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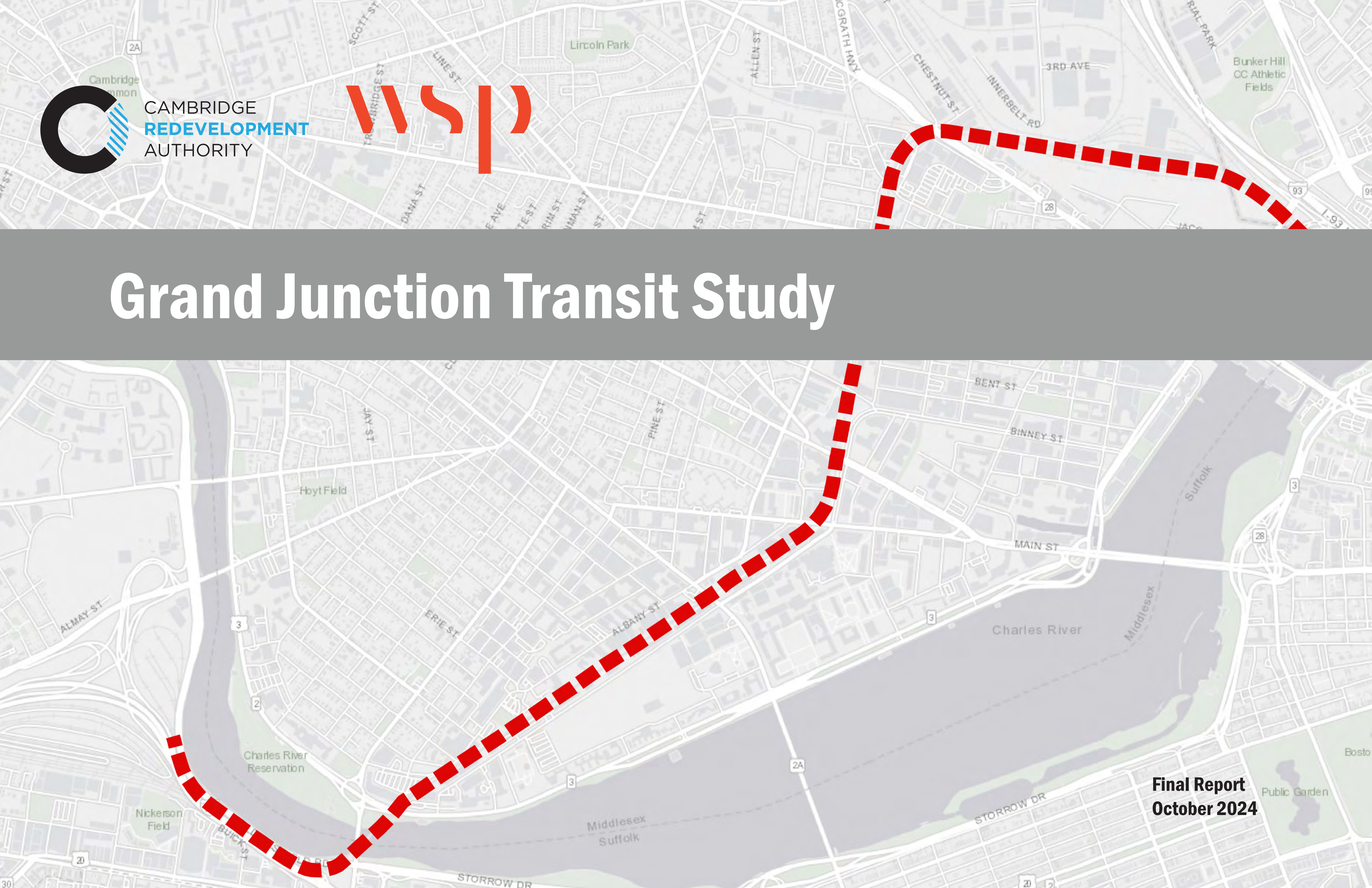
Grand Junction Transit Study



Final Report
October 2024

CAMBRIDGE REDEVELOPMENT AUTHORITY

October 2, 2024

Dear CRA Board,

The Grand Junction corridor has long been considered an untapped opportunity to connect growing areas of Boston and Cambridge. Seven years ago, the Kendall Square Mobility Task Force, established by MassDOT, laid out priorities for transportation investments to support the continued development of the district. One of the Task Force's key recommendations was the use of the Grand Junction for both rail transit and a multi-use path to connect Kendall to North Station and the emerging growth in Allston Yards. Since then, the City of Cambridge has advanced the planning and design of the multi-use path alongside the tracks, and has constructed the path through Grand Junction Park and Binney Street Park. Additionally, the MBTA's 2020 Rail Vision Plan included a rail shuttle linking North Station and a future West Station, further emphasizing the ability of this corridor to augment the region's transit system.

The Grand Junction Transit Feasibility Study (Study) builds on these and other plans to test the viability of alternative concepts for passenger rail service along the existing corridor. The Study was conducted by WSP and funded as a mitigation from BXP for the expansion of development rights in the Kendall Square Urban Redevelopment Project (KSURP).

The Study concluded that there is significant potential demand for frequent rail transit service connecting North Station to Allston via Kendall Square and reinforces that a two-track alignment could be designed alongside a multi-use path through Cambridge. This study reviewed previous planning work, explored various transit modes, and modelled potential ridership. This Study identified potential station locations that would serve Cambridgeport, MIT/Mass. Ave, Kendall Square, and East Cambridge. Even with conservative assumptions, it was shown that electrified train service at 15-minute intervals would attract substantial ridership and provide a key linkage within the region's transit network. With the anticipated commercial and residential development in Kendall Square and Allston Yards, delivering frequent transit service alongside the multi-use path on the Grand Junction will provide a sustainable transportation spine to support the growth of the Commonwealth's innovation economy.

In the Study, WSP recommended utilizing Electric Motor Units (EMUs) as the transit vehicle given this type of vehicle is compatible with the ongoing rail uses along the Grand Junction. As technology evolves for vehicle design and track controls, the transit vehicle selection for this urban corridor will be worth further study and review. Further, while the Study explored an alternative route providing service to the communities to the north, the required railway crossovers to travel north from Cambridge would interfere with the MBTA's plan to provide significantly more frequent service along the northern commuter rail lines as set forth in the Rail Vision Plan and the MBTA Rail Transformation Program. This broader commuter rail service expansion with frequent train service between North Station and communities to the north like Chelsea and Lynn would provide a better solution to transit equity goals than the northern Grand Junction alternative contemplated in the Study. Likewise, a connection further west to Newton created conflicts with increased Commuter Rail service on the Worcester line and was not considered by the Study. Thus, the Study focuses its operational recommendations and infrastructure analysis on the Core Route between North Station and West Station through Kendall Square to avoid conflicts with the anticipated increase in train frequency along the commuter rail routes.

We expect that this Study will be a catalyst to launch a renewed discussion regarding this under-utilized rail corridor. As is the nature of the science that drives innovation in Kendall Square, the conceptual transit design decisions made for this Study, such as the type of train vehicles considered and the frequency of their service, should be reviewed and analyzed critically. It is understood that significant future design and engineering work will be required to plan stop locations and intersection designs, their corresponding traffic and safety impacts. In addition, it is critical to study how the future transit service can safely co-exist with bicycle and pedestrian movement along the future multi-use path and across roadways. However, the interest throughout Kendall Square for delivering future multimodal service within the Grand Junction corridor is strong and worth ongoing study, and certainly should not be dismissed due to technical uncertainty at this time. Likewise, the initial capital and operational cost estimates are preliminary figures, and the full transit concept is dependent on decisions that will be made within other regional transportation projects like the North Station Draw One Replacement Project and Allston Multimodal Project. Given that the commercial and residential development of East Cambridge is already supporting the operation of a successful commuter bus service, innovative solutions to funding this rail transit investment are worth exploring. As the Study clearly demonstrates, the potential of the Grand Junction to provide a valuable transit link serving the KSURP, the CRA is enthusiastic about the opportunity and looks forward to the next phases of planning for the corridor.

Sincerely,

Tom Evans, Executive Director

Grand Junction Transit Study

Final Report
October 2024

Table of Contents

List of Tables

List of Figures

1. Previous Studies, Projects, and Initiatives

This chapter contains a review of previous studies, projects, and initiatives that have taken place within the Grand Junction corridor, including the planning, development, and infrastructure context of the railbed. Previous transportation, planning, and development studies are described, along with their data, analysis, proposals, and recommendations, in order to understand the infrastructure, regulatory, and market conditions influencing any potential use of the corridor. Additionally, such examination provides valuable insight into lessons from prior efforts with regard to improving distinct segments or elements of the study area.

As outlined below, the review of previous studies focused on summarizing key conclusions across a range of topics and identifying persistent considerations or recurring themes. After assessing the extensive technical documentation produced over the past two decades to determine the takeaways, this study also identifies other unanswered questions that have emerged since these previous studies were conducted.

- Key Topics Explored within Previous Studies
  - Grade Crossings
  - Impacts on Vehicle and Non-Motorized Traffic
  - Speeds and Travel Time
  - Costs/Return on Investment
  - Ridership and Benefits
  - Station Locations
  - Transit Services and Types of Demand Examined
    - Modes
    - Headways
    - Markets
- Recurring Considerations Raised within Previous Studies
  - Integration with City of Cambridge Multi-Use Path
  - Integration with MBTA Commuter Rail at West Station & North Station
  - BU Railroad Bridge
  - Multimodal Corridor Safety
- Questions that Remain Unanswered and Worthy of Potential Examination within This Study
  - Integration with Other MBTA Services
  - Implications of the Green Line Extension
  - Corridor Development – Recent, Present, & Future Changes in Population + Employment
    - Different Demand for and Connections with Kendall Square to Other Areas
    - Transit-Dependent/Employees
    - Students – Allston, Other Areas

As detailed in Chapter 3 – Alternatives Development, the previous alternatives studied in these reports informed the Universe of Alternatives for this study. Similarly, prior templates and methodologies helped inform the evaluation of alternatives for this study. The list below presents valuable findings gleaned from the 15 plans that touched upon the Grand Junction corridor since 2001.

- The primary studied rail option consists of commuter rail service between a future West Station in Allston (at the site of the former Beacon Park Yard) and North Station.
- A single Cambridge station, typically located near Kendall Square, was assumed in nearly every study.
- Although earlier reports investigated the extension of Framingham/Worcester Line service along the corridor, with full Commuter Rail consists equipped with diesel locomotives, more recent studies have solely focused on shuttle service involving the use of DMUs and EMUs.
- Many studies found BRT and LRT options to be infeasible.

- Providing for continued freight, Amtrak, and MBTA operations rail use along the corridor, as well as the new multi-use path, should be considered prerequisites for future alternatives. Elements of these may affect design direction at station locations.
- Many issues still need to be fully addressed, such as connections with existing commuter tracks in Allston and in Cambridge, the Charles River Crossing near the BU Bridge, and terminal capacity at North Station.
- Potential ridership markets north of Cambridge along the old Grand Junction ROW (current Newburyport/Rockport Commuter Rail) have not been studied.
- Although single and double-track rail service were examined in several studies, it appears that double-tracking would be beneficial, particularly in helping secure the desired 15-minute frequencies.
- The now completed Green Line Extension provides limitations that were not previously envisioned and would need to be assessed in detail with regard to future movements in and out of North Station.

Table 1 lists the relevant plans and documents reviewed for this study while Table 2 presents a high-level summary of key elements of each study, project, or initiative.

A detailed description of each study reviewed is provided on the pages that follow, organized based on the primary mode assessed within the particular study.

Table 1. Previous Studies Reviewed

Study Name	Year	Issuing Entity
Grand Junction Multi-Use Path	2001	Cambridge Bicycle Committee
Grand Junction Rail with Trail	2006	City of Cambridge
Grand Junction Improvement Options Review	2010	Harvard University
Urban Ring	2010	MassDOT OTP
Grand Junction Branch Line Study	2012	MIT
Grand Junction Transit Expansion	2012	MIT (MS Engineering Studio)
Grand Junction Transportation Feasibility Study	2012	MassDOT (CTPS)
MIT Property Feasibility Study	2014	MIT
Preliminary Operations Plan for Urban Rail: North Station to West Station Shuttle	2014	Rachel Burckardt
Better Rapid Transit for Greater Boston	2015	The Greater Boston BRT Study Group (ITDP & Barr Foundation)
Grand Junction Feasibility Review	2016	City of Cambridge
KSMTF Final Report	2017	Kendall Square Mobility Task Force
GO Boston 2030	2017	City of Boston
Transport Kendall	2019	CRA, City & KSA
MBTA Rail Vision	2019	MassDOT OTP
West Station Area Transit Study	2022	MAPC
Silver Line Extension Alternatives Analysis	2024	MassDOT OTP

Table 2. Summary of Alternatives and Outcomes from Previous Studies

Year	Previous Study	Author	Proposed Alternative	Extent of Proposed Alternative	Outcomes / Notes
2001	Grand Junction Multi-Use Path	Cambridge Bicycle Committee	Multi-Use Grand Junction Path	From Boston side of the Charles River to Somerville	Considers Light Rail + Freight + Path Cross-sections and Conceptual Designs
2006	Grand Junction Rail with Trail	City of Cambridge	Rail with Trail	Charles River to Gore Street	Evaluation of Ownership, Existing Conditions, Utilities, and Concept Design
			Rail with Trail and Rapid Bus	Charles River to Gore Street	Evaluation of Ownership, Existing Conditions, Utilities, and Concept Design
2010	Urban Ring	MassDOT	Route 5 (Sullivan to Ruggles)	Via BU Railroad Bridge and Kendall Square	Suspended Due to Cost
			Route 6 (Harvard to JFK/UMass)	From Harvard to JFK/UMass via Beacon Park Yard	Suspended Due to Cost
2010	Grand Junction Improvement Options	Harvard University	Continuation of Existing Use	As Existing	N/A
			Urban Ring BRT	See Urban Ring Alignment above	See Notes above for 2010 MassDOT *Urban Ring*
			Multi-Use Path	Transit Between North Station and West Station Trail from BU Bridge to Somerville Community Path	In Progress
			Urban Rail Shuttle	Shuttle Service from North Station to West Station Also notes a shuttle between North Station and Riverside	DMU Fleet Proposed
			Worcester Line to North Station	Existing Framingham/Worcester Line and Amtrak Intercity from Springfield	Suspended in Favor of South Station Expansion
2012	Grand Junction Branch Line Study	MIT	Worcester Line to North Station Intercity Connection	Worcester to North Station	Eight Sub-Alternatives (Station at Kendall [Y/N], Speed [15/30 MPH], and Frequency [6/12 Trains per Day]) Locomotive-hauled, EMU and DMUs All Considered
2012	Grand Junction Transit Expansion	MIT M.S. Engineering Studio	Commuter Rail Expansion	Worcester Line to North Station via Grand Junction	Existing Commuter Rail Infrastructure and Routing Explored as a Final Alternative
			FRA Compliant DMUs	Worcester to North Station or Auburndale to North Station	Both Routes Explored as Final Alternatives
			FRA Non-Compliant DMUs	Auburndale to North Station or West Station to North Station	Ruled Out for Ease of Introduction (FRA Compliance)
			Electrification	Spur of Green Line from Lechmere or Separate Green Line	Ruled Out for Cost and Ease of Introduction (FRA Compliance)
			Rail in Tunnel under Corridor	Underground after BU Bridge, Re-Emerging before Fitchburg Line Tracks	Investigated an underground Kendall Square Station; Corridor could be used by Commuter Rail, DMU Trains, or Electrified trains; Ruled out due to Cost + Ease of Introduction
			Bus Rapid Transit	Auburndale to North Station or Sullivan Square via Lechmere	Ruled Out Because It Was Not Mutually Exclusive with Rail on Corridor (Such Service Could Be Implemented on Adjacent Roads Instead of Existing Railbed)

Year	Previous Study	Author	Proposed Alternative	Extent of Proposed Alternative	Outcomes / Notes
2012	Grand Junction Transportation Feasibility Study	CTPS / MassDOT	Worcester Line to North Station Intercity Connection	Worcester to North Station	See Notes above for 2012 MIT *Grand Junction Branch Line Study*
2014	MIT Property Feasibility Study	MIT	Multi-Use Path Campus Impact Evaluation	250 ft West of Pacific to just North of Main Street	Evaluation of Impacts to MIT Properties and Critical Assets from Path and On-Going Freight Rail Operations No Transit Alternatives Proposed or Evaluated
2014	Grand Junction Preliminary Operations Plan	Rachel J. Burckardt	Shuttle Service Operations Feasibility	North Station to West Station Shuttle	Three Stations (Kendall, MIT/Mass Ave, and Cambridgeport) Assumed
2015	Better Rapid Transit for Greater Boston	ITDP/Barr Foundation	Sullivan to Longwood BRT	Crossing River at Mass Ave or BU Bridge	Use of BU Railroad Bridge Not Explored
			Harvard to Nubian BRT	Via Allston	Closely Mirrors *Go Boston 2030* Routing, Which Proposed to Use Grand Junction
2016	Grand Junction Feasibility Review	City of Cambridge	Urban Ring	Sullivan to Ruggles, also Harvard to JFK/UMass	See Notes above for 2010 MassDOT *Urban Ring*
			Worcester Line Intercity Connection to North Station	Worcester to North Station	See Notes above for 2012 MIT *Grand Junction Branch Line Study*
			Bus Rapid Transit (ITDP)	Sullivan Square to Longwood	See Notes above for 2015 ITDP *Better Rapid Transit for Greater Boston*
			DMU Rail Service	North Station or Sullivan Square to West Station or Riverside/Auburndale	Riverside and Sullivan Square Termini Proposed in Task Force #8
2017	KSMTF	Kendall Square Mobility Task Force	Rail with Trail	Transit Between North Station and West Station Trail from BU Bridge to Somerville Community Path	Request for new transit demand forecasts for the corridor and 25% design
2017	Go Boston 2030	City of Boston	Longwood Medical, Kendall Square, and Harvard Square Rapid Bus	Longwood to Harvard and Kendall via the Grand Junction	Exact Routing Was Not Described, Connections to Kenmore Square, Longwood, Kendall, Harvard, the Orange Line (Sullivan), further Red Line (Alewife), and Route 1 Bus (Mass. Ave) Noted
			Grand Junction Path	BU Railroad Bridge to Somerville	Report Notes Support for Path Implementation
2019	Transport Kendall	CRA, Kendall Sq Assn., Cambridge	Rail with Trail	Transit Between North Station and West Station Trail from BU Bridge to Somerville Community Path	Request for new Grand Junction transit study as part of mitigation for the Eversource Development
2019	MBTA Rail Vision	MBTA	Grand Junction Shuttle (Alternatives 3, 5 & 6)	North Station to West Station via Kendall 15 min Headways During Peak	Fully EMU Fleet/Electrified Service in all Alternatives
2022	West Station Area Transit Study	MAPC	Improved Commuter Rail Service	Rail Vision Alt. 3, 4, 5, and 6	See Notes above for 2019 MBTA *Rail Vision*
			Bus Rapid Transit	No Proposed Corridors Use the Grand Junction	N/A
			Bike/Pedestrian Connections	Grand Junction Path	See Notes above for 2006 City of Cambridge *Grand Junction Rail with Trail*
2024	Silver Line Extension Alternatives Analysis	MassDOT	Silver Line Extension (SL6) to Kendall	Terminus in Kendall (Alt 4, 5, 7)	Impact to Ridership/Demand Projections for New Transit Service Along the Grand Junction

1.1. Recent Studies that Influenced Formation of 2024 Grand Junction Transit Feasibility Study

1.1.1. Grand Junction Feasibility Review and Transport Kendall (Kendall Square Mobility Task Force, 2017-19)

This study builds upon the three-pronged approach of *Transport Kendall*, which called for future investment in the region's transportation network to serve the growth of Kendall Square as a regional hub for the innovation economy, and to relieve congestion in the region. One of the three key frameworks advanced in *Transport Kendall* is the **transformation of the Grand Junction corridor into a new multimodal link, through both the completion of the currently under construction multi-use path, as well as long-term transit service** along the corridor. Since 42 percent of jobs in Cambridge and 33 percent of residents are located within a ½ mile of the Grand Junction according to this report, future connections along the Grand Junction corridor will improve mobility and community.

The Grand Junction multi-use path is contemplated as an off-street bicycle and pedestrian connection between the Boston University (BU) Bridge on the Charles River and Somerville. A new facility would provide a missing link between the Somerville Community Path, the Paul Dudley White Bike Path, and paths proposed in the on-going Allston I-90 Interchange project.

The report noted that passenger transit service along the corridor has been studied in a variety of forms for the better part of the past two decades. *Transport Kendall* calls for a **new public transit service connecting Allston's future West Station, Cambridge's Kendall Square, and North Station in downtown Boston**. Such a service would alleviate long trips and downtown transfers for passengers traveling between Allston and Kendall Square, time spent in congestion for shuttle bus passengers travelling between North Station and Kendall Square, and general strain on the MBTA's central subway system by providing people faster and direct routes to major activity centers located outside of downtown Boston.

Additionally, the study suggested **exploring other alternative route alignments**, including:

- West Station to Everett or Chelsea
- West Station to Lynn, Salem, or Beverly via Kendall Square
- Riverside to North Station
- Riverside to Lynn
- Back Bay/Lansdowne to North Station

To achieve these goals, *Transport Kendall* proposed four recommended actions:

1. Convene Regional Stakeholders to Advance a Common Vision of a Regionally Connected Multi-Use Path
2. Analyze and Communicate the Benefits of Regional Connections
3. Develop a Grand Junction Transit Concept
4. Update Grand Junction Transit Demand Estimates

1.1.2. Grand Junction Feasibility Review (City of Cambridge, 2016)

In December of 2016, the City of Cambridge's Kendall Square Mobility Task Force published a thorough, comprehensive technical report offering a detailed analysis of the feasibility of a variety of transit services along the corridor. The report explored **potential service frequencies (Table 3), equipment and ROW dimensions, station dimensions and spacing, grade crossings, capital and operations and maintenance costs, as well as potential time-savings**.

Table 3. Service Alternatives Assessed within the GJ Feasibility Review (City of Cambridge, 2016)

Service Frequency	Peak Hour Trips	Station Spacing (miles)	Infrastructure Necessary	Average Operating Speed	Capital Costs
Regional / Commuter	1 - 4	2.0	Utilize Existing, Passing at Sidings	25-35 mph (Dedicated ROW)	Low to Moderate
Intermediate	4 – 10	0.2 – 1.0	Dedicated Rail ROW or Two-Lane Roadway	10-20 mph	Moderate to High
Rapid Transit	10 - 30	0.2 – 1.0	Major Civil & Grade Separation	15-25 mph	High to Very High

In addition to the three levels of service frequency, the report considered three varieties of equipment that could be utilized to operate service along the Grand Junction. A **BRT-based alternative using 40- or 60-foot articulated electric transit buses with overhead contact systems or battery-electric motors could further limit noise or localized emissions**. Compliant DMUs could share tracks with other rail equipment, including the occasional MBTA Commuter Rail, Amtrak, and freight trains, which utilize the corridor, though they would likely be noisier and produce greater emissions than electric buses. **Non-compliant DMUs on the corridor would require a waiver from the FRA; strict time separation would also be needed from competing rail uses**, which might render the corridor unacceptable to other stakeholders.

Significant ROW constraints could limit service possibilities on some sections of the corridor. A **single-track shuttle service would require 33-37 feet of ROW, along with either FRA-compliant equipment or temporal separation**. Intermediate service would likely need double-tracking, which requires 47-51 feet of ROW, not including station platforms. A second track could unlock possibilities for non-compliant equipment, or more robust service opportunities with compliant equipment. **Service on a high frequency bi-directional transitway (i.e., a transportation corridor that initially features Bus Rapid Transit service but could eventually be transitioned to Light Rail Transit) would only be possible south of Main Street given anticipated ROW requirements (60-65 feet)**. However, such an arrangement would not necessitate the use of compliant equipment or implementing temporal separation. In each alterative, the addition of station stops would increase the required ROW width and, in higher frequency services, would produce a greater impact on intersecting traffic at grade crossings.

Ultimately, service on the Grand Junction **would require several other capital improvements to facilitate connections to the existing regional public transit network**. The following list outlines **key constraints identified** within the 2016 assessment.

- Connections to North Station
  - Station tracks and platforms are near or at capacity
- Integration with Commuter Rail traffic along the Fitchburg Line
  - Would be challenging for non-compliant equipment
- Crossing the Green Line Extension
  - Potential geometric and/or compliance-based constraints
- Access to Sullivan Square
  - Complex process to integrate with existing infrastructure
- Railroad Bridge across the Charles River
  - Poor condition
  - Would need improvements to accommodate expanded service
- Interfacing with Framingham/Worcester Line / Access to Future West Station
  - Level of difficulty subject to track configurations and service plans

When evaluating travel times for potential riders, the report found **significant time savings for riders traveling between Riverside and Kendall, as well as North Station and Kendall.** Ultimately, there were **limited time savings reported between Sullivan Square and Kendall, as well as between Newtonville and Kendall.**

Consequently, the report ultimately concluded that the costs would not be justified by the benefits of implementing rapid transit service on a 20–25-year planning horizon. The report **recommended the City of Cambridge advance a design north of Main Street with two tracks and south of Main Street with one track and a bi-directional transitway.** The report also acknowledged ongoing multi-use path planning efforts along the corridor and suggested that path designs not preclude any of the alternatives presented in the report, while minimizing potential path/transit conflicts. The report also recommended **coordination with MassDOT and the MBTA to study assets impacting potential service operations, like platform and track capacity at North Station, crossing the Green Line Extension, the use of the railroad bridge across the Charles River, and the ultimate configuration of West Station.**

1.2. Studies of Grand Junction Rail Planning, Feasibility, and Operations

Rail Vision is the latest in a series of studies of passenger rail service along the Grand Junction corridor over the previous two decades. These previous studies, as well as the opportunities and constraints they highlight, follow in this section.

1.2.1. MBTA Rail Vision (MassDOT, 2019)

The MBTA undertook a comprehensive review of its Commuter Rail network to identify opportunities for significantly enhancing the system's transit capacity and access. After assessing a broad range of long-term infrastructure and service investment scenarios in 2019, the MBTA's Fiscal Management and Control Board endorsed the transformation of the commuter rail into a more "productive, equitable and decarbonized enterprise."

In three of the six analyzed alternatives, *Rail Vision* proposed new passenger service consisting of **electric-multiple units (EMUs) shuttle service operating every 15 minutes** within the region's core. This included **new service along the Grand Junction corridor between West Station and North Station, with a stop in Kendall Square**.

Since the Grand Junction is presently not utilized for revenue service, *Rail Vision* noted that **significant upgrades would be needed to initiate such service**. In each of the three alternatives that contemplated use of the corridor, new revenue service would require the following:

- Electrification of the rail line
- Installation of additional tracks
- Upgrades to existing tracks
- Facilitate long-haul connections to North and West Station
- Construction of a new station in Kendall Square

Assuming these constraints could be overcome, *Rail Vision* **forecasted significant shuttle ridership demand along the corridor**. *Rail Vision's* Alternative 5 projected 3,100 daily trips along the Grand Junction shuttle, while Alternative 6 estimated 4,500 trips each day. It should be noted that a portion of the increase in projected ridership for Alternative 6 (compared to Alternative 5) was due to use of a North-South Rail Link and a corresponding fare structure.

1.2.2. Grand Junction Improvement Options Study (Harvard University, 2010)

Noting the robust history of planning studies along the corridor, the Grand Junction Improvement Options Study, developed for Harvard University, explored the current physical and operational considerations along the Grand Junction to determine which previously proposed alternatives were mutually exclusive or complementary. The report considered conditions and **constraints along the project corridor between Sullivan Square and former Beacon Park Yard**.

- The **configuration of the tracks over the Charles River and Storrow Drive bridges limits operation to a single track** and the columns supporting the existing I-90 viaduct are located in such a manner that limits modification to the Grand Junction tracks.
- The segment between Sullivan Square and the Fitchburg Commuter Rail Line is a multiple track segment; however, its configuration is constrained due to the presence of the I-93 viaduct, Sullivan Square MBTA Orange Line station, and other MBTA Commuter Rail tracks which provide access to the Commuter Rail Maintenance Facility.

- **At the junction with the Fitchburg Line, the current alignment only permits one track**. From the Fitchburg Line to Main Street, there are multiple right-of-way (ROW) encroachments which may complicate double tracking.
- The MIT Brain and Cognitive Sciences Building, though not constructed at the time of the study, was anticipated to present a similar constraint.

The report noted five potential future uses of the Grand Junction corridor, including continuation of the existing use (i.e., limited Amtrak, freight, and non-revenue commuter rail service), a multi-use path, a busway via the Urban Ring concept, and two rail transit alternatives – one with FRA-compliant DMU service between North Station and West Station and another that routed the Worcester Commuter Rail Line directly into North Station. Key constraints posed by each of these concepts in the Harvard study are outlined below.

1. Multi-use Path – Construction could limit the ability to double-track significant portions of the corridor or to operate a BRT service.
    a. Pedestrian bridge over the Charles River has independent utility and could be constructed under any alternative.
2. Urban Ring Busway – "Locally Preferred Alternative" included use of the existing Charles River/Storrow Drive bridges.
    a. The corridor is particularly constrained under the I-90 viaduct, due to CSX's curve radius requirements, which forbid curves tighter than the existing curve, an approximate 500-foot radius.
    b. Either physical or temporal separation would be needed for the operation of light rail along the rail corridor to comply with FRA requirements.
    c. Unless freight rail operations to Chelsea were to be eliminated, or the I-90 viaduct was to be removed or redesigned, BRT was unlikely to be feasible.

Due to the geometric constraints under the I-90 viaduct, a DMU rail service and BRT Urban Ring service were found to be incongruent. A Framingham/Worcester Line service originating from North Station would benefit from double-tracking, but due to anticipated limited service frequencies (i.e., 20-minute headways or greater), a second track would not be a requirement.

1.2.3. Grand Junction Branch Line Study (MIT, 2012)

This 2012 study, conducted by MIT, responded to MassDOT's proposal to divert some Framingham/Worcester Line service to North Station in order to alleviate some congestion at South Station. The report explored constraints on the rail service, potential noise and vibration impacts that could result from a new service, and trade-offs associated with potential station locations.

Like other studies, this study noted the lack of direct connections between the Grand Junction and the Worcester and Fitchburg Lines. Notably, the report concluded that **the curve into the Beacon Park Yard and the curve across the Fitchburg Line are "hard curves", unable to be flattened due to geometric and physical constraints**. Construction of **double-track segments or new station stops would severely limit MIT's existing access road along the ROW**, making it such that most of MIT's construction and maintenance activities would be within fouling distance of the tracks. Additionally, because the existing Grand Junction corridor is "dark" territory (i.e., no rail signal infrastructure), **signals would need to be installed and grade crossings would need to be upgraded**.

The report also focused extensively on the potential impacts that any noise and vibration resulting from a new transit service might present to MIT's campus, which includes nearby sensitive assets and research labs. **Based on a low-speed, low-frequency alternative, the report concluded that there could be moderate to severe levels of impact for noise-sensitive receptors** located along the Grand Junction corridor. However, given baseline ambient noise and vibration levels, and the fact that multiple daily trains were operating along the Grand Junction at the time of publication, the study concluded that it would be unlikely that these potential impacts would significantly detract from campus activities.

Six potential station locations were proposed, including four capable of accommodating full-length Commuter Rail trains and two locations that would only allow for shorter trainsets (e.g., DMUs). Table 4 shows benefits and disadvantages associated with each potential station location based on the trainset capacity that would be offered.

1.2.4. Grand Junction Transportation Feasibility Study (CTPS / MassDOT, 2012)

Conducted to evaluate the feasibility, benefits, and impacts of adding Framingham/Worcester Line Commuter Rail service originating and terminating at North Station via the Grand Junction, this 2012 report, produced by the Central Transportation Planning Staff (CTPS) for MassDOT, provided a detailed analysis of existing conditions and potential service alternatives along the Grand Junction corridor. The report utilized data from the MBTA's 2008-2009 on-board passenger survey and CTPS-collected traffic, pedestrian, and bike counts to evaluate potential ridership demand and model transportation impacts for all modes along the corridor, including travel conditions at the six vehicular grade crossings and two pedestrian grade crossings. The report noted **substantial existing daily vehicular, pedestrian, and cyclist traffic moving through the Massachusetts Avenue and Broadway grade crossings, as well as significant daily bus ridership** on eight major bus routes.

CTPS modeled **ridership projections based on an increase in daily service on the Framingham/Worcester Line from 21 trains in the 2010 base year to 30 trains by 2035**. Operational line improvements allowed all trains on the Line to terminate at Worcester. A possible urban ring circumferential transit system (discussed later in this section) was not included in this analysis, as the Urban Ring project had been suspended. A mixed-use path along the Grand Junction corridor was also not included in the analysis but was explicitly not precluded by possible commuter rail service.

With the expansion of Framingham/Worcester Line service and the introduction of Commuter Rail service on the Grand Junction corridor, the report **projected that Framingham/Worcester Line ridership would grow by 34.3 percent between 2010 and 2035. Trips between Worcester and North Station would save between 2 and 9 minutes while those between Worcester and Kendall Square would save between 24 and 26 minutes.**

Table 4. Potential Platform Locations Assessed within the GJ Branch Line Study (MIT, 2012)

Mode Accommodated by Platform	Approximate Platform Location	Advantages	Disadvantages
Commuter Rail (Nine-Car)	West of Massachusetts Avenue	• Provide bus and campus connections • Ability for trains to pass each other (double-track location)	• Situated far from Kendall Red Line connections • Overpass needed to access the platforms (in certain configurations) • Limit access to the back of some MIT buildings
Commuter Rail (Nine-Car)	East of Massachusetts Avenue	• Closer to Kendall Square • Provide similar bus and campus connections	• Would require relocating an existing pedestrian crossing • Would also limit access to the back of some MIT buildings
Commuter Rail	Between Binney St & Broadway	• Access via existing pedestrian facilities • Close to Kendall Square • Provide campus access and bus connections	• Platform would only accommodate seven cars • Far away from the main portion of MIT's campus
Commuter Rail (Nine-Car)	North of Binney Street	• Close to Kendall Square	• Most of MIT's campus would lie outside its catchment area • Lacks direct bus connections • Noise and vibration impact to surrounding community
Diesel Multiple Unit (DMU)	Main Street (Beneath MIT Building 46)	• Closest station location to Kendall Square • Serve most of MIT's campus, aside from western portion	• Adjacent buildings might be affected, including labs at Brain & Cognitive Sciences • Not able to accommodate full-length CR trainsets
Diesel Multiple Unit (DMU)	Main Street & Broadway	• Close to Kendall Square • Serve most of MIT campus • Allow for direct bus connections	• Not able to accommodate full-length CR trainsets

The report explored **eight possible service alternatives** along the Grand Junction corridor. Each alternative uniquely combined three variables, as outlined below.

1. Operating speed (15 or 30 MPH)
2. Service frequency (6 or 12 trains per day)
3. Presence of a station stop near Kendall Square (Yes or No).

Each scenario assumed no freight conflicts, direct-track connections onto the Fitchburg Route Main Line, automatic protection devices at all grade crossings, improvements to the Beacon Park Yard (site of future West Station) to connect to the main track of the Framingham/Worcester Line, but no other substantial changes to the Grand Junction ROW (i.e., **no additional double-track**).

Ultimately, these eight scenarios were collapsed into two alternatives: one having the least transit demand and lowest impact on bikes, pedestrians, and vehicular traffic, and another having the greatest transit demand while presenting the greatest impacts to non-transit users. The lower bound scenario traveled at lower speeds but operated less frequently and without a station stop near Kendall Square. The upper bound scenario traveled more frequently, at higher speeds, and with a station stop near Kendall Square.

The lower bound and upper bound scenarios both produced more daily boardings than the No-Build case: 300 and 600, respectively. Most of the new trips were auto diversions, while other new boardings shifted from the Fitchburg Line, private bus service, or other transit modes. Many of these trips were ultimately bound for the Financial District, Seaport District, and Longwood Medical Area. These **auto diversions, even assuming full diesel Commuter Rail operations on the Grand Junction, resulted in a reduction of airborne pollutants and emissions**.

The report found that **non-transit users would experience between 63 seconds (lower bound) and 89 seconds (upper bound with a station stop), on average, of gate-down time due to rail service on the Grand Junction. This delay would occur once or twice per hour, depending on service frequency.** At the time of the report's publication, the intersections near Grand Junction grade crossings all operated at a traffic level of service (LOS) of a C or better. Based on 2035 projected traffic volumes, **it would require two to three signal cycles after a train crossing to process 95th percentile queues. This translates to between one and four minutes of delay for cars, trucks, and buses depending on the crossing and direction of travel.**

Overall, the report estimated that the lower bound service alternative would cost approximately $21 million, while the upper bound alternative would cost approximately $30 million, with the major difference being the approximate cost of building a station at Kendall Square ($7.5 million). The report concluded by noting that, based on its findings, **MassDOT determined that it would pursue an expansion of South Station instead of introducing Framingham/Worcester Line service to the Grand Junction.**

1.2.5. Grand Junction Transit Expansion (MIT MS Engineering Studio, 2012)

This 2012 MIT Civil and Environmental Engineering thesis developed models for service schedules, ridership demand, and marginal cost/revenue for Commuter Rail service along the Grand Junction and expanded upon the CTPS study by **exploring the benefits of DMUs compared to diesel locomotive service** along the corridor.

Like the CTPS report, this analysis also assumed that the track configuration remained the same along the Grand Junction, with a new station constructed near Kendall Square. Other assumptions included signal, rail, track bed, and safety improvements along the corridor, as well as seamless interlocking connections to the Framingham/Worcester Line and Fitchburg Line. Notably, a second Grand Junction station stop, near the Beacon Park Yard (now site of future West Station) and Boston University was also included in the alternatives.

The report initially considered six alternatives: traditional push-pull diesel commuter rail service, compliant DMUs, non-compliant DMUs, light rail, bus rapid transit, and depressing the corridor into a rail tunnel. Electrification (light rail) and tunneling were ruled out due to substantial capital costs. Non-compliant DMUs were ruled out due to the need for temporal separation, resulting in complicated scheduling. BRT was ruled out because it could be achieved independently of the Grand Junction ROW and would not relieve commuter rail capacity constraints. The three alternatives listed below were advanced for consideration:

1. Traditional Commuter Rail between Worcester and North Station
2. FRA-Compliant DMU service between Worcester and North Station
3. FRA-Compliant DMU service between Auburndale and North Station

Assuming the **MBTA's $7.5 million-dollar (at the time) typical station construction estimate**, the report estimated the cost of building DMU stations at $6.5 million due to the shorter platform. However, due to necessary environmental remediation, a station near Boston University (in lieu of West Station, which was not considered within that report) would cost $12 million. Total vehicle costs would range between $50-$116 million for DMUs or between $132-$199 million for traditional commuter rail vehicles.

1.2.6. Grand Junction Preliminary Operations Plan for Urban Rail (2014, Rachel Burckardt)

The perceived necessity to double-track the entire Grand Junction in order to deliver a high-quality rail service presents a challenge with the narrow ROW at some points along the corridor. This report **explored the feasibility of 15, 20, and 30-minute headways for passenger rail service along the Grand Junction without double-tracking** the entire line.

Two new tracks at North Station on an unused existing platform would provide boarding, alighting, and layover space. The service would utilize the existing two-track Fitchburg Line from Tower A and make a two-track connection into the Grand Junction. The service would **operate on a single track between Medford Street and Massachusetts Avenue**, including at a station stop at Broadway/Kendall Square. **South of Massachusetts Avenue, the service would again be double-tracked, before returning to a single track to cross the Charles River** to interface with the Framingham/Worcester Line. Along the Framingham/Worcester Line, the service would operate on two tracks to and from West Station.

Assuming this alignment, where passing could only occur on the double-tracked segments, 30-minute headways could be operated with two DMU train sets. 20-minute headways could be operated with three DMU train sets, and 15-minute headways could be operated with four DMU train sets. **For service occurring more than twice hourly, two dedicated platforms would be needed at North and West Station as layover facilities**. 15-minute headways would require four DMU train sets while 20-minute headways would necessitate three DMU train sets. As noted elsewhere, connections to North and West Station along the Fitchburg and Worcester Commuter Rail Lines remain constrained.

1.2.7. West Station Study (MAPC, 2022)

This 2022 report, authored by MAPC with input from CTPS and staff from the City of Boston and City of Cambridge, provided a **roadmap to mitigating the planned rapid growth of Allston Landing, the home of the future West Station**. The report estimates that the West Station area will see 22,000 trips every morning in a 2040 build case, a **growth of over 8,000 daily trips relative to pre-pandemic levels** (13,700 trips). If transit remains limited and parking abundant, an estimated 58% of those trips would be by car, contributing to congestion, crashes, pollution, and heat islands, while only 17% would occur via transit or 25% by an active mode.

This analysis studied several infrastructure-service-policy scenarios to evaluate their impact on transportation conditions. These include the implementation of the MBTA's *Rail Vision* (Alternatives 3, 4, 5, or 6)[1], three BRT corridors with 9-minute headways between West Station and Harvard Square, Kendall Square and the Longwood Medical Area, expanded cycling and pedestrian connections (beyond those previously outlined in the Allston Multimodal Project), and two parking rates (free or $18 per day).

To facilitate the Grand Junction Shuttle Service contemplated within *Rail Vision*, this study's station design for West Station included two platforms that would be used for a future Grand Junction service. The report also noted a bicycle and pedestrian connection along the rail corridor extending from Allston across the Charles River to Kendall Square.

Based on modeled travel mode, implementing BRT with connections to West Station would improve transit ridership mode share by between 1.7 and 3.2 percent while decreasing auto mode share by between 2.1 and 3.8 percent. **Implementing *Rail Vision* scenarios was projected to improve transit mode share by between 6.5 and 8.1 percent and decrease auto mode share by between 11.0 and 12.9 percent**. *Rail Vision* Alternative 6, which had mostly 15-minute systemwide frequencies and a Grand Junction shuttle, had the greatest mode shift away from cars toward transit. However, the report **found only a small but net positive ridership impact for a once every 15 minutes Grand Junction shuttle from West Station to Kendall Square and North Station (Alternative 6)** but noted limitations in exploring other service alternatives along the Grand Junction corridor.

Based on the model results, the report outlined the key takeaways listed below.

- Need for rapid bus service to facilitate easy neighborhood connections that cannot be addressed via Commuter Rail
- Need for high frequency rail service to reduce greenhouse gas emissions and vehicle miles traveled
- Challenge faced by transit when competing with abundant and cheap parking
- Need for a comprehensive parking policy for the region

[1] Each *Rail Vision* alternative, except Alternative 4, includes shuttle service on the Grand Junction.

- Need to expand walking and biking connections
- Desire to encourage a land-use framework that allows for Allston Landing to function as a live-work-play neighborhood

1.3. BRT Planning, Feasibility, and Operations

1.3.1. Urban Ring Project (MassDOT, 2010)

The 2008 Draft Environmental Impact Statement (DEIS) and subsequent Revised Draft Environmental Impact Report (RDEIR) reflect the most comprehensive analyses available for the Urban Ring Phase 2 project. The project was designed to improve transit access, mobility, capacity, reduce crowding in the central subway, and support smart growth and transit-oriented development by creating dedicated ROW to facilitate Bus Rapid Transit (BRT) service.

The Locally Preferred Alternative (LPA) included dedicated roadway both on surface roads and in a tunnel through the Fenway/Longwood Medical Area to facilitate high frequency service supplied by high-capacity buses serving transit stations, aided by advanced communication to limit delay at signals and offer real-time information to riders. The service was planned to travel along five overlapping routes:

- BRT 1: Airport Blue Line Station to Kendall Square
- BRT 2: Logan Airport West Garage to Wellington Station
- BRT 5: Sullivan Square to Ruggles Station
- BRT 6: Harvard Square to JFK/UMass Station
- BRT 7: Yawkey [Lansdowne] to Mystic Falls (Everett Avenue)

BRT Route 5 would **utilize portions of the Grand Junction ROW as a two-way busway to cross the Charles River, but otherwise travel parallel to the Grand Junction corridor to connect into Kendall Square via Albany Street.** The service would access University Road via an underpass on Boston University property to continue south.

BRT service connecting to Allston was also a new proposal at the time of the DEIS's publication. This alignment traveled from Harvard Square through Allston, passed beneath the Massachusetts Turnpike and through the Beacon Park Yard, before eventually aligning with BRT Route 5 near the BU Bridge.

In addition to offering a one-stroke solution to a booming region's transit and development woes, the Urban Ring Phase 2 project was also designed with (and carried capital costs associated with) improvements for shared-use path facilities. The aforementioned route patterns were intended to accommodate a Rail-with-Trail project on the Grand Junction through Cambridge and **the proposed reconstruction of the Grand Junction Railroad Bridge would build a shared-use path linking both sides of the Charles River**. The report also noted a variety of environmental improvements, such as reduced air pollution and reduced energy usage, largely driven by a projected decrease of 41,500 daily auto trips.

The Urban Ring Phase 2 project was **ultimately suspended due to the significant cost of implementation**, with capital estimates at $2.4 billion (2007 constant dollars) and an annual operation and maintenance cost of $35 million. Although the **portion of the project connecting East Cambridge and Ruggles Station was projected to carry 116,500 daily riders**, it accounted for nearly $1.9 billion, nearly 80 percent, of the overall project cost.

1.3.2. Go Boston 2030 (City of Boston, 2017)

Go Boston 2030, the City of Boston's transportation master plan, includes several long-term projects which would impact the feasibility of transit service on the Grand Junction corridor. Most notably, *Go Boston 2030* calls for **rapid bus service connecting West Station, Longwood Medical Area, Kendall Square, and Harvard Square**. This route would utilize existing roadways, as well as a dedicated ROW along the Grand Junction rail corridor. This high-frequency, limited-stop service **would connect to the Green Line at Kenmore Square, Commuter Rail service along the I-90 corridor at the future West Station, and the Red Line and MBTA Route 1 bus along Massachusetts Avenue** in Cambridge.

South of the Charles River, connections for this proposed BRT route are facilitated through a West Station Mobility Hub, which would provide local bus connections, Commuter Rail service via the Framingham/Worcester Line, and new pedestrian connections with the surrounding communities. *Go Boston 2030* proposes Commuter Rail service to be enhanced significantly along the I-90 corridor through Boston into Newton, approaching subway-like service frequencies.

While a new rapid bus route along the Grand Junction would need to fit within the existing rail ROW, *Go Boston 2030* **also notes the City of Boston's support for the Grand Junction multi-use path, which would connect Commonwealth Avenue in Allston to the Community Path in Somerville**. To achieve all these aims, *Go Boston 2030* **underscores the need for coordination with surrounding communities on regional projects**, like those noted above.

1.3.3. Better Rapid Transit for Greater Boston (ITDP & Barr Foundation, 2015)

In Spring of 2015, in partnership with the Institute for Transportation & Development Policy (ITDP) and the Barr Foundation, the Greater Boston BRT Study Group released a report identifying opportunity corridors for gold-standard BRT throughout greater Boston. After initially identifying 12 possible corridors, the report ultimately explored five high potential corridors. **While the report did not propose any BRT routes that utilize the Grand Junction corridor, two of the 12 have the potential to interface** with the Grand Junction corridor.

A BRT route between Sullivan Square and Ruggles would connect these life sciences hubs and serve rapid development happening in Somerville and Kendall Square. The report noted two possible ways for this route to cross the Charles River: the Massachusetts Avenue (Harvard) Bridge or BU Bridge. The **Grand Junction railroad bridge was not considered as an option**. The connection between Sullivan Square and Lechmere was noted as challenging for creating a dedicated ROW for a bus, although the on-going Silver Line Extension Alternatives 4, 5, and 7 propose routing a new service along this alignment via dedicated bus lanes.

A BRT route between Harvard Square and Nubian Square would also connect academic and life-science clusters. This route, traveling from Harvard Square, through Allston along Commonwealth Avenue, to Fenway and through the Longwood Medical Area to Nubian Square, **closely mirrors the BRT route**

proposed in *Go Boston 2030*, which later proposed utilizing the Grand Junction corridor to connect Longwood to Harvard and Kendall Squares.

1.3.4. Silver Line Extension Alternatives Analysis (MassDOT, 2024)

The Silver Line Extension (SLX) project investigated different alignments and service frequency options to enable high-quality transit connections between the Revere Beach Parkway corridor (Chelsea, Everett, Medford) and the major activity centers of Kendall Square and downtown Boston. Seven preliminary alternatives , more than half of which would connect Everett to either downtown Boston or Kendall Square via a new Silver Line service (SL6), were studied. The other three alternatives involved extending the existing SL3 from its Chelsea terminus to an existing Orange Line station (either Sullivan Square, Wellington, or Malden Center) via Everett, with some service operating in bus lanes. Although the chosen locally preferred alternative (LPA) extends the Existing SL3 from the Chelsea terminal to the existing Sullivan Square Orange Line Station, it is worth mentioning that three discrete alternatives were examined linking Everett and Kendall Square, which would provide greater connectivity to regional destinations and increase demand for multi-modal connections along the Grand Junction corridor.

1.4. Multi-Use Path & Future Transit Interface

1.4.1. Grand Junction Multi-Use Path (Cambridge Bicycle Committee, 2001)

This 2001 report prepared by the City of Cambridge's Bicycle Committee recommended an urban multi-use path along the Grand Junction corridor. Alongside a new multi-use path, the study intended to maintain existing rail uses and also accommodate the proposed Urban Ring project or a possible linear park (as proposed by Cambridge's Green Ribbon Open Space Committee). Such a path would provide connections between the Charles River basin and North Point (now known as "Cambridge Crossing") and serve as both a major commuter and recreational route.

The report noted that **one bay of the Grand Junction railroad bridge remains unused**, as well as **significant width under the Memorial Drive underpass in the absence of a second track, providing an opportunity for a potential path**. The corridor becomes more constrained with railway tracks near Ft. Washington Park, making a path in this segment more challenging to implement. The report noted a variety of pinch-points or adjacent land-uses north of Massachusetts Avenue that might complicate the introduction of a multi-use path. The report also concluded that it is unlikely that any additional tracks or sidings would be needed between the Charles River and Somerville to maintain existing railroad operations.

A multi-use path along the Grand Junction corridor also would expand the regional path network, connecting Boston and the Charles River paths, and via short, proposed connections, the Emerald Necklace, the Somerville Community Path, and the Minuteman Path. With these connections, the path would make commuting by bike or on foot a more attractive regional option, potentially mitigating some commuter traffic.

The proposal called for a 12-foot-wide path along the Grand Junction ROW, in accordance with AASHTO guidelines. The proposal also **recommends three feet of horizontal clearance (buffer) from the fence separating the path and the railroad tracks** and between the path and any existing buildings or walls. This creates a minimum cross-section of 18 feet. The design speed of the path is suggested to be 20 MPH. **With a single freight track and a path, a minimum typical cross-section of 35 feet was envisioned**. With bi-directional light rail, one freight track, and the path, the minimum typical needed cross-section increased to 68 feet.

1.4.2. Grand Junction Rail + Trail (City of Cambridge, 2006)

This report directly acknowledged and built upon the foundation of the 2001 report, while analyzing in further detail the possibility of a multi-use path along the Grand Junction corridor alongside existing freight operations and the Urban Ring. The report **investigated two alternative alignments of the Grand Junction path, one utilizing the entire remaining ROW outside of rail operations and another accommodating one-way BRT alongside existing freight**.

In alignment with the Bike Committee report, this analysis also recommended a 12-foot-wide path with shoulders of two to three feet, along with three feet of side-to-side clearance from buildings or other vertical obstructions, and a typical setback of 20 feet from the centerline of the railroad tracks to the edge of the shared-use path.

In the Rail-with-Trail (only) alternative, some segments between the Charles River and Ft. Washington Park would have limited separation between the shared-use path and tracks. In addition, some MIT properties would be impacted. **For the Rail-with-Trail + One-Way BRT alternative, creating safe at-grade crossings across both the Grand Junction rail corridor and BRT transitway would create heightened conflicts for shared-use path users**.

Similar challenges exist between Ft. Washington Park and Massachusetts Avenue, with the most significant being establishing a safe at-grade crossing for all corridor users at Massachusetts Avenue.

The corridor redesign would need to work in concert with **MIT, the sole adjacent landowner between Massachusetts Avenue and Main Street**. Since the Urban Ring proposal did not propose BRT in the ROW between Main Street and Binney Street, less conflict was anticipated along that stretch of the corridor, but a **safe at-grade crossing of Main Street was a key constraint that remained to be resolved**.

Several parcels between Binney Street and Cambridge Street constrain the corridor, which could require acquiring property or ROW rights, redesigning parking aisles, augmenting building additions, or encroaching on alley/drives. **Connections beyond Gore Street, including connections to the Somerville Community Path, were not explored in the study**.

The report concluded that a Rail-with-Trail (only) alternative would be the easier scenario to implement, with the trail situated on the northwest side of the Grand Junction ROW. **Though judged to be feasible, implementing the Rail-with-Trail + One-Way BRT alternative would be more challenging and require removal of some rail sidings**. The report calculated that a Rail-with-Trail (only) alternative would cost approximately $7.9 million, compared to a Rail-with-Trail + One-Way BRT cost of approximately $15.7 million.

1.4.3. MIT Property Feasibility Study (MIT, 2014)

Unique compared to the other studies, the landowner-focused MIT Property Study explored the impact of the proposed multi-use path on MIT's adjacent campus, buildings, and assets. **MIT utilizes a portion of the Grand Junction, under their ownership between Pacific and Main Street, as a service road** (approximately eight to 12 daily vehicular movements). **Portions of the corridor are also frequently closed for construction, maintenance, and repair to adjacent buildings**. There is a wide variety of physical features that line the corridor (e.g., buildings, fences, gas tanks, loading docks, access doors, dumpsters, and parking spaces). Given the nature of their utility, some of these assets may be particularly sensitive to disturbances emanating from adjacent land uses (e.g., rail car horns).

The report noted that transit service, especially a second track along the corridor, could result in inferior access to MIT buildings and the elimination of the service road. Loss of the service road would introduce conflicts with users of the multi-use path.

The report's preferred alternative retains the service road, path, and existing rail tracks, except near Waverly Street. In terms of dimensions, the report concluded that at least 23 feet of ROW would be needed for shared use path and service road separation, with anything less effectively functioning as a low traffic shared street. Due to a narrow ROW near Waverly Street, path and service road separation would not be possible. To resolve this constraint, the report suggested diverting the path onto Waverly Street, with improvements to the roadway design.

2. Existing Conditions

This chapter documents the current state of the Grand Junction corridor based on a review of transportation planning traffic and development data. Key issues and opportunities within each topic area are summarized on the next page.

2.1. Key Takeaways

This section summarizes the Existing Conditions memo by presenting issues and opportunities for a future transit option along the corridor within the City of Cambridge, as revealed through a review of transportation and development information. To provide a regional context, Figure 1 on the next page presents an overlay of existing transit services near the Grand Junction corridor, alongside potential key drivers of a future transit offering along the corridor (e.g., long-term capital investments by other parties, an incoming utility courtesy of Eversource). Table 5 on page 2-3 offers a topic-by-topic summary of key insights from the review, which are classified as either an issue, opportunity, or topic worthy of further consideration going forward.

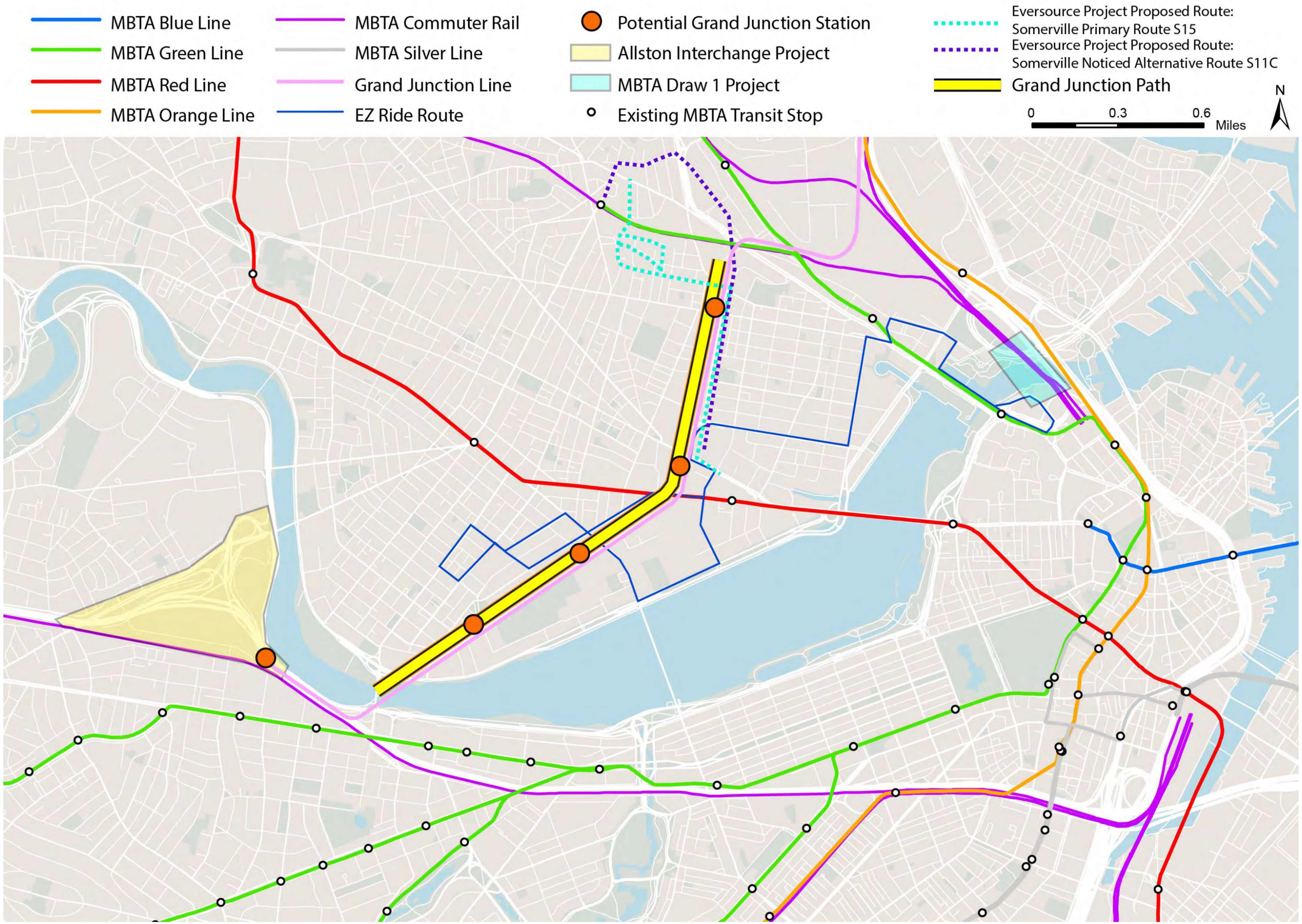


Figure 1. The Grand Junction Traverses Myriad Transit Modes and Offerings (e.g., MBTA Rapid Transit, Commuter Rail and Bus, and the EZRide Shuttle), But is Increasingly Constrained

Table 5. Opportunities, Issues, and Other Topics Worthy of Further Consideration

Topic Area	Opportunities	Issues	Items Worthy of Further Consideration
External Projects that May Influence the Feasibility and/or Extent of Transit Options	• MBTA North Station Draw One Bridge Replacement will increase over-the-river train capacity by 50 percent, deliver a third span, and create an additional platform • Once completed, West Station will offer a logical southern terminus, with four tracks (two for Worcester, two for Grand Junction) and three platforms tucked within a mixed-use campus development projected to add over 6,100 jobs and 4,700 residents by 2040	• Timing for the completion of Draw One Bridge Replacement is several years in the future and not yet advertised by the MBTA • Construction of MassDOT's I-90 Allston Multimodal project will create a two-year construction period during which rail traffic over the Charles River will be impeded • Timing for build-out of West Station is relatively uncertain (2035-2045) and likely to follow completion of the grounding of I-90 in Allston	• Upcoming Multi-use Path will introduce a greater potential for non-motorized conflicts at three locations (Main, Binney and Cambridge Streets) where the path transitions to the other side of the rail right-of-way (ROW) • Eversource's Greater Cambridge Energy project will create a new utility line along the corridor from Medford / Gore Street to Broadway, with an east-to-west transition across the rails near Cambridge Street
Track Configuration and Rail Operations	• Double-track is present at southern end, namely the "long siding" from Massachusetts Avenue to Memorial Drive • The rail ROW once accommodated multiple tracks • The Grand Junction Path is being designed in a manner to allow a double-track railroad throughout Cambridge • Existing bypass track adjacent to I-90 leads from Beacon Park Yard to Worcester Line's Boston Landing, offering a potential interim solution absent the build-out of West Station	• Primarily a single-track corridor, with double track between Massachusetts Avenue and Memorial Drive • No direct Inbound connection to the MBTA Commuter Rail's Worcester Line; currently a reverse move would be required • Diamond crossing at Fitchburg Line limits connections into North Station (only an Outbound interface is available)	• Except for segments owned by MIT, MassDOT owns the corridor and maintains operating rights over the entirety of the corridor • CSX holds legacy freight rights of access • MBTA and Amtrak use the southerly single-track bridge over the river to transfer equipment between different lines and maintenance bases
At-Grade & Bridge Crossings		• Nine grade crossings (six streets and three walkways) • Single-track on the once double-track bridge over the Charles River results from a tight curve on the Allston side • There are no gates at four of the grade crossings, including two streets with the highest volumes of pedestrian crossings	• Adding gates to the four crossings that lack them • Review of the design for the new Grand Junction connection in Allston to determine if it can accommodate a double-track connection
Longitudinal Utilities			• MIT maintains various infrastructure on either side of the rail ROW between Pacific and Main Streets, with limited occupations east of Mass. Avenue • Existing underground telecommunications line runs along one side of the corridor, with transition at Mass. Avenue • Existing steam pipe runs alongside the corridor between Broadway and Main Street • City's stormwater infrastructure lies east of the rail ROW between Broadway and Binney Street
Demographics	• Over 76,500 people commuted to job sites within a half-mile of the corridor in 2019, with nearly two-thirds coming from homes located beyond Cambridge, Somerville and Boston • From 2016 to 2040, forecasts anticipate an additional 71,800 jobs (+14.9%) and 48,400 residents (+36.1%) within a half-mile of the corridor (running from North Station to West Station) • High population and employment growth anticipated at both ends (east Somerville and Allston), with most areas within a half-mile growing by at least 10% through 2040		
Adjacent Land Uses	• South of Binney Street, the rail ROW is bordered by world-class institutional/research, commercial and light industrial uses	• Access to such uses in order to facilitate the exchange of raw materials (e.g., trucks deliver gas or refrigerated liquid fuels to labs) is afforded by vehicular service aisles that run parallel and adjacent to	

Topic Area	Opportunities	Issues	Items Worthy of Further Consideration
		the rail ROW, which may hinder the potential use of these areas for transit-related activities like pedestrian circulation to future platforms	
Environmental	• Majority of study corridor has one or more Environmental Justice designations, with similar status continuing to the north and south	• According to the Massachusetts Coast Flod Risk Model[2], the low-lying area along the approach into North Station, which begins east of where the Green Line Extension diverges, shows a probability of inundation during a 100-year storm by 2050 (when accounting for sea level rise) as does the Fitchburg Line corridor to some extent.	• There are 12 open Underground Storage Tanks (USTs) within a quarter-mile of the Grand Junction, including 11 in Cambridge
Transit	• Adjacent to a host of public transit services, including core Rapid Transit (Red Line) and six MBTA bus routes, as well as EZRide shuttle • Bustling Kendall/MIT Red Line station (approximately 1,800 boardings per hour during the PM peak period) • Commuter Rail alignments to the south (Worcester Line, 15% of system pre-COVID) and north (Fitchburg Line, 7% of system pre-COVID) serve longer-distance trips ○ Lansdowne ranked third on its line for Outbound PM Peak boardings (approximately 325 boardings per hour) • Considerable bus activities via EZRide Shuttle, as well as the MBTA stops near Massachusetts Avenue (around 600 boardings) and Kendall Square (nearly 500 boardings)		• Avoiding duplication of existing transit services (e.g., EZRide shuttle)

Active Transportation	• Cambridge's PTDM data shows 15% of those commuting to Kendall use non-motorized modes, with a similar non-motorized mode share (12%) is also true for the broader eastern Cambridge region
	• BlueBike ridership data indicates there is existing demand both along the corridor and between the major termini at either end
		• City's Multi-use Path Study from 2019 included the following estimates of peak hour pedestrian crossings:
		  ○ Broadway – Approximately 450 / 300 during AM / PM
		  ○ Massachusetts Avenue – Approximately 325 / 360 in AM / PM
		  ○ Main Street – Approximately 135 / 125 during AM / PM
		  ○ Cambridge Street – 150 / 100 during AM / PM	

Vehicular Traffic		• PM Peak driver delays at intersections near at-grade crossings of Binney Street (LOS F) and Massachusetts Avenue (LOS E) • Peak hour volumes highest near Massachusetts Avenue (1,084), Cambridge Street (1,074), and Broadway (953)	
Emergency Response			• Delays near crossings at Massachusetts Avenue and Broadway are important given access to Boston hospitals • Cambridge Police Headquarters on 6th Street is east of the Grand Junction, with some responses requiring a crossing • Cambridge and Somerville Fire and EMS services, as well as private EMS services, are located proximate to the corridor and may also require crossing the tracks • MGH dispatches from Spaulding Hospital Cambridge, located one mile west along Cambridge Street
Parking	• Long-term potential to add parking in the developed Kendall Square area is declining and will only grow more constrained		

[2] Interactive map available from the Massachusetts Office of Coastal Zone Management at https://experience.arcgis.com/experience/23d861b79aed450eb8972013dd28579b/page/MA-Coast-Flood-Risk-Model/?views=2050-Flood-Depths---1%25

2.2. Grand Junction Track Configuration and Current Rail Operations

This section provides a description of the existing configuration of the Grand Junction rail line within the City of Cambridge, as well as the terminus areas located to the north and south in Somerville and Boston. Remnants of the corridor further north, which once reached the piers of East Boston, are still in operation in Somerville, Everett and Chelsea (Figure 2).

