the Study Area intersections will be discussed for each of the two alternatives described above. The following defines the three segments:

1. State Street: Main Street to Berkshire Avenue/ Boston Road
2. Boston Road: Berkshire Avenue/ State Street to Pasco Road
3. Boston Road: Pasco Road to the Eastfield Mall

6.2.1 State Street

In general, this segment is characterized by higher traffic volumes, especially as you get closer to downtown. There is a restricted right-of-way in many areas as the corridor transitions between downtown and a more retail based corridor (to the east). Along this corridor are businesses, residences, parks, cultural amenities, institutions, and major historical assets. In addition, the State Street corridor is the home to the federal courthouse and the MassMutual Center; which is the premier arena and convention center in Western Massachusetts. For much of this corridor, buildings and/or historic features are located at or near the back of sidewalk, providing limited options for bus station placement and roadway widening. The State Street corridor was recently reconstructed in 2010 with a $17M Federal Earmark.

State Street at Main Street

In general, this intersection is constrained by buildings immediately at the back of sidewalk on both sides of the roadway; including the Mass Mutual Center. The State Street roadway cross section at the intersection consists of two turn lanes (a left- and right-turn lane), two through lanes (one eastbound and one westbound), and on-street parking spaces along the southerly side of the roadway. As a result of these constraints, the following impacts could be realized with the implementation of any BRT system:

- The ten (10) parking spaces along the southerly side of State Street would need to be eliminated. It is noted that these spaces are used by the adjacent businesses, who do not have off-street parking; therefore, they are highly utilized.
- All construction activities would need to occur within the traveled way. Reducing the number of through lanes or turn lanes during construction would degrade traffic operations. To limit these impacts, nighttime construction or a roadway detour may need to be considered. Nighttime construction could increase construction costs.
- The intersection of State Street and Main Street currently show the need for a dedicated westbound right-turn lane (on State Street) and a dedicated southbound left-turn lane (on Main Street). These lanes should be maintained in any BRT alternative considered.

Full-Build: Alternative 1B Impacts

This BRT alternative would require the conversion of travel lane (in each direction) on the east leg of State Street and north leg of Main Street to a dedicated bus lane. Reducing the number of lanes on State Street at this intersection would have a significant impact on the overall operations for this location and increase vehicle queueing. To accommodate this BRT system:

- The traffic signal would need to be retrofitted or reconstructed to accommodate new signal heads for the bus lanes.
- The existing left-turn lane would need to be eliminated, since roadway widening is unlikely and there would be the need to accommodate an additional through bus lane. Removing this left-turn lane would negatively impact the traffic signal operations.
- Since there is only one through lane in each direction, longer queues and an overall degradation of traffic operations can be expected. More specifically, the inbound bus lane would need to transition to the right (off-center) so that the existing westbound left-turn lane can be maintained.

- The ten (10) on-street parking spaces along State Street would likely need to be eliminated to accommodate the inbound and outbound bus lanes; and especially if a bus station is proposed within vicinity of this intersection.
- Any reconfiguration of the existing signal layout could be challenging as the corners of the buildings, narrow sidewalks, limited right-of-way, and utility vaults under sidewalks could present challenges for locating mast arms, pedestrian signal posts, and wheelchair ramps.
- At least to the intersection of Dwight Street (the next Study Area intersection), the right-of-way appears to be at the back of sidewalk; which is also at the face of the adjacent buildings. Therefore there is likely no opportunity to acquire right-of-way for roadway widening without impacting buildings, as a result, the existing roadway cross section would need to be altered to avoid impacts and accommodate the preferred cross section.
- More specifically, any widening could require the narrowing of sidewalks and the elimination of existing on-street parking and tree plantings. It is noted that this section of State Street has a history of large utility vaults being directly under the sidewalk. These vaults typically connect to the adjacent building's basement. Further investigation of this area is needed to verify limits of vaults, if any.
- The estimated area of impact to accommodate this alternative for this intersection could be approximately 3,200 square feet; acquisition of property does not seem to be possible without purchasing adjacent buildings.

Hybrid Build Impacts

No physical improvements at this location are required to accommodate this alternative and there should be little or no impacts to traffic operations, as signal timing adjustments and TSP would only be proposed.

State Street at Dwight Street & Maple Street

The intersection of State Street with Dwight Street and Maple Street is confined by buildings located near the back of sidewalks, so there is little room to widen the roadway without impacting sidewalk widths. Based on the existing traffic volumes, the westbound left-turn movement from State Street onto Maple Street could be restricted in order to improve (although minimal) the overall intersection operations.

