5

Alternatives Analysis

Chapter 4 presented a preliminary screening of alternatives that were identified as having the potential to address the corridor's transportation system issues and deficiencies and to meet the goals and objectives of the study. This chapter presents more detailed evaluations of the alternatives progressed.

Alternatives Analysis

This section expands on the previous discussion for each alternative progressed for further study. The details of each analysis vary for each alternative, based on the specific evaluation criteria relevant to the alternative.

Alternative 1: Bike Lanes East of School Street

Alternative 1 would provide a five-foot bike lane in each direction of Arsenal Street east of School Street to the Charles River. As noted in Chapter 4, narrowing the travel lanes to 11-feet would not be sufficient to create enough space for the provision of five-foot bike lanes within the existing right-of-way. Therefore, this analysis considered two options:

- Maintaining consistent five-foot bike lanes while further narrowing the outside travel lanes where necessary. The outside travel lane along the corridor would vary from 10.3 feet to 10.9 feet.
- Maintaining 11 foot outside travel lanes and providing a variable width bike lane from 4.2 feet 4.9 feet.

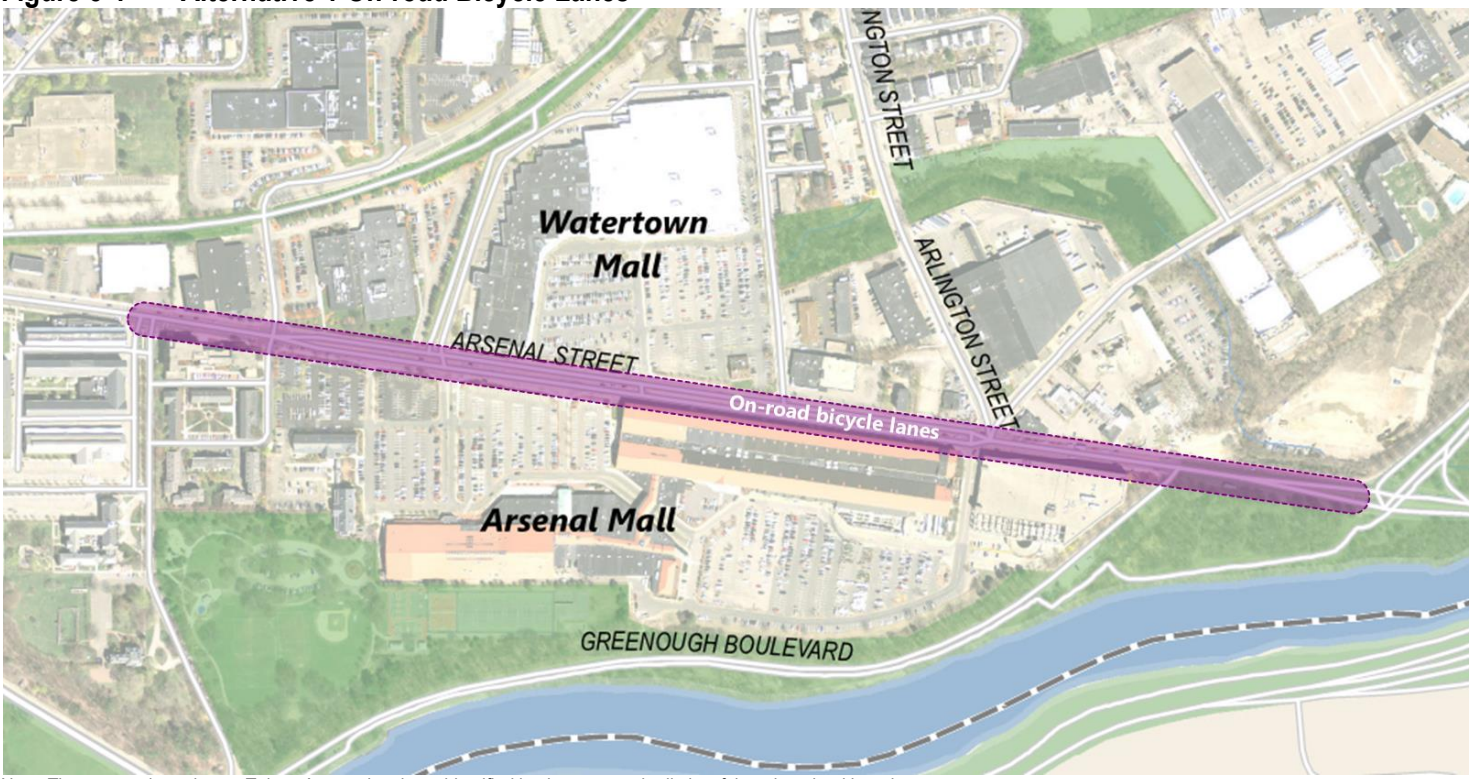
Once east of Arlington Street, 11-foot travel lanes and five-foot bike lanes could be accommodated approaching Greenough Boulevard. West of School Street, the bike lanes would connect with the existing two-way bike path (north side) to form a continuous bike route along Arsenal Street from Irving Street to the river (with planned connections further west in the future). The improved biking connectivity

along the corridor is likely to encourage biking as an alternative means of traveling and therefore reduce auto dependency. From a public health perspective, it could have a positive impact by reducing vehicle miles traveled and automobile congestion on Arsenal Street and results in reduced greenhouse gas emissions and transportation-related noise. It also encourages Complete Streets as a component of healthy community design. Alternative 1 has limited or neutral impacts on safety, public transit service, and the natural environments along the corridor.

While MassDOT's minimum width for bicycle lanes is five feet, federal guidance allows some flexibility for areas with constrained right-of-way. Based on that guidance, either option could be appropriate for the corridor. Also, athenahealth has recently proposed installing bicycle lanes along Arsenal Street in front of their property, from Wooley Avenue to Talcott Avenue, that are slightly less than five feet wide. Their proposed changes require restriping the roadway within the existing curb to curb width, with no alterations to sidewalk or private property. As shown in Figure 5-1, the project limits of Alternative 1 would ultimately meet the athenahealth project, providing a more uniform cross-section if the bike lanes are of roughly the same width. Varying the width of the bike lane, as opposed to the outside travel lane was also preferred by the town, which has established a 11-foot minimum width for vehicular travel lanes.

A review of available 1997 ground survey data along Arsenal Street allowed for the development of a conceptual plan to determine right-of-way constraints along the corridor and the expected varying width of the bike lanes. This full plan is provided in the Appendix. The conceptual plan holds 11-foot travel lanes, 10-foot turn lanes, and existing median widths along Arsenal Street. In general, once past the Arsenal Mall driveway, the right-of-way widens to provide 4.9-foot bike lanes on the south side of the roadway and 4.5-foot bike lanes on the north side of the roadway. The corridor generally widens to the east and the most constrained (or narrow) area is between Talcott Avenue and the main Arsenal Mall driveway.

Figure 5-1 Alternative 1 On-road Bicycle Lanes



Note: The western boundary at Talcott Avenue has been identified by the town as the limits of the athenahealth project.

Figure 5-2 illustrates a possible cross-section within the constrained area, which would provide 11-foot travel lanes and 4.3-foot bicycle lanes or shoulders. As the town develops this alternative further, consideration should be given wherever possible to modification of medians and the potential to shift the roadway center line to maximize the space available for bicyclists.

Figure 5-2 Alternative 1 Cross-Section Example in Areas with Constrained Rights Of Way

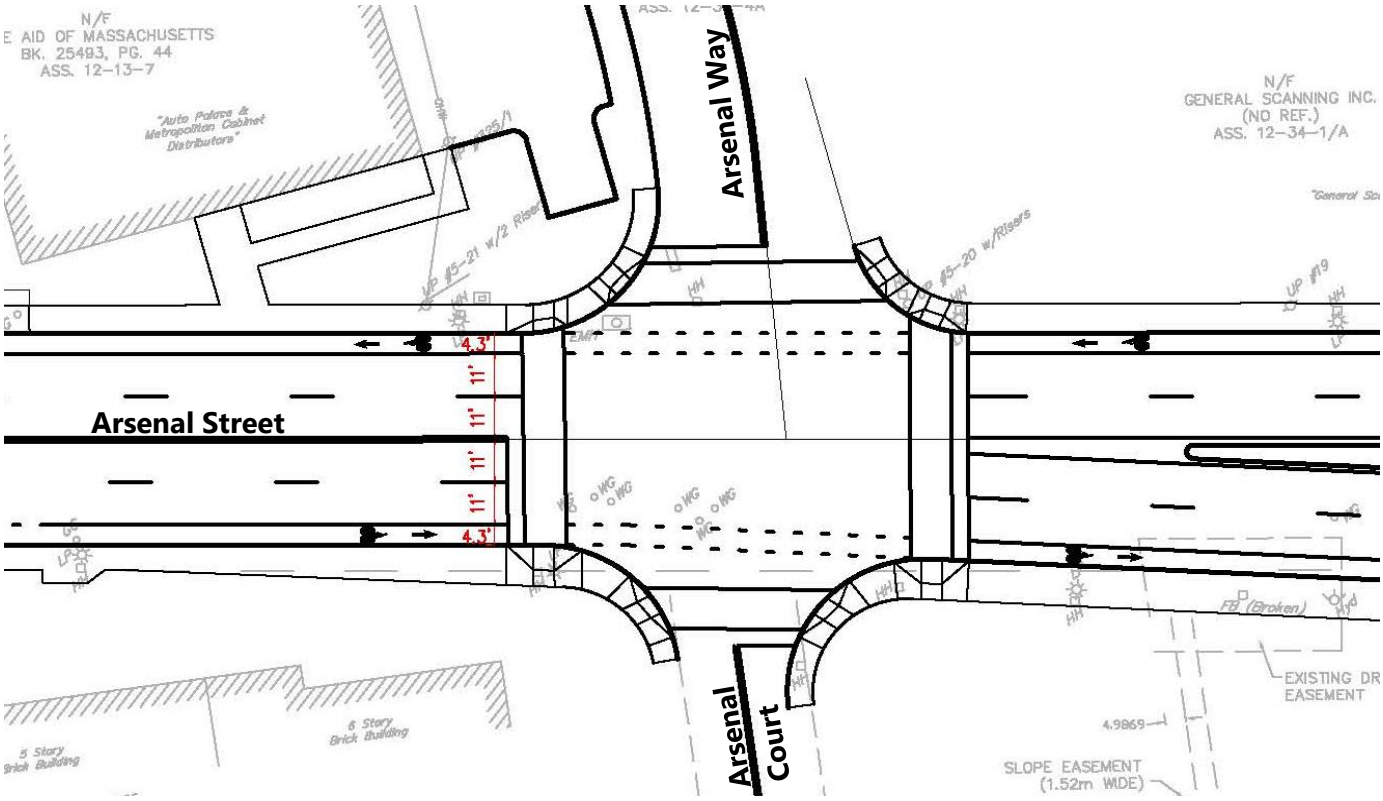


Table 5-1 considers the results of the analysis discussed above, summarizes the complete evaluation of Alternative 1 against the study goals and objectives, and provides a preliminary order-of-magnitude construction cost estimate. The cost for this alternative would be based on the construction methods preferred by the town. For example, the town may choose to remove the existing striping and restripe with new paint or remove a thin layer of asphalt and repave the road. A range of costs are provided to account for this. The inclusion of dedicated bike lanes along the corridor is a short-term recommendation.

Table 5-1 Alternative 1 Evaluation and Recommendation

✓ ● ✖ ***PHO***	Positive Impact Neutral Impact Negative Impact Public Health Objective		
Goals	**Objectives**	**Impact**	**Comments**
Mobility Benefits	Decrease congestion and reduce delays (PHO)	●[1]	1. This alternative focuses on encouraging means of non-motorized transportation, with the overall ambition of improving mobility over the longer-term.
	Improve system reliability	●[1]	
	Minimize local street impacts	●[1]	
	Maintain emergency vehicle and first responder mobility	●[1]	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	●	
	Address current design standard deficiencies (PHO)	●	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	✓	2. Completes a more direct connection between Watertown Square and the Paul Dudley White path system through dedicated accommodations.
	Improve existing public transportation services (PHO)	●	
	Coordinate existing transit services	●	
	Improve bike and pedestrian connections (PHO)	✓[2]	
	Promote active transportation (PHO)	✓	
Economic Development Impacts	Support existing and projected economic development	●	3. Improves connectivity for those that may not have access to automobile or transit options.
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	●	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	✓	
	Improve access to the regional highway system	●	
	Avoid/minimize/mitigate social equity impacts	✓[3]	
	Incorporate healthy community design features (PHO)	✓	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●	
	Avoid/minimize/mitigate impacts to the natural environment	●	
	Minimize greenhouse gas emissions (PHO)	✓	
	Reduce CO and particulate matter impacts (PHO)	✓	
	Minimize transportation-related noise impacts along the corridor (PHO)	✓	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	✓[4]	4. Bike lanes can encourage use of non-motorized transportation.
Public Support	Encourage consensus through an open and inclusive process	Yes	
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	$75,000-$2.1M	Range reflects ability to modify striping only or repave the roadway
Recommendation	***On-road bike lanes are recommended. Where practical, the town should strive to achieve a five-foot width.***		

Alternative 3: Cross Connectivity between the Greenway and Charles River

Alternative 3 would improve access to the Charles River for pedestrians and bicyclists by providing cross connections south from the Watertown Greenway/ Arsenal Street to the river to the south. Several connections, through both public and private property, are being advanced by the Town of Watertown and private developers. These connections are shown in Figure 5-3 and include:

- **athenahealth:** The campus development includes plans to establish a pedestrian/bicycle corridor to the west of a proposed parking garage along Wooley Avenue. The path would be integrated into the proposed traffic signal at the intersection of Arsenal Street and Wooley Avenue, providing a controlled crossing of Arsenal Street. The corridor would travel through the campus and provide access to North Beacon Street, opposite Charles River Road. Both Kingsbury Avenue and Talcott Avenue are planned to include pedestrian and bicycle accommodations.
- **Arsenal Park Connector:** The Town of Watertown is working with LivableStreets Alliance to extend the existing spur of the Watertown-Cambridge Greenway from where it terminates at Arsenal Street next to the Watertown Mall through Arsenal Park and to North Beacon Street. Routing of the pathway is currently being developed.
- **Arsenal Yards:** Bicycle connections are being considered as part of the redevelopment of the Arsenal Mall site, including a potential mixed-use path to Greenough Boulevard.
- **Hanover/Elan Union Market:** An east-west pathway is being constructed on the north sides of these two developments to improve connectivity to the neighborhood. The pathway will connect to Birch Road and provides an opportunity to access Walnut Street and points north.

Providing cross connections between the Watertown Greenway/Arsenal Street and the Charles River has several positive public health effects. It improves pedestrian and bicycle connections among residential areas, employment centers, and the regional recreational trail systems. In doing so it encourages active transportation and promotes healthy living as an important aspect of healthy community design. In addition, it helps reduce automobile dependency and hence traffic congestion on and around Arsenal Street, and could result in fewer greenhouse gas emissions and transportation-related noise.

Analysis of Alternative 3 considered potential additional north-south connections west of Wooley Avenue to further improve access between the Charles River and residential neighborhoods both north and south of Arsenal Street. As shown in Figure 5-3, Irving Street, Beechwood Avenue, and Louise Street/Paul Street were considered as they each provide continuous connections between Arsenal Street and the river.

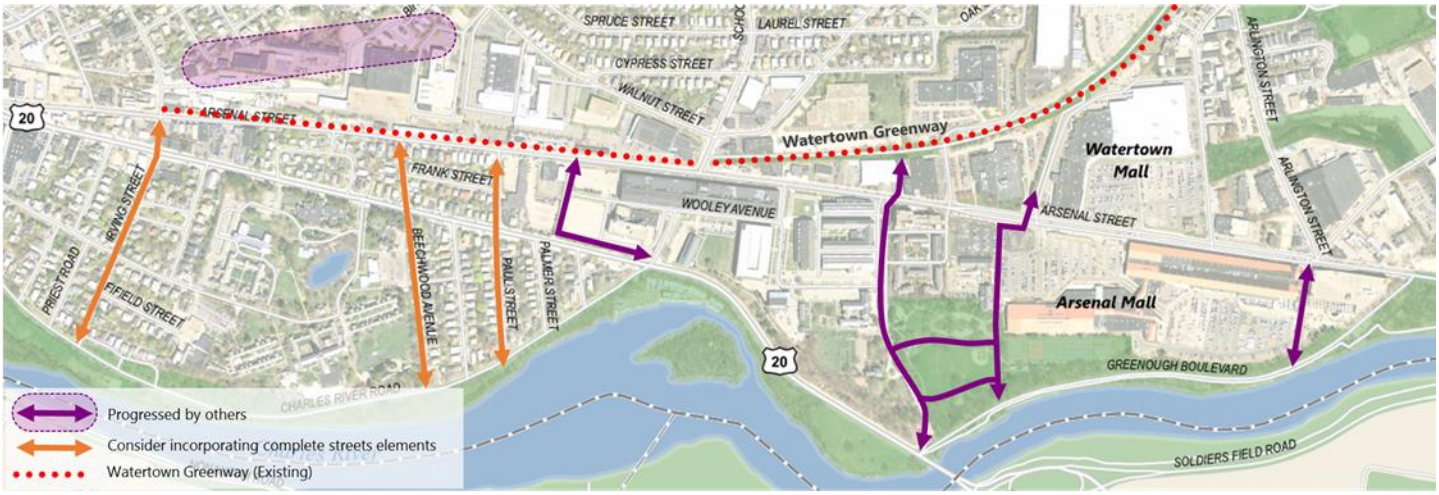
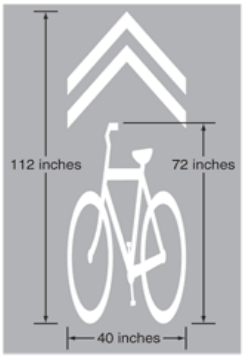


Figure 5-3 Alternative 3 Cross Connectivity between the Greenway and Charles River



Source: 2009 Manual on Uniform Traffic Control Devices

Shared lane markings ("sharrows") are pavement markings that indicate a shared environment for bicycles and motor vehicles and do not require additional roadway space. This type of treatment can be used to reinforce the legitimacy of bicycle traffic on a roadway and support a complete bikeway network.