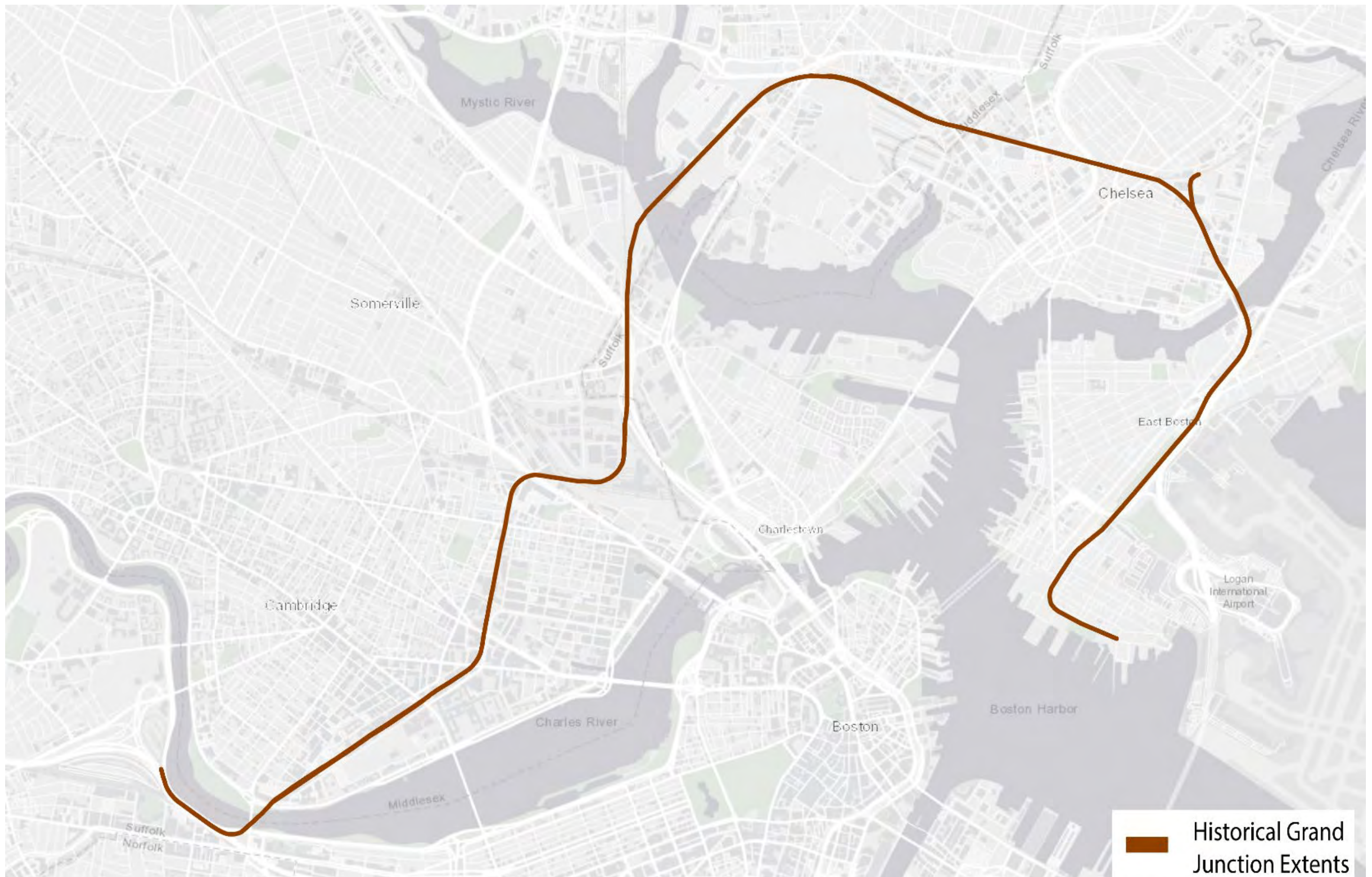


Figure 2. Historical Extents of the Grand Junction Railroad (Source: MassDOT Rail Inventory)

2.2.1. Ownership

Ownership of the rail corridor is divided between two parties: MassDOT, which holds the majority of the land, and MIT, which holds two segments. (Figure 3). In 2012, the Massachusetts Department of Transportation (MassDOT) purchased the line from its owner (Pan Am Railways). However, CSX still retains (but does not currently exercise) freight rights by virtue of purchasing Pan Am Railways in 2022. MassDOT maintains the right to operate over all segments. These operating rights extend to include the two legacy segments listed below, which were previously purchased by the MIT from the New York Central Railroad in the mid-1900s.

- A short segment adjacent to 640 Memorial Drive
- From behind 240 Albany Street (see figure below) to Broadway

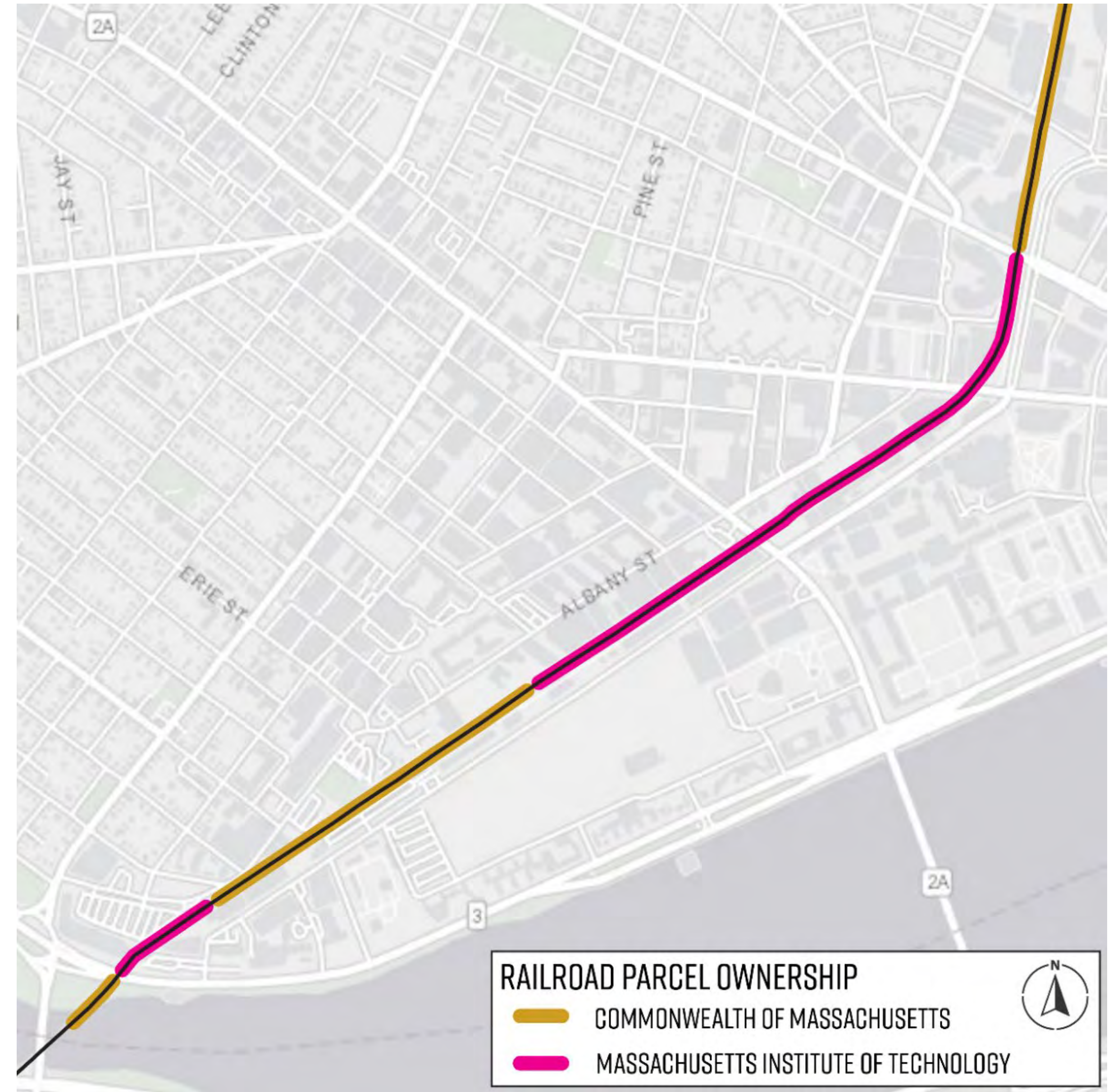


Figure 3. MIT Owns Two Select Segments of the Rail Corridor near the Southern End (Source: MassDOT Rail Inventory)

2.2.2. Track Configuration

Within the City of Cambridge, the Grand Junction rail corridor is primarily a single-track line, with one double-track section (known as the "long siding") situated at the southern end between Massachusetts Avenue and Memorial Drive. At one time, the Grand Junction right of way once accommodated multiple tracks. Figure 4 details the track configuration within Cambridge and at either end, including the presence of rail infrastructure (e.g., interlockings, overhead or undergrade bridges), key station platforms and vehicular at-grade crossings. The remainder of this section discusses the present conditions of infrastructure that is located near the study's primary termini – West Station to the south and North Station to the north – but outside of the City of Cambridge.

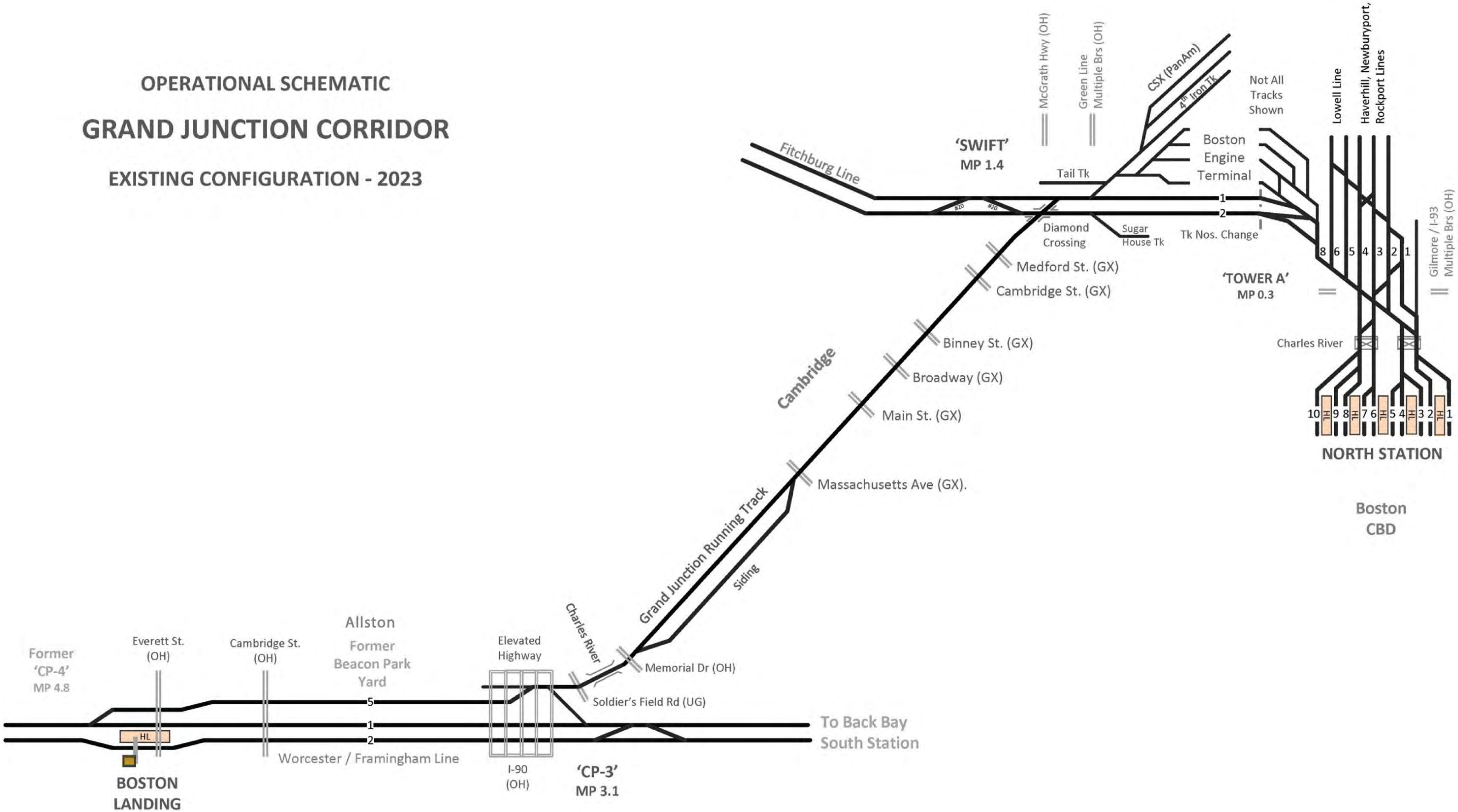


Figure 4. Operational Schematic of the Grand Junction Corridor (2023) (Source: WSP)

At the southern end, the Grand Junction narrows to one track as it passes beneath the Department of Conservation and Recreation (DCR)-owned Memorial Drive before crossing over the Charles River via a rail bridge. Only one of the bridge's two original tracks remains, with all train traffic using the tracks located on the eastern half of the structure. Heading southwest into Boston, the rail corridor crosses over DCR's Soldiers Field Road / Storrow Drive before touching down in Allston near the beginning of I-90's elevated viaduct section.

Driven by the river crossing and the need to maintain vertical clearance over/under adjacent highways, this area is characterized by considerable geometric, topographic, and infrastructure constraints that, when combined, complicate the provision of future direct Boston-bound connections from the Grand Junction to the Worcester Line (as illustrated in Figure 5). Given these issues, rail connections towards Back Bay and/or South Station would most prudently be facilitated by a reverse move, as opposed to a capital-intensive application of modern engineering.

As currently configured, the Grand Junction trackage does not directly interface with the Worcester Line until just west of the center-island platforms at Boston Landing near Everett Street (i.e., approximately one mile past the future West Station). After crossing the river and completing a 90-degree turn, the rail corridor briefly continues northwest beneath the I-90 viaduct before heading due west through the remnants of the former Beacon Park Yard, which is slated to house the future West Station in tandem with Harvard's Allston Landing development.

In this area, the Grand Junction runs parallel to, but does not intersect with, the two-track Worcester Line, and is situated between I-90 to the north and the Commuter Rail main line to the south. Continuing west from the former Beacon Park Yard and parallel to I-90, a bypass track located north of the Worcester main line leads towards Boston Landing (i.e., width for at least three tracks is already present between Boston Landing and West Station). Before meeting the Outbound CR track west of the Boston Landing platforms, the Grand Junction, as well as the Worcester Line, pass beneath three overhead structures (Cambridge Street, pedestrian bridge, and Everett Street).

At the northern end, the single-track Grand Junction exits Cambridge near Medford Street/Gore Street and begins curving eastward within the City of Somerville towards the McGrath Highway overhead bridge. The rail alignment links into the Outbound direction of the MBTA's Fitchburg Line via Track 1 and continues east along the CR corridor towards the Boston Engine Terminal (BET). A direct Inbound connection on the Fitchburg Line via the southerly Track 2 is inhibited by the existing diamond crossing. After passing under three overhead bridges (Green Line Extension) and the Somerville Community Path, the corridor reaches North Station via various interlockings and the two-span, four-track North Station Draw One bridge.

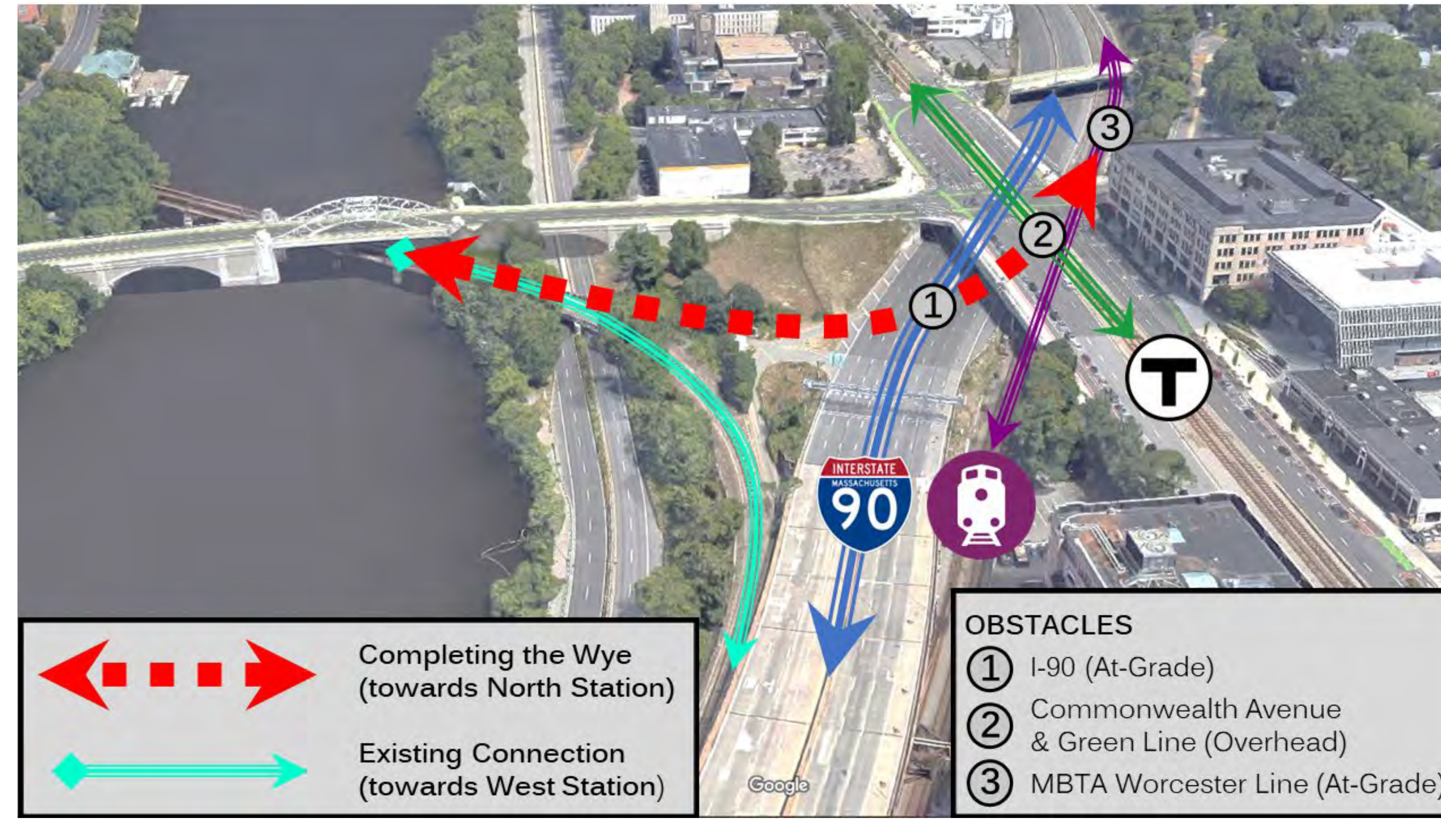


Figure 5. Formidable Obstacles to Direct Inbound Connections to Boston via the Grand Junction Bridge over the Charles River (Source: Google)

2.2.3. Current Rail Operations

The Grand Junction is currently used by passenger rail operators to transfer equipment between terminal station and maintenance bases, though CSX continues to reserve the right to move freight along the line. The principal maintenance facility for the MBTA is located near the northern edge of the Grand Junction corridor at the BET), as shown to the right of Figure 4. The MBTA uses the Grand Junction to transfer Commuter Rail equipment between its North Side and South Side operations (lines serving North Station and South Station, respectively). Similarly, Amtrak uses the Grand Junction to facilitate equipment moves for its *Downeaster* service that operates between North Station and Portland-Brunswick, Maine. The Grand Junction enables Amtrak to move this *Downeaster* equipment to its Southampton Street maintenance facility in Boston, which is located farther south of South Station on the opposite side of the Charles River.

2.3. At-Grade Crossings

There are six at-grade vehicular crossings, along with three additional non-motorized crossings concentrated in the southern half of the rail corridor (south of Main Street). In addition to flashing signals, all non-motorized crossings also include gates that serve to reduce incursions into the rail ROW during active train crossings. Owing to their proximity to adjacent signalized intersections, four of the six vehicular crossings provide flashing signals, with gates present only at the two northernmost vehicular crossings (Cambridge Street and Medford Street/Gore Street). Table 6 shows the number of non-rail travel features to be crossed, the type of grade protection equipment in place, and pedestrian volumes for the AM and

PM peak via the 2019 *Grand Junction Pathway Memo*. Data related to the number of vehicles operating near these at-grade crossings is provided within the Vehicular Traffic section.

Broadway and Massachusetts Avenue are, by far, the busiest crossings in terms of pedestrian movements over the rail corridor, with peak hour counts ranging from approximately 300 to 425 persons per hour (i.e., one non-vehicular conflict every eight to 12 seconds during the peak). These corridors also serve as major bike thoroughfares. However, these vehicular crossings, with nearby, high-volume, signalized intersections, do not currently include gate protection. While five of the nine crossings provide crossing protection in the form of flashing signals and gates, these fixtures tend to be present where pedestrian volumes are lightest (i.e., non-motorized crossings at Fort Washington and Pacific Street, as well as Cambridge Street).

Table 6. Physical and Operating Characteristics of At-Grade Crossings

Location	Sidewalks	Bike Lanes	Travel Lanes (Total)	Type of Crossing Protection	AM (PM) Peak Hour Pedestrian Volume +
Fort Washington	Crossing Available	Crossing Available	N/A	Flashing Signals & Gates	31 (15)
Pacific Street	Crossing Available	Crossing Available	N/A	Flashing Signals & Gates	82 (53)
Massachusetts Avenue	2	2	4	Flashing Signals Only	321 (364)
Mid-Block [MIT Bldg. 42 / Future Bldg. 45] 51-57 Vassar Street	Crossing Available	Crossing Available	N/A	Flashing Signals & Gates	--
Main Street	2	2	3	Flashing Signals Only	134 (125)
Broadway	2	2	4	Flashing Signals Only	432 (312)
Binney Street	2	0	3	Flashing Signals Only	40 (36)
Cambridge Street	2	2	2	Flashing Signals & Gates	151 (104)
Medford Street / Gore Street	2	2	2	Flashing Signals & Gates	--

+ - Pedestrian volumes were retrieved from the 2019 Grand Junction Pathway Memo

2.4. Bridge Crossings

In addition to the over-the-river bridges required to reach the termini at West Station and North Station, the Grand Junction passes beneath two vehicular bridges near the Cambridge city limits – Memorial Drive to the south and McGrath Highway to the north, in Somerville. Dimensions, condition ratings, and vehicular traffic information are provided in Table 7.

Table 7. Physical and Operating Characteristics of Vehicular Bridge Crossings (Source: USDOT FHWA)

Bridge ID	Carrying Roadway	Min. Vertical Underclearance	Min. Lateral Underclearance	Deck Condition	Superstructure Condition	Substructure Condition
C010114DJDOT NBI	Memorial Drive (47,200 AADT)	16.1 ft	21.0 ft	6 – Satisfactory	5 – Fair	5 – Fair
S170255E3DOT NBI	McGrath Highway (32,700 AADT)	20.9 ft	5.9 ft on left and right	5 – Fair	4 – Poor	4 – Poor

To the south, the Memorial Drive underpass historically permitted double-track segments, though only one track over the river remains, which is the result of a tight curve on the Allston side of the river. To the north, the presence of a McGrath Highway viaduct support column immediately west of the Grand Junction's merge presents an obstacle to be overcome in the potential development of a double-track segment leading towards North Station[3], as shown in Figure 6.

[3] The de-elevation of sections of McGrath Highway has been studied for the past several decades and was finally programmed in the MPO FFY 2024-2028 TIP. In early 2024, MassDOT and the city of Somerville announced that work to demolish the elevated section of McGrath Highway could begin by 2028. Although the Grand Junction is located south of the portion of the highway proposed to be "grounded" (between Broadway in Somerville and Rufo Road in Cambridge), the situation needs to be monitored for potential impacts as design moves forward; 25 percent design for the project is expected by the end of 2024. For more information, please consult MassDOT's 2013 report *Grounding McGrath: Determining the Future of the Route 28 Corridor.*

Figure 6. McGrath Highway Support Column Presents an Obstacle to Double-track Extension towards North Station (Source: Google)

2.5. Longitudinal Utilities

Along the entire Grand Junction corridor there are underground, longitudinal utilities. As part of the Grand Junction Multi-use Path Project, the majority of the corridor has undergone an extensive review of utilities within or adjacent to the rail ROW. For significant stretches of the corridor, a telecommunications line runs alongside the rail ROW. South of Massachusetts Avenue, the line is on the west side of the tracks. North of Massachusetts Avenue, the line switches to the east side of the tracks, where it continues west.

On the west side of the tracks between Pacific Street and Massachusetts Avenue, as well as on both sides of the tracks between Massachusetts Avenue and Main Street, the private owner (MIT) maintains water supply and return pipes, gas lines, electrical, and telecommunications infrastructure. Most of these utilities fall outside the main rail easement; however, there are some utilities that fall within the disused spur track easement located just east of Massachusetts Avenue.

The City of Cambridge maintains stormwater sewer infrastructure to the east side of the tracks between Broadway and Binney Street.

As noted above, upon its construction, Eversource's *Greater Cambridge Energy Project* will introduce a new longitudinal utility to the Grand Junction corridor. Although a final determination is expected in 2024, one of the alignments under consideration would run along the east side of the corridor from Medford Street/Gore Street to Cambridge Street before switching to the west side of the tracks from Cambridge Street to Broadway. A proposed alignment is displayed in Figure 1 at the beginning of this chapter.

2.6. External Projects that May Influence the Feasibility and/or Extent of Transit Options along the Grand Junction Corridor

2.6.1. MassDOT Allston Multimodal Project

This project will replace the deteriorating Massachusetts Turnpike/Interstate 90 (I-90) viaduct with an at-grade interchange in Boston's Allston neighborhood while also enhancing the multimodal transportation infrastructure in the area via a new layover facility for Massachusetts Bay Transportation Authority (MBTA) Commuter Rail, a new transit center (West Station), and improved track infrastructure. The project is also expected to straighten the highway, resulting in improvements to safety and regional mobility, and create new urban development opportunities (Allston Landing) and open space. According to the most recent Boston Region MPO Long-Range Transportation Plan, the Allston Landing development, situated immediately north of the proposed West Station and anchored by a new Boston-based campus of Harvard University, is projected to add 6,131 jobs and 4,704 residents between 2016 and 2040.

Whenever the Allston Multimodal project does break ground, there will eventually be a multi-year period during which all rail traffic over the Grand Junction Railroad on the Boston side of the Charles River will be significantly impeded by construction operations. Although a final project schedule has yet to be determined, MassDOT anticipates that intensive, multi-year construction project to begin within the next three to nine years.

The Grand Junction Railroad's southern terminus lies near the proposed West Station site. This new transit hub will include three platforms and four tracks, two of which will be dedicated for Worcester Line Commuter Rail (CR) service and two which will be utilized for Grand Junction rail service. However, utilizing the future West Station as the southern terminus for a new transit service along the study corridor is fundamentally contingent on the timing of the station's construction. In 2024, the project was awarded a $335.4 million from the U.S. Department of Transportation's "Reconnecting Communities and Neighborhoods Grant Program" (RCN). Based on the current project understanding, this study does not anticipate the opening of West Station until at least 2035, with ribbon-cutting potentially as late as 2045.

2.6.2. City of Cambridge Grand Junction Multi-use Path Study

The Grand Junction Multi-use Path is a proposed continuous, off-street, multi-use path running adjacent to the rail ROW on either side of the existing railroad tracks between the Boston University Bridge and Somerville. This path will connect many Cambridge neighborhoods, as well as link together the Massachusetts Institute of Technology (MIT) campus, business districts, and regional resources like the Charles River.

This study assumes that the Multi-use Path will be constructed and hence, its configuration, operation and maintenance needs must be considered within each study alternative. As shown in Figure 7, one segment was completed in 2016 by the CRA and a second segment is presently under construction by the City of Cambridge. The City of Cambridge has committed funding to the full design and construction of the Multi-use Path Project from Binney Street to the Somerville City Limits. MIT has committed funding to the design and construction of the remainder of the multi-use path on the portions of the ROW that it owns.

The path has been designed to accommodate the double-tracking of the Grand Junction Railroad throughout Cambridge. Recent plans indicate that non-motorized traffic along the Multi-use Path will shift from one side of the rail ROW to the other in the vicinity of the existing at-grade crossings at Main Street (shift from west to east), Binney Street (shift from east to west), and Cambridge Street (shift from west to east).

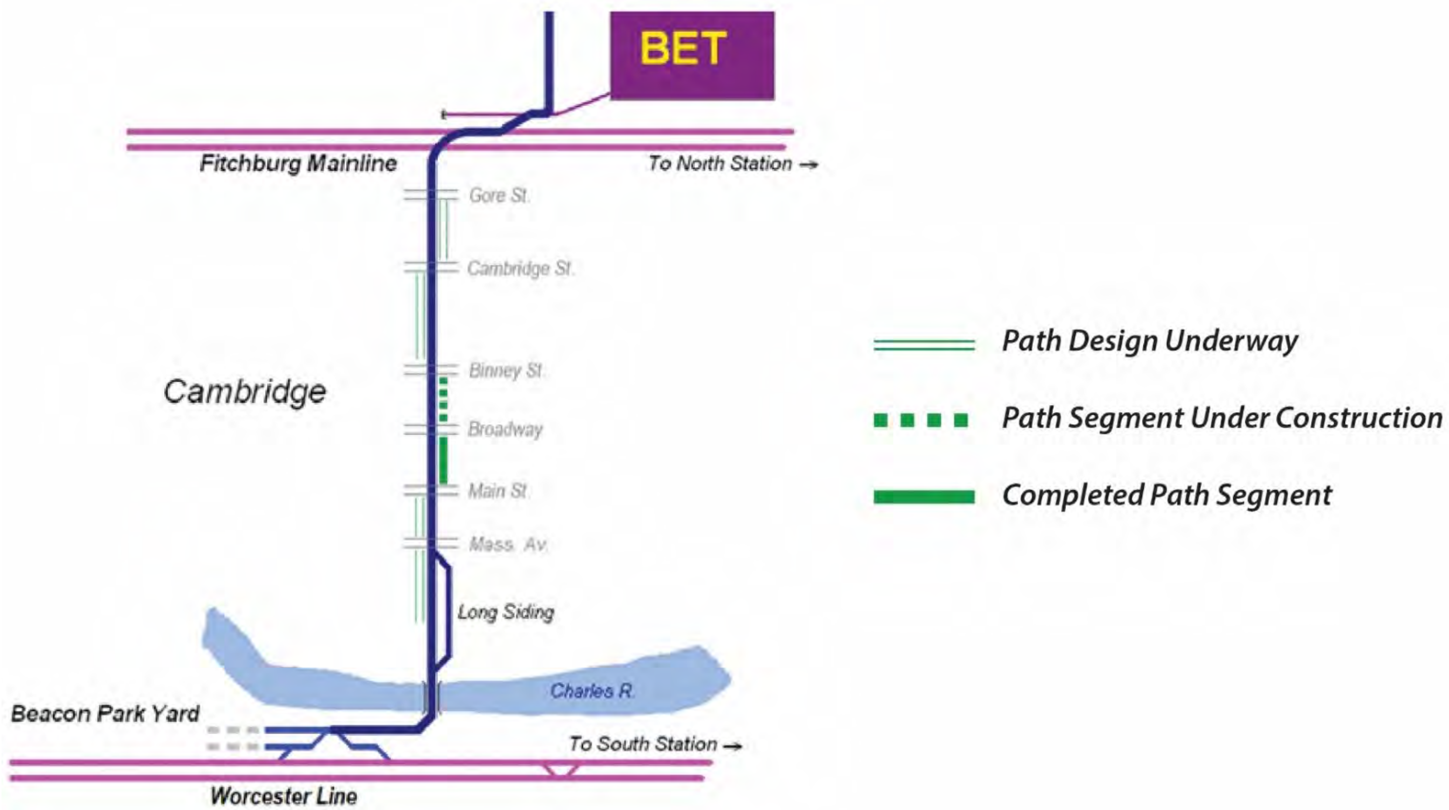


Figure 7. Grand Junction Railroad Corridor and Proposed Crossings of Multi-use Path Project

The City of Cambridge and its design team are presently working on final design plans and technical and design issues throughout the path corridor, as well as legal agreements with MIT and MassDOT. The City anticipates a near-final design will be presented to the public at the completion of final design, with phased construction to occur once the design and permitting processes are complete.

2.6.3. MBTA North Station Draw One Bridge Replacement

The MBTA's North Station Draw One Bridge project will significantly improve passenger rail operations, replacing two spans constructed in 1931 and integrating capacity and signal upgrades at the base of operations for the MBTA Commuter Rail's North Side. Four different commuter rail lines as well as, w Amtrak's *Downeaster* presently use these two spans. This project will increase capacity by adding one additional span (total of three) and two new tracks (total of six), as well as a restored platform at North Station (total of six central platforms with 12 tracks). A 2020 structure type study concluded that introducing a third span would also offer the region flexibility during the interim construction period, in addition to network redundancy over the long-term.

To avoid prolonged outages and routine service disruptions, the MBTA has undertaken extensive operations modelling to optimize the sequence and phasing of the planned construction program. Rail Traffic Controller (RTC) simulations indicate the potential to maintain full weekday access to North Station (i.e., four bridge tracks and 10 station tracks) by shifting a portion of the construction work to weekends when frequencies are lower, with minor reductions in weekend access to the facility (i.e., two bridge tracks, six station tracks).[4] The timing for completing this project is still several years away and has not yet been published by the MBTA.

2.6.4. Eversource's Greater Cambridge Energy Project

As part of Eversource's *Greater Cambridge Energy Project*, a new underground substation is planned to be constructed in Kendall Square. Five underground duct banks housing eight new 115 kV transmission lines will connect to existing area substations. One of the preferred potential alignments is proposed to run on the east side of the Grand Junction ROW between Medford Street / Gore Street and Cambridge Street, then continue along to the west side of the ROW between Cambridge Street and Broadway (see Figure 1 for reference). A final determination of alignment(s) from the Commonwealth's Energy Facilities Siting Board is anticipated in early 2024. It is envisioned that Eversource would commence construction shortly thereafter.

[4] These RTC Models include extensive analysis of track and train consist reconfigurations, double-birthing, and other improvements at North Station to mitigate construction impacts. The report notes a proposed 15-minute headway DMU service from North Station to West Station, but does not model its impact.

2.7. Demographics

Spurred by its vibrant and diverse residential communities, varied job opportunities across growing economic sectors, and institutions of higher education, the Grand Junction study corridor has experienced rapid growth over the past two decades. This section presents observations and projections of population and employment adjacent to the study corridor.

2.7.1. Demographic Forecasts from Central Transportation Planning Staff

The following figures present background forecasts of population (Figure 8 and Figure 9) and employment change (Figure 10 and Figure 11) at the Traffic Analysis Zone (TAZ) level based on data obtained from the Central Transportation Planning Staff's (CTPS) statewide model and a one half-mile buffer.

Please note that these data, developed in 2019 for the Boston MPO's Long Range Transportation Plan *Destination 2040*, pre-date the COVID-19 pandemic and its impacts. In this series, the initial map shows the percentage change and the second displays absolute change.

Base totals, projections, and anticipated change for population and employment within a half-mile radius of the study corridor are shown in Table 8. Between 2016 and 2040, CTPS forecasts anticipate a 14.9% increase in total employment within the study area. In the same period, population is projected to climb at more than double the rate of employment (increase of 36.1%).

In terms of population, the highest percentage increases are anticipated in east Somerville, along with Boston's Allston (mostly reflecting growth via Allston Landing) and Seaport neighborhoods. The majority of the study area within a half-mile is projected to experience population increases greater than 10%, with absolute increases of 100 people or more for each TAZ. In portions of booming east Somerville, the increase is greater than 50%, or over 200 people per TAZ. In terms of jobs (desk locations), growth is also expected throughout the entire study area, with the strongest forecast on the east side of the corridor near Kendall Square. Additionally, substantial increases in jobs are anticipated within the developing areas of Boynton Yards and Brickbottom adjacent to the Grand Junction's sharp eastward turn towards North Station, as well as areas south of the Charles River in Allston near the proposed West Station, with employment increases greater than 50% in large portions of the area, and over 500 in absolute increase.

Table 8. Projected Employment and Population Change in a one half-mile buffer of Grand Junction Corridor– 2016 -- 2040 (Source: CTPS Statewide Model)

Category	Base Year (2016)	Future Projection (2040)	Change	% Change
Employment	482,184	553,948	**71,764**	**14.9%**
Population	133,919	182,304	**48,385**	**36.1%**

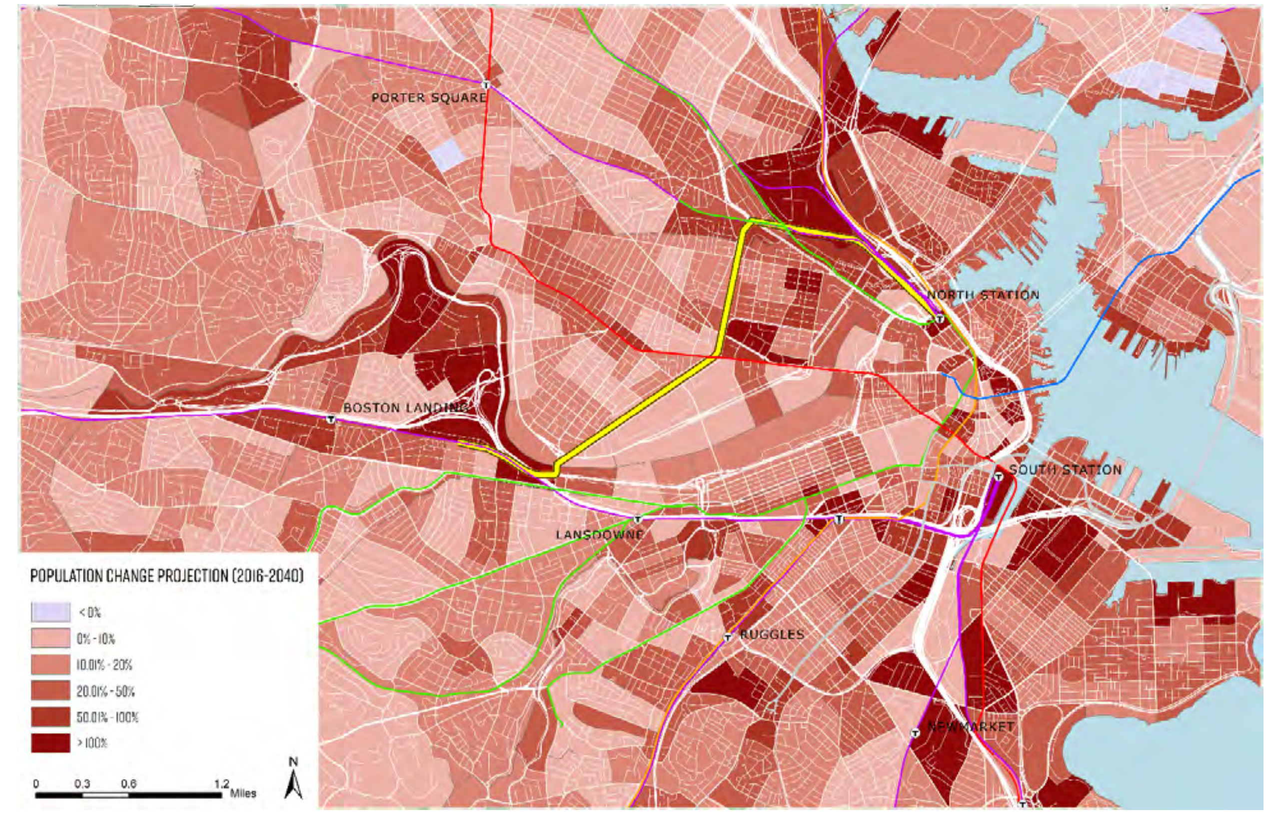


Figure 8. Population – Base Projected Change – 2016 to 2040 (Source: CTPS TAZ Level Projections for 2016 and 2040)

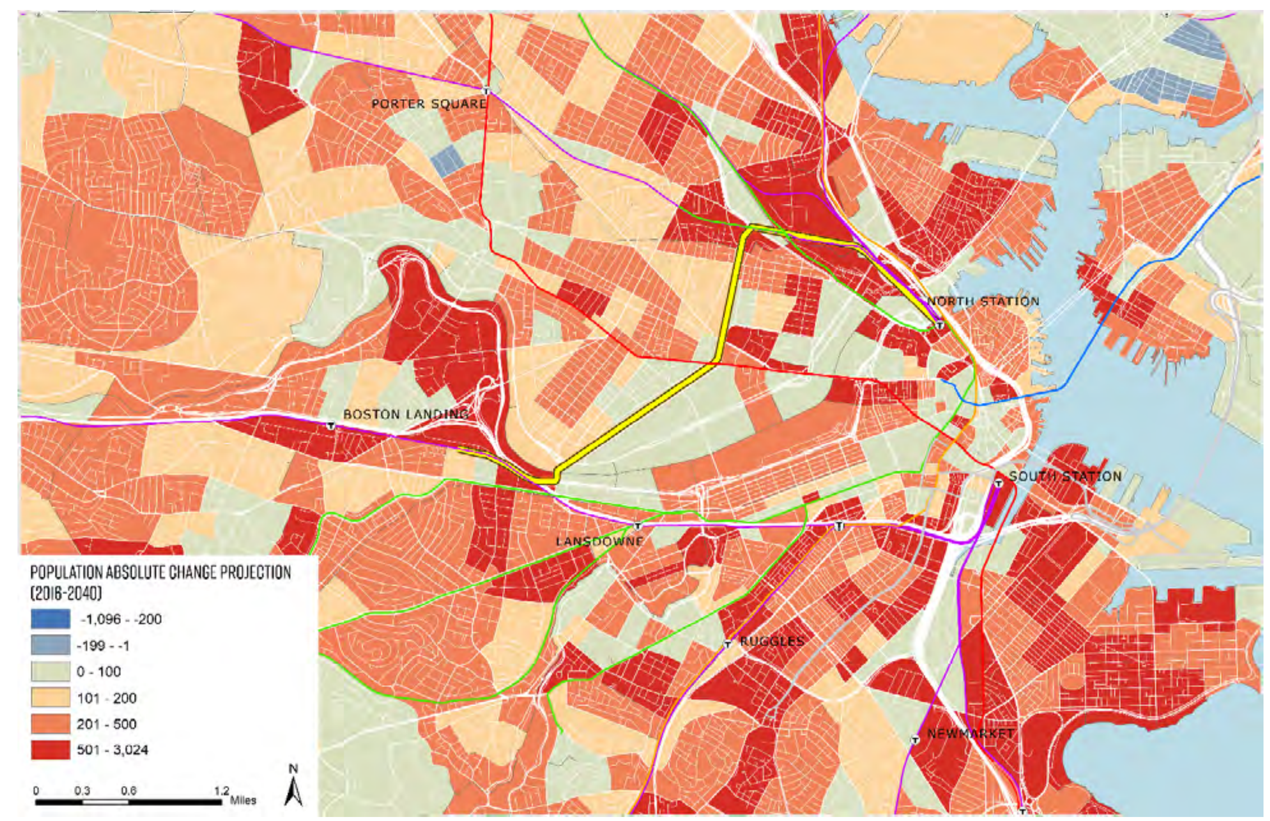


Figure 9. Population – Base Projected Absolute Change – 2016 to 2040 (Source: CTPS TAZ Level Projections for 2016 and 2040)

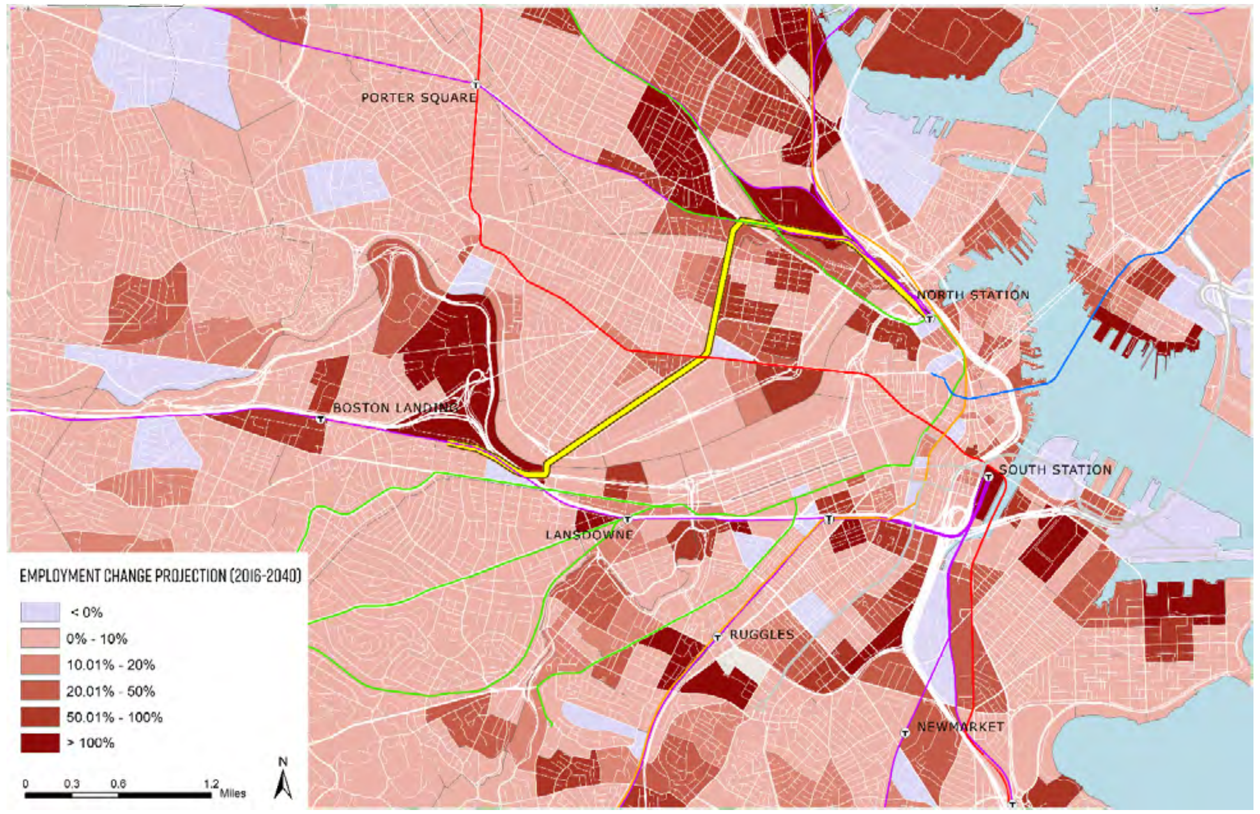


Figure 10. Employment – Base Projected Change – 2016 to 2040 (Source: CTPS TAZ Level Projections for 2016 and 2040)

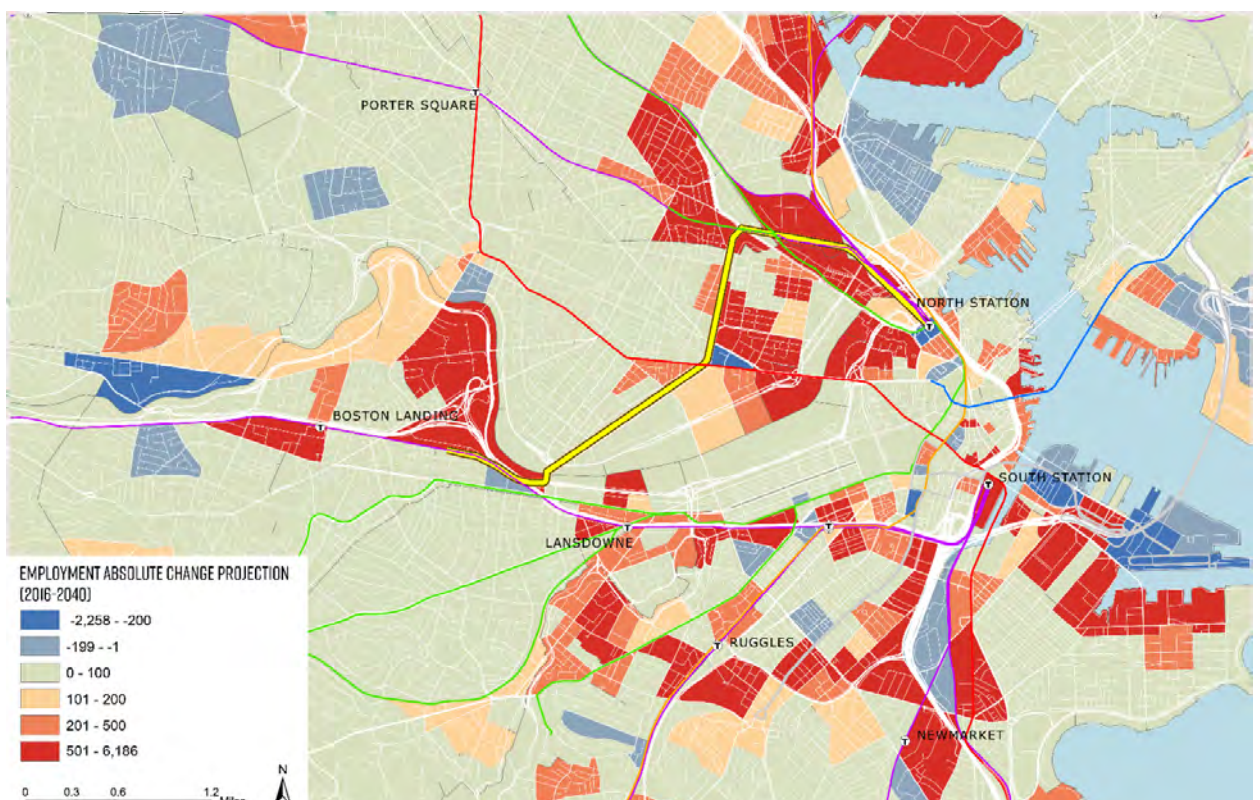


Figure 11. Employment – Base Projected Absolute Change - 2016 to 2040 (Source: CTPS TAZ Level Projections for 2016 and 2040)

2.7.2. Demographics from Longitudinal Employer Household Data

The density of home locations for workers reporting to job sites near the project corridor is shown in Figure 12 based on data from the US Census Bureau's 2019 Longitudinal Employer Household Dataset (LEHD). A total of 76,542 people are employed within a one half-mile of the potential service area of the corridor. Just over one-third (36%) of the workers reporting to job sites in the study area come from home locations in Boston (17%), Cambridge (12%), and Somerville (6%).

As shown in Table 9 and illustrated in Figure 12, workers in the study area mostly live within the I-495 loop, and along North Side Commuter Rail lines. Towns within Route 128/I-95 have the highest share of residents reporting to jobs along the study corridor. A relatively minor share of the project corridor's overall commuting base consists of workers completing long-distance journeys via major highways from Connecticut, Rhode Island, New Hampshire, as well as western Massachusetts.

Table 9. Commuters to Project Corridor based on Home Location (Source: Census LEHD)

Town	Number of Workers	Percentage of Workers
Boston	13,342	17.4%
Cambridge	9,234	12.1%
Somerville	4,896	6.4%
Arlington	2,167	2.8%
Newton	2,043	2.7%
Medford	1,854	2.4%
Brookline	1,789	2.3%
Quincy	1,640	2.1%
Belmont	1,445	1.9%
Malden	1,392	1.8%
Lexington	1,311	1.7%
Waltham	1,264	1.7%
Watertown	1,104	1.4%
Brockton	773	1.0%

2.8. Adjacent Land Uses

The neighborhoods adjacent to Grand Junction corridor are home to a diverse set of residential, commercial, and institutional land uses. South of Fort Washington Park is a mixture of MIT-owned buildings, private bio-technology firms, and light industrial land uses. Between Ft. Washington Park and Main Street, the adjacent land uses consist almost exclusively of MIT-owned parcels.

In the segment from Massachusetts Avenue to Main Street, there are two MIT structures that span over the railroad corridor – a co-generation energy plant (just north of Massachusetts Avenue) and the Brain & Cognitive Sciences Complex, or Building 46 (just south of Main Street). If a continuous double-track segment were developed alongside these uses, there is the potential for conflicts in the form of either a change in vehicular access (eliminate access to a service aisle at co-generation plant) or impacts to pedestrian circulation (east side of Brain & Cognitive Sciences Building).

The corridor navigates Kendall Square between Main Street and Binney Street, running alongside large bio-technology firms like Moderna, Draper, Amgen and Merck, as well as several bio-technology research institutions.

North of Binney Street, the adjacent neighborhood becomes increasingly residential on the west side of the track and features dense clusters of single-family homes, apartments, and neighborhood amenities like churches and restaurants. The completion of construction at 325 Binney Street will create 366,500 square feet of new Office/Research & Development space in this area. Industrial uses dominate the east side of the tracks along Fulkerson Street until near Spring Street, where it becomes more residential. Residential land uses continue on both sides of the tracks north of Cambridge Street to the city limits.

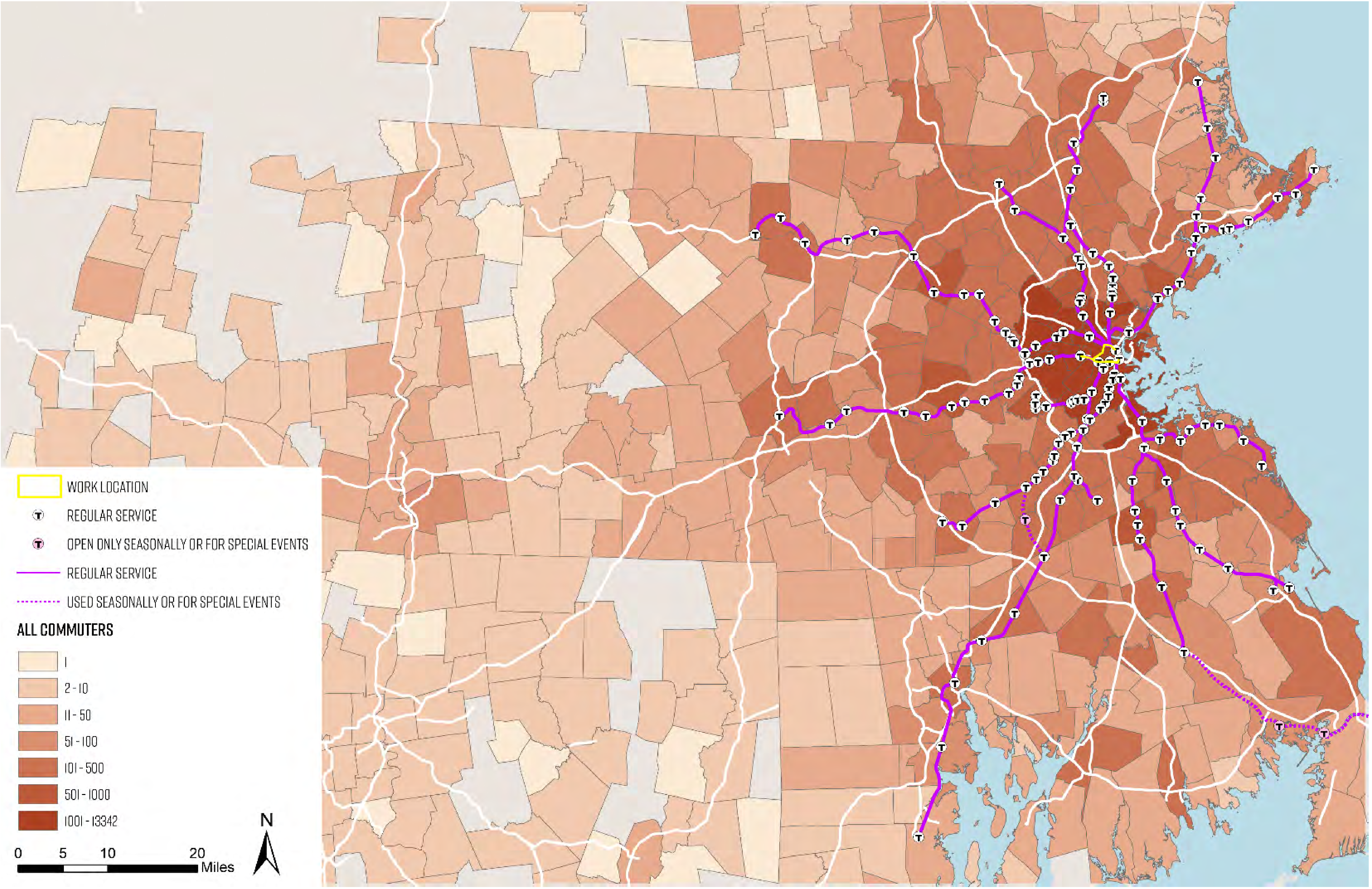


Figure 12. Origin Locations for Workers Working in Potential Service Area of Project Corridor (Source: Census 2019 LEHD)

2.9. Environmental

2.9.1. Environmental Justice

The entire Grand Junction corridor passes through Minority Census block groups (Figure 13), with many of these areas also further qualifying as Environmental Justice (EJ) communities based on the Income and / or English Isolation categories.

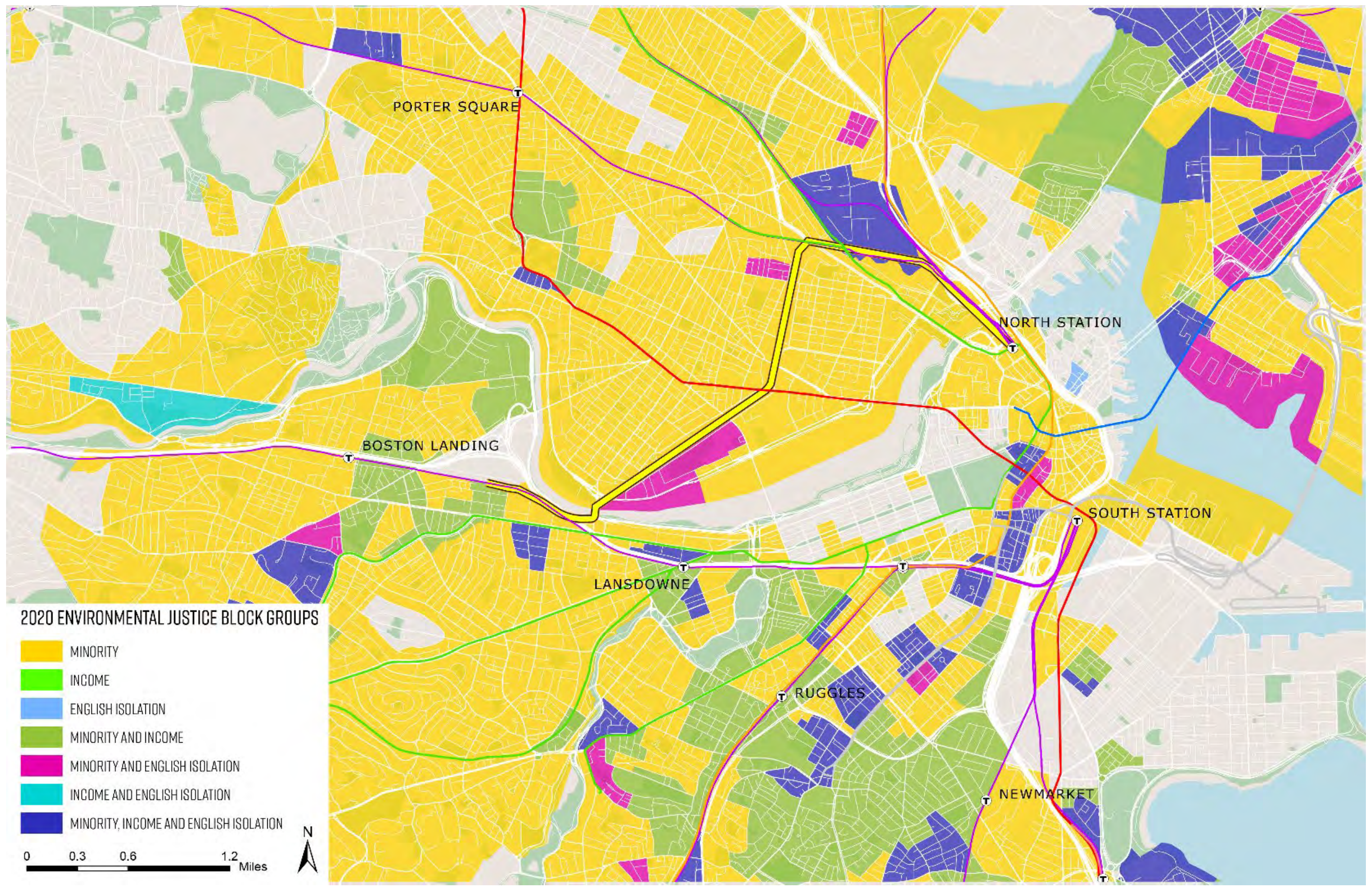


Figure 13. Environmental Justice Block Groups (Source: MassGIS 2020 Environmental Justice data)

2.9.2. Areas of Critical Environmental Concern

There are no areas designated as Areas of Critical Environmental Concern (ACEC) along the Grand Junction Railroad Corridor. A review of the NHESP Priority Habitats of Rare Species layer did not reveal any previous observations of rare wildlife along the corridor. However, there are known to be twelve open underground storage tanks (USTs) within a quarter mile of the corridor, as outlined below.

