Improving the Framingham, MA Commuter Rail Station

Civil Engineering Major Qualifying Project

Submitted to the faculty of Worcester Polytechnic Institute
in partial completion of the Degree of Bachelor of Science.

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Abstract

The goal of this project was to design a new train station with increased service in Framingham to help revitalize its downtown. The MBTA has resolved to electrify the commuter rail, enabling faster, more frequent service. Our group worked with TransitMatters to investigate how the Framingham station can be redesigned to support increased train capacity and service. This report also discusses how a new station design can encourage multimodal transportation and improve access around the station for all forms of transportation. In our designs, we focused on resolving the congestion of the roadways in the downtown area, investigated grade separation of the railroad tracks, and determined the improvements needed to best serve current train riders and Framingham residents.

Executive Summary

Background & Problem

Framingham, Massachusetts is located in an opportunistic geographic location about halfway along a passenger rail line between Worcester and Boston — the two largest cities in New England. The current train station is poorly connected to the city's downtown, limiting benefits to residents and local businesses, while the grade crossings compound congestion issues. The Massachusetts Bay Transportation Authority (MBTA) runs the commuter rail line between Worcester and Boston, and unanimously adopted resolutions to convert the commuter rail from diesel to electric trains, providing all-day, clock face 15-minute service across the entire system (MBTA, 2020a); a massive improvement in service quality. This requires an improved train station that can enable greater access to fast and frequent transportation and spur new development in Framingham.

Goal

The goal of this project was to design a new train station with increased service in Framingham to help revitalize the downtown.

Needs of stakeholders

We contacted stakeholders such as the MBTA, CSX Transportation (who runs freight rail through the station area), the City of Framingham, and Framingham residents and train passengers to determine their needs in a station design. Framingham residents such as Mayor Charlie Sisitsky were able to help us identify key issues such as traffic in downtown Framingham. Additionally, railway experts provided many considerations in scheduling and train station design requirements that would constrain possible designs.

State of Existing Station

Our team performed GIS analyses around Framingham and nearby Natick Center stations. We found that Natick had significantly fewer crashes, was much more pedestrian and biker friendly, and despite having fewer people and jobs, it provided better access to them and had more people walking and biking to its train station compared to Framingham. Framingham's station is surrounded by large parking lots rather than people and jobs, resulting in this disparity.

Design Options

Using the data on the state of the existing station and the needs of stakeholders, we determined two operationally feasible and politically viable design options that would address the problems the city faces.

The first design option improves the existing station by creating walking paths and bike lanes to the station, improving bicycle infrastructure around downtown Framingham and recommending bus service that coordinates with the train schedule. A small bus circle would also be created at the station in its north parking lot. The station would also have high-level platforms for faster and more accessible boarding on and off the train.

The second design option is a grade-separated design, where passenger trains travel over an elevated bridge rather than through at-grade crossings. It includes the improvements from the first design except the bus circle. A four-track station can accommodate frequent local and express service with cross-platform transfers and expanded service locations such as to Framingham State University, the Framingham business park and Marlborough. The station would be moved closer to the heart of downtown Framingham and the Blandin Hub (the current bus hub), enabling easier transfers between the buses and train services. The station would also be closer to higher job and population densities, making it a more accessible location by walking and biking.

In addition, we also proposed a new zoning overlay in Framingham. The existing zoning ordinance prevents walkability and transit-oriented development and needs to be revised in order to enable new developments, spurred by the train station, to revitalize downtown.

Conclusion

Electrification of the commuter rail enables fast and frequent service to Framingham. Framingham can redesign its train station, build amenities for alternate transportation and revise its zoning ordinance to improve multimodal access, decrease congestion, and revitalize its downtown.

Acknowledgements

This project could not have been done without the help of many professionals that advised, supported, and gave information for this project. We would like to thank **Rick McKenna** of Framingham, Massachusetts who was able to get the findings from our project exposed to many stakeholders in the City of Framingham. Rick also inspired us to brainstorm design options for the train station after reading his report “International Place” and meeting with him. He also connected us with Mayor of Framingham **Charlie Sisitsky**, who we would also like to thank for taking the time to meet with us and discuss the possibility of our project becoming a reality for Framingham. We would also like to thank **TransitMatters** — specifically Ethan Finlan, Jay Flynn, Jim Aloisi, Jarred Johnson, and Alon Levy — who introduced us to the Framingham train station and played a large role in the direction of our research. They also provided us with critical information about the transit industry and specifications. We would like to thank our academic advisor **Professor Suzanne LePage** who has advised this project and provided excellent feedback, guidance, and connections throughout its entirety. Lastly, we thank all of our interviewees: Director of System Installation for the MBTA **David Perry**, Framingham Planner **Shane O’Brien**, Board Member of the Friends of the Bruce Freeman Rail Trail **Ed Kross,** and Transit Access Report co-author **Rubén Morgan.** They all gave us very useful information and answered many questions we had.

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Abstract	B.B.	J.C.
Executive Summary	J.C.	B.B.
Acknowledgements	J.C.	J.P.
Capstone Design Statement	B.B.	T.S.
Professional Licensure Statement	M.S.	J.P.
Chapter 1: Introduction	J.P., T.S., J.C.	All
An Overview of the Problem	All	All
Goal Statement	All	All
Objectives	All	All
Chapter 2: Background	All	All
History of Framingham	J.C.	J.P.
History of the Framingham-Worcester Rail Line	J.P.	J.C., T.S.
Existing Conditions of the Framingham-Worcester Rail	B.B.	J.P.
Massachusetts East-West Passenger Rail Initiative	J.P.	T.S.
Existing Conditions of the Station	B.B.	J.P.
An In-Depth Explanation of the Problem	J.P.	T.S.
TransitMatters: Regional Proof of Concept Study	J.P.	T.S.
MBTA Future Visions	B.B.	T.S.
Case Study on Grade Separation: Redwood City, CA	J.P.	B.B.
Downtown Framingham 2009 Study	J.P.	T.S.
Framingham Master Plan 2020	J.C	T.S.
The Transportation Dividend	J.P.	B.B.
Chapter 3: Methodology		
Objective #1: Understand Existing Scope of Knowledge	J.C.	B.B., J.P.
Identify Current Station Amenities	J.C.	B.B., J.P.

Identify Potential Stakeholders	J.C.	B.B., J.P.
Objective #2: Analyze Existing Infrastructure, Usage, and Stakeholders	J.C.	J.P.
Analyze Walkability Maps	J.C.	B.B., J.P.
Identify Current Bike Infrastructure	J.P.	J.P.
Evaluate Current Bus Access Issues	J.C.	J.P.
Determine Vehicle Patterns in Downtown Framingham	J.P.	J.P.
Evaluate Passenger Utilization on the Framingham-Worcester Line	J.C.	J.P.
Collect Stakeholder Opinion	J.C.	J.P.
Objective #3: Determine and Evaluate Design Alternatives	J.C.	J.P.
Analyze Grade Separation	J.C.	J.P.
Develop Potential Timetables	J.C.	J.P.
Evaluate Accessibility	J.C.	J.P.
Chapter 4: Findings		
Walkability Networks	J.C.	B.B., J.P.
Walkability Around the Framingham Station	J.C.	B.B., J.P.
Comparing Walkability Networks of Framingham and Natick	J.C.	B.B., J.P.
Bicycle Access	T.S.	J.C., J.P.
Bike Network Near Framingham Station	J.C.	J.P.
Future Bike Path Plans	T.S.	J.P.
Bus Access Issues	J.C.	J.P.
Turning Movement Counts	J.P.	J.P.
Parking Study	J.P.	J.P.
Crash Data	J.C.	J.P.
Crash Data in Downtown Framingham	J.C.	B.B., J.P.
Crash Data in Natick, MA	J.C.	B.B., J.P.
Accessibility Near Framingham and Natick Stations	J.C.	J.P.
Average Ridership Values	J.P.	J.P.
Cost of Riding the Train versus Driving	J.C.	J.P.

Transportation to and from Commuter Rail Stations	J.P.	T.S.
Commuting Cost Analysis	J.C.	J.P.
Commuting Cost Analysis: Time	J.C.	J.P.
Commuting Alternative: Carpooling	J.C.	J.P.
Community Input	J.C.	J.P.
Constraints of Grade Separation	J.P.	T.S.
Cost of Grade Separation	J.P.	T.S.
Interlockings	J.P.	J.C.
Elevations of Grade Separation	J.P.	J.C.
Modified Forms of Grade Separation	J.P.	J.C.
Effects on Downtown Framingham	J.P.	T.S.
Potential Timetables for Framingham-Worcester Line	T.S.	J.P.
Timetable Possibilities with a Two-Track Station	T.S.	J.P.
Timetable Possibilities with a Four-Track Station	T.S.	J.P.
Timetable Possibility for Extreme Off-Peak/Minimum Service	T.S.	J.P.
Chapter 5: Design Options & Recommendations		
Designs Not Considered for Evaluation	J.P.	T.S.
Grade Separating Both Passenger and Freight Rail	J.C., J.P.	T.S.
Expansion of the Existing Station	J.P.	T.S.
Elevated Passenger Rail in Place	J.P.	T.S.
Design Option #1: Basic Design	J.P.	J.C.
Walking and Biking Improvements	J.P.	T.S.
Bus Improvements	J.P.	J.C.
Effects on Vehicles	J.P.	T.S.
Necessary Zoning Changes for Better Developments	J.C.	J.P.
Fare Policy	T.S.	J.P.
Design Option #2: Long-Term Design	T.S., J.C.	J.P.
Station Location	J.C.	J.P.

Grade Separation Profile	T.S.	J.P.
Walking, Biking, Bus, and Vehicle Connections	T.S.	J.P.
Four Track Station	T.S.	J.P.
Grade Separation	T.S.	J.P.
Potentially Redirecting Freight Train Traffic	T.S.	J.P.
Chapter 6: Conclusions	J.C., M.S.	B.B.

Capstone Design Statement

Worcester Polytechnic Institute (WPI) requires all students to complete a capstone design project, which is known as the Major Qualifying Project (MQP), as part of its graduation requirements. This project meets the capstone design requirement by providing a new design to the current Framingham, Massachusetts commuter rail station which will improve multimodal access to the station, support increased transit ridership, increase the frequency of trains traveling through the station and the downtown area, and enable more frequent service to more destinations; together, these improvements will support improvements to downtown Framingham. The current station is located in the western portion of downtown Framingham, which is at grade and contains small high-level platforms. Our project looked into evaluating different design criteria and determining which improvements would be the most beneficial for the station, current and future riders, and the city.

Constraints associated with this project include:

1. **Economic**

   When considering different design criteria, it is important to keep in mind the cost that is associated with the project. We could propose multiple different improvements to the station and make it the most ideal station possible, but if the cost is not feasible, the project will not be taken seriously by major public stakeholders.

2. **Social**

   Construction along the rail line might impact rail service as well as vehicular and pedestrian circulation, causing delays for passengers, visitors, and residents alike. Interrupting service at this station for an extended period of time may cause an unfavorable outlook on the project by the local community and other communities along the rail line.

3. **Political implications**

   The proposal for a redesign of Framingham station must have political backing from the city and state government. Both city and state governments must ultimately make the decision that the project is beneficial enough to complete and worthy of priority status.

2. **Environmental**

   There may be negative environmental effects from the construction of the proposed design; for example, the nearby Farm Pond residential areas may be affected. On the other hand, improved train service and multimodal transportation across downtown would enable environmentally friendly travel with fewer emissions.

3. **Constructability**

   Land is also important to consider in the potential redevelopment with the new station. Ideally, the station can be placed within existing right-of-way, but some private property may need to be bought or some roadway areas may need to be repurposed by the city in order to construct certain design alternatives.

Professional Licensure Statement

Becoming a professional licensed engineer is critical as ethics and laws are fundamental within civil and environmental engineering professions. To become a professional licensed engineer, individuals will typically follow the sequence outlined below:

1. Obtain a four-year degree from an accredited institution.
2. Pass the Fundamentals of Engineering (FE) exam.
3. Work for four years under a Professional Engineer.
4. Pass the Principles and Practice of Engineering (PE) exam.

Professional engineers are individuals that have attained the highest level of knowledge within their respective field and renew their licenses regularly in order to maintain high standards. Since only professional engineers are allowed to approve engineering plans for public and private clients, these individuals carry greater authority and responsibility than unlicensed engineers. As a result, professional licensure is a necessary step to advance in a civil or environmental engineering career. Throughout our project, we worked closely with engineering-related topics and worked alongside professionals from many different fields. As this project involved real-world applications of engineering, we were able to better understand the responsibilities of being a professional engineer.