Based on a review of the existing curb-to-curb width and an understanding of the limited right-of-way along all each of these roadways, installation of bike lanes would require potentially significant changes to traffic circulation patterns (such as the creation of one-way streets). Other Complete Streets elements, such as shared lane markings could be considered by the town to improve north-south connectivity and accommodated within the existing right-of-way.

Irving Street, Beechwood Avenue, and Louise Street/Paul Street were each reviewed to determine physical changes that would be needed to support striping formal bike lanes. It should be noted that for the purposes of this analysis, the back of sidewalk on each side of the street was assumed to be the right-of-way line. If any of the accommodations discussed below were progressed, field survey would be required to establish the right-of-way.

- **Irving Street:** The cross-sectional width of Irving Street varies from roughly 36 to 40 feet. This width is not sufficient to accommodate minimum travel lane widths, bicycle lanes, and sidewalks meeting ADA guidelines. Creation of a one-way street would be difficult for traffic circulation, as there is no nearby parallel route to serve traffic in the opposite direction. Therefore, shared lane markings were determined to be the most advantageous.
- **Beechwood Avenue:** The cross-sectional width of Beechwood Avenue varies from 37 to 40 feet. This width is not sufficient to accommodate minimal travel lane widths, bicycle lanes, and sidewalks meeting ADA guidelines. When also considering the adjacent Louise Street/Paul Street corridor, Beechwood Avenue may be a candidate to convert to one-way. Given the recent traffic signal changes at the intersection of Beechwood Avenue at Arsenal Street, one-way northbound may be beneficial, however further assessment of traffic flow patterns would be required if this option were to be considered. With the elimination of a travel lane, the roadway can accommodate a northbound

vehicular travel lane, northbound bike lane and a southbound contra-flow bike lane. Options such as separated bike lanes and shared use paths could also be considered but would likely not warrant the associated cost given the low traffic volume along the roadways. It is noted that the Perkins School for the Blind provides parking access via Beechwood Avenue. Travel patterns to/from this location would have to be carefully considered.

- **Louise Street/Paul Street:** The cross-sectional width along Louise and Paul Streets vary from 36 to 40 feet. As noted above, there is a possibility to convert Louise/Paul Street to one-way southbound in conjunction with Beechwood Avenue. Additional study of traffic circulation patterns is needed to understand potential localized impacts. The creation of on-road bike lanes provides a dedicated space for bicyclists who may live in the neighborhood or want to connect from the Watertown Greenway to the river. Specific to the one-way pair of Beechwood Avenue and Louise Street/Paul Street, Frank Street should also be included in the evaluation to determine the potential for impact.

Overall, traffic volumes on these roadways are low and speeds are moderate. Through the public informational meetings, residents within the neighborhood expressed frustration with respect to "cut-through" traffic. To the extent possible, any changes to bicycle accommodations should also include discussion of traffic calming measures to offset the potential for further impacts. Further community outreach is needed to develop specific recommendations within the neighborhood, with respect to possible one-way streets, shared lane markings and the potential to formalize crossing connections to the Paul Dudley White path across Charles River Road.

Final costs and the potential for environmental permitting for this alternative would be based on the outcome of this outreach. Based on aerial photographs and MassGIS data, the pathways at Charles River Road/Greenough Boulevard may be within jurisdictional resource areas and/or buffer zones associated with the Charles River and regulated under the Massachusetts Wetlands Protection Act (310 CMR 10.00) and the Watertown Wetlands Ordinance, thus requiring submission of a Notice of Intent (NOI) application. Depending on the type of connection made (if any), Alternative 3 could require the following wetlands resource related regulatory permits:

- Local/State – Order of Conditions from Watertown Conservation Commission
- Federal – National Pollution Discharge Elimination System (NPDES) Construction General Permit from U.S. Environmental Protection Agency (USEPA)

Table 5-2 considers the results of the analysis discussed above and summarizes the complete evaluation of Alternative 3 against the study goals and objectives. Cross-connectivity to the river is a short-term recommendation.

Table 5-2 Alternative 3 Evaluation and Recommendation

✓	Positive Impact
●	Neutral Impact
✖	Negative Impact
PHO	Public Health Objective

Goals	Objectives	Impact	Comments
Mobility Benefits	Decrease congestion and reduce delays (PHO)	●	1. Can be planned in a way that reduces potential for cut-through and improves streetscape. Care should be taken to avoid harmful property impacts.
	Improve system reliability	●	
	Minimize local street impacts	●[1]	
	Maintain emergency vehicle and first responder mobility	●	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	●	
	Address current design standard deficiencies (PHO)	●	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	✓	
	Improve existing public transportation services (PHO)	●	
	Coordinate existing transit services	●	
	Improve bike and pedestrian connections (PHO)	✓	
	Promote active transportation (PHO)	✓	
Economic Development Impacts	Support existing and projected economic development	●	2. Improves connectivity for those that may not have access to automobile or transit options.
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	●	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	✓	
	Improve access to the regional highway system	●	
	Avoid/minimize/mitigate social equity impacts	✓[2]	
	Incorporate healthy community design features (PHO)	✓	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●	3. Potential environmental impacts in creating formalized connections to the pathways along Charles River Road/ Greenough Boulevard.
	Avoid/minimize/mitigate impacts to the natural environment	✖[3]	
	Minimize greenhouse gas emissions (PHO)	✓	
	Reduce CO and particulate matter impacts (PHO)	✓	
	Minimize transportation-related noise impacts along the corridor (PHO)	✓	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	✓	
Public Support	Encourage consensus through an open and inclusive process	TBD	Requires further outreach.
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	N/A	Shared lane markings are roughly $150 each.[2]
Recommendation	***Continue to support paths being planned independent of this study. Advance the consideration of Complete Streets elements with additional community outreach.***		

2 Unit cost assumes thermoplastic shared lane markings.

Alternative 5: Road Diet East of School Street

Alternative 5 was further developed to improve multimodal conditions by considering a road diet for the four-lane section of Arsenal Street from east of School Street to Greenough Boulevard. Two potential road diet options were considered (Figure 5-4):

- Option 1: One general travel lane and one shared bus/bike lane in each direction
- Option 2: One general travel lane westbound and two general purpose and one shared bus/bike lanes eastbound

Under both options, the curb-to-curb width would not be modified.

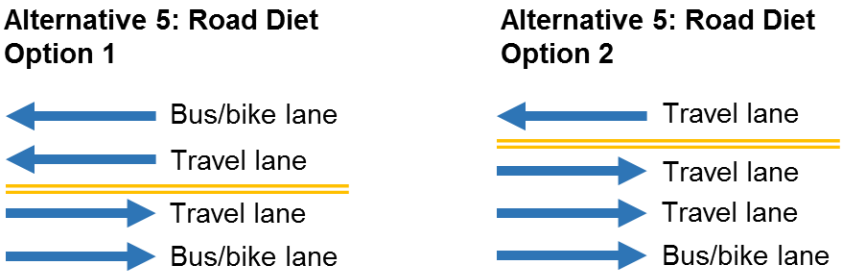


Figure 5-4 Alternative 5 Road Diet Schematics

Analysis of Alternative 5 included a roadway capacity threshold evaluation and identification of potentially impacted parallel routes. The threshold evaluation established the approximate reduced capacity of Arsenal Street with a road diet implemented and compared that to the projected demand. The reduced capacity was established based on guidance in the 2010 HCM which states that the theoretical capacity of a two-lane highway is 3,200 vehicles per hour (in both directions). Assuming a 50 percent reduction in capacity for the presence of signals and other geometric conditions along the corridor, the assumed capacity was 1,600 vehicles per hour in both directions, or 800 vehicles per hour per lane. This capacity was compared to projected 2040 traffic volumes along several key segments of the corridor. The results of this comparison are presented in Table 5-3.

Table 5-3 Alternative 5 Roadway Capacity Threshold Analysis

Option 1 (Eastbound and Westbound Diversion)				
	AM Peak Hour		PM Peak Hour	
Arsenal Street Segment	2040 Volume	Diverted Traffic (Percent Diverted)	2040 Volume	Diverted Traffic (Percent Diverted)
East of School Street				
EB	1,610	810 (50%)	845	45 (5%)
WB	500	n/a (n/a)	1,230	430 (35%)
East of Arsenal Project Main Driveway				
EB	1,040	240 (23%)	980	180 (18%)
WB	700	n/a (n/a)	880	80 (9%)
East of Arlington Street				
EB	1,480	680 (46%)	1,270	470 (37%)
WB	995	195 (20%)	1,085	285 (26%)
Option 2 (Westbound Diversion Only)				
	AM Peak Hour		PM Peak Hour	
Arsenal Street Segment	2040 Volume	Diverted Traffic (Percent Diverted)	2040 Volume	Diverted Traffic (Percent Diverted)
East of School Street				
EB	1,610	0 (0%)	845	0 (0%)
WB	500	n/a (n/a)	1,230	430 (35%)
East of Arsenal Project Main Driveway				
EB	1,040	0 (0%)	980	0 (0%)
WB	700	n/a (n/a)	880	80 (9%)
East of Arlington Street				
EB	1,480	0 (0%)	1,270	0 (0%)
WB	995	195 (20%)	1,085	285 (26%)

n/a: Not applicable since the projected 2040 volume could be accommodated in one lane.

It should be noted that a review of turning movement counts indicates that a significant number of Arsenal Street trips have destinations within the segment being considered for a road diet. As such, achieving the diversions outlined in Table 5-3 to maintain acceptable traffic operations may not be feasible.

Analysis of Alternative 5 also included identification of parallel routes anticipated to be impacted if a road diet were implemented along Arsenal Street. Potential impacted parallel routes are shown in Figure 5-5.

To the south, the North Beacon Street, Greenough Boulevard, Soldiers Field Road, and Birmingham Parkway corridors would likely experience increased traffic volumes. There are limited options to travel between Arsenal Street and these southern parallel routes and increases to traffic in residential neighborhoods via Beechwood Avenue and Louise Street and/or through the athenahealth campus would be expected.

Diversion routes to the north are more limited and include Dexter Avenue, Nichols Avenue, Grove Street, and the local streets connecting these roadways.

While the road diet's potential to improve public transit service and encourage biking as alternative means of traveling could provide positive public health benefits along Arsenal Street, the diversion routes would bear the brunt of displaced traffic and related public health impacts.

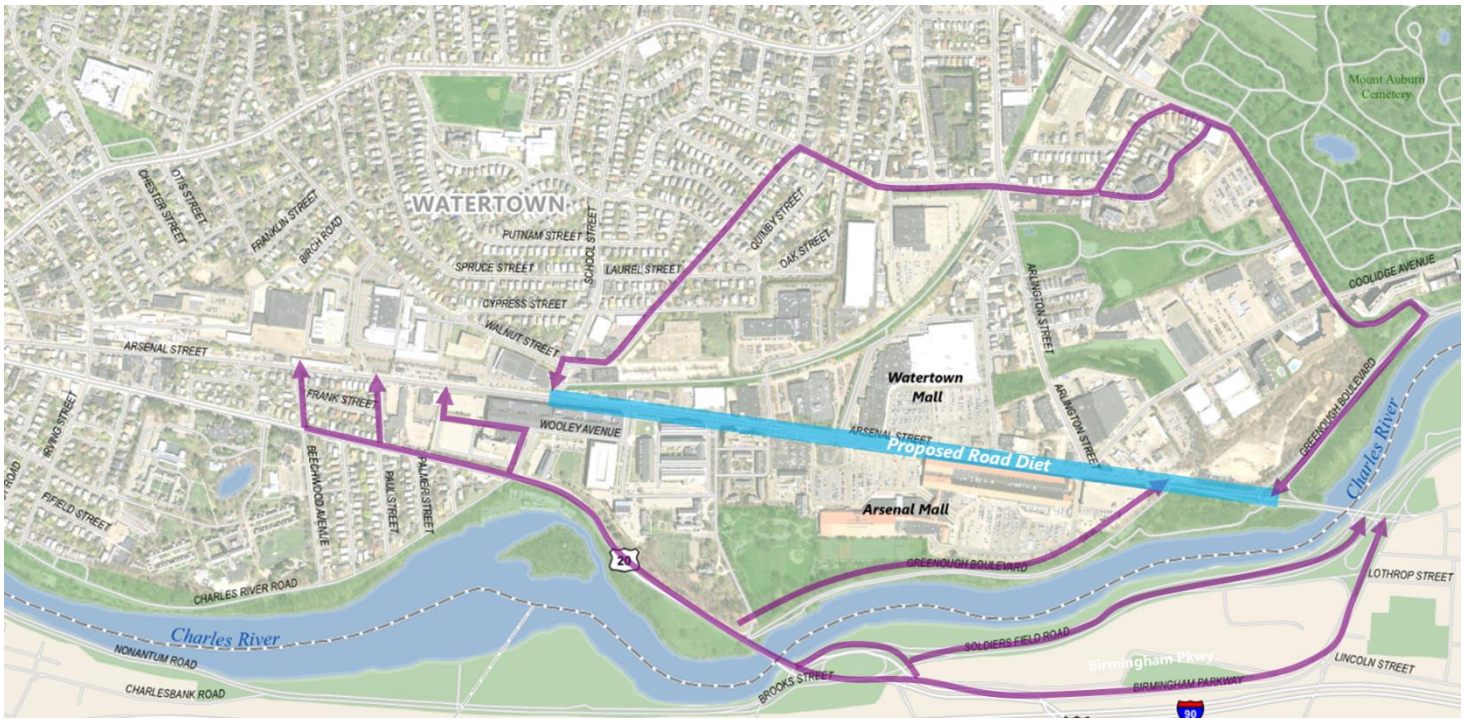


Figure 5-5 Alternative 5 Potential Impacted Parallel Routes

Table 5-4 considers the results of the analysis discussed above, summarizes the complete evaluation of Alternative 5 against the study goals and objectives. Due to severe impacts to mobility along Arsenal Street, including the potential to constrain access to several major employers, safety concerns related to bus/bike conflicts in the dedicated lane over a relatively short length, and the potential negative effects a reduced cross-section could have on economic development along the corridor, Alternative 5 is not recommended. Secondarily, there was concern expressed about the potential for traffic diversion related to this alternative, as the majority of diversion routes are primarily residential in nature and therefore less able to absorb levels of diversion while maintaining reliable access for residents.

Table 5-4 Alternative 5 Evaluation and Recommendation

✓	Positive Impact
●	Neutral Impact
✖	Negative Impact
PHO	Public Health Objective

Goals	Objectives	Impact	Comments
Mobility Benefits	Decrease congestion and reduce delays (PHO)	✖	1. While a road diet could improve transit operations on this section, the overall system reliability. would not markedly improve. 2. Increased Arsenal Street and neighborhood congestion may affect emergency response times.
	Improve system reliability	●1	
	Minimize local street impacts	✖	
	Maintain emergency vehicle and first responder mobility	✖2	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	●	
	Address current design standard deficiencies (PHO)	●	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	●3	3. Overall benefits would be noted within the area of the road diet only. Additional conflict points may be created in transition areas and sustained benefits would not be noted outside the project limits.
	Improve existing public transportation services (PHO)	✓3	
	Coordinate existing transit services	●3	
	Improve bike and pedestrian connections (PHO)	✓3	
	Promote active transportation (PHO)	✓3	
Economic Development Impacts	Support existing and projected economic development	✖4	4. Traffic diversions result in decreased visibility for Arsenal Street businesses. 5. Opportunity to improve landscaping.
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	✖4	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	✓	
	Improve access to the regional highway system	●	
	Avoid/minimize/mitigate social equity impacts	✓	
	Incorporate healthy community design features (PHO)	✓5	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●	6. Traffic diversions result in longer trips and increased emissions; Arsenal Street congestion anticipated to increase.
	Avoid/minimize/mitigate impacts to the natural environment	●	
	Minimize greenhouse gas emissions (PHO)	✖6	
	Reduce CO and particulate matter impacts (PHO)	✖6	
	Minimize transportation-related noise impacts along the corridor (PHO)	●	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	✖	
Public Support	Encourage consensus through an open and inclusive process	n/a	
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	n/a	Alternative 5 discarded.
Recommendation	***Discard Alternative 5 from consideration due severe impacts to Arsenal Street mobility and anticipated parallel route diversions.***		

Alternative 6: Soldiers Field Road Gateway Improvement

Alternative 6 considered options for the Soldiers Field Road gateway to improve operations and enhance safety. The original alternative included improvements along Arsenal Street from Soldiers Field Road at Birmingham Parkway through Arsenal Street at Coolidge Ave/Arlington Avenue. Due to ongoing development work and study near the intersection of Soldiers Field Road at Birmingham Parkway through the City of Boston, the project team was asked to refocus Alternative 6 on the area between Greenough Boulevard and Coolidge Avenue/Arlington Avenue. The refined alternative now considers two options to relocate the Coolidge Avenue approach to the intersection:

- **Option 1: Arlington Street Relocation -** Restricting access to the intersection from Coolidge Avenue and creating a new connection between Coolidge Avenue and Arlington Street (Figure 5-6). The new intersection of Arlington Street and Coolidge Avenue would be signalized.