Full-Build: Alternative 1B Impacts

Since this intersection consists of a four-lane cross section, this alternative would convert a through movement travel lane in each direction to a dedicated bus lane. This would provide two lanes for traffic flow and two lanes for bus movement. Eliminating a through lane at this intersection would result in longer vehicle queues and an overall degradation of traffic operations since the roadway capacity (for vehicles) is being reduced by half. To accommodate this BRT system:

- The traffic signal would need to be retrofitted or reconstructed to accommodate new signal heads for the bus lanes.
- At least to the intersection of Chestnut Street (the next Study Area intersection), any widening, and in turn right-of-way impacts, would likely have to occur on the northerly side of the roadway, where there are wider sidewalks and a planted/ stone area. This area could have potential right-of-way impacts. If widening was performed on one side of the roadway, the alignment of the travel lanes would need to be looked at more closely.
- The roadway cross section would likely need to be widened by approximately 2- feet to 4-feet to bring the existing shoulders up to current standards. It should be noted that any roadway widening will result in impacts to one or both of the existing sidewalks. This widening could have an impact of approximately 1,200 square feet; which could include the acquisition of property.

Hybrid Build Impacts

No physical improvements at this location are required to accommodate this alternative and there should be little or no impacts to traffic operations as only TSP and traffic signal improvements would be implemented.

State Street at Chestnut Street & Maple Street

Similar to the intersection of Dwight Street and Maple Street, the intersection of State Street with Chestnut Street and Maple Street is confined by buildings located adjacent to the back of sidewalk. In addition, the historic Quadrangle Park is adjacent to the intersection (at the northeast corner). Based on the existing traffic volumes, the westbound left-turn movement could be restricted (from State Street onto Maple Street) in order to improve (although minimal) overall intersection operations; there is no dedicated turn-lane for this movement.

Full-Build: Alternative 1B Impacts

This BRT alternative would convert two of the four travel lanes on State Street to a dedicated bus lane. Since this reduces roadway capacity (for vehicles), it would result in longer queues and an overall degradation of traffic operations. To accommodate this BRT system:

- The traffic signal would need to be retrofitted or reconstructed to accommodate new signal heads for the bus lanes.
- It seems that widening could be accomplished within the existing right-of-way by adjusting the sidewalk and planted tree belts widths on one or both sides of the roadway. If these widths needed to be maintained, then the roadway widening could significantly increase and impact right-of-way.
- The roadway cross section would likely need to be widened by approximately 2-feet to 4-feet to bring the existing shoulders up to current standards. Any widening could have an impact of approximately 3,200 square feet; which could include the acquisition of property.

This includes roadway modifications between the intersections of Chestnut Street/ Maple Street and Byers Street; which is the next unsignalized non-Study Area intersection.

Hybrid Build Impacts

No physical improvements at this location are required to accommodate this alternative and there should be little or no impacts to traffic operations as only TSP and traffic signal improvements would be implemented.

State Street at Federal Street

The intersection of State Street at Federal Street should have available right-of-way to accommodate BRT improvements; however, some of the existing features such as the planted median, on-street parking, landscape buffer and sidewalks widths could be reduced in width and/ or eliminated. It is noted that the on-street parking on the southwesterly side of the roadway is heavily utilized by the adjacent businesses since they do not have any off-street parking. In addition, the Springfield Armory is located on the northwesterly corner of the intersection and the sidewalk, fence and some of the larger trees have historical significance.

Full-Build: Alternative 1B Impacts

This BRT alternative would convert two of the four travel lanes on State Street to a dedicated bus lane. Eliminating a through lane in each direction on State Street to a dedicated bus lane, resulting in longer queues and an overall degradation of traffic operations. To accommodate this BRT system:

- There are two electric vaults located on the northerly side of the State Street westbound approach. One is on the northeasterly corner (with two metal grates) and the second is located around 250-feet east of the intersection. Both of these structures would need to be investigated by the owner to see if they could be adjusted to the proposed roadway grade if the roadway is widened.
- There is a historic monument also located on the westbound approach (northerly side of the roadway) that could be impacted if the roadway is widened.
- The intersection would likely need to be fully reconstructed, due to the locations of the proposed bus stations on each leg of State Street and to retrofit or reconstruct the traffic signal to accommodate the BRT lane changes. There appears to be room available to widen the roadway within the existing right-of-way with the elimination (or narrowing) of the median and landscape buffer along this stretch of State Street. The placement of the bus stations would require widening on each side of State Street in order to accommodate the required lane shifts for buses. Maintaining the median and landscape buffers would likely trigger the need for additional right-of-way when accommodating lane changes and bus stations.
- The roadway cross section would likely need to be widened by approximately 2-feet to 4-feet to bring the existing roadway shoulders up to current standards. It should be noted that any roadway widening will result in impacts to one or both of the existing sidewalks.