Table of Contents

Abstract i
Executive Summary ii
Acknowledgements iv
Authorship v
Capstone Design Statement ix
Professional Licensure Statement xi
Table of Contents xii
List of Tables xv
List of Figures xvi
Chapter 1: Introduction 1
1.1. An Overview of the Problem 2
1.2. Goal Statement 3
1.3. Objectives 3
Chapter 2: Background 4
2.1. History of Framingham 4
2.2. History of the Framingham-Worcester Rail Line 4
2.3. Existing Conditions of the Framingham-Worcester Rail 5
2.4. Massachusetts East-West Passenger Rail Initiative 8
2.5. Existing Conditions of the Station 9
2.6. An In-Depth Explanation of the Problem 11
2.7. TransitMatters: Regional Rail Proof of Concept Study 14
2.8. MBTA Future Visions 16
2.9. Case Study on Grade Separation: Redwood City, CA Station 16
2.10. Downtown Framingham 2009 Study 24
2.11. Framingham Master Plan 2020 25
2.12. The Transportation Dividend 25
Chapter 3: Methodology 28
3.1. Objective #1: Understand Existing Scope of Knowledge 28
3.1.1. Identify Current Station Amenities 28
3.1.2. Identify Potential Stakeholders 28
3.2. Objective #2: Analyze Existing Infrastructure, Usage, and Stakeholder Opinion 29
3.2.1. Analyze Walkability Maps 29

3.2.2. Identify Current Bike Infrastructure 29
3.2.3. Evaluate Current Bus Access Issues 29
3.2.4. Determine Vehicle Patterns in Downtown Framingham 30
3.2.5. Evaluate Passenger Utilization on the Framingham-Worcester Line 31
3.2.6. Collect Stakeholder Opinion 31
3.3. Objective #3: Determine and Evaluate Design Alternatives 31
3.3.1. Analyze Grade Separation 31
3.3.2. Develop Potential Timetables 32
3.3.3. Evaluate Accessibility 32
Chapter 4: Findings 33
4.1. Walkability Networks 33
4.1.1. Walkability Around the Framingham Station 33
4.1.2. Walkability Around the Natick Station 35
4.1.3. Comparing Walkability Networks of Framingham and Natick 36
4.2. Bicycle Access 37
4.2.1. Bike Network Near Framingham Station 39
4.2.2. Future Bike Path Plans 41
4.3. Bus Access Issues 42
4.4. Turning Movement Counts 45
4.5. Parking Study 48
4.5. Traffic Safety Analysis 50
4.6.1. Crash Data in Downtown Framingham 51
4.6.2 Crash Data in Natick, MA 53
4.7. Accessibility Near Framingham and Natick Stations 54
4.8. Average Ridership Values 57
4.9. Cost of Riding the Train versus Driving 60
4.9.1. Transportation to and from Commuter Rail Stations 61
4.9.2. Commuting Cost Analysis 61
4.9.3. Commuting Cost Analysis: Time 62
4.9.4. Commuting Alternative: Carpooling 63
4.10. Community Input 64
4.11. Constraints of Grade Separation 65
4.11.1. Cost of Grade Separation 65
4.11.2. Interlockings 68

4.11.3. Elevations of Grade Separation 69
4.11.4. Modified Forms of Grade Separation 70
4.11.5. Effects on Downtown Framingham 71
4.12. Issues with Zoning 71
4.13. Potential Timetables for the Framingham-Worcester Line 74
4.12.1. Timetable Possibilities with a Two-Track Station 76
4.12.2. Timetable Possibility with a Four-Track Station 80
4.12.3. Timetable Possibility for Extreme Off-Peak/Minimum Service 82
Chapter 5: Design Options & Recommendations 83
Chapter 5.1. Designs Not Considered for Evaluation 84
Chapter 5.1.1. Grade Separating Both Passenger and Freight Rail 84
Chapter 5.1.2. Expansion of the Existing Station 86
Chapter 5.1.3. Elevated Passenger Rail in Place 88
Chapter 5.2. Design Option #1: Basic Design 89
Chapter 5.2.1. Walking and Biking Improvements 92
Chapter 5.2.2. Bus Improvements 94
Chapter 5.2.3. Effects on Vehicles 96
Chapter 5.2.4. Necessary Zoning Changes for Better Developments 96
Chapter 5.2.5. Fare Policy 97
Chapter 5.3. Design Option #2: Long-Term Design 97
Chapter 5.3.1. Station Location 98
Chapter 5.3.2. Grade Separation Profile 99
Chapter 5.3.3. Walking, Biking, Bus, and Vehicle Connections 102
Chapter 5.3.4. Four Track Station 105
Chapter 5.3.5. Grade Separation Considerations 107
Chapter 5.3.6. Potentially Redirecting Freight Train Traffic 107
Chapter 6: Conclusion 110
References 111
Appendix A: Frequency and Speed Analysis for All Stations on the Framingham-Worcester Line 118
Appendix B: Velocity Calculation for Trains Traveling Uphill to a Height of 24 Feet with Engine Off 121
Appendix C: Proposal 122

List of Tables

Table 4.1. Evaluation of Different Modes of Transportation Between Framingham and Boston 62
Table 4.2. Minimum Off-Street Parking Spaces for Residential Structures in Framingham 72
Table 4.3. Minimum Off-Street Parking Spaces for Residential Structures in Boston 73

List of Figures

Figure 1.1. Map of the Northeast United States 1
Figure 2.1. Historic Passenger Rail Lines 5
Figure 2.2. Route of the Framingham-Worcester Rail Line 6
Figure 2.3. Pre-Pandemic Summer Train Schedule 7
Figure 2.4. Summer 2021 Train Schedule 8
Figure 2.5. Rail Map of the Entire State of Massachusetts 8
Figure 2.6. Annotated Map of the Framingham Commuter Rail Station 10
Figure 2.7. Map of Framingham Based on Data from the Framingham Property Viewer 11
Figure 2.8. At-Grade Crossings in Downtown Framingham 12
Figure 2.9. Mini High-Level Platform at Framingham Station 13
Figure 2.10. Timetable Proposed by TransitMatters 15
Figure 2.11. Redwood City Rail Station and Its Surrounding Road Networks 17
Figure 2.12. Changes to Brewster Avenue for Design Alternatives 1 and 2 18
Figure 2.13. Changes to Broadway for Design Alternative 1 19
Figure 2.14. Changes to Broadway for Design Alternative 2 20
Figure 2.15. Changes to Brewster Avenue for Design Alternative 3 21
Figure 2.16. Changes to Broadway for Design Alternative 3 21
Figure 2.17. Changes to Broadway for a Different Variation of Design Alternative 3 22
Figure 2.18. Changes to Broadway and Brewster Avenue for Design Alternative 4 23
Figure 4.1. Framingham Walkability Map 34
Figure 4.2. Natick Center Walkability Map 35
Figure 4.3. Comparing the Walkability Networks 36
Figure 4.4. Bike Lane Classifications 37
Figure 4.5. BART Station Amenities 38
Figure 4.6. Walk Network, Perceived Bike Network, and Bike Network in Framingham 39
Figure 4.7. Perceived Walking Network vs. Perceived Biking Network in Framingham 40
Figure 4.8. MassDOT Bicycle Facilities 41
Figure 4.9. MWRTA System Map 42
Figure 4.10. Weekday Morning Bus Schedule for the 4S Route 43

Figure 4.11. Weekday Morning Train Schedule for Framingham to Boston 43
Figure 4.12. Route 135-Route 126 Intersection Turning Movement Counts 46
Figure 4.13. Route 135-Bishop Street Intersection Turning Movement Counts 47
Figure 4.14. Cumulative Weekday Parking Utilization Estimates in Framingham 49
Figure 4.15. Cumulative Weekend Parking Utilization Estimates in Framingham 50
Figure 4.16. Vehicle Crashes Near the Framingham Station from 2020 51
Figure 4.17. The Number of Pedestrian-Related Crashes by Cluster in Framingham 52
Figure 4.18. AADT for Road Segments Around Framingham Station 52
Figure 4.19. Vehicle Crashes Surrounding the Natick Center Station from 2020 53
Figure 4.20. The Number of Pedestrian-Related Crashes by Cluster in Natick 53
Figure 4.21. AADT for Road Segments Around Natick Center Station 54
Figure 4.22. Mode of Access to Commuter Rail Stations 55
Figure 4.23. Population Densities Near Commuter Rail Stations 56
Figure 4.24. Job Densities Near Commuter Rail Stations 56
Figure 4.25. Average Ridership Per Train at Framingham in the Inbound Direction 58
Figure 4.26. Average Ridership Per Train at Framingham in the Outbound Direction 59
Figure 4.27. Estimated Travel Time for the Weekday Morning Commuter 63
Figure 4.28. Framingham Mayor Sisitsky and the WPI Train Team at the Forum 64
Figure 4.29. Completed Grade Separation in Lima, Ohio 66
Figure 4.30. Potential Grade Separation at Whipple Avenue 67
Figure 4.31. Potential Grade Separation Locations in Redwood City 68
Figure 4.32. Approximate Locations of CP21 and CP22 69
Figure 4.33. Stops Along the Framingham-Worcester Commuter Rail Line 74
Figure 4.34. Half-Mile Walkshed Around Each Station on the Framingham-Worcester Line 75
Figure 4.35. Two-Track Station Service Pattern 1 Map 77
Figure 4.36. Two-Track Station Service Pattern 2 Map 78
Figure 4.37. Four-Track Station Service Pattern Map 80
Figure 4.38. Minimum Service Pattern Map 82
Figure 5.1. Common Current Routes of Freight Trains 86
Figure 5.2. Potential Existing Four-Track Station Layout 87
Figure 5.3. Operational Conflicts of Railroad Tracks 88

Figure 5.4. Aerial View of Design Option 1 90
Figure 5.5. Design of Canopy Covering 91
Figure 5.6. Design of Ramps and Staircases 92
Figure 5.7. Current and Future Biking and Walking Paths 93
Figure 5.8. Close-up Aerial View of Bus Circle 95
Figure 5.9. Design Plans of Station and Grade Separation 98
Figure 5.10. Proposed New Location for the Elevated Train Station 99
Figure 5.11. Comparing Elevated Rail Heights for Freight and Passenger Trains 100
Figure 5.12. Grade Separation Layout 101
Figure 5.13. Elevation of Tracks Going West from Grade Separation 102
Figure 5.14. Walking and Biking Paths Around the Station 103
Figure 5.15. Grade-Separated Track Layout on East Side of Station 104
Figure 5.16. Platform Diagram for Four-Track Station 105
Figure 5.17. Track Layout for Design Option 2 106
Figure 5.18. Framingham Freight Parcels 108

Chapter 1: Introduction

The Framingham-Worcester commuter rail is a 44.2-mile passenger rail line operated by the Massachusetts Bay Transportation Authority (MBTA) that connects Boston and Worcester, MA, serving 18 train stations and connecting New England's two largest cities. Though it is the fastest mode of public transit between these cities, it is relatively slow, taking 1.5 hours when a private car can travel the same distance in under an hour. Improving the speed and frequency of public transit is important to support the daily needs of residents. TransitMatters, a non-profit organization that is dedicated to improving public transportation — specifically rail — within the Boston and Greater Boston areas, performs analyses to identify solutions for faster, more frequent, and more accessible transit.

A crucial station along the line is in Framingham, MA, which is a city located in Massachusetts approximately 20 miles west of Boston, Massachusetts and 172 miles from New York City (Figure 1.1). Trains at Framingham travel slowly when approaching and leaving the station due to at-grade crossings; increasing train service along the Framingham-Worcester line might further hamper downtown travel. Improving the station would enable faster travel by all modes of transportation in Framingham and might revitalize the downtown area.

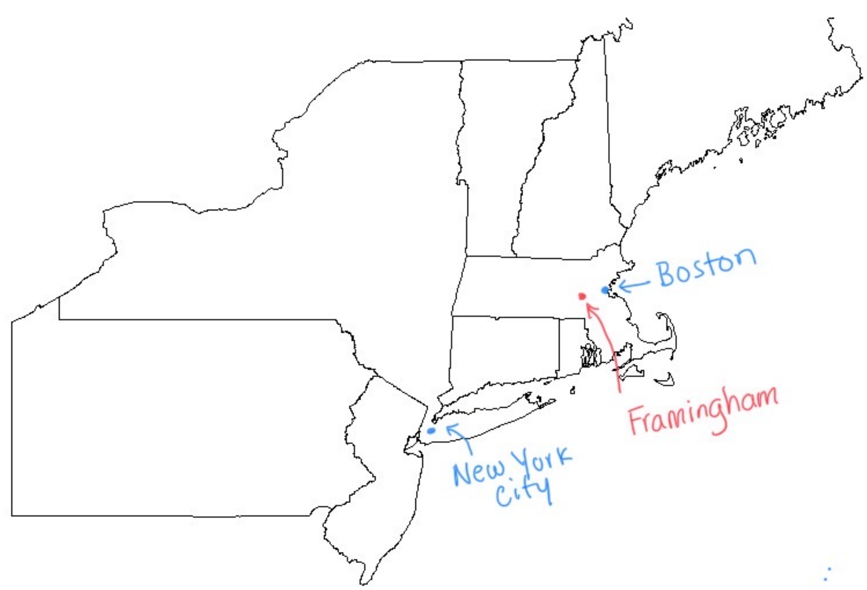


Figure 1.1. Map of the Northeast United States

Improving the commuter rail (as well as the abundant network of rails within Massachusetts) is always on the radar of TransitMatters. Equity, in terms of mobility and economic opportunity, are at the forefront of TransitMatters' vision for the future of rail and bus services. This is especially evident when overviewing their five major goals that define its scope of work: an expanded bus service to 24 hours, 7 days a week; more equitable transit fares; a reinvented and revitalized commuter rail system; a redesigned bus network; and the introduction of mobility hubs. Regarding their third goal, they believe the keys to creating a functional, high-speed, and efficient commuter rail system include system-wide electrification, high-level platforms, improved infrastructure to relieve bottlenecks, frequent all-day service, and free transfers (TransitMatters, 2019).

With their commitment to improving the commuter rail systems in the Greater Boston area, their knowledge and vision perfectly aligns with the improvements needed at the Framingham commuter rail station to make it more efficient and accessible by the local population. TransitMatters assisted our project by overseeing our progress and acting as mentors. Specifically, their relationship to us and the project included: helping to target our action items, contextualizing the Framingham station, and answering any questions regarding improvements and accessibility within and around the station.