  Several traffic control methods were considered for the new intersection. Based on capacity analysis results and safety concerns the best options were a roundabout or traffic signal. To limit the right-of-way impacts associated with the option, a traffic signal was preferred. Based on traffic projections with the roadway relocation, the peak hour traffic signal warrant would be met. Signal warrant evaluation and traffic signal operations would be further refined if the town chooses to advance this option. It is noted that a roundabout can be reconsidered if property impacts are not considered a concern.

- **Option 2: Arsenal Street Relocation -** Restricting access to the intersection from Coolidge Ave and creating a new connection between Coolidge Avenue and Arsenal Street (Figure 5-7). Coolidge Avenue would intersect Arsenal Street at a new, signalized intersection that would likely incorporate Greenough Boulevard South.

  Due to heavy traffic volumes and adjacent DCR lands and recreational trails, a traffic signal would be the preferred method of traffic control at this proposed location. For analysis purposes, it was assumed that Greenough Boulevard South would be included in the traffic signal if Option 2 is progressed and the intersection is signalized. Based on available data, the intersection meets the peak hour traffic signal warrant and would likely meet additional warrants. Signal warrant evaluation and traffic signal operations would be further refined if the town chooses to advance this option.

It should be noted that access to businesses along Coolidge Avenue would remain open under both improvement options and that both improvement options include modifications to the existing traffic signal phasing and timing (along with upgrading signal equipment) at the intersection of Arsenal Street and Arlington Street.

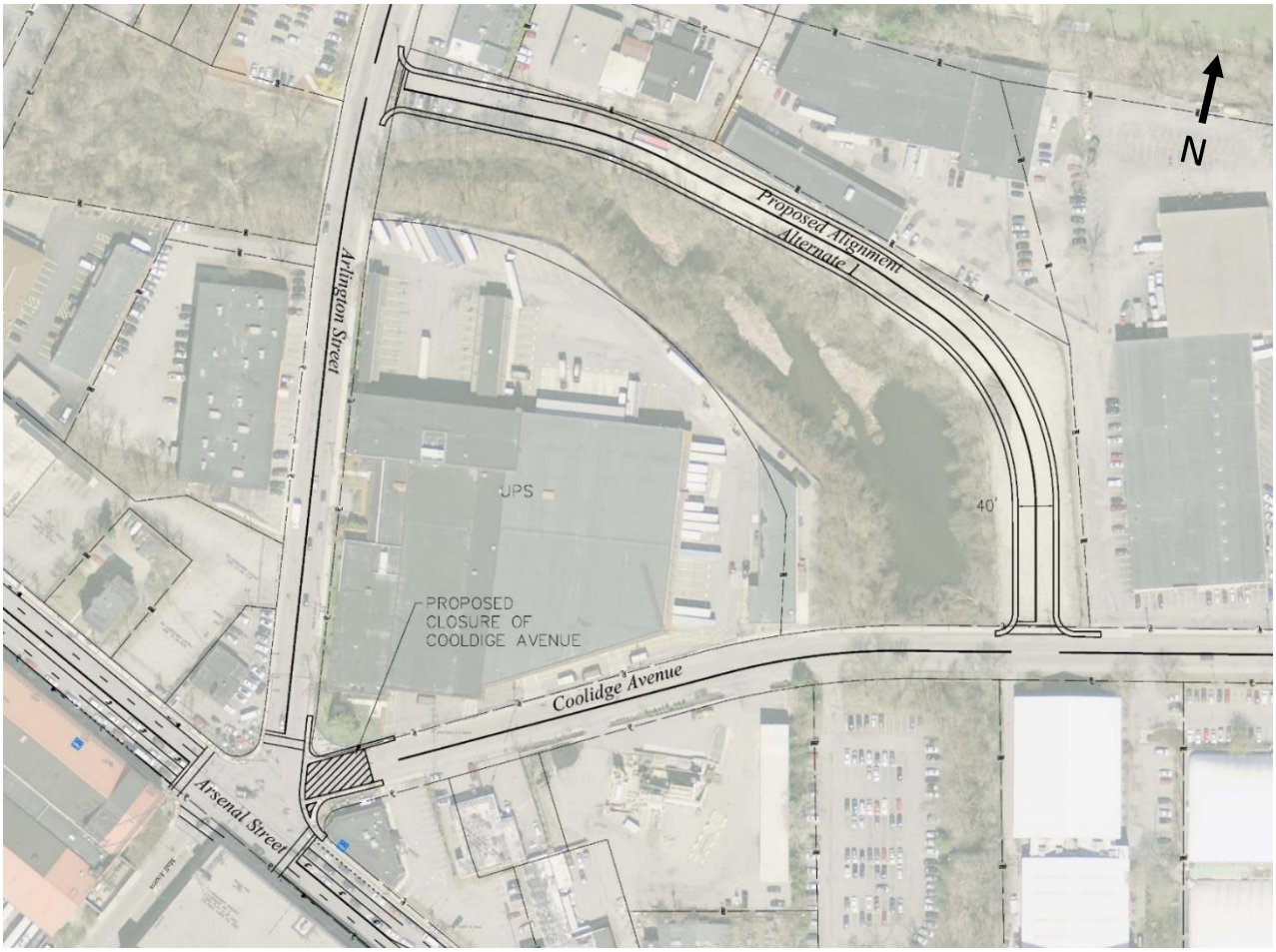


Figure 5-6 **Option 1 Arsenal Street at Arlington Street/Coolidge Avenue Proposed Improvements**

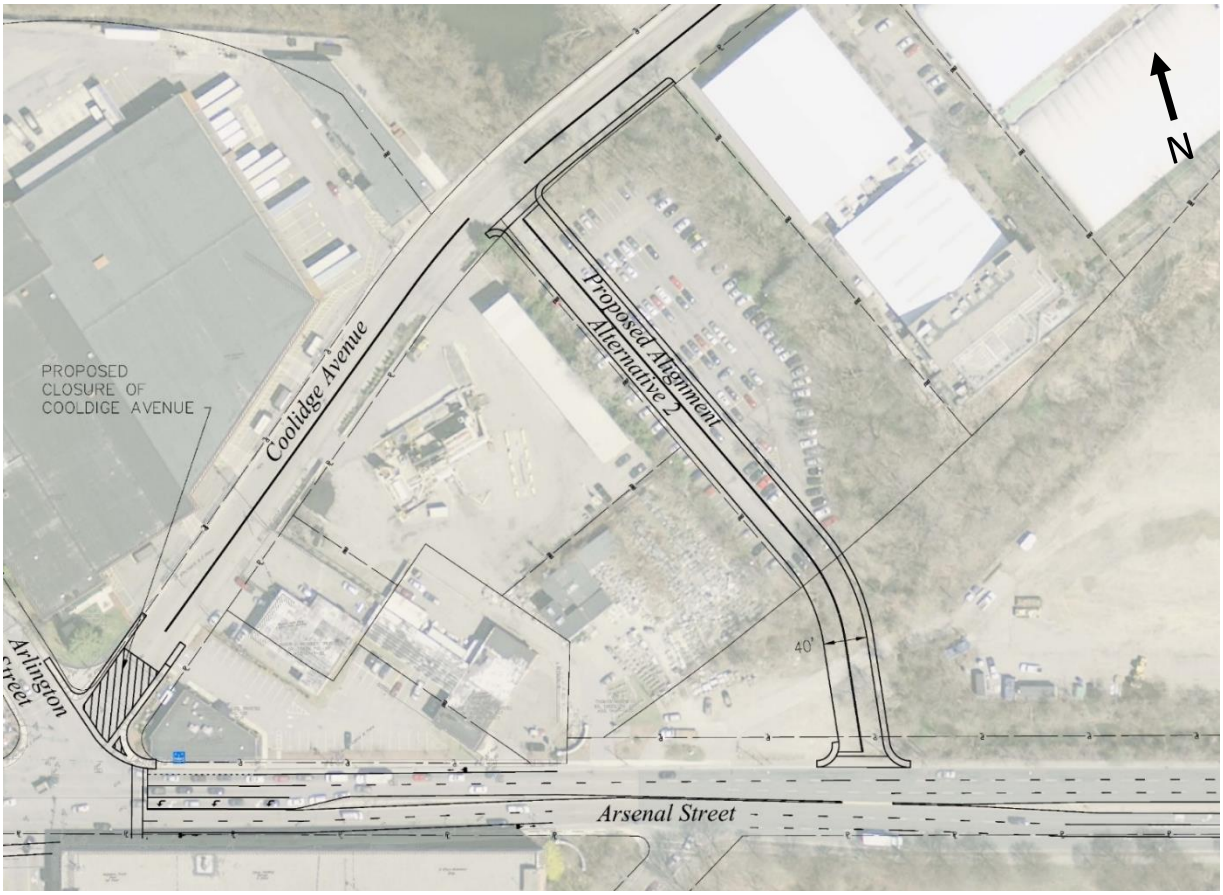


Figure 5-7 Option 2 Arsenal Street at Arlington Street/Coolidge Avenue Proposed Improvements

Alternative 6 represents a gateway entrance to the Arsenal Street Corridor and improvements that facilitate better traffic flow help support retail and other businesses that rely on drive-by traffic as a stimulant for their customer base (economic activity). These improvements also increase pedestrian safety and connectivity at the intersections and help mitigate potential safety hazards. Restriping the section of Arsenal Street between Arlington Street and Greenough Boulevard, which improves the lane alignment, will help enhance mobility and safety by reducing driver confusion. Collectively these incremental improvements can lead to enhanced public health and economic growth. However, preliminary concepts do include disrupting direct access to the businesses along this section of Arsenal Street and Coolidge Avenue, which may affect consumer and redevelopment opportunities.

Both options considered are in proximity to sensitive environmental resources and would require environmental permitting.

- Option 1, the relocation of Coolidge Avenue to the north, would be within jurisdictional resource areas and/or buffer zones associated with Sawins Pond and regulated under the WPA and the Watertown Wetlands Ordinance, thus requiring the filing of a NOI application.

- Option 2, the relocation of Coolidge Ave to the south, would be within jurisdictional resource areas and/or buffer zones associated with a perennial stream and requiring the filing of a NOI application.

Option 2 may also require additional permitting. A portion of the land where the alignment intersects with Arsenal Street previously belonged to the federal government and was recently transferred to DCR. As DCR is currently, and at this time independently, planning the next steps for the property, it is unclear what additional regulatory action may be required if this option was chosen to move forward.

Alternative 6 could require the following wetlands resource related regulatory permits:

- Local/State – Order of Conditions from Watertown Conservation Commission
- Federal –NPDES Construction General Permit from USEPA
- The potential for additional permitting related to the recent transfer of land from the federal government to DCR

Traffic Analysis

Evaluation of Alternative 6 included intersection capacity analysis of each option using Synchro 8 software. Evaluation criteria include, level of service (LOS), intersection delay, and queue length. Level of service is a qualitative measure that considers factors such as roadway geometry, speed, travel delay, freedom to maneuver, and safety. Level of service, ranging from A (best operating conditions) to F (worst operating conditions), provides an index to the operational qualities of a roadway segment or an intersection. Tables 5-5 and 5-6 summarize the capacity analysis results.

The results of the analysis indicate that regardless of the option chosen, relocating Coolidge Avenue has the potential to decrease overall intersection delay by at least 55 percent, with improved overall levels of service from LOS F to LOS D or better. If the town chooses to install traffic signals at the newly created intersections, the alternatives also allow for additional protected pedestrian crossing opportunities, although improvements to congestion may be more muted with the introduction of increased vehicle delay. The proposed improvements also provide enhanced intersection safety by altering lane use groupings and providing separate signal phasing for conflicting approaches and movements. While the data do not suggest the intersection is a high crash location, the alignment of Arlington Street, Coolidge Avenue, and the driveway to the rear entrance of the Arsenal Mall creates an awkward intersection geometry where it is difficult to establish who has the right-of-way. The proposed improvements simplify the geometry and allow for improved sight lines.

Table 5-5a Alternative 6: Option 1 Capacity Analysis Summary (Morning Peak Hour)

		2040 Future Conditions					2040 Future Conditions Option 1				
Movement		**v/c[1]**	**Delay[2]**	**LOS[3]**	**50th Q[4]**	**95th Q[5]**	**v/c**	**Delay**	**LOS**	**50th Q**	**95th Q**
Arsenal Street at Arlington Street/ Coolidge Ave/ Home Depot Driveway											
Arsenal Street	EB LT	0.76	71	E	137	217	0.93	94	F	111	#240
	EB TH-TH/RT	0.84	48	D	346	425	0.74	33	C	253	327
Arsenal Street	WB LT	0.69	80	F	77	#172	0.78	84	F	61	#150
	WB TH-TH/RT	>1.20	>120	F	~507	#695	0.97	54	D	298	#436
Home Depot Driveway	NB LT/TH	0.34	50	D	38	84	0.67	77	E	42	#106
	NB RT	0.26	4	A	0	20	0.28	9	A	0	42
Arlington Street	SEB LT	-	-	-	-	-	0.90	54	D	311	#435
	SEB LT/TH/RT	-	-	-	-	-	0.92	55	D	292	#422
	SEB LT/TH-TH/RT	>1.20dl	>120	F	~488	#584	-	-	-	-	-
Coolidge Avenue	SWB LT/TH-TH/RT	0.58	22	C	44	128	-	-	-	-	-
	Overall		**>120**	**F**				**50**	**D**		
Arlington Street at Coolidge Avenue Extension											
Coolidge Avenue	EB LT/TH/RT	-	-	-	-	-	0.03	14	B	3	14
Coolidge Avenue	WB LT/TH/RT	-	-	-	-	-	0.61	27	C	68	#136
Arlington Street	NB LT/TH/RT	-	-	-	-	-	0.51	7	A	76	140
Arlington Street	SB LT/TH/RT	-	-	-	-	-	0.80	17	B	187	#416
	Overall		**-**	**-**				**15**	**B**		

1 – volume to capacity ratio
2 – average delay in seconds per vehicle
3 – Level of Service
4 – 50th Percentile Queue, in feet
5 – 95th Percentile Queue, in feet
~ – 50th percentile volume exceeds capacity, queue may be longer
# - 95th Percentile volume exceeds capacity, queue may be longer
m - Volume for 95th Percentile queue is metered by upstream signal
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound; SEB = Southeastbound; SWB = Southwestbound
LT = Left-turn; TH = Through; RT = Right-turn

Table 5-5b Alternative 6: Option 1 Capacity Analysis Summary (Evening Peak Hour)

		2040 Future Conditions					2040 Future Conditions Option 1				
Movement		**v/c[1]**	**Delay[2]**	**LOS[3]**	**50th Q[4]**	**95th Q[5]**	**v/c**	**Delay**	**LOS**	**50th Q**	**95th Q**
Arsenal Street at Arlington Street/ Coolidge Ave/ Home Depot Driveway											
Arsenal Street	EB LT	0.74	70	E	127	204	0.81	72	E	101	#218
	EB TH-TH/RT	0.83	48	D	337	416	0.66	27	C	231	308
Arsenal Street	WB LT	0.72	81	F	82	#182	0.55	53	D	63	#122
	WB TH-TH/RT	>1.20	>120	F	~586	#778	0.86	35	C	311	#447
Home Depot Driveway	NB LT/TH	0.48	53	D	65	113	0.70	66	E	72	#129
	NB RT	0.37	11	B	8	48	0.27	7	A	0	33
Arlington Street	SEB LT	-	-	-	-	-	0.78	50	D	173	270
	SEB LT/TH/RT	-	-	-	-	-	0.71	41	D	142	234
	SEB LT/TH-TH/RT	0.52	42	D	153	220	-	-	-	-	-
Coolidge Avenue	SWB LT/TH-TH/RT	0.46	15	B	22	84	-	-	-	-	-
	Overall		**95**	**F**				**37**	**D**		
Arlington Street at Coolidge Avenue Extension											
Coolidge Avenue	EB LT/TH/RT	-	-	-	-	-	0.03	10	B	2	12
Coolidge Avenue	WB LT/TH/RT	-	-	-	-	-	0.37	15	B	39	83
Arlington Street	NB LT/TH/RT	-	-	-	-	-	0.59	12	B	100	182
Arlington Street	SB LT/TH/RT	-	-	-	-	-	0.48	11	B	85	147
	Overall		**-**	**-**				**12**	**B**		

1 – volume to capacity ratio
2 – average delay in seconds per vehicle
3 – Level of Service
4 – 50th Percentile Queue, in feet
5 – 95th Percentile Queue, in feet
~ – 50th percentile volume exceeds capacity, queue may be longer
# - 95th Percentile volume exceeds capacity, queue may be longer
m - Volume for 95th Percentile queue is metered by upstream signal
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound; SEB = Southeastbound; SWB = Southwestbound
LT = Left-turn; TH = Through; RT = Right-turn

Table 5-6a Alternative 6: Option 2 Capacity Analysis Summary (Morning Peak Hour)