This widening could have an impact of approximately 4,400 square feet; which includes limits from the signalized mid-block pedestrian crossing to the west, to a point midway between Federal Street and Oak Street to the east. If existing medians, on-street parking, or planted tree belts need to be maintained, then the widening could increase and right-of-way would be needed over multi parcels.

Hybrid Build Impacts

No physical improvements at this location are required to accommodate this alternative and there should be little or no impacts to traffic operations as only TSP and traffic signal improvements would be implemented.

State Street at Saint James Avenue

The intersection of State Street at Saint James Avenue should have available right-of-way to accommodate BRT improvements; however, some of the existing features such as the planted median, landscape buffer and sidewalks widths could be reduced in width and/ or eliminated. Some buildings are located at or near the back of the sidewalk on the southerly side of the roadway; however, the sidewalks appear to be wider and there is a landscape buffer present. Under both BRT alternatives the westbound left-turn movement could be restricted to improve (although minimal) overall traffic operations.

Full-Build: Alternative 1B Impacts

This alternative would convert two of the four travel lanes on State Street to a dedicated bus lane. Reducing the number of lanes on State Street at this intersection would have a significant impact on the overall operations for this location and increase vehicle queueing. To accommodate this BRT system:

- The traffic signal would need to be retrofitted or reconstructed to accommodate new signal heads, new curbing alignment for the bus lanes.
- There is room available to widen the roadway cross section within the existing right-of-way with the elimination of the median and landscape buffer along State Street. The roadway cross section would likely need to be widened by approximately 2-feet to 4-feet to bring the existing shoulders up to current standards. Roadway widening will likely result in impacts to one or both of the existing sidewalks. The area of impact could be approximately 3,200 square feet from a point midway between Federal Street and Oak Street to Orleans Street; which is the next unsignalized non-Study Area intersection to the east. This area of impact could likely increase or require right-of-way (over multiple properties) if the existing median and landscaped tree belts are maintained.

Hybrid Build Impacts

No physical improvements at this location are required to accommodate this hybrid alternative; however, if the westbound right-turn lane is used as a queue jump lane, the following could be required:

- Reconstruction or retrofit of the existing traffic signal to accommodate traffic signal head visibility; in addition, traffic signal timings would need to be modified to accommodate the queue jump.

- Widening of the northwesterly side of the intersection to accommodate the use of the queue jump and the shift of the buses through the intersection. The required widening could be up to 10-feet, for a length of up to 100-feet, to allow the buses to safely move back into the traffic stream. This widening would likely require the traffic signal span pole foundation on that corner to be relocated, resulting in the traffic signal as a whole being reconstructed. The sidewalk and signal work in this area could require approximately 500 square feet or right-of-way. More design is needed to verify.

State Street at Eastern Avenue & Catharine Street

The intersection of State Street and Eastern Avenue and Catharine Street has limited available space to widen the roadway on the eastern leg of the intersection due to the immediate location of existing buildings (Indian Motorcycle Building) and the school property fences.

Full-Build: Alternative 1B Impacts

This BRT alternative would convert two of the four travel lanes on State Street to a dedicated bus lane. Reducing the number of lanes on State Street at this intersection would have a significant impact on the overall operations for this location and increase vehicle queueing. To accommodate this BRT system:

- The traffic signal would need to be retrofitted or reconstructed to accommodate new signal heads, signal timings and phases for the bus lanes.

- Placing a bus station on the northwesterly leg of the intersection would require widening in other areas of the intersection to accommodate a roadway shift through the intersection for the BRT system. This would likely impact right-of-way. More details have been presented in previous chapters on station impacts.

- Since the northbound Eastern Avenue approach has dual left-turn lanes, and a westbound through lane is being removed on State Street, this northbound approach will need to be restriped to accommodate only one dedicated left-turn movement.

- Mason Square is located on the southwesterly corner of the intersection; which has parkland significance; in addition, the historic Indian Motorcycle building is located on the southeasterly side of the intersection. Impacts to these property may require coordination with the local Historic Commission and/ or the State.

- The roadway cross section would likely need to be widened by approximately 2-feet to 4-feet to bring the existing shoulders up to current standards. It should be noted that any roadway widening will result in impacts to one or both of the existing sidewalks. From Buckingham Street to Rutland Street, two non-Study Area intersections, the area of impact could be approximately 6,400 square feet. If existing medians, on-street parking, or planted tree belts need to be maintained, then this area of impact could increase and require right-of-way acquisitions over multiple properties.