1.1. An Overview of the Problem

The Framingham-Worcester line travels through areas where there is a high volume of people that travel in and out of Boston. With Framingham being located halfway between Worcester and Boston, it has the potential to serve as a hub for rail service. Commuting into Boston already poses a large problem to drivers as Massachusetts Interstate 90 (I-90) suffers from slow-moving backups during rush hours; impending construction will only worsen this. Commuter rail service takes more than double the time of driving to travel between Worcester and Boston due to the frequent number of stops and speed caps to which the diesel trains operated by Massachusetts Bay Transit Authority (MBTA) must adhere. Commuter rail speeds immediately east of the Framingham station are currently limited by two at-grade road crossings with crossing guards. While an increase in speed and train frequency is necessary for increased ridership, poor access to and within the station limit the ridership to the station as well as the ability for increased service to revitalize downtown Framingham.

1.2. Goal Statement

The goal of this project was to design a more accessible station enabling the Massachusetts Bay Transportation Authority (MBTA) to provide increased service that will help revitalize downtown Framingham.

1.3. Objectives

After having identified some key problems with the current train station setup at Framingham, we outlined the objectives that guided our process in satisfying our overall goal for this project:

1. Understand the existing scope of knowledge.
    a. Review existing literature relevant to the Framingham station (such as history of the station and the surrounding area, TransitMatters and MBTA reports, and case studies of similar station setups).
    b. Identify stakeholders.
2. Collect and analyze data on existing infrastructure, usage, and stakeholder opinion.
    a. Analyze walkability maps surrounding Framingham and Natick Center stations.
    b. Identify current bike infrastructure at the station and in the surrounding area.
    c. Evaluate current issues with bus access in downtown Framingham.
    d. Determine vehicle patterns in downtown Framingham.
    e. Evaluate passenger utilization on the Framingham-Worcester line.
    f. Collect stakeholder opinions.
3. Determine and evaluate design improvements for multiple alternatives.
    a. Analyze grade separation.
    b. Develop potential timetables for various levels of service.
    c. Evaluate accessibility for each design.

Chapter 2: Background

2.1. History of Framingham

After the American Revolutionary War, with such a convenient location halfway between the two largest cities in New England — Boston and Worcester — Framingham became a major stop for one of the earliest forms of transportation, stagecoach ("History of Framingham", 2021). Framingham was a popular spot to make repairs to carts or switch horses, which allowed for more people to explore the city. Because of this, more customers visited Framingham businesses, causing the local economy to thrive. In the late 1800s, a station for the steam engine train was created in the downtown area. Framingham saw a massive growth in its economy, population, and development due to the influx of people coming to and from the city on the rail ("History of Framingham", 2021).

2.2. History of the Framingham-Worcester Rail Line

The Framingham-Worcester rail originated in the early 1800s. In the early 1900s, Worcester, one of the most central towns in Massachusetts, became the point of division regarding how each half of the east-west rail line in Massachusetts would be developed further. East of Worcester saw a boom in commuter development; westward saw a continuation of intercity service with no other major developments. Amtrak, founded in 1971, immediately took over service west of Worcester while the Massachusetts Bay Transportation Authority (MBTA) began overseeing the line east of Worcester (South Station, 2021). The MBTA and Amtrak swapped ownership over the commuter rail twice, once in 1987 and again in 2003. In 1994, rush hour trains returned between Worcester and Framingham after service was discontinued in 1975; this service was further expanded in 1996 (Mufti & Leonard, 2013).

Both Framingham and Worcester had multiple rail lines and streetcar networks and were hubs in their respective areas. However, many former passenger rail lines are now solely used by freight or have been dismantled and converted to recreational paths for use by pedestrians and bicyclists (Figure 2.1).

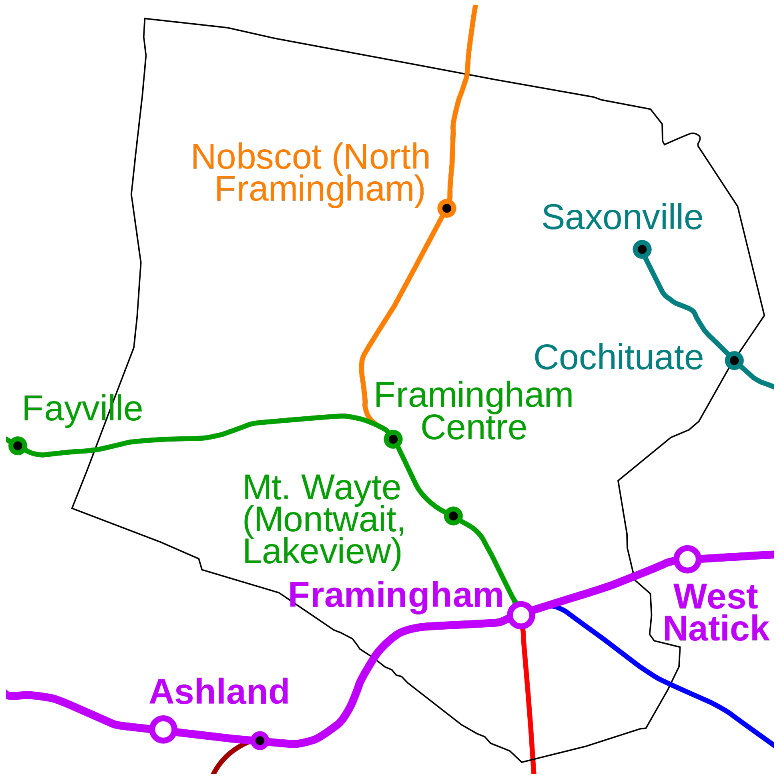


Figure 2.1. Historic Passenger Rail Lines. The purple line is the existing commuter rail, the orange line serves Lowell (being converted into a walking/biking path), the green line Marlborough (currently freight), the blue line Mansfield (currently freight) and the red line Milford (currently freight) (Wikipedia contributors, 2021).

2.3. Existing Conditions of the Framingham-Worcester Rail

As it currently stands, the Framingham-Worcester Rail is owned and operated by the MBTA. Previously, CSX Transportation — a freight railroad company — owned the Worcester-Framingham line and had priority access to the line, inhibiting the expansion of passenger rail service. The year 2012 saw an acquisition of the line by the MBTA, allowing for passenger service to expand as well as infrastructure improvements along the entirety of the rail to be made (MassDOT, 2021a).

According to pre-pandemic data, the Framingham-Worcester line is MBTA's second busiest with over 18,000 weekday riders on average. The commuter portion (the portion MBTA owns) lies between Worcester and Boston, Massachusetts. The line provides service at 18 stops which include suburbs and smaller towns (Figure 2.2), but a majority of its weekday rider-base works in Boston (TransitMatters, 2019). Fares can cost riders anywhere between $2.40 and

$13.25 depending on the distance traveled; unlimited access to the commuter rail for a weekend can be purchased for $10.00. Monthly commuter rail passes will cost riders anywhere in the range from $80.00 to $426.00 depending on preference of access to different services and rail lines (MBTA, 2021a).

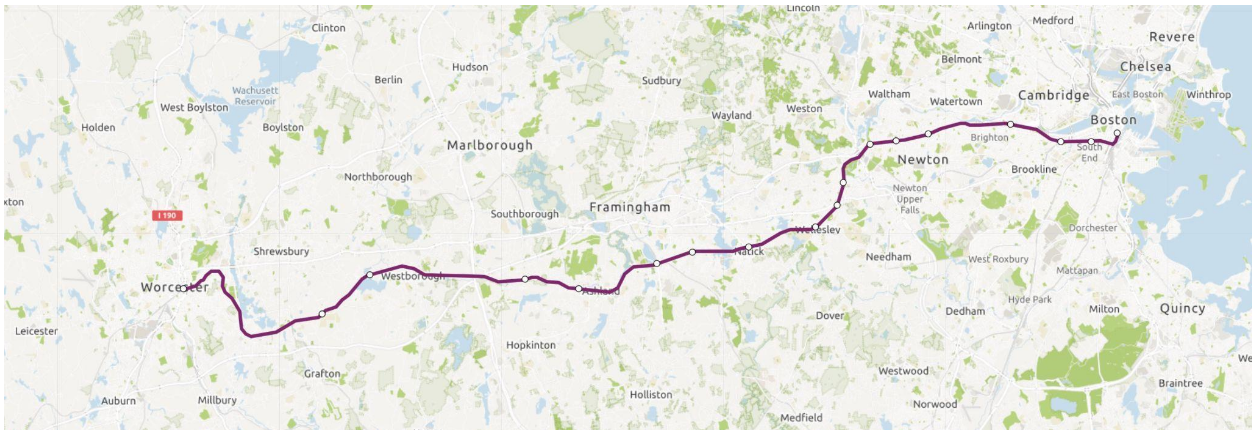


Figure 2.2. Route of the Framingham-Worcester Rail Line (MBTA, 2021b)

The Framingham-Worcester line does not encounter many geographical hurdles along its route. The landscape between Worcester and Boston is relatively flat with zero slopes greater than one percent grade present. 21 sharp turns (defined as horizontal curves greater than approximately two degrees) exist between the two cities, causing trains to slow down in order to safely traverse these sections. Trains are able to travel as fast as 79 miles per hour, but only 11 percent of the commute is spent traveling at this speed due to the number of stops and sharp turns; this is why it takes trains — especially those that stop at all stations — 1.5 hours to travel its 44-mile stretch. The entire rail line is double-tracked, meaning two trains can travel simultaneously without fear of collision, and some sections are triple-tracked as well, enabling overtakes, which is when a faster-traveling train moves past a slower-moving train in the same direction on an adjacent railroad track (MassDOT, 2021a).

Pre-pandemic, the Framingham-Worcester line provided irregular service concentrated at peak hours, including trains that stopped at all stops and trains that skipped stops (Figure 2.3). All trains — except a single morning train to Boston and a single evening train to Worcester — stopped at Framingham. Trains ran approximately every two hours on weekends, stopping at all stations.

FRAMINGHAM/WORCESTER LINE effective May 21, 2018

Massachusetts Bay Transportation Authority — KEOLIS

Monday to Friday — Inbound to Boston

Zone	Station		500	502	582	504	584	506	586	508	588	510	552	590
			AM											
	Bikes Allowed		🚲											
8	Worcester	♿	4:45	5:15	-	5:50	-	6:22	-	6:57	-	7:24	8:00	-
8	Grafton	♿	4:58	5:28	-	6:03	-	6:35	-	7:10	-	7:37	-	-
7	Westborough	♿	5:02	5:32	-	6:07	-	6:39	-	7:14	-	7:41	-	-
6	Southborough	♿	5:11	5:41	-	6:17	-	6:48	-	7:23	-	7:50	-	-
6	Ashland	♿	5:15	5:45	-	6:22	-	6:52	-	7:27	-	7:54	-	8:34
5	Framingham	♿	5:26	5:55	6:04	6:31	6:39	7:02	7:15	7:37	7:49	8:04	-	8:45
4	West Natick	♿	5:31	6:01	6:09	6:36	6:44	7:08	7:20	7:43	7:54	8:10	-	8:50
4	Natick Center		5:36	6:05	6:14	-	6:49	-	7:25	-	7:59	8:15	-	8:55
3	Wellesley Square		5:41	-	6:19	-	6:54	-	7:30	-	8:04	8:20	-	9:00
3	Wellesley Hills		5:45	-	6:23	-	6:58	-	7:34	-	8:08	8:24	-	9:04
3	Wellesley Farms		5:48	-	6:26	-	7:01	-	7:37	-	8:11	8:27	-	9:07
2	Auburndale		5:53	-	6:31	-	7:06	-	7:42	-	8:16	-	-	9:12
2	West Newton		5:56	-	6:34	-	7:09	-	7:45	-	8:19	-	-	9:15
1	Newtonville		5:59	-	6:37	-	7:12	-	7:48	-	8:22	-	-	9:18
1A	Boston Landing	♿	L 6:04	-	L 6:42	-	L 7:17	-	L 7:54	-	L 8:28	L 8:39	-	L 9:23
1A	Yawkey	♿	L 6:09	L 6:24	L 6:47	L 6:59	L 7:22	L 7:34	L 7:59	L 8:09	L 8:33	L 8:44	L 8:55	L 9:28
1A	Back Bay	♿	L 6:14	L 6:29	L 6:52	L 7:04	L 7:27	L 7:39	L 8:04	L 8:14	L 8:38	L 8:49	L 9:00	L 9:33
1A	South Station	♿	6:20	6:35	6:58	7:10	7:33	7:45	8:10	8:20	8:44	8:55	9:06	9:39