		2040 Future Conditions					2040 Future Conditions Option 2				
Movement		**v/c[1]**	**Delay[2]**	**LOS[3]**	**50th Q[4]**	**95th Q[5]**	**v/c**	**Delay**	**LOS**	**50th Q**	**95th Q**
Arsenal Street at Arlington Street/ Coolidge Ave/ Home Depot Driveway											
Arsenal Street	EB LT	0.76	71	E	137	217	0.30	62	E	21	51
	EB TH-TH/RT	0.84	48	D	346	425	1.03	77	E	~453	#590
Arsenal Street	WB LT	0.69	80	F	77	#172	0.49	57	E	96	m122
	WB TH-TH/RT	>1.20	>120	F	~507	#695	0.74	38	D	287	#541
Home Depot Driveway	NB LT/TH	0.34	50	D	38	84	0.68	94	F	43	#107
	NB RT	0.26	4	A	0	20	0.26	9	A	0	48
Arlington Street	SEB LT	-	-	-	-	-	0.72	40	D	310	350
	SEB LT/TH/RT	-	-	-	-	-	0.72	40	D	306	347
	SEB LT/TH-TH/RT	>1.20dl	>120	F	~488	#584	-	-	-	-	-
Coolidge Avenue	SWB LT/TH-TH/RT	0.58	22	C	44	128	-	-	-	-	-
	Overall		**>120**	**F**				**52**	**D**		
Arsenal Street at Coolidge Avenue Extension/Greenough Boulevard South											
Arsenal Street	EB LT	-	-	-	-	-	0.84	37	D	99	m133
	EB TH-TH/RT	-	-	-	-	-	0.66	11	B	186	m299
Arsenal Street	WB LT/TH-TH/RT	-	-	-	-	-	0.85	31	C	353	467
Greenough Boulevard	NB LT/TH/RT	-	-	-	-	-	0.77	54	D	142	#270
Coolidge Street	SB LT/TH/RT	-	-	-	-	-	0.49	23	C	70	149
	Overall		**-**	**-**				**23**	**C**		

1 – volume to capacity ratio
2 – average delay in seconds per vehicle
3 – Level of Service
4 – 50th Percentile Queue, in feet
5 – 95th Percentile Queue, in feet
~ – 50th percentile volume exceeds capacity, queue may be longer
# - 95th Percentile volume exceeds capacity, queue may be longer
m - Volume for 95th Percentile queue is metered by upstream signal
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound; SEB = Southeastbound; SWB = Southwestbound
LT = Left-turn; TH = Through; RT = Right-turn

Table 5-6b Alternative 6: Option 2 Capacity Analysis Summary (Evening Peak Hour)

		2040 Future Conditions					2040 Future Conditions Option 2				
Movement		**v/c[1]**	**Delay[2]**	**LOS[3]**	**50th Q[4]**	**95th Q[5]**	**v/c**	**Delay**	**LOS**	**50th Q**	**95th Q**
Arsenal Street at Arlington Street/ Coolidge Ave/ Home Depot Driveway											
Arsenal Street	EB LT	0.74	70	E	127	204	0.39	54	D	34	71
	EB TH-TH/RT	0.83	48	D	337	416	0.92	50	D	337	#465
Arsenal Street	WB LT	0.72	81	F	82	#182	0.29	49	D	78	m108
	WB TH-TH/RT	>1.20	>120	F	~586	#778	0.71	20	B	156	#542
Home Depot Driveway	NB LT/TH	0.48	53	D	65	113	0.49	53	D	60	97
	NB RT	0.37	11	B	8	48	0.23	5	A	0	31
Arlington Street	SEB LT	-	-	-	-	-	0.74	56	E	148	218
	SEB LT/TH/RT	-	-	-	-	-	0.71	52	D	137	206
	SEB LT/TH-TH/RT	0.52	42	D	153	220	-	-	-	-	-
Coolidge Avenue	SWB LT/TH-TH/RT	0.46	15	B	22	84	-	-	-	-	-
	Overall		**95**	**F**				**37**	**D**		
Arsenal Street at Coolidge Avenue Extension/Greenough Boulevard South											
Arsenal Street	EB LT	-	-	-	-	-	0.56	18	B	40	m64
	EB TH-TH/RT	-	-	-	-	-	0.53	7	A	136	m149
Arsenal Street	WB LT/TH-TH/RT	-	-	-	-	-	0.79	18	B	272	373
Greenough Boulevard	NB LT/TH/RT	-	-	-	-	-	0.67	47	D	93	#182
Coolidge Street	SB LT/TH/RT	-	-	-	-	-	0.45	18	B	34	99
	Overall		**-**	**-**				**15**	**B**		

1 – volume to capacity ratio
2 – average delay in seconds per vehicle
3 – Level of Service
4 – 50th Percentile Queue, in feet
5 – 95th Percentile Queue, in feet
~ – 50th percentile volume exceeds capacity, queue may be longer
# - 95th Percentile volume exceeds capacity, queue may be longer
m - Volume for 95th Percentile queue is metered by upstream signal
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound; SEB = Southeastbound; SWB = Southwestbound
LT = Left-turn; TH = Through; RT = Right-turn

Table 5-7 considers the results of the analysis discussed above, summarizes the complete evaluation of Alternative 6 against the study goals and objectives, and provides a preliminary order-of-magnitude construction cost estimate. Intersection improvements at Arsenal Street and Arlington/Grove Street, along with modified striping to extend bicycle lanes to Greenough Boulevard North are long-term recommendations. As will be discussed in Chapter 6, there are short and medium term action items associated with developing these improvements further.

Table 5-7 Alternative 6 Evaluation and Recommendation

✓	Positive Impact
●	Neutral Impact
✖	Negative Impact
PHO	Public Health Objective

Goals	Objectives	Impact	Comments
Mobility Benefits	Decrease congestion and reduce delays (PHO)	✓	1. Benefits offset by the installation of new traffic signals. 2. May have potential to slightly alter emergency response times to/from Mount Auburn Hospital. Design can consider mountable curb for emergency access.
	Improve system reliability	●[1]	
	Minimize local street impacts	●[1]	
	Maintain emergency vehicle and first responder mobility	●[2]	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	✓[3]	3. Eliminating Coolidge Avenue at the intersection improves geometry and reduces vehicle conflicts.
	Address current design standard deficiencies (PHO)	✓	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	●	4. Benefits may be offset by the installation of new traffic signals.
	Improve existing public transportation services (PHO)	●[4]	
	Coordinate existing transit services	●	
	Improve bike and pedestrian connections (PHO)	✓	
	Promote active transportation (PHO)	✓	
Economic Development Impacts	Support existing and projected economic development	✓	
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	✓	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	●	
	Improve access to the regional highway system	●	
	Avoid/minimize/mitigate social equity impacts	●	
	Incorporate healthy community design features (PHO)	●	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●	5. May require extensive environmental permitting. 6. Benefits offset by installation of new traffic signals.
	Avoid/minimize/mitigate impacts to the natural environment	✖[5]	
	Minimize greenhouse gas emissions (PHO)	●	
	Reduce CO and particulate matter impacts (PHO)	●[6]	
	Minimize transportation-related noise impacts along the corridor (PHO)	●	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	✓	
Public Support	Encourage consensus through an open and inclusive process	TBD	Requires further outreach.
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	$1.5 – 2M	Cost dependent on option selected.
Recommendation	***Facilitate outreach to affected stakeholders are further refine concepts to determine whether a preferred alternative can be progressed.***		

Alternative 7: Watertown Square Gateway Improvements

Alternative 7 considers improvements to operations and safety for the Watertown Square gateway. The intersections included under this alternative are (1) Arsenal Street/Main Street at Mt. Auburn Street/Galen Street/Charles River Road and (2) Galen Street at Watertown Street/Nonantum Road.

The findings of the recently completed RSA at Galen Street and Watertown Street were considered when determining improvement options for the Watertown Square gateway. The RSA proposed vehicle phasing changes, incorporation of a flashing yellow arrow, and increased pedestrian clearance intervals. The improvement options include:

- Signal timing/phasing modifications
- Improved coordination between the intersections on either side of the river
- Intersection geometry (lane usage)
- Pedestrian accommodation enhancements
- Overhead (mast arm) wayfinding signage along all approaches
- The potential to relocate Charles River Road

A conceptual rendering of the proposed improvements is shown in Figure 5-8.

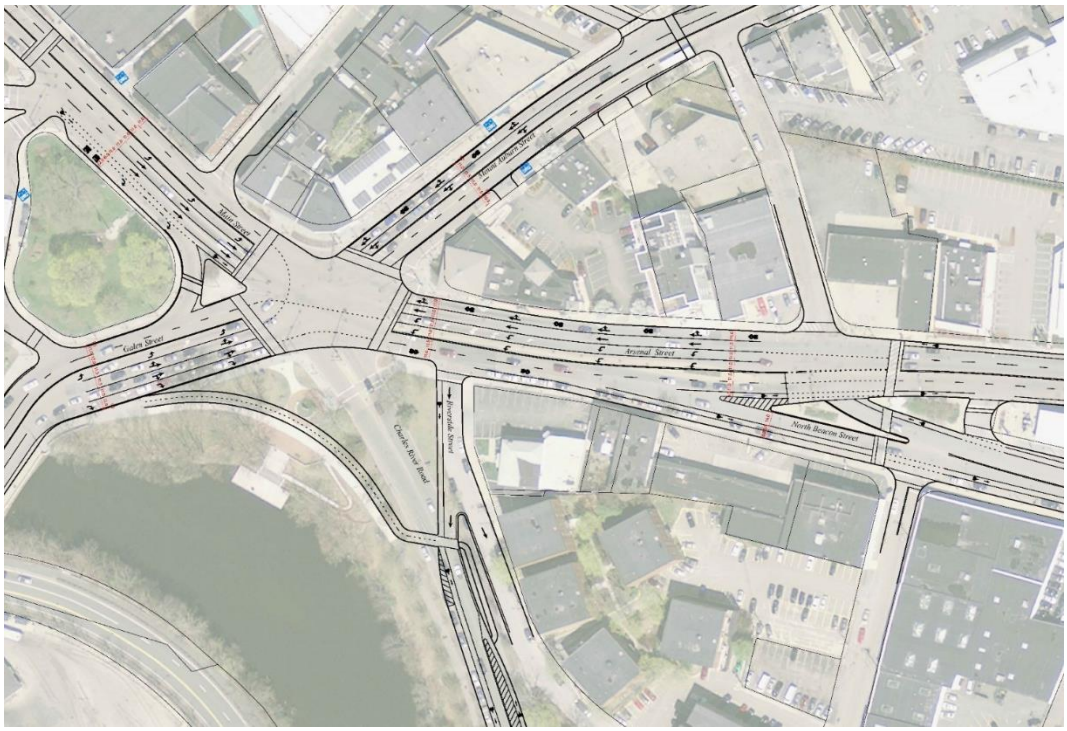


Figure 5-8 Conceptual Rendering of Watertown Square Proposed Improvements

The concept represents the first step in an iterative design development process. It is expected that specific, targeted public outreach would continue to shape and enhance this alternative as it is further developed. Through the Working Group process, there was discussion of additional shared-use paths through the newly created park land on the south side of the intersection, the need for a more refined look at "cut-through" traffic in the neighborhood adjacent to Charles River Road, and the potential to add an eastbound bus stop immediately east of Riverside Street. There was also significant discussion of landscaping opportunities along the new open spaces created by the discontinuance of Charles River Road.

The reconstruction of Watertown Square would include enhanced wayfinding by providing lane designation signage on traffic signal mast arms and considering pedestrian scale wayfinding directing users to various trails, the fishing pier, Perkins School, the Mosesian Center for the Arts and other area attractions. It also includes the potential to reintroduce a Route 70/70A bus stop adjacent to the Route 71 bus terminus. This stop has been previously relocated to the west due to traffic congestion. However, by removing a direct link between the two routes, transit connections have become more difficult and pedestrians are unable to see whether they are about to miss a connecting bus. Restoring the bus stop on the far side of the intersection does have some challenges, given existing levels of congestion, but would elevate the importance of a transit connection over facilitating traffic flow, a key consideration in the town's continued work in reestablishing placemaking throughout Watertown Square.

A common criticism raised by several members of the Working Group and at public meetings is the difficulty for cross connectivity on the bridge itself, both north/south and east/west. It was noted that many pedestrians are making bus connections between Watertown Square and Watertown Yard and/or the Charles River Greenway. These connections are currently achieved by pedestrians crossing outside of designated crosswalks and through traffic or vehicles queued at each of the traffic signals. The analysis of this alternative included a qualitative look at landscape features that may help improve or channelize pedestrian connectivity as part of this alternative. As the concept is further refined, there are several opportunities for landscaping along the areas adjacent to Watertown Square. As the open space transitions over the river towards Watertown Yard, there is less of an opportunity for improved landscaping, as the area narrows significantly and is needed for sidewalks of adequate width.

Enhanced pedestrian opportunities are created with the discontinuance of Charles River Road. Should this change be realized, and the MBTA amenable, an additional bus stop at Riverside Street would allow for a connection between the Route 70/70A bus and Watertown Yard which does not require crossing from one side of the bridge to the other. This potential expansion of parkland would create additional green space along the Charles River Greenway, which promotes healthy community design and supports active outdoor living.

Improved pedestrian crossings may also be created by modifications to the crash protection on the bridge itself. Removing the jersey barriers currently lining the bridge for crash protection (the decorative, historic railing along the river is not sufficient protection in the event of a vehicular crash where the vehicle may leave the roadway) and replacing them with ornamental crash-rated fencing can improve aesthetics over the bridge and channelize pedestrians towards designated crossing locations.

The discontinuance/relocation of Charles River Road would require coordination with DCR and may impact parkland along the Charles River. Impacts to DCR land would require the filing of a MEPA Environmental Notification Form (ENF) and a release of this land through the Article 97 state legislative process. It is anticipated that any impacts could be offset by the expansion of parkland within the existing Charles River Road alignment, increasing overall green space adjacent to the river path.

Based on aerial photographs and MassGIS data, Alternative 7 would impact jurisdictional resource areas and/or buffer zones associated with the Charles River and regulated under the WPA and the Watertown Wetlands Ordinance, thus requiring the filing of a NOI application.

Alternative 7 would require the following wetlands resource related regulatory permits:

- Local/State – Order of Conditions from Watertown Conservation Commission, MEPA ENF, and Conformance with EEA Article 97 Land Disposition Policy
- Federal –NPDES Construction General Permit from USEPA

Traffic Analysis

Analysis for this alternative included an intersection capacity analysis using Synchro 8 software to evaluate the improvement options impacts. For signalized intersections, the evaluation criteria include level of service, intersection delay, and queue length. Table 5-8 and 5-9 summarizes the capacity analysis results.

The proposed improvements positively benefit the intersection operations, along with improving safety, by altering lane use groupings, modifying traffic signal phasing, shortening pedestrian crossings and eliminating the Charles River Road approach to the intersection (traffic destined to Charles River Road would use Riverside Street). Operations at the signalized intersection for morning and evening peak hours experience a least a 40 percent decrease in overall delay with improved overall intersections from LOS F to LOS E or better. The improved traffic operations are primarily generated from the elimination of Charles River Road, with the total number of traffic signal phases being reduced from five to four.

While the traffic analysis focuses more specifically on the north side of the river, decreased congestion and delays are expected on both sides of the river, thereby

reducing greenhouse gas emissions and improving public transit services. The proposed improvements also help mitigate safety hazards at the intersections by reducing driver confusion and improving mobility for all roadway users. The recommended pedestrian enhancements at Watertown Square and Watertown Street/Nonantum Road at Galen Street will enhance pedestrian safety and connections at these locations, promoting healthy and active transportation while improving multimodal access in the area and to recreational river uses.