- One UST at Somerville Auto Services (57 Warren Street, Somerville)
- Two USTs at Draper Laboratory (555 Technology Square & 1 Hampshire Street, Cambridge)
- Two open and three closed USTs at Sunoco (266 Massachusetts Avenue Cambridge)
- Four USTs at MIT (59 Vassar Street, Cambridge)
- One UST at Brammer Bio (250 Binney Street, Cambridge)
- Two open and two closed USTs at Cottage Farm Station (660 Memorial Drive, Cambridge)

There are also 66 closed USTs within a quarter mile of the corridor. These closed USTs are listed in the Appendix on page APP-3.

2.9.3. Floodplains

Based on projections from the Massachusetts Coast Flood Risk Model (MC-FRM), which account for sea level rise, Figure 14 shows the probability of coastal flood exceedance (left) and the expected depth of inundation in the event of a 100-year storm in the year 2050 (right). In order to develop conceptual adaptation strategies, MassDOT developed the MC-FRM in 2020 to assess the vulnerability of its coastal transportation systems relative to future sea level rise and coastal storm surges. As shown in Figure 14, the low-lying area to the north near the BET and the approach into North Station is forecast to experience inundation during a 100-year storm in 2050 (given sea level rise). Although not depicted, it should be noted that significant portions of the Grand Junction corridor fall within the 2050 inundation limits of the 200- and/or 500-year storm.

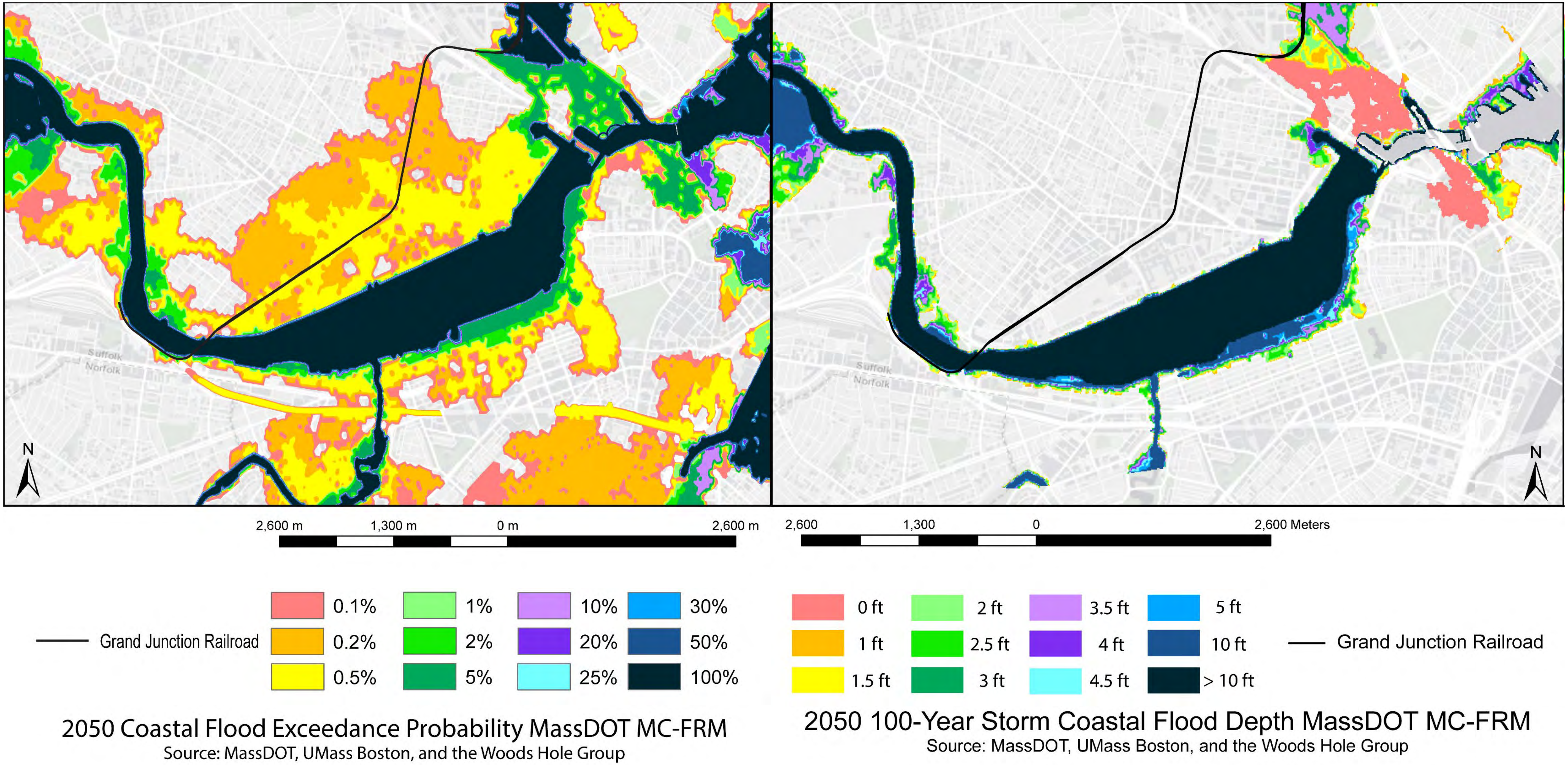


Figure 14. 2050 Flood Projections – Probability of Coastal Flood Exceedance (left) and Projected Flood Depths for a 100-Year Storm Event (right) (Source: Massachusetts Coast Flood Risk Model (MC-FRM))

2.10. Transit

As it maneuvers between Allston and North Station, the Grand Junction crosses through or near a host of transit modes and services, including three Rapid Transit Lines, two Commuter Rail Lines, several MBTA bus corridors, a well-patronized, privately-operated EZRide shuttle service, and many other privately-operated shuttles affiliated with nearby corporations and institutions. This section presents service frequency and ridership information for the adjacent public transit options based on service levels in Spring 2023 (Rapid Transit) and Fall/Winter 2022 (Commuter Rail), along with historical ridership data published by the MBTA.

As defined in the MBTA's Service Delivery Policy for rapid transit and buses, the AM peak period begins at 7:00 AM and ends at 8:59 AM. The PM peak period begins at 4:00 PM and ends at 6:29 PM. Given the preliminary nature of this study, all of these existing and proposed facilities and services should be considered as potential tie-ins for a future transit option along the rail corridor.

It should be noted that the Rapid Transit data only accounts for gated station entries recorded in October 2022. Given how this data was collected (i.e., taps of fare media at gated Rapid Transit stations), this dataset is unable to shed light on the extent to which a given station experiences activity as a result of in-station transfers or contributions from street-level stops (that lack fare gates). Such data do not accurately reflect transfer-heavy Rapid Transit stations that either connect different colored lines (e.g., Park Street for Red-Green, Downtown Crossing for Red-Orange, North Station for Green-Orange, State Street for Orange-Blue) or serve as major hubs along the Green Line (e.g., Kenmore, Park Street and North Station). However, this shortcoming does not affect this study's analysis, given that the Rapid Transit stations in the study area – Kendall and Lechmere – were not home to multiple lines and thus did not have internal transfers. All boardings for these stations were external gated boardings and thus were wholly captured in the dataset.

2.10.1. Rapid Transit

Red Line

The MBTA's Red Line Rapid Transit subway runs underneath the Grand Junction, with nearby stations at Kendall/MIT (Main Street between Ames and Broadway-Third Street) and Central Square. Weekday peak period headways along the Cambridge portion of the Red Line are scheduled for 7-8 minutes, and 8 minutes off-peak. However, recent MBTA maintenance work has resulted in slow zones along much of the Red Line and those headways are unfortunately not being met. Table 10 shows the top five stations by daily boardings based on the gated station entry data. While Harvard and Central each recorded more boardings overall, Kendall/MIT showed a strong weekday trend (over 8,500 trips) and a spike during the PM Peak (nearly 3,900 trips, equivalent to averaging 26 boardings per minute across a 2.5-hour period). Prior to 2020, Kendall/MIT was the third-busiest rapid transit station in the entire MBTA system in terms of gated station entries, with an average of 16,575 weekday daily boardings.

Table 10. Average Weekday Gated Red Line Boardings by Time Period (Source: MBTA, October 2022)

Station	AM Peak Boardings	PM Peak Boardings	Daily Boardings
Harvard	1,215	3,028	**10,587**
Central	1,445	2,471	**8,986**
Kendall/MIT	477	3,883	**8,544**
South Station	1,195	2,666	**7,847**
Davis	1,706	930	**5,540**

Green Line

The MBTA's Green Line has branches that run both north and south of the Grand Junction, with nearby stations at Amory Street (B Branch) and Kenmore (B – C – D Branches) to the south in Boston, and Lechmere (D – E Branches and Union Square (D Branch) to the north in Cambridge and Somerville, respectively. Weekday headways on each Green Line branch are 6-8 minutes during the peak periods, and 7-12 minutes during the off-peak. Table 11 shows the top five stations by daily boardings based on the gated station entry data, as well as at Riverside station which lies south of the Worcester Commuter Rail Line station at Auburndale. It should be noted that these data only cover gated station entries and do not include any street-running segments of the Green Line, the Green Line Extension, or internal transfers from other Rapid Transit lines (e.g., to the Red Line at Park Street or Downtown Crossing). Copley has the most boardings in each of the peak periods. Like many downtown Rapid Transit stations, Copley, Kenmore, Hynes Convention Center, and Park Street each show a stronger spike during the PM peak. The most recent data available for Lechmere station were from 2019 (i.e., before it was closed during its renovation for the Green Line Extension). MBTA systemwide ridership in October 2022 was 61 percent of the systemwide ridership recorded in October 2019. This discounting factor has been applied to the Lechmere data to produce the boardings in the below chart.

Table 11. Average Weekday Gated Green Line Boardings by Time Period (Source: MBTA, October 2022)

Station	AM Peak Boardings	PM Peak Boardings	Daily Boardings
Copley	625	2,697	**7,967**
Kenmore	495	1,528	**5,651**
Hynes Convention Center	355	1,774	**5,321**
Park Street	231	1,872	**5,037**
North Station	544	793	**3,313**
Riverside	93	153	**457**
Lechmere 2019 data discounted	724	1,064	**3,486**

Orange Line

While the MBTA's Orange Line does not intersect with the Grand Junction, it is situated in close proximity to nearby stations to the south (Back Bay) and north (Sullivan Square, Assembly, and Community College). Weekday peak period headways along the Orange Line are 7-10 minutes, and 8-12 minutes off-peak. Table 12 shows the top five stations by daily boardings based on the gated station entry data, as well as two stations of interest located near the Grand Junction. These data do not account for internal transfers from those already riding Rapid Transit (e.g., someone who arrived at North Station via the Green Line and transferred to the Orange Line without crossing a fare gate). In the AM peak, the top station is Forest Hills, with 1,774 boardings. During the PM peak, the top station is State Street, with 2,765 boardings (nearly 44 percent of its daily total). Assembly, Back Bay, and Community College also see large shares of daily boardings in the PM peak period, with Back Bay having the highest of these three (nearly 37 percent of its daily total). Sullivan Square is more balanced, with a similar count of boardings during each peak.

Table 12. Average Weekday Gated Orange Line Boardings by Time Period (Source: MBTA, October 2022)

Station	AM Peak Boardings	PM Peak Boardings	Daily Boardings
Back Bay	635	2,520	**6,818**
North Station	1,056	1,540	**6,432**
Forest Hills	1,774	873	**6,318**
State Street	178	2,765	**6,313**
Sullivan Square	886	808	**4,299**
Community College	247	532	**2,215**
Assembly	267	560	**1,942**

2.10.2. Commuter Rail

MBTA Commuter Rail service passes by each end of the Grand Junction. The Framingham/Worcester Line ("Worcester Line") passes near the southern terminus in Allston, with the closest existing station being Lansdowne (approximately a mile southwest of the river crossing). In the opposite direction along the line, Boston Landing is located approximately 1.5 miles west of the river crossing. The planned West Station, which is anticipated to come via MassDOT's Allston Multimodal project, would be approximately two-thirds of a mile west of the river crossing. The Fitchburg Line passes by the Grand Junction's northern Cambridge section, with North Station as its closest station. Compared to Rapid Transit and buses, Commuter Rail has slightly different, broader peak period definitions, with the AM peak spanning from 6:00 AM and 9:15 AM and the PM peak between 3:00 PM and 6:15 PM. The most recent Commuter Rail ridership data are from the summer of 2018 and provide Inbound and Outbound boardings and alightings for each station.

Worcester Line

The Worcester Line runs through 12 towns and cities between Worcester and Boston and serves 18 stations (Figure 15). Based on the Fall/Winter Schedule (displayed on the Appendix's page APP-1), which went into effect on October 17, 2022, the Worcester Line operates 25 inbound trains to South Station on weekdays, with 20 departing from Worcester and five from Framingham. There are 23 outbound trains departing South Station on weekdays, with 20 terminating in Worcester and three ending in Framingham. During the peak periods, service is hourly at Worcester and approximately every 30 minutes at Framingham. All trains serve Back Bay and South Station.

Figure 15. Worcester Line Service (Effective October 17, 2022)

This Line operates according to four basic service patterns:

- Local (all stops) service between Worcester and South Station
- Local service between Framingham and South Station
- Local service between Worcester and Wellesley Farms, with express service between Wellesley Farms and Back Bay
- Express service between Worcester, Framingham and South Station, with Boston-based stops at Lansdowne and Back Bay

In 2018, the Worcester Line reported 9,350 Inbound boardings and 9,280 Outbound boardings on an average weekday. This line accounted for about 15 percent of the total MBTA Commuter Rail trips on a typical weekday prior to COVID-19.

The three most heavily used stations in terms of daily weekday Inbound boardings are Worcester Union Station (1,300), Framingham (1,000), and West Natick (910). The two stations closest to the southern portion of the Grand Junction, Boston Landing and Lansdowne, see 480 and 155 daily Inbound boardings, respectively. Not surprisingly, 77 percent of all Inbound boardings on the line occur during the AM peak. During the AM peak, South Station is the primary alighting station, accounting for almost 53 percent of alightings, while Back Bay accounts for 30 percent of Inbound alightings.

Nearly three-quarters (74 percent) of Outbound daily boardings on this line take place during the PM peak period. The three most heavily used stations on this line in terms of Outbound daily weekday boardings are South Station (5,440), Back Bay (2,260), and Lansdowne (1,040).

2.10.3. Bus Service

MBTA

Multiple MBTA bus routes (six), along with the privately-operated EZRide Shuttle, presently traverse through at-grade crossings with the Grand Junction, as shown in Figure 16. Table 13 displays these services along with their respective peak headways and daily weekday boardings. The most frequent service is the Route 1 bus, which operates 10–15-minute headways during the peak periods along Massachusetts Avenue.

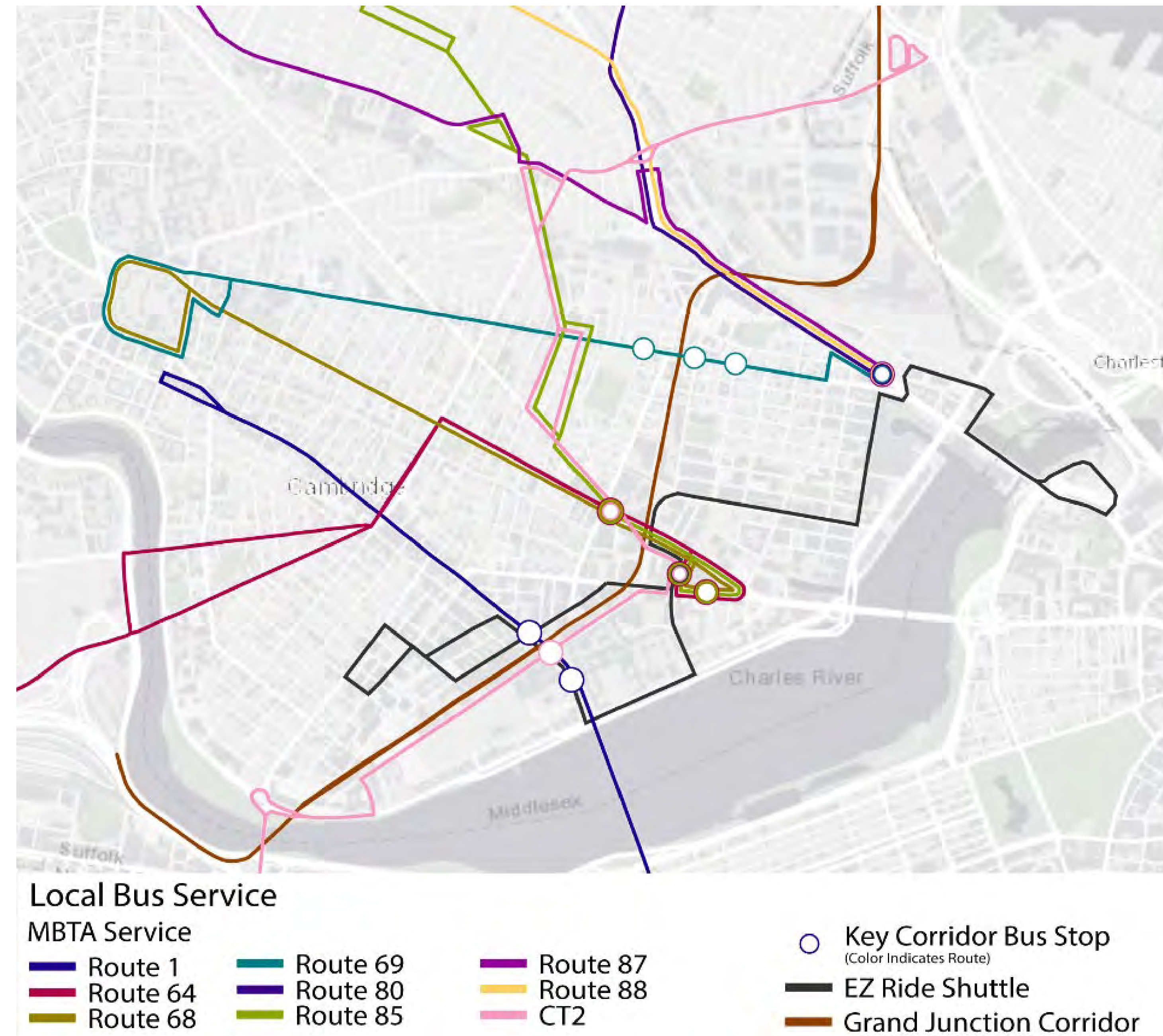


Figure 16. Bus Routes Adjacent to the Grand Junction Corridor

The MIT area along Massachusetts Avenue between 77 Massachusetts Avenue and Albany Street is served by MBTA bus Routes 1 and CT2. Across the two routes' multiple stops, this cluster area sees a weekday average of 594 boardings. Just over half (51 percent) of these riders board in front of MIT's library and student center, while most of the rest board at Albany Street, which is located north of the Grand Junction's crossing with Massachusetts Avenue near multiple life science labs. The remaining share (less than 10 percent) board at the CT2 stop located at Vassar Street at Massachusetts Avenue.

The Kendall Square area, served by MBTA bus Routes 64, 68, 85, and the CT2, has a daily weekday average of 507 boardings. Nearly two in five (39 percent) of those riders board directly at the Kendall/MIT Red Line station, one-third board near Ames Street at Broadway Street, and one-quarter board northwest of the Red Line station near the lab spaces along Hampshire Street and Cardinal Medeiros Avenue.

The cluster of six bus stops along Cambridge Street near the Grand Junction, served by Route 69, averages a total of 242 weekday boardings. Further from the corridor, the bus stop at Lechmere Station, which is served by Routes 69, 80, 87 and 88, has a daily average of 911 boardings on a typical weekday.

Table 13. Grand Junction Area Bus Routes (Source: MBTA, Fall 2021)

Crossing	Bus Route	Peak Headway (min.)	Daily Weekday Line Boardings
Massachusetts Avenue	1	10-15	7,815
Broadway	64	20-30	1,050
	68	45-55	244
	85	35-50	252
	CT2	25-40	1,147
Cambridge Street	47	20	3,622
	69	15-20	1,537
	80	30	1,007
	87	15-20	1,925
	88	15-20	1,774
Multiple Crossings	EZRide Shuttle	10-15	5,336

Potential Impact of Bus Network Redesign

The MBTA's Bus Network Redesign project (BNRD) is intended as a long-term re-envisioning of the MBTA's bus network. BNRD seeks to increase service frequencies throughout the service network while balancing impacts to coverage and stop access times. The following changes have been adopted for area bus routes and stand to be implemented in the next five years.

- High frequency service (every 15 minutes or better daily, including weekends)
  - Route 1
  - New Route T101, which will connect Medford Square, Sullivan Square, Community College, Lechmere, and Kendall Square
  - Route 47, which will include an extension between Central and Union Squares
  - Route 70, which will include an extension between Central and Kendall Squares
- Improved service frequencies (every 30 minutes or better daily, including weekends)
  - Routes 64 and 69
  - Route 90, which will be extended from Davis to Clarendon Hill
- CT2 will be rebranded as the new Route 85 and extended to Assembly Square using Route 90 routing between Rapid Transit stations at Union, Sullivan, and Assembly Squares
- Eliminated Service
  - Current routes 85 and 88
  - Route 80 service south of Davis

EZRide Shuttle and Other Shuttles

The EZRide shuttle provides connectivity between residential and employment destinations in Cambridge and Boston, as well as direct access to multiple Rapid Transit stations, including Kendall Square (Red), Lechmere (Green), and North Station (Green-Orange-Commuter Rail-Amtrak). AM and PM peak hour service frequencies are 4-6 trips. During the midday period, service is reduced to the area around Kendall Square and MIT, as shown in Figure 17. The privately-operated bus service is funded by the Charles River Transportation Management Association (TMA), which aims to reduce single-occupancy vehicle commute trips to/from the businesses near Cambridge's Kendall Square. The most recent (2020) observation of EZRide shuttle ridership reported over 5,300 daily weekday boardings, which is greater than most MBTA bus routes.

Many other employers in eastern Cambridge provide their own shuttle services from rapid transit stations to their worksites. Shuttle service is also provided between Kendall Square rapid transit and the Cambridgeside Galleria. The Longwood Medical Area (LMA) shuttle, operated by the Longwood Collective (formerly MASCO), links eastern Cambridge to both Harvard Square as well as the LMA. MIT operates a number of shuttles linking its campus to the Kendall Square rapid transit station as well as to other Cambridge and Boston locations. Ridership data for these privately-operated shuttles are not published publicly and were not available for analysis as part of this study.

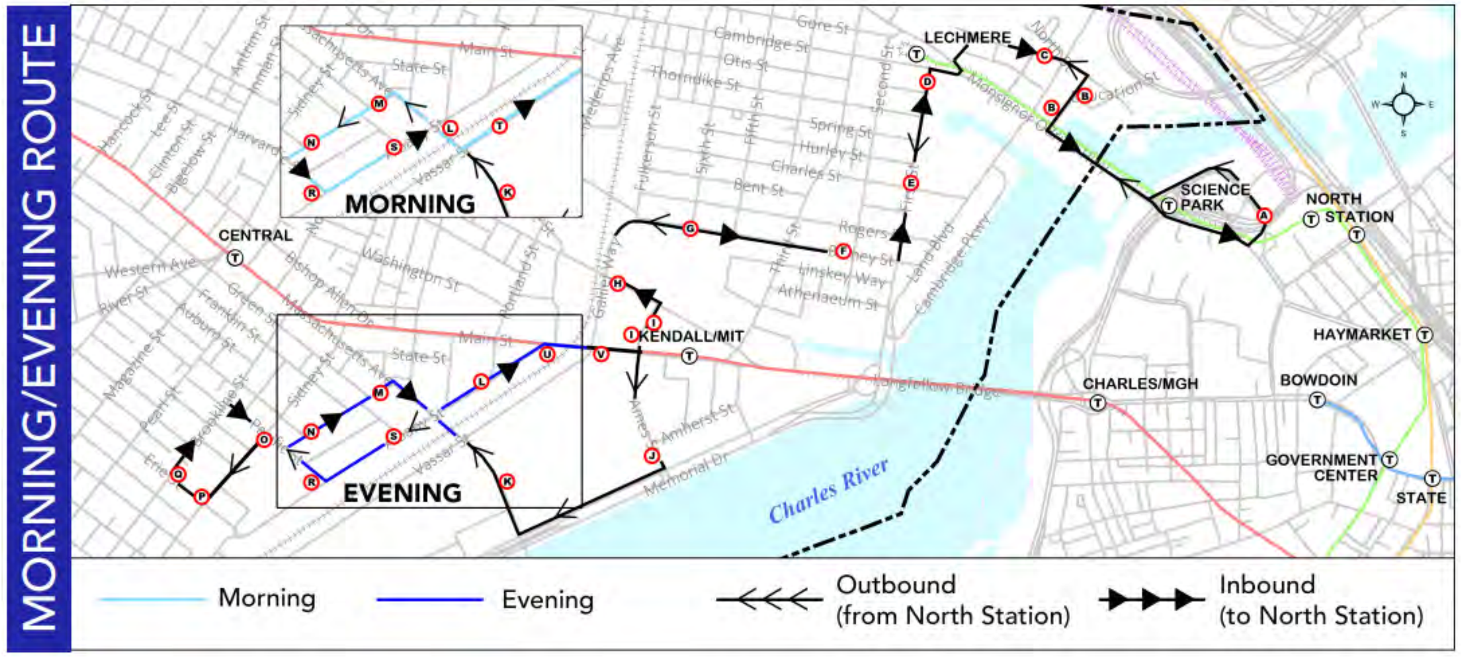


Figure 17. EZRide Shuttle Route Map (Source: Charles River TMA)

2.11. Active Transportation

Non-motorized modes are important components of Cambridge's transportation system. In 2015, Cambridge ranked first nationwide among cities of 100,000 or more in terms of the share of residents using non-motorized modes for commuting, with a rate of 31 percent, more than 10 times the national average[5] (ACS 2011-2013, Transportation Trends in Cambridge 2015). The City of Cambridge's 2019 Parking and Transportation Demand (PTDM) data observed that approximately 15 percent of Kendall Square commuters used non-motorized modes, with seven percent using bikes and eight percent walking. When all eastern Cambridge workplaces were analyzed in the 2022 PTDM, the non-motorized mode share is slightly lower (12 percent), with both walking and biking comprising approximately six percent each for this considerably larger geographic area.

2.11.1. Pedestrian Movements

There is already significant pedestrian traffic across the Grand Junction's nine at-grade crossings, six of which also include vehicular movements. Broadway and Massachusetts Avenue are the busiest crossings in terms of pedestrian movements over the rail corridor, followed by Main Street and Cambridge Street. Based on data collected by the City's 2016 Multi-use Path Study, observations of AM / PM peak- hour pedestrian movements in 2019 at intersections adjacent to the Grand Junction rail corridor indicated the following crossing frequencies:

- Broadway – every 8 seconds in the AM Peak and 12 seconds in the PM Peak
- Massachusetts Avenue – every 11 seconds in the AM Peak and 10 seconds in the PM Peak
- Main Street – every 27 in the AM Peak and 29 seconds in the PM Peak
- Cambridge Street – every 24 seconds in the AM Peak and 35 seconds in the PM Peak

2.11.2. Bicycle

Bicycle infrastructure has expanded in recent years in Cambridge. In 2020, the City passed the Bicycle Lane Ordinance, codifying a commitment to building separated bicycle infrastructure along major routes. Separated and shared bike lanes, bike racks, and bikeshare stations have been constructed across the city to improve access and safety for bicyclists. In addition to private ownership, the bikeshare market has proliferated throughout Cambridge.

Automatic Traffic Recorder (Eco-Totem) Counts

The City of Cambridge operates an Eco-Totem bicycle counter on Broadway in Kendall Square near the Kendall/MIT Red Line Rapid Transit station. Using an in-ground loop detector, this type of counter tallies cycling trips and records weather observations. As shown in Figure 18, while the number of cyclists along the corridor remains below pre-pandemic levels, overall ridership has been steadily recovering, with Fall 2022's monthly high approaching 75 percent of the 2019 figures (approximately 39,100 versus 53,900 trips).

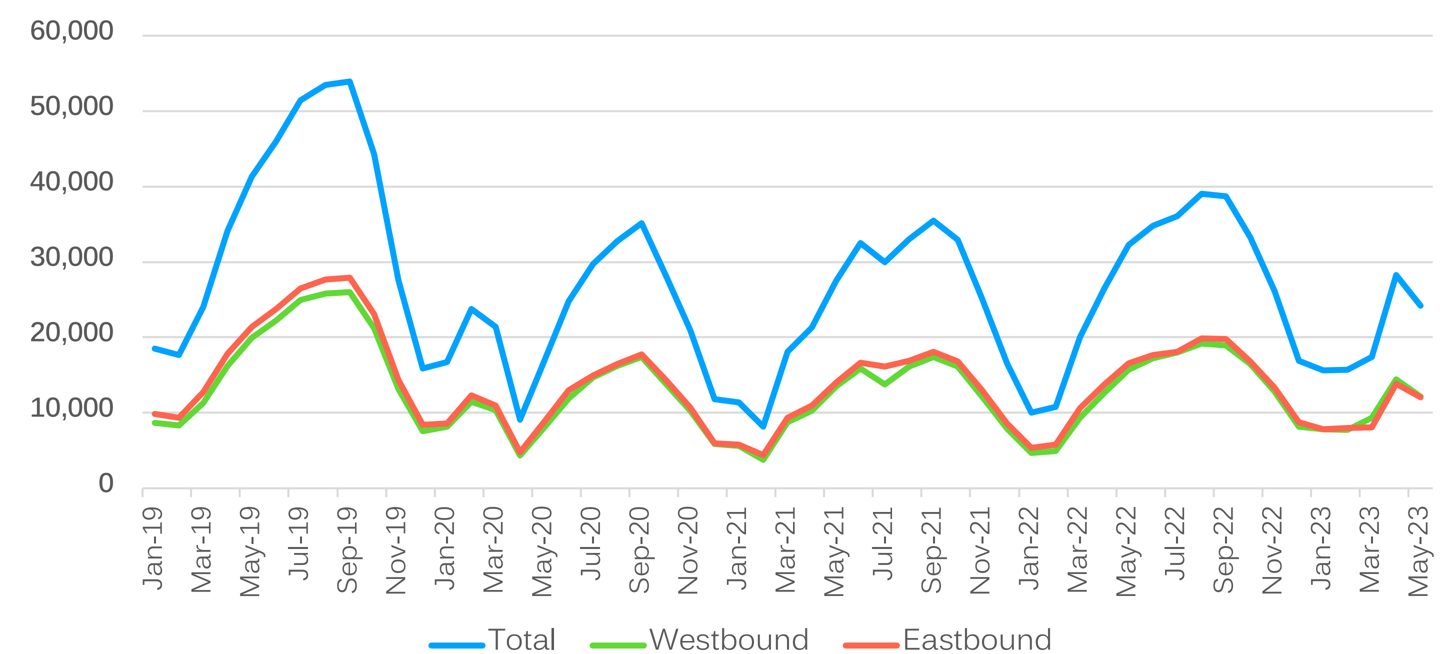


Figure 18. 2019-2022 Bicycling Volumes along Broadway near the Kendall/MIT Red Line Rapid Transit Station (Source: City of Cambridge & Eco-Totem)

[5] City of Cambridge. *Transportation Trends in Cambridge 2015.* https://www.cambridgema.gov/-/media/Files/Traffic/factsheet_cambridgetransportationfinaledits91515as.pdf

BlueBike Bikeshare

The City of Cambridge is one of 13 municipal owners of BlueBike, a robust regional public bikeshare system. A total of 17 BlueBike stations are presently situated within a 1/8-mile radius of the Grand Junction corridor. As shown in Figure 19, four of these stations are located north of Binney Street near Gore Street and Cambridge Street. Nine stations lie around Kendall Square, many of them clustered near Binney Street and Main Street. The remaining four stations are located south of Kendall Square between Massachusetts Avenue and the Charles River. Ridership for each of these three groups of stations for four months in 2019 and 2022 is outlined in Table 14 and Table 15.

The stations in the area south of Kendall along the corridor see greater usage than the other stations combined along the corridor, with one exception. This is likely related to the large, mostly car-free, student presence at MIT. All five of the top origin corridor stations (nearly 58 percent of trips in the 2022 sample) were located on or near the MIT campus: MIT at Massachusetts Avenue/Amherst Street, MIT Pacific Street at Purrington Street, MIT Vassar Street, Ames Street at Main Street, and MIT Stata Center at Vassar Street/Main Street. Similarly, the same MIT-related stations were reported as the highest destination stations along the corridor, also comprising approximately 58 percent of the trips. The most heavily used station was MIT at Massachusetts Avenue/Amherst Street, which accounted for 20 percent of both trip origins and destinations along the corridor.

Figure 19. BlueBike Stations along the Grand Junction Corridor (Source: BlueBike March 2024)

Table 14. Monthly BlueBike Trips with Origins in the Corridor

Location / Month	January		April		July		October	
Year	2019	2022	2019	2022	2019	2022	2019	2022
North of Kendall Square	N/A	1,477	N/A	3,200	N/A	4,856	2,521	5,411
Kendall Square	5,064	4,062	9,559	11,986	15,210	16,367	16,396	17,111
South of Kendall Square	5,626	7,420	12,003	18,753	16,257	21,430	20,077	26,124

Table 15. Monthly BlueBike Trips with Destinations in the Corridor

Location / Month	January		April		July		October	
Year	2019	2022	2019	2022	2019	2022	2019	2022
North of Kendall Square	N/A	1,309	N/A	3,035	N/A	4,843	2,446	5,411
Kendall Square	4,884	4,062	9,690	12,372	14,784	17,179	16,900	17,358
South of Kendall Square	5,200	7,095	11,042	18,307	15,887	20,945	19,408	25,794

Review of a four-month sample of BlueBike origin-destination data indicates that trips not only occur across the corridor, but they also occur *along* the corridor, including to and from the study's primary urban rail station termini at North Station and West Station. This is of particular relevance to this study, as it indicates existing travel demand (currently met by bicycle) and the presence of travel markets connecting the study corridor and potential rail transit termini at either end.

Bikeshare trips originating along the corridor had 385 unique destinations, covering a wide variety of geographies within the BlueBike network. Other popular Cambridge destinations outside of the corridor included Central Square and Harvard Square. The top 20 destination stations for trips with origins along the corridor and the top 20 origin stations for bikeshare trips destined for stations near the project corridor are displayed on pages APP-4 and APP-5 of the Appendix. Most trips are either inter-corridor trips or trips that begin at BlueBike stations close to the project corridor. This indicates either short trips or round trips taken on a single BlueBike.

2.12. Vehicular Traffic

Multiple data sources were used to analyze existing vehicular traffic volumes and performance at intersections with or near the Grand Junction rail corridor. These include traffic counts from the 325 Binney Street Application for Special Permit report (2020), the Volpe Exchange Parcel Traffic Impact Study (2019), and the City's Grand Junction Multi-use Path Project (2019). From these sources, average delay and vehicle level of service (LOS) data were obtained and compiled in Table 16, organized from the southern end of the Grand Junction towards the northern end. These same data sources provided traffic volume data in the form of turning movement counts (TMCs) and automated traffic recorders (ATRs). AM and PM peak hour volumes for both directions are compiled in Table 17. It should be noted that only PM peak period delay and level of service data was available along Massachusetts Avenue.

Since trains cannot travel through an at-grade crossing at the same time pedestrians, motor vehicles and bikes do, any change in passenger traffic along the Grand Junction rail corridor could ultimately have an influence on non-train operations and safety, and vice versa. The list below summarizes key auto-related metrics concerning vehicular operations near at-grade crossings of the Grand Junction.

- Longest Delays
  - Binney Street at Fulkerson Street/Galileo Galilei Way – PM Peak – LOS F; 83 seconds of delay
  - Massachusetts Avenue at Albany Street – PM Peak – LOS E; 71 seconds of delay
  - Cambridge Street at Third Street – AM Peak – LOS E; 74 seconds of delay
  - Broadway at Galileo Galilei Way/Fulkerson Street – AM Peak – LOS D; 45 seconds of delay
- Highest Volumes
  - Massachusetts Avenue at Vassar Street – PM Peak – 1,084 vehicles
  - Cambridge Street/Warren Street at Cardinal Medeiros Avenue – AM Peak – 1,074 vehicles
  - Broadway at Galileo Galilei Way/Fulkerson Street – PM Peak – 953 vehicles
  - Broadway at Galileo Galilei Way/Fulkerson Street – AM Peak – 916 vehicles

Table 16. Recent Observations of Vehicular Delay and Automobile Level of Service (Various Sources)

	AM Peak		PM Peak		Data Source	
Intersection	Delay (s/veh)	VLOS	Delay (s/veh)	VLOS	Year	Document
Massachusetts Avenue at Albany Street	N/A		71	E	2019	Grand Junction Path Memo
Main Street/Galileo Galilei Way at Vassar Street	18	B	25	C		
Binney Street at Fulkerson Street/Galileo Galilei Way	37	D	83	F		
Broadway at Galileo Galilei Way	45	D	51	D		
Broadway at Hampshire Street/Technology Square	37	D	39	D		
Cambridge Street/Third Street	74	E	35	C	2019	Volpe Exchange Parcel TIS
Cambridge Street/Warren Street at Cardinal Medeiros Avenue	35	C	42	D	2020	325 Binney Street Application for Special Permit

Table 17. Recent Observations of Motor Vehicle Volumes (Various Sources)

	Volume Crossing the Grand Jct.						Data Source	
	AM Peak			PM Peak				
Intersection	EB/NB	WB/SB	Total	EB/NB	WB/SB	Total	Year	Document
Massachusetts Avenue at Vassar Street	N/A			567	517	**1,084**	2019	Grand Junction Path Memo
Main Street/Galileo Galilei Way at Vassar Street	316	491	**807**	480	403	**883**		
Binney Street at Galileo Galilei Way/Fulkerson Street	225	163	**388**	522	26	**548**		
Broadway at Galileo Galilei Way	483	433	**916**	419	534	**953**		
Cambridge Street/Warren Street at Cardinal Medeiros Avenue	525	549	**1,074**	459	496	**955**	2018	325 Binney Street Application for Special Permit

Table 18 shows the average annual daily traffic (AADT) along several nearby bridges, beginning in the north near I-93 and sweeping south along the Charles River towards Cambridgeport. The highest car volumes are along Route 28/O'Brien Highway near the Museum of Science (nearly 36,000 vehicles per day) and the Western Avenue bridge that serves as a municipal on-ramp to I-90.

Table 18. Motor Vehicle Crossings of Nearby Bridges in 2021 (Source: MassDOT Road Inventory)

Bridge Crossing	Average Annual Daily Traffic (AADT)
Gilmore	26,458
Route 28/O'Brien Highway (East of Museum Way)	35,910
Longfellow	19,249
Massachusetts Avenue	15,979
River Street	18,509
Western Avenue	28,032

2.13. Emergency Response

The map in Figure 20 shows the location of firehouses, emergency medical service (EMS) facilities, and police departments relative to the Grand Junction corridor.

For emergency medical trips traveling from Cambridge across the Charles River to hospitals in Boston, the interfaces with the Grand Junction at Massachusetts Avenue and Broadway are especially critical, as these roads provide direct access to bridges over the Charles River. Mass General Hospital/Brigham operates an ambulance service based at Spaulding Rehabilitation Center on Cambridge Street, which is sited approximately one mile west of the rail corridor. This service transports patients to Mass General (likely via the Longfellow Bridge) and Brigham & Women's in the Longwood Medical Area (likely utilizing the Massachusetts Avenue or Boston University Bridges).

Cambridge Fire and EMS, in partnership with Pro EMS, provides primary ambulatory 911 responses throughout the City of Cambridge. While these vehicles circulate the City responding to calls, they are likely to use the facilities listed below to access nearby neighborhoods.

- Cambridge Street to enter/exit East Cambridge
- Binney Street, Broadway and/or Main Street to get to/from Kendall Square
- Massachusetts Avenue to access MIT's campus, as well as Central Square and Harvard Square

MIT also operates its own student-run EMS service and is likely to utilize similar grade crossings to serve the extents of the University campus. Cataldo Ambulance is located near the East Somerville Green Line Station and, as Somerville's primary 911 responder and a back-up responder in both Cambridge and Boston, is also likely to use various Grand Junction grade crossing. First responders will occasionally provide mutual aid to surrounding municipalities (i.e., responders from Boston, Cambridge, Somerville, and other surrounding communities will also interface with the Grand Junction corridor).

Figure 20. Emergency Response Locations near the Grand Junction Corridor (Source: MassGIS, City of Cambridge GIS)

The Somerville Fire Department covers the area adjacent to the Medford Street/Gore Street crossing, which falls within Somerville city limits. The Cambridge Fire Department divides the city into districts for dispatching ladders and engines. There is only one city-wide district for rescue dispatching.

- Ladder District Two interfaces with the Grand Junction along Cambridge Street, Binney Street, and Broadway. This district serves the East Cambridge and Wellington-Harrington neighborhoods.
- Ladder District Three intersects the Grand Junction at Main Street and Massachusetts Avenue. This district serves the remainder of the study corridor south of Broadway, as well as Area 2/MIT, The Port, Cambridgeport, and portions of Riverside and Mid-Cambridge.
- Engine District Two features the at-grade crossings at Main Street and Massachusetts Avenue. This district includes portions of the Port and Cambridgeport.
- Engine District Three connects with the Grand Junction at Binney Street. This district includes a small portion of Wellington-Harrington along Binney Street.
- Engine District Five includes the at-grade crossings at Cambridge Street and Broadway. This district includes the remainder of Wellington-Harrington and portions of Mid-Cambridge.

The Somerville Police dispatch to the areas adjacent to the Medford Street/Gore Street crossing, which falls within Somerville city limits. The Cambridge Police Department headquarters is located on 6th Street, directly adjacent to the Binney Street at-grade crossing of the Grand Junction. Cambridge police officers are dispatched into sectors or car routes throughout the city. Many of these Cambridge Police patrol areas are delineated by the Grand Junction, as outlined below.

- Sector One (Car Patrol 1R and 3R) interfaces with the Grand Junction via the at-grade crossings at Cambridge Street and Binney Street. This sector includes the neighborhoods of East Cambridge, Wellington-Harrington, and portions of Area 2/MIT.
- Sector Two (Car Patrol 4R and portions of 6R) intersects the Grand Junction at Broadway and Main Street. This sector includes the neighborhoods of The Port and Mid-Cambridge.
- Sector Three (Car Patrol 5R and portions of 6R) crosses with the Grand Junction at Massachusetts Avenue. This sector includes the neighborhoods of Cambridgeport and portions of Area 2/MIT and Riverside.

2.14. Parking

Public and private parking is available near the Grand Junction corridor. Based on data provided from Boston Properties and parkopedia.com, Table 19 shows the number of parking spaces offered in various garages around Kendall Square, for a total of 8,891 spaces.

Table 19. Parking Capacity Near Kendall Square by Facility (Source: Boston Properties, Parkopedia.com)

Garage	Count of Parking Spaces
KSURP Blue (demolished 2023)	1,136
KSURP Green	650
KSURP Yellow	732
350 Kendall Street	1,410
One Broadway	430
Tech Square	1,593
One Kendall	1,330
Binney Street	500
Cambridge First Street Garage	1,110
Total Spaces	8,891

2.14.1. Public Parking Facilities

The brown lines in Figure 21 represent on-street metered public parking stalls. Of the approximately 3,100 metered parking spaces throughout the City of Cambridge, nearly one in eight on-street spaces (444) are located within an 1/8-mile of the Grand Junction corridor. A municipal-owned and operated public parking garage at 35 First Street in East Cambridge offers approximately 1,110 parking stalls.

2.14.2. Private Parking Facilities

Three parking garages in Kendall Square are managed by Boston Properties: Kendall Center Blue (North)[6] (built in 1990), 4 Kendall Center Green (East) (built in 1995), and 7 Kendall Center Yellow (West) (built in 2005 and subject to the PTDM ordinance). These privately-owned facilities offer a total of 2,664 parking spots near the MBTA Red Line Rapid Transit station (Figure 22). Each garage's total capacity and 2019 average weekday peak occupancy are shown in Table 20.

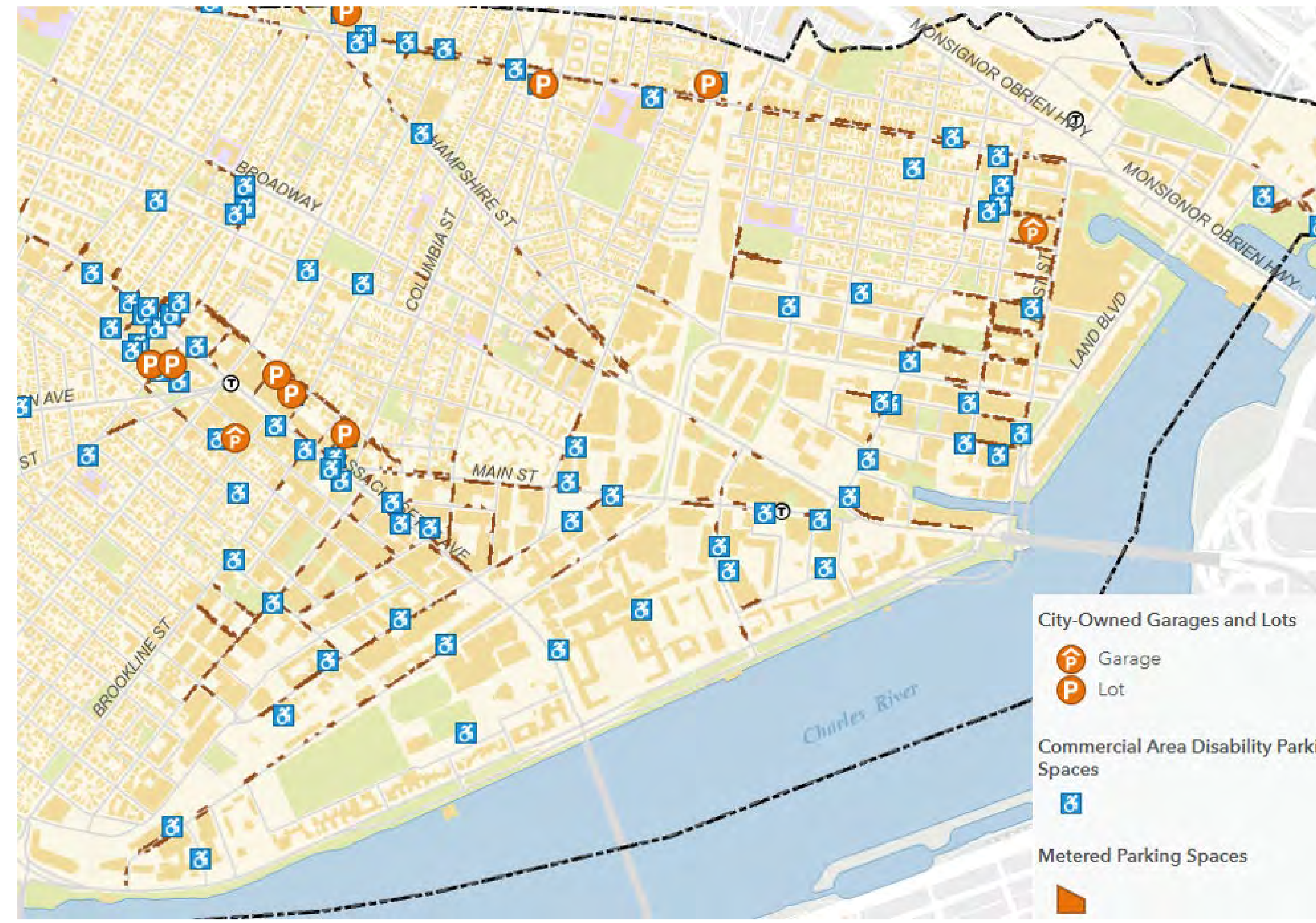


Figure 21. Public Parking Spaces near the Grand Junction Corridor (Source: City of Cambridge - Park a Car in Cambridge - City of Cambridge, MA (cambridgema.gov))

[6] The Blue Garage, demolished in early 2023, will be replaced by underground garage space at 290 and 250 Binney Street. Construction is expected for completion in approximately 2030.

Table 20. Average Weekday Parking Occupancy at Three Private Parking Garages– 2019 (Source: Boston Properties)

Garage	Capacity	Average Weekday Peak Occupancy
Blue (North)	1,136	85%
Green (East)	650	94%
Yellow (West)	732	92%

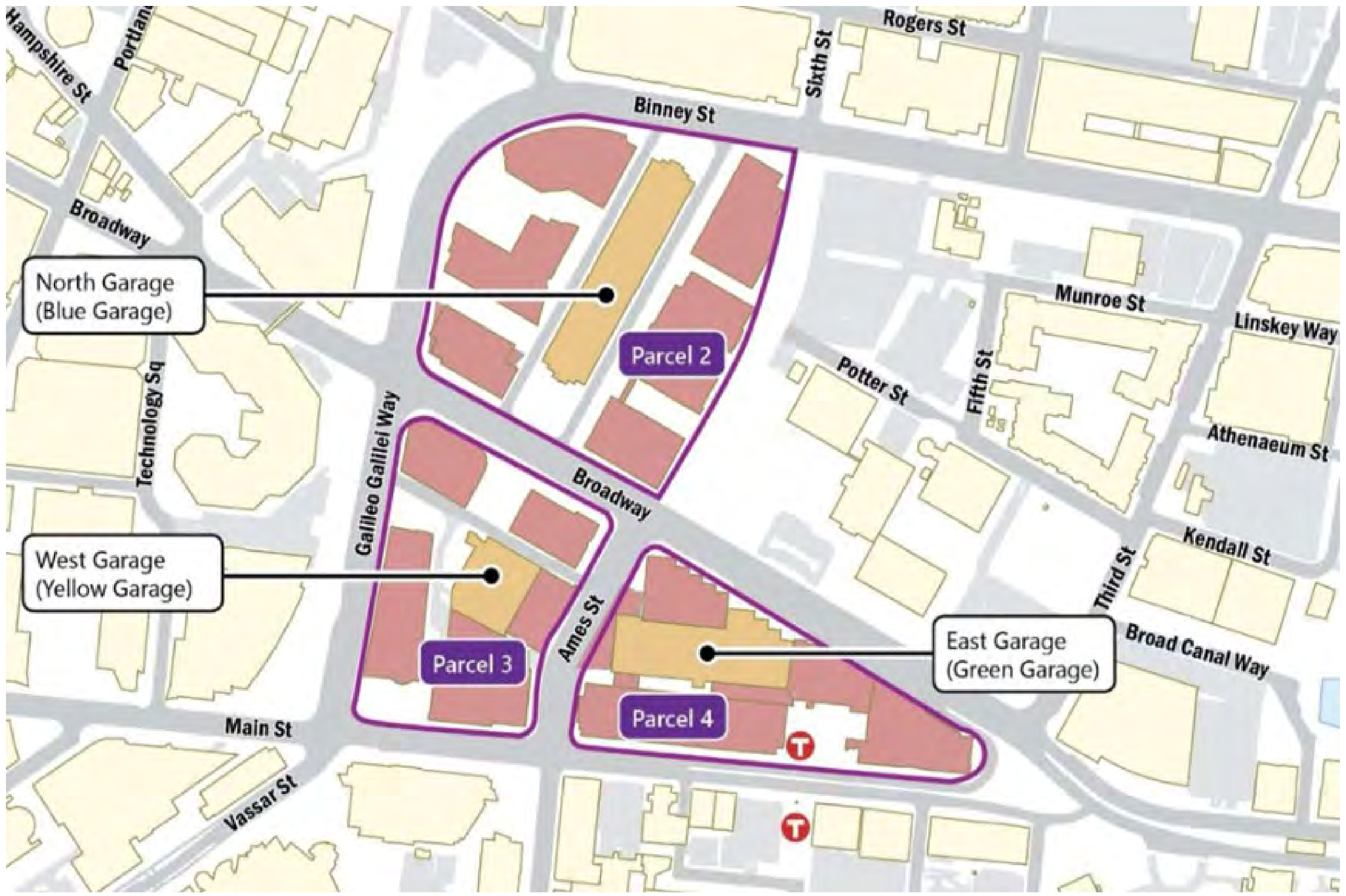


Figure 22. Locations of the Three Private Parking Garages Assessed (Source: VHB)

To understand how demand for parking facilities shifts throughout the day near Kendall Square, detailed occupancy data for these three facilities were obtained from a 2018 KSURP Transportation Analysis Update and manual data entry (2022).[7] In both years, peak occupancy occurred between noon and 1:00 pm. Occupancy across an average weekday is presented in Figure 23 and is based on the KSURP data source.

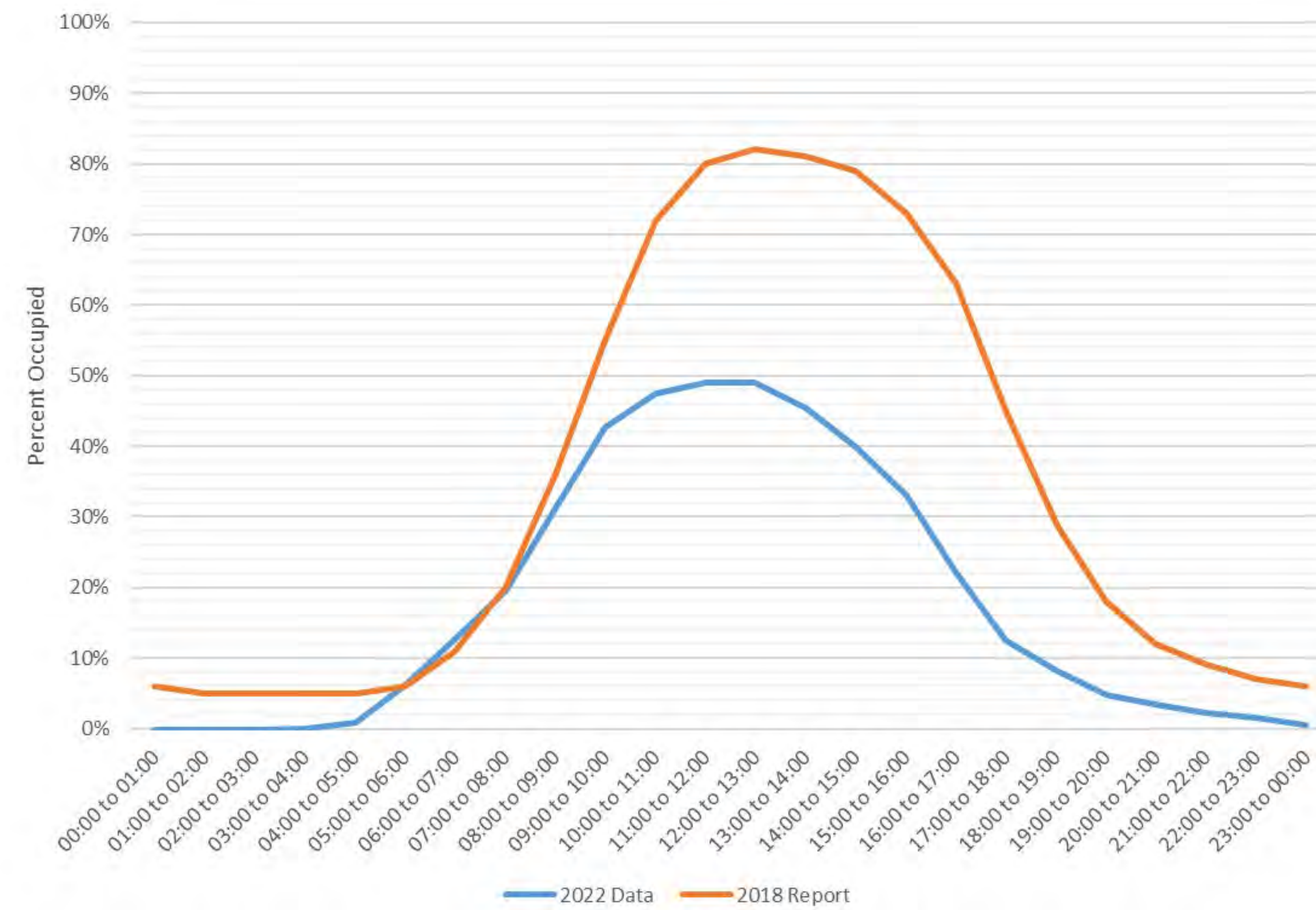


Figure 23. Average Weekday Parking Occupancy by Time of Day at Three Private Parking Garages – 2018 & 2022 (Source: City of Cambridge & VHB)

While the 2018 report indicated that peak occupancy across the three garages was 82 percent, the pandemic-era data from 2022 reported it to be only 49 percent. One possible reason for the lower occupancy in 2022 could be work-from-home policies affecting offices located around Kendall Square. As return-to-office plans are implemented, the occupancy in these garages will likely increase. Nevertheless, even with currently reduced parking occupancy there remains little real estate left in Kendall Square that could be developed into additional parking. Thus, the potential to add parking in this relatively built-out area is declining, and that trend will almost certainly continue.

[7] The 2018 report analyzed weekday hourly occupancy for all three garages during the highest occupancy month (October). The 2022 data provided hourly entries and exits, which were used to calculate the occupancy of the three garages during weekdays. The 2018 report can be accessed on the City website at the following address: https://www.cambridgema.gov/-/media/Files/CDD/ZoningDevel/SpecialPermits/sp315/sp315_TransportationAnalysis_VHB_20180914.pdf

3. Alternatives Development

This chapter shows the universe of alternatives assessed within this study, defines key characteristics of the service alternatives that will be subjected to further analysis.

3.1. Key Takeaways

To inform the advancement of a transit alternative along the study corridor, this chapter reviews a wide range of potential options in terms of mode and equipment used, service routes, and headways or frequencies. For each of these major items, insights from previous studies are discussed, followed by a formal recommendation regarding which mode, equipment, service routes, and headways will be subjected to further detailed analysis within this study. The list below outlines the most salient insights from the Alternatives Development process:

TRANSIT MODE/EQUIPMENT

- Determination of Urban Rail as the most feasible mode
  - Light Rail was considered, but dismissed due to limited possibilities for integration into the existing light rail network, complex grading geometries, existing uses need for physical and temporal separation from other modes, and Right-of-Way limitations.
  - Commuter Rail was dismissed due to headway restrictions, long and heavy trainsets, potential diesel-emissions, and noise impacts to the surrounding neighborhood.
- Desire to avoid the use of fossil fuels, with potential equipment options consisting of either Electric Multiple Unit (EMU) or Battery-EMU (B-EMU) trainsets.

TRANSIT SERVICE ROUTE & FREQUENCY

- This study's subsequent Demand Analysis and Infrastructure Improvements tasks will assess the potential of new passenger service operating along two alignments:
  - Core Route between West Station and North Station
  - Extended Route linking communities further north (Everett, Chelsea, Revere and Lynn) with a future West Station via the Grand Junction, additional trackage, and the Newburyport / Rockport Line
- Proposed alternatives will vary service frequency along the Core Route, with trains every 15 minutes (option "a") or every 17.5 minutes (option "b"). The second alternative will use the same Core Route variations while also layering additional trips between West Station and Lynn via the Extended Route.
  - Alternative 1a – Every 15 minutes along Core Route
  - Alternative 1b – Every 17.5 minutes along Core Route
  - Alternative 2a – Every 15 minutes along Core Route, 30 minutes along Extended Route
  - Alternative 2b – Every 17.5 minutes along Core Route, 30 minutes along Extended Route
- Need for the proposed new service to work without major grade crossing and traffic disruptions.

3.2. Feasibility Assumptions Inherent to Alternatives Development

Based on past explorations of transit on Grand Junction, this study is limited to alternatives that contemplate the use of Rail.

The scope also limits the potential universe to a collection of Rail-based alternatives that use a two-track layout. Based on a review of parcel dimensions and available ROW, there simply is not enough room available to house a third-track segment. As documented in previous studies, a relatively consistent right-of-way (ROW) width of at least 60-65 feet (as noted by IBI Group) or 68 feet (as suggested by the Cambridge Bicycle Committee) would need to be maintained to adequately accommodate a three-track layout.

In addition to the need to accommodate existing and potential rail uses by others (e.g., passenger rail equipment moves by MBTA and Amtrak, enduring or "legacy" rights of access for freight carriers), there is also the need to allow for the future implementation of the City of Cambridge's planned Multi-Use Path Project, which is currently in design.

In addition, only Federal Railroad Administration (FRA)-compliant vehicles are considered (i.e., the use of non-compliant vehicles is inherently out of scope). This intentional limitation is intended to prevent the advancement and further analysis of alternatives that would inevitably interrupt existing passenger and/or freight services, and ultimately prove challenging to implement.

Since legacy freight rights will endure until ceded by the carrier (CSX) and physical separation (explained in the next section) does not appear to be achievable within the existing ROW, the assumed need to avoid the use of non-compliant vehicles for a new passenger rail service effectively narrows the potential universe of alternatives even further (e.g., Light Rail Transit becomes less competitive since it would only be able to achieve FRA-compliant operations via temporal separation (without requiring additional ROW)).

3.3. FRA Compliance

"FRA Compliance" requires multiple elements of the system be in accordance with the specific regulatory sections codified by the FRA. While there are many sections within the federal code, the following design-oriented topics, among others, must be addressed:

- Vehicle occupant safety (both passenger and crew)
- Vehicle stop capability and braking system
- Vehicle performance through curves and maximum speed ranges
- Vehicle crashworthiness standards
    - For Freight, Commuter Rail, and Intercity Passenger Rail cars, vehicle frames must achieve a minimum of 800,000 lbs. of buff strength.
    - Other Rail-based Transit vehicles (i.e.., those found within the MBTA Rapid Transit network) typically have a buff strength of half that value.
- Meeting requirements for having a horn, a bell, an approved headlight and ditch light arrangement, proper design of stairs and grab bars, etc.

When such Other Rail-based transit vehicles are proposed to operate along a shared corridor (i.e., one that also allows higher buff strength Commuter Rail, Intercity Passenger Rail, and/or Freight services), the operating environment must rely on at least one of the forms of separation described in Table 21.

Table 21. Forms of Separation Capable of Achieving FRA Compliance

FORM OF SEPARATION	Temporal	Physical
Method	Isolates the rail line for a specific period of time for use by a given vehicle class (e.g., Rapid Transit during day, other uses at night)	Dedicates a specific track to a vehicle class in order to fundamentally separate vehicles with different buff strengths
Effects	• Expensive in practice, as it requires extraordinary cooperation with all operators, multiple times a day • Unlikely to be tolerated by existing operators	• To preserve freight rights and accommodate the continued movement of Commuter Rail and Intercity Passenger vehicles to/from maintenance facilities, while also integrating a new Grand Junction service using vehicles of a different buff strength, one track would need to be set aside for each use. • In the absence of a third track, a new Grand Junction-based service would be relegated to single-track operations, which would fail to offer riders with a reliable and time-competitive alternative to existing services (e.g., EZRide shuttle).
Applicability to the Grand Junction	• Limited applicability, as it does not address how a new service would reach key MBTA terminals (e.g., North Station)	• Limited applicability, as there are fundamental right-of-way limitations relative to the existing trackage (e.g., existing research labs, restaurants, etc.), particularly in light of the multi-use path currently under design by the City.