Zone	Station		512	514	516	518	520	592	522	594	524	596	526	528	530	532	534	536
			AM		PM													AM
	Bikes Allowed		🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲
8	Worcester	♿	8:50	10:35	12:05	1:55	3:50	-	5:20	-	6:05	-	7:20	8:30	9:00	9:35	11:20	12:20
8	Grafton	♿	9:03	10:48	12:18	2:08	4:03	-	5:33	-	6:18	-	7:33	8:43	9:13	9:48	f 11:33	f 12:33
7	Westborough	♿	9:07	10:52	12:22	2:12	4:07	-	5:37	-	6:22	-	7:37	8:47	9:17	9:52	f 11:37	f 12:37
6	Southborough	♿	9:16	11:01	12:31	2:21	4:16	-	5:46	-	6:31	-	7:46	8:56	9:26	10:01	f 11:46	f 12:46
6	Ashland	♿	9:20	11:05	12:35	2:25	4:20	-	5:50	-	6:35	-	7:50	9:00	9:30	10:05	f 11:50	f 12:50
5	Framingham	♿	9:31	11:16	12:46	2:36	4:31	5:40	6:01	6:20	6:46	7:05	8:01	9:11	9:41	10:16	f 12:01	f 1:01
4	West Natick	♿	9:36	11:21	12:51	2:41	4:36	5:45	6:06	6:25	6:51	7:10	8:06	9:16	9:46	10:21	f 12:06	f 1:06
4	Natick Center		9:41	11:26	12:56	2:46	4:41	5:50	-	6:30	-	7:15	8:11	9:21	9:51	10:26	f 12:11	f 1:11
3	Wellesley Square		9:46	11:30	1:00	2:50	4:45	5:54	-	6:34	-	7:19	8:15	9:25	9:55	10:30	f 12:15	f 1:15
3	Wellesley Hills		9:50	11:34	1:04	2:54	4:49	5:58	-	6:38	-	7:23	8:19	9:29	9:59	10:34	f 12:19	f 1:19
3	Wellesley Farms		9:53	11:37	1:07	2:57	4:52	6:01	-	6:41	-	7:26	8:22	9:32	10:02	10:37	f 12:22	f 1:22
2	Auburndale		f 9:58	f 11:42	f 1:12	-	-	-	-	-	-	f 7:31	-	-	-	-	f 12:27	f 1:27
2	West Newton		f 10:01	f 11:45	f 1:15	-	-	-	-	-	-	f 7:34	-	-	-	-	f 12:30	f 1:30
1	Newtonville		f 10:04	f 11:48	f 1:18	-	-	-	-	-	-	f 7:37	-	-	-	-	f 12:33	f 1:33
1A	Boston Landing	♿	L 10:09	-	-	L 3:07	L 5:04	L 6:13	L 6:24	L 6:53	L 7:09	L 7:42	L 8:32	L 9:42	L 10:12	L 10:47	L 12:38	-
1A	Yawkey	♿	L 10:14	L 11:56	L 1:26	L 3:12	L 5:09	L 6:18	L 6:29	L 6:58	L 7:14	L 7:47	L 8:37	L 9:47	L 10:17	L 10:52	L 12:43	L 1:41
1A	Back Bay	♿	L 10:19	L 12:01	L 1:31	L 3:17	L 5:14	L 6:23	L 6:34	L 7:03	L 7:19	L 7:52	L 8:42	L 9:52	L 10:22	L 10:57	L 12:48	L 1:46
1A	South Station	♿	10:24	12:06	1:36	3:22	5:19	6:28	6:39	7:08	7:24	7:57	8:47	9:57	10:27	11:02	12:53	1:51

Trains in purple box indicate peak period trains.

Saturday & Sunday — Inbound to Boston

Zone	Station (Saturday Train # / Sunday Train #)		1500 / 2500	1502 / 2502	1504 / 2504	1506 / 2506	1508 / 2508	1510 / 2510	1512 / 2512	1514 / 2514	1516 / 2516
			AM			PM					
	Bikes Allowed		🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲
8	Worcester	♿	7:00	8:50	10:50	12:50	2:30	4:30	6:30	8:30	11:00
8	Grafton	♿	7:13	9:03	11:03	1:03	2:43	4:43	6:43	8:43	f 11:13
7	Westborough	♿	7:17	9:07	11:07	1:07	2:47	4:47	6:47	8:47	f 11:17
6	Southborough	♿	7:25	9:15	11:15	1:15	2:55	4:55	6:55	8:55	f 11:25
6	Ashland	♿	7:30	9:20	11:20	1:20	3:00	5:00	7:00	9:00	f 11:30
5	Framingham	♿	7:40	9:30	11:30	1:30	3:10	5:10	7:10	9:10	f 11:40
4	West Natick	♿	7:44	9:34	11:34	1:34	3:14	5:14	7:14	9:14	f 11:44
4	Natick Center		7:49	9:39	11:39	1:39	3:19	5:19	7:19	9:19	f 11:49
3	Wellesley Square		7:54	9:44	11:44	1:44	3:24	5:24	7:24	9:24	f 11:54
3	Wellesley Hills		7:57	9:47	11:47	1:47	3:27	5:27	7:27	9:27	f 11:57
3	Wellesley Farms		8:00	9:50	11:50	1:50	3:30	5:30	7:30	9:30	f 12:00
2	Auburndale		f 8:04	f 9:54	f 11:54	f 1:54	f 3:34	f 5:34	f 7:34	f 9:34	f 12:04
2	West Newton		f 8:07	f 9:57	f 11:57	f 1:57	f 3:37	f 5:37	f 7:37	f 9:37	f 12:07
1	Newtonville		f 8:10	f 10:00	f 12:00	f 2:00	f 3:40	f 5:40	f 7:40	f 9:40	f 12:10
1A	Boston Landing	♿	L 8:16	L 10:06	L 12:06	L 2:06	L 3:46	L 5:46	L 7:46	L 9:46	L 12:16
1A	Yawkey	♿	L 8:21	L 10:11	L 12:11	L 2:11	L 3:51	L 5:51	L 7:51	L 9:51	L 12:21
1A	Back Bay	♿	L 8:25	L 10:15	L 12:15	L 2:15	L 3:55	L 5:55	L 7:55	L 9:55	L 12:25
1A	South Station	♿	8:30	10:20	12:20	2:20	4:00	6:00	8:00	10:00	12:30

Monday to Friday — Outbound from Boston

Zone	Station		501	581	583	503	505	587	507	589	509	511	513
			AM										
	Bikes Allowed		🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲
1A	South Station	♿	4:50	4:57	5:30	5:55	6:10	6:48	7:20	7:30	8:50	10:15	11:55
1A	Back Bay	♿	4:55	5:02	5:35	6:00	6:15	6:53	7:25	7:35	8:56	10:21	12:01
1A	Yawkey	♿	5:00	5:07	5:40	6:05	6:20	6:58	7:30	7:40	9:01	10:26	12:06
1A	Boston Landing	♿	-	-	-	-	-	7:03	7:35	7:45	9:06	f 10:31	f 12:11
1	Newtonville		-	f 5:16	-	-	-	-	-	-	-	f 10:36	f 12:16
2	West Newton		-	f 5:20	-	-	-	-	-	-	-	f 10:40	f 12:20
2	Auburndale		-	f 5:23	-	-	-	-	-	-	-	f 10:43	f 12:23
3	Wellesley Farms		-	5:26	5:53	-	6:33	7:12	-	7:54	9:15	10:46	12:26
3	Wellesley Hills		-	5:29	5:56	-	6:36	7:15	-	7:57	9:18	10:498	12:29
3	Wellesley Square		-	5:33	6:00	-	6:40	7:19	-	8:01	9:22	10:52	12:32
4	Natick Center		-	5:37	6:05	-	6:44	7:23	-	8:05	9:26	10:56	12:36
4	West Natick	♿	5:21	5:42	6:10	6:24	6:49	7:28	-	8:10	9:30	11:01	12:41
5	Framingham	♿	5:25	5:47	6:15	6:29	6:54	7:33	7:53	8:15	9:35	11:06	12:46
6	Ashland	♿	5:31	-	-	6:35	7:00	-	7:59	8:21	9:41	11:12	12:52
6	Southborough	♿	5:36	-	-	6:40	7:05	-	8:04	-	9:46	11:17	12:57
7	Westborough	♿	5:44	-	-	6:49	7:14	-	8:13	-	9:55	11:26	1:06
8	Grafton	♿	5:48	-	-	6:54	7:19	-	8:18	-	10:00	11:31	1:11
8	Worcester	♿	6:01	-	-	7:07	7:32	-	8:31	-	10:13	11:45	1:24

Zone	Station		515	517	519	591	521	593	523	595	525	527	551	529	531	533	535	537
			PM															
	Bikes Allowed		🚲										🚲	🚲	🚲	🚲	🚲	🚲
1A	South Station	♿	2:00	3:30	4:20	4:30	5:00	5:10	5:40	5:50	6:15	6:45	7:35	7:45	8:35	9:35	10:30	11:30
1A	Back Bay	♿	2:06	3:36	4:26	4:36	5:06	5:16	5:46	5:56	6:21	6:51	7:41	7:51	8:41	9:41	10:36	11:36
1A	Yawkey	♿	2:11	3:41	4:31	4:41	5:11	5:21	5:51	6:01	6:26	6:56	7:46	7:56	8:46	9:46	10:41	11:41
1A	Boston Landing	♿	f 2:16	3:46	-	4:46	-	5:26	-	6:06	6:31	7:01	-	8:01	f 8:51	f 9:51	f 10:46	f 11:46
1	Newtonville		f 2:21	3:51	-	4:51	-	5:31	-	6:11	-	7:06	-	f 8:06	f 8:56	f 9:56	f 10:51	f 11:51
2	West Newton		f 2:25	3:55	-	4:55	-	5:35	-	6:15	-	7:10	-	f 8:10	f 9:00	f 10:00	f 10:55	f 11:55
2	Auburndale		f 2:28	3:58	-	4:58	-	5:38	-	6:18	-	7:13	-	f 8:13	f 9:03	f 10:03	f 10:58	f 11:58
3	Wellesley Farms		2:31	4:02	-	5:01	-	5:42	-	6:22	6:43	7:16	-	8:16	9:06	10:06	11:01	12:01
3	Wellesley Hills		2:34	4:05	-	5:04	-	5:45	-	6:25	6:46	7:19	-	8:19	9:09	10:09	11:04	12:04
3	Wellesley Square		2:37	4:09	-	5:08	-	5:49	-	6:29	6:50	7:23	-	8:22	9:12	10:12	11:07	12:07
4	Natick Center		2:41	4:14	4:54	5:12	-	5:53	-	6:33	6:54	7:27	-	8:26	9:16	10:16	11:11	12:11
4	West Natick	♿	2:46	4:19	5:00	5:17	5:35	5:59	6:15	6:38	6:59	7:32	-	8:31	9:21	10:21	11:16	12:16
5	Framingham	♿	2:51	4:25	5:06	5:23	5:43	6:05	6:22	6:44	7:05	7:37	-	8:36	9:26	10:26	11:21	12:21
6	Ashland	♿	2:57	4:32	5:12	-	5:50	-	6:29	-	7:11	7:43	-	8:42	9:32	10:32	11:27	12:27
6	Southborough	♿	3:02	4:37	5:17	-	5:55	-	6:34	-	7:16	7:48	-	8:47	9:37	10:37	11:32	12:32
7	Westborough	♿	3:11	4:46	5:26	-	6:05	-	6:43	-	7:25	7:57	-	8:56	9:46	10:46	11:41	12:41
8	Grafton	♿	3:16	4:51	5:31	-	6:11	-	6:49	-	7:30	8:02	-	9:01	9:51	10:51	11:46	12:46
8	Worcester	♿	3:30	5:04	5:45	-	6:25	-	7:03	-	7:44	8:15	8:45	9:15	10:05	11:05	12:00	1:00

Trains in purple box indicate peak period trains.

Saturday & Sunday — Outbound from Boston

Zone	Station (Saturday Train # / Sunday Train #)		1501 / 2501	1503 / 2503	1505 / 2505	1507 / 2507	1509 / 2509	1511 / 2511	1513 / 2513	1515 / 2515	1517 / 2517
			AM			PM					
	Bikes Allowed		🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲	🚲
1A	South Station	♿	6:40	8:40	10:40	12:40	2:20	4:20	6:20	8:20	10:40
1A	Back Bay	♿	6:46	8:46	10:46	12:46	2:26	4:26	6:26	8:26	10:46
1A	Yawkey	♿	6:49	8:49	10:49	12:49	2:29	4:29	6:29	8:29	10:49
1A	Boston Landing	♿	f 6:54	f 8:54	f 10:54	f 12:54	f 2:34	f 4:34	f 6:34	f 8:34	f 10:54
1	Newtonville		f 7:01	f 9:01	f 11:01	f 1:01	f 2:41	f 4:41	f 6:41	f 8:41	f 11:01
2	West Newton		f 7:04	f 9:04	f 11:04	f 1:04	f 2:44	f 4:44	f 6:44	f 8:44	f 11:04
2	Auburndale		f 7:07	f 9:07	f 11:07	f 1:07	f 2:47	f 4:47	f 6:47	f 8:47	f 11:07
3	Wellesley Farms		7:11	9:11	11:11	1:11	2:51	4:51	6:51	8:51	11:11
3	Wellesley Hills		7:14	9:14	11:14	1:14	2:54	4:54	6:54	8:54	11:14
3	Wellesley Square		7:17	9:17	11:17	1:17	2:57	4:57	6:57	8:57	11:17
4	Natick Center		7:22	9:22	11:22	1:22	3:02	5:02	7:02	9:02	11:22
4	West Natick	♿	7:26	9:26	11:26	1:26	3:06	5:06	7:06	9:06	11:26
5	Framingham	♿	7:31	9:31	11:31	1:31	3:11	5:11	7:11	9:11	11:31
6	Ashland	♿	7:37	9:37	11:37	1:37	3:17	5:17	7:17	9:17	11:37
6	Southborough	♿	7:41	9:41	11:41	1:41	3:21	5:21	7:21	9:21	11:41
7	Westborough	♿	7:49	9:49	11:49	1:49	3:29	5:29	7:29	9:29	11:49
8	Grafton	♿	7:55	9:55	11:55	1:55	3:35	5:35	7:35	9:35	11:55
8	Worcester	♿	8:10	10:10	12:10	2:10	3:50	5:50	7:50	9:50	12:10

Figure 2.3. Pre-Pandemic Summer Train Schedule. Effective from May 21, 2018 to an unknown date (MBTA, 2021c).

Now, during the work week, trains currently depart from either Boston or Worcester approximately every hour on the hour, which is a more consistent and frequent schedule than before (Figure 2.4). Though, some trains from Boston turn around at Framingham and some skip stops east of Framingham to provide faster Boston-Worcester service; all trains stop at Framingham. An increase in service is seen during the afternoon as trains depart Boston approximately every half hour starting around 3:00 p.m. until 11:00 p.m. Weekend service is similar to pre-pandemic service, except it starts earlier (MBTA, 2021c).