Table 5-8 Alternative 7 Capacity Analysis Summary (Morning Peak Hour)

		2040 Future Conditions					2040 Future Conditions with Proposed Improvements				
Movement		**v/c[1]**	**Delay[2]**	**LOS[3]**	**50th Q[4]**	**95th Q[5]**	**v/c**	**Delay**	**LOS**	**50th Q**	**95th Q**
Galen Street/Mount Auburn Street & Charles River Road at Main Street/Arsenal Street											
Main Street	EB LT	0.32	45	D	73	129	0.68	86	F	105	167
	EB TH	1.17	>120	F	~452	#584	0.96	74	E	475	#619
	EB RT	1.03	73	E	~319	#549	0.82	23	C	163	347
Arsenal Street	WB LT	0.86	72	E	222	#375	0.86	84	F	184	#255
	WB TH-TH/RT	0.72	48	D	225	291	0.71	51	D	352	452
Galen Street	NB LT	0.64	55	E	122	m155	0.68	65	E	257	m318
	NB TH-TH/RT	>1.20dl	>120	F	~526	m#598	-	-	-	-	-
	NB LT/TH-TH/RT	-	-	-	-	-	0.96	81	F	380	m#481
	NB RT	-	-	-	-	-	0.91	84	F	318	m#449
Mount Auburn Street	SB LT	0.48	36	D	58	103	-	-	-	-	-
	SB TH-TH/RT	1.09	115	F	~291	#413	1.01	109	F	~392	#534
Charles River Road	NWB LT/TH/RT	>1.20	>120	F	~280	#448	-	-	-	-	-
	Overall		**>120**	**F**				**71**	**E**		
Galen Street at Watertown Street/Nonantum Road											
Watertown Street	EB LT	0.55	35	C	214	310	1.01	103	F	~254	#429
	EB TH/RT	>1.20	>120	F	~576	#791	0.64	39	D	383	513
Nonantum Road	WB LT/TH-TH/RT	>1.20	>120	F	~378	#498	0.97	80	F	307	#444
Galen Street	NB TH-TH/RT	0.47	23	C	209	263	0.50	32	C	276	336
Galen Street	SB LT/TH-TH	0.75	48	D	443	m431	0.79	25	C	209	m331
	SB RT	0.31	1	A	4	m3	0.34	1	A	7	m13
	Overall		**>120**	**F**				**42**	**D**		

1 – volume to capacity ratio
2 – average delay in seconds per vehicle
3 – Level of Service
4 – 50th Percentile Queue, in feet
5 – 95th Percentile Queue, in feet
~ – 50th percentile volume exceeds capacity, queue may be longer
# - 95th Percentile volume exceeds capacity, queue may be longer
m - Volume for 95th Percentile queue is metered by upstream signal
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound; NWB = Northwestbound
LT = Left-turn; TH = Through; RT = Right-turn

Table 5-9 Alternative 7 Capacity Analysis Summary (Evening Peak Hour)

		2040 Future Conditions					2040 Future Conditions with Proposed Improvements				
Movement		**v/c[1]**	**Delay[2]**	**LOS[3]**	**50th Q[4]**	**95th Q[5]**	**v/c**	**Delay**	**LOS**	**50th Q**	**95th Q**
Galen Street/Mount Auburn Street & Charles River Road at Main Street/Arsenal Street											
Main Street	EB LT	0.43	47	D	101	167	0.74	76	E	116	186
	EB TH	0.79	51	D	251	322	0.98	73	E	359	#498
	EB RT	>1.20	>120	F	~543	#774	0.64	10	A	17	120
Arsenal Street	WB LT	1.19	>120	F	~375	#573	0.94	86	F	251	#359
	WB TH-TH/RT	0.98	73	E	328	#464	0.91	54	D	421	#582
Galen Street	NB LT	0.95	87	F	186	m#275	0.94	77	E	291	m#428
	NB TH-TH/RT	>1.20	>120	F	~438	m#553	-	-	-	-	-
	NB LT/TH-TH/RT	-	-	-	-	-	0.99	77	E	320	m#428
	NB RT	-	-	-	-	-	0.95	80	E	262	m#395
Mount Auburn Street	SB LT	0.29	31	C	34	68	-	-	-	-	-
	SB TH-TH/RT	0.96	78	F	227	#343	1.02	92	F	~281	#404
Charles River Road	NWB LT/TH/RT	>1.20	>120	F	~316	#522	-	-	-	-	-
	Overall		**119**	**F**				**68**	**E**		
Galen Street at Watertown Street/Nonantum Road											
Watertown Street	EB LT	0.55	33	C	247	355	0.94	74	E	230	#440
	EB TH/RT	>1.20	>120	F	~619	#837	0.65	33	C	335	465
Nonantum Road	WB LT/TH-TH/RT	>1.20	>120	F	~321	#437	0.92	67	E	225	#346
Galen Street	NB TH-TH/RT	065	33	C	296	371	0.71	40	D	339	422
Galen Street	SB LT/TH-TH	0.73	36	D	407	m304	0.79	20	C	262	m#355
	SB RT	0.49	2	A	42	m24	0.52	3	A	60	m80
	Overall		**107**	**F**				**36**	**D**		

1 – volume to capacity ratio
2 – average delay in seconds per vehicle
3 – Level of Service
4 – 50th Percentile Queue, in feet
5 – 95th Percentile Queue, in feet
~ – 50th percentile volume exceeds capacity, queue may be longer
# - 95th Percentile volume exceeds capacity, queue may be longer
m - Volume for 95th Percentile queue is metered by upstream signal
EB = Eastbound, WB = Westbound; NB = Northbound; SB = Southbound; NWB = Northwestbound
LT = Left-turn; TH = Through; RT = Right-turn

Table 5-10 considers the results of the analysis discussed above, summarizes the complete evaluation of Alternative 7 against the study goals and objectives, and provides a preliminary order-of-magnitude construction cost estimate. Improvements to Watertown Square are medium-term recommendations. It is noted that the selection of certain funding sources (such as Transportation Improvement Program funding) may delay construction of the project to the long-term due to availability of funds.

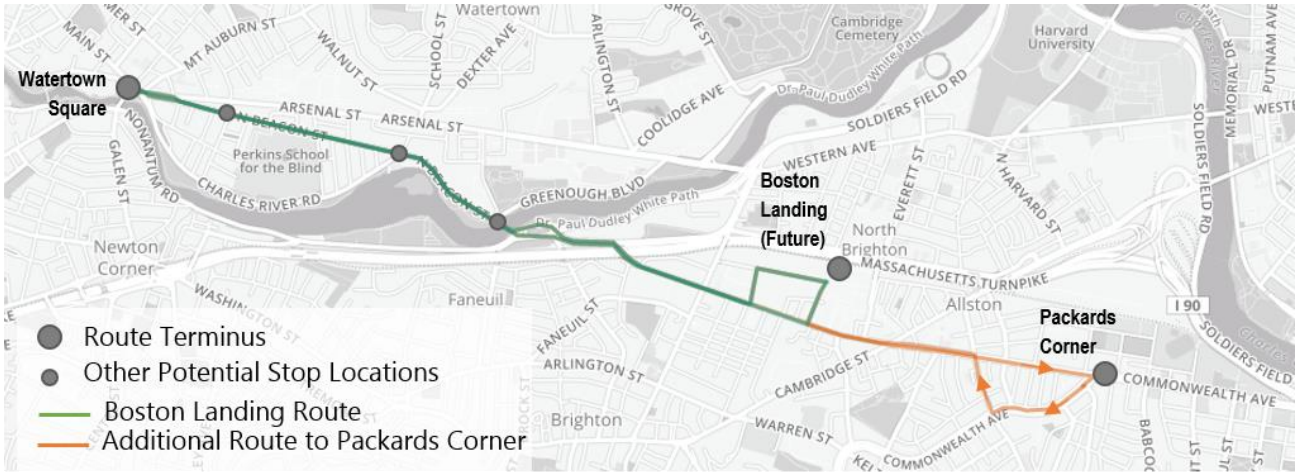
Table 5-10 Alternative 7 Evaluation and Recommendation

✓	Positive Impact
●	Neutral Impact
✖	Negative Impact
PHO	Public Health Objective

Goals	Objectives	Impact	Comments
Mobility Benefits	Decrease congestion and reduce delays (PHO)	✓	
	Improve system reliability	✓	
	Minimize local street impacts	●	
	Maintain emergency vehicle and first responder mobility	✓	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	✓1	1. Addresses several noted safety deficiencies.
	Address current design standard deficiencies (PHO)	✓1	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	●	2. Directly links existing bus routes. 3. Considers additional dedicated accommodations. 4. Combined with other improvements, may further promote active transportation.
	Improve existing public transportation services (PHO)	✓2	
	Coordinate existing transit services	✓2	
	Improve bike and pedestrian connections (PHO)	✓3	
	Promote active transportation (PHO)	●4	
Economic Development Impacts	Support existing and projected economic development	✓	5. Reduced congestion has the potential to improve consumer drive-by experience, but is not expected to noticeably enhance economic activity as a result of this alternative. Collectively, incremental improvements would minimize negative effects and enhance economic activity.
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	●5	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	●	
	Improve access to the regional highway system	✓	
	Avoid/minimize/mitigate social equity impacts	●	
	Incorporate healthy community design features (PHO)	✓	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●	6. Requires environmental permitting.
	Avoid/minimize/mitigate impacts to the natural environment	✖6	
	Minimize greenhouse gas emissions (PHO)	✓	
	Reduce CO and particulate matter impacts (PHO)	✓	
	Minimize transportation-related noise impacts along the corridor (PHO)	✓	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	✓	
Public Support	Encourage consensus through an open and inclusive process	TBD	Requires further outreach.
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	$1.5M	
Recommendation	***Progress concept plan through design development, focusing on additional public outreach and securing project funding***		

Alternative 10: Express Bus along North Beacon Street

Alternative 10 considers supplementing the existing MBTA Route 70/70A service with express bus service along North Beacon Street to improve connections between Watertown and Boston. The route would begin in Watertown Square and travel east along North Beacon Street. As this alternative was refined, two route termini to the east were considered: the future Boston Landing MBTA Commuter Rail station (anticipated opening Spring 2017 with access to South Station) and Packards Corner on the MBTA Green Line "B" branch (access to Copley Square/Park Street), as shown in Figure 5-9. Figure 5-9 also show potential stop locations. It is envisioned that the service would have limited stops (i.e., at only one or two of the potential locations shown).



Source: MBTA, using Remix software. Modified to add potential stop locations

Figure 5-9 Alternative 10 Express Bus Routes

Analysis of this alternative included an evaluation of ridership potential and preliminary estimates of travel times, service headways, and the number of buses required to run the service.

Journey to work data[31] were reviewed to estimate the number of commuters from East Watertown to Allston/Brighton, the Boston Core, and the South Boston Waterfront who may use the express bus service. An estimate of non-work based trips was also included. The data reviewed were collected from 2006 to 2010, before significant growth in the South Boston Waterfront had materialized. Therefore, the results of this evaluation for trips to this area should be considered conservative.

A review of commuting data indicates that the service could draw a minimum of 50 to 60 riders during the peak hours. Based on the data available, the majority of potential express bus riders would be destined for the Boston Core; however potential future

[31] U.S. Census Bureau, American Community Survey 2006-2010 Five-year estimates.

commuting trips to South Boston Waterfront could increase these preliminary estimates. Ridership estimates are included in the Appendix.

Working with the MBTA, an evaluation of potential peak period cycle times along both route options based on a combination of Google Maps travel time data and a cursory review of Route 57 and 64 segment run times was conducted. The shorter route is approximately 2.5 miles from Watertown Square to Boston Landing. One-way travel time during peak commuter periods is estimated to be 20 minutes (total route cycle time is 40 minutes). It should be noted that for this type of express bus service to be effective scheduling would need to be closely coordinated with the Boston Landing MBTA Commuter Rail to ensure an efficient transfer time between the services. While the Boson Landing schedule is not currently available, considering the estimated cycle time and coordination needs, it is anticipated that a minimum of two buses would be required to operate express bus service from Watertown Square to Boston Landing (assuming a planning capacity of 40 passengers per bus).

It should be noted that existing MBTA resource constraints preclude implementation of this service in the short-term without shifting resources from other routes. Based on the route termini and anticipated service parameters, the express bus is not expected to divert significant ridership from Routes 70/70A. However, if this alternative is advanced further, a more detailed evaluation of diversion potential from Routes 70/70A and/or other MBTA express buses using origin-destination-transfer (ODX) data should be conducted to determine if a shift in resources from those services to the North Beacon Street express bus is feasible. Alternatively, implementation of the express bus service as a shuttle by another provider (e.g., Watertown Transportation Management Association or a private entity) could be pursued. A pilot shuttle could help evaluate the service and demonstrate a shift from other MBTA services, enabling justification of a permanent shift of MBTA resources to this service.

Extending service from Boston Landing to Packards Corner was also considered. This extension adds approximately 1.6 miles and up to 22 minutes to the cycle time due to the peak period congestion along Brighton Avenue, Commonwealth Avenue, and Harvard Avenue. Given this increase in cycle time and the continued need to coordinate schedules with Boston Landing, extension of express bus service to Packards Corner is not recommended at this time. However, if service to Boston Landing is successful, extension of the route to Packards Corner or other major transit nodes (e.g., West Station, Longwood, Back Bay, etc.) could be considered.

Additional transit service options along North Beacon Street would enhance existing public transportation services and facilitate reduced auto dependency. The mode shift will likely result in reduced greenhouse gas emissions associated with automobile travel, although the environmental benefits may not be significant considering additional bus emissions. Regardless, and although the new transit service would not serve Arsenal Street directly, additional public transit options contribute to the public health vitality of the Arsenal Street corridor.

Table 5-11 considers the results of the analysis and summarizes the evaluation of Alternative 10 against the study goals and objectives. A cost estimate is not provided since it will vary based on the design and operation of the pilot program. Pilot program service is being recommended in the medium-term followed, if successful by permanent service in the long-term. While it is anticipated the MBTA would assist in developing a pilot program, it is noted that this type of service (primarily peak commuter service only) is not typically provided by the MBTA and permanent service would likely require a private operator. It is also noted that subsequent to the development and analysis of this alternative, and the recommendations developed herein, the MBTA has released a service policy for pilot programs[32] that may alter this recommendation.

[32] Policy of the Evaluation and Selection of MBTA Service Pilots, MBTA, March 27, 2017.

Table 5-11 Alternative 10 Evaluation and Recommendation

✓	Positive Impact
●	Neutral Impact
✖	Negative Impact
PHO	Public Health Objective

Goals	Objectives	Impact	Comments
Mobility Benefits	Decrease congestion and reduce delays (PHO)	●	1.Potential to reduce crowding on 70/70A and/or other express bus services.
	Improve system reliability	✓1	
	Minimize local street impacts	●	
	Maintain emergency vehicle and first responder mobility	●	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	●	
	Address current design standard deficiencies (PHO)	●	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	✓	2. Provides an additional transportation option. Potential educational benefits for Perkins School for the Blind. 3. Opportunity to provide connection to Boston Landing Station, however requires schedule coordination.
	Improve existing public transportation services (PHO)	✓2	
	Coordinate existing transit services	✓3	
	Improve bike and pedestrian connections (PHO)	●	
	Promote active transportation (PHO)	●	
Economic Development Impacts	Support existing and projected economic development	✓4	4. Provides access to main economic corridor (Arsenal Street) but service is not on the corridor directly.
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	●	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	●	
	Improve access to the regional highway system	●	
	Avoid/minimize/mitigate social equity impacts	●	
	Incorporate healthy community design features (PHO)	●	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●	5. Limited quantifiable greenhouse gas and/or and CO and particulate matter reductions anticipated.
	Avoid/minimize/mitigate impacts to the natural environment	●	
	Minimize greenhouse gas emissions (PHO)	●5	
	Reduce CO and particulate matter impacts (PHO)	●5	
	Minimize transportation-related noise impacts along the corridor (PHO)	●	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	✓	
Public Support	Encourage consensus through an open and inclusive process	Yes	
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	TBD6	6. Cost will vary depending on type of bus, available fleet, and entity running pilot service.
Recommendation	***Advance Alternative 10 as a study recommendation. Consider potential service between Watertown Square and Boston Landing as a pilot commuter shuttle program. Discard extending service to Packards Corner.***		

Alternative 11: Transit Signal Priority (TSP)

Alternative 11 considers implementation of Transit Signal Priority (TSP) at signalized intersections along the Arsenal Street corridor. Implementation of TSP would enhance service along Route 70/70A between the Watertown Square and Soldiers Field Road gateways.

Analysis of this alternative included a review of existing bus stop locations in relation to signalized intersections, proximity to other bus stops, and the total number of bus stops along the corridor between the gateways. Since the benefit of TSP is affected primarily by bus stop location and frequency, the analysis considered any adjustments that would be required to maximize system effectiveness. The following bus stop adjustments were assumed:

- Relocating the eastbound stop at School Street to the far side of the intersection
- Consolidating the eastbound stop at Arsenal Court
- Consolidating the westbound stop at Talcott Avenue
- Relocating the westbound stop at Arlington Street/Coolidge Avenue to the far side of the intersection

The future conditions VISSIM model, discussed previously in Chapter 3, was used to determine where implementing TSP would be most beneficial. This was done by comparing the projected travel times along the corridor both with and without TSP, and including and excluding the gateway locations on either end of the corridor. The results of the comparison are presented in Table 5-12.

Table 5-12 Expected Changes in Travel Time with TSP

	Morning Peak Hour				Evening Peak Hour			
	Passenger Car		Bus		Passenger Car		Bus	
	percent	travel time	percent	travel time	percent	travel time	percent	travel time
1: Eastbound - excluding gateways	12%	38s	30%	1m 59s	-47%	-5m 25s	-16%	-1m 49s
2: Westbound - excluding gateways	-1%	-4s	-50%	-7m 6s	-39%	-4m 11s	-60%	-12m 10s
3: Eastbound - including gateways	-7%	-1m 43s	8%	2m 18s	11%	3m 4s	1%	20s
4: Westbound - including gateways	10%	1m 22s	-25%	-6m 7s	-17%	-4m 16s	-29%	-9m 19s

Travel time expressed in minutes (m) and seconds (s). Negative travel time denotes time savings.

During the morning peak hour in the westbound direction, and during the evening peak hour in both directions (excluding the gateways in all cases), the reduction in travel time indicates TSP would improve operations for passenger cars and buses along the corridor.

If the gateway intersections are included in the TSP system, time savings become less reliable, particularly for transit serving the eastbound direction. It is noted that bus operations in the westbound direction are projected to be substantially improved if the gateways are included in the system. However, at Watertown Square this improvement would be specific to the Route 70/70A buses and to the detriment of the Route 59 and Route 71 buses which run along other legs of the intersection. Since installation of TSP should not prioritize one bus over another (and such a practice would not be supported by the MBTA), TSP should not be considered in Watertown Square. A similar condition exists at the Arsenal Street/Soldiers Field Road/Birmingham Parkway intersection, where the Route 86 bus operates on Birmingham Parkway and Western Avenue. However, given the operational differences in that traffic signal timing/phasing, which include only one traffic signal affecting bus operations and use of an exclusive right-turn lane along the route, it may be advantageous in the future to include the location in the TSP system, particularly if an adjacent system is considered for Western Avenue.