Although the use of non-compliant vehicles along the Grand Junction is theoretically feasible, existing use of the corridor by higher buff strength vehicles, such as those depicted in Figure 24, effectively precludes the introduction of lower buff, Rapid Transit-like vehicles along the rail corridor.

Figure 24. MBTA Commuter Rail Train Traversing At-Grade Crossing at Main Street (Credit: Transport Kendall)

3.4. Mode, Vehicles, and Equipment

As documented in Task 1, previous studies have identified a broad realm of approaches to initiating new passenger rail service along the Grand Junction. Table 22 offers a comprehensive overview of the various modes and equipment combinations assessed over the past two decades. For additional information, background, and detail concerning the nature of these concepts, please consult Chapter 1 (*Previous Studies, Projects and Initiatives*).

3.4.1. Concepts Previously Assessed

Bus Rapid Transit (BRT)

Aside from the scope-based rejection, the provision of BRT service along a rail corridor that will continue to host freight and/or passenger rail-based movements for the foreseeable future would constitute a non-compliant alternative in the absence of physical separation. Given the future implementation of the City's multi-use path, , sustained use of the existing rail, and the limits of the existing ROW, and neighboring land ownership, there would not be sufficient width to accommodate a two-way BRT service alternative along the Grand Junction corridor, as previously identified in other studies.

Beyond the regulatory hurdles and significant stakeholder impacts, the capital costs associated with simply removing the existing rail along the Grand Junction would be relatively high. When considering the additional capital outlay required to actually pave the way for a two-way BRT service, such an approach ultimately becomes less cost-effective when compared with other alternatives that would not entail such a structural change.

As it would require its own operating envelope when adjacent to active railroads, BRT would also limit the extent of service alternatives further north. Given the narrow width of the MBTA Commuter Rail's (CR) Newburyport/Rockport Line, which would not be sufficient to house both the existing CR and a proposed bus-based alignment, BRT service alternatives that operate north of Sullivan Square would not be possible within the confines of the existing state-owned ROW.

Furthermore, as BRT fixed guideways are typically made of impervious surfaces (e.g., concrete), such a standard approach would ultimately lead to an increase in the percent of impervious cover within the 100-year floodplain.

Figure 25. Modes – Bus Rapid Transit: MBTA Silver Line BRT, Boston, Massachusetts (Credit: Wikimedia; User Pi.1415926535 https://en.wikipedia.org/wiki/File:MBTA_route_SLW_bus_approaching_World_Trade_Center_station,_March_2017.JPG)

Table 22. Modes Considered in Previous Studies

STUDY \ MODE CONSIDERED	Commuter Rail	Urban Rail	Diesel Multiple Units	Heavy Rail Transit (Underground Tunnel)	Light Rail Transit	Bus Rapid Transit
Silver Line Extension (SLX) Alt. Analysis (MassDOT)						X
West Station Area Transit Study (MAPC)		E				X
MBTA Rail Vision (MBTA \ MassDOT OTP)		E				
GoBoston 2030 (City of Boston)						X
Transport Kendall (Kendall Square Mobility Task Force)		X				
Grand Junction Feasibility Review (City of Cambridge)	X	D	C, N			X
Better Rapid Transit for Greater Boston (Greater Boston BRT Study Group)						X
Grand Junction Preliminary Operations Plan for Urban Rail (R. Burckardt)		D	C			
MIT Property Feasibility Study (MIT)						
Grand Junction Transportation Feasibility Study (MassDOT \ CTPS)	X					
Grand Junction Transit Expansion (MIT \ MS Engineering Studio)	X		C, N	X	X	X
Grand Junction Branch Line Study (MIT)	X		C			
Urban Ring (MassDOT)						X
Grand Junction Improvement Options (Harvard University)	X	D	C			X
Grand Junction Rail with Trail (City of Cambridge)	X					

X = Considered
D = Considered as Diesel-based
E = Considered as Electric
C = Considered as FRA-compliant DMUs
N = Considered as Non-compliant DMUs

Light Rail Transit

Although it is a rail-based mode, the application of Light Rail Transit (LRT), such as the MBTA's existing Green Line service (Figure 26), along the Grand Junction would still face a host of regulatory, physical, and financial challenges before arriving at an alternative that neatly ties in with existing transit offerings in the region while honoring recent developments along the corridor.

Figure 26. Modes – Light Rail: MBTA Green Line, Greater Boston, MA (Credit: Wikimedia; User Pi.1415926535 https://en.wikipedia.org/wiki/File:Type_9_on_Reservoir_yard_leads,_March_2022.JPG)

Since LRT contemplates the use of passenger equipment that would fall into a different FRA vehicle classification than the rail equipment already moved along the corridor (i.e., freight trains, Amtrak passenger coaches, and MBTA Commuter Rail coaches), a new FRA-compliant LRT service would only be achieved via temporal or physical separation as outlined above.

If two additional LRT tracks cannot be accommodated alongside the existing track(s) and the under design multi-use path, then Physical Separation should not be considered a viable option. Although Temporal Separation could still be considered feasible, such an approach would, nevertheless, constrain the range of operating windows and service patterns that could otherwise be achieved with the use of compliant vehicles.

While battery-catenary LRT systems have begun to emerge (e.g., Australia's Parramatta Light Rail), current approaches to LRT within the MBTA Rapid Transit Network categorically rely on the use of overhead catenary systems (OCS). If developed to meet the current fleet, implementation of LRT along the Grand Junction would rely on the construction of OCS along the entire extent of the corridor. Putting aside the incremental capital costs associated with implementing OCS to enable LRT service, which would be considerable, such equipment would still need to be housed along a width-constrained rail corridor abutted by existing institutional, commercial, and residential structures.

At a practical level, the ability for a Grand Junction-based LRT service to physically tie-in with existing transit services is relatively limited at either end.

Headed north from Medford / Gore Street, the corridor passes through a sharp eastbound horizontal curve and beneath McGrath Highway / Squires Bridge en route to connecting to the Outbound track of the Fitchburg Line (an Inbound connection does not presently exist). In this area, the Green Line Extension descends from an elevated profile to an at-grade alignment in order to pass beneath the same roadway bridge en route to Union Square (Figure 27). Within the vicinity of where these tracks would logically connect, the Fitchburg Line trackage lies adjacent to, but substantially beneath, the Green Line's elevated transition, with one intervening stub track (at-grade with Fitchburg Line). If the horizontal and vertical profile of the Green Line's underpass segment (and the presence of the McGrath Highway Overpass that ultimately constrains them) are to be taken as fixed design elements, then a direct tie-in with the Green Line Extension should not be considered feasible. As the horizontal curve begins just north of Medford Street, providing a more indirect tie-in with the Green Line by turning west towards Union Square and then reversing direction, would require the acquisition of substantial land within the City of Somerville in order to house the associated railroad infrastructure.

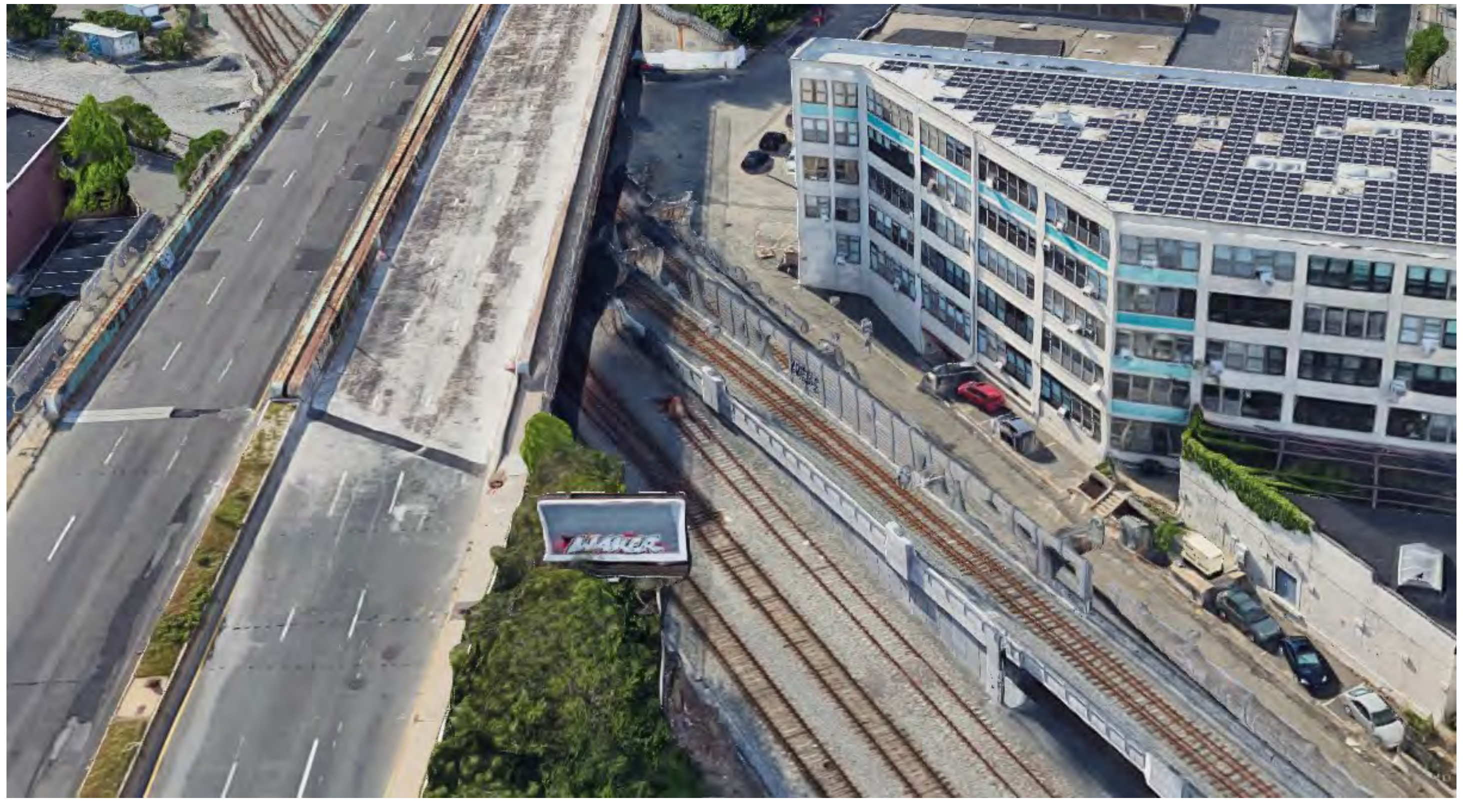


Figure 27. Modes – Light Rail: Challenging Tie-Ins to the North Amidst Elevated Green Line Extension and Elevated McGrath Highway (Credit: Google Earth)

The portion of the corridor south of the BU Bridge, explored in further detail within Back Bay/Lansdowne – North Station ("Completing the Wye") on page 3-14, also presents a complex, constrained, and capital-intensive engineering challenge for potential Green Line connections.

Heavy Rail Transit (via an Underground Tunnel)

Similar to Light Rail, Heavy Rail Transit (HRT), such as the MBTA's existing Red Line service (Figure 28), is a rail-based mode that would face several major physical and financial challenges that effectively preclude its consideration as a feasible mode for new transit service along the Grand Junction.

A 2012 MIT study considered the potential impacts of a grade separated or tunneled passenger rail service on the Grand Junction corridor. While the study concluded that a tunnel could be expected to resolve many issues associated with operating new service in the corridor, it "would be a massively expensive undertaking accompanied by significant disruptions" in the area, with impacts to the communities along the corridor. Costs estimates developed in 2012 for a tunneled alternative were estimated to be in the hundreds of millions of dollars. Based upon this previous analysis and the understanding that costs would be higher given the conceptual level of investigation, it is reasonable to assume that an underground tunnel option would be cost-prohibitive.

An alternative to a fully tunneled option, which could potentially lower the overall cost, along with the duration and level of construction impacts, would be a partial underground tunnel. Such an approach would develop a smaller segment of the Grand Junction corridor as a tunnel, as opposed to the entire corridor. However, given the slope guidelines for HRT vehicles, the overall length of the corridor and the distance between existing at-grade crossings, the avoidance of which would be one of the primary reasons for tunneling, the corridor is too short to support a partial underground tunnel option.

Figure 28. Modes –Heavy Rail: MBTA Red Line, Boston, MA (Credit: Wikimedia; User Pi.1415926535 https://en.wikipedia.org/wiki/Red_Line_%28MBTA%29#/media/File:Inbound_train_arriving_at_Charles_MGH_station,_July_2019.JPG)

Commuter Rail

Several previous analyses investigated the potential for MBTA Commuter Rail trains (Figure 29) to service the Grand Junction corridor. First and foremost, the Commuter Rail option is FRA compliant, a critical, and required component of any option that would be subjected to further analysis within this study. A Commuter Rail alternative could also interline with existing rail operations and provide improved opportunities for crossing the Mystic River (e.g., via the existing bridge along the Newburyport/Rockport Line). Having the capacity to integrate with existing rail offerings improves the long-distance viability for travel along the Grand Junction corridor and could help facilitate travel between Cambridge and communities further north.

While these benefits elevate this alternative above some of the others, there are also restricting factors that limit the viability of Commuter Rail as a feasible alternative for the Grand Junction corridor. As currently operated, a Commuter Rail alternative would offer less frequent service for riders than some of the other options, particularly the BRT and LRT alternatives. Due to the nature of this service type, there would be few, if any, opportunities for integration with more locally oriented transit connections, particularly the

Green Line and other Rapid Transit services, which serves to limit the appeal of operating a new rail service along such a densely populated corridor.

Commuter Rail trainsets are also typically longer than other rail transit consists, resulting in constraints due to vehicle length in a heavily populated, dense, urban environment. Longer and heavier trainsets could also pose challenges in the form of a heightened safety risk for non-rail occupants (e.g., those walking and biking) and increased delays for drivers near at-grade crossings that would be associated with additional gate downtime.

Figure 29. Modes – Commuter Rail: MBTA, Greater Boston, MA (Credit: Patricia Harris / Boston Globe)

Diesel Multiple Unit (DMU) Trains

A DMU consists of a diesel-fired combustion locomotive attached to several passenger traincars, as shown in Figure 30. This is the same type of technology employed by the MBTA throughout Greater Boston to operate its Commuter Rail service concept. DMUs are a known emitter of noxious mobile-source emissions, including nitrogen oxides, sulfur oxides, particulate matter, carbon dioxide, carbon monoxide, hydrocarbons, and other greenhouse gases. Community engagement efforts conducted within previous studies consistently raised quality of life concerns pertaining to the nuisance imposed on the physical environment (noise, vibration, air) by diesel-based operations and idling.

Given the inherent reliance on diesel fuels for operation of DMU trainsets, and the known pollutants associated with that operation, opportunities for the MBTA and the City of Cambridge to orient themselves towards a sustainable and resilient future while utilizing these types of vehicles are significantly limited, if not fully precluded. The use of diesel fuels on the corridor would be in direct opposition to the City of Cambridge's stated commitment to limit the use of fossil fuels and move towards a net zero transportation network. Pursuing a diesel-based rail alternative is unlikely to generate a new service that is well-received and supported by local stakeholders.

Furthermore, a diesel-based approach along a new passenger line would run counter to state climate goals and the MBTA Fiscal Control Board's previous formal endorsement of an all-electric, high-frequency urban rail network (Alternative 6). In fact, previous Rail Vision scenario modeling indicated a higher-frequency network operated by DMUs might lead to more pollution generated than avoided.

Figure 30. Equipment – Diesel-Based Multiple Unit Train (Stadler Fast Light Intercity and Regional Train (FLIRT)): TEXRail, Dallas-Fort Worth, TX

3.4.2. Recommendations for Further Analysis within This Study

Urban Rail

Developing rail transit connecting commercial and residential hubs throughout Greater Boston will require introducing an emerging service concept in the region: Urban Rail. While this service would be operated with trains that look like Green Line trains, the equipment would be FRA compliant, thereby allowing it to operate on existing Commuter Rail tracks. This is especially important in locations where the existing right-of-way is constrained (e.g., bridge crossing). While an Urban Rail service along the Grand Junction would not be directly integrated with other Rapid Transit lines, it would provide new rail transit access to rapidly expanding areas like Kendall Square and Allston Landing, as well as residential communities that currently lack proximate access to rail transit.

While this concept would be new to the region, there are numerous examples of Urban Rail operations throughout the United States and internationally. Urban Rail trainsets are typically shorter in length than traditional commuter rail consists, making them more appropriate for an urban setting. They often feature frequent service (i.e., headways of 15 to 20 minutes) and equipment that operates on either combustion of liquid fuels (e.g., diesel) or electricity. This section further discusses the implementation of Electric Multiple Unit (EMU) trains and Battery-Electric Multiple Unit (B-EMU) trains.

In prior planning processes, the community expressed significant concerns about the negative impacts this equipment type would have on multi-modal circulation at grade crossings, as well as the noise, vibration and air quality impacts that would result. Informed by previous outreach efforts along the corridor, this study has ruled out extending traditional diesel-based, six-car Commuter Rail service to serve the Grand Junction. With clear decarbonization mandates from the Commonwealth and proposed legislation to mandate timelines for electrifying the Commuter Rail system at-large, initial passenger service provided by electric-powered equipment is cost-effective, climate-conscious, and community-sensitive when compared to a future retrofit of diesel-based equipment.

Electric Multiple Unit (EMU) Trains

Electric Multiple Unit (EMU) trains provide significant benefits compared to DMUs or locomotive-hauled units. EMU trainsets generate less noise and vibration as they travel, which is a particular benefit adjacent to residential land uses, sensitive assets such as research facilities and laboratory spaces, or when operating service in the early morning or late-night hours. Because of its electric power source, there are no mobile-source emissions generated as the train operates. Additionally, these trains can safely accelerate more rapidly, allowing for reduced station dwells and gate down-time, as well as a smoother ride for passengers, compared to diesel-based alternatives.

Like the current Green Line system, operating EMUs on the Grand Junction would require new electrical infrastructure to be installed. These trains receive power through overhead catenary equipment, powered by substations along the electrified corridor (see Figure 31). This electrical equipment would need to be sited within the rail ROW, presenting an additional consideration in designing track configurations and platforms that respond to the future implementation of a Grand Junction multi-use path. Long-term costs associated with maintaining and repairing this infrastructure would also need to be considered.

Figure 31. Equipment – Electric-Based Multiple Unit Train (Stadler FLIRT 160): (Credit: Stadler)

Battery-Electric Multiple Unit (B-EMU) Trains

Battery-Electric Multiple Unit (B-EMU) trains are an emerging mode that allows for discontinuous electrification – a concept currently being considered by the MBTA's Office of Rail Transformation as it sets forth to implement the service patterns recommended through *Rail Vision*.

Similar to EMUs, these trains also operate with no mobile-source emissions and reduced noise and vibration compared to diesel-powered equipment. However, this equipment avoids the right-of-way hurdles associated with the need to develop continuous OCS in a dense urban corridor, with the potential to operate "off-wire" along shorter segments (Figure 32). This approach can lower capital costs and overcome challenging obstacles like moveable bridges, low-clearance overhead structures, and tunnels more easily.

Though B-EMUs still require some degree of electrical infrastructure for re-charging the batteries, this infrastructure may be able to be clustered closer to the termini instead of broadly distributed across the entire length of the rail corridor, potentially reducing challenges associated with consistently siting the electrical infrastructure within the rail right-of-way.

Current B-EMU technology provides for approximately 80 miles between charges, with a 15-minute recharging time via OCS at the terminals, which could be a limiting factor in service planning. While this technology is more prominent internationally, CalTrain announced it would be launching a first-in-the nation pilot of B-EMU technology in August 2023. [8]

[8] Caltrain to Pilot First-in-the-Nation Bi-Level Dual Electric and Battery Powered Train to Expand Zero-Emission Service (2023)

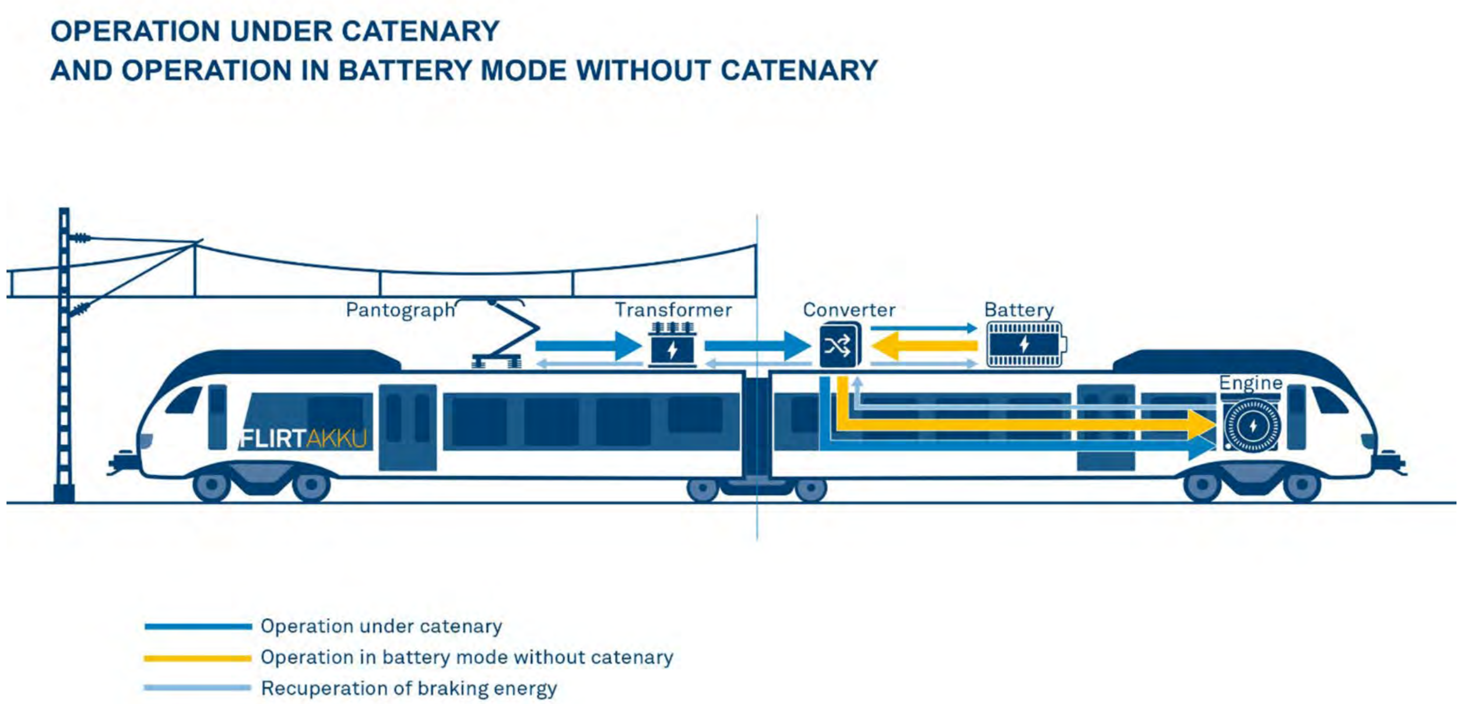


Figure 32. Equipment – Battery-Electric Multiple Unit Train (Stadler FLIRT AKKU): (Credit: Stadler)

3.5. Service Route and Market Considerations

3.5.1. Concepts Previously Assessed

A summary of service patterns and markets served within the concepts previously proposed is shown in Table 23 and Figure 33. It should be noted that some of the connections indicated were assessed for non-Rail transit modes (e.g., Urban Ring's BRT connection between Sullivan Square – Longwood/Ruggles).

In reviewing the previous planning efforts, the most frequently studied service pattern would connect North Station – West Station, followed by North Station – Riverside/Auburndale/Worcester. Although westerly connections to Riverside/Auburndale/Worcester from North Station would fulfill *Rail Vision's* high-level goal of providing Urban Rail service between points within Route 128 and downtown Boston, this specific market pair was not explicitly identified as one of that plan's priority corridors.

Prior to the state's current pursuit of South Station Expansion, many of the older reports focused on creating an extension of the MBTA Commuter Rail's Framingham/Worcester Line via the Grand Junction corridor that would allow a portion of the Line's six-car consists to serve North Station instead of South Station.[9] More recent studies tended to focus on providing a new shuttle service along the Grand Junction via diesel- or electric-based multiple unit trains, which would allow for potential tie-ins with the existing Commuter Rail system. There has been little to no investigation of market ties between the study area and communities further north (e.g., Everett, Chelsea).

Connections to the communities located north of the MBTA's North Side CR maintenance facility (e.g., Chelsea, Everett, Revere, and/or Lynn) have not been studied in-depth, particularly with respect to the feasibility of a rail-based transit offering. However, *Rail Vision* identified future Urban Rail connections between Lynn and downtown Boston as a priority corridor.

[9] MBTA has always envisioned a Grand Junction service pulling into North Station by using Tracks 11 and 12, along with Platform 6, all of which are anticipated to come with the North Station Draw One Bridge Replacement project.

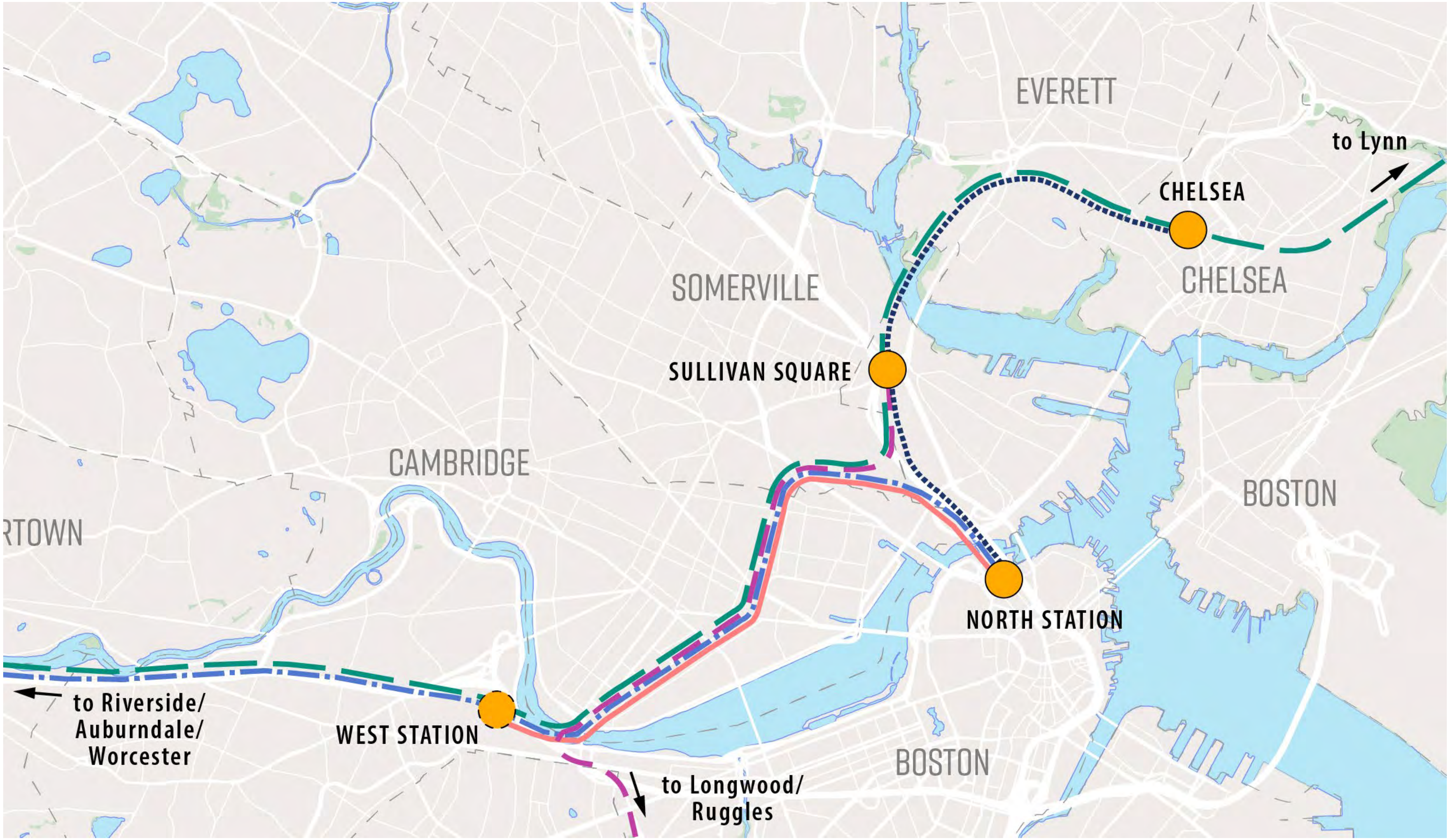


Figure 33. Service Routes Assessed within Previous Studies

Table 23. Service Routes Considered in Previous Studies

NORTHERN TERMINUS	North Station	Sullivan Square	North Station	Lynn / Chelsea / Everett	Chelsea / Everett
SOUTHERN TERMINUS	West Station	Longwood / Ruggles	Riverside / Auburndale / Worcester	West Station / Riverside	North Station / Kendall Square
Silver Line Extension (SLX) Alternatives Analysis (MassDOT)					X
West Station Area Transit Study (MAPC)	X				
MBTA Rail Vision (MBTA \ MassDOT OTP)	X				
Transport Kendall (Kendall Square Mobility Task Force)	X		X	X	
Grand Junction Feasibility Review (City of Cambridge)	X	X	X		
Better Rapid Transit for Greater Boston (Greater Boston BRT Study Group)		X			
Grand Junction Preliminary Operations Plan for Urban Rail (R. Burckardt)	X				
Grand Junction Transportation Feasibility Study (MassDOT \ CTPS)			X		
Grand Junction Transit Expansion (MIT \ MS Engineering Studio)	X		X		
Grand Junction Branch Line Study (MIT)			X		
Urban Ring (MassDOT)		X			
Grand Junction Improvement Options (Harvard University)	X		X		
Grand Junction Rail with Trail (City of Cambridge)	X				

3.5.2. Recommendations for Further Analysis within This Study

As reviewed in Table 23 and Figure 33, previous studies primarily investigated a Rail-based option between the future West Station and North Station (i.e., this study's "Core Route"). In developing a range of alternatives for an "Extended Route" to investigate further within this study, extensions from the Core Route (West Station – North Station) should focus on the access and mobility benefits from these services in terms of both existing demand (i.e., trips that would shift from other modes or services) and incremental ridership associated with trips stemming from new developments in and around the service corridor.

For example, a possible extension to Everett, Chelsea, Revere and Lynn could provide improved connectivity and transit travel times for existing riders of other services, as well as new connection to areas where development potential exists. Such an approach would offer transit connectivity to Kendall Square (a technology and employment hub) while also allowing for an incremental increase in ridership. In addition, by further spreading the benefits of capital investment in transit infrastructure beyond the cities of Cambridge and Boston, introducing new connections north of the Mystic River would expand the proverbial table of support for future implementation efforts.

The following list defines the universe of markets and connections considered within this study. To help put these connections into their regional transportation context, a summary graphic of the existing regional transit network is offered in Figure 34.

- West Station – North Station
- West Station – Everett/Chelsea/Revere/Lynn
- Back Bay/Lansdowne – North Station ("Completing the Wye" with the Worcester Commuter Rail)
- Riverside – North Station
- Riverside – Everett/Chelsea/Revere/Lynn

The remainder of this section reviews potential approaches to developing new transit connections between these existing rail stations and offers reasoning as to the feasibility and desirability (or lack thereof) of providing a new service link between these specific market pairs.

West Station – North Station

Numerous previous studies focused on the development of a new Rail-based transit connection linking the future West Station with North Station. In terms of transportation and development connections, such an approach would provide riders the potential to transfer between the existing Red Line service that anchors Kendall Square and other transit services and destinations accessible from either end, including those listed below.

- North Station
  - MBTA Commuter Rail – Four Lines
    - Newburyport/Rockport
    - Fitchburg
    - Haverhill
    - Lowell
  - MBTA Rapid Transit
    - Green Line – Two Branches
      - D – Union Square – Riverside
      - E – Medford/Tufts – Heath Street
    - Orange Line – Oak Grove – Forest Hills
  - Amtrak Intercity Passenger Rail – Downeaster
- West Station
  - MBTA Commuter Rail – One Line
    - Worcester/Framingham
  - West Station Bus Facility

However, the ultimate timing for realizing such a service is fundamentally contingent on the implementation schedules of the two regional infrastructure projects (Allston Multimodal Interchange and MBTA North Station Draw One Bridge Replacement) that lie at either end. Although the Allston project has recently received a $335.4 million federal grant, since neither of these efforts has developed a detailed financing plan, final construction timelines and durations have not yet been established. While a temporary southern terminus may be possible as an interim alternative in the event of delays to MassDOT's West Station (e.g., in Cambridgeport before the river crossing), this service route fundamentally relies on the completion of the MBTA's Draw One Bridge Replacement project. That effort is anticipated to resolve existing capacity limitations associated with the Charles River crossing (North Draw One) and the North Side terminal by constructing a third span with two new tracks (50% increase in spans, 50% increase in trackage) and establishing a sixth platform at North Station (20% increase in terminal capacity).

Based on current visions for MassDOT's Allston Multimodal Project, this study anticipates that the future West Station will be constructed in Allston on the site of the former CSX Beacon Park Yard, and will provide the infrastructural foundations necessary to eventually support cross-platform transfers between Worcester CR mainline trains and future Grand Junction-based rail services. Similarly, recent engineering studies conducted in support of the MBTA's North Station Draw One Bridge Replacement Project contemplate the integration of future Grand Junction-based rail services within the context of the overall implementation program (i.e., improvements to both North Station and the adjacent drawbridge spans) will eventually enable Grand Junction-based trains to reach the North Side terminal via a reinvigorated Platform 6. Grand Junction service at North Station was examined in several *Rail Vision* alternatives and was discussed in March 2024 by the MBTA in the context of Traction Power Planning for Regional and Urban Rail Services.

Aside from the Grand Junction trackage located within the City of Cambridge and the two terminals, connecting a future West Station to North Station would entail use of the facilities listed below.

- State-owned railroad bridge over the Charles River leading towards the Allston neighborhood
- Grand Junction trackage within the City of Boston leading towards future West Station
- Grand Junction trackage within the City of Somerville leading towards North Station
- MBTA CR Fitchburg Line tracks in Somerville and Boston that lead towards North Station (only one of the two tracks (Outbound) is currently configured to facilitate direct transitions between the Grand Junction trackage and connections at North Station)
- MBTA North Station Draw One Bridge in the City of Boston

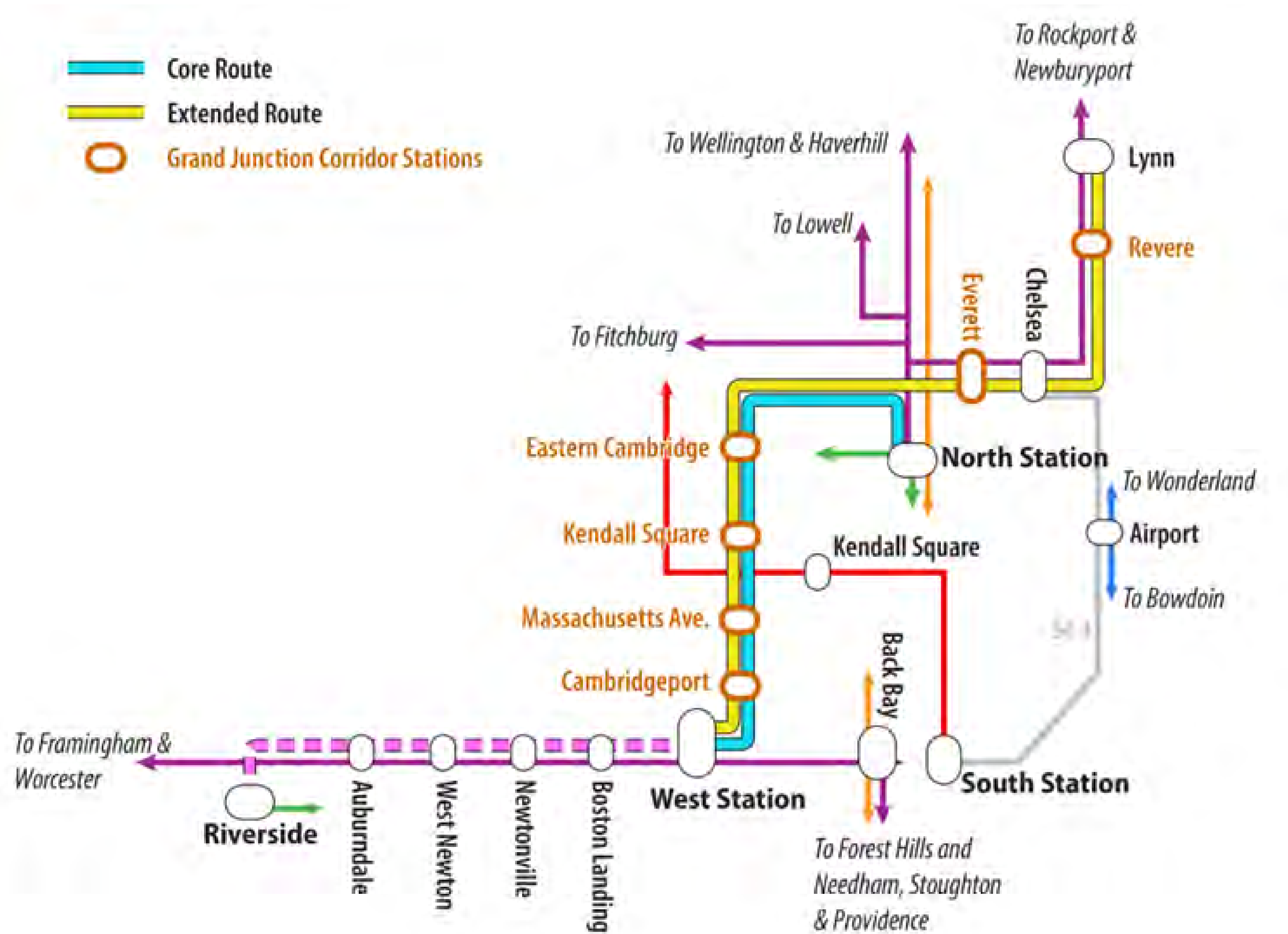


Figure 34. Conceptual Map of the Universe of Potential Service Routes

West Station – Everett/Chelsea/Revere/Lynn

As noted previously, a North Station – Lynn connection was identified as a priority corridor for the establishment of new Urban Rail service within the MBTA's *Rail Vision* study. As developed within that study, such a service would link the various Environmental Justice communities located north of the Mystic River and adjacent to the MBTA Commuter Rail's Newburyport/Rockport Line with high-frequency access to downtown Boston and North Station's numerous transit connections. Within *Rail Vision*, such a North Station-bound service would utilize the Newburyport/Rockport Line ROW and then cross the North Station Draw One Bridge to reach the North Side's base of operations.

Alternatively, a West Station-bound approach would make use of the trackage leading around the Boston Engine Terminal (MBTA Commuter Rail's North Side Vehicle Maintenance Facility) in order to link communities along the Newburyport/Rockport Line with the Grand Junction corridor and the Red Line services at Kendall Square. Such an approach would connect the transit services listed below.

- Commuter Rail Stations in Chelsea, Revere and Lynn
    - SL3 Station – Chelsea
    - Blue Line Station – Revere
    - Bus connections at Chelsea, Revere, and Lynn
    - MBTA Commuter Rail – One Line
        - Newburyport/Rockport
- West Station
    - MBTA Commuter Rail – One Line
        - Worcester/Framingham
    - New MBTA Bus Hub above the rail terminal

In terms of markets served, a West Station – Everett/Chelsea/Revere/Lynn connection would offer Environmental Justice communities north of the Mystic River access to a wealth of opportunities near downtown Boston (a strong theme identified within *Rail Vision*) and also facilitate direct access to other opportunities and transit services anchored at Kendall Square and/or Allston's future West Station. Aside from the fact that integrating stops at Sullivan Square and Assembly Square would be technically challenging, markets adjacent to these stations already reap the benefits of high-frequency transit. Thus, servicing these two stations with a new Grand Junction-based offering would likely offer smaller incremental benefits to these Orange Line-adjacent Environmental Justice communities compared to those north of the Mystic River who currently lack access to high-frequency transit services.

Beyond the Grand Junction trackage located within the City of Cambridge and elements associated with reaching West Station (already identified above), connecting a future West Station with Environmental Justice communities in Everett, Chelsea, Revere and Lynn would entail use of the existing facilities listed below.

- Grand Junction trackage within the City of Somerville
- Brief segment of the MBTA CR Fitchburg Line tracks in Somerville leading towards the Boston Engine Terminal (only the Outbound track is currently configured to facilitate direct transitions)
- Single crossover, which is sited near Life Storage in the City of Somerville, to transition between the Fitchburg Line and Grand Junction trackage in order to reach destinations further north
- Trackage within the City of Somerville that leads east and then north, moving between two MBTA maintenance facilities (Inner Belt Carhouse to the west, North Side Commuter Rail Maintenance Facility to the east)
- Trackage within the City of Boston that leads north towards the Orange Line's Sullivan Square Station (i.e., a segment of double-track situated directly west of the Orange Line's trackage commonly referred to as the "third and fourth iron")
- Trackage associated with the MBTA Commuter Rail's Newburyport/Rockport Line, located in various municipalities, to reach stations north of the Mystic River, including its bridges over the Mystic River, Chelsea Creek and waterbodies associated with the Rumney Marsh Area of Critical Environmental Concern

Aside from these existing facilities, developing a West Station-bound connection to Everett, Chelsea, Revere and Lynn would also require new track elements (e.g., crossovers, interlockings, signals, etc.) that enable trains to transition across the Orange Line Rapid Transit ROW to reach the Newburyport/Rockport Line's ROW (located on the opposite side of the Orange Line from the third and fourth iron) within the vicinity of the station at Sullivan Square. Given that the City of Everett lacks a rail station, providing a station stop in that community would require constructing a new rail station. Such a station would, however, provide the opportunity to capture an untapped market for rapid transit.

Other Service Concepts Dismissed as Comparatively Not Worthy of Further Assessment

Back Bay/Lansdowne – North Station ("Completing the Wye")

One previously proposed concept, which was not examined in detail within previous studies and is colloquially referred to as "Completing the Wye," contemplated creating a Green Line loop by extending the LRT corridor southward along the Grand Junction ROW from Red Bridge Junction in Somerville, across the existing bridge over the Charles River, and up to the Green Line's B Branch along Commonwealth Avenue in Boston's Allston neighborhood near Boston University. However, complications lie on the other side of the Charles River.

Towards the south, connecting to the existing B Branch would be a technical feat, likely exert significant impacts to local and regional mobility during the construction period, and could prove cost-prohibitive given the complexity of weaving a new transit alignment into the fabric of the existing transportation infrastructure near the bridge's landing in Allston. As shown in Figure 35, the grade of the landing of the rail bridge over the river relative to those of Storrow Drive, I-90 (partially elevated), Commonwealth Avenue (fully elevated), the MBTA CR's Framingham/Worcester Line, and the vehicular-based BU Bridge represents a very complex multimodal transportation environment.

If utilizing the existing track alignment, the current interchange would require that train traffic exiting the Grand Junction travel some distance toward Boston Landing Station before reversing back toward Lansdowne and Back Bay. The study team anticipated that such a push-pull operation alone would add an extra 10 minutes of travel time, which could complicate existing operations on the Worcester Line.

Figure 35. Multi-Dimensional Complexities Constrain the Range of Approaches to Transit Tie-ins South of the Charles River, Boston, MA (Credit: Google Earth)

Temporary Southern Terminus at Boston Landing

West of Allston's future West Station, the corridor continues as a single-track freight segment situated between a double-track Worcester / Framingham Line to the south and I-90 to the north. The single-track segment continues until just west of the center platforms at Boston Landing station. Although the study team initially pursued investigating Boston Landing as a contingency southern terminus (in the event of long-term delays in the build-out of West Station), discussions with MBTA Railroad Operations revealed that this trackage is actively being rebuilt as part of the on-going campus Allston campus development. In addition, the MBTA noted that the segment of trackage between Boston Landing and West Station is anticipated to play a key role in the future rail network by facilitating meets / overtakes for planned zonal express services.

Riverside – North Station

A Riverside – North Station connection would represent a westerly extension of the West Station – North Station option, with the service stopping at existing Commuter Rail stations along the Worcester Line in Boston (Boston Landing) and Newton (Newtonville, West Newton and Auburndale), ahead of reaching the Green Line D Branch's southern terminus at Riverside Station. Such an approach would connect the transit services listed below.

- West Station
  - MBTA Commuter Rail – One Line
    - Worcester/Framingham
  - New MBTA Bus Hub
- Commuter Rail Stations along the Worcester Line
  - Four additional stations served (Boston Landing, Newtonville, West Newtown and Auburndale
- Riverside Station
  - Green Line D Branch (service towards Union Square in Somerville)

In terms of markets served, a Riverside – North Station connection by way of the Worcester Line and the Grand Junction would largely overlap with existing services and fail to offer a travel time competitive with existing services. Furthermore, given that the alignment would traverse three of the Commonwealth's most prosperous municipalities, such an approach to establishing new rail service along the Grand Junction would provide further transit-related benefits to areas with relatively limited shares of Environmental Justice communities.

Beyond the Grand Junction trackage located within the City of Cambridge and elements associated with reaching West Station and North Station (already described above), connecting a future West Station with Riverside Staton would rely on the existing facilities listed below.

- MBTA CR Worcester Line trackage within the City of Boston and Newton that leads west towards the intersection of I-90 and I-95/Route 128
- MBTA Green Line trackage (one existing track) and infrastructure (crossover near Mile Post 10.8) that allows trains to transition between the two-track Worcester Line and the single-track segment leading towards Riverside Station

The existing interface between the Green Line and the CR trackage would likely need to be upgraded (addition of another lead-in track, more robust interlocking, signals, etc.) in order to provide reliable movements for both the new Grand Junction service and Commuter Rail operations along the Worcester Line.

Riverside – Everett/Chelsea/Revere/Lynn

Unifying the northern and southern extensions discussed above, a Riverside – Everett/Chelsea/Revere/Lynn connection would provide new access to Kendall Square for communities north and south of the City of Cambridge. However, in addition to the infrastructure and operational challenges previously described for West Station – Everett/Chelsea/Revere/Lynn, as well as the additional elements necessary to facilitate a reliable Worcester Line-to-D Branch transition in the City of Newton, such an approach would generate a relatively slow end-to-end offering. While this alignment is not infeasible, it would entail higher capital, as well as operations and maintenance costs compared with other alignments and connections raised previously.

3.6. Headway / Frequency

Several competing elements were considered when developing the range of potential service frequencies that are tested in Task 3. *Rail Vision* assumed that its Urban Rail services would operate at 15-minute headways. Thus, this frequency was assumed to be "acceptable" in terms of operations and competitiveness. In terms of competitiveness with other services, present ways of reaching eastern Cambridge from North Station by transit are via the EZ Ride shuttle and via a two-seat Rapid Transit trip. In 2023, EZ Ride operated in peak periods at a 12 minute frequency, although it ran at frequencies of between 8-10 minutes prior to the onset of COVID-19. Detailed travel time analyses of these services are provided within Task 3.

Underlying concern of grade-crossing closures and resultant traffic impacts in eastern Cambridge stemming from possible Grand Junction operations limited the service frequencies considered within the universe of alternatives. A Core Route between North Station and West Station operating at 15-minute headways (*Rail Vision*) would have eight instances per hour of grade crossing conflicts. This was viewed as the most robust possible frequency option for this core alignment. Given the desire to incorporate connections to the North Shore in Alternative 2, only less frequent service – 17.5 and 20- minute headways – was subsequently tested on this Core Route.

Since the goal was to minimize the number of conflicts along the ROW, both on the Newburyport/Rockport Line and along the Grand Junction, relatively long but plausible headways (30 minutes) were assumed for the North Shore service. Layering the trips along the core alignment and those for services to the North Shore, would result in between 10 to 12 instances of grade crossing conflicts per hour within the City of Cambridge. Although more frequent service would provide better access to opportunities, the additional train trips associated with more frequent service entail increased gate downtime. Thus, a narrow band of headway parameters – 15, 17.5, and 20 minutes on the core alignment and 30 minutes on the North Shore service – were tested within this study.

3.7. Short List of Operations Alternatives

The assessment of previous studies clearly identified a regional desire for further technical analysis of a Rail-based option connecting West Station and North Station (i.e., "Core Route"). In addition to the Core Route, an "Extended Route" that connects the future West Station with communities north of the Mystic River, including Everett, Chelsea, Revere and Lynn, will also be subjected to further study. A summary of the service routes and frequencies are presented in Table 24 and Table 25, respectively, along with Figure 36.

Table 24. Service Routes to Be Assessed

MODE \ ROUTE	Core Route	Extended Route
Mode	Urban Rail	Urban Rail
Equipment	EMU or B-EMU	EMU or B-EMU
Route Considered	West Station – North Station	West Station – Everett, Chelsea, Revere, Lynn

Table 25. Operations Alternatives to Be Assessed

HEADWAY \ ROUTE	Alternative #1	Alternative #2
Core Route	15-minutes	20-minutes (17.5-minutes)
Extended Route	30-minutes	30-minutes
Effective Frequency – City of Cambridge	10-minutes	12-minutes

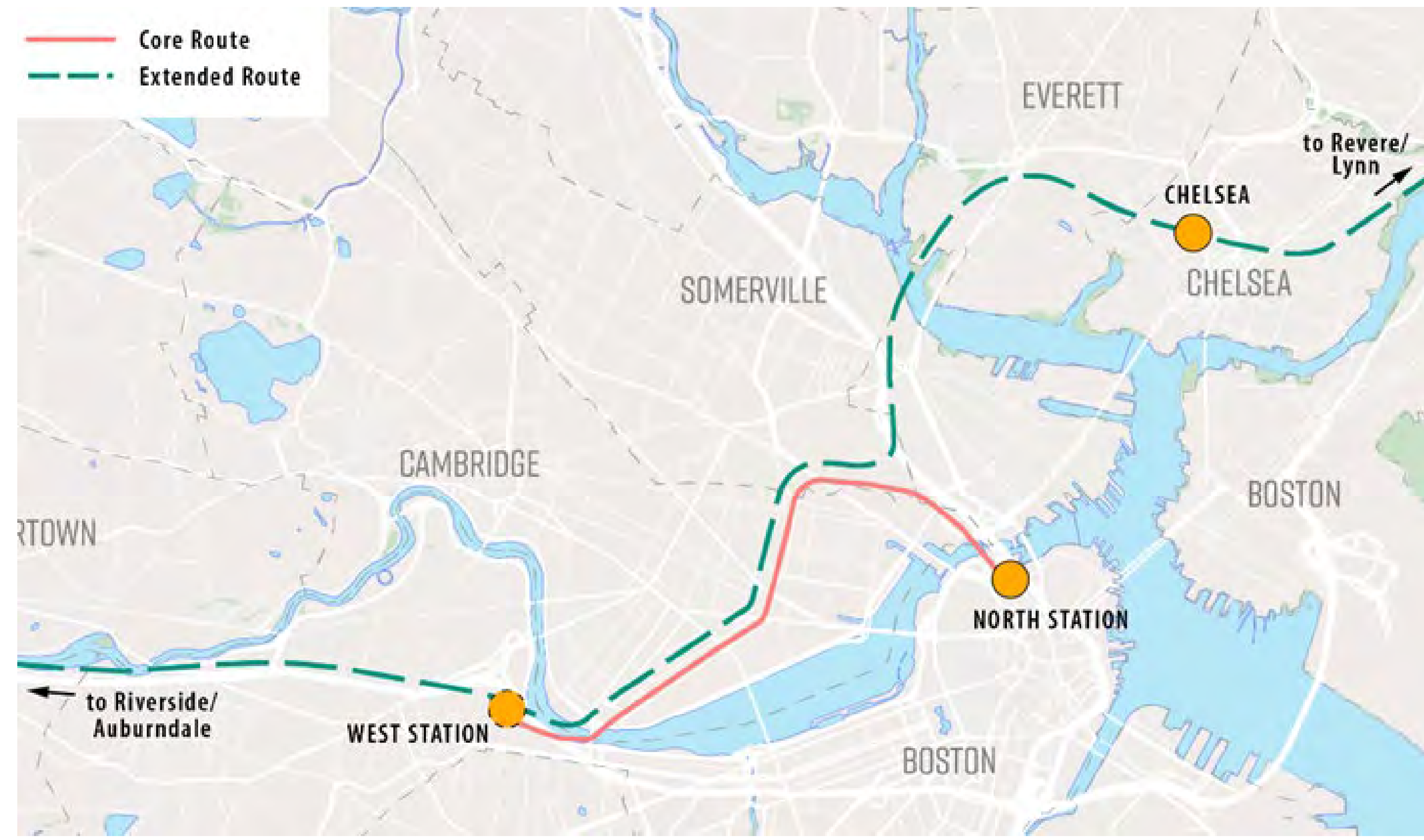


Figure 36. Short List Alternatives – Core Route (Orange) and Extended Route (Blue) – Would Connect Future West Station to Either North Station (Core) or Everett / Chelsea / Revere / Lynn (Extended)

Previous studies have contemplated two potential approaches to establishing connections to/from communities located further north, with one route terminating at North Station and another option continuing further south past West Station towards Riverside.

To develop such northerly connections, a new rail service could potentially extend northward from Cambridge, traversing the area around the maintenance facility and then transitioning to the MBTA's Newburyport/Rockport Line ROW to reach Assembly Square, Everett, Chelsea, Revere, and eventually Lynn. Such an approach would address the spirit of *Rail Vision's* goal of providing Urban Rail service between Lynn and Boston and provide a similarly-suited service.

Alternatively, if the Newburyport/Rockport Line ROW is not available to accommodate Grand Junction related service, a new rail-based service could potentially be extended north from the Squires Bridge / Red Bridge Junction area near the Green Line Extension to serve a northern terminus at Sullivan Square. However, this route would entail mingling with the various North Side CR lines that flow in / out of North Station, as well as substantial physical changes to the non-mainline tracks (e.g., “the third and fourth iron”) that lead from the MBTA’s North Side maintenance facility and parallel the Orange Line station along its western edge, before terminating just south of Assembly Square.

Figure 37. MBTA General Manager Steve Poftak Speaks at the 2021 Chelsea Station Ribbon-cutting with MassDOT Secretary Jamey Tesler and Community Leaders (Credit: MassTransit Magazine)

4. Demand Analysis

This chapter presents a range of estimates for potential ridership of a new Grand Junction-based rail service based on a review of existing and future markets.

4.0. Key Takeaways

Recognizing the caveats and limitations noted at the end of this chapter, there appears to be significant ridership potential for a new passenger service along the Grand Junction based on the sheer volume of existing transit users whose commute times could potentially be improved.

Initial base year daily ridership estimates for a core Grand Junction service between North Station and West Station resulting from existing transit commute markets, new ridership attracted from other modes by perceived reduced travel times, and intra-eastern Cambridge ridership, are anticipated to fall between

- 5,800 daily boardings, which is more than twice the recorded 2018 Fairmount Line daily ridership (2.652)[10]
- Approximately 9,600 – 9,800 daily boardings, which would rank as the sixth most used MBTA commuter rail line when compared with the 2018 recorded data.

When projected out to a 2040 horizon year, daily ridership would range between

- Approximately 6,500-6,600 daily boardings, which is 2.5 times the recorded 2018 Fairmount Line ridership.
- Approximately 11,000 – 11,200 daily boardings, which would rank as the fifth most used MBTA commuter rail line when compared with the 2018 recorded data.

This proposed core service, operating at either 15- or 17.5-minute frequencies, would have four new Cambridge stations located in between terminals at North Station and West Station.

It should be recognized that this modeling effort uses estimates that almost wholly focus on commute trips, as opposed to discretionary activities (e.g., all trips not related to work duties). Ideally, one would use a travel demand model, calibrated to the eastern Cambridge region, for all purposes, with the latest demographic and transportation system assumptions. Nevertheless, the projections demonstrate that there is ample ridership potential based on the amount of transit commutes centered around eastern Cambridge from other parts of the Boston area that could benefit from a Grand Junction service.

Initial base year ridership estimates for the aforementioned core Grand Junction service operated in conjunction with an additional service between Lynn and West Station that would only attract existing transit commuters, are anticipated to be greater than 2018 daily ridership on two commuter rail lines (Fairmount, Kingston/Plymouth) on the lower bound while upper bound ridership would be higher than recorded on all but four commuter rail lines in 2018 (Franklin, Providence/Stoughton, Worcester/Framingham, Newburyport/Rockport). When projected out to a 2040 horizon year, the lower bound daily ridership would be greater than recorded on five lines in 2018, while the upper bound daily ridership projection would still be greater than daily ridership recorded on all but three commuter rail lines. This proposed service, operating at 30-minute frequencies, would have stations in Lynn, Revere, Chelsea, and Everett in addition to the four new aforementioned Cambridge stations and West Station.

[10] 2018 daily commuter rail ridership can be found on page APP-6 of the Appendix

4.1. Introduction

The two distinct proposed Grand Junction rail transit services identified in Task 2 (i.e., Alternative 1 with 15-minute headways along a Core Route between North Station and West Station alongside an Extended Route with 30-minute headways between four selected North Shore Communities and West Station, Alternative 2 serving the same termini with a reduced 17.5-minute headway along the Core Route) were evaluated for their ridership potential. The team developed projections for both the base year (2022) and a future year (2040) at the line-level on a daily basis, as opposed to a station-level basis or by time period. For more information about the 2022 ridership estimates, please see pages APP-7 – APP-8 of the Appendix.

The team's approach was primarily rooted in quantitative observations of existing historical transit work trip demand along the potential Grand Junction service corridors (i.e., it does not seek to provide an exhaustive search of markets by integrating conjectures about "anticipated" demand that may stem from future development, latent travel, or technological improvements). In fact, with the exception of the intra-eastern Cambridge market, the analysis is wholly reliant on estimates of commute trips already being made to and from eastern Cambridge via existing transit offerings (i.e., potential riders whose current transit-based commute times would be improved if they switched to a more time-competitive Grand Junction service). Considerably more robust ridership forecasts would result if non-work trips (e.g. shopping, school, tourism, medical) and non-home-based trips were explicitly analyzed. Higher ridership would also result if the forecasting analysis was conducted in discrete fashion for individual time periods (AM peak, PM peak, midday, night) as it normally occurs in traditional travel-demand modeling. Non-technical elements that affect ridership, such as the branding of an urban rail service, distinct from the rest of the commuter rail system due to its frequencies or amenities, also might produce ridership increases.

As noted in the caveats that conclude this chapter, given the currency issues associated with the available MPO model forecasts, this study's projections may even result in underprediction.

4.2. Transit Commuters

4.2.1. Data Sources

The major source of trips for a potential Grand Junction service will be existing commuter trips to and from eastern Cambridge presently made on transit. Table 26 shows estimates of home origins for workers reporting to jobs located in eastern Cambridge based on estimates provided within the U.S. Census Bureau's 2019 Longitudinal Employer-Household Dynamics (LEHD) dataset. The distribution of the top home locations is summarized in Figure 38. Across the Commonwealth, more than 76,000 workers residing within Massachusetts were estimated to work in eastern Cambridge.

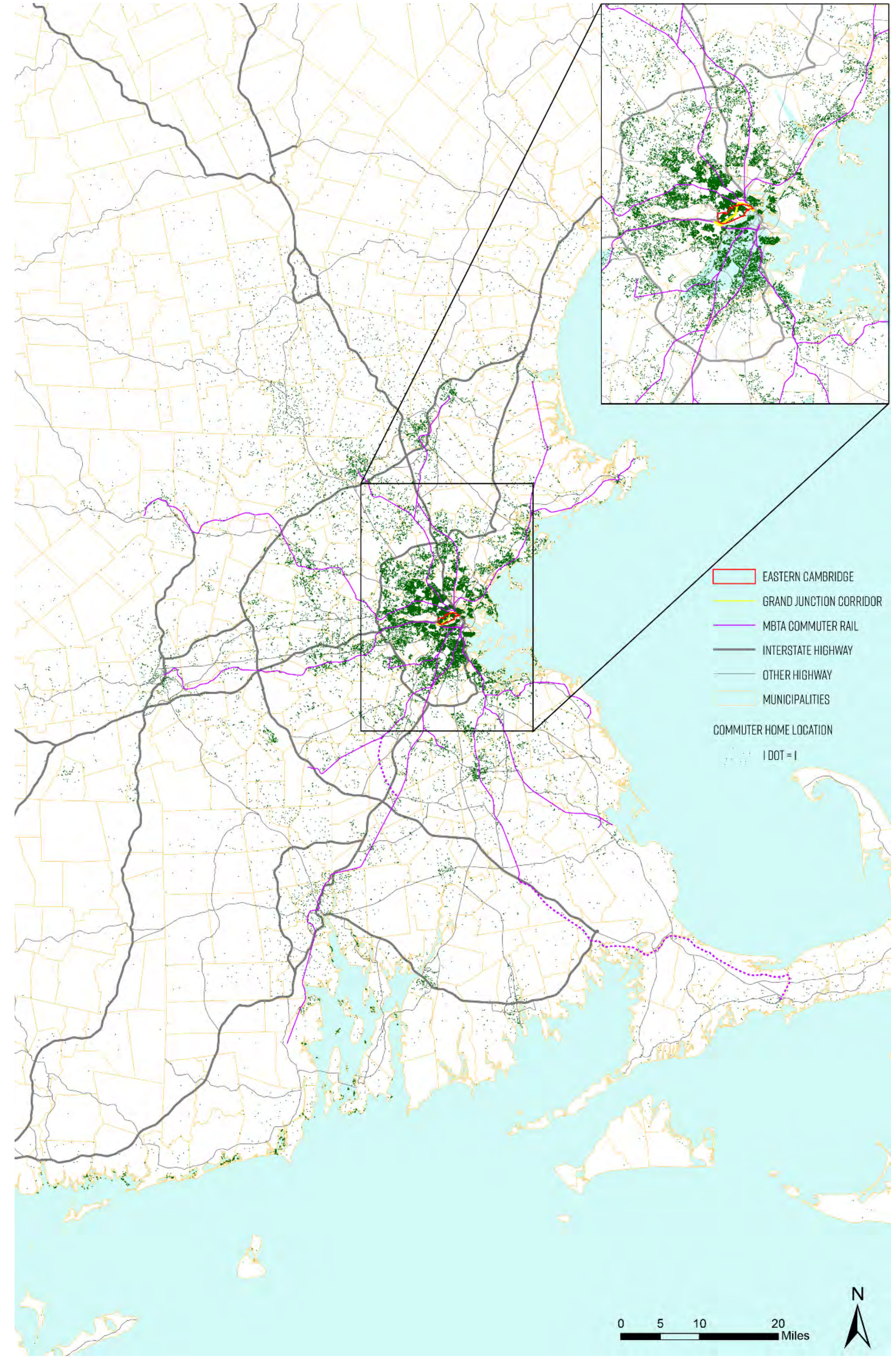


Figure 38. Map of Home Origins for Workers Reporting to Eastern Cambridge (Source: Census, 2019 LEHD)

Table 26. Communities Reporting 500 or more Home Origins of Workers Reporting to Eastern Cambridge (Source: Census, 2019 LEHD)

Community	Workers
Boston	13,342
Cambridge	9,234
Somerville	4,896
Arlington	2,167
Newton	2,043
Medford	1,854
Brookline	1,789
Quincy	1,640
Belmont	1,445
Malden	1,392
Lexington	1,311
Waltham	1,264
Watertown	1,104
Brockton	773
Revere	730
Winchester	714
Lynn	706
Everett	686
Framingham	676
Melrose	676
Weymouth	618
Acton	597
Woburn	590
Chelsea	572
Needham	522
Wakefield	500

As part of its Parking and Transportation Demand Management (PTDM) program and ordinance, the City of Cambridge requires employers to annually collect commute data about their staff, including community/zip code of origin (typically understood to be their place of residence) and primary mode used to complete their commute. The latest PTDM data were collected in 2019 and 2022. It should be noted that the 2019 data was collected solely from employers in the immediate Kendall Square area while the 2022 data reflected commute-based trips to work sites located throughout a broader area – eastern Cambridge.