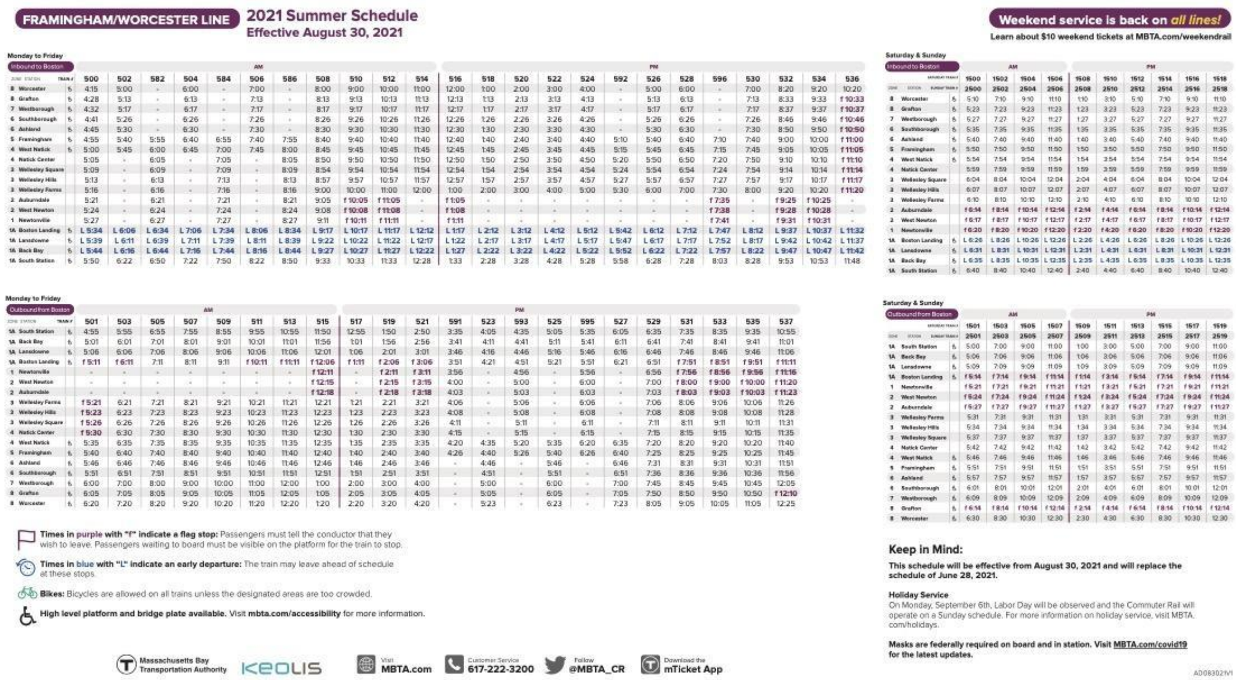


Figure 2.4. Summer 2021 Train Schedule. Effective from August 30, 2021 to Oct 10, 2021 (MBTA, 2021c).

2.4. Massachusetts East-West Passenger Rail Initiative

Beginning in 2018, the Massachusetts Rail State Rail Plan recommended exploring the possibility of introducing regular rail service to communities west of Worcester. Known as the East-West Rail project, this initiative explores the different design options of providing more frequent rail service as far as Springfield and Pittsfield, Massachusetts. As shown in the rail map below (Figure 2.5), Springfield and Pittsfield, MA are located 91 and 151 miles, respectively, from Boston.

Figure 2.5. Rail Map of the Entire State of Massachusetts (MassDOT, 2021a).

Currently, the stretches of rail between Pittsfield and Worcester are owned and operated by CSX Transportation. Passenger rail, as it stands today, is practically nonexistent west of Worcester; Amtrak operates a once-per-day train, known as the Lakeshore Limited, that stops at Pittsfield, Springfield, Worcester, Framingham, and Boston.

The East-West project explored several design options for public transit between Eastern and Western Massachusetts, including buses, electric trains, and diesel locomotives. If built, this may increase the number of trains traveling through Framingham.

2.5. Existing Conditions of the Station

Framingham station is currently a two-track station with platforms oriented along the railway line going east-west, with side platforms adjacent to the rails. The trains going west to Worcester stop at the Framingham platform to the north, and the trains going east to Boston stop at the Framingham platform to the south. The platforms are connected by a pedestrian bridge over the tracks, which also includes two elevators for wheelchair accessibility. While the historical train station is still present, it is in use as a restaurant and is neither owned by freight rail companies nor the MBTA ("Framingham Master Plan", 2020).

There are bike racks along the platforms, and bike lockers are located at the westbound platform. The station is parallel to Waverly Street (State Highway 135) and is located next to a grade crossing at Irving Street (State Highway 126). There are parking lots to the north and south of the station (Figure 2.6). The south parking lot is long and narrow, while the north parking lot is much larger. Both combined have 167 parking spaces (Jessen, 2016).

Figure 2.6. Annotated Map of the Framingham Commuter Rail Station (Google Maps, n.d.)

Currently, the station is managed by the MWRTA (MetroWest Regional Transit Authority), which runs buses that serve the station. The MWRTA receives parking revenue to pay for bus shelters (Jessen, 2016). This allows the MBTA to save money on managing the station, and the MWRTA can use FTA (Federal Transit Administration) funds to maintain the station. However, with the exception of some of the north parking lot, the station is largely owned by the Georgetown & High Line Railway (Figure 2.7). Further investigation is needed regarding the agreement between MBTA and freight rail companies in relation to their use of the station (MapGeo, 2021).

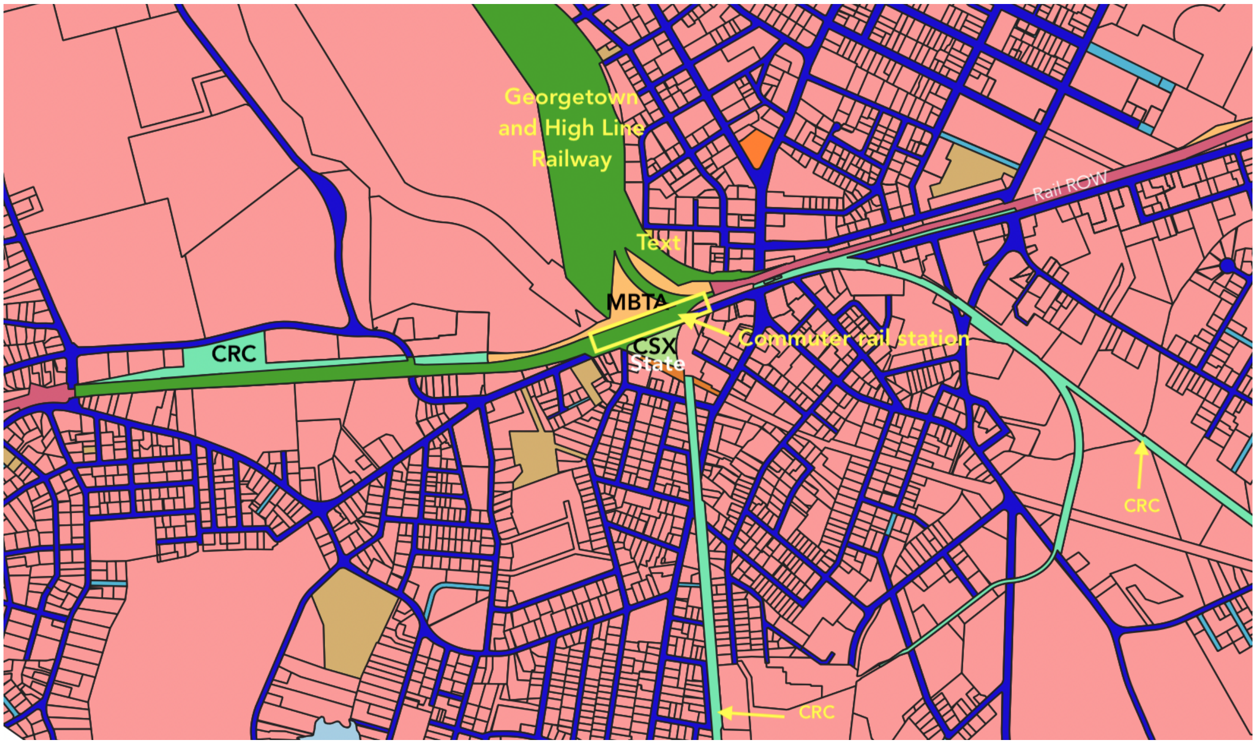


Figure 2.7. Map of Framingham Based on Data from the Framingham Property Viewer (MapGeo, 2021)

The green areas in Figure 2.7 show the Georgetown and High Line railway properties. The Consolidated Rail Corporation (CRC) owns the properties in cyan, and CSX property is represented by light green. MBTA properties are labeled in light ochre, and the commuter rail station (approximate and not including parking) is labeled with a yellow box. The state owns a small parcel of land just south of the commuter rail station. Note that the Georgetown and High Line Railway, CRC, and CSX all have the same ownership address, so, despite the different names, they are probably all the same entity.

2.6. An In-Depth Explanation of the Problem

Plans are currently being laid out for a major construction project on Interstate 90 near Allston, which will create many bottlenecks and slow down vehicle traffic considerably (even more than how it is currently during rush hours). The construction that will take place on I-90 is assumed to be a six- to ten-year process; therefore, an alternative use of transportation becomes highly valuable to city-goers and commuters. One of the most efficient forms of public transportation is trains, but in order for that to be true, the train station must be accessible and easy to get to. The City of Framingham's Master Land Use Plan outlined a recent evaluation of current bus routes and their efficiency. It also discussed some future plans, which included servicing some of the most critical points in the city, including the train station ("Framingham Master Plan", 2020). The Master Plan also says Framingham is committed to accommodating other forms of transportation to bus stations and the train station, such as walking and biking, by creating more paths and sidewalks to these transportation hubs ("Framingham Master Plan", 2020). Not having a convenient way of getting to the train station makes the option of traveling by train less favorable, contributing to more traffic on I-90. This will cause even more headaches for commuters attempting to get into the city by car during the Allston construction.

The Framingham station itself suffers from a problem faced by many rail networks around the globe: at-grade road crossings. The Framingham Commuter Rail station sits directly adjacent to the busy Route 135-Route 126 intersection (circled in red in Figure 2.8); a half-mile east of the station is the Route 135-Bishop Street intersection (circled in blue in Figure 2.8). These at-grade crossings force trains to slow down when leaving or entering Framingham station anywhere east of the station. Road traffic is also affected as, very obviously, traffic cannot cross the rails while a train is occupying the intersection. Additionally, upon observation, it became quickly apparent that pedestrians like to walk alongside the tracks, which causes train conductors to slow down even more for fear of hitting them. The at-grade crossings do nothing but hinder rail efficiency as well as create large vehicle bottlenecks in the busy corridors nearby the station.

Figure 2.8. At-Grade Crossings in Downtown Framingham (Google Maps, 2021)

A large accessibility problem in terms of its station layout is also found at Framingham station. With its current setup, there are two different platform levels — one that is at the level of a train car (otherwise known as a high-level platform) and one that is at street level (Figure 2.9). Boarding time and accessibility are largely affected by this design. For example, those who are disabled are likely not able to board from the street-level platform because they will be unable to climb the steep steps up to the train. All of these passengers would need to enter from the small high-level platform, which would take a considerable amount of time since the high-level platform only serves one or two train car entrances. This vastly increases the time spent at the station, wasting precious minutes that could have been spent traveling.

Figure 2.9. Mini High-Level Platform at Framingham Station

The Framingham station is currently set up in favor of commuters parking their car at the station and then boarding a train. The infrastructure surrounding the station does not lend itself well to arriving at the station via an alternative transportation method. A bus stop currently exists on the street in front of the station. The pick-up and drop-off area for individuals using rideshare services exists in front of the station, although it is very small with a less-than-ideal setup. Bicyclists have access to storage lockers at the station, but their travel to the station is a bit complicated. Dedicated bike lanes are not present on Route 135 in front of the station, meaning bikes are encouraged to share the road with vehicles. There are also no other pedestrian and bicycle lanes nearby that lead to the station from other densely populated areas of Framingham.

2.7. TransitMatters: Regional Rail Proof of Concept Study

TransitMatters is a non-profit organization that works to support transportation around the Boston area by advocating for and advancing the best-proven practices. They do this work with the vision of making an equitable, sustainable, and reliable public transportation system accessible to everyone in Metropolitan Boston (TransitMatters, 2019). One high-impact, low-cost initiative they advocate for is modernizing the commuter rail system. TransitMatters believes the regional rail system should provide frequent, all-day service with elements such as level-boarding, systemwide electrification, and free transfers (TransitMatters, 2019). This high level of service on the Framingham-Worcester line could be critical to alleviate congestion with the future construction plans on I-90, and it would be an equitable solution for users with flexible work schedules.

The report outlines that train speeds can be massively increased with electrifying the rails, relaxing speed limits, improving track where needed, and building high-level platforms. Currently, trains are capped at a travel speed of 60 MPH despite the line being able to support 90 MPH to 100 MPH travel speeds; many of the straight portions of track would be able to accommodate these higher speeds. Curves throughout the network would need to be redesigned to allow for trains to travel more quickly through them. High-level platforms would allow passengers to board and deboard faster, decreasing the time a train is idle at the station, and therefore enable trains to travel faster. (TransitMatters, 2019).

Additionally, a third track between Framingham and Wellesley would allow trains to overtake one another, which would be necessary for simultaneously running local and express trains. However, this would be a high-cost project with many logistical issues realigning the tracks and the stations (TransitMatters, 2019).