Based on the analysis above, performance of TSP at the following intersections showed measurable benefits:

- Arsenal Street at North Beacon Street and Taylor Street
- Arsenal Street at Hanover Driveway
- Arsenal Street at Beechwood Avenue
- Arsenal Street at School Street
- Arsenal Street at Talcott Avenue
- Arsenal Street at Arsenal Court
- Arsenal Street at Arsenal Mall Driveway
- Arsenal Street at Watertown Mall

Table 5-13 considers the results of the analysis discussed above, summarizes the complete evaluation of Alternative 11 against the study goals and objectives, and provides a preliminary order-of-magnitude construction cost estimate. Transit Signal Priority is recommended for implementation in the short term, utilizing a system that would work with transponders currently installed in the bus fleet. New detector loops dedicated to TSP at the locations identified above are required to facilitate implementation. Traffic signal cabinet assembly upgrades would also be required. However, the assembly upgrades are also required for implementation of Alternative 17 (see below) and as such, this cost is not included in this alternative.

Table 5-13 Alternative 11 Evaluation and Recommendation

✓	Positive Impact
●	Neutral Impact
✖	Negative Impact
PHO	Public Health Objective

Goals	Objectives	Impact	Comments
Mobility Benefits	Decrease congestion and reduce delays (PHO)	✓1	1. Benefits limited to locations along Arsenal Street where TSP is implemented. 2 Where benefits are noted along Arsenal Street, side streets may experience increased delay.
	Improve system reliability	✓	
	Minimize local street impacts	✖2	
	Maintain emergency vehicle and first responder mobility	●	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	●	
	Address current design standard deficiencies (PHO)	●	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	●1	1. Over time, auto dependency can be reduced as technology advances and bus times may be reduced further.
	Improve existing public transportation services (PHO)	✓	
	Coordinate existing transit services	●	
	Improve bike and pedestrian connections (PHO)	●	
	Promote active transportation (PHO)	●	
Economic Development Impacts	Support existing and projected economic development	●	
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	✓	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	●	
	Improve access to the regional highway system	●	
	Avoid/minimize/mitigate social equity impacts	●	
	Incorporate healthy community design features (PHO)	●	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●	
	Avoid/minimize/mitigate impacts to the natural environment	●	
	Minimize greenhouse gas emissions (PHO)	✓	
	Reduce CO and particulate matter impacts (PHO)	✓	
	Minimize transportation-related noise impacts along the corridor (PHO)	●	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	●	
Public Support	Encourage consensus through an open and inclusive process	Yes	
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	$250,000	Does not include cost for upgrade of traffic signal cabinet assembly (see Alternative 17).
Recommendation	***Install TSP along the corridor east of Watertown Square***		

Alternative 13: Transit Stop Turnouts/Curb Extensions

The evaluation of transit stop turnouts/curb extensions include both a spatial and operational review of bus stops along the corridor. The following cases were evaluated:

- Can the location (or immediate vicinity) provide a fully ADA compliant sidewalk with a bus stop turnout?
- Can the location (or immediate vicinity) provide a curb extension without impacting existing or potential future on-street bicycle accommodations?
- How does the potential for transit stop turnout/curb extension affect bus operations?

As discussed in previous sections, while sidewalks exist along both sides of the entire corridor, many locations either only minimally meet current ADA guidelines or have utility pole and/or tree pit obstructions. There are limited opportunities to widen the sidewalk without impacts to private property and as such it was deemed infeasible to provide transit stop turnouts. In consultation with the MBTA, it was also determined that use of turnouts during peak hours might be counterproductive due to difficulties re-entering the travel lane.

The MBTA's preference along the route would be for curb extensions. Curb extensions allow the sidewalk to extend beyond the curb at bus stop locations to facilitate loading and unloading passengers without the bus exiting the travel lane. Due to right-of-way constraints, the provision of curb extensions would require eliminating dedicated bicycle lanes near bus stops and the creation of mixing zones where the bicyclist is required to merge into and out of traffic along the route. Based on the traffic volume along the roadway, curb extensions would also impact through travel of vehicles, potentially increasing vehicle idle time. Since the provision of dedicated bicycle lanes are an important component to active transportation along the corridor, and given the number of bus stops and the frequency with which bicycle lanes would have to transition, curb extensions are not recommended.

Table 5-14 considers the results of the analysis discussed above and summarizes the complete evaluation of Alternative 13 against the study goals and objectives. Alternative 13 is removed from further consideration due to an inability to provide a means to adequately accommodate both transit operations and bicycling without impacting private property and the related difficulty with bus operations along the corridor. As the corridor continues to redevelop, opportunities to incorporate these features without impacts to the bicycle and pedestrian network should be considered.

Table 5-14 Alternative 13 Evaluation and Recommendation

✓ ● ✖ *PHO*	Positive Impact Neutral Impact Negative Impact Public Health Objective	Curb Extension	Turn out	
Goals	**Objectives**	**Impact**	**Impact**	**Comments**
Mobility Benefits	Decrease congestion and reduce delays (PHO)	✖	✓	
	Improve system reliability	✓	✖	
	Minimize local street impacts	✖	✓	
	Maintain emergency vehicle and first responder mobility	✖	✓	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards*	●		
	Address current design standard deficiencies (PHO)	●		
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	●	●	1. Impacts are specific to the development of this alternative and not the use of curb extensions where adequate right-of-way is provided.
	Improve existing public transportation services (PHO)	●	●	
	Coordinate existing transit services	●	●	
	Improve bike and pedestrian connections (PHO)	✖[1]	●	
	Promote active transportation (PHO)	✖[1]	●	
Economic Development Impacts	Support existing and projected economic development	●		
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	●		
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	●		
	Improve access to the regional highway system	●		
	Avoid/minimize/mitigate social equity impacts	●		
	Incorporate healthy community design features (PHO)	●		
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●		
	Avoid/minimize/mitigate impacts to the natural environment	●		
	Minimize greenhouse gas emissions (PHO)	●		
	Reduce CO and particulate matter impacts (PHO)	●		
	Minimize transportation-related noise impacts along the corridor (PHO)	●		
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	●		
Public Support	Encourage consensus through an open and inclusive process	N/A		
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	N/A		
Recommendation	***Discard Alternative 13 from consideration due to difficulty with MBTA bus operations and impacts to non-motorized transportation opportunities.***			

Alternative 14: Transit Shelters

As discussed in Chapter 4, the ability to provide bus shelters was considered for eight locations that meet the MBTA's guidelines for eligibility. Each of the locations was reviewed to determine whether a bus shelter could be installed within the existing right-of-way and in such a way that an accessible path could be provided around the shelter.

The review found that none of the eight eligible locations could accommodate bus shelters within the available right-of-way. However, three locations could accommodate bus shelters with minor impacts to adjacent properties, primarily to grass buffers along the property line. These locations are:

- Opposite Louise Street (westbound)
- Talcott Avenue/Arsenal Court (eastbound)
- Elm Street (westbound)

It is noted that a fourth location, the bus stop opposite School Street, could accommodate a shelter if relocated as proposed in Alternative 11 above. The relocated bus stop would likely have moderate property impacts and require the adjacent property owner to adjust the existing fence line.

Figure 5-10 presents a standard MBTA bus shelter. The MBTA's Bus Stop Planning and Design Guidelines (October 2013) provides additional shelter examples, including narrow shelters (which should be considered for the locations identified above) and different style shelters that can be considered if being funded by the municipality.

Source: MBTA Draft Bus Stop Planning and Design Guidelines (October 2013)

Figure 5-10 Standard MBTA Bus Shelter

Table 5-15 considers the results of the analysis discussed above, summarizes the complete evaluation of Alternative 14 against the study goals and objectives, and provides a preliminary order-of-magnitude construction cost estimate.

Table 5-15 Alternative 14 Evaluation and Recommendation

✓	Positive Impact
●	Neutral Impact
✖	Negative Impact
PHO	Public Health Objective

Goals	Objectives	Impact	Comments
Mobility Benefits	Decrease congestion and reduce delays (PHO)	●	
	Improve system reliability	●	
	Minimize local street impacts	●	
	Maintain emergency vehicle and first responder mobility	●	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	●	
	Address current design standard deficiencies (PHO)	●	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	●	
	Improve existing public transportation services (PHO)	✓	
	Coordinate existing transit services	●	
	Improve bike and pedestrian connections (PHO)	●	
	Promote active transportation (PHO)	●	
Economic Development Impacts	Support existing and projected economic development	●	1. Promotes the use of transit and increase public health contributors along Arsenal Street.
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	●	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	✓	
	Improve access to the regional highway system	●	
	Avoid/minimize/mitigate social equity impacts	✓	
	Incorporate healthy community design features (PHO)	✓[1]	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●	
	Avoid/minimize/mitigate impacts to the natural environment	●	
	Minimize greenhouse gas emissions (PHO)	●	
	Reduce CO and particulate matter impacts (PHO)	●	
	Minimize transportation-related noise impacts along the corridor (PHO)	●	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	●	
Public Support	Encourage consensus through an open and inclusive process	Yes	
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	$40,000 per shelter	Does not include property easements, or modifications to sidewalk or utilities.
Recommendation	***Install bus shelters in the above referenced locations.***		

Alternative 15: Existing Transit Service Improvements

Alternative 15 considers improvements to the MBTA's existing Route 70 and 70A services, including potential routing, service frequency, and schedule adjustments. Service frequency and schedule adjustments that are possible given the MBTA's existing bus fleet, resources, and systemwide priorities could improve bus service provided on the Arsenal Street Corridor as well as along the entire Routes 70/70A in the short term. In the medium-term and beyond, expanding the bus fleet could support further adjustments to routing, schedules, and increased service frequency.

The Alternative 15 evaluation conducted as part of this study was specifically focused on addressing concerns on the Arsenal Street Corridor; therefore, it is important to note that any specific recommendations and associated capital and operating costs will need to be further analyzed and refined within the context of the larger MBTA system as part of the MBTA's systemwide service planning processes.

Routing Adjustments

The analysis of routing adjustments considered the following:

- potential termini adjustments for some or all Route 70/70A trips,
- splitting up the Route 70/70A into distinct and shorter routes,
- adding limited-stop express service or consolidating stops on all trips, and
- combining segments of the Route 70A with other existing MBTA bus routes.

Termini Adjustments

Operational reliability on the Routes 70 and 70A is challenged in part by the long lengths of these existing routes. Shortening the length of the routes by adjusting the termini for some or all trips would support improved operational reliability for bus services along the Arsenal Street Corridor.

The evaluation of potential termini adjustments considered the ridership distribution along the existing Routes 70 and 70A to assess opportunities to shorten the route length without reducing service to a high proportion of route ridership. MBTA ridership data from October 2015 were used to identify the stops that have the greatest number of passenger boardings and alightings and evaluate how many passengers would be negatively affected by changing the route termini.

To examine potential termini adjustments to Routes 70 and 70A, it is essential to understand which locations drive ridership on the routes. Table 5-16 examines the total number of boardings and alightings at the 10 busiest locations (grouping inbound and outbound stops). In both the inbound and outbound directions, the

Central Square stops have the highest combined boardings and alightings by a large margin, in every time period. Therefore, all trips should continue to serve Central Square in all time periods.

Table 5-16 demonstrates that the Watertown/Arsenal Mall, Watertown Square, and Waltham Center locations (highlighted in gray) are key ridership drivers. The Watertown/Arsenal Mall stop has limited potential as a terminus because it would divide the Arsenal Street Corridor into multiple routes, and create a two-seat ride to Central Square from the high-ridership Waltham Center and Watertown Square locations. As such, Watertown/Arsenal Mall was dismissed as a potential terminus location, and the potential to adjust the route terminus to either Watertown Square and/or Waltham Center was further assessed.

Table 5-16 Total Number of Daily Boardings and Alightings by Location

Inbound Stop Name	Outbound Stop Name	Total Daily Boardings & Alightings
Massachusetts Ave. @ Pearl St.	Green St. @ Pearl St.	2,544
Green St. @ Magazine St.	Green St. @ Magazine St.	1,402
Carter St. @ Waltham Comm. Rail	Carter St. @ Waltham Comm. Rail S	1,182
Main St. @ Cross St.	Main St. @ Merchants Row	1,080
500 Arsenal St. – Watertown + Arsenal Mall	Arsenal St. @ Watertown + Arsenal Mall	721
Franklin St. @ Sidney St.	Franklin St. @ Sidney St.	637
Western Ave. @ Everett St.	Western Ave. @ Everett St.	378
Arsenal St. Opp. Arlington St.	Arsenal St. @ Arlington St.	306
River St. Opp. Blackstone St.	Western Ave. @ Putnam Ave.	305
Arsenal St. Opp. Elm St.	Arsenal St. @ Elm St.	291

Source: MBTA Loading Data for October 2015 (provided by MBTA).

As demonstrated in Table 5-17, the number of inbound boardings occurring before Watertown Square (Main Street @ Cross Street) ranges from approximately 47-66 percent of total trip boardings in any given period (aggregated across all trips within each period), and is greater than 50 percent in all periods other than the Evening. Similarly, as demonstrated in Table 5-18, the number of outbound alightings occurring after Watertown Square (Main Street @ Merchants Row) ranges from 54-71 percent of total trip alightings in any given period. Adjusting the terminus to Watertown Square would therefore reduce service to a high proportion of passengers in any period and in both directions. The individual trip-level data show a similar pattern as the aggregated period-level data, although a wider range, with no fewer than 25 percent of inbound boardings before Watertown Square and no fewer than 33 percent of outbound alightings after Watertown Square on any given trip.

The analysis findings show a lesser, but still substantial impact when considering Waltham Center (Carter Street @ Waltham Commuter Rail / Moody Street @ Main Street) as a terminus. As demonstrated in Tables 5-17 and 5-18, the number of

inbound boardings occurring before Waltham Center ranges from 19-25 percent of total trip boardings in any given period (aggregated across all trips within each period), and the number of outbound alightings occurring after Waltham Center ranges from 18-29 percent of total trip alightings in any given period. Adjusting the terminus to Waltham Center would therefore also reduce service to a high proportion of passengers in any period and in both directions. The individual trip-level data show a similar pattern as the aggregated period-level data, although a wider range, with no fewer than 10 percent of inbound boardings before Waltham Center and no fewer than 10 percent of outbound alightings after Waltham Center on any given trip. In summary, adjusting termini on existing trips without providing additional service to the remainder of the route would result in reduced service to a substantial percentage of riders.

Table 5-17 Percentage of Inbound Boardings by Segment and Period

	Period							
Segment	Night / Sunrise	Early AM	AM Peak	Midday Base	Midday school	PM Peak	Evening	Late Evening
70/70A Before Waltham Center	22%	19%	21%	25%	22%	24%	22%	21%
70/70A Before Watertown Square	66%	65%	65%	61%	55%	53%	47%	55%

Source: MBTA Loading Data for October 2015 (provided by MBTA).

Table 5-18 Percentage of Outbound Alightings by Segment and Period

	Period							
Segment	Night / Sunrise	Early AM	AM Peak	Midday Base	Midday school	PM Peak	Evening	Late Evening
70/70A After Waltham Center	28%	29%	27%	23%	22%	18%	25%	23%
70/70A After Watertown Square	68%	63%	54%	55%	62%	59%	71%	70%

Source: MBTA Loading Data for October 2015 (provided by MBTA).

Route Splitting

As an alternative to termini adjustment, splitting the Routes 70 and 70A into distinct and shorter routes could allow for improved operational reliability without reducing the service provided on any given segment. Based on the termini analysis described above, Watertown Square and Waltham Center were identified as logical places to split the Routes 70 and 70A. Splitting routes at Waltham Center provides an additional

benefit as it already serves as the location where Routes 70 and 70A diverge, and because fewer passengers would be affected by such a change.

Splitting routes at Waltham Center would establish three separate routes, illustrated in Figure 5-11: University Park – Cedarwood/Market Place Drive (the existing Route 70, which would continue to serve all existing Route 70 passengers), Waltham Center – North Waltham (the "Loop Circulator" portion of the existing Route 70A, which would replace Route 70A service in this area at similar or greater frequencies), and University Park – Waltham Center (the "Trunk Route" shared between the existing Routes 70 and 70A, which would replace Route 70A service in this area at similar or greater frequencies and supplement the existing Route 70 service through this corridor). This split would improve reliability and on-time performance for all passengers due to the decreased length and number of stops on each route. The split routes would also allow for more targeted service increases to meet demand. For example, providing one additional bus to serve the Trunk Route could be more impactful in reducing passenger crowding than providing one additional bus to serve the entire existing Route 70 or Route 70A. However, the split routes would add a transfer for Route 70A passengers traveling from one side of Waltham Center to the other.