Hybrid Build Impacts

No physical improvements at this location are required to accommodate this hybrid alternative; however, if the eastbound right-turn lane is used as a queue jump lane, the following could be required:

- Reconstruction or retrofit of the existing traffic signal, signal timings and phases to accommodate traffic signal head visibility and operations associated with the queue jump lane.
- Widening of the southeasterly side of the intersection to accommodate the use of the queue jump and the shift of the buses through the intersection. This could require widening of between 5-feet and 10-feet; which could require additional right-of-way. This area of impact could be approximately 1,000 square feet. It is noted that right-of-way is limited in this are due to the close proximity of the adjacent building and parking lots.

State Street at Gaucher Street and Benton Street

The intersection of State Street at Gaucher Street and Benton Street is limited by the Roosevelt Avenue Bridge located on the western side of the intersection. This bridge was reconstructed in 2011 shortly after the State Street improvement project. In effort to improve the overall (although minimal) traffic operations at this intersection, the eastbound left-turn movement from State Street onto Gaucher Street could be eliminated.

Full-Build: Alternative 1B Impacts

This BRT alternative would convert two of the four travel lanes on State Street to a dedicated bus lane. Reducing the number of lanes on State Street at this intersection would have a significant impact on the overall operations for this location and increase vehicle queueing. To accommodate this BRT system:

- The traffic signal would need to be retrofitted or reconstructed to accommodate new signal heads, signal timings and phases for the bus lanes.
- The Roosevelt Avenue Bridge, located just to the west of this intersection, is a constraint. Any widening through over this bridge would likely require it to be reconstructed. When the bridge was rehabilitated in 2009 the construction cost was around $1.0M to $1.5M. It can be expected that if this bridge needs to be fully reconstructed, it would likely be significantly more than that cost.
- The roadway cross section would likely need to be widened by approximately 2-feet to 4-feet feet to bring the existing shoulders up to current standards. It should be noted that any roadway widening will result in impacts to one or both of the existing sidewalks. The

approximate area of impact is 3,200 square feet. If existing planted tree belts need to be maintained, and bus buys shifted, then widening could increase.

Hybrid Build Impacts

No physical improvements at this location are required to accommodate this alternative and there should be little or no impacts to traffic operations as only TSP and traffic signal improvements would be implemented.

State Street – Other Locations

In addition to the seven (7) Study Area intersections along State Street; there are nine (9) additional signalized intersections and more than twenty (20) unsignalized intersections that would be impacted by the implementation of a BRT system. The following provides a general overview of some of the potential impacts.

Full-Build: Alternative 1B Impacts

This BRT alternative would convert two of the four travel lanes on State Street to a dedicated bus lane. The following provides an overview of potential impacts at other intersections along the corridor.

- Right-of-way would be needed where the proposed bus stations are to be located. These needs could range between 10-feet and 20-feet at each location. More details are provided in a previous chapter.
- The removal of the through lane along the corridor should accommodate the majority of the width needed to accommodate bus lanes mid-block (or between intersections); however, adjustments to the roadway cross section would be required to accommodate the lane shifts between new bus lanes, new bus stations, and intersections. This would result in widening, and requiring right-of-way or narrowing of medians, sidewalks, or removal of tree belts to offset impacts. This shift could vary from 2-feet to 10-feet depending on locations.
- For the non-Study Area signalized intersections of Oak Grove Avenue and Blunt Park Road, and other intersections where traffic signals have bus station; it can be expected that roadway widening is needed to accommodate. For this alternative, it would likely require the reconstruction of the entire intersection.
- Signalized intersections that currently have left-turn lanes would need to have the signal heads retained for these movements. New signal heads would need to be accommodated for bus lanes, and as a result, mast arms or strain poles would need to be retrofitted or reconfigured. This could require the entire intersection to be reconstructed.
- Due to the reduction of a through travel lane in each direction along State Street, it would likely be significantly harder to make a left-turn movement from the side streets at unsignalized intersections along the corridor. This is due to the fact that more cars in one lane creates less gaps in traffic than with the same amount of traffic in two lanes.