Reflecting the fundamental shift that the COVID-19 pandemic created for desk-based jobs, the 2022 dataset revealed both a decrease in commute trips (approximately 30 percent of eastern Cambridge workers reported full-time work-from-home (WFH) in 2022) and transit mode shares (from approximately 38 percent to 18 percent). Recognizing the inherent limitation of the two PTDM data sources (i.e., employer-reported samples that are not indicative of global behaviors across all workers reporting to eastern Cambridge), they are still very helpful in understanding modal choices by Kendall Square employees.

4.2.2. Estimate of Existing Transit Commuters

The major source of trips for a potential Grand Junction service will be existing commuter trips to and from eastern Cambridge presently made on transit. Daily Home-Based Work (HBW) trips are often used as proxies for commuter rail trips given their regularity and predictability.

The total number of workers estimated within the 2019 LEHD data was judged to be the best empirical source of data to gauge the overall volume of workers reporting to eastern Cambridge from various communities, as it effectively serves as a recent proxy for peak employment in the area. For each origin community, the City's 2019 PTDM dataset was leveraged to define the transit commute share for those destined for work sites in the Kendall Square area. To create a 2022 base year estimate of workers traveling to eastern Cambridge using transit, these two elements were multiplied together, then discounted by 30 percent to account for the post-COVID WFH phenomenon that was reflected in the 2022 PTDM survey. This approach does not account for hybrid work schedules (part-time WFH), as such data was unavailable from the PTDM nor does it account weekday variability relative to hybrid work schedules. Additionally, the average MBTA daily ridership across all modes in October 2023 was at 62 percent of its pre-pandemic level (October 2019). Rapid Transit was only at 51 percent of its level from 4 years prior, while Commuter Rail had returned to 81 percent of its pre-pandemic level. The 30 percent discount is a fair median between these two modal levels, especially given the Grand Junction Services designation as Urban Rail. Hence, the projections produced in this analysis are a "highest-case scenario" in which every non-full-time WFH employee is commuting as opposed to a portion of them.

Several existing transit commuter markets for eastern Cambridge were identified and estimated using this approach. The base year estimates shown in Table 27 represent existing markets of transit users who are commuting to and from eastern Cambridge (i.e., those who might otherwise switch to a new service along the Grand Junction service under the right set of travel time/service conditions). Note that the upper bound total of these markets (7,770) reflects a service that would outperform the 2018 daily ridership observed along the Haverhill Line (ranked seventh among MBTA's 12 Commuter Rail Lines). The lower bound total (3,885) reflects a level of activity that would be nearly 50% greater than the daily total observed in 2018 along the least used Commuter Rail line (Fairmount Line).

Table 27. Existing 2022 Transit Commute Markets for Eastern Cambridge Served by Grand Junction

Potential Market for a New Grand Jct. Service	Upper Bound (100%) – Estimated Current Transit Trips	Lower Bound (50%) – Estimated Current Transit Trips
Riders Transferring at North Station	4,851	2,426
Worcester Line Riders Transferring at South Station	1,838	919
Allston/Brighton Travelers	570	285
Lynn/Revere/Chelsea/Everett	1,132	566
Lynn/Chelsea Overlap with North Station Market (To Be Subtracted from Total)	621	311
Totals	7,770	3,885

4.3. Primary Forecasting Methodology (Travel Times Compared to Existing Transit)

The primary method of forecasting potential ridership relies on comparing the travel times between major markets using existing and proposed transit services. The major considerations include travel time, wait time (headways) and transferring. The travel time methodology does not account for other factors that influence travel behavior (e.g., fare, modal preferences, vehicle preferences, reliability, safety and comfort).

4.3.1. Travel Time Components and Weights

The overall time considerations of this review focus on the identified potential connections that might use the Grand Junction service. The tables in the following sections show estimates of actual total time and perceived time.

Actual travel time was defined to be the sum of the components listed below.

- Walk/Access Time
  - Time to reach the first transit service location from an initial origin point
  - Walk times associated with transfer activities
  - Walk times based on distances from Google Maps and an assumed speed of 175 feet per minute (2.92 feet per second)
- First Wait Time
  - For Non-Commuter Rail Transit Services = ½ AM Peak period headways
    - Based on service levels codified in the 2016 regional model
  - For Commuter Rail Services
    - For headways <= 20 minutes = ½ AM peak period headways
    - For headways >20 minutes = 12.25 + ((1/8) * (Headways – 30))
    - Based on 2018 AM peak period scheduled headways
    - Corrected for rider familiarity with schedules so that no wait time is ever greater than 15 minutes, which aligns with industry standards (i.e., people time their arrival to stations to match infrequent service)
- In-vehicle Time
  - Based on AM peak period schedules for all transit except EZ-Ride
  - EZ-Ride based on AM peak period trip records from October 2016, as derived from Automatic Passenger Counter (APC) and Automatic Vehicle Locations (AVL) records
- Transfer Wait(s) Time = ½ AM Peak period headways
  - Based on service levels codified in the 2016 regional model
- Transfer Penalty
  - CTPS model assumes an eight minute penalty for every transfer, regardless of location or modes

In an effort to provide a more intuitive sense of whether existing riders may actually switch to a new service offering, the concept of perceived time was also leveraged. This version of travel time seeks to normalize the hassle associated with out-of-vehicle travel time components (e.g., transfer time, walk time) by representing the new offering solely in terms of an estimated in-vehicle time. Historic weights[11] from the CTPS travel demand model were applied to the in-vehicle time component as outlined below.

- Walk Time = 1.60
- First Wait = 1.10
- Transfer Wait = 2.45

4.3.2. Eastern Cambridge Model Location

Within this study's model, the eastern Cambridge point was assumed to be 10 Cambridge Center (i.e., the northwest corner of Broadway at Ames Street).[12] As shown in Figure 39, this location is central to the study area and lies roughly the same distance from the Red Line station and a point along the Grand Junction Line just north of Main Street representing a possible Grand Junction rail station.

[11] Previously used in the 2016 *Grand Junction Feasibility Review.*

[12] This location was previously used in the 2017 *Grand Junction Feasibility Review.*

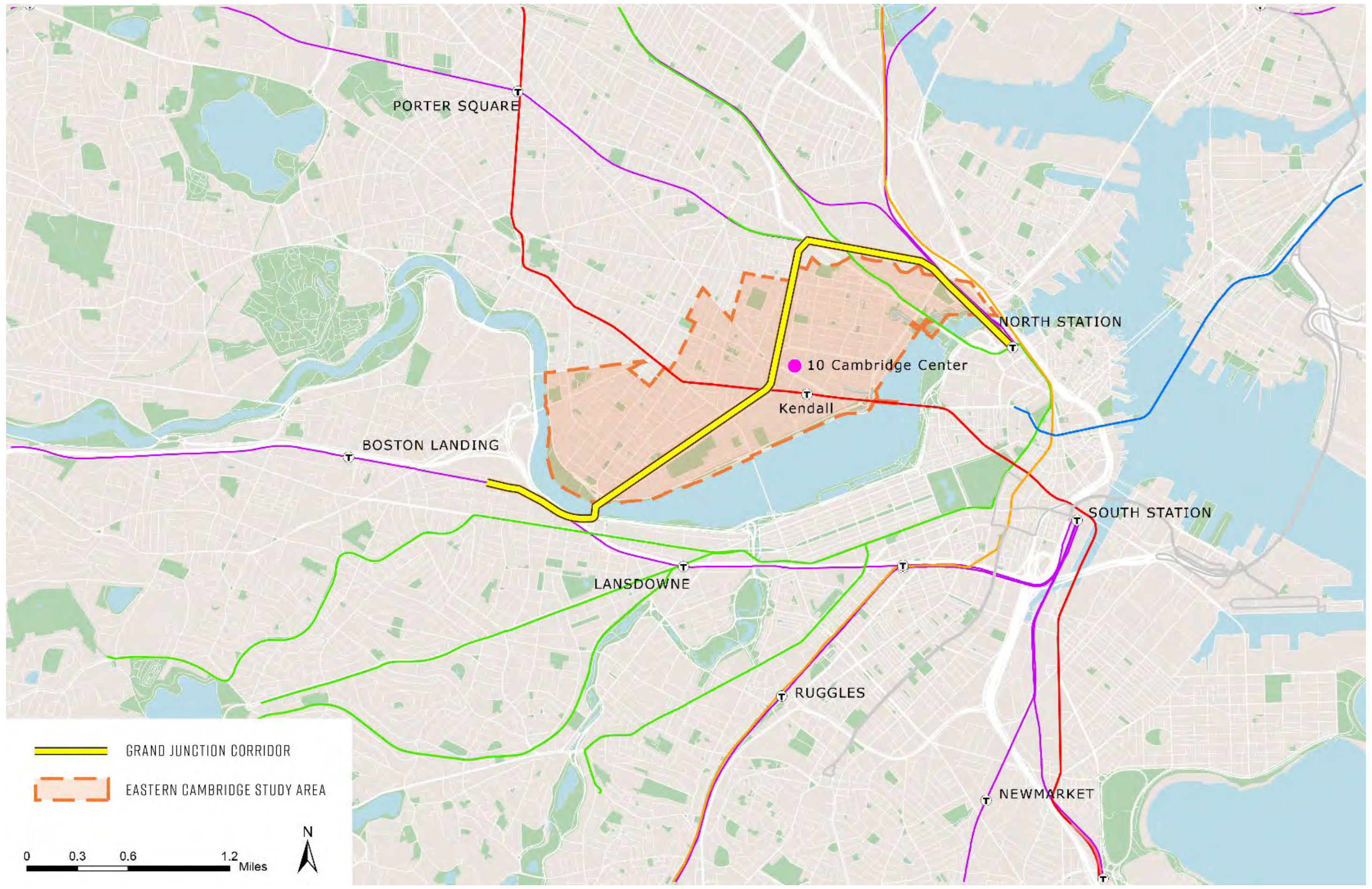


Figure 39. Eastern Cambridge Study Area Location As Defined within the Model

4.3.3. Potential Limitations and Approaches to Sensitivity Analysis

Forecasts generated by this approach measure ridership potential, providing an indication of the relative magnitude and upper bound of ridership that could occur with the introduction of this service. However, the underlying assumption of all riders choosing the transit service with the lowest weighted travel time is problematic for several reasons. It is unlikely that every commuter currently using transit to travel and from eastern Cambridge would shift to Grand Junction service if given the opportunity.

However, at a methodological level, there is not enough available information regarding transfer behaviors and travel patterns to thoughtfully inform the type of data-driven work that would be necessary to establish multi-path transit assignment models (e.g., something besides an all or nothing assignment model).[13] The 2022 PTDM study did not collect information at a sufficient level of granularity that might otherwise allow for further analyses regarding discrete transfer patterns. Thus, since multi-path transit assignment cannot be achieved, an all-or-nothing transit assignment is assumed, despite its simplistic nature. The option with the lowest weighted travel time is projected to attract all of the riders since people seek to minimize their travel times.

One way to possibly address this over-assignment dilemma is to assume that, despite providing the lowest weighted travel time of any service, not all the existing transit commuter markets will switch to Grand Junction service. Presumably, a majority of users would opt for the lowest perceived travel time. Thus, we can assume at least half (50 percent) of the estimated transit users for each market would be expected to use the service with the lowest perceived travel time.

Thus, the all-or-nothing approach would create an upper bound for measuring the maximum potential amount of ridership attracted by the Grand Junction service based purely on travel time savings. A lower bound scenario would assume that only half of the transit riders that stand to benefit would actually switch. These bounds taken together – an upper bound of all existing users switching and a lower bound of 50 percent – provide a plausible range in which the projected ridership probably would fall for each distinct market.

4.4. Potential Sources of Additional Ridership

4.4.1. Travel Time-Related Shifts by Non-Transit Users

In addition to existing transit riders who stand to reach their destinations faster via a Grand Junction service, travelers on other non-transit modes (e.g., driving) will be attracted to the new service. Industry elasticities (i.e., percentage change in ridership resulting from each percentage change in travel time) were used to quantify and forecast new transit riders that would shift from non-transit modes due to the improvement in travel time afforded by a Grand Junction service relative to their current options. Traveler response to changes in in-vehicle time ranged from –0.2 to –0.6, with –0.35 being a middle option. In other words, for each one percent decrease in travel time, ridership is expected to increase by 0.2 percent (low), 0.35 percent (medium), or 0.6 percent (high).[14]

4.4.2. Future Forecasts

The Boston MPO travel demand model, which is maintained by CTPS, was examined for the growth in home-based work trips between the base year (2016) and the future year (2040) for each discrete commuter market. After adjustments to only reflect growth between the 2022 base year and the 2040 horizon year, projections of future riders in 2040 were generated by applying these new percentages to the calculated number of estimated current transit users who would use the Grand Junction service.

[13] In order to probe at these questions, a more targeted effort would need to be undertaken in addition to the regular PTDM, including detailed follow-up with individual participants. Questions would need to be asked in different ways to avoid disclosing user-specific information on path making. The data would also need to be cleaned in a different fashion (currently nearly half of transferees do not report using a mode other than commuter rail, seeming to indicate that they walk from North or South Station). Furthermore, a statistically significant sample would need to be obtained.

[14] Litman, "Transit Price Elasticities and Cross-Elasticities", Journal of Public Transportation, Vol. 7, No. 2, 2004, p. 47; Ecosometrics, Inc, "Patronage Impacts of Changes in Transit Fares and Services", Sept. 1980; TRR 818, "Ridership Response to Changes in Transit Services", 1981, p.17; Litman, "Evaluating Public Transit Costs and Benefits: Best Practices Guidebook", May 9, 2006, p. 14.

CTPS calibrates its model to the entire MPO region for use in its *Destination 2040* Long Range Transportation Plan (LRTP) work, unless it is contracted for specific project work. Hence the available data used for this project was calibrated for this LRTP work. It is critically important to note that the data received from the MPO travel demand model was not calibrated specifically to the eastern Cambridge study area and its current transit services. A specific calibration of the travel demand model would have involved precise temporal and modal representation of the existing trip making behavior (for all trip purposes) and transportation conditions associated with eastern Cambridge. This would have involved matching empirical data for transit services and roadways as well as observed travel patterns related to the study area, with the goal of replicating the base year situation as closely as possible. This analysis only focuses on observed daily work travel patterns for the study area and does not attempt to represent other travel characteristics. Despite these imprecisions, these future forecasts provide insight into overall future ridership growth potential and regional trends.

4.5. Potential Commuter Markets

This section reviews the various eastern Cambridge commuter-based markets outlined below and provides estimates of existing and future ridership. Commute trips were not considered for non-Cambridge markets, such as between the Worcester/Framingham Line market and the North Station area or between the four specified North Shore communities and Allston/Brighton. Pages APP-7 and APP-8 of the Appendix contain the 2022 base year estimates for each of these markets.

1. Commuters from the north transferring at North Station
2. Worcester / Framingham Line commuters transferring at South Station
3. Allston/Brighton commuters
4. Commuters from Lynn, Revere, Chelsea, and Everett

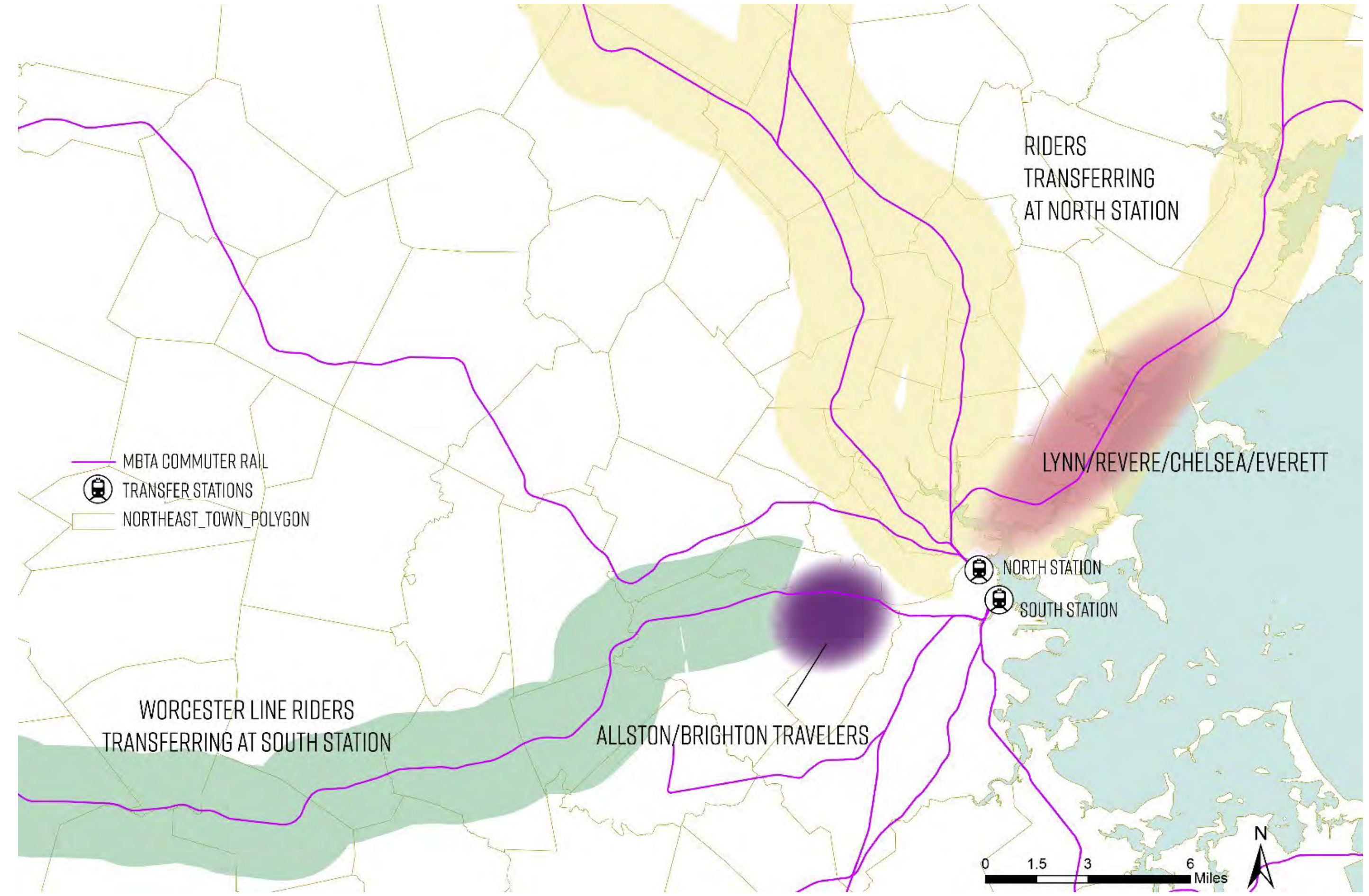


Figure 40. Commuter Markets

4.5.1. North Side Commuters Currently Using North Side Commuter Rail Lines and Transferring to Another Transit Option at North Station

This segment of the potential market reflects existing transit users who, if a Grand Junction service was in place, would transfer to the new service at North Station, as opposed to their current pattern (i.e., transferring to other transit services at North Station). As previously seen in Table 27, approximately 4,850 daily trips based in communities served by the Newburyport/Rockport, Haverhill, and Lowell Commuter Rail lines (i.e., all North Side Lines except the Fitchburg Line) presently use transit to move between their place of residence and worksites located in eastern Cambridge on a daily basis.

Travel Time Assessment for Trips within the Market

As shown in Table 28, Grand Junction service introduced from North Station at either a 15- or a 17.5-minute frequency would provide faster perceived travel times between North Station and a representative point in Kendall Square (10 Cambridge Center) than current offerings like the EZ-Ride shuttle or the Orange, Green and Red Rapid Transit Lines. The transit offerings listed in Table 3 are by no means exhaustive (they echo the transit offerings from the 2016 *Grand Junction Feasibility Review*). For those within this market, the tipping point for the Grand Junction shuttle appears to be a 20-minute service frequency. In other words, services operating with headways above 17.5 minutes would cease to be advantageous over existing transit services like the EZ-Ride Shuttle or the Red/Green Rapid Transit combination.

Projected Ridership within the Market

For each of the competitive headway options, Table 29 presents the range of daily future ridership for the upper bound and lower bound scenarios. These forecasts include additional ridership attracted from non-transit modes due to the improved perceived travel time. At the 15-minute service level, the travel time savings will result in approximately 0.9 to 2.6 percent growth in ridership from new transit users, while the 17.5-minute service level would generate between 0.1 to 0.4 percent of additional ridership.

As noted at the end of this chapter, significant portions of the projected future employment growth in eastern Cambridge used in the travel demand model are being outpaced by actual development; thus, underestimation of the projected ridership is likely.

Even in the lower bound scenario, future year ridership for this market is comparable to 2018 daily Fairmount line ridership (2,652). The upper bound scenario is approximately 1.8 times higher than the Fairmount Line ridership in the base year and more than double in the future year.

Although the upper bound numbers seem high, it is important to note that the EZ-Ride Shuttle, which was not even the transit service with the lowest perceived travel time, reported a pre-COVID daily ridership of 5,300.

Table 28. Existing and Potential Times between North Station and Eastern Cambridge (10 Cambridge Center) for the North Side Commuter Rail Transit Market

SERVICE OPTION \ TRAVEL TIME (min)	Transfer Wait	Walking / Access Time	In-Vehicle Time	Total Time	Transfer Penalty	Perceived Time
Via Red and Green Lines (existing)	3.8	7	9	19.8	8	37.4
Via Red and Orange Lines (existing)	5	8	11	24.0	8	44.1
Via EZ-Ride Shuttle (existing)	4.8	5.4	18.7	28.9	0	39.1
Via Grand Jct. 15-min Headways (potential)	7.5	4	9	20.5	0	33.8
Via Grand Jct. 17.5-min Headways (potential)	8.8	4	9	21.8	0	36.8
Via Grand Jct. 20-min Headways (potential)	10	4	9	23.0	0	39.9

Pre-COVID Frequency Assumptions: 5 minutes on Rapid Transit lines and both Green Line branches, EZ-Ride headways assumed at pre-COVID level.
Perceived Travel Time Weighting Assumptions: First Wait (1.1), Transfer Wait (2.45), Walk/Access (1.6). Transfer penalty removal = 8 minutes. First Wait time is unused because the assumption is that patrons are transferring from a previous transit service (CRR). Weights applied come from those used within the CTPS travel demand model.

Table 29. Projected 2040 Daily Grand Junction Ridership between North Station and Eastern Cambridge (10 Cambridge Center) for Workers Transferring at North Station (North Side CR Transit Market)

HEADWAYS \ SCENARIO	Lower Bound			Upper Bound		
	Users Shifting from Other Transit	*New Transit Users*	*Total Riders*	*Users Shifting from Other Transit*	*New Transit Users*	*Total Riders*
Via Grand Jct. 15-min Headways	2,664	22	2,666	5,287	138	5,425
Via Grand Jct. 17.5-min Headways	2,464	3	2, 647	5,287	21	5,308

Lower Bound Assumptions: Only 50% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.2 travel time elasticity used to measure increased ridership due to modal shift
Upper Bound Assumptions: 100% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.6 travel time elasticity used to measure increased ridership due to modal shift.

4.5.2. Commuters Currently Using the Worcester/Framingham Commuter Rail Line and Transferring at South Station to/from the Red Line

This segment of the potential market represents existing transit users who, if a Grand Junction service was in place, would transfer to the new service at the future West Station, compared to their current approach (i.e., transferring to the Red Line at South Station). As previously displayed in Table 27, approximately 1,850 people based in communities served by the Worcester/Framingham Line use transit to access worksites in eastern Cambridge. Although the service would terminate at the future West Station, the closest existing MBTA Commuter Rail station (Boston Landing) was used as a proxy for calculating in-vehicle time estimates for those using the Worcester Line.

Travel Time Assessment for Trips within the Market

As seen in Table 30, Grand Junction service introduced at either a 15-, 17.5-, or 20-minute frequency would provide faster perceived travel times between West Station and Kendall Square (10 Cambridge Center) compared to current transit offerings, such as MBTA Bus Route 64 or a combination of Commuter Rail/Red Line services.

Unlike the market noted above, which had a 17.5-minute threshold to remain competitive against existing transit offerings for commuters based north of Boston, the magnitude of potential travel time savings for those in the Worcester-based commuter market would be large enough such that even a 20-minute headway would still provide a competitive option relative to existing services.

Projected Ridership within the Market

Table 31 shows the range of daily ridership generated by the upper bound and lower bound scenarios for each of the headway options in the future year, including additional ridership attracted from non-transit modes due to the improvement in perceived travel time. The modest differences in perceived travel times between the Grand Junction and the best existing option (approximately five to ten minutes) are expected to generate additional ridership. At a 15-minute headway, the travel time savings will result in approximately 2.4 to 7.3 percent growth in ridership, with 17.5-minute headways affecting a 1.7 to 5.1 percent growth in ridership. The 20-minute service level would produce between 1.0 and 3.1 percent growth from new transit users.

When adjusted to reflect growth between the base and horizon years, the MPO travel demand model predicts approximately 14.25 percent growth for this market between 2022 and 2040 (2016 to 2040 at 19 percent growth).

Table 30. Existing and Potential Times between West Station (Boston Landing) and Eastern Cambridge (10 Cambridge Center) for Workers Transferring from the Worcester/Framingham Line

SERVICE OPTION \ TRAVEL TIME (min)	Transfer Wait	Walking / Access Time	In-Vehicle Time	Total Time	Perceived Time
Via Red Line (existing)	2.5	8	25	35.5	43.9
Via Grand Jct. 15-min Headways (proposed)	7.5	4	8	19.5	32.8
Via Grand Jct. 17.5-min Headways (proposed)	8.8	4	8	20.8	35.8
Via Grand Jct. 20-min Headways (proposed)	10	4	8	26	38.9
Via MBTA Bus Route 64 (existing)	10	9	22	41	60.9

Pre-COVID Frequency Assumptions: 5 minutes on Red Line, Route 64 at 20 minutes
Perceived Travel Time Weighting Assumptions: First Wait (1.1), Transfer Wait (2.45), Walk/Access (1.6). First Wait time is unused because the assumption is that patrons are transferring from a previous transit service (CRR). Weights applied come from those used within the CTPS travel demand model.

Table 31. Projected 2040 Daily Grand Junction Ridership between West Station and Eastern Cambridge (10 Cambridge Center) for Workers Transferring from the Worcester/Framingham Line

	Lower Bound			Upper Bound		
HEADWAYS \ SCENARIO	*Users Shifting from Other Transit*	*New Transit Users*	*Total Riders*	*Users Shifting from Other Transit*	*New Transit Users*	*Total Riders*
Via Grand Jct. 15-min Headways	1,057	18	1,075	2,114	139	2,253
Via Grand Jct. 17.5-min Headways	1,057	11	1,068	2,114	94	2,208
Via Grand Jct. 20-min Headways	1,057	4	1,061	2,114	51	2,165

Lower Bound Assumptions: Only 50% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.2 travel time elasticity used to measure increased ridership due to modal shift
Upper Bound Assumptions: 100% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.6 travel time elasticity used to measure increased ridership due to modal shift.

4.5.3. Current Allston/Brighton Commuters (Not Transferring from the Worcester/Framingham Line)

This segment of the potential market stems from existing transit users based in the Boston neighborhoods of Allston and Brighton who, if a Grand Junction service was in place, would transfer to the new service at the future West Station, as opposed to their current routine (i.e., using the MBTA's Route 64, connecting with Red Line services at South Station, or transferring at Boston Landing). The 2022 PTDM revealed that over 550 people in Allston/Brighton use transit to commute to and from eastern Cambridge.

Travel Time Assessment for Trips within the Market

As shown in Table 32, Grand Junction service introduced at either a 15-, 17.5-, or 20-minute frequency would provide faster perceived times between the future West Station and Kendall Square (10 Cambridge Center) when compared to existing transit offerings like the MBTA Bus Route 64 or a combination of Commuter Rail/Red Line services.

Similar to the trend estimated for commuters currently using the Worcester Line, headways up to 20 minutes would still be considered competitive relative to existing services for workers based in Allston/Brighton.

Projected Ridership within the Market

Table 33 displays the range of daily ridership generated by the upper bound and lower bound scenarios for each of three headway options. These forecasts include additional ridership attracted from non-transit modes due to improvements in perceived travel time. The considerable differences in perceived travel times between the Grand Junction scenarios and the best existing option (approximately 12 to 15 minutes) will produce additional ridership, but to a lesser degree in terms of absolute numbers, given the smaller base draws relative to the other markets above. At the 15-minute service level, the travel time savings will result in approximately 8.6 to 28.3 percent growth in additional ridership, with the 17.5-minute service level would generate between 7.7 and 25 percent added ridership. The 20-minute service level would produce between 6.7 and 21.7 percent.

Adjusting for the difference between the MPO travel demand's model base year of 2016 to this study's 2022, this market is projected to grow by approximately 52.5 percent by 2040 (base growth from 2016 to 2040 assumed to be near 70 percent).

Table 32. Existing and Potential Times between West Station (Boston Landing) and Eastern Cambridge (10 Cambridge Center) for Workers Not Transferring from the Worcester/Framingham Line

SERVICE OPTION \ TRAVEL TIME (min)	First Wait	Transfer Wait	Walking / Access Time	In-Vehicle Time	Total Time	Transfer Penalty	Perceived Time
Via South Station and Red Line (existing)	13	2.5	13	25	53.5	8	72.9
Via Grand Jct. 15-min Headways (proposed)	7.5	0	8	8	23.5	0	29.1
Via Grand Jct. 17.5-min Headways (proposed)	8.8	0	8	8	24.8	0	30.4
Via Grand Jct. 20-min Headways (proposed)	10	0	8	8	26	0	31.8
Via MBTA Bus Route 64 (existing)	10	0	7	22	39	0	44.2

Pre-COVID Frequency Assumptions: 5 minutes on Red Line, Route 64 at 20 minutes, Worcester/Framingham Line at peak period frequency (approximately 26 minutes)
Perceived Travel Time Weighting Assumptions: First Wait (1.1), Transfer Wait (2.45), Walk/Access (1.6). Weights applied come from those used within the CTPS travel demand model.

Table 33. Projected 2040 Daily Grand Junction Ridership between West Station and Eastern Cambridge (10 Cambridge Center) for Workers Not Transferring from the Worcester/Framingham Line

HEADWAYS \ SCENARIO	Lower Bound			Upper Bound		
	Users Shifting from Other Transit	*New Transit Users*	*Total Riders*	*Users Shifting from Other Transit*	*New Transit Users*	*Total Riders*
Via Grand Jct. 15-min Headways	435	37	472	869	247	1,116
Via Grand Jct. 17.5-min Headways	435	33	468	869	217	1,086
Via Grand Jct. 20-min Headways	435	29	464	869	189	1,058

Lower Bound Assumptions: Only 50% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.2 travel time elasticity used to measure increased ridership due to modal shift
Upper Bound Assumptions: 100% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.6 travel time elasticity used to measure increased ridership due to modal shift.

4.5.4. Commuters from North Shore Communities – Lynn, Revere, Chelsea, Everett

As previously shown in Table 27, nearly 1,150 daily one-way transit trips are estimated to occur between the four selected North Shore Communities (i.e., Lynn, Revere, Chelsea and Everett) and eastern Cambridge. While commuter rail stations currently exist in Lynn and Chelsea, new facilities would have to be built in Revere and Everett for this service. This section compares two distinct methodologies of forecasting ridership stemming from these North Shore communities.

Travel Time-Based Methodology

Assessment for Trips within the Market

As shown in Table 34, Grand Junction service introduced at a 30-minute headway would provide drastically faster perceived travel times between Lynn and Kendall Square (10 Cambridge Center) than transit services currently allow, including the following:

- Everett – 57 minute savings (64 percent reduction)
- Lynn – 38 minute savings (46 percent reduction)
- Revere – 37 minute savings (48 percent reduction)
- Chelsea – 7 minute savings (16 percent reduction)

Table 34. Existing and Potential Travel Times between Selected North Shore Communities and Eastern Cambridge (10 Cambridge Center) for the Existing Transit Market (30-minute Headways)

COMMUNITY	*SERVICE \ TRAVEL TIME (min)*	First Wait	Transfer Wait	Walking / Access Time	In-Vehicle Time	Total Time	Transfer Penalty	Perceived Time
Lynn	*CRR, Red, Green Lines (existing)*	11.3	3.8	10	29	54.1	16	82.6
Lynn	*Via Grand Jct. 30-min Headways (proposed)*	12.3	0	8	18.3	38.6	0	44.6
Revere	*Blue, Orange, Red Lines (existing)*	2.5	5	13	24	44.5	16	75.8
Revere	*Via Grand Jct. 30-min Headways (proposed)*	12.3	0	8	12.9	33.2	0	39.2
Chelsea	*Silver, Red Lines (existing)*	5	2.5	12	32	51.5	8	70.8
Chelsea	*Via Grand Jct. 30-min Headways (proposed)*	12.3	0	9	9.2	30.5	0	37.1
Everett	*Bus, Orange, Red Lines (existing)*	5	5	13	35	58.0	16	89.6
Everett	*Via Grand Jct. 30-min Headways (proposed)*	12.3	0	8	6.2	26.5	0	32.5

Pre-COVID Frequency Assumptions: 5 minutes on Red Line, Orange Line, and Green Line Branches; 10 minutes on Silver Line, 10 minutes on buses between Everett and Sullivan Square Station, Route 64 at 20 minutes, Newburyport/Rockport Line at peak period frequency (approximately 22.5 min). GJ IVTT calculated by WSP
Perceived Travel Time Weighting Assumptions: First Wait (1.1), Transfer Wait (2.45), Walk/Access (1.6). Weights applied come from those used within the CTPS travel demand model.

Projected Ridership within the Market

Table 35 presents the range of ridership generated by the upper bound and lower bound scenarios for a Grand Junction service providing service every 30 minutes to/from the selected North Shore communities. These estimates include additional ridership attracted from non-transit modes due to improvements in perceived travel time. Such considerable travel time savings will generate ridership and effect modal shift, with additional growth from new transit users estimated at approximately 14.5 to 51.1 percent.

Table 35. Projected 2040 Daily Grand Junction Ridership between Selected North Shore Communities and Eastern Cambridge (10 Cambridge Center) for Transit Commuter Market (30-minute Headways) – Travel Time Basis

COMMUNITY \ SCENARIO	Lower Bound			Upper Bound		
	Users Shifting from Other Transit	*New Transit Users*	*Total Riders*	*Users Shifting from Other Transit*	*New Transit Users*	*Total Riders*
Lynn	214	28	242	428	188	616
Revere	175	24	199	350	166	516
Chelsea	131	17	148	261	121	382
Everett	110	22	132	219	171	390
Total	**630**	**101**	**731**	**1,259**	**645**	**1,904**

Lower Bound Assumptions: Only 50% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.2 travel time elasticity used to measure increased ridership due to modal shift
Upper Bound Assumptions: 100% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.6 travel time elasticity used to measure increased ridership due to modal shift.

Methodology Using Mode Shares from Analogous Communities

Assessment for Trips within the Market

The analogous geography approach focuses on identifying other Boston area geographies with similar headways on fixed-guideway service to eastern Cambridge. This prediction approach relies on using mode shares for analogous outlying (and Environmental Justice) communities that currently have a one-seat fixed-guideway ride to eastern Cambridge.

Residents in Quincy and Braintree both had access to Red Line branch services operating every 10 to 18 minutes prior to the pandemic. The 2019 PTDM revealed that the transit mode share for Kendall Square employees reporting from Quincy and Braintree was 75 and 78.9 percent, respectively. Reflecting the impact of COVID-19 and WFH, the 2022 PTDM revealed much lower transit mode shares for Quincy (42 percent) and Braintree (19.9 percent). Applying the 30 percent WFH discounting factor to the 2019 PTDM transit mode shares would result in mode shares of 52.5 (Quincy) and 55.2 percent (Braintree). Thus, for this analogous communities approach, the assumption was a lower bound of 20 percent transit mode share and an upper bound of 56 percent.

Projected Ridership within the Market

The analogous approach relies on identifying and then generalizing travel behavior found within similar communities in response to the presence of a given transit offering (e.g., a specific mode operating at a certain level of frequency). An initial base reflecting potential ridership for a Grand Junction-based service operating at 15-minute headways to/from selected North Shore communities was developed to be consistent with the analogous communities approach. However, since this study contemplates headways that would be distinctly longer (i.e., every 30 minutes, not every 15 minutes), industry elasticities reflecting reduced service frequencies were applied to the initial base's 15-minute service to quantify the loss in ridership due to these longer headways.

Table 36 provides upper and lower bound estimates in the base and horizon year for a 30-minute service connecting the Grand Junction with North Shore communities. Using this approach, it is predicted that approximately 600 to 2,200 one-seat commute trips to/from these communities could use the service in the base year, with the range rising to 650 to 2,450 trips by 2040. The upper bound of this range is within ten percent of the daily ridership reported on the Fairmount Line in 2018 (2,650).

Table 36. Projected Daily Grand Junction Ridership between Selected North Shore Communities and Eastern Cambridge (30-minute Headways) – Analogous Communities Approach

COMMUNITY \ SCENARIO	2022 BASE		2040 FUTURE	
	Lower Bound (20%)	*Upper Bound (56%)*	*Lower Bound (20%)*	*Upper Bound (56%)*
Lynn	123	580	169	646
Revere	148	600	175	668
Chelsea	152	470	137	523
Everett	157	564	164	627
Total	**580**	**2,215**	**645**	**2,464**

General Assumption: 2019 LEHD data indicating eastern Cambridge worker origin community
Lower Bound Assumptions: 20% transit mode share and frequency-based elasticity of -0.9 to reflect a 30-minute headway. [15]
Upper Bound Assumptions: 56% transit mode share and frequency-based elasticity of –0.46 to reflect a 30-minute headway. [16]

Comparison of Results Using the Two Methodologies

When results from the two approaches are compared (Table 35 and Table 36), the second approach (generalizing mode share from analogous communities) predicts fewer trips when compared with typical travel time-based methods, with a base year 2022 lower bound difference near 100 and an upper bound change of approximately 500 trips for a 30-minute frequency on this service.

4.6. Non-commuter Markets

Non-commute markets are very difficult to predict given the limited data collected regarding non-HBW trip making. As non-commute data are typically gathered through broad and geographically extensive household travel surveying and sampling efforts (e.g., National Household Travel Survey, 2011 Massachusetts Statewide Travel Survey[17]), leveraging such data would provide limited applicability to this relatively small (and rather unique) study area. It should also be noted that, unlike work trips, non-commute trip making occurs with less regularity.

Nonetheless, a sense of the volume of potential non-commute markets can be discerned by exploring how the CTPS regional travel demand model represents non-HBW trip making within both time horizons. The MPO model predicts growth of 46 percent in total non-commute trip-making between eastern Cambridge and the Allston/Brighton area between 2016 and 2040, likely due to Harvard University's Allston Landing mixed-use campus development, which will be enabled via the MassDOT Multimodal Interchange project. According to the model, non-commute trip-making via transit is predicted to grow by 55 percent during that time.

The MPO model predicts total trip-making between eastern Cambridge and the North Shore communities (Lynn, Revere, Chelsea and Everett) to grow by four percent from 2016 to 2040. However, given the minimal non-commute, transit-based trip-making estimated for the base year, estimates of future growth would exert a relatively limited, minimal influence on general trip-making behavior for this particular market.

4.7. Intra-Eastern Cambridge Markets

Both commute and non-commute transit markets are difficult to forecast given eastern Cambridge's relatively small geography, as well as the preference of both residents and workers to use non-motorized transportation modes to complete a sizable share of overall trips. In fact, the MPO model estimated that in the 2016 base year, the highest modal percentage of all intra-eastern Cambridge trips (for all trip purposes) belonged to non-motorized modes – approximately 45 percent. Putting aside the considerable non-motorized contributions estimated for this particular area, facilitating a modal shift from non-motorized modes to motorized ones (e.g., transit) is, in general, often difficult to achieve. Nonetheless, the MPO model predicts growth of 16 percent in total trip making within the eastern Cambridge area between 2016 and 2040 and 18 percent growth in transit trips in the area during that time. Recognizing these are pure model figures, they still indicate a substantial theoretical transit-using market who could potentially switch to a Grand Junction-based service. Moreover, the construction of the Cambridge Crossing development presents more potential opportunities for intra-eastern Cambridge travel, both for work and non-work purposes. Although the modeled demography for Cambridge Crossing shows a 40 percent growth in employment and nearly 90 percent growth in population, actual development (at least in the commercial and service sectors) appears to be outpacing these projections. Since the growth forecasts for this market generated by the model are likely underestimated, any ridership projections based on such growth factors would also be underestimated.

4.7.1. Service and Geographic Analogies

Within eastern Cambridge, the Grand Junction service would serve as a distributor and circulator transit service for local trips along the alignment, operating at regular frequencies throughout the day. If 15 or 17.5-minute headways are assumed on the West Station-North Station service, alongside 30-minute service between West Station and North Shore communities, the combined headway for new service within the City of Cambridge would be 10 or 12 minutes, respectively.

Densely developed eastern Cambridge is home to major employment, retail, universities, and services, similar to a typical metropolitan area's central business district / downtown. An analogue to what service along the Grand Junction would mean or "feel like" to those in the City of Cambridge would be urban

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[15] VTPI, "Transit Price Elasticities and Cross-Elasticities", Nov. 5, 2021, p. 20

[16] Barton-Aschman Associates, "Traveler Response to Transportation System Changes", July 1981; TRR 818, "Ridership Response to Changes in Transit Services", 1981, p.15; TCRP Web Document 12, "Traveler Response to Transportation System Changes: Interim Handbook", March 2000, p. 9-8

[17] Although MassDOT has recently released RFPs for conducting a new statewide household travel survey, the timing regarding study initiation and release of final data outputs remains unclear.

streetcars. Such operations provide frequent fixed-guideway service that circulates and distributes riders among downtown activity centers.

As shown in Table 37, daily ridership estimates for the eight American streetcar systems with lengths less than three miles mostly fall in the range of 2,000 to 4,000 daily riders. Average use across these systems yields approximately 2,100 daily weekday riders. This imperfect daily average of streetcar ridership was assumed for Grand Junction travel within eastern Cambridge. This simplistic analogous estimate does not take into account elements such as employment or residential density, fare, service frequency, nor does it consider the nature of the ridership. Based on the CTPS model data, intra-eastern Cambridge trips would grow by 12 percent between 2022 and 2040, equating to a future year total of approximately 2,350 weekday riders within this market.

Table 37. American Streetcar Services Less than Three Miles in Length

STREETCAR SYSTEM \ STATISTIC	LENGTH (mi)	AVERAGE WEEKDAY RIDERSHIP	YEAR OF ESTIMATE
Atlanta	2.7	500	Q2 2023
*Tampa **	2.7	3,169	2022
Memphis	2.0	800	Q1 2023
KC	2.2	4,205	2022
*Dallas **	2.5	1,923	2022
Salt Lake City	2.0	2,031	2022
Milwaukee	2.1	2,121	July 2023
DC	2.4	2,100	Q2 2023
Average	**2.3**	**2,106**	**N/A**

Note *: Dallas and Tampa systems are average daily, not average weekday ridership
Sources: 2019 LEHD data indicating eastern Cambridge worker origin community
https://www.apta.com/wp-content/uploads/2023-Q2-APTA-Ridership.pdf
https://www.apta.com/wp-content/uploads/2023-Q1-Ridership-APTA.pdf#page=3
https://www.tmj4.com/news/local-news/the-hop-sees-continued-increase-in-ridership-since-2020
https://www.ksl.com/article/50455699/a-streetcar-thats-desired-whats-causing-the-s-lines-ridership-surge
https://kcstreetcar.org/wpcontent/uploads/2023/01/KCStreetcar_2022-12_Ridership.pdf
https://en.wikipedia.org/wiki/List_of_United_States_light_rail_systems

4.8. Ridership Forecasts

4.8.1. North Station – West Station (Core Route)

To produce the ridership for a Core Grand Junction service operating between North Station and West Station at either 15- or 17.5-minute frequencies throughout the day, contributions from each of the commuter-based markets reviewed above would be combined, except those related to the North Shore communities, with the trips stemming from the intra-eastern Cambridge market.

Table 38 shows the upper and lower bound projections for a 15- or 17.5-minute Grand Junction service between North Station and West Station. The lower bound condition would produce approximately 5,800 daily riders in the base year, which is slightly less than the 2018 daily ridership for the Kingston/Plymouth Line (see page APP-6 of the Appendix for a table of ridership of existing Commuter Rail Lines). The upper bound scenario would produce 9,600 to 9,800 daily riders in 2022 for 15- and 17.5-minute headways respectively, which are slightly higher than the 2018 daily observations along the Fitchburg Line. This demonstrates proven ridership potential - were a Grand Junction service to open today (using the 2022 base scenario as a proxy) it would have greater ridership than the Fairmount Line and perhaps enough to rank as the sixth highest commuter rail line in the system. In 2040, the lower bound scenario is forecast to generate approximately 6,500 to 6,600 daily riders, which is slightly less than the 2018 daily ridership of the Needham Line, the ninth busiest commuter rail line. The upper bound scenario would produce about 11,000 daily riders in 2040, which would rank as the fourth highest commuter rail line for daily ridership in 2018.

Table 38. Ridership Forecasts for North Station–West Station Service (Core Route)

HEADWAYS \ SCENARIO	2022 BASE		2040 FUTURE	
	Lower Bound	*Upper Bound*	*Lower Bound*	*Upper Bound*
Via Grand Jct. 15-minute Headways	5,797	9,781	6,563	11,144
Via Grand Jct. 17.5-minute Headways	5,770	9,614	6,533	10,951

Lower Bound Assumptions: Only 50% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.2 travel time elasticity used to measure increased ridership due to modal shift
Upper Bound Assumptions: 100% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.6 travel time elasticity used to measure increased ridership due to modal shift

Even if the large intra-eastern Cambridge market (2,100 base, 2,350 future) was removed from the analysis, the base year range would be 3,700 (lower bound) and 7,500 to 7,800 riders (upper bound) while the future year range would be 4,200 (lower bound) and 8,600 to 8,800 (upper bound). For both the future and base years, the analysis indicates that the lower bound daily ridership would still be considerably greater than the 2018 value for the least busy commuter rail line while the upper bound projections would see greater ridership than half the existing lines.

4.8.2. North Station – West Station + Lynn – West Station (Extended Route)

To potentially broaden the scope of benefits associated with a considerable capital investment, this alternative assesses all of the same commute-based markets while also incorporating those pertaining to the selected North Shore communities. The analogous methodology for North Shore commuter ridership prediction, which has a wider range between its upper and lower bounds, was chosen over the travel-time methodology for this particular market to reflect the largest variance in projected daily ridership.

The inclusion of the Lynn-West Station service would result in increased service on the Cambridge portion of the Grand Junction, thus producing 10 to 12-minute headways on the portion of the service shared by both the Lynn-West Station and the North Station-West Station services.

In the base year, the lower bound scenario would produce approximately 6,100 daily riders, which would be slightly less than the 2018 estimate for the Greenbush Line. The upper bound scenario would produce 11,300-11,500 daily riders, which would represent the fifth busiest Commuter Rail line in the system circa 2018 (only surpassed by the Franklin, Newburyport/Rockport, Worcester/Framingham and Providence/Stoughton Lines).

For the future year, the lower bound scenario is forecast to generate approximately 7,000 daily riders, which would be slightly less than the Haverhill Line's 2018 contributions. The upper bound scenario for 2040 would produce about 13,000 daily riders, which would be greater than any Commuter Rail Line in 2018 except for the Newburyport/Rockport, Worcester/Framingham and Providence/Stoughton Lines.

Table 39. Ridership Forecasts for North Station–West Station Service (Core Route) + 30-minute Lynn-West Station Service (Extended Route)

HEADWAYS \ SCENARIO	2022 BASE		2040 FUTURE	
	Lower Bound	*Upper Bound*	*Lower Bound*	*Upper Bound*
Via Grand Jct. 15-minute Headways	6,082	11,485	6,946	13,210
Via Grand Jct. 17.5-minute Headways	6,059	11,338	6,920	13,032

Non-North Shore Community Commuter Market Assumptions: Same as assumptions in Table 38
North Shore Community Commuter Market Assumptions: Same as assumptions in Table 36
Other Assumptions: Uses mode share analogy approach for Lynn-West Station, otherwise approximately 500 fewer riders in the Upper Bound scenario and 100 more in the in the Lower Bound. Combined headways on the Cambridge portion of the would be 10 minutes (15-minute scenario) and 12 minutes (17.5-minute scenario), respectively.

There is a large existing potential market for this service, even with 30-minute headways on the North Shore service. Even if only half of existing transit riders able to use a future 2040 Grand Junction service switch despite having reduced travel times (lower bound), the 2040 ridership will be greater than the any of the individual records from 2018 for the Fairmount, Greenbush, Kingston/Plymouth, Middleboro/Lakeville, and Needham Lines.

Even if the large intra-Cambridge market (2,100 base, 2,350 future) was removed from the analysis, the base year ranges would be between 4,000 and 7,500 riders for 2022, and between 4,500 and 10,800 in 2040. Lower bound ridership would be approximately 1.5 times the 2018 Fairmount Line daily ridership in the base year and approximately 1.7 times greater in 2040. However, the upper bound projections would be greater than the Haverhill Line for the base year and slightly less than the Lowell Line in 2040.

4.9. Caveats

- This analysis is based on the best available data at the time of the study. CTPS is currently in the process of developing a new model set, TDM23, which is to be based upon more recent data. The model set used for this study was based on travel patterns recorded in the 2010 Census, as well as data captured in the 2011 Massachusetts household travel survey. The base year for the model is 2016. The 2040 future year projections were based on the *Destination 2040* LRTP adopted by the Boston Region MPO in 2019. Demography and transportation project assumptions were part of the development of *Destination 2040*. However, recent CRA data shows the Kendall Square area growing faster than these projections, which show an employment increase of approximately 17 percent over the 2016 base year. CRA data shows that the planned commercial development alone is expected to be a 50 percent increase over the 2016 base year. This newer more robust data likely indicates that potential future ridership would be even higher than projected in this study.
- This model was not calibrated to the study area, but instead was regionally calibrated.
- The analogous assumption for intra-Cambridge ridership, based on an average daily total from eight representative American streetcar systems, is simplistic, based only on system length. Other key area and system characteristics were not considered, such as: density of development along the corridor; right-of-way type (fully or only partially exclusive); running pattern (single direction loop versus bi-directional); fare; headways; and primary trip purpose (commute, shopping, tourism). Not examining these salient system elements has resulted in a usable but imperfect estimate for the intra-Cambridge market.
- The analysis assumes bus and Rapid Transit schedules and data from the pre-COVID era, 2016, so as to conform with the travel demand model's 2016 base year. However, Commuter Rail schedules and data were assumed based on records from Fall 2018, which was the closest data set to the 2016 base year. With minimal modifications, such as the introduction of services that now exist (i.e., SL3 and GLX services and stations), these transit assumptions were retained in the future 2040 scenario.
- It should be recognized that MBTA service, ridership, and schedules have drastically changed since 2016, especially as a result of the COVID-19 pandemic. Moreover, the MBTA has adopted an entire systemwide bus network redesign (BNRD) and is poised to implement it in the future. Changes on bus, Rapid Transit (save the aforementioned exceptions), and Commuter Rail service were not assumed for the future year scenario.
- Post COVID-19 assumptions were calculated as a 30 percent reduction in commute trips to/from jobs based in eastern Cambridge due to the full-time work from home phenomenon that was demonstrated within the City's 2022 PTDM dataset. A detailed post-COVID study of travel patterns needs to be undertaken.

- This analysis does not take into account many other factors influencing transit usage (e.g., fares, crowding, reliability, vehicles, safety, comfort, etc.)

4.10. Other Notes

An attempt was made to use FTA's Simplified Trips-On-Project Software (STOPS) model for this study given the focus on commute trips, which is a central feature of STOPS. However, initial tests disclosed major problems with applying the STOPS model to this particular study area, specifically the rigidity of commute trip patterns, as well as use of national, as opposed to local, elements.

STOPS relies heavily on the Census' journey to work data (in this case dating back to 2010), which presented a problem for the study area given the rapid redevelopment of eastern Cambridge, as well as Assembly Square, Cambridge Crossing, South Boston, and Everett (near Encore Boston Harbor). The CTPS model, although based on similar Census data, has been able to correct regional trip-making patterns given this redevelopment, while STOPS was not able to readily do so. Implementation of such corrections in STOPS was judged to be extremely lengthy and too time-consuming to be properly executed within the context of this study's timeframe.

5. Infrastructure Needs and Operational Analysis

This chapter offers an assessment of infrastructure needs and an operational analysis for each of the alternatives. Given the commitment of MassDOT and the City of Cambridge for a two-track Grand Junction, these analyses investigate a two-track facility between the Charles River crossing and the Fitchburg Commuter Rail Line approaching North Station.

5.1. Key Takeaways

There is enough space currently existing along nearly the entire Grand Junction Railroad Right-of-Way (ROW) in Cambridge to accommodate two-tracks for passenger rail service. Two minor exceptions, one each at Binney and Cambridge Streets, would require additional slivers of right-of-way, 1.5 feet and 3 feet respectively, to provide the necessary clearance. These are needed at these two pinch points because the track alignment must transition horizontally as it crosses those two streets since the ROW is somewhat offset on either side of the streets. Cambridge's proposed multi-use path, although running in the overall Grand Junction corridor, could be located entirely outside the existing railroad ROW or track easements.

Figure 41 shows the selected alignments contained within Alternatives #1 and #2. This analysis primarily investigates the infrastructure improvements that would be necessary to initiate 15- or 17.5-minute headways along the Grand Junction's Core Route between West Station and North Station (i.e., Alternative #1), most notably double-tracking. Infrastructure improvements located beyond the City of Cambridge limits were addressed at a conceptual level (e.g., connections to Worcester and Fitchburg Lines for both Alternatives, additional junction improvements near Fitchburg to facilitate trips towards Lynn \ Revere \ Chelsea \ Everett along Alternative #2's Extended Route). This analysis includes order of magnitude costs related to infrastructure improvements (e.g., track, junctions, signals, platforms, etc.), with separate scenarios for fully-electrified versus battery-electric operations, as well as those related to vehicle procurement.

This analysis has disclosed several key findings about the feasibility of the selected alternatives. None of the proposed infrastructure improvements needed for Grand Junction service would disqualify either alternative from consideration. Double-tracked passenger rail service can readily co-exist with the multi-use path planned by the city of Cambridge within the Grand Junction ROW. There is enough ROW space to safely accommodate both projects. Nonetheless, the project is still dependent on the completion of several key infrastructure elements, such as the upgrade to the Charles River Crossing, a connection to West Station, and Draw One, from other planned major MassDOT and MBTA projects. Although adequate minimization of potential delays to vehicular throughput on cross streets when passenger trains traverse at-grade crossings was judged to be conceptually feasible due to employed mitigation measures, further detailed study is needed to understand the impact of these roadway closures on traffic.

Both examined alternatives are operationally feasible although Alternative #2 is operationally challenging for a number of reasons. Greater coordination will need to occur with the MBTA than in Alternative #1 as coordination with two additional Commuter Rail lines (Newburyport/Rockport and Haverhill) will need to occur. Not surprisingly, this alternative is more costly than Alternative #1 because of additional track upgrade, two additional station platforms (Everett, Revere), and a turnback facility in Lynn.

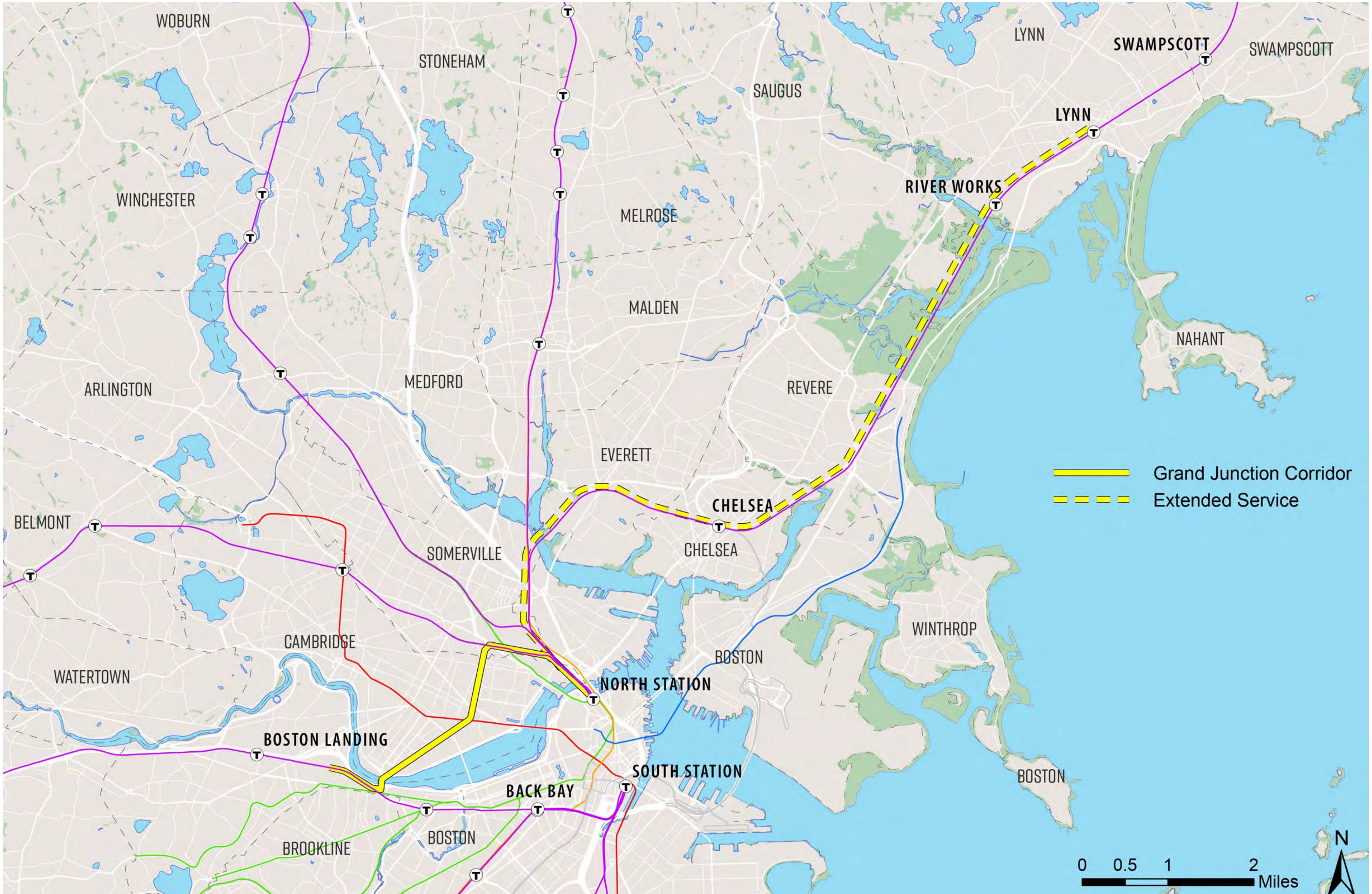


Figure 41. Selected Alignments - West Station to North Station (Core Route) and West Station to Lynn / Revere / Chelsea / Everett (Extended Route)

Three distinct implementation scenarios for the realization of Grand Junction service were examined. The two major ones compared and contrasted differences between having the MBTA or a local proponent advance the project, while the third scenario investigated possibilities for early implementation, prior to the completion of the major MassDOT and MBTA infrastructure projects in the study area. Conceptual timelines were developed for each of these scenarios.

Potential Cambridge station locations along the corridor in strategic areas – Cambridgeport, Massachusetts Avenue, Kendall Square, and Eastern Cambridge – were evaluated for feasibility. Criteria for judging the viability of sites included the examination of adjacent land uses, transit connections, bikeshare connections, grade crossings, potential platform layouts, and stop spacing within the alignment. Of the fifteen (15) evaluated sites, eight (8) were judged to be infeasible/unfavorable locations for station platforms, three (3) were rated very favorably, and four (4) were rated as being moderately favorable/feasible sites. Viable station locations exist in each of the four aforementioned strategic Cambridge areas.

5.2. Definition of Rail Infrastructure Improvements

The existing Grand Junction Running Track is maintained and operated by the MBTA as a connecting track for the purpose of transferring passenger equipment in slow-speed movements, typically not exceeding 10 mph. In FRA terms, it would be classified as an FRA Class 1 railroad (i.e., 10 mph for freight and 15 mph for passenger) and "dark", meaning it currently has no signal system. To operate effective passenger service on the Grand Junction a number of infrastructure improvements are necessary, including:

- Double tracking
- Renewal of the track structure
- Providing direct track connections to the Fitchburg and Worcester Lines
- Bridge improvements crossing the Charles River approaching West Station and approaching North Station
- Train signal (including mandatory positive train control, or PTC)
- Traction power (if electric- or battery-electric-powered vehicles are used)
- Grade crossing upgrades including interconnections with adjacent traffic signal systems.

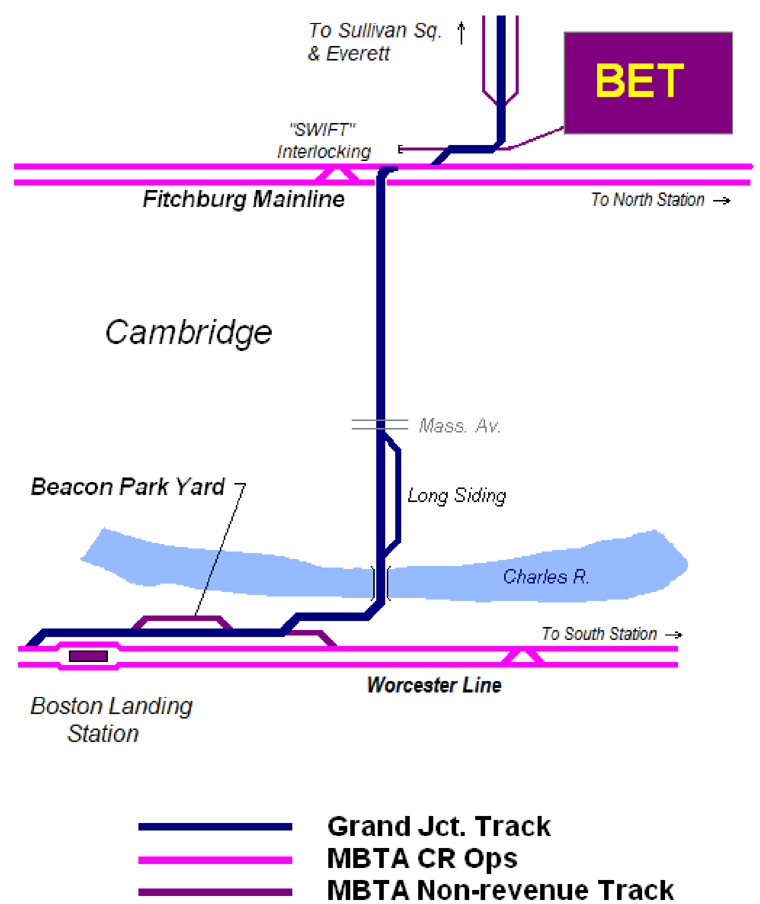


Figure 42. Existing Track Configuration of the Grand Junction Running Track

- Possible mitigation measures to address noise and vibration, preclude public access, and address potential safety concerns.