Through the plans suggested by TransitMatters, the Framingham-Worcester line can achieve four local trains per hour in both directions. TransitMatters also suggests introducing local and express service, utilizing the potential third rail to help with this initiative. The timetable (Figure 2.10) outlines the time improvements and new service patterns included in TransitMatters future vision for the Framingham-Worcester line. It is important to note that this timetable is possible assuming the construction of the third track between Framingham and near Wellesley.

Travel Times

FRAMINGHAM/WORCESTER			
Station	Local	Express	Current
South Station	**0:00**	**0:00**	0:00
Back Bay	0:03	0:03	0:06
Lansdowne	0:05	0:05	0:11
West Station	0:08	0:07	--
Boston Landing	0:10	(0:08)	0:16
Newton Corner	0:13	(0:10)	--
Newtonville	0:15	(0:11)	0:21
West Newton	0:17	(0:12)	0:25
Auburndale	0:19	(0:12)	0:28
Wellesley Farms	0:22	(0:14)	0:32
Wellesley Hills	0:24	(0:15)	0:35
Wellesley Square	0:26	(0:16)	0:39
Natick Center	0:30	(0:18)	0:44
West Natick	0:32	(0:19)	0:49
Framingham	**0:35**	**0:21**	0:55
Ashland	(0:38)	0:25	1:02
Southborough	(0:42)	0:29	1:07
Westborough	(0:46)	0:33	1:16
Grafton	(0:51)	0:38	1:21
Worcester	**(0:57)**	**0:45**	1:34

Times in parentheses on the express trains indicate the time at which the train will pass a station without stopping; on the local trains they indicate the time the train would serve the station if it kept running local to Worcester.

Figure 2.10. Timetable Proposed by TransitMatters (TransitMatters, 2019)

Essentially, local trains would travel between South Station and Framingham while express trains would travel the entire length. Express trains would notably not stop at any station between West Station and Framingham. On the contrary, local trains would stop at every station between these two points, but, again, trains would turn around at Framingham. Due to this method of scheduling, the Framingham station would essentially become a hub for transfers between local and express service. Additionally, with the desire to increase train speeds and overall efficiency on the commuter line, express trains would be able to travel between South Station and Worcester in 45 minutes — less than half the time it currently takes (TransitMatters, 2019).

2.8. MBTA Future Visions

The MBTA's Fiscal Management and Control Board (FCMB) voted in late 2019 to support a future vision of the MBTA that is in line with TransitMatters' vision: fast, electric, frequent (15-minute) service across the entire network; the first steps toward electrifying the commuter rail would also be taken (DeCosta-Kilba, 2019). It is important to note that this vote took place before the pandemic, and the report outlining MBTA's future vision was completed and shared in February 2020.

Included in this report are six alternatives regarding future trajectories of service in the MBTA network, ranging from small optimizations of the current system to a complete (electric) overhaul. Each alternative targets different needs for the MBTA to boost the transit system by increasing the frequency of the commuter rail.

The purpose of alternative one is to optimize the current system by expanding the amount of running trains and improving various stations and tracks. Alternatives two and three target optimizing regional rail to key stations for diesel and electric, respectively. This will be achieved through replacing trains with newer, more efficient models and adding more platforms at South Station for increased train frequency. Alternatives four and five aim to increase urban rail service for diesel and electric, respectively. These alternatives will be achieved through expanding the train fleet and increasing the number of boarding platforms to provide equal service in both directions all day. These alternatives also would see the addition of more platforms at South Station to maintain the increased frequency (MBTA, 2020a).

Alternative six consists of investing $6.5 billion to replace and expand the train fleet with self-powered electric vehicles to create a fully electrified rail system. Alternative six will link the North and South Stations (commonly known as the North-South Rail Link) for inner core travel as well as adding track and platforms to offer 15-minute frequency to all stations along the line (MBTA, 2020b). Alternative six most closely aligns with the vision TransitMatters has for the future of rail in eastern Massachusetts.

2.9. Case Study on Grade Separation: Redwood City, CA Station

Between San Francisco and San Jose, California lies an approximately 50-mile stretch of rail operated by Caltrain. Redwood City is situated halfway between these two cities. This system provides many parallels to the Framingham-Worcester line. They both are similar in length, provide service between a major and moderately sized city, and have the potential for the station mid-way between these two noteworthy destinations (respectively on either line) to become a transfer hub between local and express trains. The cities themselves — Framingham and Redwood City — also share many similarities, offering increasingly growing populations and downtown areas as well as being plagued with a major hurdle when it comes to increasing trains-per-hour: at-grade rail crossings.

The Redwood City station interacts with more streets than the Framingham station. Its station is sandwiched directly between two cross-streets that serve higher-traffic corridors parallel on either side of the station. Additionally, there are five smaller cross-streets both to the left and right of the station (Figure 2.11). Framingham finds itself directly adjacent to Route 126, a cross-street that sees a significant amount of throughput and proximal to another cross-street a few hundred feet down the line. Framingham is obviously a less complicated scenario in comparison to Redwood's situation (Redwood City, 2020).

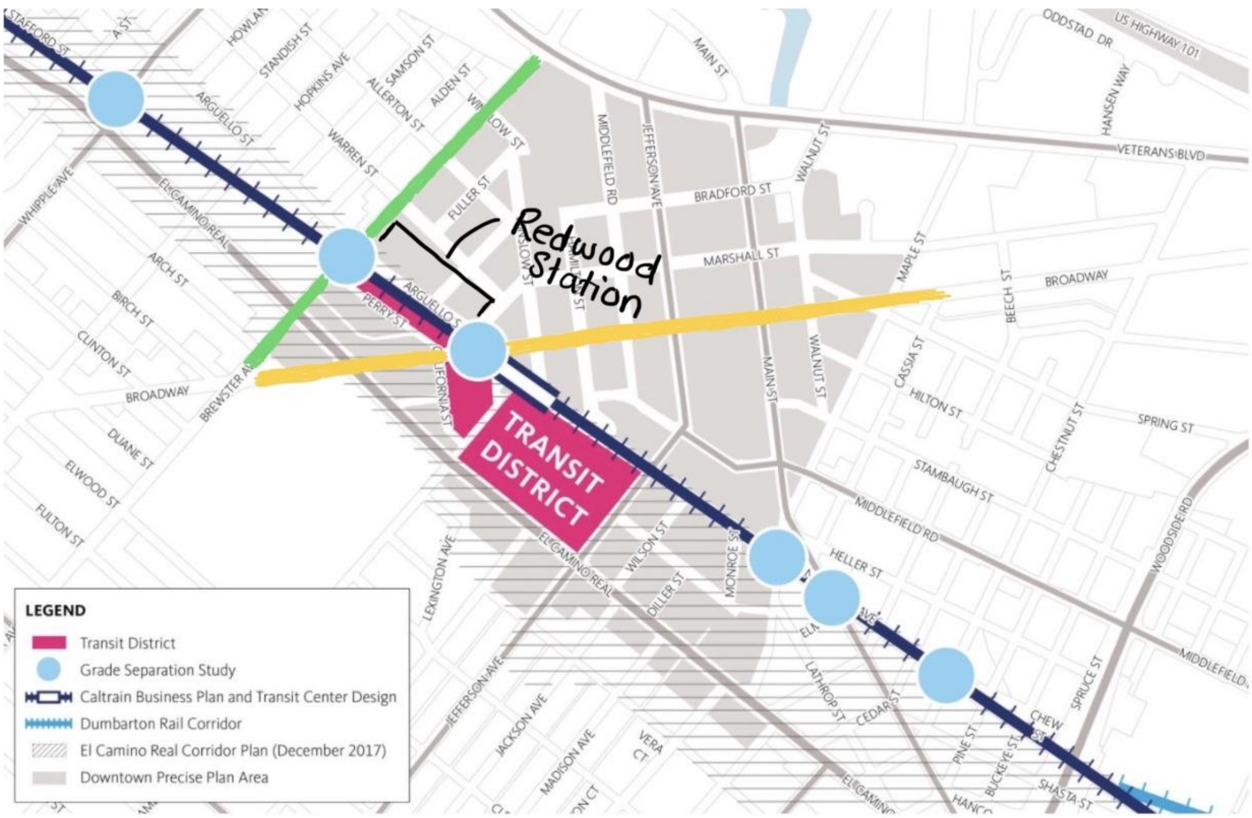


Figure 2.11. Redwood City Rail Station and its Surrounding Road Networks. Existing at-grade crossings are marked with a blue dot (Redwood City, 2020).

In all cases of separating grades, roadways underneath bridge structures with rails passing above need a 24-foot distance from the base of the road to the top of the rail. This ensures that cars have enough headway to pass under the bridge while also providing enough room for the physical steel bridge beam. Additionally, each scenario will include an elevated station containing four rails with central platforms (Redwood City, 2020).

The current planning proposals offer four different scenarios regarding the two streets directly adjacent to and crossing underneath the Redwood Station — Brewster Avenue (marked in green in Figure 2.11) to the north and Broadway (marked in yellow in Figure 2.11) to the south (Redwood City, 2020).

In the first suggestion, Brewster Avenue would remain at its current grade with the station being elevated to provide a 15’-6” clearance between the road and the underside of the bridge structure. The design also includes a bike/pedestrian ramp directly from the sidewalk within the tunnel up to the station above. Broadway would similarly remain at-grade and pass underneath the rails above with a 15’-6” clearance. A bike/pedestrian ramp with direct access to the sidewalk below in the tunnel is also included (Redwood City, 2020).

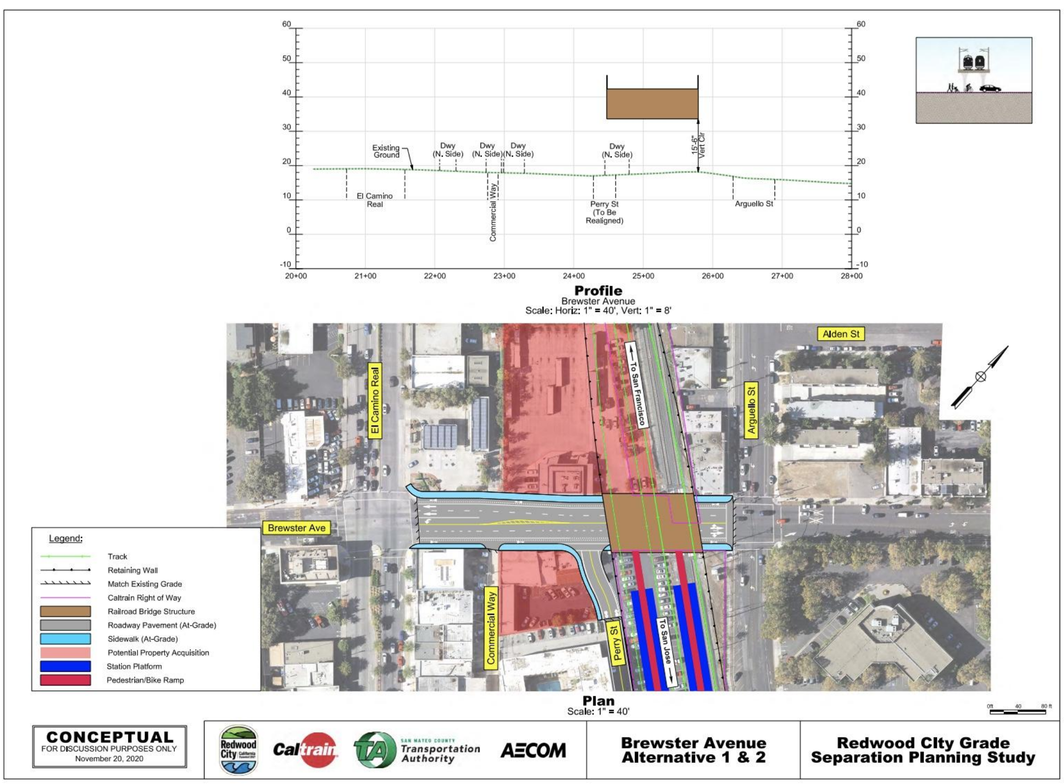


Figure 2.12. Changes to Brewster Avenue for Design Alternatives 1 and 2 (Redwood City, 2020)