- In addition, to making left-turns from the side streets, making left-turns from the main line (State Street) would could create unsafe conditions by stopping traffic in one lane versus the two lanes that are there today; unless vehicles are allowed to use the bus lanes to complete turning maneuvers.
- As a result of decreasing the roadway and intersection capacity for this alternative, traffic patterns could dramatically change resulting in many drivers looking for alternative routes.
- In addition to impacting the corridor, a total of 18 signalized intersections would likely need to be retrofitted or reconstructed. This includes seven (7) Study Area and eleven (11) non-Study Area signalized intersections.
- Potential areas of impacts were identified under each Study Area intersection above. For the remainder of the State Street Corridor, if the cross section needed to be widened by 2-feet to 4-feet the area of impacts for all other areas along the corridor (not including Study Area impacts) could be approximately 36,900 square feet over a number of properties. Study Area intersection impacts could be approximately 24,800 square feet; which is the total from each summary above.

Hybrid Build Impacts

Physical infrastructure impacts relating to this BRT alternative are expected to be limited to locations with existing right-turn lanes that could be utilized as a queue jump lane for the buses. In these cases (westbound/ inbound at St. James Avenue and eastbound/ outbound at Eastern Avenue) impacts would be limited to widening on the opposing corner to allow for the buses to safely merge back into the State Street traffic flow. Right-turn lanes currently only exist at the Study Area intersections and as such those impacts were previously estimated to be approximately 1,500 square feet.

Other traffic signals may need to be reconstructed as a result of any widening and if the widening falls within the location of traffic signal foundations. Traffic signal timing changes, signal phases and signal coordination should be accommodated within the existing infrastructure.

6.2.2 Boston Road (east of Berkshire Avenue to west of Pasco Road)

This is the segment of Boston Road that was last reconstructed in 1997. Due to the antiquated infrastructure, it would need to be fully reconstructed to implement any BRT alternative. The existing roadway cross section within this segment transitions from four-lanes with turn lanes at intersections to a consistent five-lane segment; which includes a Two-Way-Left-Turn-Lane (TWLTL). The right-of-way varies greatly along this segment with some areas significantly restricted by buildings located at the back of the existing sidewalk; for example west of Bay Street to Berkshire Avenue. For this reason, a curb side alternative (Hybrid) is likely not feasible for this stretch of roadway without increasing the cost of the project for ROW acquisitions.

Boston Road at Bay Street & Breckwood Boulevard

The right-of-way surrounding the intersection of Boston Road at Bay Street and Breckwood Boulevard is restricted by adjacent off-street parking and buildings on each corner of the intersection. The need to maintain the existing westbound left-turn lane further limits opportunities for widening and providing dedicated bus lanes with adding a significant cost to the project.

Full-Build: Alternative 1B Impacts

This BRT alternative would convert a travel lane in each direction on Boston Road to a dedicated bus lane. Reducing the number of lanes on State Street at this intersection would have a significant impact on the overall operations for this location and increase vehicle queueing. The proposed cross section, including maintaining the westbound left-turn lane, can be incorporated within the existing right-of-way with minor widening. To accommodate this BRT system:

- The traffic signal would need to be retrofitted or reconstructed to accommodate new signal heads, and new signal timings and phases for the bus lanes.
- Some minor widening might be needed to provide wider shoulders that meet current design standards for bicycle accommodations.
- Widening in this area would be limited to approximately 5-feet to accommodate all users and require additional right-of-way. The area of impact could be approximately 7,000 square feet distributed over several properties.

Hybrid Build Impacts

Due to right-of-way restrictions just west of this intersection, a BRT system would need to utilize/ share the general travel lanes. Minor widening of between 2-feet and 4-feet on both sides of the roadway could still be required to accommodate improvements associated with current lane. The area of impact could be approximately 5,600 square feet distributed over several properties.

Boston Road – Other Locations

In addition to the Study Area intersection discussed above, there could be an additional nine (9) signalized intersections and more than twenty (20) unsignalized intersections that would be impacted by a BRT system. The following provides a general summary of some of the key impacts associated with areas outside this Project's Study Area.

Full-Build: Alternative 1B Impacts

- Utilizing a 13-foot center running bus lane, an 11-foot through travel lanes, a 5-foot shoulder and a 6-foot sidewalk in each direction, this cross section would require roadway widening (and ROW acquisition) of approximately 4-feet to 8-feet in areas along the corridor where there is no TWLTL present; unless existing medians, on-street parking, or planted tree belts would need to be maintained, then the widening could significantly increase.

- The majority of right-of-way impacts under this alternative would be isolated where the proposed bus stations are to be placed and the section of Boston Road west of Bay Street to Berkshire Avenue. This section of the corridor has a constrained ROW with buildings at (or near) the back of walkway.