5.2.1. Track Improvements

This section describes track improvements including the following elements:

- Existing Conditions
- Double Tracking
- Renewal of the track structure
- Providing direct track connections to the Fitchburg and Worcester Lines
- Interlocking and crossovers to support the proposed operations.
- Identification of proposed bridge upgrades across the Charles River at the BU Bridge and North Station based on plans by others for West Station (MassDOT Allston Multimodal Interchange) and the MBTA Draw One Bridge Replacement Project

5.2.1.1 Definition of Terms

The discussion of track improvements requires the use of three important terms:

- *Railroad right-of-way*: This refers to the land owned by the railroad or rail agency in which the track or tracks would be constructed. MassDOT bought the Grand Junction railroad right-of-way (ROW) in Cambridge from CSX Transportation in September 2009. This however excludes a section of the ROW that was acquired by MIT in the mid-1900s. Although MassDOT owns the ROW, the MBTA is the designated operator, responsible for maintenance of track and other railroad infrastructure as well as traffic control on the line. The railroad ROW line is a property line defining the land owned by the railroad or rail agency.
- *Track Easement*: This refers to the land owned by MIT but where permission to maintain the track and operate trains is granted by MIT to the railroad owner, currently MassDOT.
- *Grand Junction Corridor*: This is a more general term that includes the ROW, track easements and other adjacent land outside the ROW or easements. "Corridor" does not refer specifically to property ownership. For example, while the path would be in the Grand Junction "corridor" it would not be in the Grand Junction ROW, but instead on land located outside the ROW.

The track for the Grand Junction Running Track always lies within either the ROW or track easements. The proposed multi-use path would follow the "corridor" but would be outside the ROW or track easements.

5.2.1.2 Existing Conditions

Presently the Grand Junction Running Track is a combination of both single and double track. The existing double track section, known as "the long siding," is located between Memorial Drive and Massachusetts Avenue (Figure 2). The current configuration is a considerable reduction from the four- and five-track configuration of the Grand Junction that existed in the early 1900s. Although tracks have been removed and portions of the ROW sold off to abutters, the remaining ROW is typically wide enough to accommodate two to four tracks. Currently, there are two different owners:

- **MIT Ownership**: From south of Massachusetts Avenue to Broadway, the right-of-way is owned by MIT and a track easement is provided on for the behalf of the state.
- **State Ownership**: From Broadway to the Fitchburg Mainline, the railroad right-of-way is owned by MassDOT and operated by the MBTA.

Where MassDOT owns the ROW, the current single-track sections generally have sufficient ROW for a second track, with two exceptions at pinch points as discussed in this section. Where MIT owns the ROW, the existing track easements only encompass the tracks as they now exist.

5.2.1.3 Double Tracking

MassDOT, the MBTA, and the City of Cambridge have all recognized the need for double tracking for potential future passenger service on the Grand Junction. MassDOT and the MBTA have established the requirement that double tracking, not precluded by any adjacent development, will be necessary for any planned passenger rail operations in the ROW.[18] The City of Cambridge, aware of this prerequisite, designed their multi-purpose pathway paralleling the Grand Junction tracks through Cambridge to not preclude a double track configuration.

This design exercise proves that a double-track alignment is feasible but there are some minor impacts related to double-tracking. These include two minor "sliver" ROW acquisitions (at Binney and Cambridge Streets) and access issues to MIT facilities (between Massachusetts Avenue and Main Street).

The double-track design did not include consideration of stations. Issues associated with station locations are discussed in Section 4.5 (Potential Station Locations). Discussions of the connections to the Fitchburg Mainline and to West Station are in Section 4.1.1.5 Providing Direct Track Connections to the Worcester and Fitchburg Lines.

The double track concept involves extending the existing double track from the long siding just south of Massachusetts Avenue to the Fitchburg Mainline as illustrated in Figure 43. **Please consult the final page of the Appendix for a roll plan displaying the location of double-track in the corridor.**

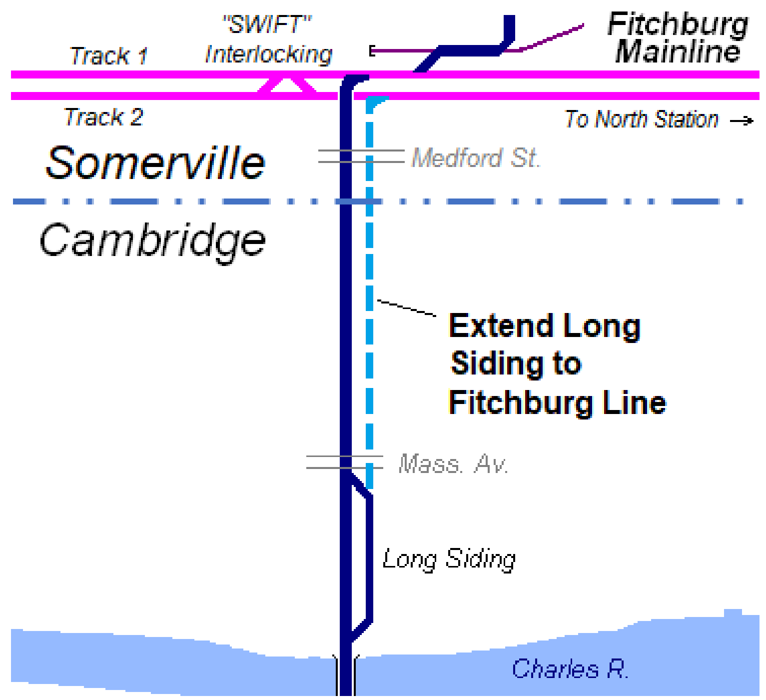


Figure 43. Concept for Double-tracking from Massachusetts Avenue to the Fitchburg Mainline

Note that this design is an illustrative example demonstrating the feasibility of double tracking. It is only conceptual in nature; the alignment could be further refined to address constraints and potentially reduce the impacts described above. Further refinement would require a detailed survey of existing conditions and existing rights-of-way, which could be accomplished in a follow-up effort.

Details Associated with Double Tracking

Generally, a proposed new second track would be located east of the existing track within the existing ROW. Where MIT owns the railroad ROW, between the end of the existing double track and Broadway, a second track would require widening the existing track easement, currently a single-track easement provided by MIT on behalf of the state. Coordination with MIT would need to occur, as this easement, including a spur track easement at points, will need to be widened to accommodate a second track.

From Broadway to Medford Street, where MassDOT owns the ROW, a second track can be accommodated within the existing ROW with two exceptions at Binney and Cambridge Street. Double tracking would also require relocating the grade crossing equipment at the six roadway crossings, as well as one at-grade pedestrian crossing.

Approaching Massachusetts Avenue

The existing track configuration transitions from two tracks to a single track before crossing Massachusetts Avenue. The siding track (easterly track) curves towards the main track and the two merge in a turnout, sometimes referred to as a track switch. In the proposed two-track configuration the second track would extend across Massachusetts Avenue.

From south of Massachusetts Avenue to Broadway, the right-of-way is owned by MIT and track easements are provided: one for the main track and a second for the second or siding track. In the two-track configuration, the current siding track easement would need to be extended to Massachusetts Avenue. This is displayed on page APP-9 of the Appendix.

The proposed multi-use path would be located outside the track easement, and west of the existing track.

Massachusetts Avenue to Main Street

The existing track configuration is a single track within a single-track easement since the underlying owner of the land is MIT. In the proposed two-track configuration a second track would be added to the east of the existing track. This would require a widening of the single-track easement to include the second track.

[18] A double-track line provides greater operational flexibility than a single-track, particularly for frequent train operations (e.g., headways less than 30 minutes). In a single-track operation, the schedule must be set up so that only one train in one direction is scheduled to operate on the length of single track. A train in the other direction must wait on the double track section until the first train leaves the single-track section. This results in a bottleneck that limits the frequency of trains. In addition, if a train is running late, it can cause cascading delays to other trains.

This is the most complex segment for double tracking in the study area due to the proximity of MIT facilities. Although there is horizontal space physically to construct the second track east of the existing segment, its construction may impact access to existing MIT facilities.

Figure 44. View from Massachusetts Avenue Looking North towards the MIT Co-generation Plant, Which Spans over the Existing Track

The first major MIT facility north of Massachusetts Avenue is the co-generation energy plant. As shown in Figure 44, part of this facility spans over the existing track. Since MBTA and Amtrak trains currently pass under this structure, the height is not an issue. Although there is horizontal room to the right (east) of the existing track to fit a second track, developing the new track segment would eliminate the existing service aisle (i.e., vehicular access to the rear of the MIT buildings that abut Vassar Street, which are depicted on the right in Figure 44).

Consultation would be needed with MIT on possible accommodations necessary to add a second track. For a detailed description of the MIT facilities and equipment in this area, please see the October 2014 report titled "Grand Junction Community Path and MIT Property Feasibility Study."

The next building that spans the track is MIT's Brain & Cognitive Sciences Complex, which fronts both Main Street and Vassar Street. There is adequate physical space horizontally and vertically for the second track, but development of a second track east of the existing line may present impacts to pedestrian circulation for those interfacing with the eastern half of the building (i.e., less room for those accessing the left side of the building from Main Street).

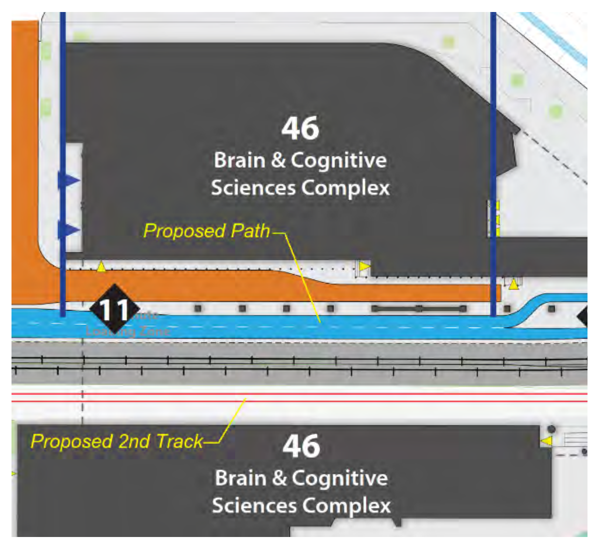


Figure 45. Plan View of the 2nd Track and Proposed Path at the MIT Brain and Cognitive Sciences Building

As displayed in Figure 45, the proposed multi-use path would be located on the west side of the existing track, outside the track easement.

Main Street to Broadway

The existing track configuration is a single track within a single-track easement, as the underlying owner of the land is MIT. In the proposed two-track configuration, the second track would be added to the east of the existing track. This would require a widening of the single-track easement to include the second track. Please see page APP-10 of the Appendix for a visual representation of this double-tracking.

Double tracking this segment would impact Grand Junction Park, which presently occupies the land area situated between the existing track easement and Galileo Galilei Way from Main Street to Broadway. Grand Junction Park is the only section of the multi-use path that has been constructed and is in use. It will also require relocating a district energy steam line.

Broadway to Binney Street

The existing track configuration is a single track within the existing railroad right-of-way owned by MassDOT. In the proposed two-track configuration, the second track would be added to the east of the existing track. There is a proposed shifting of the existing track approaching Binney Street to accommodate the track configuration north of Binney Street.

In this segment, the ROW is sufficiently wide for the second track's construction. Impacts would include the removal of the billboards near Broadway (located east of corridor on the north side of the road) and potential impacts to existing utilities in the ROW or adjacent to it.

Eversource's proposed Greater Cambridge Energy Project, which is shown in Figure 46, includes a proposed new power transmission line, connecting a proposed underground substation in Kendall Square, Cambridge with the existing Substation 404 in Union Square, Somerville. The "preferred route" known as Somerville Route S15 would run along the Grand Junction corridor from Broadway and Medford Street, with construction slated for 2024 and an in-service date of late 2028.[19]

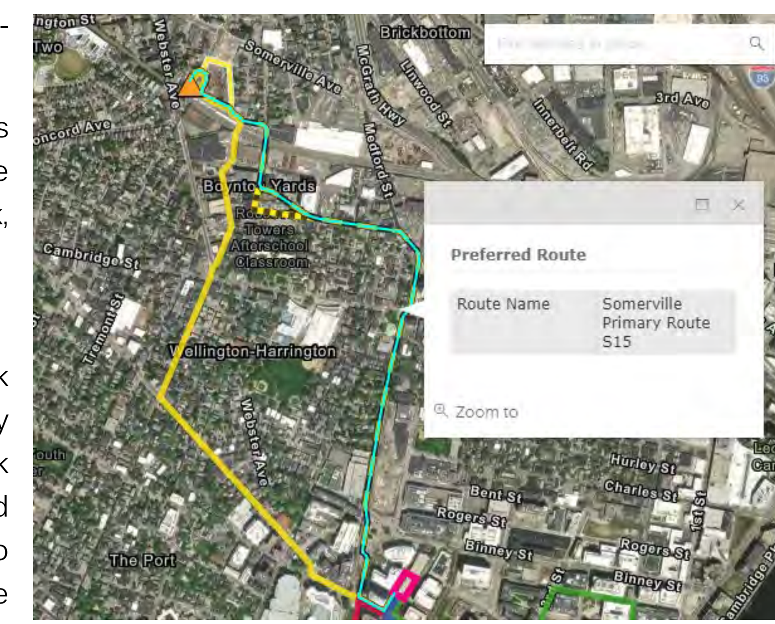


Figure 46. A New Power Transmission Line between Kendall Square and Somerville's Union Square Has Been Proposed along the Grand Junction from Broadway to Medford Street ("Eversource Somerville Route S15")

The multi-use path is under construction and is located outside the railroad ROW, east of the existing track and adjacent to Binney Park, which is due to open in 2024.

Binney Street to Cambridge Street

The existing track configuration is a single track within the existing railroad ROW owned by MassDOT. In the proposed two-track configuration, the second track would be added to the east of the existing track. However, to optimize the location of the two tracks within the existing ROW, much of the existing track would need to be shifted. The objective of the shifting is to locate both tracks within the existing ROW,

[19] Eversource, Greater Cambridge Energy Project fact sheet, (Reference: https://www.eversource.com/content/docs/default-source/projects-infrastructure/gcep-fact-sheet.pdf?sfvrsn=4f0ffc36_2)

while providing at least 8.5 feet of clearance at any pinch point. Additional side clearance would be provided with the existing ROW where available.

There are two pinch points, one each at Binney and Cambridge Streets, where a sliver of additional right-of-way would be needed for the minimum horizontal clearance. This would require acquisition from properties east of the existing ROW. Please see pages APP-11 and APP-12 of the Appendix to view this in detail. The slivers are triangular shaped with their maximum widths - approximately 1.5 feet at Binney Street and 3 feet at Cambridge Street - adjacent to the two streets. In part, these are needed as the track alignment must transition horizontally as it crosses these two streets, as the ROW boundaries are offset on either side of these street.

Binney Street serves as another transition point for the proposed multi-use path. The proposed multi-use path would be located outside the railroad ROW, west of the existing track in this segment.

The Eversource transmission line would also run through this segment, although it is not clear if it would run within the railroad ROW or within the alignment of the proposed path, outside the railroad ROW.

Cambridge Street to Medford Street

The existing track configuration is a single track within the existing railroad ROW owned by MassDOT. In the proposed two-track configuration, the second track would be added to the east of the existing track as the two tracks can be accommodated within the existing railroad ROW. For discussion of the double tracking between Medford Street and the Fitchburg line, see Section Direct Connection at the Worcester Line.

The multi-use path would be located east of the tracks. The Eversource transmission line would also run through this segment to Medford Street.

ROW and Easement Considerations

Based on this illustrative two-track alignment, the ROW and easement considerations can be summarized as follows:

- Two minor (“sliver”) acquisitions would be required near the Binney Street and Cambridge Street intersections.
- From the end of the “long siding” to Broadway, the existing track easement on property owned by MIT would need to be expanded to incorporate the second track.

Table 40 lists the ROW and easement considerations by segment.

Table 40. ROW and Easement Considerations for Double-Tracking)

Segment of Interest	Potential Effect or Influence
Memorial Drive to End of “Long Siding”	Maintain existing double track within existing track easements
End of “Long Siding” to Massachusetts Avenue	Expand track easement to include extension of double track.
Massachusetts Avenue to Main Street	Expand track easement to include extension of double track.
Main Street to Broadway	Expand track easement to include extension of double track.
Broadway to Binney Street	ROW can accommodate double tracking
Binney Street to Cambridge Street	ROW can accommodate double tracking with sliver takings at Binney Street and Cambridge Street
Cambridge Street to Medford Street	ROW can accommodate double tracking

5.2.1.4 Renewal of the Track Structure

For regular passenger service, the existing track structure would be renewed, including replacing the existing jointed rail with 136 lb. continuously welded rail (CWR), installing new ties, and renewing the ballast. As the Grand Junction service would be connected to the MBTA commuter rail system, the upgrading of the tracks should be in accordance with MBTA commuter rail standards (Figure 47). This work would also include drainage improvements where needed. A properly drained track-bed is essential for smoothly riding passenger service.

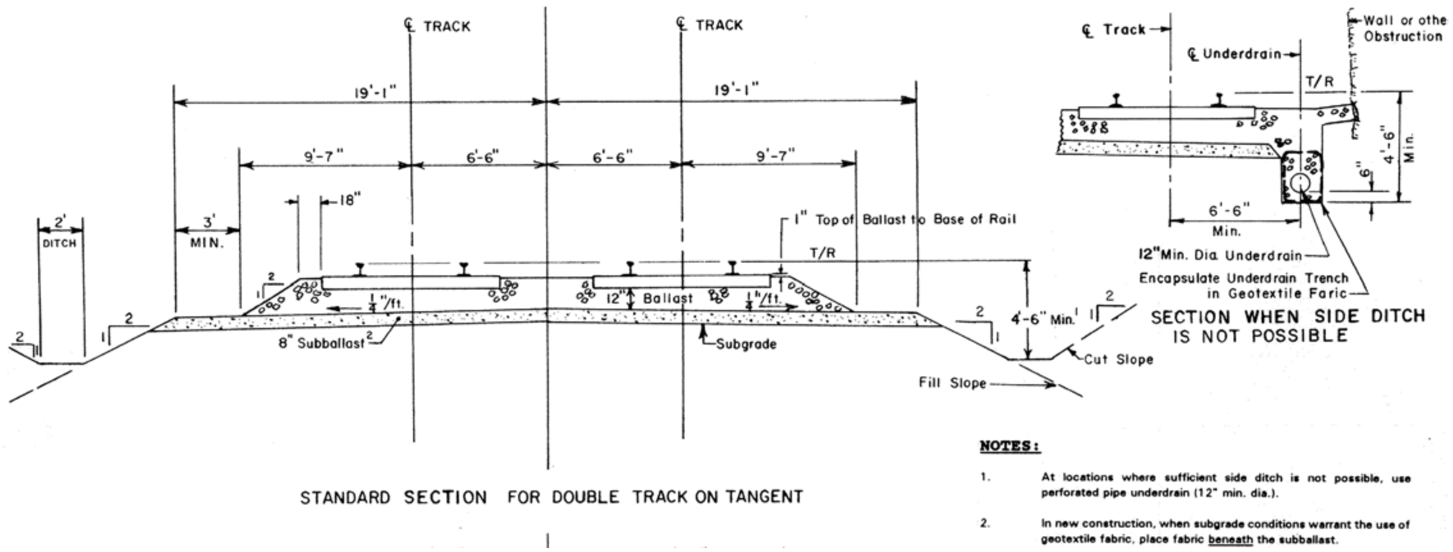


Figure 47. The Grand Junction Would Be Upgraded to MBTA Commuter Rail Track Standards

5.2.1.5 Providing Direct Track Connections to the Worcester and Fitchburg Lines

For access to West Station on the Worcester Line and North Station or points north (e.g., Everett, Chelsea, Revere and Lynn), existing connections to the Worcester and Fitchburg Lines need to be modified, as summarized below.

Connection	Existing Configuration	Proposed Configuration
Worcester Line	Indirect connection to the former Beacon Park freight yard	Direct connection to West Station
Fitchburg Line	Single track connection to Track 1 of the Fitchburg Line	Double track connection to the Fitchburg Line

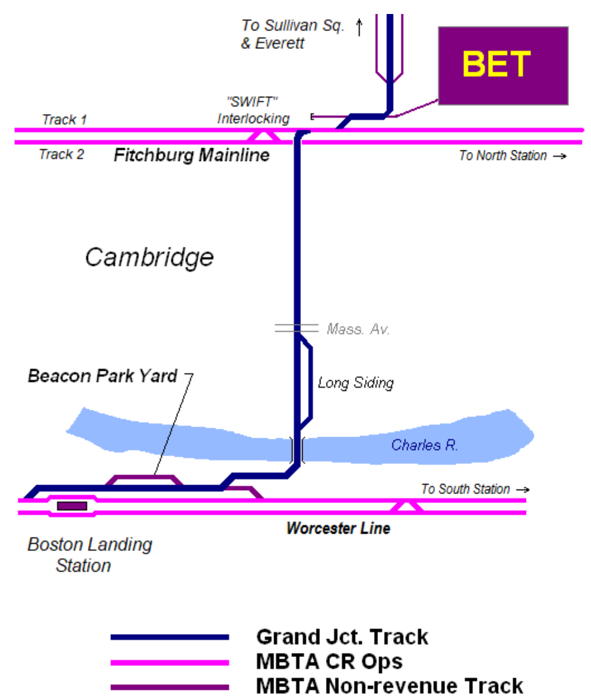


Figure 48. Existing Track Configurations for the Grand Junction and Its Connections to the Worcester and Fitchburg Lines

The current connection to the Worcester Line dates to when the Grand Junction was primarily a freight line and the New York Central (and later Penn Central, Conrail and CSX) served the line from Beacon Park yard.

The present connection to the Fitchburg Line was reconfigured as part of the Green Line Extension (GLX) project. By connecting directly to Track 1, it provides a direct connection to the MBTA Commuter Rail Maintenance Facility (aka, the Boston Engine Terminal or BET), as well as the freight connection to the remaining sections of the Grand Junction Running Track in Everett and Chelsea (Figure 48).

Direct Connection at the Worcester Line

The track configuration in Figure 49 is based on the latest proposed plan for West Station via MassDOT's Allston Multimodal Interchange Project. The current design envisions a double track configuration on the bridge over the Charles River, continuing into two dedicated tracks with a center island platform at West Station.

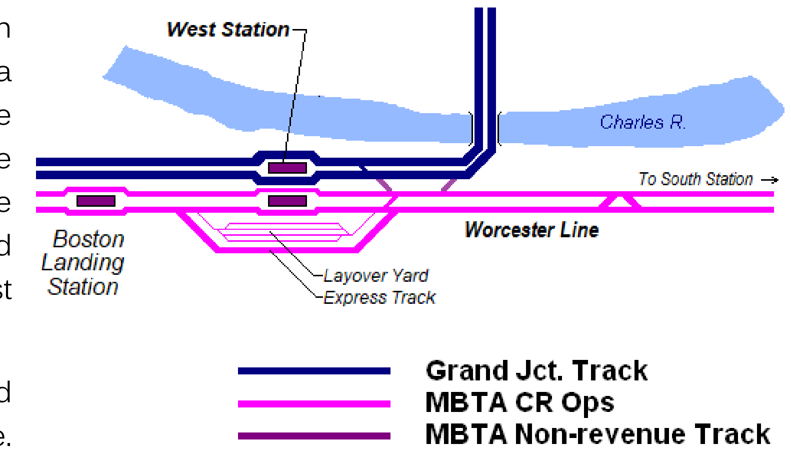


Figure 49. Proposed Configuration of Worcester Line from the Charles River Crossing to West Station

As proposed, the Grand Junction trains would not have to merge onto the Worcester Line. Therefore, the Grand Junction can be scheduled without consideration of possible conflicts with trains operating on the Worcester Line.

This configuration allows for a possible extension of the Grand Junction service west along the Worcester Line to the Newton stations and a possible termination at Riverside station if desired in the future.

Reconfigured Connection at the Fitchburg Line

The reconfigured connection at the Fitchburg Line would merge the double track Grand Junction into the double track Fitchburg Line, as shown in Figure 50. A portion of this junction is situated beneath the Squire Bridge, where McGrath Highway / MA Route 28 crosses over the tracks. In addition, the GLX tracks are located immediately north of Track 1 of the Fitchburg Line.

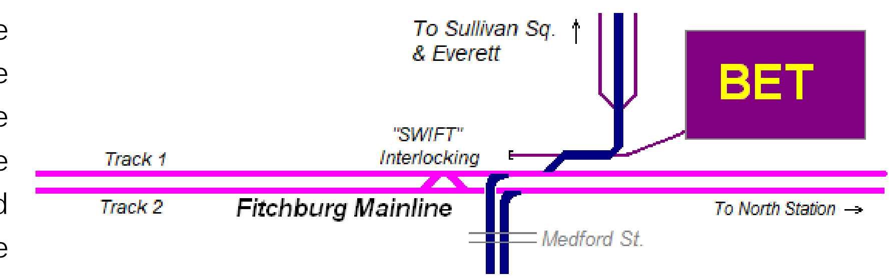


Figure 50. Conceptual Configuration for a Double-track Grand Junction Merging with a Double-track Fitchburg Line (Note: "BET" stands for Boston Engine Terminal – MBTA's Commuter Rail Maintenance Facility in Somerville)

This approach would require reconfiguring the existing track between Medford Street and the Fitchburg Line to accommodate the second track. Discussions with MBTA Railroad Operations staff revealed that the Grand Junction to Fitchburg Line connection has been reconfigured several times in the past.

This configuration sets up the West Station to North Station service. For a potential service to Sullivan Square station or beyond (i.e., Everett, Chelsea, Revere and Lynn), note that there is currently only a single-track connection from Track 1 of the Fitchburg Line to the section of the Grand Junction that connects to the MBTA Eastern and Western Routes (i.e., the Rockport/Newburyport and Haverhill Lines). There are two options to address this track configuration. For infrequent service (e.g., 30 minute or greater headways), it would be possible to leave this as a short single-track section. The other alternative is to double track this segment, including a two-track connection to the Fitchburg Mainline and a two-track connection to the Eastern and Western Routes.

5.2.2. Signal Improvements

This section discusses the addition of a train control system to the Grand Junction. As the only mode alternative being considered is Urban Rail, this section focuses on the signal system necessary to operate such an alternative.

Currently, the Grand Junction Running Track does not have a signal system, which is known as “dark” territory. This is a feasible approach to train control, given the few trains that operate on the line (typically two or fewer per day). As it is a single-track line, only one train can occupy the line at a given time.

A modern train signal system would be required for proposed passenger rail service on the Grand Junction. With a single-track line, as exists now, the train dispatcher issues a train order to the train before it is allowed to go onto the Grand Junction. Until the train order is received, the train must stay at a location off the line. When the train has cleared the Grand Junction, then the engineer reports to the train dispatcher that they are clear, and the train dispatcher can then authorize another train to enter the line. With frequent train service, this form of train control would be inadequate.

A modern signal system would include both physical signals at key locations (e.g., interlockings or junctions), such as those shown in Figure 51, and cab signals in the locomotive or control car. The system would also entail track circuits that can detect the location of a train. Such a system would serve to maintain a safe distance between trains and also regulate the passage of trains through interlockings and junctions (such as the junction with the Fitchburg line). The signal system would also be integrated with the grade crossing active warning systems (AWSs), informing the AWSs of approaching trains.

The signal system must also include Positive Train Control (PTC), a system that will activate a train’s breaks to prevent it from approaching too close to a preceding train and also prevent the train from exceeding the speed limit. Since the Grand Junction

Junction’s signal system would need to be compatible with that of the commuter rail system. This way, any locomotives or control trains would travel over the commuter rail system, the Grand cab cars that can operation on the commuter rail system would be able to operate on the Grand Junction.

Figure 51. Example Signal at Interlocking Where a Branch Line Joins the Mainline (Worcester Mainline Merge in Framingham)

5.2.3. Traction Power Improvements

Traction power would need to be added to support electric-powered operations, whether it is fully electric operations (e.g., electric locomotive-hauled trains or electric multiple units, also known as EMUs) or battery-electric trains (e.g., battery-electric locomotive-hauled trains or battery-electric multiple units [B-EMUs]). The term “traction power” refers to the electric power required to propel electric vehicles.

5.2.3.1 Infrastructure for Electric Operations

Infrastructure elements for electric operations include:

- Overhead Contact System (OCS) – an overhead wire suspended above the track that provides electric power to the locomotive or EMUs.
- Traction Power Supply System – distributes power from the traction power substation to the OCS.
- Traction Power Substations – a series of transformers, located at regularly spaced intervals along the line, which convert commercial power down to a voltage which can be used by the locomotive or EMUs (typically 25,000 volts in New England). Each substation is usually fed by two independent commercial power lines.

Given the short length of the Grand Junction, it would not be necessary to have a traction power substation along the Grand Junction. Instead, traction power substations could be located along the Fitchburg and Worcester lines. Typical spacing of substations on Amtrak’s Northeast Corridor (with the same voltage) is four to five miles.

If the Grand Junction were to be fully electrified, there would be a series of poles and overhead wires as shown in Figure 52. The photo shows the OCS system along the Geen Line Extension in Somerville, and any electrification of the MBTA commuter rail system would be similar. The poles would be situated along either side of the right-of-way and would not require more than two feet of width beyond that which would be required for an unelectrified line.

Figure 52: Overhead Contact System Overview - Poles and Guy Wires Suspend the Contact Wire above Each Track (MBTA Green Line Extension; Somerville, MA).

5.2.3.2 Infrastructure for Battery-Electric Operations

The advantage of battery-electric operations is that the entire line does not need to be modified to house overhead wires and poles associated with the transmission of electricity. Instead, there are two typical approaches to recharging the train’s batteries. The MBTA Rail Vision anticipates a combination of both:

- Terminal Recharging – With this option, there would be the typical OCS located over the terminal stations. While the train is waiting to make its next trip, it would put up its pantograph and recharge.
- En-Route Recharging – With this option, a segment of the line is equipped with the typical OCS. While under the wire, the B-EMU can run off the electric power while recharging its batteries.

Typically, B-EMU vehicles can operate 20 or more miles between charge. For a short-distance operation like the Grand Junction (i.e., 4.5 miles from West Station to North Station or 13 miles from West Station to Lynn), the entire one-way run could be made without the need for en-route recharging.

For those portions of a battery-electric operation where recharging is provided (e.g., terminals or en-route segments), the infrastructure is essentially the same as for full electrification (i.e., OCS, traction power supply systems, and traction power substations), as shown to the left in Figure 53.

If the Grand Junction were to be operated with battery-electric trains, it would not require the series of poles and overhead wires as shown in Figure 52.

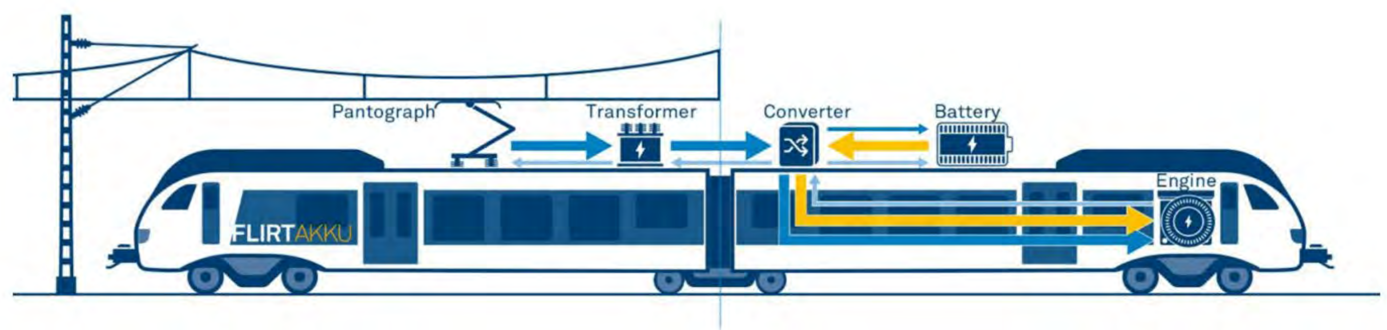


Figure 53. B-EMU Power Schematic – Capable of Operating through On-line Charging via a Typical OCS (Left) and Battery-powered Operations along Sections of Track without OCS (Credit: Stadler, FLIRT AKKU)

5.2.3.3 Train Storage and Maintenance for Electric or Battery-Electric Operations

Implementing either fully electric or battery-electric operations would require facilities for the overnight storage of the new trainsets, as well as vehicle maintenance facilities. As the MBTA's Rail Vision proposes that the same vehicles be used for all Urban Rail lines (including a Grand Junction-based service), there might likely be multiple storage or layover yards (convenient to each line) and likely a single central facility for maintenance. While the details would be determined by the MBTA, the options would likely include:

- Converting portions of existing storage and maintenance facilities to accommodate electric or battery-electric trains.
- Repurposing facilities, such as the existing coach shop in Readville or the maintenance-of-way equipment shop in West Cambridge
- Constructing new train layover facilities and vehicle maintenance facilities that can perform inspection and servicing of the urban rail trainsets.

For the Grand Junction operation, the optimum storage or layover locations would be the proposed layover yard at West Station (in Beacon Park Yard) or at the layover tracks next to the main Commuter Rail Maintenance Facility in Somerville. This would minimize the distance and time involved in moving trains from the terminal station to the layover facility, a process known as "deadheading" which adds costs to the operation in terms of labor costs and vehicle operating costs.

5.2.4. Grade Crossing Improvements

Grade crossing improvements would be necessary for the introduction of passenger rail service on the Grand Junction. Table 41 shows current and proposed infrastructure at grade crossings along the rail line within the City of Cambridge. Figure 54 displays which new elements at each grade crossing are proposed as part of this study.

Most grade crossings currently have flashers, but do not have gates. If passenger rail service were to exist on the Grand Junction, all crossings should have flashers and gates. Furthermore, the current timing for flasher / gate activation is based on the current 10 mph operations and would need to be modified to accommodate faster operating trains.

To optimize overall traffic operations, it is assumed the grade crossing warning systems would have a pre-emption interconnection with the vehicle traffic control systems at signalized intersections that are adjacent to the Grand Junction. For further information concerning approaches to vehicular controls and pre-emption, see Section 5.3.5.

Table 41. Grade Crossings

Crossing	Type	Existing Equipment	Proposed Equipment
Pedestrian Walkway at Fort Washington	Pedestrian	Flashers, gates, bell	Same as existing
Pedestrian Walkway at Pacific Street	Pedestrian	Flashers, gates, bell	Same as existing
Massachusetts Avenue	Roadway	Flashers and bell (no gates)	Flashers, gates, bell, pre-emption interconnection with traffic signals at Vassar and Albany Streets
Pedestrian Walkway between Mass. Ave and Main St	Pedestrian	Flashers, gates, bell	Same as existing
Main Street	Roadway	Flashers and bell (no gates)	Flashers, gates, bell, pre-emption interconnection with traffic signals at Vassar and Albany Streets
Broadway	Roadway	Flashers and bell (no gates)	Flashers, gates, bell, pre-emption interconnection with traffic signals at Vassar Street/Galileo Way
Binney Street	Roadway	Flashers and bell (no gates)	Flashers, gates, bell, pre-emption interconnection with traffic signals at Galileo Way
Cambridge Street	Roadway	Flashers, gates, bell	Same as existing
Medford Street	Roadway	Flashers, gates, bell	Same as existing

Figure 54. Map of Proposed Grade Crossing Improvements

5.2.5. Possible Mitigation Measures

Any increase in rail operations will have impacts on abutting land uses including residential neighborhoods, commercial uses, and the MIT campus. Impacts would include those generally stemming from noise and vibration associated with an increase in train movements along the corridor. In addition, the introduction of a double-track corridor would create site-specific effects for MIT-owned maintenance and operations facilities that abut the tracks, including impacts to pedestrian circulation and the loss of connectivity to a service aisle. However, appropriate mitigation measures could be implemented to offset some of these negative impacts.

Based on a qualitative assessment of the impacts, this section lists mitigation measures typically considered for similar urban rail projects. A more detailed study of impacts and mitigation is encouraged for future study beyond this report.

Track Bed Mitigation

Continuous welded rail (CWR) will be installed for any proposed passenger rail operations. CWR reduces vibrations and noise at the rail joints. Another potential mitigation strategy would be the use of ballast mats that can reduce vibration impacts.

Noise Barriers

The increased rail traffic would likely increase the overall noise generated from the rail corridor. Mitigation for noise would include noise barriers and window treatments that reduce noise transmission. Noise walls would only be effective at sites where the wall intersects the direct line path of noise from the source to the receiver. Given the height of the buildings close to the tracks throughout much of the corridor, this option would involve very high walls with associated costs and visual intrusion. For this reason, acoustical window treatments would be a more appropriate treatment for adjacent buildings over two stories high.

Quiet Zone Crossing Upgrades

A Quiet Zone designation would exempt the trains from the mandatory horn blowing as they approach a grade crossing. Given the transition away from diesel-fired locomotives, train horn noise would be the loudest noise impact of increased service along the Grand Junction. Given the relatively short spacing between the corridor's six roadway and three pedestrian crossings, in the absence of a Quiet Zone designation, there would be a near continuous sounding of the horn throughout the corridor. One can witness this now, even with the slow (10 mph maximum) speed of equipment transfer trains that pass through the corridor typically in the evening.

If it proves desirable to convert one or more of the existing grade crossings into Quiet Zones, the host municipality, namely the City of Cambridge, must be the applicant in petitioning the FRA for a Quiet Zone. This application would be accompanied by a location-specific report looking at all aspects of crossing safety. The report would also recommend a level of crossing protection that would otherwise typically exceed the level of protection required in the absence of a Quiet Zone designation. One example of enhanced protection might be four-quadrant gates which prevent a vehicle from driving around a gate when it is down. A median barrier approaching the crossing could also be used for the same purpose.

Pedestrian Crossing

Presently, there is a degree of "informal" track crossing that occurs outside of the established road and pedestrian grade crossings. Increased rail traffic would be accompanied by a tighter fencing of the right-of-way, thereby intentionally restricting the track crossing locations available for pedestrians for safety reasons. One possible mitigation to consider in a future study would be the provision of one or more new pedestrian crossings. While there is a likely demand for additional crossings (e.g., between Binney and Cambridge Streets), the MBTA and MassDOT are not in favor of adding grade crossings, as their policy is only to eliminate grade crossings where and when possible.

5.2.6. Summary of Infrastructure Improvements

Table 42 offers an itemized summary of the major infrastructure elements that would be required to implement the services and frequencies proposed in Alternative 1 (Core Route only) and Alternative 2 (Core Route + Extended Route). The primary differentiators between Alternatives 1 and 2 are the need to incorporate turnback facilities at Lynn Station for Alternative 2, which would be associated with operating the Extended Route, as well as two incremental improvements at the Fitchburg line (i.e., one additional turnout (three total), along with a new crossover (one total)) that would help trains more effectively navigate between the Grand Junction line within the City of Cambridge and communities served by the Extended Route further north.

Table 42. Summary of Infrastructure Improvements

Segment	Item	Description	Alternative 1 – Quantity	Alternative 2 – Quantity
Mainline Through Cambridge	Upgrade Existing track	New CWR, ties, and ballast; Drainage improvements from Charles River to the Fitchburg Line	2.7 miles	Same as Alternative #1
	New Second Track	Rail elements related to the installation of an additional running track from Massachusetts Ave to Medford St	1.3 miles	Same as Alternative #1
	New train signal system	Convert the “dark” territory to a signaled operations corridor	2 miles	Same as Alternative #1
	Electrification or provisions for battery-electric operations	For the fully-electrified options, OCS elements would be required along the corridor in Cambridge.	2 miles (if electrified)	Same as Alternative #1
	Upgrade grade crossings	New equipment including flashers, gates, and bells; interconnect with traffic signals	6 roadway crossings and 3 pedestrian crossings	Same as Alternative #1
	Noise and vibration mitigation	To be determined after noise and vibration study	Cost for this item is not included separately at this time, since a detailed noise and vibration study has not yet been performed. Instead, an allowance for this type of mitigation is included as part of the Contingency	Same as Alternative #1
	Fencing	Fence ROW to prevent pedestrian intrusions	4 miles (Memorial Drive to Fitchburg Line, both sides of ROW)	Same as Alternative #1
Stations	Station platforms assuming two side platforms at each station.	Station platforms including canopies, railings, seating, signage, lighting, and typical amenities for MBTA stations.	Assume 4 stations and 8 platforms	Same as Alternative #1
South Connection	Upgrade Charles River Crossing	Possible rehabilitation and upgrading of existing rail bridge.	***This cost is currently unknown as a separate structural assessment is necessary. Therefore, the cost is not included in this study.***	Same as Alternative #1
	Connection to West Station	0.5 miles of double track between Memorial Drive and West Station	This cost is assumed to be included in the Allston Viaduct MassDOT project as part of the rail relocation work	Same as Alternative #1
North Connection	Connection to Fitchburg Line	Revise existing interlocking at Fitchburg Line (“Swift”) to accommodate a two-track	Remove existing turnout and diamond; replace with 2 new turnouts and 1 new diamond	Same as Alternative #1, but also includes another new turnout and a new crossover at “Swift” interlocking, as well as provisions for a turnback facility at Lynn Station

5.3. Operations Simulation

This section identifies run times for the two alternatives and an assessment of the minimum feasible headway.

5.3.1. Minimum Feasible Headway

The issue of minimum feasible headways was addressed in Chapters 2 and 3. The 15-minute headways associated with Rail Vision's Urban Rail was used as a starting point for potential service frequency. Starting with the 15-minute headway, consideration was given to both shorter and longer headways. The constraints on the minimum feasible headway were both found to be operational considerations – grade crossings and the mixing of Grand Junction trains with existing service on other lines.

Grade Crossing Constraints

Concern was raised by stakeholders regarding the disruption of grade crossings and impacts to multimodal traffic (vehicles, pedestrians, bicycles, and buses) on the corridor's six cross streets. Specifically, stakeholders noted potential impacts to vehicular mobility, such as changes in response times for emergency vehicles and the ability to maintain on-time performance along existing MBTA bus routes. For a discussion of approaches to mitigating potential traffic impacts, please consult Section 5.3.5

With Alternative 1's Core Route (West Station to North Station) service operating every 15 minutes in each direction, approximately eight gate closures per hour would be expected. For each gate closure, the duration would be approximately 40 seconds accounting for the approach time (30 seconds) plus about another 10 seconds for the train to pass through the grade crossing allowing the gates to raise and the flashers to stop.

In addition to the Alternative 1 frequencies along the Core Route, Alternative 2 adds an overlay service along the Extended Route between West Station and Lynn. A service frequency of 30 minutes along this Extended Route was assumed, which would result in a combined headways of either 10-minutes or 12-minutes on the Cambridge section of the Grand Junction. This level of service would increase the gate closures from eight to approximately twelve per hour at each crossing.

Constraints Due to Operating on Other Lines

As described previously, the Core Route (West Station to North Station) requires operating on the Fitchburg Line to reach North Station. Thus, the string line diagrams included in Section 5.3.3 show how Grand Junction commercial trains could mix with the current schedule of Fitchburg Line trains. If a 15-minute urban rail service was added to the Fitchburg Line (per Rail Vision), the scheduling of both lines would require careful coordination of operations to minimize conflicts, particularly at the "Swift" interlocking in Somerville, where the Grand Junction merges onto the Fitchburg Line.

Based on current plans for West Station, the Grand Junction service does not require operating on the Worcester Line to get to West Station. Current schematics show a separate two track configuration between West Station and the Charles River crossing at the BU Bridge, with the Worcester mainline serving a separate island platform at West Station.

A West Station to Everett, Chelsea, Revere and/or Lynn line (i.e., the Extended Route served within Alternative 2) would require not only consideration of Fitchburg line operations for a brief stretch at "Swift" interlocking, but also consideration of scheduled service on both the Haverhill and Newburyport / Rockport lines.

Longer headways (up to 20 minutes) were also considered for the Core Route; the ridership analysis, however, showed that for headways greater than 17.5 minutes, the Grand Junction rail service did not provide any trip time advantage over existing travel options.

Thus, the recommendations for operations simulation are as follows:

- Core Route – West Station to North Station: 15-minute headways.
- Extended Route – West Station to Lynn: 30-minute headways.

5.3.2. Mainline Operations

The "mainline" in this context refers to the Grand Junction between the Charles River crossing at the BU Bridge and the junction with the Fitchburg line at "Swift" interlocking in Somerville. The simulations assume that a two-track Grand Junction mainline is provided.

5.3.3. Terminal Operations: North Station, West Station, and Lynn Central Station

The operations modeling incorporated the MBTA's anticipated accommodation of a Grand Junction passenger rail service at both North Station and West Station. Proposals for how to accommodate Grand Junction trains turning back at Lynn Central Station, which would be necessary for Alternative 2's Extended Route service, were also developed.

- For **North Station**, this analysis assumes that a Grand Junction service would use the platform at Tracks 11 and 12, which are currently inaccessible but would become accessible with the Draw One Bridge Replacement project. After the Draw One project has been completed, the Grand Junction trains could approach North Station on the Fitchburg Line and use the westerly tracks over the Draw One Bridge. For a 15-minute headway, Tracks 11 and 12 would have to be dedicated to the Grand Junction operation to allow for time to turn around a train (approximately 15 minutes to allow for the break test) and provide for schedule protection should a train arrive late.
- For **West Station**, the MBTA, along with other project proponents, have developed a station configuration with dedicated Grand Junction tracks that allow for transfers between the Worcester and Grand Junction lines at West Station. Two Grand Junction tracks are provided. These plans also include a two-track Grand Junction line between West Station and the Charles River crossing at the BU Bridge. Therefore, the Grand Junction track can run independent of the trains on the Worcester Line.

- For **Lynn Central Station,** termination for a West Station to Lynn service could be provided by a turnback track located north of the station platforms (see Figure 55). The current track configuration at Lynn includes a significant spread of the two-track north of the existing island platform. A turnback track long enough to hold an anticipated four-car trainset could be constructed along with turnouts from each track. A Grand Junction train arriving at Lynn would discharge its passengers and then enter the turnback track where it would wait for the return trip. At that time, it would leave the turnback track for the main Boston-bound track and pick up passengers at Lynn to start its trip to West Station.

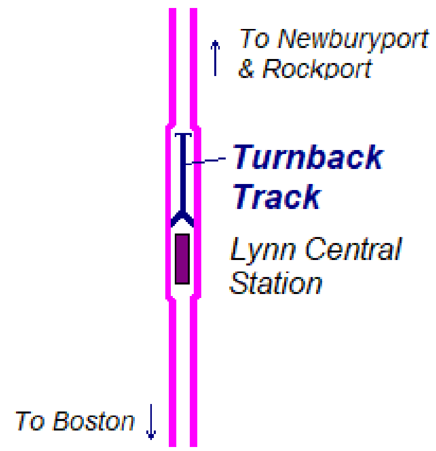


Figure 55. Conceptual Configuration for a Turnback Track at Lynn Central Station

5.3.4. Operational Simulation

The study team utilized a spreadsheet-based trip time estimator (TTE) for analysis and simulation of proposed operations. The TTE was previously developed for the USDOT Commercial Feasibility Study as a simpler way to determine run times for various rail services from light and heavy trail through high-speed rail systems. The spreadsheet has been checked against published timetables for commuter and intercity service on many projects and rail lines, including many of lines of the MBTA commuter rail system. The results have generally indicated that the study team's TTE produces a timetable where the arrival times at stations are within a minute or two of the published timetable. Thus, the project team has determined that the spreadsheet produces realistic travel times for planning studies such as the Grand Junction study. The use of this spreadsheet provides illustrative travel times suitable for planning studies with much less effort than using a more sophisticated train performance calculator program.

For this study, we used the TTE template and input the parameters including:

- Maximum authorized speed (MAS) for each segment of track:
  - For the Grand Junction in Cambridge, this is 40 mph for the tangents (straight track) and slower for the curves (based on how tight the radius is).
  - For the extension to Lynn, the MAS used is based on the MBTA's published track charts, which varies from 25 to 70 mph.
  - Each segment of track is defined by the starting and ending mileposts.
- The acceleration and breaking performance of the train. For this, we used the performance parameters of the Stadler FLIRT

The output of the spreadsheets includes:

- Travel times for each route
- Speed profile
- String line diagrams (space-time graphs) showing the proposed train operations.

Operational simulations were modeled for two services:

- Core Route – West Station to North Station
- Extended Route – West Station to Everett, Chelsea, Revere and Lynn

As noted above, the West Station to North Station operation must consider current operations on the Fitchburg Line but does not require consideration of operations on the Worcester Line based on the currently proposed track configuration between West Station and the Charles River crossing at the BU Bridge.

5.3.3.1 West Station to North Station Operations

The operational analysis is based on the following:

- Two Grand Junction tracks from West Station to "Swift" interlocking
- A two-track junction with the Fitchburg line
- Operation between "Swift" and North Station on the existing two-track Fitchburg line
- Completion of the "Draw 1" bridge replacement project providing:
  - Six tracks crossing the Charles River at "Draw 1"
  - Access to Tracks 11 and 12 for the Grand Junction service
  - Tracks 11 and 12 are dedicated to the Grand Junction service.
- Track, signal, and grade crossing improvements as described in Section 4.1
- Operations with EMUs or B-EMUs per the current MBTA Rail Vision plans
  - Maximum speed of 40 mph
- Four stops in Cambridge
  - 30 seconds dwell time at each stop
- A "green light" railroad (i.e., no delays due to other trains on the line)
- No delays at grade crossings
- An allowance of 5% is added to the travel time for short delays due to conflicts with service on the Fitchburg line, particularly if either service is running late.

Table 43 and Table 44 show an illustrative timetable for the proposed operations in each direction on Grand Junction between West Station and North Station. Figure 56 and Figure 57 show the speed profiles for operations in each direction. Figure 58 provides illustrative sting lines for 5 to 9 AM weekday service for both the Grand Junction trains and the existing train service on the Fitchburg Line. The string lines show that it would be possible to schedule Grand Junction service without interfering with the existing service on the Fitchburg Line.

Consideration of a Third Fitchburg Line Track

Based on the string line diagrams, a third track is not warranted at this time between the junction of the Grand Junction and Fitchburg Lines at "Swift" interlocking and "Draw 1" bridge. There is enough capacity for both services on a two-track configuration. Should a new 15-minute headway Urban Rail service be added to the Fitchburg Line, a more detailed analysis may be needed.

Table 43. Timetable: West Station to North Station

	Station Stops								Speed Between Stations		
	Station	Elapsed Distance	Arrival *	Departure *	Dwell	Travel Time between Stations	Added Delay	Travel Time between Stations	Run	Oper.	Max.
			w/ added delay	w/ added delay		no added delay		w/ added delay			
		(Miles)	(Min.)	(Min.)	(Min.)	(Min.)	(Min.)	(Min.)	(MPH)	(MPH)	(MPH)
1	West Station	0		0.0							
2	Cambridgeport	1.25	4.5	5.0	0.5	4.5	0.0	4.5	16.7	15.0	30
3	Mass. Ave	1.75	6.2	6.7	0.5	1.2	0.0	1.2	25.1	17.7	40
4	Kendall Square	2.2	8.0	8.5	0.5	1.3	0.0	1.3	21.1	15.2	30
5	Eastern Cambridge	2.8	9.8	10.3	0.5	1.3	0.0	1.3	26.8	19.5	40
6	North Station	4.5	17.5	17.5	0	7.2	0.0	7.2	14.3	14.3	25
	No. of runs between stops		5						Total Additional Delay=	0.0	min.
Total Run & Dwell Times (no delay, no pad)					2.0	15.5					
Total Run & Dwell Times (plus delay)				17.5							
Arrival Time w/ Pad		5%	19								

Trip Summary	Elapsed Milage	Start Time	End Time	Total Dwell	Total Run Time (Padded) *		Run Speed	Oper. Speed	Max. Speed
		(Min.)	(Min.)	(Min.)	(Min.)		(MPH)	(MPH)	(MPH)
End of Run Summary	4.5	17	19	2	16		16.9	14.2	40

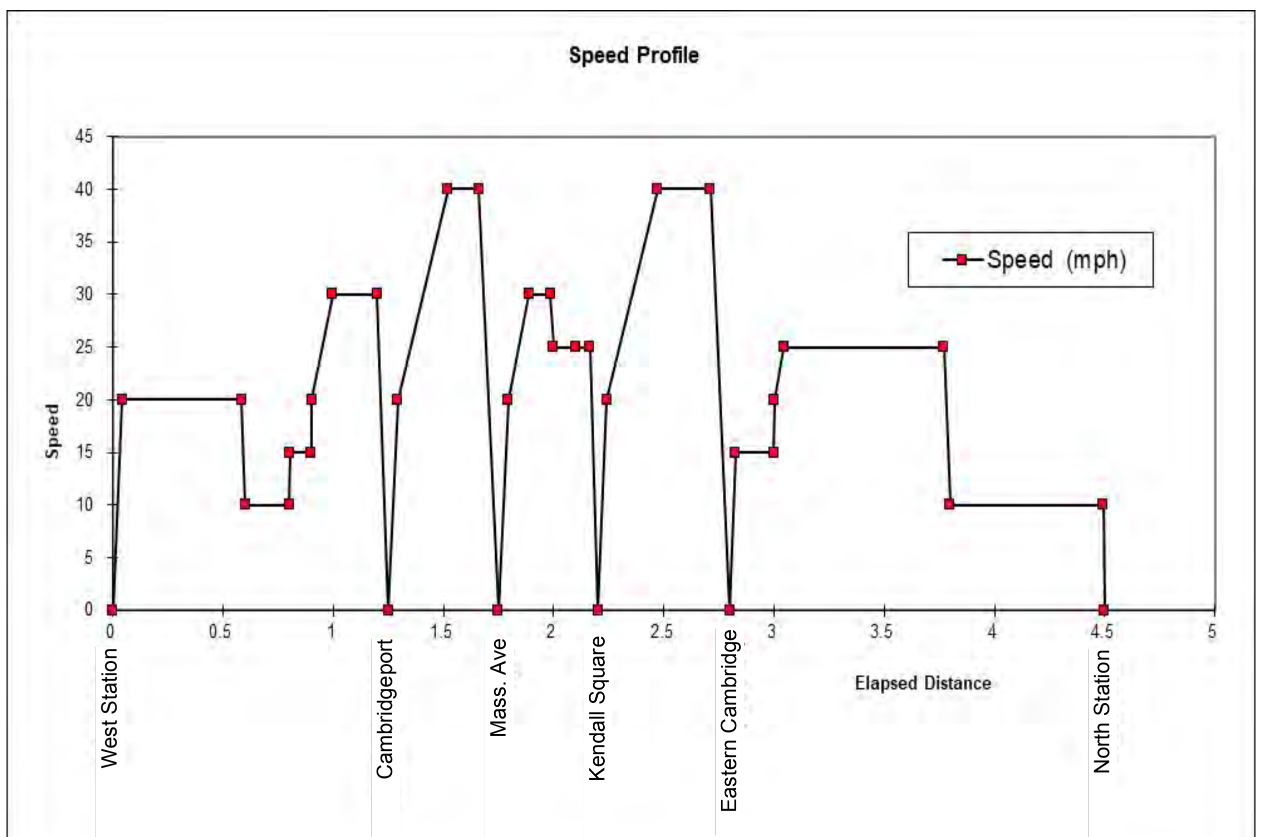


Figure 56. Speed Profile for Grand Junction service from West Station to North Station

Table 44. Timetable: North Station to West Station

	Station Stops								Speed Between Stations		
	Station	Elapsed Distance	Arrival *	Departure *	Dwell	Travel Time between Stations	Added Delay	Travel Time between Stations	Run	Oper.	Max.
			w/ added delay	w/ added delay		no added delay		w/ added delay			
		(Miles)	(Min.)	(Min.)	(Min.)	(Min.)	(Min.)	(Min.)	(MPH)	(MPH)	(MPH)
1	North Station	0		0.0							
2	Eastern Cambridge	1.7	7.2	7.7	0.5	7.2	0.0	7.2	14.2	13.2	25
3	Kendall Square	2.3	9.0	9.5	0.5	1.3	0.0	1.3	26.8	19.5	40
4	Mass. Ave	2.75	10.8	11.3	0.5	1.3	0.0	1.3	21.1	15.2	30
5	Cambridgeport	3.25	12.5	13.0	0.5	1.2	0.0	1.2	25.2	17.7	40
6	West Station	4.5	17.5	17.5	0	4.5	0.0	4.5	16.6	16.6	30
	No. of runs between stops		5						Total Additional Delay=	0.0	min.
Total Run & Dwell Times (no delay, no pad)					2.0	15.5					
Total Run & Dwell Times (plus delay)				17.5							
Arrival Time w/ Pad		5%	19								

Trip Summary	Elapsed Milage	Start Time	End Time	Total Dwell	Total Run Time (Padded) *		Run Speed	Oper. Speed	Max. Speed
		(Min.)	(Min.)	(Min.)	(Min.)		(MPH)	(MPH)	(MPH)
End of Run Summary	4.5	18	19	2	16		16.9	14.2	40

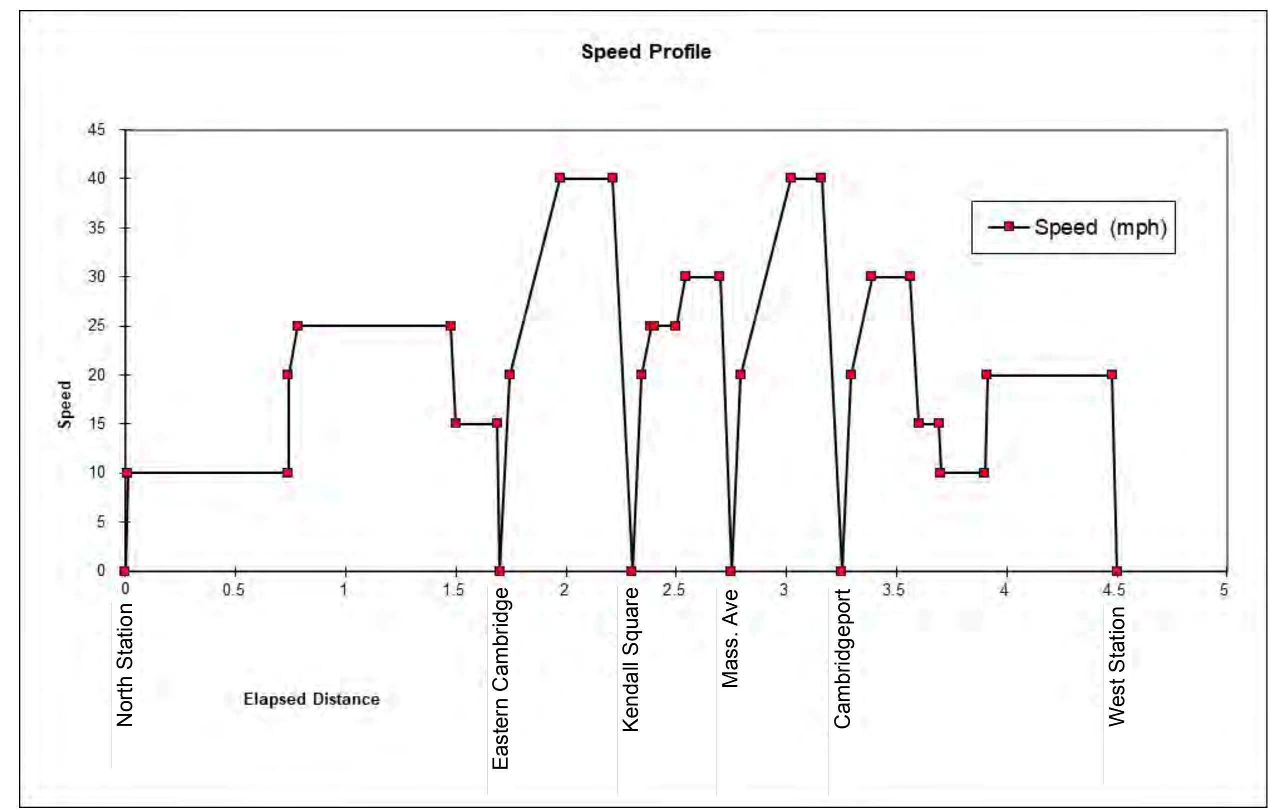


Figure 57. Speed Profile for Grand Junction service from North Station to West Station

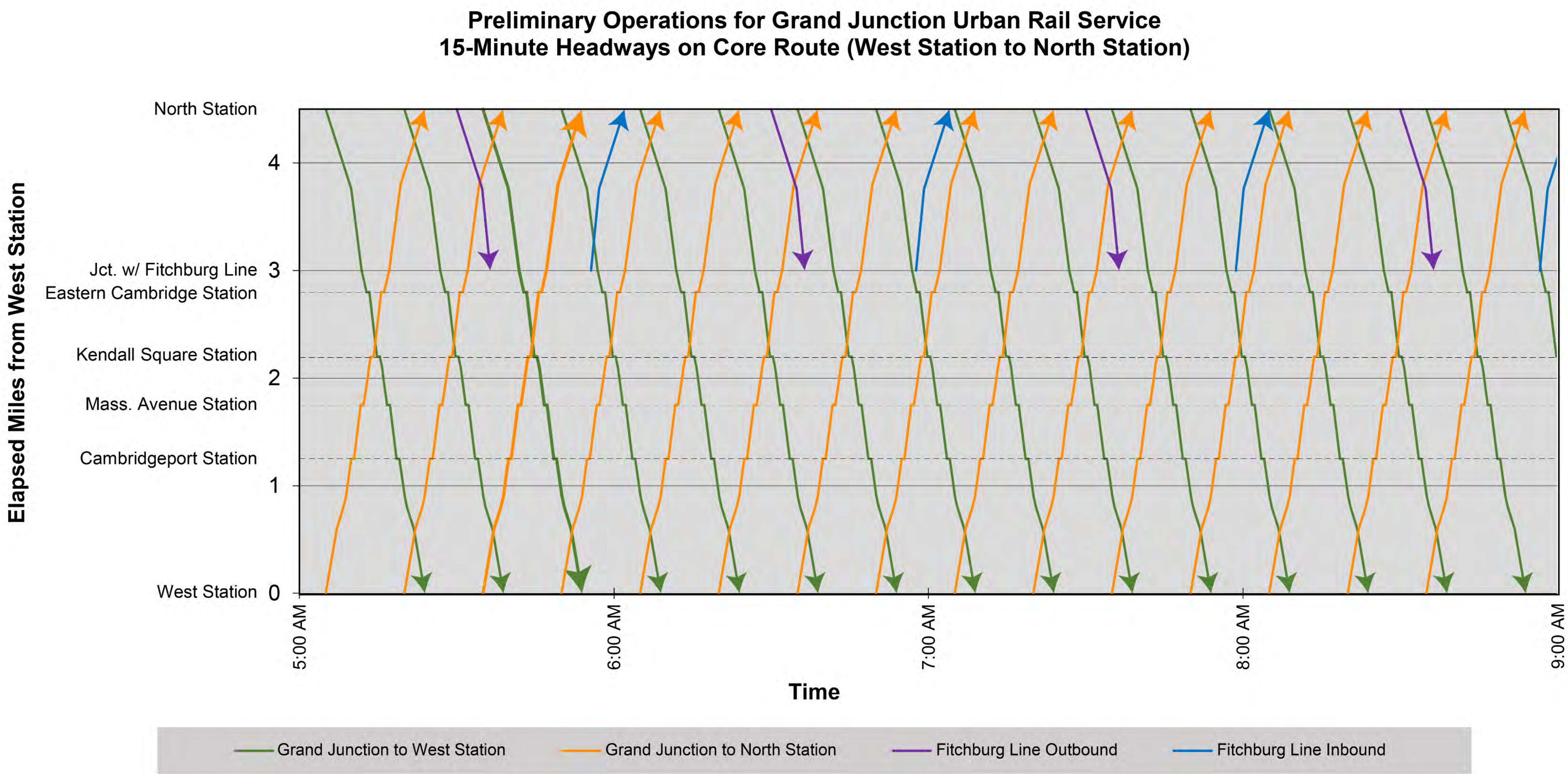


Figure 58. String Line Diagrams for Grand Junction Core Route Service between West Station and North Station (Every 15 Minutes)

Consideration of Operations at "Draw 1"

The drawbridge operations at "Draw 1" (the Charles River crossing adjacent to North Station) constrains the movement of trains in and out of North Station. Currently, there are two bascule bridges, each with two tracks for a total of four tracks. The MBTA's Draw 1 replacement project, which is currently in design, will increase this to a total of six tracks. The added tracks would augment the arrival/departure capacity of North Station and provide access to the two currently inaccessible tracks at the terminal (Tracks 11 and 12).