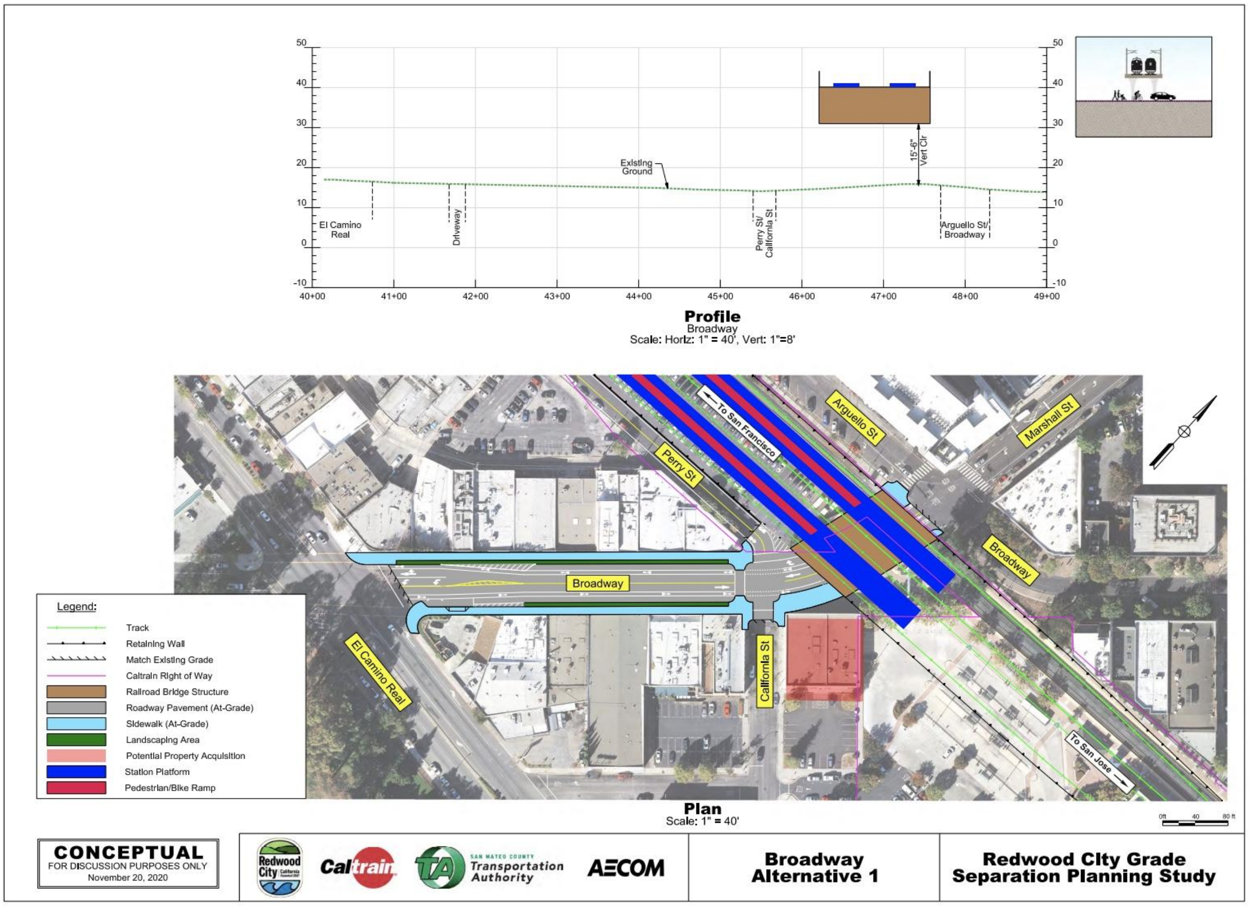


Figure 2.13. Changes to Broadway for Design Alternative 1 (Redwood City, 2020)

The second suggestion contains minimal changes for Brewster Avenue, with its only change being an increase in road clearance to 17'-1". Broadway would undergo much greater changes, consisting of moving Broadway and the intersection immediately next to the station slightly below its existing grade. An approximate four-foot vertical change in grade would take place at its most extreme points with a maximum of three percent grades connecting the roads from its new to existing grades. A 15'-6" clearance would be implemented at the Broadway crossing. The bike/pedestrian ramps at either street would be maintained (Redwood City, 2020).

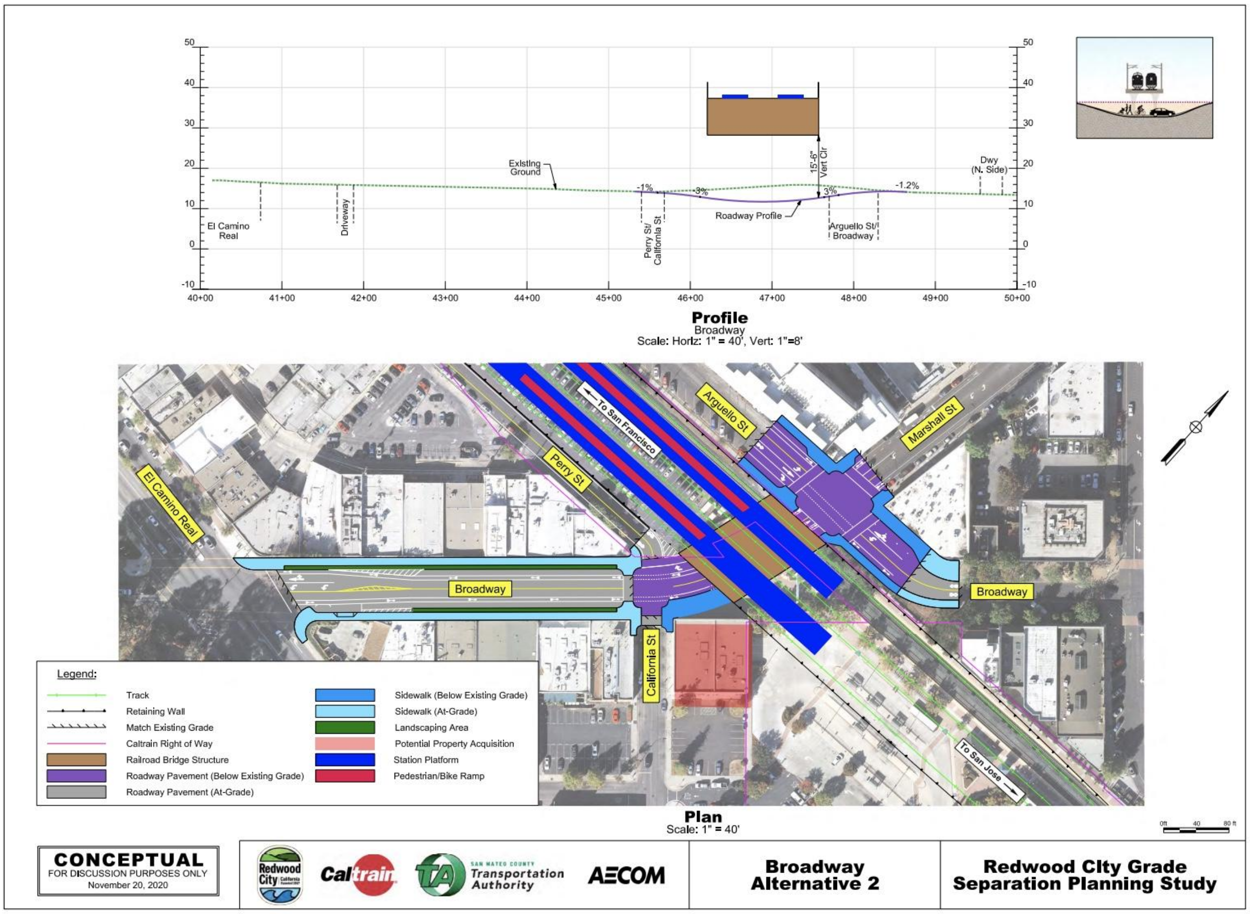


Figure 2.14. Changes to Broadway for Design Alternative 2 (Redwood City, 2020)

The third alternative suggests grade changes for Brewster Avenue but the complete elimination of the crossing at Broadway. Brewster Avenue would be moved below grade by approximately nine feet directly underneath the station. 6.5 percent grades (at the most extreme) would be used to bring the road from the existing grades below the station and back up to the other side. The bike/pedestrian ramps at Brewster Avenue would be maintained. Regarding Broadway, a landscaping planter would cut off the existing crossing underneath the station. Perry Street, which runs directly parallel to the station, as well as California Street, would serve as outlets to this newly shortened section of Broadway. New bike/pedestrian ramps would be built on either side of the rail tracks, which would connect to the sidewalks on the sides of the station (Redwood City, 2020).

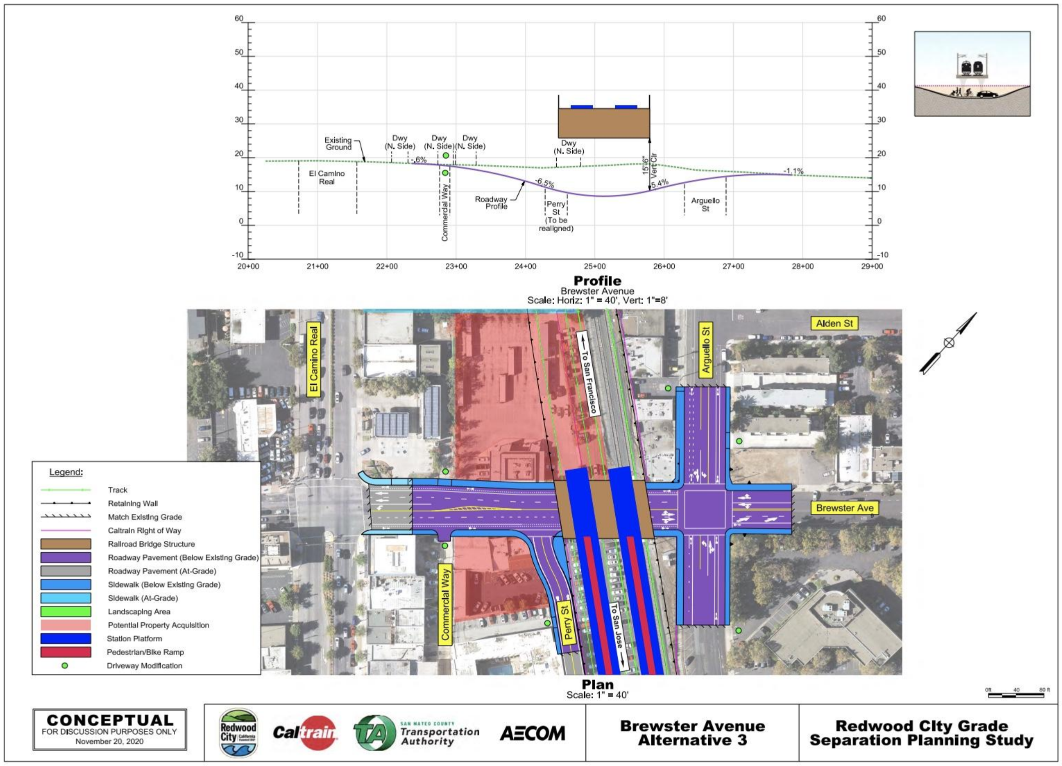


Figure 2.15. Changes to Brewster Avenue for Design Alternative 3 (Redwood City, 2020)

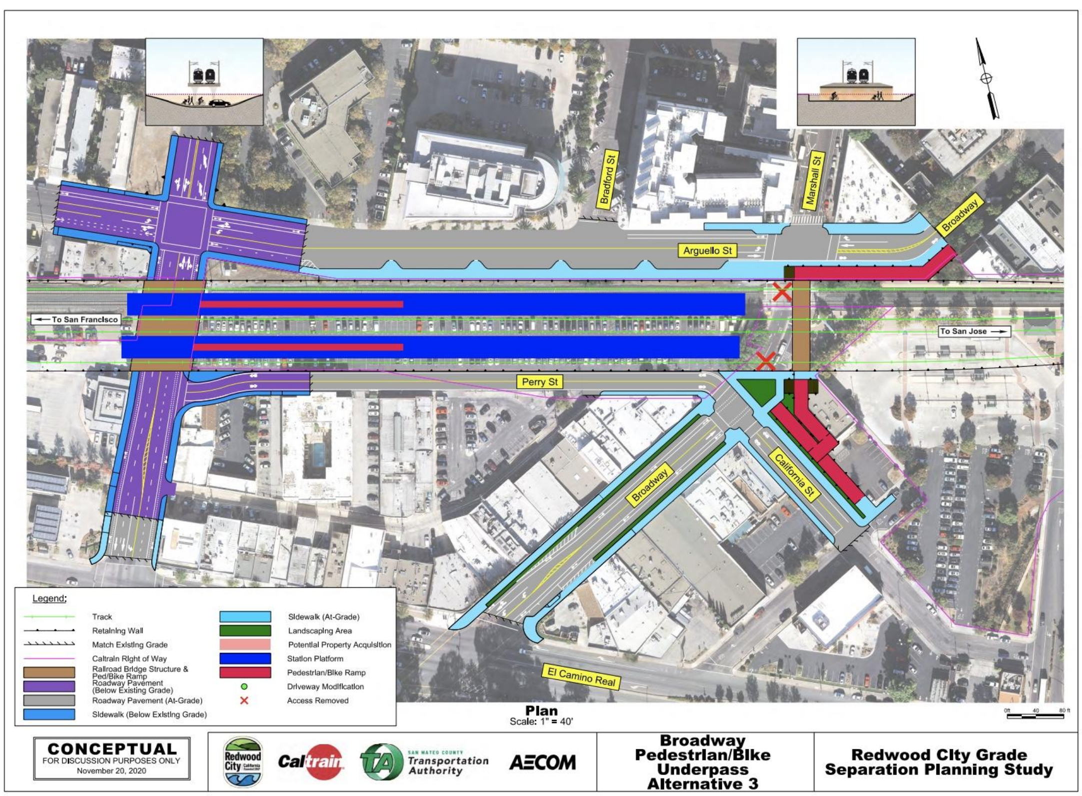


Figure 2.16. Changes to Broadway for Design Alternative 3 (Redwood City, 2020)

A separate variation of the third alternative would see the same grade changes to Brewster Avenue as described in the previous paragraph but would also include more extreme grade variations for Broadway, effectively keeping the underpass on that side of the station. A maximum of 8.5 percent grades would be used to connect the newly lowered Broadway approximately 16 feet below its existing grade. A 15’-6” clearance height would be maintained at the Broadway crossing. Additionally, the typical bike/pedestrian ramps that extend from the tunnel directly up to the station platform would be implemented (Redwood City, 2020).