- The intersection of State Street at Boston Road/ Berkshire Avenue would need to be reconstructed to accommodate a westbound dedicated bus lane. Widening at this location would likely require the acquisition of the existing gas station on the north side of Boston Road, as St. Michael's Cemetery is located on the southerly side and impacts to this parcel are likely not desirable.

- Potential areas of impacts were identified under each Study Area intersection above. For the remainder of this section of the Boston Corridor, if the cross section needed to be widened by 2-feet to 4-feet the area of impacts for all other areas along the corridor (not including Study Area impacts) could be approximately 44,000 square feet over a number of properties. Study Area intersection impacts could be approximately 7,000 square feet.

Hybrid Build Impacts

- Utilizing two 11-foot travel lanes, one 13-foot bus lane/ shoulder, and one 6-foot sidewalk in each direction; or an 82-foot cross section (not accounting for turn lanes), this BRT alternative could be carried between Pasco Road and Morton Street (just east of Bay Street), before transitioning to a traditional shared bus lane configuration with transit signal priority.

- Additional right-of-way impacts relating to this BRT alternative are expected to be limited to locations where proposed bus stations would be placed and the section of Boston Road between Bay Street and Pasco Road. This assumes that the dedicated curb side is not extended further west than Morton Street (just east of Bay Street).

- The area of impact to accommodate this BRT alternative within the limit of the existing TWLTL could be approximately 24,000 square feet. The majority of this is likely to be accommodated within the existing right-of-way, assuming that widening would vary from 4-feet to 8-feet.

- The area of impact to accommodate this BRT alternative within the limits where the curb side bus lane would not be proposed, or Morton Street to Berkshire Avenue, could be approximately 20,000 square feet. This assumes that widening would vary from 2-feet to 4-feet to accommodate bicycles and minor lane width deficiencies. The majority of this is likely to be accommodated within the existing right-of-way.

- In areas where the TWLTL does not exist, but the curb side dedicated lane is proposed, this could require upwards of 20-feet of widening. The area of impact to accommodate this BRT alternative could be approximately 88,000 square feet. From Morton Street to Pasco Road about 70% of this would be property acquisitions. Some of the specific significant impacts could include:

- The elimination of parking on the north side of the roadway in the vicinity of 510 Boston Road
- Shifting of the roadway to the south in the vicinity of Arnold Avenue to avoid buildings on the north side of Boston Road
- Potential parking impacts on both sides of Boston Road between Baltimore Avenue and Wilkes Street
- Potential wetland impacts on the north side of Boston Road in the vicinity of Shumway Street.

- The total area of impact could be approximately 132,000 square feet with the majority of this being outside the right-of-way.

6.2.3 Boston Road (Pasco Road to Eastfield Mall)

This segment, which was recently reconstructed in 2015, is the principal retail corridor within the City of Springfield and has over one million square feet of retail uses in its immediate vicinity. The cross section is primarily four lanes with a planted median and turn lanes at intersections. The right-of-way (ROW) varies and there are several off-street parking areas that would be impacted if the roadway was widened where the sidewalk would need to be moved back.

Boston Road at Pasco Road and Wrentham Road

The intersection of Boston Road at Pasco Road and Wrentham Road is constrained due to the right-of-way being located just off the back of sidewalk. There several properties that have off-street parking in this area. In addition, a stone masonry wall along the northeasterly corner of the intersection was recently reconstructed as the parking lot to the adjacent retail property is elevated.

Full-Build: Alternative 1B Impacts

- Eliminating an eastbound travel lane at this intersection would require that the southbound shared left/ through lane on Pasco Road be converted to a through-only lane. This would significantly impact operations.

- Due to the shifting and re-designation of lanes, all signal heads would likely need to be either replaced or repositioned. This may require the need for new mast arms.

- If this section of the corridor needed to be widened to accommodate bicycles or meet current design standards, the area of impact assuming widening of 2-feet to 4-feet could be approximately 5,200 square feet. However, there would be significant costs associated with even minimally widening this area as the previous improvements were aimed to minimize impacts to adjacent properties.

Hybrid Build Impacts

No physical improvements at this location are required to accommodate this alternative and there should be little or no impacts to traffic operations as only TSP and traffic signal improvements would be implemented.

Boston Road at Parker Street

The intersection of Boston Road at Parker Street is limited in right-of-way, but there is some opportunity for minor land takings.

Full-Build: Alternative 1B Impacts

This BRT alternative would convert one of two travel lanes in each direction on Boston Road to a dedicated bus lane.