During the course of construction of this MBTA-led effort, there will be further constraints on the operational capacity at North Station and at the northern crossing of the Charles River. Therefore, it is highly unlikely that a Grand Junction service can be launched until the MBTA's Draw One Bridge Replacement project is completed and the additional capacity is provided at North Station. Due to the constraints of the existing tracks, there is no location available near North Station for a temporary terminus until such time as the Draw One Bridge Replacement project is completed.

5.3.3.2 West Station to Lynn Operations

The operational analysis is based on the following:

- Two Grand Junction tracks from West Station to "Swift" interlocking near the Fitchburg line
- A two-track junction with the Fitchburg line
- Operation between "Swift" and North Station on the existing two-track Fitchburg line
- Completion of the "Draw 1" bridge replacement project providing:
  - Six tracks crossing the Charles River at "Draw 1"
  - Access to Tracks 11 and 12 for the Grand Junction service
  - Tracks 11 and 12 are dedicated to the Grand Junction service.
- Track, signal, and grade crossing improvements as described in Section 4.1.
- Operations with EMUs or BEMUs per the current MBTA Rail Vision plans
- Four stops in Cambridge
- 30 seconds dwell time at each stop
- Maximum speed of 70 mph
- A "green light" railroad (i.e., no delays due to other trains on the line)
- No delays at grade crossings
- An allowance of 5% to the travel time is added for short delays due to conflicts with service on the Fitchburg line, particularly if either service is running late. A more detailed analysis would involve examining a range of delay time allowances that could be applied to estimate the impact of other (non-Fitchburg) North Side services.

Table 45 and Table 46 present illustrative timetables for the proposed operations in each direction on Grand Junction between Lynn and West Station. Figure 59 shows string lines for 5 to 9 AM weekday service for both the Grand Junction trains and the existing train service on the Fitchburg, Haverhill, and Newburyport/Rockport lines.

The string lines indicate how these Grand Junction trains would have to be coordinated with the schedule for trains on three of the North Side CR Lines: Fitchburg, Haverhill, and Newburyport/Rockport. To develop this illustrative example of integrating Grand Junction service into the existing schedules, it was necessary to deviate from a strict 30-minute headway to avoid conflicts with the currently scheduled CR services. Even with careful operations planning, the service to Lynn may be impacted by any delays on any of the three CR Lines. Operationally, this alignment would be considerably more complex than the Core Route.

With these concerns, the on-time reliability of Grand Junction service to Lynn via the Extended Route would not be as reliable as a West Station to North Station service via the Core Route, as the operations along the latter would only have to be coordinated with one other CR Line. In addition, the MBTA was concerned that adding a Grand Junction service to Lynn will reduce the capacity on the other lines and introduce the potential for cascading delays to other CR Lines stemming from perturbations along the Grand Junction. Overall, the Extended Route to Lynn is less feasible in consideration of schedule reliability.

Table 45. Timetable: Lynn to West Station

	Station Stops								Speed Between Stations		
	Station	Elapsed Distance	Arrival *	Departure *	Dwell	Travel Time between Stations	Added Delay	Travel Time between Stations	Run	Oper.	Max.
			w/added delay	w/added delay		no added delay		w/added delay			
		(Miles)	(Min.)	(Min.)	(Min.)	(Min.)	(Min.)	(Min.)	(MPH)	(MPH)	(MPH)
1	Lynn Sta.	0		0.0							
2	Revere Sta.	4.5	4.9	5.4	0.5	4.9	0.0	4.9	54.8	49.7	70
3	Chelsea	6.5	8.6	9.1	0.5	3.1	0.0	3.1	38.4	33.1	70
4	Everett	7.85	11.6	12.1	0.5	2.5	0.0	2.5	32.4	27.0	45
5	Eastern Cambridge	10.3	16.5	17.0	0.5	4.4	0.0	4.4	33.2	29.8	60
6	Kendall Square	10.9	18.3	18.8	0.5	1.3	0.0	1.3	26.8	19.5	40
7	Mass. Ave	11.35	20.1	20.6	0.5	1.3	0.0	1.3	21.1	15.2	30
8	Cambridgeport	11.85	21.8	22.3	0.5	1.2	0.0	1.2	25.1	17.7	40
9	West Sta.	13.1	26.8	26.8	0	4.5	0.0	4.5	16.6	16.6	30
	No. of runs between stops:		8				Total Additional Delay=			0.0	min.
	Total Run & Dwell Times (no delay, no pad)				3.5	23.3					
	Total Run & Dwell Times (plus delay)			26.8							
	Arrival Time w/ Pad:	5%	29								

Trip Summary									
	Elapsed Milage	Start Time	End Time	Total Dwell	Total Run Time (Padded) *		Run Speed	Oper. Speed	Max. Speed
		(Min.)	(Min.)	(Min.)	(Min.)		(MPH)	(MPH)	(MPH)
End of Run Summary	13.1	19	29	4	24		32.8	27.1	70

Table 46. Timetable: West Station to Lynn

	Station Stops								Speed Between Stations		
	Station	Elapsed Distance	Arrival *	Departure *	Dwell	Travel Time between Stations	Added Delay	Travel Time between Stations	Run	Oper.	Max.
			w/added delay	w/added delay		no added delay		w/added delay			
		(Miles)	(Min.)	(Min.)	(Min.)	(Min.)	(Min.)	(Min.)	(MPH)	(MPH)	(MPH)
1	West Station	0		0.0							
2	Cambridgeport	1.25	4.5	5.0	0.5	4.5	0.0	4.5	16.7	15.0	30
3	Mass. Ave	1.75	6.2	6.7	0.5	1.2	0.0	1.2	25.1	17.7	40
4	Kendall Square	2.2	8.0	8.5	0.5	1.3	0.0	1.3	21.1	15.2	30
5	Eastern Cambridge	2.8	9.8	10.3	0.5	1.3	0.0	1.3	26.8	19.5	40
6	Everett	5.25	14.7	15.2	0.5	4.4	0.0	4.4	33.3	29.9	60
7	Chelsea	6.6	17.8	18.3	0.5	2.5	0.0	2.5	32.1	26.8	45
8	Revere Sta.	8.6	21.4	21.9	0.5	3.1	0.0	3.1	38.5	33.2	65
9	Lynn Sta.	13.1	26.8	26.8	0	5.0	0.0	5.0	54.5	54.5	70
	No. of runs between stops:		8				Total Additional Delay=			0.0	min.
	Total Run & Dwell Times (no delay, no pad)				3.5	23.3					
	Total Run & Dwell Times (plus delay)			26.8							
	Arrival Time w/ Pad:	5%	29								

Trip Summary									
	Elapsed Milage	Start Time	End Time	Total Dwell	Total Run Time (Padded) *		Run Speed	Oper. Speed	Max. Speed
		(Min.)	(Min.)	(Min.)	(Min.)		(MPH)	(MPH)	(MPH)
End of Run Summary	13.1	15	29	4	24		32.8	27.1	70

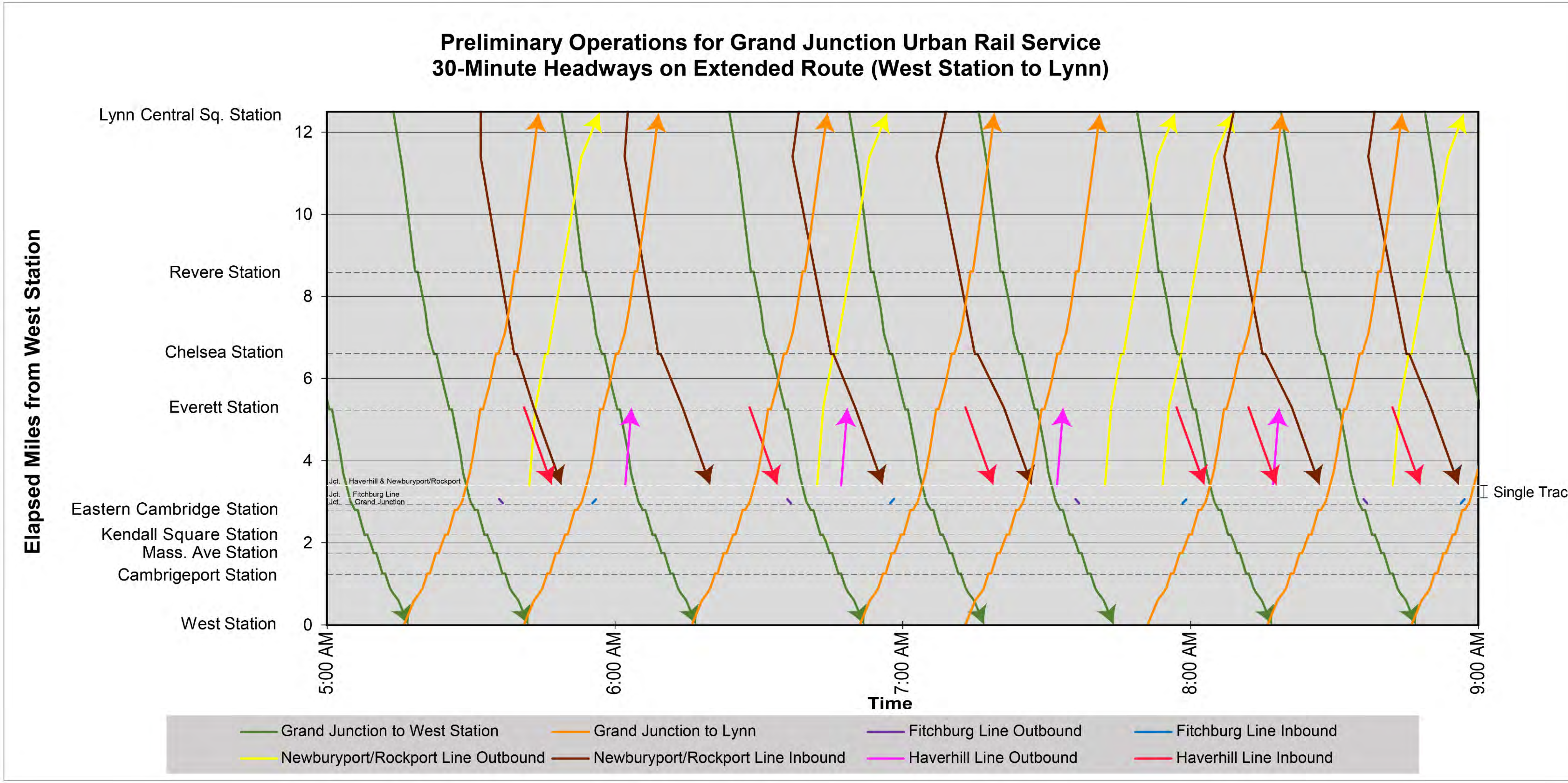


Figure 59. String Line Diagrams for Grand Junction Extended Route Service between West Station and Lynn (Every 30 Minutes)

5.3.5. Traffic Evaluation for Grade Crossings

With six roadway grade crossings in Cambridge, traffic operations at these junctions are a key consideration within an analysis that assumes a sizeable growth in passenger rail trips along the Grand Junction. The primary concern relates to potential delays to vehicular throughput on cross streets when passenger trains traverse the at-grade crossings.

5.3.5.1 Summary of Current Active Warning Systems (AWSs)

The summary of AWSs is presented in Section 5.2.4. As noted, all crossings have flashers, but only two have both flashers and gates:

- Massachusetts Avenue Flashers
- Main Street Flashers
- Broadway Flashers
- Binney Street Flashers
- Cambridge Street Flashers & gates
- Medford Street Flashers & gates

5.3.5.2 Current Operation at Grade Crossings

Current rail operations are at a maximum speed of 10 mph. As the train approaches a crossing it sounds the horn. It approaches the crossing slowly until the flashers are activated. Where there are no gates, the train may have to wait for vehicular traffic to clear the track before proceeding through the grade crossing.

5.3.5.3 Upgraded Grade Crossing Active Warning Systems

To accommodate passenger operations while seeking to minimize traffic delays due to “gate down” time, proposed upgrades would include:

- New AWSs with both flashers and gates at each grade crossing. This is typical for passenger rail operations, particularly those with frequent service.
- Predictor type controller that aligns gate-down before train arrival with train speed. This minimizes gate-down time if a train is operating slower than track speed.
- Pre-emption of traffic signals at adjacent intersections. This will help clear vehicles on the tracks through the signalized intersection and also provide red signals to vehicular traffic to further encourage drivers to avoid encroaching into the grade crossing.
- For locations where a station platform is sited near a crossing, AWSs should rely on manual activation so that a train servicing the platform does not inadvertently activate the AWS. This could be done via a push-button activator that is triggered by the train crew once they are ready to depart the platform. This approach, which is currently used by the MBTA Commuter Rail at Canton station, eliminates “gate down” when the train is at the station but not ready to approach the grade crossing.

5.3.5.4 Coordination of AWSs with Adjacent Signalized Intersections and Path Crossings

The six roadway grade crossings have added complexity due to nearby signalized intersections and the street crossings of the City’s parallel proposed multi-use path. Figure 60 shows an example at Massachusetts Avenue, with signalized intersections east and west of the tracks and the proposed path just west of the tracks.

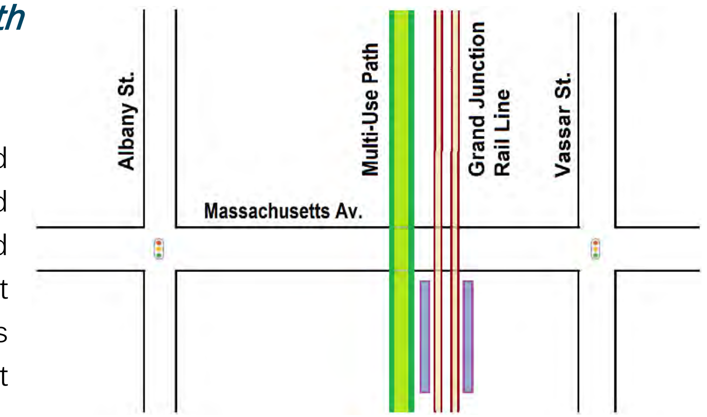


Figure 60. At Massachusetts Avenue, There Are Two Signalized Intersections on Either Side of the Grand Junction and a Proposed Crossing of the Multi-Use Path (Immediately West).

Table 47 summarizes the configurations of adjacent intersections and the multi-use path at each grade crossing.

Table 47. Adjacent Intersections and Path Location at Grade Crossings

Crossing Street	Adjacent Signalized Intersections	Location of Multi-Use Path
Massachusetts Avenue	Albany Street (west of tracks) and Vassar Street (east of tracks)	West of tracks
Main Street	Vassar Street/ Galileo Galilei Way (east of tracks)	Switches west of tracks to east
Broadway	Galileo Galilei Way (east of tracks)	East of tracks
Binney Street	Fulkerson (east of tracks)	Switches east of tracks to west
Cambridge Street	Pedestrian crossing (east of tracks)	Switches west of tracks to east
Medford Street	None	Path ends east of tracks

For each crossing, the existing traffic signals would be redesigned to accommodate the configuration of the railway grade crossing, adjacent signalized intersections, and the multi-use path crossing:

- The traffic control section would have a pre-emption interconnection with the grade crossing AWS. When a train approaches, the pre-emption will override the normal traffic signal phasing and prohibit vehicular movements that would cross the tracks.
- The multi-use path crossing would also be controlled by traffic signals coordinated with the adjacent intersections and with the pre-emption from the grade crossing AWS.

5.3.5.5 Pre-emption

With pre-emption, an approaching train overrides the ongoing traffic signal cycle. The duration of the pre-emption would include two components:

- Approach Time – 30 seconds – time from when the approaching train triggers the AWS, thereby initiating the flashers and bell and lowering the gates until the train enters the crossing.
- Crossing Time – 10-15 seconds – time from when the train enters the crossing until it clears the crossing, thereby allowing for the gates to rise and the flashers and bell to cease. Based on a 4-car urban rail train traveling at 20 to 30 mph, this would amount to approximately 10 to 15 seconds.

Thus, the total pre-emption time would likely range from 40 to 45 seconds. During this pre-emption time, the traffic signal would cycle to a Clearance Phase, followed by one or more Concurrent Phases, as described below. The objective for the traffic signal designer would be to maximize throughput at the adjacent intersection despite the gate closure. In a future stage, traffic operations modeling should simulate these locations as if they possessed a traffic control device.

Clearance Phase

The objective of the clearance phase is to allow any vehicles on or adjacent to the tracks to clear the tracks while not allowing other traffic to approach the grade crossing. This phase starts when the approaching train triggers the AWS to start the flashers and bells and begin lowering the gates.

Figure 61 shows an example of a clearance phase at Massachusetts Avenue. Note how the phase allows for Massachusetts Avenue traffic situated between Albany and Vassar Streets to clear that block without any conflicts at the adjacent intersections:

- Albany Street
  - Green: Massachusetts Avenue WB
  - Red: Massachusetts Avenue EB; Albany St. NB & SB
  - Don't Walk: All crosswalks.
- Multi-Use Path
  - Don't Walk
- Vassar Street
  - Green: Massachusetts Avenue EB
  - Red: Massachusetts Avenue WB; Vassar St. NB & SB
  - Don't Walk: All crosswalks.

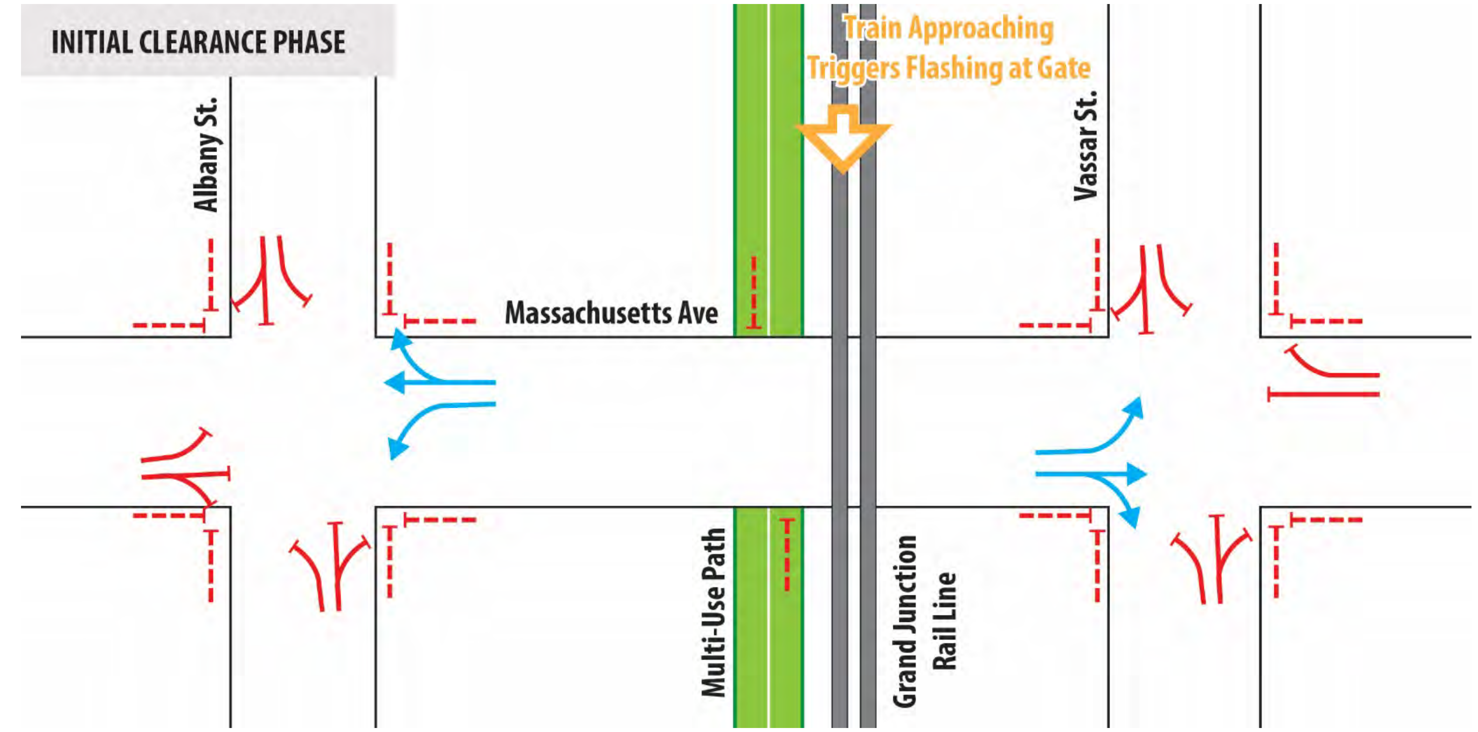


Figure 61. Example of a Clearance Phase at Massachusetts Avenue

Concurrent Phase(s)

Once the block is cleared, the remainder of the "gate-down" period can be sequenced with one or more concurrent phases, where north-south vehicle and pedestrian movements can occur while the train is passing in a north or south direction.

Concurrent Phase 1

Figure 62 shows a possible concurrent traffic phase during the "gate down" period.

- Grade Crossing
  - Gates down
- Albany Street
  - Green: Albany St. NB & left turn: Massachusetts Av. EB right turn
  - Red: Massachusetts Avenue EB (straight and left turn) & WB; Albany St. SB
  - Walk: East side crossing Massachusetts Ave.
  - Don't Walk: All other crosswalks.
- Multi-Use Path
  - Walk
- Vassar Street
  - Green: Vassar St. SB & left turn; Massachusetts Av. WB right turn
  - Red: Massachusetts Avenue EB & WB (straight and left turn); Vassar St. NB
  - Walk: West side crossing Massachusetts Ave.

- Don't Walk: All other crosswalks.

Concurrent Phase 2

Figure 63 shows a possible concurrent traffic phase during the "gate down" period.

- Grade Crossing
  - Gates down
- Albany Street
  - Green: Albany St. NB (straight) & SB (straight and right turn)
  - Red: Massachusetts Avenue EB & WB; Albany St. SB (left turn) & NB (right turn and left turn)
  - Walk: East side crossing Massachusetts Ave.
  - Don't Walk: All other crosswalks.
- Multi-Use Path
  - Walk
- Vassar Street
  - Green: Vassar St. SB (straight) & NB (straight and right turn)
  - Red: Massachusetts Avenue EB & WB; Vassar St. NB (left turn) & SB (left and right turn)
  - Walk: West side crossing Massachusetts Ave.
  - Don't Walk: All other crosswalks.

After the Preemption

Once the train has passed, the traffic signal system would revert to its normal cycle. The initial phase after the pre-emption would clear the queue of EB and WB traffic that had been waiting on the gate closure.

Additional Analysis

Additional traffic analysis would be necessary to develop signal phasing that incorporates the restrictions of the pre-emption for gate-closure. Such traffic modeling would determine the overall delay to east-west vehicular traffic attributable to the increase in anticipated frequency of train operations along the Grand Junction.

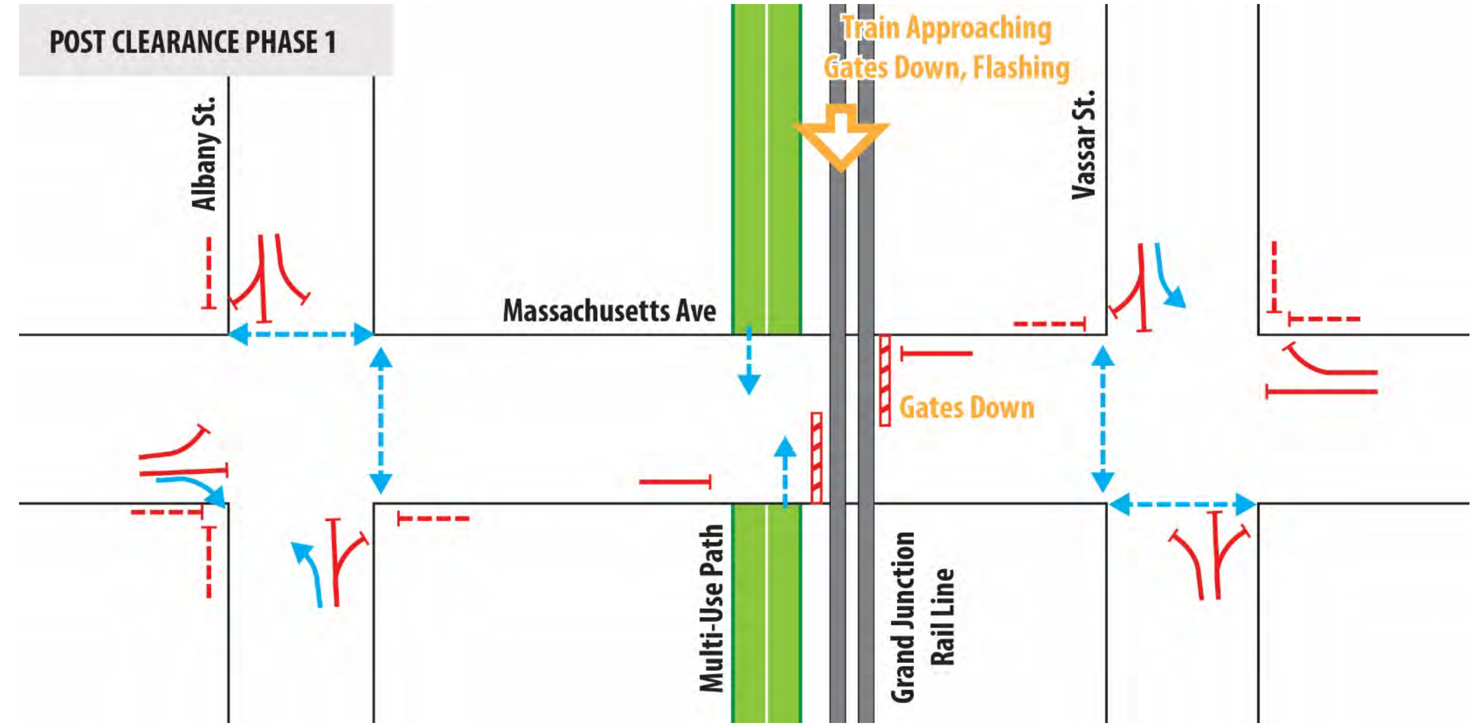


Figure 62. Example of a Concurrent Phase during a Gate Down Event (Phase 1)

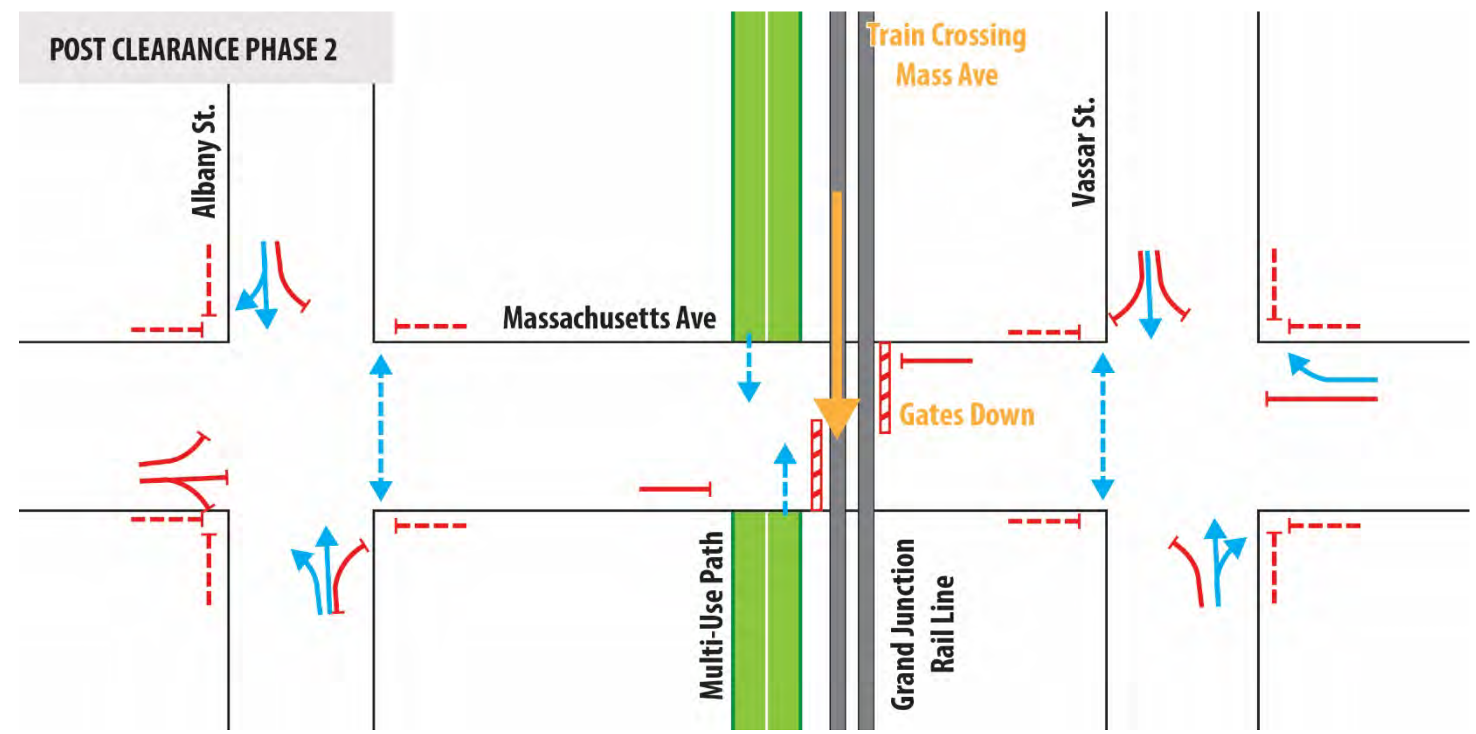


Figure 63. Example of a Concurrent Phase during a Gate Down Event (Phase 2)

5.4. Implementation Scenarios

This section considers three implementation scenarios describing how a Grand Junction passenger service could be realized. Depending on the proponent or approach, each scenario would have a different anticipated timeframe.

- **Scenario #1 – Implementation as Part of Rail Vision**: This implementation scenario will also consider the Grand Junction line as one part of an Urban Rail network as proposed in Rail Vision. The timeframe will be in the sequence of implementation as currently anticipated by the MBTA.
- **Scenario #2 – Local Proponent Advances Project**: This implementation scenario will consider expediting the implementation of the Grand Junction service by a local proponent who would advance the project through the planning process in consultation with the MBTA but ahead of the anticipated Rail Vision implementation schedule.
- **Scenario #3 – Early Implementation**: This early implementation scenario would look at how a Grand Junction service could be implemented prior to the major adjacent projects – the MassDOT Allston Interchange/West Station project and the MBTA's replacement of the Draw 1 bridge approach to/from North Station.

An illustrative summary of the overall project timeline under each implementation scenario is provided in Figure 64 through Figure 66. Within the figures, the length of each task shown reflects its duration relative to other efforts relative to both other tasks within that scenario and among the scenarios themselves.

Each of the scenarios must include the following planning, design, procurement, and construction steps:

1) Completion of early planning
2) Identification of funding plan
3) Funding in place for Preliminary Engineering (PE) and environmental concern (NEPA / MEPA)
4) Conduct PE and environmental clearance (NEPA / MEPA)
5) Funding in place for Final Design (FD)
6) Final design
7) Funding in place for procurement and construction
8) Vehicle procurement (in coordination with MBTA)
9) Construction
10) Testing, startup, and commissioning
11) Startup

5.4.1. Scenario #1 – Part of Rail Vision

This implementation scenario considers the Grand Junction line as one part of an Urban Rail network as proposed by Rail Vision. The timeframe will be in the sequence of implementation as currently anticipated by the MBTA. The first three urban rail services are slated to occur on the Newburyport/Rockport Line, the Providence Line, and the Fairmount Line. Service on the Grand Junction Line is not envisioned in these initial steps and would occur at later stages of the commuter rail system's transformation.

With the MBTA determining the timeline, the best timeline would be to start the PE/NEPA/MEPA phase for the Grand Junction service after the implementation of urban rail services on these first three lines. However, depending on funding and the priorities of the MBTA at the time, the start of the PE/NEPA/MEPA phase could be later. Figure 64 shows a conceptual timeline for Scenario #1.

5.4.2. Scenario #2 – Local Proponent Advances Project

This implementation scenario considers expediting the implementation of the Grand Junction service by a local proponent who would advance the project through the planning process in consultation with the MBTA but ahead of the anticipated Rail Vision implementation schedule. This approach could expedite the realization of Grand Junction service by advancing many steps of the planning and design process ahead of the timeline of Rail Vision. Still, there are external constraints that a local proponent cannot control, and these constraints may control the date of service implementation:

- Procurement of urban rail vehicles by the MBTA
- Completion of West Station
- Completion of Draw 1

Depending on the schedule of these three constraints, Scenario #2 may not provide any significant timeframe advantage over Scenario #1. However, having a local proponent lead the planning, environmental and design phases could have advantages. A local proponent may have a better understanding of local transportation needs and specific concerns relative to potential community impacts (e.g., noise, vibration, visual impacts). In addition, a local proponent may also be better positioned to negotiate for right-of-way for track and stations, depending on the nature of the entity advancing the effort.

Figure 65 shows a conceptual timeline for Scenario #2. The blue bars represent steps that could be led by a local proponent.

5.4.3. Potential Approaches to Early Implementation

This early implementation scenario investigates how a Grand Junction service could be implemented prior to the completion of other major infrastructure projects that will eventually be undertaken by MassDOT and the MBTA (i.e., the West Station/Allston Multimodal Interchange reconstruction and the replacement of North Station Draw One Bridge). Figure 66 shows a conceptual schedule for Scenario #3 showing a shortened timeframe to allow for an interim startup of the Grand Junction station using alternative terminal stations as well as a later date for full service between West Station and North Station.

Temporary West Terminus

In lieu of terminating at West Station, an interim terminal could be established in the Cambridgeport neighborhood. This would allow for service to stations in Cambridge from North Station and/or communities to the north.

Temporary East Terminus

In lieu of terminating at North Station, the service could terminate along the Newburyport/Rockport Line at Lynn or another location. While preliminary consideration was given to the notion of developing an interim northern terminus at Sullivan Square, this concept was ultimately deemed infeasible based on feedback received from MBTA Railroad Operations staff.

The proposed approach would create a temporary platform at the Sullivan Square Orange Line station by leveraging a pair of freight tracks located immediately west of the Orange Line, which are commonly referred to as the "3rd and 4th iron." These tracks have historically been used primarily for freight service along the Newburyport/Rockport Line to reach sites in Everett, Chelsea and Peabody. MBTA staff noted significant existing freight movements along the third and fourth tracks (mostly Boston Sand & Gravel), along with lingering freight activity near the former site of the New England Produce Market. In short, pursuing this approach would likely generate impacts to freight activities along the line such that the relocation of freight uses would be required. As some of these existing adjacent freight-related uses pertain to scrap metal, cement, and cold storage, finding new locations is likely to be relatively difficult, come at a premium cost, and inevitably disrupt existing commercial operations during the transition time.

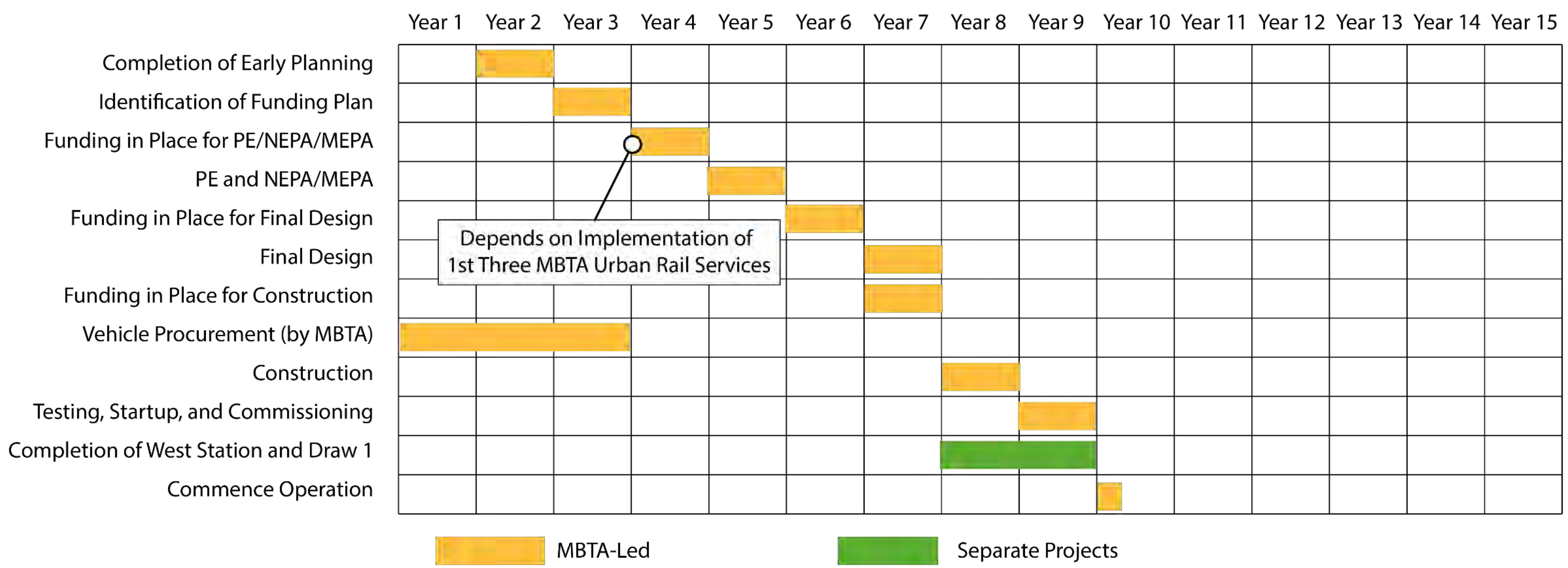


Figure 64. Conceptual Implementation Timeline for Scenario #1

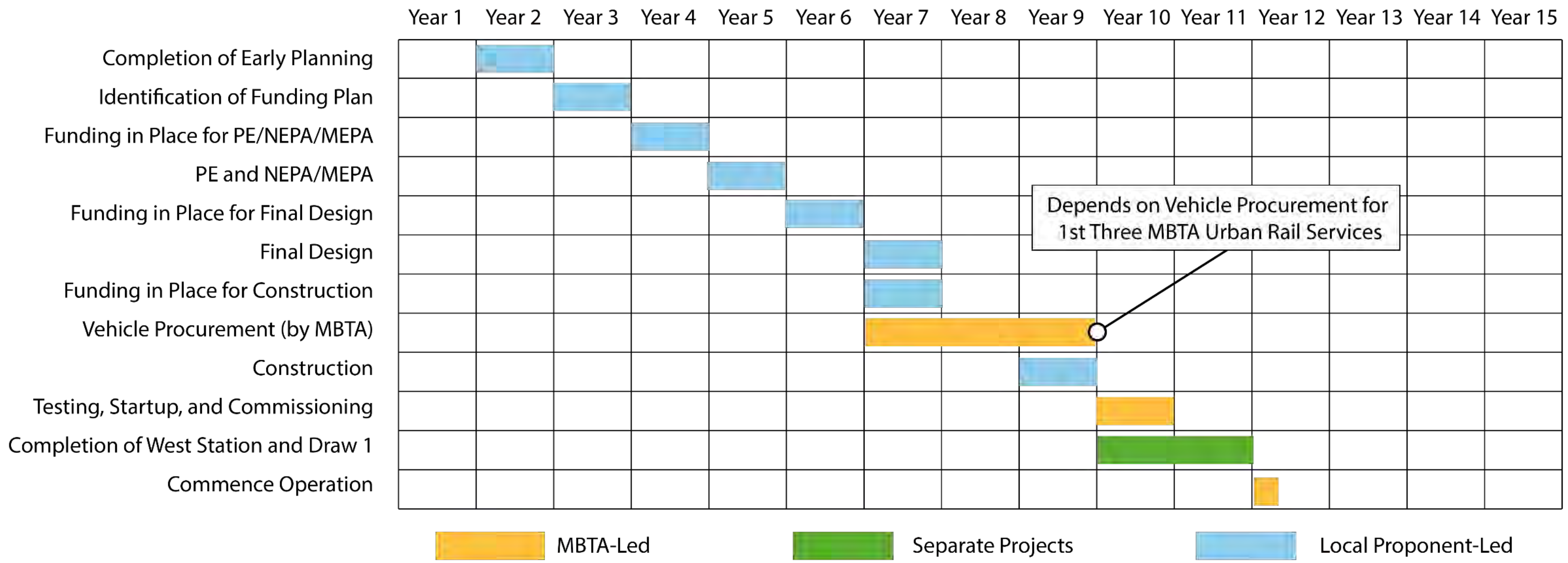


Figure 65. Conceptual Implementation Timeline for Scenario #2

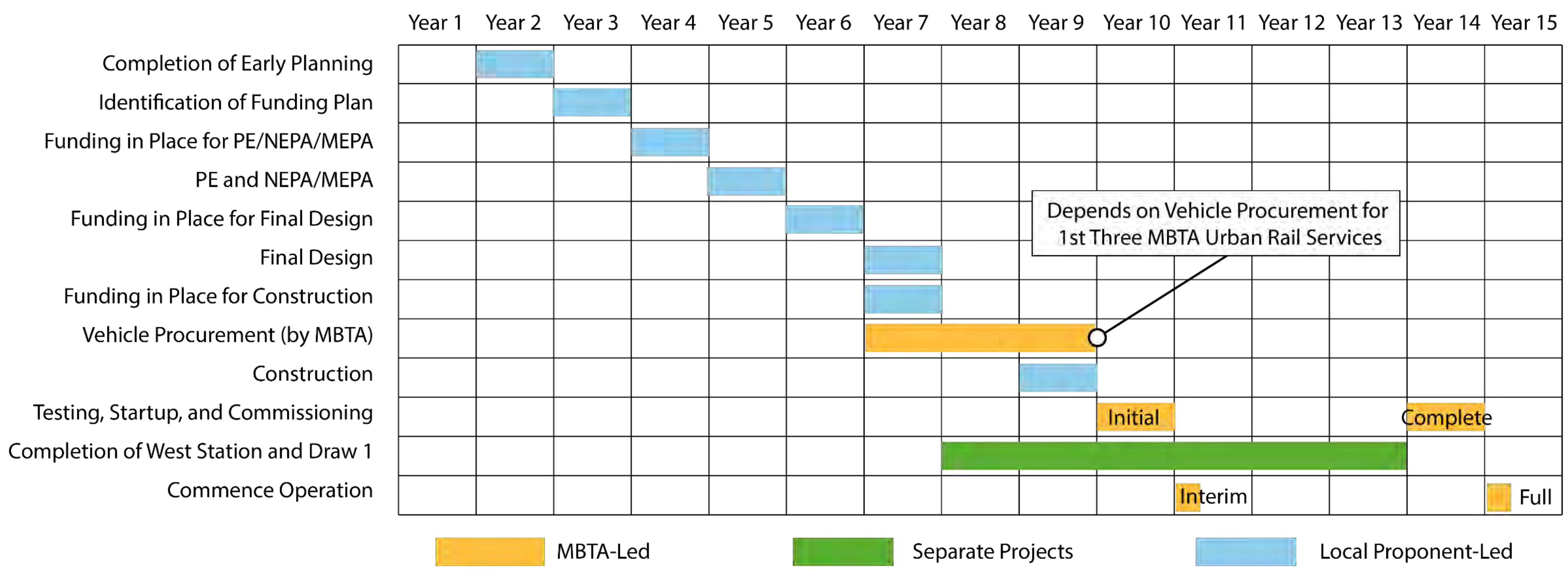


Figure 66. Conceptual Implementation Timeline for Scenario #3

5.5. Conceptual Cost Estimates

The study team prepared a conceptual opinion of approximate "order of magnitude" costs related to the track and infrastructure improvements presented above for each of the alternatives, as summarized in

Table 48. The costs presented account for tracks, signals station platforms and other improvements within the City of Cambridge, as well as the improvements noted below north of the community. Vehicle procurement costs are presented separately from the track and infrastructure improvements within Section 5.5.3. The costs assume construction by a public entity. Two options were prepared for both alternatives, with each alternative generating one cost estimate that assumes full electrification and another that relies on battery-electric propulsion (i.e., assuming the line is not electrified).

The cost estimates shown immediately below do not include vehicle procurement, which is covered in 5.5.3, but rather reflect the capital cost associated with infrastructure improvements from Memorial Drive to the Fitchburg Line at "Swift" interlocking assuming the conditions outlined below. For a combined estimate of capital costs, inclusive of infrastructure and rolling stock, see Table 55 on page 5-30.

- This estimate excludes West Station, which would be incidental to the MassDOT Allston Interchange Project. The MassDOT Allston Interchange Project also includes the Grand Junction tracks from West Station to the south abutment of the existing rail bridge over the Charles River.
  - For the electric option, this estimate assumes electrification of the
- This estimate does NOT include any rehabilitation of the existing rail bridge over the Charles River which passes under the BU Bridge. Without a full structural evaluation to determine the work necessary to add back the second track, it is not currently possible to estimate the cost of this work.
- This estimate does include these costs related to the Charles River bridge:
  - Adding a 2nd track up to the existing long siding.
  - Electrification of both tracks from the abutment on the south side of the Charles River bridge to the existing siding.
- This estimate excludes the following work related to MBTA Projects:
  - For the implementation of Urban Rail as part of the MBTA Rail Vision:
    - For the electric options: electrification of the inner sections of commuter rail lines:
      - Fitchburg Line from North Station to "Swift" interlocking or beyond
      - Haverhill Line from North Station to the Mystic River crossing or beyond
      - Newburyport/Rockport Line from North Sation to Lynn or beyond.
    - For the batter-electric operation:
      - Terminal charging at North Station
      - Possible electrification of commuter rail lines within the limits described above.
  - Draw 1 Bridge Project including access to the platform at Tracks 11 and 12.
- The infrastructure work is tallied in Table 42 of Section 5.2.6.
- For the battery electric operation, it is assumed that no electrification infrastructure is required between Memorial Drive and the Fitchburg Line.
- For Alternative #2 the estimate is based on the following:
  - The additional track upgrade would be limited to the single-track line between "Swift" interlocking on the Fitchburg line to the connection with the Haverhill and Newburyport/Rockport lines.
    - Electrification on the Newburyport/Rockport Line would be included in the Rail Vision project to electrify the inner portion of this line.
  - New station side platforms at:
    - Everett
    - Revere.
  - The cost includes a turnback facility at Lynn station, including electrification of the turnback facility. For the battery-electric option, the turnback electrification would allow for terminal recharging.
- The cost for mitigation (e.g., for noise, vibrations, etc.) is not separately estimated. However, it can be considered included in the 50% contingency).
- Prices are in 2024 dollars. To estimate construction cost at a later date, an escalation factor would be required.

Table 48. Summary of Capital Costs (Excludes Vehicle Procurement)

ALTERNATIVE \ ELECTRIFICATION	**Fully-Electric Operation**	**Battery-Electric Operation**
Alternative #1	$282,280,000	$187,260,000
Alternative #2	$323,900,000	$294,030,000

5.5.1. Alternative #1

Table 49 displays the estimated cost with full electrification of the line. Table 50 shows the estimated cost for battery electrification operations.

Table 49. Capital Costs – Alternative 1 – Full Electrification (Electric Operations)

Project: Grand Jct. Double Track with Stations - Electrified					
	Memorial Drive to Fitchburg Line at "Swift" Interlocking				
Estimate of Probable Capital Cost					
Item of Work					**Estimated Cost**
Trackwork					$ 24,160,000
Signals					$ 26,210,000
Electrification					$ 48,360,000
Grade Crossings					$ 10,230,000
Stations					$ 8,440,000
Fencing & Other Misc. Improvements					$ 1,250,000
Total Estimated Construction Cost -Base (without contingencies)					**$ 118,650,000**
ROW Acquisition		5	Acres	$5,000,000	$ 25,000,000
Total Estimate Construction & ROW Acquistion Cost (without contingencies					**$ 143,650,000**
Contingencies		50%			$ 71,830,000
Total Estimated Construction Cost - with contingencies					**$ 215,480,000**
EIS, Preliminary & Final Design		12%			$ 25,860,000
Program Management (Design Phase & Construction)		4%			$ 8,620,000
Insurance, Permits, Legal, Review Fees		7%			$ 15,080,000
Testing & Inspection		8%			$ 17,240,000
Total Probable Cost (Base 2024$)					**$ 282,280,000**

Table 50. Capital Costs – Alternative 1 – No Electrification (Battery Electric Operations)

Project: Grand Jct. Double Track with Stations - Battery Electric Operations					
	Memorial Drive to Fitchburg Line at "Swift" Interlocking				
Estimate of Probable Capital Cost					
Item of Work					**Estimated Cost**
Trackwork					$ 24,160,000
Signals					$ 26,210,000
Electrification					$ -
Grade Crossings					$ 10,230,000
Stations					$ 8,440,000
Fencing & Other Misc. Improvements					$ 1,250,000
Total Estimated Construction Cost -Base (without contingencies)					**$ 70,290,000**
ROW Acquisition		5	Acres	$5,000,000	$ 25,000,000
Total Estimate Construction & ROW Acquistion Cost (without contingencies					**$ 95,290,000**
Contingencies		50%			$ 47,650,000
Total Estimated Construction Cost - with contingencies					**$ 142,940,000**
EIS, Preliminary & Final Design		12%			$ 17,150,000
Program Management (Design Phase & Construction)		4%			$ 5,720,000
Insurance, Permits, Legal, Review Fees		7%			$ 10,010,000
Testing & Inspection		8%			$ 11,440,000
Total Probable Cost (Base 2024$)					**$ 187,260,000**

5.5.2. Alternative #2

Table 51 shows the estimated cost with full electrification of the line. Table 52 presents the estimated cost for battery electrification operations.

Table 51. Capital Costs – Alternative 2 – Full Electrification (Electric Operations)

Project: Grand Jct. Double Track with Stations - Electrified					
	Memorial Drive to East-West Route near Highline Bridge + Turnback at Lynn				
	Includes new platforms at Everett & Revere				
Estimate of Probable Capital Cost					
Item of Work					**Estimated Cost**
Trackwork					$ 33,810,000
Signals					$ 34,560,000
Electrification					$ 50,140,000
Grade Crossings					$ 11,630,000
Stations					$ 8,440,000
Fencing & Other Misc. Improvements					$ 1,250,000
Total Estimated Construction Cost -Base (without contingencies)					**$ 139,830,000**
ROW Acquisition		5	Acres	$5,000,000	$ 25,000,000
Total Estimate Construction & ROW Acquistion Cost (without contingencies					**$ 164,830,000**
Contingencies		50%			$ 82,420,000
Total Estimated Construction Cost - with contingencies					**$ 247,250,000**
EIS, Preliminary & Final Design		12%			$ 29,670,000
Program Management (Design Phase & Construction)		4%			$ 9,890,000
Insurance, Permits, Legal, Review Fees		7%			$ 17,310,000
Testing & Inspection		8%			$ 19,780,000
Total Probable Cost (Base 2024$)					**$ 323,900,000**

Table 52. Capital Costs – Alternative 2 – No Electrification (Battery Electric Operations)

Project: Grand Jct. Double Track with Stations - Battery Electric Operations					
	Memorial Drive to East-West Route near Highline Bridge + Turnback at Lynn				
	Includes new platforms at Everett & Revere				
Estimate of Probable Capital Cost					
Item of Work					**Estimated Cost**
Trackwork					$ 33,810,000
Signals					$ 34,560,000
Electrification (Recharge for Turnback at Lynn)					$ 4,120,000
Grade Crossings					$ 11,630,000
Stations					$ 29,260,000
Fencing & Other Misc. Improvements					$ 1,250,000
Total Estimated Construction Cost -Base (without contingencies)					**$ 114,630,000**
ROW Acquisition		7	Acres	$5,000,000	$ 35,000,000
Total Estimate Construction & ROW Acquistion Cost (without contingencies					**$ 149,630,000**
Contingencies		50%			$ 74,820,000
Total Estimated Construction Cost - with contingencies					**$ 224,450,000**
EIS, Preliminary & Final Design		12%			$ 26,930,000
Program Management (Design Phase & Construction)		4%			$ 8,980,000
Insurance, Permits, Legal, Review Fees		7%			$ 15,710,000
Testing & Inspection		8%			$ 17,960,000
Total Probable Cost (Base 2024$)					**$ 294,030,000**

5.5.3. Vehicle Procurement Costs

It is assumed that the Grand Junction vehicles would be the same that the MBTA acquires for its proposed urban rail service as part of the Rail Vision project. Figure 67 shows renderings of a possible EMU or B-EMU vehicles based on the Stadler KISS EMUs.

Figure 67. Example Urban Rail Vehicles As Shown in Rail Vision – Stadler 160 (Source: Rail Vision)

Number of Trainsets

The string line diagrams are used to determine how many trainsets are required. In addition to the operating trainsets, provision is made to have a "protect" trainset available in case one of the operating sets develops an operation issue and must be removed from service. The extra trainset helps protect the schedule by preventing cascading delays due to missed routes. Besides the "protect" trainset, provision is also given for another set to be inactive due to the need for periodic inspections or due to the need for servicing or repairs. Therefore, the total number of trainsets for a service would include:

- Trainsets for operating schedule
- One "protect" trainset ready for active service.
- One trainset not in service due to inspection, servicing and/or repair work.

Based on the string lines, simply operating the proposed schedules (i.e., no contingency fleet, all trains serviceable) would require the following:

- Alternative #1 with 15-minute headways: 4 trainsets
- Alternative #2 with 30-minute headways: 4 additional trainsets or 8 total.

Table 53 shows the number of trainsets to be procured for both alternatives.

Table 53. Estimated Total Trainsets

Service Route	Service Trainsets	Protect Trainset	Out of Service Trainset	Total Trainsets
Core	4	1	1	6
Extended	4	1	1	6
TOTAL	8	2	2	12

Number of Cars per Trainset

Currently, the MBTA's Commuter Rail Transformation group is anticipating that the urban rail services will be provided by 4-car trainsets. Each bilevel car would seat approximately 170, so the 4-car trainset capacity would be approximately 680. However, the demand for the Grand Junction service would only require 2-car trainsets, which is typical for many of the current DMU-operated urban rail services. Therefore, the vehicle cost estimate will reflect the costs for both 2-car and 4-car trainsets.

Vehicle Costs

Currently there are few procurements of EMUs and none yet of B-EMUs in the US. As the FRA regulations differ from elsewhere in the world, the estimated cost should only be based on recent procurement in the US. Based on the recent procurement of bi-level EMUs for the Caltrans commuter rail system (San Francisco), an estimate of $8M to $12M per EMU vehicle would be an estimated cost range.

At present, there has been only one procurement in the US of B-EMUs. This was a demonstration set for the Caltrans commuter service from San Francisco to San Joe and Gilroy, CA.[20] As it is a limited

[20] https://www.caltrain.com/media/31362/download; https://www.caltrain.com/media/31269/download; https://www.caltrain.com/media/31244/download

procurement, the unit price per car ($20M) would be higher than for a production run for a greater quantity of vehicles. Therefore, for a rough cost estimate, this study assumes the upper end for EMUs to be the low end for B-EMUs ($12M) and the upper end for B-EMUs to be the cost for the Caltrans procurement ($20M).

Table 54 presents a range of probable costs associated with procuring varying quantities of 2- or 4-car trainsets capable of full-electric or battery-electric operations.

Table 54. Range of Probable Cost for Vehicle Procurement

Service Route	Trainsets Required	Cars per Trainset	Total Cars Required	Cost – Fully Electric Operation	Cost – Battery-Electric Operation
Core	6	2-car trainsets	12	$96 M to $144 M	$144 M to $240 M
		4-car trainsets	24	$192 M to $288 M	$288 M to $480 M
Core + Extended	12	2-car trainsets	24	$192 M to $288 M	$288 M to $480 M
		4-car trainsets	48	$384 M to $576 M	$576 M to $960 M

5.5.4. Combined Infrastructure and Vehicle Procurement Costs

Table 55 shows the order-of-magnitude ranges for capital cost estimates associated with each alternative based on the type of propulsion used (fully-electric or battery-electric), the quantity of trains needed (six sets for the Core Route, 12 for Core + Extended Routes).

Table 55. Summary of Capital Costs and Vehicle Procurement Costs

ALTERNATIVE \ ELECTRIFICATION	Cars per Trainset	Fully Electric Operation	Battery-Electric Operation
Alternative #1	2-car trainsets	$378.28 M to 426.28 M	$331.26 M to $427.26 M
	4-car trainsets	$474.28 M to 570.28 M	$475.26 M to $667.26 M
Alternative #2	2-car trainsets	$515.90 M to 611.90 M	$582.03 M to $774.03 M
	4-car trainsets	$707.90 M to $899.90 M	$870.03 M to $1,254.03 M

5.6. Potential Station Locations

5.6.1. Typical Station Dimensions & Parameters

To inform the assessment of specific platform sites for each potential station location, this section defines the physical dimensions of typical station parameters (e.g., platform length, width, height, spacing). Within this analysis, station siting and design reflect MBTA's criteria for Americans with Disabilities Act (ADA) compliance, with each proposed site allowing for sufficient vertical circulation between the platforms and the adjacent grades via ADA-compliant ramps, and the development of platforms that are level with the floor of the vehicle for the "full train length" (i.e., offer a level boarding surface for a length equivalent to the length of the train consist).

In terms of platform layout / orientation, two basic configurations exist – side and center-island. For side platforms, which are shown in Figure 68, two platforms would be constructed on each side of the double-track corridor, with one platform serving each direction. In the case of center-island platforms, a single facility is constructed in the middle of the two-track alignment to serve both directions of travel, but this requires the mainline tracks to curve (i.e., widen) approaching the station.

Based on stakeholder discussions with the MBTA regarding the agency's standards for platform length, as well as their proposed use of a two-car multiple unit to determine the minimum platform length, Table 56 presents key platform dimensions for a new Urban Rail service operating along a double-tracked corridor within the City of Cambridge.

Table 56. Key Station Dimensions

PLATFORM TYPE \ LEVEL	Platform Width	Platform Length (MBTA Guidance)	Platform Height (Above top-of-rail)	Platform Spacing (Edge to Center of Track)	Track Center (MBTA Comm. Rail Standard)
Side \ High	12 ' – 0"	250 '	8 "[21]	5 ' – 7 "	14 '
Center-Island \ High	26 - 6'"	250 '	8 "[21]	5 ' – 7 "	14 '

For space-constrained corridors like the Grand Junction, as well as for locations where tracks simply cannot be shifted due to the presence of existing structures or anticipated constraints (e.g., research labs, City's proposed path, etc.), the flexibility of side platforms is a key advantage.

[21] *While the MBTA commuter rail standard height for platforms is 48" (not 8") above top of rail, potential vehicles such as the Stadler KISS 160 USA have the flexibility to operate with a mix of platform heights including both 8" and 48" above top of rail, as can be seen with doors of different heights as illustrated in Figure 57 on page 5-29. The actual height of the platform may vary from 8" above top of rail so as to be compatible with the selected vehicle for this operation.*

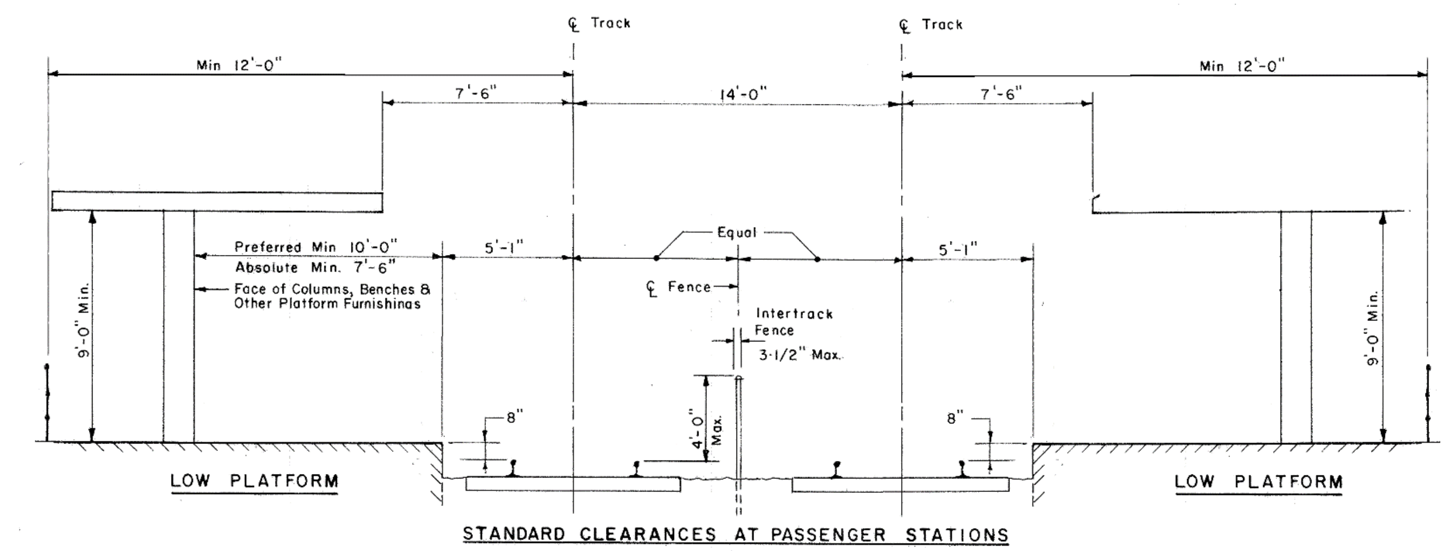


Figure 68. Low-level Side Platforms on Double-Track (Source: MBTA Railroad Operations, Drawing No. 1013)

Although they feature a greater overall width than center-island platform sections (when grouped together), side platforms can be split and staggered across intersections. Center-island platforms present advantages such as having a single location where all passengers board and detrain.