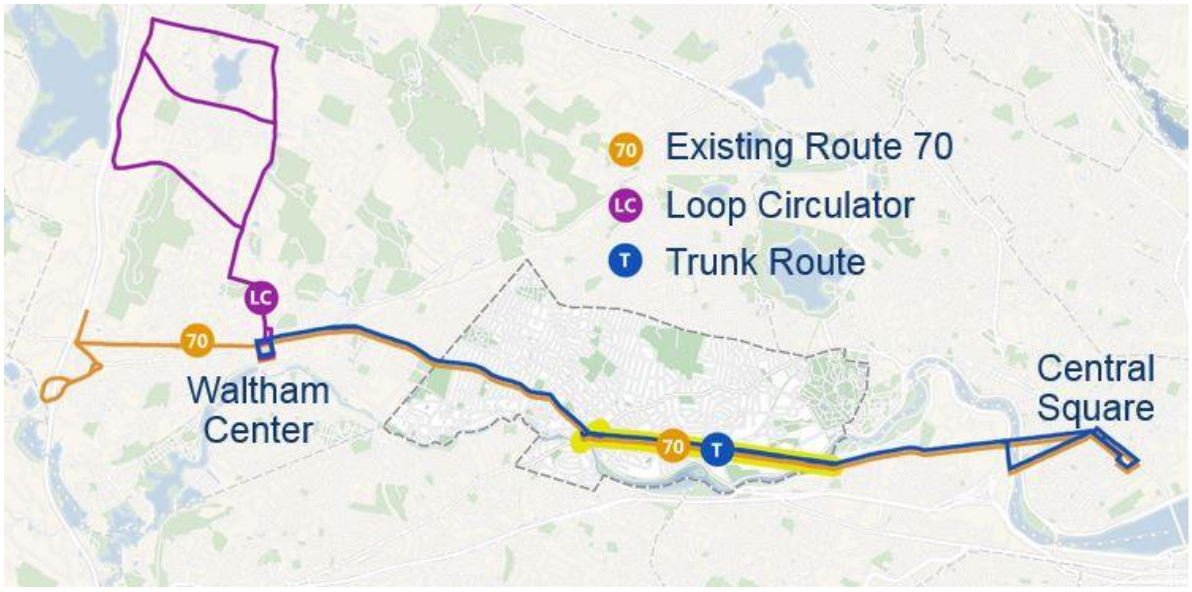


Figure 5-11 Potential Split Routes

Transfer Analysis

A transfer analysis was conducted to quantify the percentage of riders on the proposed Loop Circulator who would be impacted with an additional transfer. Transfer impacts resulting from the proposed route splitting were analyzed based on inferred origin-destination data provided by the MBTA.[33] The data indicate that approximately 71 percent of passengers who board on the Route 70A loop would require an

[33] Inferred origin-destination data for October 6, 2015 provided by the MBTA.

additional transfer with split routes. Waltham Center would become one of the largest bus-to-bus transfer locations on the MBTA system. Approximately 38 percent of passengers boarding on the Route 70A loop travel to Central Square. These passengers could benefit from a coordinated transfer to an express route at Waltham Center, or to a consolidated stop service to Central Square, as discussed in the following section of this report. In addition, alternative service improvements along the Loop Circulator, such as increased span of service, should be considered to improve service for passengers burdened by an additional transfer.

The evaluation results demonstrate that the route splitting would add a transfer for the majority of riders on the Loop Circulator. However, the benefits of increased reliability and the potential to alleviate passenger crowding through targeted service increases merits the further consideration of route splitting, along with coordinated transfers and other Loop Circulator service improvements.

Adding Limited-Stop Express Service or Consolidating Stops For All Service

The evaluation of limited-stop express bus service considered Trunk Route (Waltham Center to Central Square) limited-stop express service as an addition to existing local service, as opposed to replacing some existing local trips with limited-stop express trips. The evaluation of additional (as opposed to replacement) express service was performed in cooperation with feedback received from public stakeholders at the October 4, 2016 Arsenal Street Corridor Study public meeting. The alternative of implementing consolidated stop service for all trips was identified through the Study Team's coordination with the MBTA. Consolidated stop service would capture many of the benefits of a limited-stop express service by reducing the delay associated with stopping throughout a trip. These benefits would apply to a lesser extent on each trip (due to a lower reduction in stops) but would apply across *all* trips using consolidated stop service. In addition, consolidated stop service would promote consistency across the schedule to improve passenger usability. The following paragraphs describe the express service evaluation, with the findings and methodology largely applicable to future study and implementation of a consolidated stop service if preferred.

The express route evaluation first identified stop locations between Cambridge and Waltham Center (the trunk of the existing Routes 70 and 70A) with high potential for express service based on an analysis of passenger movements (boardings and alightings) and stop distances. Candidate express stops were identified based on the simultaneous goals of serving high-ridership locations along the Arsenal Street Corridor and along the route, providing consistency for riders with regard to inbound and outbound locations served, and providing adequate stop spacing to maximize potential travel time benefits. Figure 5-12 illustrates potential express stops for consideration based on this preliminary analysis. Tables 5-19 and 5-20 illustrate the percentage of passenger boardings and alightings along the trunk (Waltham Center to Central Square) served by the potential express stops identified in Figure 5-12, by period and direction, under existing conditions. As planning progresses, consideration

should also be given to express service at special generators (such as schools) as well as additional stop locations between Waltham Center and Watertown Square.

Figure 5-12 Route 70/70A Potential Express Stops

Table 5-19 Percentage of Trunk Boardings &Alightings at Potential Inbound Express Stops

Inbound Stop Name	AM Peak	PM Peak
Carter St. @ Waltham Comm. Rail	7.6%	8.8%
Main St. @ Cross St.	8.9%	7.9%
Arsenal St. Opp. School St.	1.8%	2.9%
500 Arsenal St. – Watertown + Arsenal Mall	-	5.7%
Western Ave. @ Mackin St.	2.8%	-
Western Ave. @ Everett St.	2.9%	3.4%
Mass Ave. @ Pearl St.	28.6%	30.5%
Franklin St. @ Sidney St.	6.5%	3.3%
Total	59.1%	62.5%

Source: MBTA Loading Data for October 2015 (provided by MBTA).

Table 5-20 Percentage of Trunk Boardings & Alightings at Potential Outbound Express Stops

Outbound Stop Name	AM Peak	PM Peak
Franklin St. @ Sidney St.	3.0%	6.0%
Green St. @ Magazine St.	22.1%	18.7%
Western Ave. @ N. Harvard St.	3.5%	2.5%
Western Ave. @ Soldiers Field	3.0%	-
Arsenal St. @ Watertown + Arsenal Mall	-	5.2%
Arsenal St. @ School St.	4.0%	1.7%
Main St. @ Merchants Row	7.7%	9.5%
Carter St. Opp. Waltham Commuter Rail	8.2%	8.4%
Total	51.6%	52.1%

Source: MBTA Loading Data for October 2015 (provided by MBTA).

Adding express service would improve transit travel times by reducing the number of stops a bus would make on a trip. Each bus stop has an associated level of delay ("dwell time") due to a number of factors (e.g., vehicle deceleration, boarding lost time, passenger boarding and alighting, traffic signal delay, reentry delay, and

acceleration).[34] While the dwell time due to passenger boarding and alighting may be similar in local and express service if the number of passengers boarding and alighting remains similar, the other factors would likely create a directional impact on the total trip dwell time based on the number of stops (i.e., reducing the number of stops would reduce the total delay). Multiple studies have found this to be the case.[35]

The potential express stops illustrated in Figure 5-12 would reduce the number of stops between Central Square and Waltham Center to seven stops in each direction during the AM Peak and PM Peak periods. In comparison, the existing local trunk service has 50 outbound and 44 inbound stops. These stop reductions can be converted to travel time reductions using an assumed 15 seconds of dwell time per stop, based on typical values of acceleration to 25 miles per hour (5.5 seconds), deceleration from 25 miles per hour (4.5 seconds), and reentry delay (0-10 seconds).[36] This would result in travel time savings on the Route 70/70A trunk of up to 10.75 minutes outbound and up to 9.25 minutes inbound. These estimates represent maximum potential time savings, since they assume that local buses currently stop at all 50 outbound and 44 inbound stops. A more conservative time savings estimate considers the average number of stops actually made per trip. Based on door cycle data provided by the MBTA, Route 70/70A buses currently stop to pick up/drop off passengers at up to two-thirds of all stop locations during the peak hours. Therefore, travel time savings on the Route 70/70A trunk would likely reach up to (approximately) seven minutes in the outbound direction and up to six minutes in the inbound direction.[37]

In addition to travel time savings, limited-stop service has been found to be more reliable than previously existing local-only service along a route.[38] Moreover, the express trips would provide additional capacity to reduce crowding and would offer the potential to accommodate projected increases in ridership demand. Although the limited-stop service could result in irregular combined (local-only and limited-stop) headways, it would reduce headway gaps by providing this limited-stop service as additional service.[39]

The addition of express service also has the potential to induce additional ridership demand through improved reliability and lower travel times, which could make the trip more attractive and competitive, and result in a modal shift.

The preliminary evaluation of express service conducted as part of this study found that adding limited-stop express service has potential to improve transit travel times

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[34] Transportation Research Board, TCRP Report 165, *Transit Capacity and Quality of Service Manual, Third Edition*, 2013, Page 6-3, Exhibit 6-1.
[35] Transportation Research Board, TCRP Report 165, *Transit Capacity and Quality of Service Manual, Third Edition*, 2013, Page 6-55.
[36] Transportation Research Board, TCRP Report 165, *Transit Capacity and Quality of Service Manual, Third Edition*, 2013, Page 6-55.
[37] Trips outside the peak period/peak direction have fewer average door cycles, and therefore would have lower travel time savings.
[38] Nicholas Hart, Boston Regional Metropolitan Planning Organization staff. "Limited-Stop Study, Phase 1: Review of Limited-Stop Bus Service" DRAFT memorandum to the Boston Regional Metropolitan Planning Organization. May 2015.
[39] Providing consistent combined headways at Waltham Center would result in variability along the Arsenal Street Corridor due to the differences in travel time between the local-only and limited-stop routes. Similarly, providing consistent combined headways along the Arsenal Street Corridor would require irregular departures from Waltham Center. However, despite this irregularity, headway gaps would decrease wherever limited-stop service is added to a local-only service operated with consistent headways.

for express bus riders and would provide additional capacity to alleviate crowding on local buses. Other initial evaluations of express service conducted by the Boston Regional Metropolitan Planning Organization[40] found that there may be potential to implement express service on the Route 70/70A, however additional improvements such as provision of dedicated bus lanes, queue jumps, and/or transit signal priority would be needed to make this route favorable for limited-stop service consideration.

Based on feedback from the MBTA, there are operational challenges associated with implementing limited-stop express service in combination with other local service on a corridor, including bus bunching and passenger confusion regarding stops served. The MBTA identified consolidating stops for all trips as an operationally preferable alternative to the addition of limited-stop express service on the Route 70/70A corridor. As noted above, consolidating stops would also save travel time through stop reduction; lesser transit travel time savings per trip would be achieved as compared to additional express service, but some travel time benefits would be provided on all trips.

It is recommended that both the addition of limited-stop express service and the consolidation of stops for all trips on the Route 70/70A be considered and further analyzed through the MBTA's systemwide service planning process as part of the next steps for this Alternative.

Route Combination

While the above routing adjustments examined changes to the existing route limits of the Route 70/70A, the route combination alternative considered combining segments of Routes 70 and 70A with other transit routes, with the goal of shifting passengers to those other routes and reducing crowding along the Arsenal Street Corridor. This analysis used transfer data to understand where route combinations would benefit Route 70/70A ridership by providing a single-seat ride instead of requiring a transfer. It examined the routes that have the highest transfer volume to or from Route 70/70A, and assessed how route combinations would affect system operations and system infrastructure.

Table 5-21 displays the daily number of transfers between Route 70/70A and other routes. The majority of transferring passengers do so between Route 70/70A and the Red Line, at a rate of nearly eight times the next most common transfer combination. More passengers transfer between Route 70/70A and the Red Line than between Routes 70/70A and all other routes combined. Improving service to reach the Red Line at Central Square could provide a greater impact than what would be possible through other bus route combinations.

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[40] Nicholas Hart, Boston Regional Metropolitan Planning Organization staff. "Limited-Stop Study, Phase 3: Limited-Stop Service Potential of MBTA Bus Routes" DRAFT memorandum to the Boston Regional Metropolitan Planning Organization. May 2015.

Outside of rail transfers, the most common transfers are between Routes 70/70A and Routes 66, 1, and 71. Of these alternatives, route combination with Routes 66 and 1 is unlikely to be beneficial on the system level as these routes have the third and fourth highest existing weekday ridership in the bus system.[41] Significantly adjusting these routes would inconvenience a high number of Route 66 and Route 1 passengers. In addition, these routes have known crowding issues[42] and thus would be unable to relieve the pressure on Routes 70/70A without additional service.

Meanwhile, although Route 71 has the most similar routing to Routes 70/70A, combining it with Routes 70/70A or extending it for a greater overlap with Routes 70/70A would pose two challenges. First, Route 71 currently operates as a trackless trolley using electric propulsion. Extending it would require either the extension of the overhead catenary system or the purchase of a new fleet of diesel or hybrid electric/diesel vehicles. Second, Route 71 currently has its own crowding concerns which would limit its ability to accommodate additional demand diverted from Routes 70/70A.[43]

Table 5-21 Route 70/70A Daily Transfers

Transfer From	Transfer To	Total
Route 70/70A	Red Line – Central Square	889
Route 70/70A	Route 71	115
Route 70/70A	Route 66	110
Route 70/70A	Route 1	98
Route 70/70A	Route 57	73
Route 70/70A	Route 86	69
Route 70/70A	All Other Routes	248
Red Line – Central Square	Route 70/70A	1004
Route 66	Route 70/70A	129
Route 1	Route 70/70A	120
Route 71	Route 70/70A	94
Route 57	Route 70/70A	74
Route 86	Route 70/70A	68
All Other Routes	Route 70/70A	271

Source: MBTA Ridership Data for October 2015 (provided by MBTA).

Other routes crossing or passing near the 70/70A would not be suitable for route combination. These routes are described below:

- Route 57 operates between Kenmore Station and Watertown Yard. Similar to Routes 66 and 1, however, Route 57 is one of the MBTA's ten highest ridership routes, and faces crowding concerns under existing conditions.

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41 MBTA ridership and Service Statistics, Fourteenth Edition, 2014.

42 MassDOT and MBTA, "State of the System Report: Bus," December 2015. This study notes that all Key Bus routes fail MBTA standards for crowding.

43 MassDOT and MBTA, "State of the System Report: Bus," December 2015. This study notes that all Key Bus routes fail MBTA standards for crowding.

- Route 86 follows Western Avenue along the same route as Route 70/70A between North Harvard Street and Market Street. Rerouting the Route 86 to serve the Arsenal Street Corridor would add considerable travel time for existing ridership on this route.
- Route 170 already serves similar destinations as the non-trunk portions of Routes 70 and 70A (north and west of Waltham Center) and provides express service to Dudley Square, running two trips per day in each direction. As this route already serves the 70/70A corridor, no additional route combinations are recommended.
- Route 52 operates between Watertown Yard and Dedham. Route 59 operates between Watertown Square and Needham Junction. Routes 502 and 504 provide express service between Watertown Square and Boston. Routes 505, 553, 554, 556, and 558 provide various express services through Waltham Center. Transfers between these routes and Route 70/70A are low, so combining these routes with Route 70/70A would not provide significant additional benefits to Route 70/70A ridership, and would have minimal effect on the Arsenal Street Corridor.
- Route 64 follows a nearly-parallel path to Central Square as the Route 70/70A, but does so through Brighton, serving Oak Square and Union Square. Rerouting the Route 64 along the Arsenal Street Corridor would add considerable travel time for existing Route 64 ridership between Oak Square and Union Square.

Recommended Routing Adjustments

Table 5-22 summarizes the initial screening of routing adjustments and the improvements recommended to advance for further planning. Of these routing adjustments, route splitting and additional limited-stop express service or consolidated stop service on all trips are recommended as medium-term improvements due to the potential benefits to reliability, travel time, and crowding along the Arsenal Street Corridor and along the larger route. These alternatives complement each other and could be developed together, including coordination of improved Trunk Route service with the Loop Circulator to achieve timed transfers at Waltham Center.

Table 5-22 Initial Screening of Routing Adjustment Alternatives

✓ Positive Impact
● Neutral Impact
✖ Negative Impact

Routing Adjustment Alternative	On-Time Performance	Crowding	Travel Times	Route Service Coverage	Recommended As Improvement?
Terminal adjustment: Watertown Square	✓	✓	●	✖	No
Terminal adjustment: Waltham Center	✓	✓	●	✖	No
Route splitting	✓	✓	●	●	Medium-Term
Additional limited-stop express service	✓	✓	✓	●	Medium-Term
Consolidated stop service for all trips	✓	●	✓	●	Medium-Term
Route combinations	●	✖	●	●	No

Service Frequency and Schedule Adjustments

The analysis of service frequency and schedule adjustments identified improvements that would relieve crowding and provide more consistent bus headways on the Routes 70/70A. Service frequency and schedule adjustments would complement the routing adjustments in the medium-term. Some service frequency and schedule adjustments could also serve as a stand-alone improvement in the short-term, pending existing MBTA fleet capacity (which is particularly constrained in the peak periods), operating budget, and systemwide priorities. The MBTA's process for evaluating and adjusting schedules includes the quarterly bus service planning process. Any potential service frequency and schedule adjustments would need to be coordinated through the MBTA's bus service planning process prior to implementation.

The analysis presented below is based on the vehicle loading analysis detailed in Chapter 3 and illustrated in Figures 3-1 through 3-4, including existing Fall 2015 loading data and 2040 future year loading projections.

Trip Adjustments to Address Crowding Issues

The findings of an analysis of potential service frequency adjustments that would alleviate existing and projected crowding issues on the Route 70/70A are summarized in Table 5-23. The analysis considers the number of individual Route 70/70A trips that typically exceed loading standards within various key time periods, and quantifies the number of additional trips that would be needed to accommodate excess demands on these overloaded trips. While the average loads across all trips during each time period may meet loading standards, this conservative trip-level analysis is intended to more fully capture impacts to the individual passenger experience. In all time periods, schedule adjustments should be considered to provide consistent headways and to redistribute demands onto trips with additional capacity, where available, which may reduce the required service level increase.