- The placement of the inbound station on the westerly leg of the intersection on Boston Road, would require widening on the southeast corner of the intersection to accommodate the required lane shifts.
- Due to the shifting and re-designation of lanes, all signal heads would likely need to be either replaced or repositioned. This may require the need for new mast arms.
- If this section of the corridor needed to be widened to accommodate bicycles or meet current design standards, the area of impact assuming widening of 2-feet to 4-feet could be approximately 7,600 square feet. However, there would be significant costs associated with even minimally widening this area as the previous improvements were aimed to minimize impacts to adjacent properties. If the grassed median was eliminated or narrower the impact area could be reduced.

Hybrid Build Impacts

No physical improvements at this location are required to accommodate this alternative and there should be little or no impacts to traffic operations as only TSP and traffic signal improvements would be implemented.

However, should the intersection utilize the eastbound right-turn lane as a queue jump lane, the southerly side of the intersection would need to be reconstructed due to the fact that the right-turn lanes are channelized and contain traffic signal equipment. In addition, widening on the southeast corner would be needed to allow buses to safely merge back into the traffic stream before approaching the intersection to the Eastfield Mall. The south side of the roadway would need to be widened up to 11-feet for a minimum of 100 feet before tapering back to existing; or an area of impact of around 1,100 square feet.

6.3 Summary of Key Findings

This chapter provides an overview and comparison of the potential roadway impacts associated with each of the preferred BRT alternatives that could be implemented within the study area. Overall, the impacts associated with the 1B Alternative are far more significant than those anticipated with the Hybrid Alternative.

The majority of impacts associated with the Full Build alternative are due to the need to accommodate the dedicated center-running bus lanes. The existing signalized intersections would need to accommodate the proposed bus lanes, and associated bus stations. Also, to meet current roadway design standards the State Street Corridor would need to be widened. The Boston Road Corridor would also need to be fully reconstructed to accommodate the center-running bus lanes.

Significant roadway impacts related to the Hybrid Alternative are primarily limited to the areas around the proposed bus stations, and intersections where existing right-turn lanes are proposed to be used as queue jump lanes. In the segment of Boston Road between Berkshire Avenue and Pasco Road, the Hybrid Alternative would have larger impacts due to widening to accommodate a dedicated curbside bus lane in the inbound and outbound directions; along with the removal of the existing TWLTL.

Chapter 7: Public Involvement

7.1 Introduction

Civic Engagement is a critical component in the development of any transit alternatives. At the commencement of this study, AECOM developed a comprehensive Civic Engagement Plan to serve as a blueprint for a successful public involvement effort. The purpose of this plan was to identify key stakeholders and develop strategies to promote the study's goals:

- Establish viable BRT options for PVTA's State Street corridor
- Connect key destinations
- Provide enhanced station areas
- Support the City of Springfield's economic development goals
- Set standard for future PVTA corridors and for other systems in the state
- Conduct effective community outreach program

The following sections provide in greater detail an overview of the study's outreach efforts and collaboration with stakeholders, all handouts, meeting notes, presentations, etc from all meetings can be found in Appendix F.

7.2 Stakeholder Involvement

7.2.1 Oversight Committee

The purpose of an Oversight Committee is to guide the development of the study through collaboration with the project team. The Oversight Committee was established at the start of the study and was comprised of representatives from the AECOM team, PVTA, VHB, City of Springfield and MassDOT. This Committee was actively involved throughout the entire course of the study participating in bi-weekly conference calls to discuss progress, review documents, provide input and comments, and to select the preferred alternative.

In addition to the bi-weekly conference calls, AECOM organized a shared communication tool, Chatter, to further coordinate with the Oversight Committee. This private site allowed AECOM to communicate with the Committee and to share project updates and documents.

7.2.2 Stakeholders

The BRT Alternatives Analysis Study would not be successful as a stand-alone initiative without the involvement of stakeholders. In coordination with the Oversight Committee, a list of key stakeholders was developed covering a wide-range of governmental agencies, local organizations, businesses and educational institutions. This list evolved throughout the study as additional stakeholders were identified.

Representatives on this list were encouraged to participate in meetings, read about the project on the website and communicate their thoughts or concerns with the project team.

7.3 BRT Site Visit to HealthLine Cleveland

In April 2015, AECOM organized a trip to Cleveland, Ohio for the Steering Committee. The purpose of this trip was for the team to visit the HealthLine, a newly built BRT route. AECOM was instrumental in the development of the HealthLine and was able to offer some insight that would be useful in developing alternatives for the State St. and Boston Rd. corridor. Some lessons learned on this trip include:

- Strong support from the business community and Economic Development Team is critical
- Vehicles and stations incorporate safety and security elements
- Gateway concept
- Route efficiency is improved
- Zoning changes to support BRT development

Figure 68: HealthLine Visit

7.4 Public Informational Meetings

Developing a robust public outreach program is a critical component to the Civic Engagement Plan. This has been an inclusive process, seeking to interact with all stakeholders on various levels. This was achieved by hosting several public informational meetings as well as attending local neighborhood and civic association meetings, meeting with major employers and canvasing the corridor to speak with local organizations and small businesses.