Nevertheless, relative to center-island approaches, side platforms are more flexible in terms of siting them within the constraints of the right-of-way and adjacent lands uses. Given the context of the existing rail corridor, this study assesses specific sites within each proposed station location for their potential to accommodate side platforms.

5.6.2. Potential Station Locations and Platform Sites

In the majority of previous studies, a single "Kendall Square" station has been assumed within the vicinity of the grade crossings at Main and Binney Streets. Other potential locations for stations have been suggested along the rail ROW near grade crossings with Massachusetts Avenue and Cambridge Street. Additional stations have also been envisioned in Cambridgeport between Massachusetts Avenue and the Charles River, in Eastern Cambridge near the Green Line's Lechmere station, and adjacent to the city limits near the Cambridge Crossing development. This last location, potentially located partially in Somerville, may encourage and would need to involve the participation of other municipalities in this Grand Junction project. The proposed path would have a synergistic relationship with Grand Junction stations (akin to the Somerville Community Path and the GLX) providing access and egress for non-motorized users.

As noted in previous studies, only one station location within the City of Cambridge would be operationally feasible north of Massachusetts Avenue due to the limited capacity of the existing single-track section. In other words, with only one track, a new service offering an appealing headway would not be able to consistently navigate meets along the corridor itself, as well as at the junction further north near North Station).

Therefore, this study assumes that the corridor would be double-tracked to provide a continuous two-track alignment from Memorial Drive (MP 0.44) to the Fitchburg Line. Such a change would allow for the creation of multiple stations within the City of Cambridge.

The study team accounted for the factors listed below in assessing potential platform sites:

- Mode and Technology
  - Overall length of corridor
  - Platform length and width
  - Appropriate station spacing
- Station Area Context
  - Adjacent land uses and development nodes
  - Surrounding roadways, existing structures, transit connections, and access points to the Grand Junction platforms from the public ROW (ideally via the City's upcoming MUPP)
- Implementation and Potential Conflicts
  - Consideration of major known utilities (e.g., steam line, communications line)
  - Feasibility of siting a platform at the particular location (e.g., constructability)

Potential platform sites at each of the five general station locations shown in Figure 69 were assessed. Table 57 and Table 58 summarize the overall feasibility rating and relevant concerns associated with potentially locating rail platforms at each of the specific sites evaluated, beginning in the south and moving northward. Within the figure and tables, the preferred platform site(s) for each of the five general station areas are represented by either a bold outline or bold text. For convenience, the preferred platform location(s) are listed alongside the general station areas below.

- Cambridgeport – Fort Washington Park (staggered on either end to avoid Section 4(f) process)
- Massachusetts Avenue – north side of intersection
- Kendall Square – either side of Broadway, with a preference for the north side
- Eastern Cambridge – south of Medford Street / Gore Street (to remain within City of Cambridge)
- Cambridge Crossing – Water Street (within City of Somerville)

The remainder of this report (Table 59 through Table 61) provides further details as to the possibilities and nuances of locating a platform at each of the 15 specific sites assessed given a proposed double-track extension north of Massachusetts Avenue.

It should be noted that since a platform serving Cambridge Crossing would be located beyond the City of Cambridge (i.e., City of Somerville) and would only be serviced by one of the two routes considered (i.e., only by trains operating to/from North Station via the Core Route), this location was not considered within the travel time modeling presented previously in Section 5.3.4 – Operational Simulation.

Figure 69. Platform Feasibility Summary

Table 57. Summary of Station Feasibility – Southern Half of Corridor (Main Street and Points South)

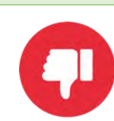
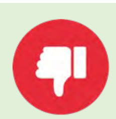
Station Area	Platform Number	Site Considered	Rating	Justification for Rating	Potential Concerns
Cambridgeport	1	Waverly/Henry / Vassar St.		Would feature strong residential access (Cambridgeport, portion of Allston located east of BU Bridge), but would require a new grade crossing	No extant grade crossing; relatively continuous wall of existing development to the east would also complicate access
	2	**Fort Washington Park**		**Would leverage existing grade crossing for access to platforms; parking lots north and south of Fort Washington Park may provide additional flexibility for siting Outbound platform adjacent to MUPP**	**Adjusting the access and platform layouts to avoid potential impacts to Fort Washington Park and MUPP; platforms would likely need to be staggered to forego undertaking a Section 4(f) regulatory process / review relative to Fort Washington Park**
	3	Pacific St.		Majority of walkshed would be occupied by expansive fields, research labs, or campus dorms, with limited catchment for residences to the west	Would impact access to service aisle for MIT properties located north of Pacific St., which are primarily used to deliver gas to research labs abutting the railroad corridor
Massachusetts Avenue	4	West (South) of Mass. Ave.		Trackage and Outbound platform would lie adjacent to a nuclear research lab immediately west of the railroad; would allow interface with MBTA Route 1; little to no impacts to MIT's service aisle compared to other Mass Ave. location	Presence of nuclear facility to the west would exert significant regulatory limitations on the overall design and placement of new transportation infrastructure within its proximity; configuring the access and platforms so as to avoid potential impacts to MUPP
	5	**East (North) of Mass. Ave.**		**Previous MIT-commissioned study (2014) contemplated using this area as a potential BRT station location; lack of existing structures adjacent to the tracks (currently used as surface parking lots)**	**Inbound platform would conflict with egress from existing MIT buildings located along Vassar St.; coordination with MIT would be needed to develop a "win-win" solution at this location; MUPP may need to be adjusted to site Outbound platform**
Kendall Square	6	South of Main St.		Could avoid siting platforms along a curve, but would entail unavoidable physical and circulation impacts to MIT building that spans over the corridor, and introduce new infrastructure adjacent to the widest section of the MUPP	Would affect pedestrian access beneath MIT Brain & Cognitive Sciences, introduce physical conflicts with its support columns, and be sited adjacent to a "two track" segment of the MUPP
	7	North of Main St.		Although it would allow additional flexibility Inbound (i.e., MUPP shifts towards Galileo Galilei Way), platforms would be located along a curve and book-ended by existing land uses that would be difficult to adjust	Curved alignment would not meet ADA and MBTA criteria; little to no room for Outbound platform given high-rise office; installation of Inbound platform may infringe on Grand Junction Park (Section 4(f))

Table 58. Summary of Station Feasibility – Northern Half of Corridor (Broadway and Points North)

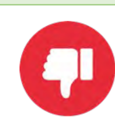
Station Area	Platform Number	Site Considered	Rating	Justification for Rating	Potential Concerns
Kendall Square (Continued)	**8**	**South of Broadway**		**Comparatively closer to Kendall Red Line station, but ROW is more constrained, with changes to existing and proposed transportation infrastructure likely necessary to accommodate Inbound platform**	**Inbound platform would require relocating the MUPP and, in turn, entail a road diet along Galileo Galilei Way, but City of Cambridge CDD staff noted they were open to considering such a change; easement may be required**
	9	**North of Broadway**		**Though slightly less proximate to Kendall Red Line station, would result in less of an impact to proposed MUPP**	**Slightly preferred over location south of Broadway (no need for road diet); easement may be required, but MUPP could likely be adjusted without encroaching into roadway (Galileo Galilei Way)**
	10	South of Binney St.		A lack of existing structures east of the tracks make this location comparatively more feasible by offering additional flexibility	Proposed MUPP, which would be located east of tracks, may need to be adjusted further east
	11	North of Binney St.		Accommodating both platforms north of the intersection would require changes to existing property arrangements and the proposed MUPP layout	Easement would be required for Inbound platform, developing Outbound platform would impact location of proposed MUPP
Eastern Cambridge	12	South of Cambridge St.		ROW is relatively more constrained, with existing structures on both sides; minor curve situated south of intersection; Outbound platform would impact location of proposed MUPP (on west side south of Cambridge St.)	Combination of curve to the south, abutting uses, and MUPP's widening to a "two track" interface at Cambridge St. make this location comparatively less feasible than options to the north
	13	North of Cambridge St.		ROW relatively less constrained; would offer proximate access to businesses, residences, and high-density senior residences (Millers River Apartments) along Cambridge St..	Proposed MUPP, which would shift to east of tracks, may need to be adjusted, but ample room appears to be available to east without encroaching into existing structure (Millers River Apartments)
	14	**South of Medford / Gore St.**		**Would provide proximate access to Twin Cities Plaza, Boynton Yards, and Cambridge St.; locating platforms south of the intersection would create stronger walkshed, avoid curve to the north, and remain within city limits**	
Cambridge Crossing (Somerville)	15	Water St.		Although proximate to major redevelopment site and MBTA Green Line service at Lechmere to the south, platform would lie adjacent to a multitude of rail tracks and the Boston Engine Terminal to the north; would only be served by the Core Route (i.e., situated off primary Grand Junction alignment); access occurs via land in Cambridge, but facility itself would be located in Somerville; currently limited ability for the public to reach the site from adjacent development (i.e., developing access from the north side would be infeasible); ROW constrained by access road, materials storage, and parking associated with the MBTA BET facility	Would entail some modification to the existing Inbound Fitchburg Line to accommodate a new island platform, potentially causing operational impacts during construction; would require coordination with additional partners beyond the MBTA and the City of Cambridge (i.e., City of Somerville and landowner(s) to the south to provide an accessible public pathway between the platform and adjacent areas)

Table 59. Considerations for Potential Station Locations – Cambridgeport & Massachusetts Avenue

PLATFORM LOCATION	**Cambridgeport – Waverly / Henry / Vassar**	**Cambridgeport – Fort Washington Park**	**Cambridgeport – Pacific St**	**Massachusetts Avenue**
Adjacent Land Uses	Walkshed captures southern Cambridgeport (including Morse School), Magazine Beach/Charles River waterfront, Hyatt Hotel, several biotech employers, MIT offices/residences, and even parts of the BU campus (via the BU bridge).	Abuts MIT graduate student dorm under construction at 269-301 Vassar St. Many parking lots surrounding site currently. Biotech abutters on north side of ROW, residential further away	Abuts high-density MIT dorms and lab buildings. Much of prime walkshed to the south is taken up by MIT athletic fields. MIT expressed need for rear access to buildings along corridor just north of Pacific St	Closest to heart of MIT campus. MIT expressed need for rear access to buildings along corridor just north of Pacific St
Platform Layout – Side / Split	Flexible (no crossing streets)	Flexible (no crossing streets)	Flexible (no crossing streets)	Flexible, consider placing platforms far enough from roadway that train does not trigger grade crossing during dwell.
Stop Spacing	3,800 ft from Mass Ave	2,800 ft from Mass Ave	1,300 ft from Mass Ave	1,500 ft from Main St
Transit Connections	Close to existing CT2 bus stop on Amesbury St and 47 stop at Brookline/Waverly		Already exists as a CT2 bus stop	Transfer to Route 1 bus as well as CT2 and LMA shuttles
BlueBike	Putnam at Brookline, Vassar at Audrey	Vassar at Audrey, Waverly at Erie	Pacific at Purrington	North of Albany St, Amherst St
Grade Crossing – Motor Vehicles?	N/A	N/A	N/A	Yes
Grade Crossing – Pedestrian	No extant grade crossing	Yes	Yes	Sidewalk of Massachusetts Avenue.
Grade Crossing – Existing Gates?	No extant grade crossing	Yes (Pedestrian)	Yes (Pedestrian)	No existing gates. Gates would be added with proposed improvements. Due to the high motor vehicle traffic with limited stacking space, the grade crossing warning system would be interconnected with the adjacent traffic signals to the east and west.

Table 60. Considerations for Potential Station Locations – Kendall Square

PLATFORM LOCATION	**Kendall Square – Main St**	**Kendall Square – Broadway**	**Kendall Square – Binney St**
Adjacent Land Uses	High density office/residential/lab uses surround	Draper Lab flanks Broadway on the west side—high density office and residential	Walkshed more residential (Wellington-Harrington and East Cambridge), office/lab uses to the south and east
Platform Layout – Side / Split	Track is on a curve of radius ~850'. Curved platform would not meet ADA and MBTA criteria. Potential platform immediately west of curve (under the MIT Brain & Cognitive Sciences building) would impact pedestrian access, as well as columns for the building as well as impacting the proposed path location.	Station could be located south or north of intersection (or split). South location closer to Kendall. North location has better stop spacing from Mass. Ave station. ROW is narrow south of intersection, but there is an opportunity to obtain an easement from Tech Square to the west. On the east side, the 2nd track would be adjacent to the existing path which is adjacent to Galileo Galilei Way. A platform south of Broadway on the east side of the tracks would require relocating the path and implementing a road diet on Galileo Galilei Way. Currently no space for platforms north or south of Broadway without obtaining easements. North of Broadway there would be less impact on the path.	Locating both platforms south of Binney improves access to Kendall Square. North of Binney, an easement would be needed to accommodate a northbound platform. Placing the southbound platform north of Binney would impact the proposed path location.
Stop Spacing	1,500 ft from Massachusetts Avenue *1,400 ft walk to Red Line at Kendall*	If platform is built at Massachusetts Ave, then this location (north of Broadway) would provide better stop spacing. 2,300 ft from Massachusetts Avenue *1,400 ft walk to Red Line at Kendall*	3,100 ft from Massachusetts Avenue / 1,900 ft from Cambridge St *2,300 ft walk to Red Line at Kendall*
Transit Connections	Closest location to Red Line transfer at Kendall Station. Kendall is a bus hub – with Routes 64, 68, 85, T70, and T101 (post-BNRD).	64 (to Central/Cambridgeport), 68 (to Harvard), 85 (to Union Square/Spring Hill)	Walk to Broadway buses
BlueBike	Main St at Vassar St / Galileo Galilei Way	Stations a block away in all directions	On-site
Grade Crossing – Motor Vehicles?	Existing at Main Street	Existing at Broadway	Existing at Binney Street
Grade Crossing – Pedestrian	Sidewalk	Sidewalk	Sidewalk
Grade Crossing – Existing Gates?	No existing gates. Gates would be added with proposed improvements. Grade crossing would be interconnected with adjacent traffic signal at Vassar Street / Galileo Galilei Way	No existing gates. Gates would be added with proposed improvements. Grade crossing would be interconnected with adjacent traffic signal at Galileo Galilei / Broadway.	No existing gates. Gates would be added with proposed improvements. Grade crossing would be interconnected with adjacent traffic signal at Fulkerson Street. One Kendall Square garage currently generates substantial traffic just west of ROW

Table 61. Considerations for Potential Station Locations – Eastern Cambridge / Boynton Yards / Twin City Plaza

PLATFORM LOCATION	**Eastern Cambridge – Cambridge St**	**Eastern Cambridge – Medford / Gore St**	**Cambridge Crossing – Water St (City of Somerville)**
Adjacent Land Uses	Commercial, low-to-medium-rise residential, Millers River senior housing high rise	Twin Cities Plaza (shopping center), Boynton Yards residential/lab development, Metro9 condos. Further from Cambridge St commercial areas and Wellington-Harrington/E Cambridge neighborhoods. Limited walkshed to north (railroad barrier)	Near Cambridge Crossing/North Point high-density, and mixed-use, but preserving access to a future platform to/from the adjacent uses would require careful coordination with the landowner. Access to the platforms would rely on land in the City of Cambridge, but the platforms would lie within the City of Somerville.
Platform Layout – Side / Split	Tight ROW south of Cambridge St. Southbound side platform would impact location of proposed path. More room for station to the north--could have both platforms/island platform north of Cambridge St. Existing track curves ~230' south of Cambridge St sidewalk.	Platforms south of Gore St would avoid sharp curve and create a stronger walkshed. NOTE: Platforms would be long enough that this station would also access Cambridge St.	Would need to relocate Fitchburg Line Inbound track. With relocated tracks, an island platform could be considered.
Stop Spacing	2,700 ft from Broadway	3,300 ft from Broadway	3,700 ft from Cambridge St 0.9 mi to North Station
Transit Connections	69 bus (Harvard to Lechmere)	Walk to 69 bus	Walk to Lechmere – GL D & E, 69, 87 and T101 buses post-BNRD
BlueBike	Stations nearby at Gore/Lambert and Berkshire/Cambridge (Valenti Branch Library)	Station at Gore/Lambert	Station at First/Morgan
Grade Crossing – Motor Vehicles?	Yes	Yes	Though conflicting vehicles would be less frequent than typical roadway grade crossings, this site lies adjacent to an informal road crossing that appears to be associated with activities taking place at the MBTA's North Side base of operations (Boston Engine Terminal)
Grade Crossing – Pedestrian	Sidewalk	Sidewalk	Would require grade-separated connection to platform
Grade Crossing – Existing Gates?	Existing gates would be retained. Grade crossing would be interconnected with traffic signal at adjacent pedestrian crossing.	Existing gates	N/A

CAMBRIDGE REDEVELOPMENT AUTHORITY

Appendices

Existing Conditions – Commuter Rail Schedules

Worcester Line Weekday Schedules (Source: MBTA, Fall/Winter 2022)

Inbound to Boston

Zone	Station / Train #	500	502	582	504	552	584	506	586	508	510	512	514	516	518	520	522	524	592	526	528	596	530	532	534	536
		AM												PM												
	Bikes Allowed	🚲	🚲								🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲
8	Worcester ♿	4:15	5:00	-	6:00	6:30	-	7:00	-	8:00	9:00	10:00	11:00	12:00	1:05	2:00	3:00	4:00	-	5:00	5:50	-	7:00	8:25	9:25	10:25
8	Grafton ♿	4:28	5:13	-	6:13	-	-	7:13	-	8:13	9:13	10:13	11:13	12:13	1:18	2:13	3:13	4:13	-	5:13	6:03	-	7:13	8:38	9:38	f 10:38
7	Westborough ♿	4:32	5:17	-	6:17	-	-	7:17	-	8:17	9:17	10:17	11:17	12:17	1:22	2:17	3:17	4:17	-	5:17	6:07	-	7:17	8:42	9:42	f 10:42
6	Southborough ♿	4:41	5:26	-	6:26	-	-	7:26	-	8:26	9:26	10:26	11:26	12:26	1:31	2:26	3:26	4:26	-	5:26	6:16	-	7:26	8:51	9:51	f 10:51
6	Ashland ♿	4:45	5:30	-	6:30	-	-	7:30	-	8:30	9:30	10:30	11:30	12:30	1:35	2:30	3:30	4:30	-	5:30	6:20	-	7:30	8:55	9:55	f 10:55
5	Framingham ♿	4:55	5:40	5:55	6:40	6:56	7:05	7:40	8:00	8:40	9:40	10:40	11:40	12:40	1:45	2:40	3:40	4:40	5:10	5:40	6:30	7:10	7:40	9:05	10:05	f 11:05
4	West Natick ♿	5:00	5:45	6:00	6:45	-	7:10	7:45	8:05	8:45	9:45	10:45	11:45	12:45	1:50	2:45	3:45	4:45	5:15	5:45	6:35	7:15	7:45	9:10	10:10	f 11:10
4	Natick Center	5:05	-	6:05	-	-	7:15	-	8:10	8:50	9:50	10:50	11:50	12:50	1:55	2:50	3:50	4:50	5:20	5:50	6:40	7:20	7:50	9:15	10:15	f 11:15
3	Wellesley Square	5:09	-	6:09	-	-	7:19	-	8:14	8:54	9:55	10:55	11:55	12:55	2:00	2:55	3:55	4:54	5:24	5:54	6:44	7:24	7:54	9:19	10:19	f 11:19
3	Wellesley Hills	5:13	-	6:13	-	-	7:23	-	8:18	8:57	9:58	10:58	11:58	12:58	2:03	2:58	3:58	4:57	5:27	5:57	6:47	7:27	7:57	9:22	10:22	f 11:22
3	Wellesley Farms	5:16	-	6:16	-	-	7:26	-	8:21	9:00	10:01	11:01	12:01	1:01	2:06	3:01	4:01	5:00	5:30	6:00	6:50	7:30	8:00	9:25	10:25	f 11:25
2	Auburndale	5:21	-	6:21	-	-	7:31	-	8:26	9:05	f 10:06	f 11:06	-	f 1:06	-	-	-	-	-	-	-	f 7:35	-	f 9:30	-	-
2	West Newton	5:24	-	6:24	-	-	7:34	-	8:29	9:08	f 10:09	f 11:09	-	f 1:09	-	-	-	-	-	-	-	f 7:38	-	f 9:33	-	-
1	Newtonville	5:27	-	6:28	-	-	7:38	-	8:33	9:12	f 10:12	f 11:12	-	f 1:12	-	-	-	-	-	-	-	f 7:41	-	f 9:36	-	-
1A	Boston Landing ♿	L 5:34	L 6:07	L 6:35	L 7:07	-	L 7:45	L 8:08	L 8:40	L 9:18	L 10:19	L 11:19	L 12:14	L 1:19	L 2:19	L 3:14	L 4:14	L 5:12	L 5:42	L 6:12	L 7:02	L 7:47	L 8:12	L 9:42	L 10:42	L 11:37
1A	Lansdowne ♿	L 5:39	L 6:12	L 6:40	L 7:12	L 7:24	L 7:50	L 8:13	L 8:45	L 9:23	L 10:26	L 11:26	L 12:21	L 1:26	L 2:26	L 3:21	L 4:21	L 5:17	L 5:47	L 6:17	L 7:07	L 7:52	L 8:17	L 9:47	L 10:47	L 11:42
1A	Back Bay ♿	L 5:44	L 6:17	L 6:45	L 7:17	L 7:29	L 7:55	L 8:18	L 8:50	L 9:28	L 10:32	L 11:32	L 12:27	L 1:32	L 2:32	L 3:27	L 4:27	L 5:22	L 5:52	L 6:22	L 7:12	L 7:57	L 8:22	L 9:52	L 10:52	L 11:47
1A	South Station ♿	5:50	6:23	6:51	7:23	7:35	8:01	8:25	8:56	9:34	10:38	11:38	12:33	1:38	2:38	3:33	4:33	5:28	5:58	6:28	7:18	8:03	8:28	9:58	10:58	11:53

Outbound from Boston

Zone	Station / Train #	501	503	505	507	509	511	513	515	517	519	521	591	523	593	551	525	595	527	529	531	533	535	537
		AM								PM														
	Bikes Allowed	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲									🚲	🚲	🚲	🚲
1A	South Station ♿	4:45	5:55	6:55	7:50	8:50	9:50	10:50	11:45	12:55	1:45	2:50	3:35	4:05	4:25	4:55	5:05	5:35	6:05	6:35	7:35	8:35	10:05	11:05
1A	Back Bay ♿	4:51	6:01	7:01	7:56	8:56	9:56	10:56	11:51	1:01	1:51	2:56	3:41	4:11	4:31	5:01	5:11	5:41	6:11	6:41	7:41	8:41	10:11	11:11
1A	Lansdowne ♿	4:56	6:06	7:06	8:01	9:01	10:01	11:01	11:56	1:06	1:56	3:01	3:46	4:16	4:36	5:06	5:16	5:46	6:16	6:46	7:46	8:46	10:16	11:16
1A	Boston Landing ♿	f 5:01	f 6:11	7:11	8:07	9:07	f 10:07	f 11:07	f 12:02	f 1:12	f 2:02	f 3:06	3:51	4:21	4:41	-	5:21	5:51	6:21	6:51	f 7:51	f 8:51	f 10:21	f 11:21
1	Newtonville	-	-	-	-	-	-	-	f 12:07	-	f 2:07	f 3:11	3:56	-	4:46	-	-	5:56	-	6:56	f 7:56	f 8:56	f 10:26	f 11:26
2	West Newton	-	-	-	-	-	-	-	f 12:10	-	f 2:10	f 3:14	4:00	-	4:50	-	-	6:00	-	7:00	f 7:59	f 8:59	f 10:29	f 11:29
2	Auburndale	-	-	-	-	-	-	-	f 12:13	-	f 2:13	f 3:17	4:03	-	4:53	-	-	6:03	-	7:03	f 8:02	f 9:02	f 10:32	f 11:32
3	Wellesley Farms	f 5:11	6:21	7:21	8:17	9:17	10:17	11:17	12:17	1:22	2:17	3:21	4:07	-	4:57	-	-	6:07	-	7:06	8:06	9:06	10:36	11:36
3	Wellesley Hills	f 5:13	6:23	7:23	8:19	9:19	10:19	11:19	12:19	1:24	2:19	3:23	4:10	-	5:00	-	-	6:10	-	7:08	8:08	9:08	10:38	11:38
3	Wellesley Square	f 5:16	6:26	7:26	8:22	9:22	10:22	11:22	12:22	1:27	2:22	3:26	4:13	-	5:03	-	-	6:13	-	7:11	8:11	9:11	10:41	11:41
4	Natick Center	f 5:20	6:30	7:30	8:27	9:27	10:27	11:27	12:27	1:32	2:27	3:30	4:17	-	5:07	-	-	6:17	-	7:15	8:15	9:15	10:45	11:45
4	West Natick ♿	5:25	6:35	7:35	8:32	9:32	10:32	11:32	12:32	1:37	2:32	3:35	4:22	4:38	5:12	-	5:38	6:22	6:38	7:20	8:20	9:20	10:50	11:50
5	Framingham ♿	5:30	6:40	7:40	8:40	9:40	10:40	11:40	12:37	1:42	2:37	3:40	4:30	4:43	5:20	5:30	5:43	6:30	6:43	7:25	8:25	9:25	10:55	11:55
6	Ashland ♿	5:36	6:46	7:46	8:43	9:43	10:43	11:43	12:43	1:48	2:43	3:46	-	4:49	-	-	5:49	-	6:49	7:31	8:31	9:31	11:01	12:01
6	Southborough ♿	5:41	6:51	7:51	8:48	9:48	10:48	11:48	12:48	1:53	2:48	3:51	-	4:54	-	-	5:54	-	6:54	7:36	8:36	9:36	11:06	12:06
7	Westborough ♿	5:50	7:00	8:00	8:57	9:57	10:57	11:57	12:57	2:02	2:57	4:00	-	5:03	-	-	6:03	-	7:03	7:45	8:45	9:45	11:15	12:15
8	Grafton ♿	5:55	7:05	8:05	9:02	10:02	11:02	12:02	1:02	2:07	3:02	4:05	-	5:09	-	-	6:09	-	7:09	7:50	8:50	9:50	f 11:20	f 12:20
8	Worcester ♿	6:16	7:26	8:26	9:23	10:23	11:23	12:23	1:23	2:28	3:23	4:26	-	5:33	-	6:03	6:33	-	7:33	8:13	9:11	10:11	11:41	12:41

Fitchburg Line Weekday Schedules (Source: MBTA, Fall/Winter 2022)

Inbound to Boston

ZONE	STATION	TRAIN #	400 (AM)	402 (AM)	404 (AM)	406 (AM)	408 (AM)	410 (AM)	412 (AM)	414 (AM)	416 (PM)	418 (PM)	420 (PM)	422 (PM)	424 (PM)	426 (PM)	428 (PM)	430 (PM)	432 (PM)
	Bikes Allowed		🚲				🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲
8	Wachusett	♿	4:25	5:25	6:25	7:25	8:25	9:25	10:25	11:25	-	1:25	-	3:25	4:25	5:25	6:25	7:25	9:25
8	Fitchburg	♿	4:33	5:33	6:33	7:33	8:33	9:33	10:33	11:33	-	1:33	-	3:33	4:33	5:33	6:33	7:33	9:33
8	North Leominster	♿	4:40	5:40	6:40	7:40	8:40	9:40	10:40	11:40	-	1:40	-	3:40	4:40	5:40	6:40	7:40	9:40
8	Shirley		4:48	5:48	6:48	7:48	8:48	f 9:48	f 10:48	f 11:48	-	f 1:48	-	f 3:48	f 4:48	f 5:48	f 6:48	f 7:48	f 9:48
8	Ayer		4:53	5:53	6:53	7:53	8:53	9:53	10:53	11:53	-	1:53	-	3:53	4:53	5:53	6:53	7:53	9:53
7	Littleton/Route 495	♿	5:01	6:01	7:01	8:01	9:01	10:01	11:01	12:01	1:01	2:01	3:01	4:01	5:01	6:01	7:01	8:01	10:01
6	South Acton	♿	5:07	6:07	7:07	8:07	9:07	10:07	11:07	12:07	1:07	2:07	3:07	4:07	5:07	6:07	7:07	8:07	10:07
5	West Concord	♿	5:11	6:11	7:11	8:11	9:11	f 10:11	f 11:11	f 12:11	f 1:11	f 2:11	f 3:11	f 4:11	f 5:11	f 6:11	f 7:11	f 8:11	f 10:11
5	Concord		5:15	6:16	7:16	8:15	9:15	f 10:15	f 11:15	f 12:15	f 1:15	f 2:15	f 3:15	f 4:15	f 5:15	f 6:15	f 7:15	f 8:15	f 10:15
4	Lincoln		5:21	6:22	7:22	8:21	9:21	f 10:21	f 11:21	f 12:21	f 1:21	f 2:21	f 3:21	f 4:21	f 5:21	f 6:21	f 7:21	f 8:21	f 10:21
3	Kendal Green		5:27	6:28	7:28	8:27	9:27	f 10:27	f 11:27	f 12:27	f 1:27	f 2:27	f 3:27	f 4:27	f 5:27	f 6:27	f 7:27	f 8:27	f 10:27
2	Brandeis/Roberts	♿	5:30	6:32	7:32	8:31	9:30	f 10:30	f 11:30	f 12:30	f 1:30	f 2:30	f 3:30	f 4:30	f 5:30	f 6:30	f 7:30	f 8:30	f 10:30
2	Waltham	♿	5:34	6:36	7:36	8:35	9:34	10:34	11:34	12:34	1:34	2:34	3:34	4:34	5:34	6:34	7:34	8:34	10:34
1	Waverley		5:39	6:41	7:41	8:40	9:39	f 10:39	f 11:39	f 12:39	f 1:39	f 2:39	f 3:39	f 4:39	f 5:39	f 6:39	f 7:39	f 8:39	f 10:39
1	Belmont		5:41	6:43	7:44	8:42	9:41	f 10:41	f 11:41	f 12:41	f 1:41	f 2:41	f 3:41	f 4:41	f 5:41	f 6:41	f 7:41	f 8:41	f 10:41
1A	Porter Square	♿	5:47	6:49	7:50	8:48	9:47	10:47	11:47	12:47	1:47	2:47	3:47	4:47	5:47	6:47	7:47	8:47	10:47
1A	North Station	♿	6:03	7:05	8:06	9:04	10:02	11:02	12:02	1:02	2:02	3:02	4:02	5:02	6:02	7:02	8:02	9:02	11:02
																			SKI

Monday to Friday

Outbound from Boston

ZONE	STATION	TRAIN #	401 (AM)	403 (AM)	405 (AM)	407 (AM)	409 (AM)	411 (AM)	413 (AM)	415 (PM)	417 (PM)	419 (PM)	421 (PM)	423 (PM)	425 (PM)	427 (PM)	429 (PM)	431 (PM)	433 (PM)
	Bikes Allowed		🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲					🚲	🚲	🚲
1A	North Station	♿	5:30	6:30	7:30	8:30	9:30	10:30	11:30	12:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30	8:50	10:50
1A	Porter Square	♿	5:40	6:40	7:40	8:40	9:40	10:40	11:40	12:40	1:40	2:40	3:40	4:40	5:40	6:40	7:40	9:00	11:00
1	Belmont		f 5:45	f 6:45	f 7:45	f 8:45	f 9:45	f 10:45	f 11:45	f 12:45	f 1:45	f 2:45	3:45	4:45	5:45	6:45	f 7:45	f 9:05	f 11:05
1	Waverley		f 5:47	f 6:47	f 7:47	f 8:47	f 9:47	f 10:47	f 11:47	f 12:47	f 1:47	f 2:47	3:47	4:47	5:47	6:47	f 7:47	f 9:07	f 11:07
2	Waltham	♿	5:52	6:52	7:52	8:52	9:52	10:52	11:52	12:52	1:52	2:52	3:52	4:52	5:53	6:52	7:52	9:12	11:12
2	Brandeis/Roberts	♿	f 5:55	f 6:55	f 7:55	f 8:55	f 9:55	f 10:55	f 11:55	f 12:55	f 1:55	f 2:55	3:55	4:55	5:56	6:55	7:55	f 9:15	f 11:15
3	Kendal Green		f 5:59	f 6:59	f 7:59	f 8:59	f 9:59	f 10:59	f 11:59	f 12:59	f 1:59	f 2:59	3:59	4:59	6:00	6:59	7:59	f 9:19	f 11:19
4	Lincoln		f 6:04	f 7:04	f 8:04	f 9:04	f 10:04	f 11:04	f 12:04	f 1:04	f 2:04	f 3:04	4:04	5:04	6:05	7:04	8:04	f 9:24	f 11:24
5	Concord		f 6:09	f 7:09	f 8:09	f 9:09	f 10:09	f 11:09	f 12:09	f 1:09	f 2:09	f 3:09	4:09	5:09	6:10	7:09	8:09	f 9:29	f 11:29
5	West Concord	♿	f 6:13	f 7:13	f 8:13	f 9:13	f 10:13	f 11:13	f 12:13	f 1:13	f 2:13	f 3:13	4:13	5:14	6:15	7:13	8:13	f 9:33	f 11:33
6	South Acton	♿	6:18	7:18	8:18	9:18	10:18	11:18	12:18	1:18	2:18	3:18	4:18	5:19	6:20	7:18	8:18	9:38	11:38
7	Littleton/Route 495	♿	6:25	7:25	8:25	9:25	10:25	11:25	12:25	1:25	2:25	3:25	4:25	5:27	6:28	7:25	8:25	9:45	11:45
8	Ayer		f 6:33	f 7:33	f 8:33	f 9:33	f 10:33	f 11:33	-	f 1:33	-	f 3:33	4:33	5:35	6:36	7:33	8:33	f 9:53	f 11:53
8	Shirley		f 6:38	f 7:38	f 8:38	f 9:38	f 10:38	f 11:38	-	f 1:38	-	f 3:38	4:38	5:40	6:41	7:38	f 8:38	f 9:58	f 11:58
8	North Leominster	♿	6:47	7:47	8:47	9:47	10:47	11:47	-	1:47	-	3:47	4:47	5:49	6:50	7:47	8:47	10:07	12:07
8	Fitchburg	♿	L 6:57	L 7:57	L 8:57	L 9:57	L 10:57	L 11:57	-	L 1:57	-	L 3:57	L 4:57	L 6:00	L 7:01	L 7:57	L 8:57	L 10:17	L 12:17
8	Wachusett	♿	7:07	8:07	9:07	10:07	11:07	12:07	-	2:07	-	4:07	5:08	6:10	7:12	8:08	9:07	10:27	12:27

CAMBRIDGE REDEVELOPMENT AUTHORITY

Existing Conditions – Closed Underground Storage Tanks within ½-Mile of Corridor (Source: US EPA)

- One UST at WM S Simpson Inc (300 Sidney Street, Cambridge)
- Two USTs at Vappi and Co Inc (240 Sidney Street, Cambridge)
- One UST at Mass Transportation Inc (187 Sidney Street, Cambridge)
- Four USTs at California Products Corp (158 Waverly Street, Cambridge)
- Three USTs at Delta Tire Co (290 Albany Street, Cambridge)
- One UST at Edith Levine (177 Massachusetts Avenue, Cambridge)
- One UST at MIT Building 3 (77 Massachusetts Avenue, Cambridge)
- One UST at MIT Building 41A (77 Vassar Street, Cambridge)
- Two USTs at U-Haul Co of Cambridge (844 Main Street, Cambridge)
- Three USTs at MIT Building 31 (70R Vassar Street, Cambridge)
- Four USTs at Polaroid Corp (600 Main Street, Cambridge)
- One UST at Four Cambridge Center (4 Cambridge Center, Cambridge)
- One UST at Five Cambridge Center (5 Cambridge Center, Cambridge)
- Four USTs at Kendall Square Service Center (100 Broadway, Cambridge)
- One UST at US Trust Data Services (141 Portland Street, Cambridge)
- Five USTs at Karli Gas (209 Broadway, Cambridge)
- Five USTs at Gulf Service Station (191-20 Broadway, Cambridge)
- Five USTs at the US Department of Transportation Building in Kendall Square
- One additional closed UST at Draper (1 Hampshire Street, Cambridge)
- Three USTs at 17 Cambridge Center (300 Binney Street, Cambridge)
- Two USTs at CEM Realty Trust (300 Bent St, Cambridge)
- One UST at August A. Busch & Co of Mass (111 Sixth Street, Cambridge)
- Nine USTs at AT&T Communications (250 Bent Street, Cambridge)
- One UST at MPW Realty Trust (225 Bent Street, Cambridge)
- One UST at University Distributing Co Inc (210 Otis Street, Cambridge)
- One UST at Wesley Marks – Marks Dispatch (33 Earle Street, Somerville)
- Two USTs at Arch Realty (120-150 McGrath Highway, Somerville)

CAMBRIDGE REDEVELOPMENT AUTHORITY

Existing Conditions – BlueBike Trip Destinations and Origins (Source: BlueBike)

BlueBike Trips – Top 20 Destinations of Trips from Corridor Stations

Destination Station	Raw Trips (Four-Month)	Percent of Trips (Four-Month)
Central Square at Massachusetts Avenue / Essex Street	8,114	5.87%
MIT at Massachusetts Avenue / Amherst Street	6,285	4.55%
Ames Street at Main Street	5,318	3.85%
MIT Pacific Street at Purrington Street	4,655	3.37%
MIT Vassar Street	4,570	3.31%
MIT Stata Center at Vassar Street / Main Street	4,464	3.23%
MIT Carleton Street at Amherst Street	3,421	2.48%
MIT Hayward Street at Amherst Street	3,128	2.26%
Kendall/MIT Red Line Station	2,921	2.11%
Lafayette Square at Massachusetts Avenue / Main Street / Columbia Street	2,806	2.03%
Beacon Street at Massachusetts Avenue	2,753	1.99%
Harvard Square at Massachusetts Avenue / Dunster Street	2,719	1.97%
Massachusetts Avenue at Albany Street	2,200	1.59%
Lower Cambridgeport at Magazine Street / Riverside Road	2,098	1.52%
Deerfield Street at Commonwealth Avenue	2,043	1.48%
Charles Circle - Charles Street at Cambridge Street	1,859	1.34%
Kennedy-Longfellow School 158 Spring Street	1,776	1.28%
University Park	1,775	1.28%
Central Sq P.O. / Cambridge City Hall at Massachusetts Avenue / Pleasant Street	1,732	1.25%
Berkshire Street at Cambridge Street	1,693	1.22%

CAMBRIDGE REDEVELOPMENT AUTHORITY

BlueBike Trips – Top 20 Origins of Trips to Corridor Stations

Origin Station	Raw Trips (Four-Month)	Percent of Trips (Four-Month)
Central Square at Massachusetts Avenue / Essex Street	6,872	4.99%
MIT at Massachusetts Avenue / Amherst Street	6,071	4.41%
MIT Pacific Street at Purrington Street	5,358	3.89%
MIT Vassar Street	5,192	3.77%
MIT Stata Center at Vassar Street / Main Street	4,224	3.07%
Ames Street at Main Street	4,072	2.96%
MIT Carleton Street at Amherst Street	3,322	2.41%
MIT Hayward Street at Amherst Street	3,201	2.32%
Lafayette Square at Massachusetts Avenue / Main Street / Columbia Street	3,193	2.32%
Kendall/MIT Red Line Station	2,816	2.04%
Beacon Street at Massachusetts Avenue	2,796	2.03%
Lower Cambridgeport at Magazine Street / Riverside Road	2,215	1.61%
Deerfield Street at Commonwealth Avenue	2,186	1.59%
Harvard Square at Massachusetts Avenue/ Dunster Street	2,177	1.58%
Massachusetts Avenue at Albany Street	2,106	1.53%
University Park	1,912	1.39%
Central Sq P.O. / Cambridge City Hall at Massachusetts Avenue / Pleasant Street	1,911	1.39%
Kennedy-Longfellow School 158 Spring Street	1,771	1.29%
Charles Circle - Charles Street at Cambridge Street	1,714	1.24%
Berkshire Street at Cambridge Street	1,708	1.24%

CAMBRIDGE REDEVELOPMENT AUTHORITY

Demand Analysis – 2018 Daily Commuter Rail Ridership (Source: CTPS, MBTA)

Line	Daily Boardings
Fairmount	2,652
Kingston / Plymouth	6,089
Greenbush	6,109
Needham	6,672
Middleboro / Lakeville	6,893
Haverhill	7,112
Fitchburg	9,302
Lowell	10,925
Franklin	11,671
Newburyport/Rockport	15,019
Worcester/Framingham	18,636
Providence / Stoughton	25,728

Demand Analysis – Projected Base Ridership within Specific Markets

For each of the competitive headway options, the below tables present the range of base year daily ridership estimates for the upper bound and lower bound scenarios for the specific markets examined in this chapter . These forecasts include additional ridership attracted from non-transit modes due to the improved perceived travel time.

Table 1. Estimated 2022 Daily Grand Junction Ridership between North Station and Eastern Cambridge (10 Cambridge Center) for Workers Transferring at North Station (North Side CR Transit Market)

	Lower Bound			Upper Bound		
HEADWAYS \ SCENARIO	*Users Shifting From Other Transit*	*New Transit Users*	*Total Riders*	*Users Shifting from Other Transit*	*New Users*	*Total Riders*
Via Grand Jct. 15-min Headways	2,425	21	2,446	4,850	127	4,977
Via Grand Jct. 17.5-min Headways	2,425	4	2,429	4,850	19	4,869

Lower Bound Assumptions: Only 50% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.2 travel time elasticity used to measure increased ridership due to modal shift
Upper Bound Assumptions: 100% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.6 travel time elasticity used to measure increased ridership due to modal shift.

As seen in Table 1 for the North Side Commuter Rail Transit, at the 15-minute service level, the travel time savings will result in approximately 0.9 to 2.6 percent growth in ridership, while the 17.5-minute service level would generate between 0.1 to 0.4 percent of additional ridership. The MPO travel demand model predicts approximately nine percent growth for this market between 2016 and 2040. When adjusted to reflect growth between the base and horizon year, the MPO model estimates 6.75 percent growth between 2022 and 2040. As noted in the chapter, significant portions of the projected employment growth in eastern Cambridge used in the travel demand model are being outpaced by actual development; thus, underestimation of the projected ridership is likely Even in the lower bound scenario, the base year ridership for this market is comparable to 2018 daily Fairmount line ridership (2,652). The upper bound scenario is approximately 1.8 times higher than the Fairmount Line ridership in the base year.

Although the upper bound numbers seem high, it is important to note that the EZ-Ride Shuttle, which was not even the transit service with the lowest perceived travel time, reported a pre-COVID daily ridership of 5,300.

As seen in Table 2, for the market comprised by workers transferring from the Worcester/Framingham Line, at a 15-minute headway, the travel time savings will result in approximately 2.4 to 7.3 percent growth in ridership, with 17.5-minute headways affecting a 1.7 to 5.1 percent growth in ridership. The 20-minute service level would produce between 1.0 and 3.1 percent.

Table 2. Estimated 2022 Daily Grand Junction Ridership between West Station and Eastern Cambridge (10 Cambridge Center) for Workers Transferring from the Worcester/Framingham Line

	Lower Bound			Upper Bound		
HEADWAYS \ SCENARIO	*Users Shifting From Other Transit*	*New Users*	*Total Riders*	*Users Shifting From Other Transit*	*New Users*	*Total Riders*
Via Grand Jct. 15-min Headways	919	22	941	1,838	134	1,972
Via Grand Jct. 17.5-min Headways	919	16	935	1,838	94	1,932
Via Grand Jct. 20-min Headways	919	9	928	1,838	57	1,895

Lower Bound Assumptions: Only 50% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.2 travel time elasticity used to measure increased ridership due to modal shift
Upper Bound Assumptions: 100% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.6 travel time elasticity used to measure increased ridership due to modal shift.

As seen in Table 3, for the Allston/Brighton market comprised by workers not transferring from the Worcester/Framingham Line, at the 15-minute service level, the travel time savings will result in approximately 8.6 to 28.3 percent growth in additional ridership, with the 17.5-minute service level would generate between 7.7 and 25 percent added ridership. The 20-minute service level would produce between 6.7 and 21.7 percent.

The considerable differences in perceived travel times between the Grand Junction scenarios and the best existing option (approximately 12 to 15 minutes) will produce additional ridership, but to a lesser degree given the smaller base draws relative to the other markets above.

Table 3. Estimated 2022 Daily Grand Junction Ridership between West Station and Eastern Cambridge (10 Cambridge Center) for Workers Not Transferring from the Worcester/Framingham Line

	Lower Bound			Upper Bound		
HEADWAYS \ SCENARIO	*Users Shifting from Other Transit*	*New Users*	*Total Riders*	*Users Shifting from Other Transit*	*New Users*	*Total Riders*
Via Grand Jct. 15-min Headways	285	25	310	570	162	732
Via Grand Jct. 17.5-min Headways	285	22	307	570	142	712
Via Grand Jct. 20-min Headways	285	19	304	570	124	694

Lower Bound Assumptions: Only 50% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.2 travel time elasticity used to measure increased ridership due to modal shift
Upper Bound Assumptions: 100% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.6 travel time elasticity used to measure increased ridership due to modal shift.

Table 4 presents the range of ridership generated by the upper bound and lower bound scenarios for a Grand Junction service providing service every 30 minutes to/from the selected North Shore communities. These estimates include additional ridership attracted from non-transit modes due to improvements in perceived travel time. Such considerable travel time savings will generate ridership, with additional growth estimated at approximately 14.5 to 51.1 percent.

Table 4. Estimated Daily Grand Junction Ridership between Selected North Shore Communities and Eastern Cambridge (10 Cambridge Center) for Transit Commuter Market (30-minute Headways) – Travel Time Basis

	Lower Bound			Upper Bound		
COMMUNITY \ SCENARIO	*Users Shifting from Other Transit*	*New Users*	*Total Riders*	*Users Shifting from Other Transit*	*New Users*	*Total Riders*
Lynn	193	25	217	385	169	554
Revere	158	22	179	315	149	464
Chelsea	118	16	133	235	108	343
Everett	99	21	119	197	153	350
Total	**566**	**82**	**648**	**1,132**	**579**	**1,711**

Lower Bound Assumptions: Only 50% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.2 travel time elasticity used to measure increased ridership due to modal shift
Upper Bound Assumptions: 100% of existing estimated transit market switches to Grand Junction service, despite reduced perceived travel time; -0.6 travel time elasticity used to measure increased ridership due to modal shift.

Infrastructure Needs and Operational Analysis – Double-Track Conceptual Layout – Detail Views

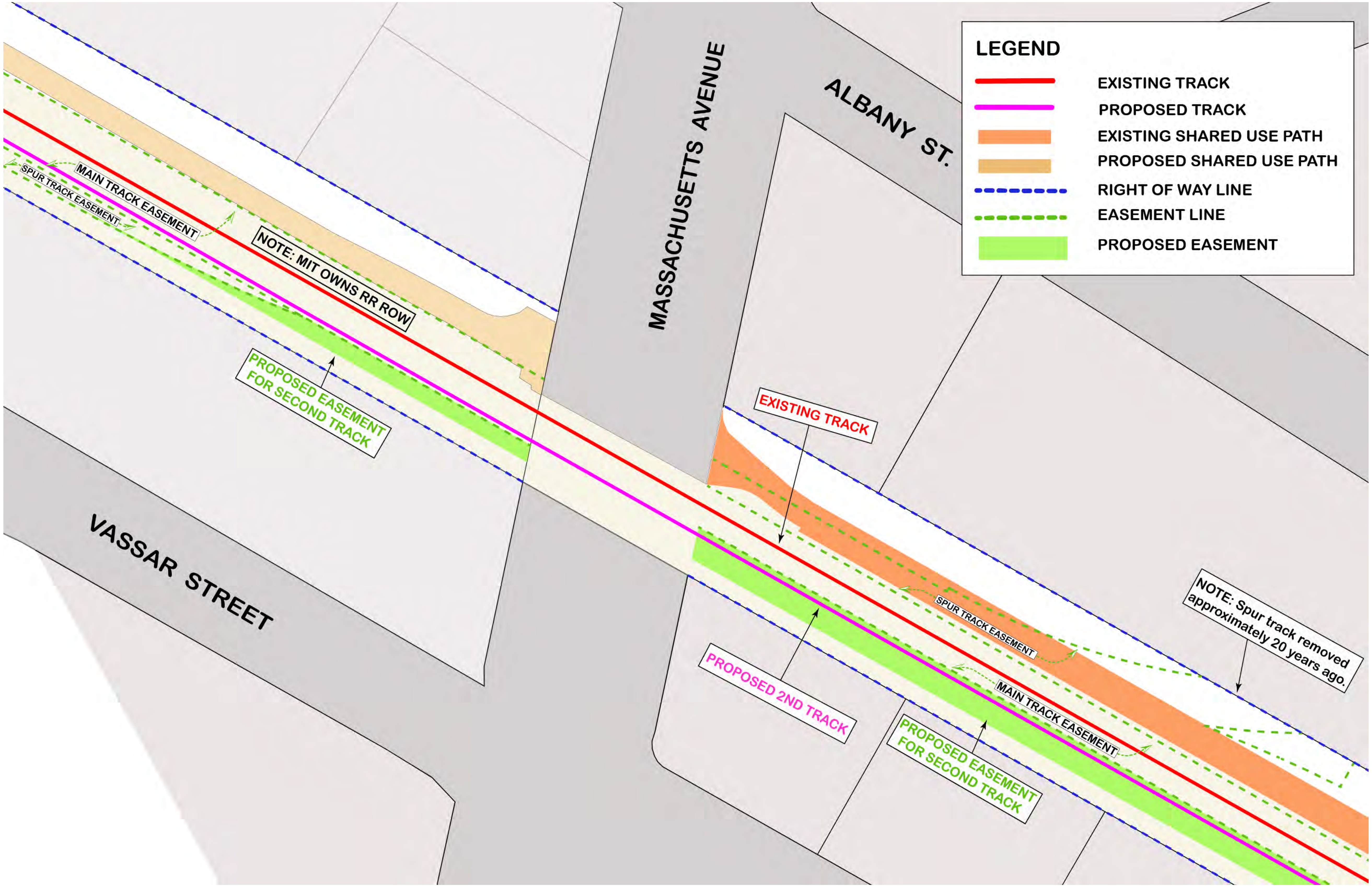


Figure 1. Double-Track Conceptual Layout – Detail View – Massachusetts Avenue

CAMBRIDGE REDEVELOPMENT AUTHORITY

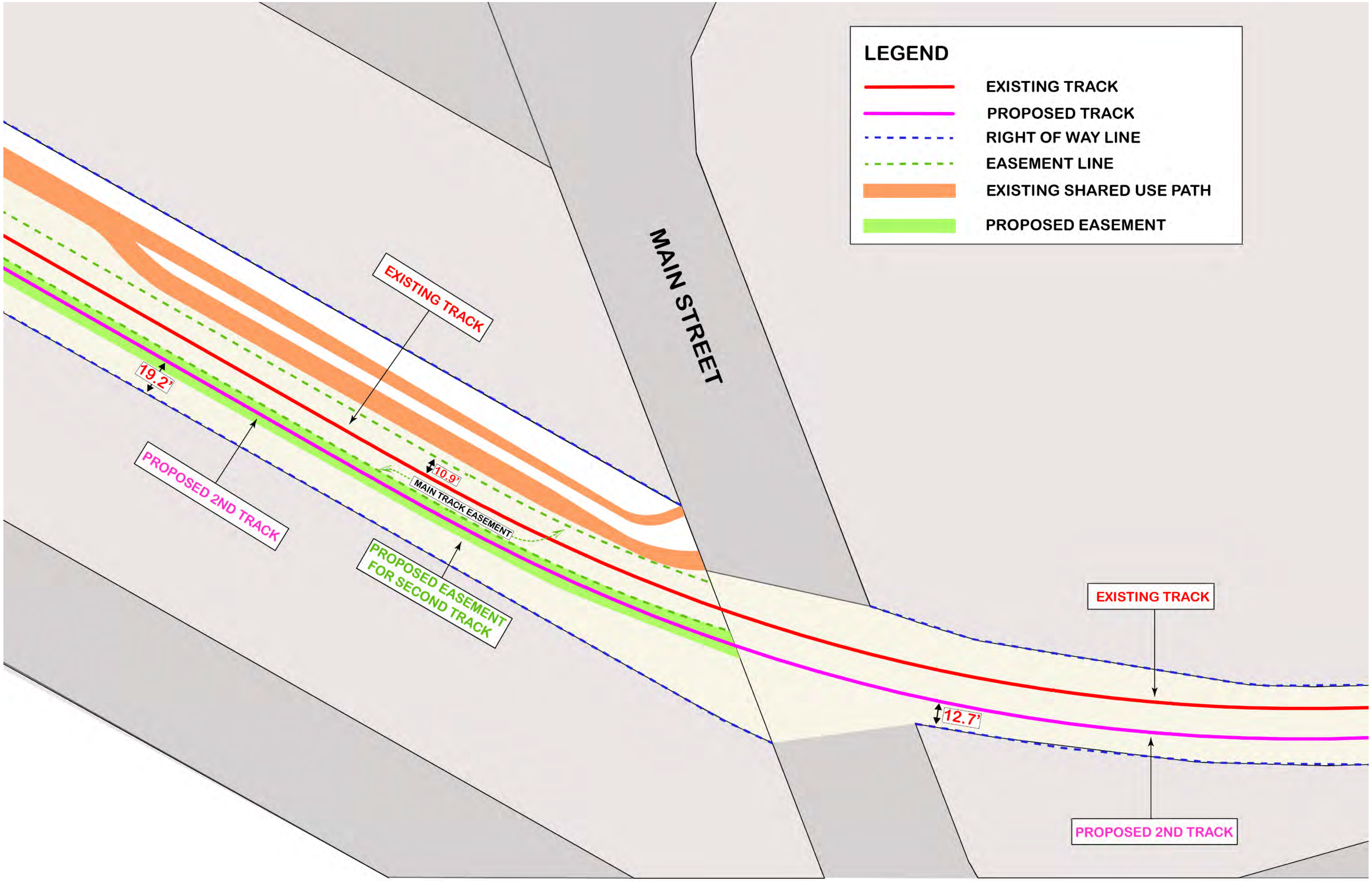


Figure 2. Double-Track Conceptual Layout – Detail View – Main Street

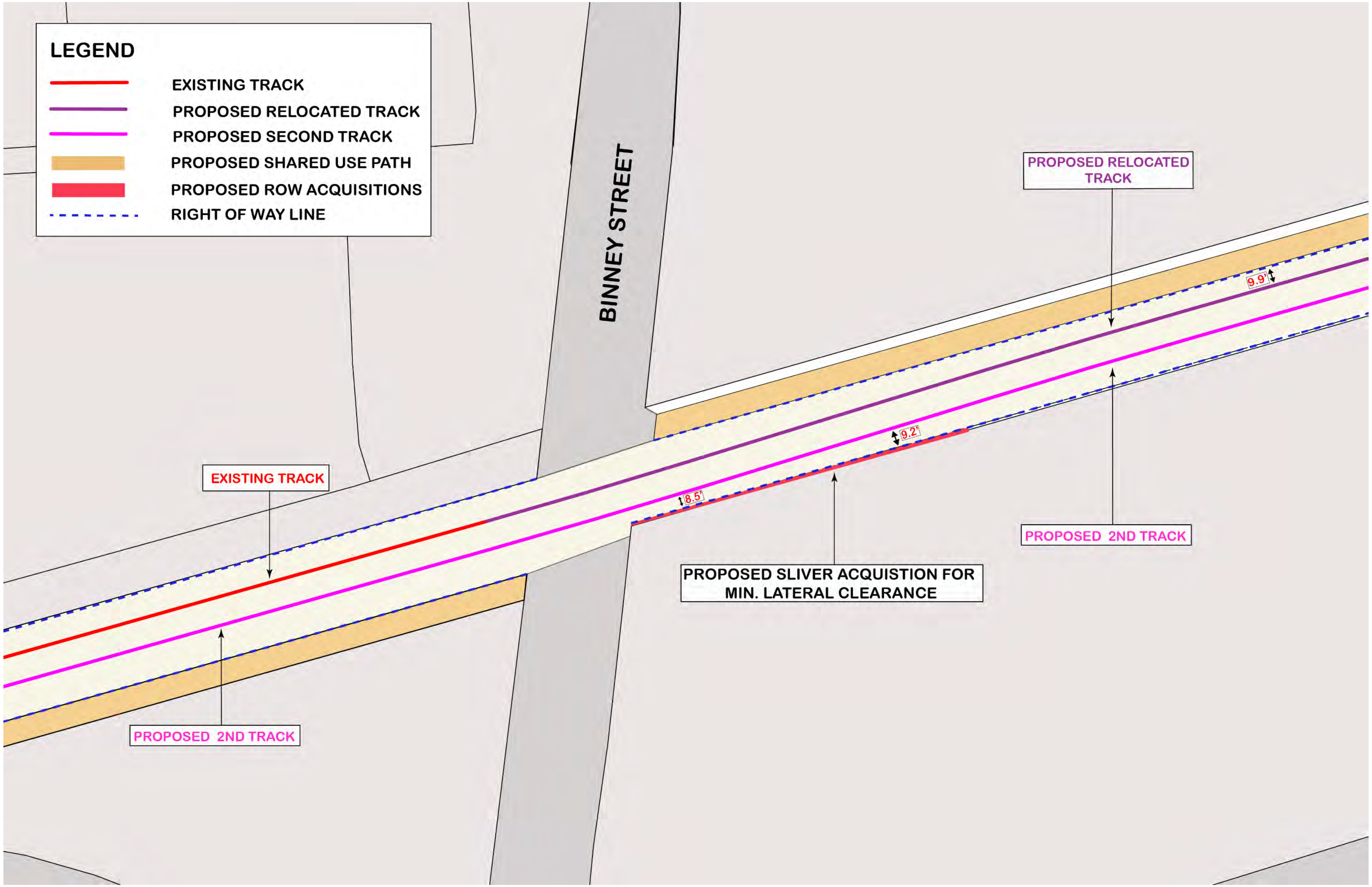


Figure 3. Double-Track Conceptual Layout – Detail View – Binney Street

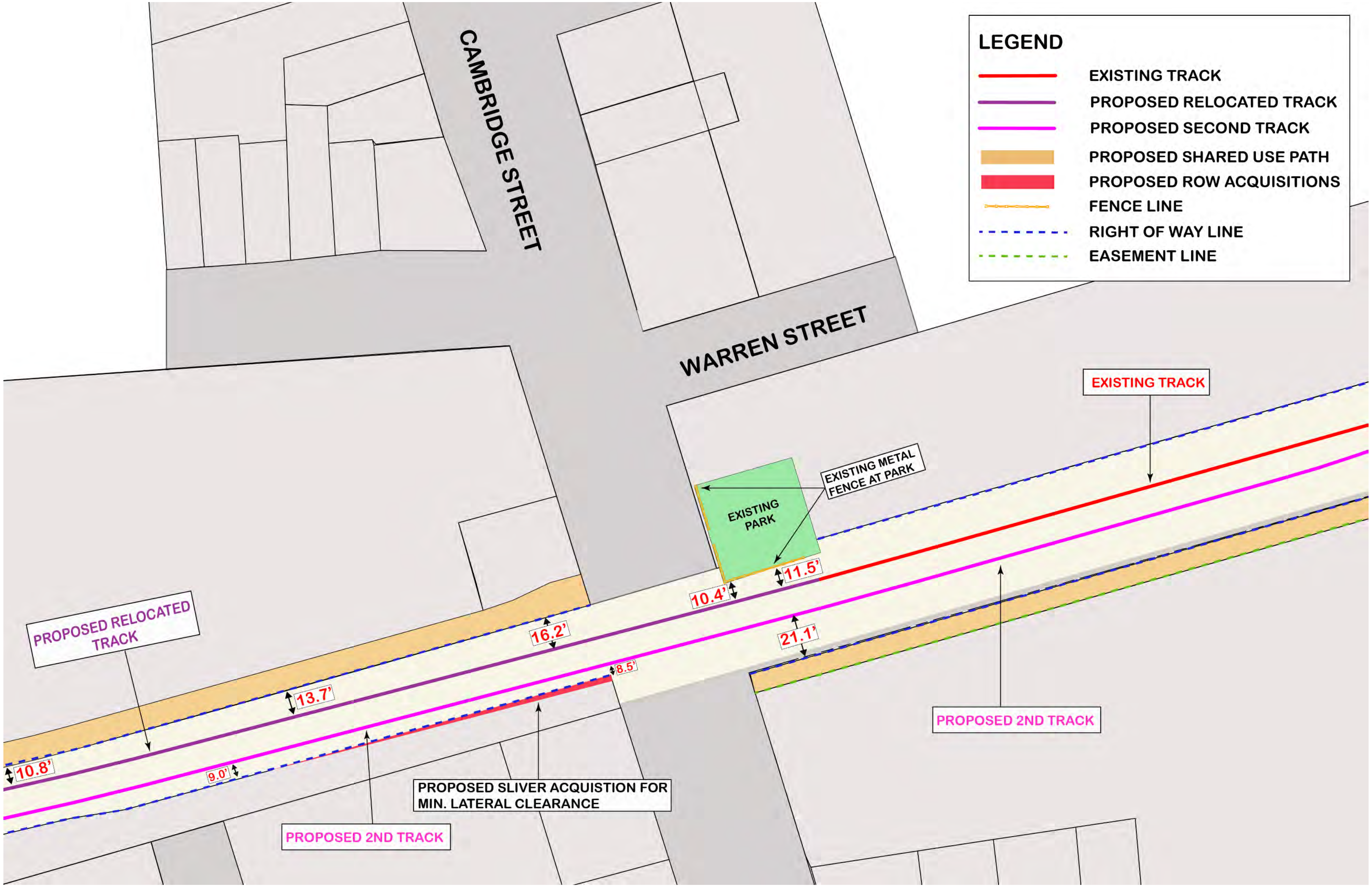


Figure 4. Double-Track Conceptual Layout – Detail View – Cambridge Street

MASSACHUSETTS AVENUE
ALBANY STREET
VASSAR STREET
VASSAR STREET
MAIN STREET
BROADWAY
HAMPSHIRE STREET
BINNEY STREET
GALILEO GALILEI WAY
MEMORIAL WAY
CAMBRIDGE STREET
WARREN STREET
EXISTING PARK
OTIS STREET
CAMBRIDGE STREET
LAMBERT STREET
CITY LIMITS
MEDFORD ST.
GORE STREET
PROPOSED EASEMENT FOR SECOND TRACK
PROPOSED SLIVER ACQUISITION
PROPOSED SLIVER ACQUISITION
LEGEND
EXISTING TRACK
PROPOSED RELOCATED TRACK
PROPOSED SECOND TRACK
EXISTING SHARED USE PATH
PROPOSED SHARED USE PATH
PROPOSED ROW ACQUISITIONS
FENCE LINE
RIGHT OF WAY LINE
EASEMENT LINE
PROPOSED EASEMENTS
CITY LINE
NOTES:
1. PATH IS BASED ON 75% DESIGN BY CITY OF CAMBRIDGE. PATH DESIGN MAY CHANGE AS DESIGN IS PROGRESSED
2. MBTA RAILROAD OPERATIONS STANDARDS REQUIRE 8.5 FOOT CLEARANCE FROM CENTERLINE OF TRACK TO EDGE OF ROW.
3. DESIGN SPEED IS 30 MPH
4. STATION PLATFORMS ARE NOT SHOWN. STATION PLATFORMS MAY REQUIRE SHIFTING OF THE PATH, ADDITIONAL ROW OR BOTH.