It is important to note that identification and implementation of specific schedule adjustments in the short-term will depend on the MBTA's existing budget and fleet capacity and will require a comprehensive and systemwide analysis as part of the MBTA's quarterly bus service planning process. It is anticipated that short-term increases to service, particularly increases during the peak period, would not be possible unless systemwide priorities and resources are reallocated.

Table 5-23 Potential Service Frequency Adjustments

	EXISTING SERVICE			2040 DEMAND		
	# of trips exceeding load standards	# of passengers in excess of load standards	Additional trips needed	# of trips exceeding load standards	# of passengers in excess of load standards	Additional trips needed
Early AM Period						
Inbound	1	11	1	2	27	1
Outbound	0	0	0	0	0	0
AM Peak Period						
Inbound	4	34	1	4	84	2
Outbound	0	0	0	4	46	1
Midday Base Period						
Inbound	0	0	0	2	7	1
Outbound	0	0	0	2	14	1
Midday School Period						
Inbound	0	0	0	2	7	1
Outbound	0	0	0	1	8	1
PM Peak Period						
Inbound	0	0	0	2	18	1
Outbound	0	0	0	4	17	1
Evening Period						
Inbound	0	0	0	2	20	1
Outbound	2	27	1	8	111	3
Late Evening Period						
Inbound	0	0	0	1	5	1
Outbound	1	5	1	3	24	1
Night/Sunrise Period						
Inbound	2	15	1	2	47	2
Outbound	0	0	0	0	0	0

Notes:

Maximum vehicle load capacity of 54 passengers during Early AM, AM Peak, Midday School, and PM Peak periods.

Maximum vehicle load capacity of 39 passengers during Midday Base, Evening, Late Evening, and Night/Sunrise periods.

Other Considerations

There are several special event demands along the corridor. For example, the Mosesian Center for the Arts often has weekday events from 8:00 – 10:00 p.m. At the

October 4, 2016 Arsenal Street Corridor Study public meeting, a resident noted that Mosesian Center for the Arts eventgoers could better use transit for the event if the event service and MBTA service were better coordinated. Improving trip reliability, via the proposed service improvements discussed as part of this alternative, would allow the MBTA to maintain consistency in scheduling and would better allow event organizers to tie special event start and end times to MBTA service and encourage use of public transit to/from events.

Recommended Service Frequency and Schedule Adjustments

Table 5-24 summarizes the impacts of the recommended trip schedule adjustments discussed in the initial screening above. These adjustments would alleviate passenger crowding by adding trips and reducing headway gaps. The reduced crowding is also expected to increase reliability and improve on-time performance by reducing friction for passenger movements for boarding and alighting, thereby reducing dwell time variability.

Table 5-24 Initial Screening of Schedule/Frequency Adjustment Alternatives

✓ **Positive Impact**
● **Neutral Impact**
✘ **Negative Impact**

Trip Schedule Adjustment Alternative	On-Time Performance	Crowding	Travel Times	Route Service Coverage	Recommended As Improvement?
Adjustments for existing demands	✓	✓	●	●	Short-Term
Adjustments for future 2040 demands	✓	✓	●	●	Medium-Term

Summary of Recommended Improvements and Next Steps

The previous sections describe routing, service frequency, and schedule adjustments that would provide service quality improvements to the MBTA's existing Route 70/70A services. The evaluation was specifically focused on addressing concerns on the Arsenal Street Corridor; therefore, any specific recommendations will need to be further analyzed and refined within the context of the larger MBTA system as part of the MBTA's systemwide service planning processes. Based on the preliminary analysis of potential Route 70/70A improvements, the recommended improvements and next steps for the short-term and medium-term are described below.

Short-Term Improvements and Next Steps

In the short-term, the MBTA may consider service frequency and scheduling improvements that can be implemented with existing resources (pending available MBTA fleet capacity, operating budget, and systemwide priorities), aimed at reducing

Route 70/70A overcrowding on specific trips and providing more evenly timed service along the Arsenal Street Corridor. Currently, four peak period and three off-peak period trips exceed load standards in the inbound direction, and three off-peak period trips exceed load standards in the outbound direction. Due to the particular constraints on MBTA fleet capacity during the peak periods, it may be most feasible to implement improvements to alleviate off-peak crowding in the short-term, unless systemwide priorities and resources are reallocated.

Next steps include further analysis and refinement of specific trip shifts and service adjustments as part of the MBTA's quarterly bus service planning process. The specific schedule recommendations that come out of the MBTA's service planning process will consider updated and expanded data sets, vehicle scheduling and interlining, crew scheduling and union rules, systemwide fleet needs and priorities, other operational decisions, and public stakeholder involvement.

Medium-Term Improvements and Next Steps

In the medium-term, the existing Routes 70 and 70A may be split into three routes, consisting of the existing Route 70, the overlapping "Trunk Route" portion of Routes 70 and 70A, and the "Loop Circulator" portion of Route 70A. Consideration should be given to improving service and/or expanding the service span on the "Loop Circulator", as the split routes would create one of the largest bus-to-bus transfer points in the MBTA system at Waltham Center. In addition, further consideration may be given to limited-stop express service on the "Trunk Route" or consolidated stop service for all trips. Finally, this package of medium-term improvements would further benefit from schedule and service frequency adjustments to accommodate future ridership demand. These adjustments may include trip shifts and additional trips, both during the off-peak and peak periods.

Next steps include further analysis and refinement of the package of medium-term improvements as part of the MBTA's longer term bus improvement plan initiative and the MBTA's bus service planning process. The MBTA's bus improvement plan initiative considers overall agency efforts that lead to partnerships, investments, and larger changes to existing bus routes. The timing for the MBTA's current bus improvement plan initiative is under development, but it is expected that the Routes 70/70A would be evaluated as part of this initiative within the next two years.[44] The MBTA's quarterly service planning process focuses on service changes made by the serving planning and scheduling teams, and will consider updated and expanded data sets, vehicle scheduling and interlining, crew scheduling and union rules, systemwide fleet needs and priorities, other operational decisions, and public stakeholder involvement.

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[44] MBTA. *Service Plan Implementation Bus Network* draft presentation to the MBTA Fiscal Management and Control Board. March 27, 2017.

Order of Magnitude Cost Estimation

Operating and capital costs for the package of Alternative 15 recommendations will depend on the final service schedule and operational decisions made through the MBTA's service planning process. Operating costs will depend on the allocation of resources across all system routes based on systemwide priorities. Capital costs associated with increased service levels on the Arsenal Street Corridor could include costs for additional bus procurement, which would likely be part of a larger MBTA systemwide vehicle procurement. The MBTA's current bus support facilities are at or near capacity, and any expansion of the vehicle fleet would also need to consider the costs associated with the expansion of bus storage and maintenance facility capacity. Due to these considerations, and the systemwide nature of the costs required to support and operate MBTA bus service, the Alternative 15 costs were developed for planning purposes only to compare alternatives within the context of this study. Costs identified herein are for planning purposes only and are not to be used for budgeting.

Preliminary order of magnitude (OOM) operating cost estimates for the Alternative 15 improvement packages were based on existing MBTA operating expenses and estimated increases in annual vehicle miles and vehicle hours required to implement the proposed recommendation packages. The OOM, planning-level incremental operating costs for Alternative 15 are estimated to total approximately $200,000 per year for the short-term recommendations and approximately $800,000 per year for the medium-term recommendations package.

Preliminary OOM, planning-level capital cost estimates for the Alternative 15 medium-term improvements package were based on an estimated fleet size requirement of four additional vehicles to accommodate route splitting and increased service levels to meet 2040 demands. Based on recent MBTA bus procurement data, the estimated capital cost for a new diesel-hybrid bus is approximately $900,000. Based on these assumptions, the OOM, planning-level capital cost for Alternative 15 is estimated to total approximately $3.6 million in the medium-term, excluding capital costs associated with required maintenance facility needs, as well as labor and other operating and maintenance costs. This study assumes that any schedule adjustments ultimately selected for short-term implementation would be accommodated without the need for additional capital investments.

Improvements Evaluation and Recommendation

Table 5-25 considers the results of the analysis discussed above and summarizes the complete evaluation of Alternative 15 against the study goals and objectives.

Table 5-25 Alternative 15 Evaluation and Recommendation

✓	Positive Impact
●	Neutral Impact
✖	Negative Impact
PHO	Public Health Objective

Goals	Objectives	Impact	Comments
Mobility Benefits	Decrease congestion and reduce delays (PHO)	●	1. The medium-term route splitting recommendation is expected to improve transit system reliability along the corridor.
	Improve system reliability	✓[1]	
	Minimize local street impacts	●	
	Maintain emergency vehicle and first responder mobility	●	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	●	
	Address current design standard deficiencies (PHO)	●	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	✓	
	Improve existing public transportation services (PHO)	✓	
	Coordinate existing transit services	✓	
	Improve bike and pedestrian connections (PHO)	●	
	Promote active transportation (PHO)	●	
Economic Development Impacts	Support existing and projected economic development	✓	
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	●	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	●	
	Improve access to the regional highway system	●	
	Avoid/minimize/mitigate social equity impacts	✓	
	Incorporate healthy community design features (PHO)	●	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	✓	2. Transit service improvements with the medium-term recommendations package are expected to increase reliability, reduce crowding, reduce travel times, and increase service frequency, all of which can induce mode shifts from auto to transit and result in emissions benefits.
	Avoid/minimize/mitigate impacts to the natural environment	✓	
	Minimize greenhouse gas emissions (PHO)	✓[2]	
	Reduce CO and particulate matter impacts (PHO)	✓[2]	
	Minimize transportation-related noise impacts along the corridor (PHO)	●	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	✓	
Public Support	Encourage consensus through an open and inclusive process	✓	
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	$3.6 Million [3]	3. Estimate excludes costs for vehicle storage and maintenance needs.
Recommendation	***Advance analysis and refinement of the short-term and medium-term transit service recommendations as part of the MBTA's systemwide bus improvement plan initiative and the MBTA's quarterly bus service planning process.***		

Alternative 17: Adaptive Signal Control (ASC)

Alternative 17 considers implementing ASC technologies along the Arsenal Street corridor to optimize traffic flow and progression. Analysis of this alterative considers various ASC technologies and evaluates their appropriateness for the corridor. The specific analysis performed is not technical in nature, rather more dependent on whether a system that the town would be able to maintain effectively, using preferred equipment and software, could be developed.

Under future conditions and with the inclusion of planned traffic signals, spacing between traffic signals along Arsenal Street would average 500 to 700 feet. This frequent spacing is a benefit for non-motorized transportation, giving both bicyclists and pedestrians more frequent, controlled locations to cross the street. But closely spaced traffic signals are known to cause driver frustration and increase incidents of yellow and red light running if the system does not function properly. In this case, ASC can be considered a smart traffic signal system, providing traffic signal coordination in "real-time" and dynamically responding to conditions in the field with relatively minor monitoring once the system is running and calibrated to accommodate traffic conditions. The system would allow for the long-term and regular collection of traffic data that the town can utilize to establish measures of effectiveness. These performance measures generated by ASC can be used to automatically evaluate corridor operations.

The project team met with the town to extensively discuss the technical parameters of ASC systems and both hardware and software requirements. The outcome of this meeting indicates that ASC would be a valuable addition to traffic management options for the town. For a fully functional and optimized system, the proposed ASC would focus on the 10 signalized intersections between Watertown Square and Greenough Boulevard North. Apart from newly installed traffic signals (two locations) the traffic signal cabinet assembly should be upgraded at all locations. Regular equipment maintenance is required and it is preferable to have a central control system within the town.

Under the current technical specifications available, it is disadvantageous to include Watertown Square in the ASC system at this time. Watertown Square could be included in an overall central system allowing for real-time monitoring of signal operations at that specific intersection via the processing and gathering of system performance measures. Through the implementation and refinement process, the town could continue to evaluate system performance to determine whether future systems could better incorporate congested intersections.

Table 5-26 considers the results of the analysis discussed above, summarizes the complete evaluation of Alternative 17 against the study goals and objectives, and provides a preliminary order-of-magnitude construction cost estimate.

Table 5-26 Alternative 17 Evaluation and Recommendation

✓	Positive Impact
●	Neutral Impact
✖	Negative Impact
PHO	Public Health Objective

Goals	Objectives	Impact	Comments
Mobility Benefits	Decrease congestion and reduce delays (PHO)	✓	
	Improve system reliability	✓	
	Minimize local street impacts	●	
	Maintain emergency vehicle and first responder mobility	✓	
Safety Improvements	Identify, eliminate, or mitigate locations and situations that pose hazards (PHO)	●	
	Address current design standard deficiencies (PHO)	●	
Accessibility and Connectivity Benefits	Reduce auto dependency (PHO)	●	1. May anecdotally improve bus travel times, but would not be designed specifically for transit improvements. This credit is noted under system reliability.
	Improve existing public transportation services (PHO)	●[1]	
	Coordinate existing transit services	●	
	Improve bike and pedestrian connections (PHO)	●	
	Promote active transportation (PHO)	●	
Economic Development Impacts	Support existing and projected economic development	✓	
	Minimize negative economic effects to tax bases; enhance local and regional economic activity	●	
	Improve non-motorized access and connectivity between business centers and employment centers (PHO)	✓	
	Improve access to the regional highway system	●	
	Avoid/minimize/mitigate social equity impacts	●	
	Incorporate healthy community design features (PHO)	●	
Environmental Impacts	Support smart growth, anti-sprawl initiatives (PHO)	●	
	Avoid/minimize/mitigate impacts to the natural environment	●	
	Minimize greenhouse gas emissions (PHO)	✓	
	Reduce CO and particulate matter impacts (PHO)	✓	
	Minimize transportation-related noise impacts along the corridor (PHO)	●	
Lasting Benefits	Develop a range of multimodal recommendations that support ongoing changes and have lasting benefits	●	
Public Support	Encourage consensus through an open and inclusive process	Yes	
Cost	Preliminary Order-of-Magnitude Construction Cost Estimate	$250,000 - $500,000[2] plus $350,000[3]	2. Dependent on type of communication and server chosen. 3. Assembly upgrades.
Recommendation	***Install ASC at 10 locations east of Watertown Square***		

Summary

Through the analysis documented in this chapter, Alternative 5 (Road Diet) and Alternative 13 (Transit Stop Turnouts/Curb Extensions) have been eliminated from further consideration. The remaining alternatives have been packaged into short-term (0 to 5 years), medium-term (5 to 10 years), and long-term actions (over 10 years). These actions are determined based on environmental permitting needs, ability to secure funding, and the amount of additional planning required to achieve implementation. Table 5-27 presents a summary of the recommended alternatives and phasing. Chapter 6, Recommendations, will build on the recommendations and phasing and establish an Action Plan with next steps for implementation.

Aesthetics

Through the Working Group process, the aesthetics of the corridor was regularly discussed, as its enhancements improve the public realm and encourage the use of non-motorized active transportation. Where incorporated in the alternatives discussion above, aesthetic improvements to landscaping, streetscaping, and the general character of the roadway serve to further enhance user experience and encourage a more vibrant mix of active, non-motorized transportation along the corridor. While streetscape improvements are considered more closely in the design phase of a project, all alternatives progressed should consider improved amenities through an increased use of landscaping, the addition of street furnishings along the corridor, improved bus stops (see Alternative 14), and the general creation of a "sense of place." For many years, the corridor has been shaped by automobile traffic commuting to, from and through East Watertown. The current redevelopment efforts along the corridor should also serve as a revitalization of the Arsenal Street community and refocus the town's efforts on providing enhanced view sheds and welcoming environments for all roadway users.

Table 5-27 Alternatives Analysis Summary and Study Recommendations

Short-term (0 – 5 years)	Medium-term (5 – 10 years)	Long-term (over 10 years)	Comments
Alternative 1: Bike Lanes East of School Street			If possible, schedule should be coordinated with athenahealth project
Alternative 3: Cross Connectivity between the Greenway and Charles River			
	Alternative 6: Soldiers Field Road Gateway Improvement *Permitting and Design*	**Alternative 6:** Soldiers Field Road Gateway Improvement *Construction*	Permitting and design could be achieved in the medium-term while construction would occur in the long-term.
Alternative 7: Watertown Square Gateway Improvements *Permitting and Design*	**Alternative 7:** Watertown Square Gateway Improvements *Construction*		Continued design development and permitting could be achieved in the short-term, with design and construction occurring in the medium-term. Depending on the funding source, Alternative 7 may extend into the long term.
	Alternative 10: Express Bus along North Beacon Street[1] *Pilot Program*	**Alternative 10:** Express Bus along North Beacon Street *Full Service*	A pilot program could be achieved in the medium-term while full service (and a determination of who would implement such service on a permanent basis) may extend into the long-term.
Alternative 11: Transit Signal Priority			
Alternative 14: Transit Shelters			
Alternative 15: Existing Transit Service Improvements *With Existing Fleet*	**Alternative 15:** Existing Transit Service Improvements *With Expanded Fleet*		Improvements that utilize the existing fleet and are possible given MBTA resources and priorities over the next five years can be achieved in the short-term, while recommendations that may require expanded fleet and further increases to resources are recommended for the medium-term.
Alternative 17: Adaptive Signal Control *Planning/Implementation*	**Alternative 17:** Adaptive Signal Control *Refinement/Upgrades*	**Alternative 17:** Adaptive Signal Control *Maintenance*	Planning and Implementation would occur in the short-term, followed by refinement/upgrades in the medium-term and maintenance over the long-term.

1 A pilot program may be expedited if advanced by a private party or the TMA