7.4.1 Open House

On June 23, 2015 an Open House event was hosted at the TD Bank Conference Center in Springfield. As the first public information meeting, the purpose of this event was for the team to introduce the project to the public and provide an overview on the study's goals and tasks. During the Open House, attendees were encouraged to interact with the team and discuss any thoughts or concerns. Towards the end of the meeting, attendees were given a tour of PVTA's new articulated bus.

Figure 69: BRT Open House

7.4.2 Project Update and Tour

Following the Open House, an event was hosted in July at the Eastfield Mall. Key stakeholders in Springfield, particularly local businesses and organizations, were invited to attend to learn more about the project and to tour the State St. and Boston Rd. corridor.

This meeting was attended by representatives from the Springfield School Administration, Springfield Museums, Pioneer Valley Planning Commission, neighborhood associations, Representative Ben Swan's office and the House of Representatives. The full list of attendees can been found in Appendix F.

Figure 70: Key Stakeholder Meeting

7.4.3 Neighborhood and Civic Associations

In addition to coordinating outreach events for stakeholders, the project team realized the significance of presenting the study to existing local associations and engaging with residents. To achieve this, the project team attended multiple neighborhood and civic association meetings, including the neighborhoods along the corridor, throughout the spring and summer of 2015. During these meetings, the team was provided the opportunity to introduce the project and have an open dialogue with the association members. The goal of these small presentations was to gather feedback from the local residents to help develop a list of alternatives. Given the length of the corridor, meeting with these associations provided the project team with a greater understanding of the different needs of each neighborhood area.

The BRT study was presented to the following associations:

Table 55: Association Meetings Attended

Association	Date
Armoury Quadrangle	June 3, 2015
Bay Area	July 7, 2015
Indian Orchard	June 10, 2015
McKnight	June 9, 2015
Old Hill	June 3, 2015
Pine Point	May 12, 2015
Maple High Six Corners	July 14, 2015

Figure 71: Armoury Quadrangle Meeting

Although these associations represented unique neighborhoods, discussions at these meetings generally revolved around similar topics. Members at the meeting often voiced similar thoughts and concerns including:

- Fare increases
- Bus stop locations
- Project timeline
- Sustainability
- Security/Safety
- Project funding
- Integration with existing bus service
- Impact to lanes/traffic on the corridor

PROJECT WEBSITE

A webpage hosted on the PVTA website was dedicated to the project. This site provided background information on what BRT is, updates on the study's progress and information on upcoming events. Visitors could also view project materials and presentations from outreach events. A comment form was available on the site for visitors to provide feedback or ask questions.

PVTA BRT Springfield

The Pioneer Valley Transit Authority (PVTA) has identified the State Street corridor as a prime opportunity to introduce Bus Rapid Transit (BRT) as a new transit service for the Springfield region. The 7.1 mile corridor is a major east-west connector in the City and one of the most heavily traveled bus routes in the PVTA system, with more than 5,000 riders a day. A recent comprehensive study proposed developing a BRT route along this corridor. This route would be the first such service (outside of the Metro Boston area) in Massachusetts and will provide increased service frequency, shorter travel times, improved stop amenities and new economic development opportunities.

What is BRT?

BRT is a cost-effective approach to transit service that cities around the world have used which blends the positive features of rail transit with the flexibility of bus transit to make riding the bus a higher-end transit service alternative. BRT improves speed, reliability, and passenger comfort and convenience. It has user friendly features: faster service and fare collection; exclusive bus lanes; stations as opposed to bus stops; unique branding and passenger information.

Purpose of the State Street Bus Rapid Transit Project

The State Street Bus Rapid Transit project begins with a feasibility study and alternatives analysis to determine the best options for implementing a bus rapid transit system in the corridor. This includes a traffic impact, bus operations, and environmental analysis, as well as assessing ridership and economic development impacts. The project goals are to:

- Provide an attractive, unique, and cost effective transit service to Downtown Springfield, State Street and the Boston Road corridor and key connecting points;
- Provide enhanced station areas that will support economic development goals established by the City of Springfield

Figure 72: Project Website

Chapter 8: Locally Preferred Alternative

Coming soon