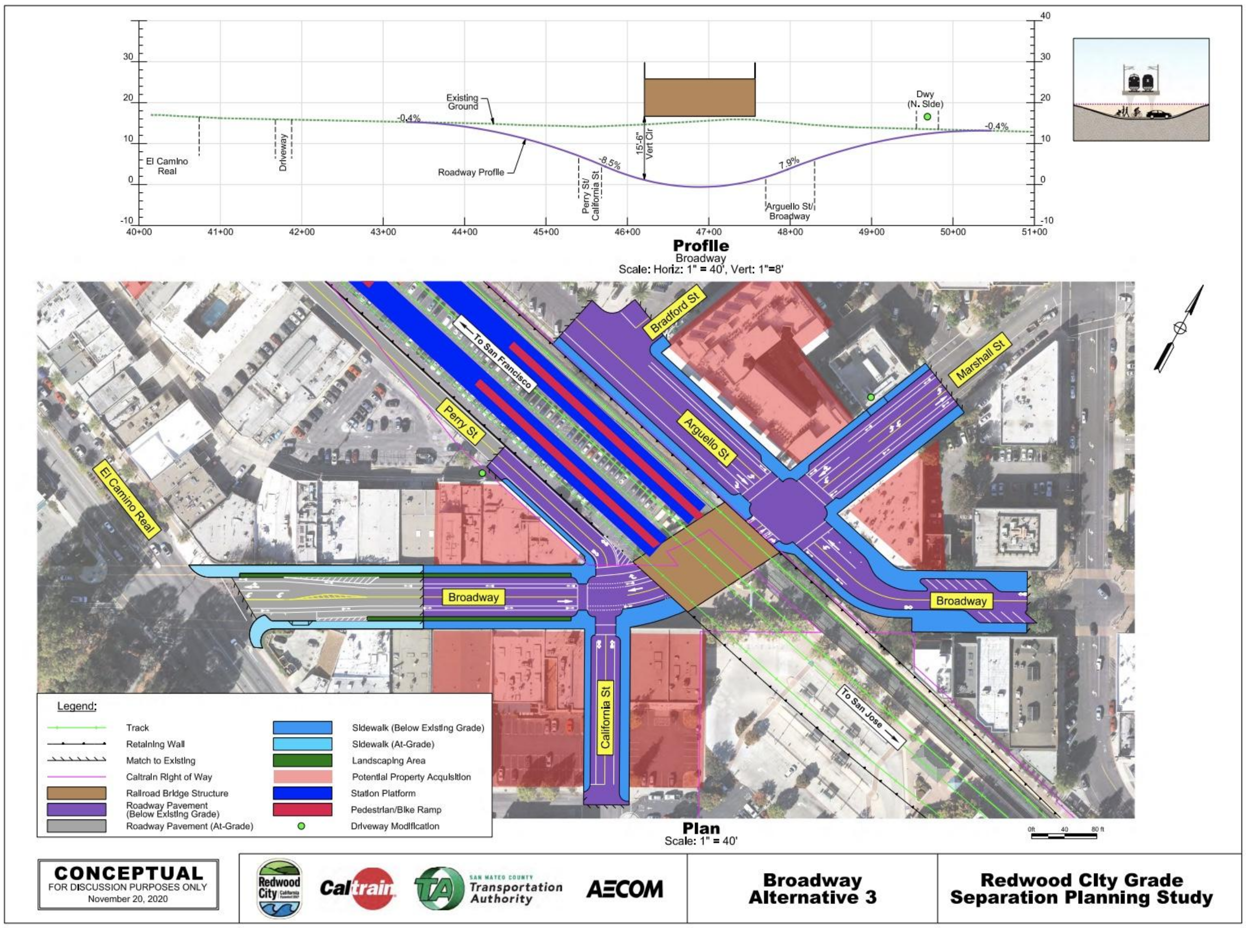


Figure 2.17. Changes to Broadway for a Different Variation of Design Alternative 3 (Redwood City, 2020).

The final proposed alternative would see the removal of both crossings. Both Brewster Avenue and Broadway would be diverted into one another via Perry Street. Additionally, bike/pedestrian paths would not be constructed at all.

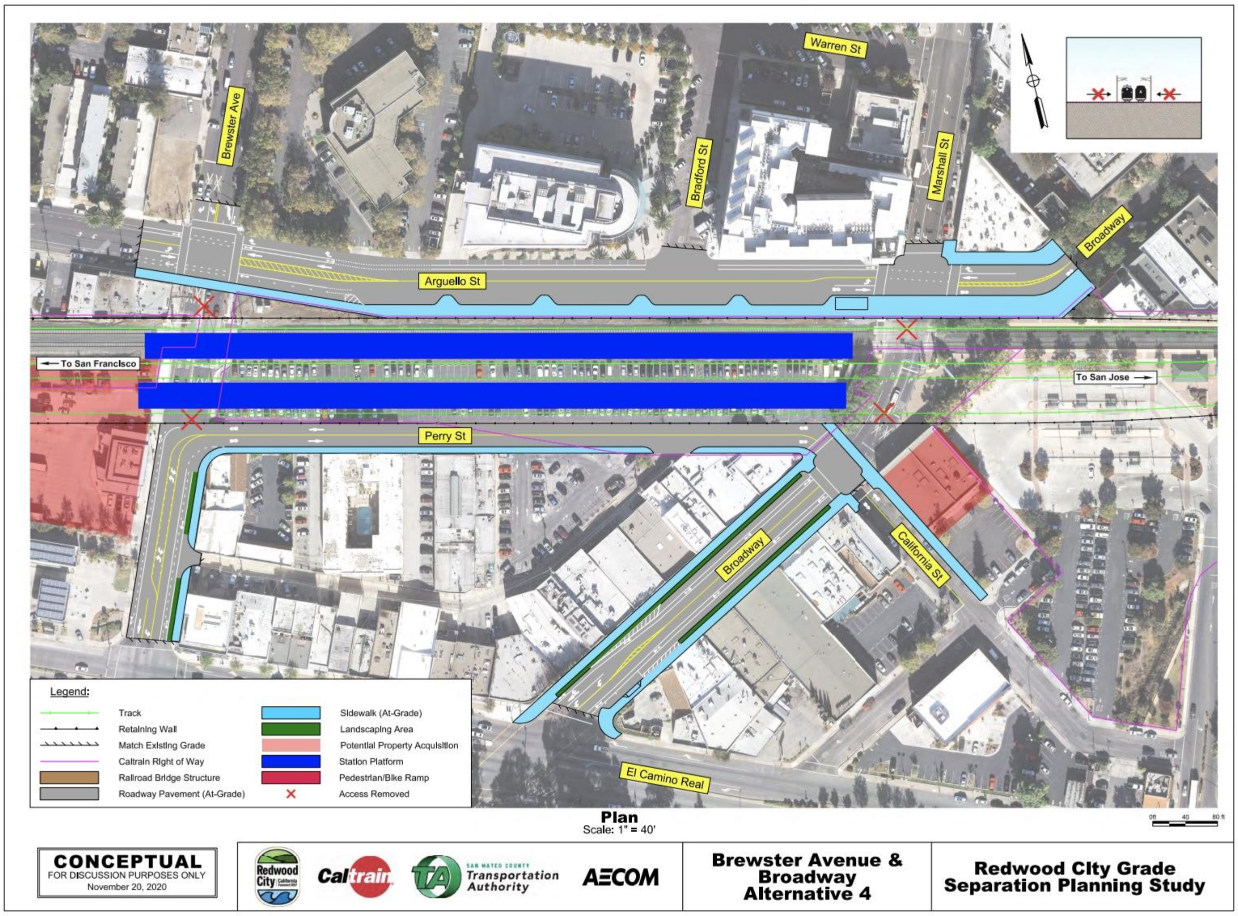


Figure 2.18. Changes to Broadway and Brewster Avenue for Design Alternative 4 (Redwood City, 2020).

In a blog post designated for discussion on the proposed alternatives of the Redwood City station in terms of its grade separation, a few key issues were highlighted. The thickness of the steel bridge beams was quickly pointed out as being excessive. A recently completed rail bridge crossing design in San Bruno, California utilized 5.5-foot bridge depths for an approximately 85-foot span — approximately 11 feet longer than the span proposed at Redwood City. The elevated Redwood City station is proposed to be built on an embankment. For each additional foot of bridge depth, an additional vertical foot of embankment must be added, effectively increasing costs and labor. The proposed 9-to-17-foot bridge depths for Redwood City are excessive, and therefore increase costs and labor (Clem, 2020).

An additional criticism of the Redwood City alternatives was specifically targeted at the fourth suggestion. This option removes both road crossings immediately adjacent to the station.

With no bike/pedestrian paths being built in this scenario, there is no clearly designed way for pedestrians or bicyclists to get to the top of the station (Clem, 2020).

2.10. Downtown Framingham 2009 Study

The 2009 Final Report of the Downtown Framingham Study by BETA Group, Inc. assessed land use and transportation in downtown Framingham, particularly the intersection of State Highways 135 and 126 next to the train station.

It is a notably car-centric study, with minor consideration of pedestrian and transit needs despite mentioning a "high volume of pedestrian activity." The study recommends an increase in car parking despite documenting low parking utilization, in part with extremely generalized parking requirement calculations that are not true for a dense urban environment such as downtown Framingham where people may not require cars. It assumes an increase in traffic volumes even though "traffic volumes have remained stable or even declined slightly" historically and assumes that any land use redevelopment will automatically increase traffic when a new development could be designed to prioritize pedestrian access. Additionally, the study does not consider that increasing parking leads to more driving and less walking in a self-fulfilling prophecy (Un, 2010).

However, with these caveats, the study has extremely detailed and useful information and insights, including traffic and parking counts. It includes the following data and analyses:

1. Land use in the area, including FAR (Floor-to-Area ratio calculations).
2. Underground utilities: electric, gas, telecommunication, water, storm drain and sewer near the railway station.
3. Number of parking spaces within downtown, classified by area, on-street, off-street and by ownership (town, public, or private).
4. Traffic volume forecasts (which appears to have flawed assumptions, as noted previously).
5. Level of service analyses, which assess car delay at intersections, including delays due to grade crossings with the rail line(s).
6. Areas of and parking demands for different land use types.
7. Key properties for redevelopment around the commuter rail station, including CSX-owned properties and key buildings to be retained beyond redevelopment.

8. Land use implication of the residential, cultural and mixed-use “Urban Design and Development strategies” around the train station, and how they would interact with various alternatives for grade-separating State Highways 135 and 126.
9. Existing utilization of area and long-term build-out calculations.

2.11. Framingham Master Plan 2020

As mentioned in *Chapter 2.6 An In-Depth Explanation of the Problem*, the Framingham Master Land Use Plan outlines the city’s vision for the future in all aspects. The document is updated constantly, the intent being to ensure that the municipality is provided with the most relevant guidance in all its future endeavors (“Framingham Master Plan”, 2020).

Within the guiding document, it states the vision for Framingham is to be “the heart of MetroWest Boston that is culturally vibrant and provides members of the community access to affordable and diverse housing options, educate opportunities for all, transportation that is efficient and easy to utilize, supportive of all businesses that choose to locate in Framingham, safe and attractive neighborhoods and villages, cultural and historical resources, and a community representing its people” (“Framingham Master Plan”, 2020). This vision the city has clearly does not just want good public transportation, but, rather, they are looking to make Framingham a more attractive place to live and visit. The city speaks about supporting all businesses in Framingham, and a great way to make those businesses flourish is to physically bring more people to the city. This is also justification for improving the rail service in Framingham; more access means more economical opportunity.

2.12. The Transportation Dividend

A 2018 study, known as the Transportation Dividend, analyzed the existing conditions of the MBTA rail system in Boston and discussed its impact on the local economy. A brief look at the study reveals that the rail network found within Boston (known colloquially as the T) has a substantially positive impact on the city’s economy. To put it into terms of a statistic, the MBTA’s annual operation provides the city with $11.4 billion in economic benefit, which is considerable when compared to its $2 billion operating budget. This figure was calculated based on what infrastructure, travel costs, and travel time increases would be required for all 1.3 million weekday MBTA users to successfully travel in and around Boston without the MBTA’s services. The MBTA has seen a 6.7 percent reduction in daily car trips, $640 million annually in vehicle crash savings, and $3.6 billion in savings annually in terms of travel costs, which is a result of decreased gas, tolls, car maintenance, and car insurance costs for T users. Boston is known nationally as one of the most congested cities and would be unable to function without the MBTA's services, specifically the T. The city is able to move so many people around the city because of the vast network of rails underground, which also allows the city to produce six times more GDP than the national average (Dimino et al., 2018).

Accessibility to the stations is also an extremely integral piece of why the T propels the city of Boston to such economic heights. Within Metropolitan Boston, 25 percent of the region's households and 37 percent of the region's jobs exist within a half-mile radius of one of the 268 rapid transit or commuter rail stations. Not only does this provide residents and employees with an extremely convenient alternative mode of transportation to vehicles, but it also increases property values, resulting in $160 million in additional property tax revenues (Dimino et al., 2018).

As the MBTA looks into the future, they have three main investment strategies they can choose from. First, the organization could look into spending $7.3 billion to bring the system up to a "State of Good Repair." This would provide much needed enhancements and efficiency improvements to the rail and bus networks. It is projected that $400 million in additional yearly revenue would be achieved from these modifications (Dimino et al., 2018).

Secondly, giving attention to the rail lines that see the most use within Boston would be considered a step above the previous spending strategy. The changes to these lines would see actual improvements over the existing infrastructure, not just fixing the line to operate at an acceptable level of performance. Such changes are already in the works, such as new fleets on the red and orange lines in addition to signal improvements and the construction of additional maintenance facilities. The orange line will see a 30 percent increase in service while the red line will see a 50 percent increase. The green and silver lines have been identified as the next rails that would need to see improvements made to the same degree as they are both traveled on frequently by passengers (Dimino et al., 2018).

The last spending method would see investment in various service enhancements that would transform the entire MBTA system. Creating infill stations (stations between two existing stations), reimagining the commuter rail, making bus transit more rapid, and utilizing ferries are a few of the many changes this spending method would bring (Dimino et al., 2018).

Overall, it is clear how impactful a successful transit system can have on a city in terms of use and economic implications. Rail is an important transportation method with real, far-reaching impacts on its surrounding community and economy.

Chapter 3: Methodology

The goal of this project was to design a more accessible station enabling the MBTA to provide increased service that will help revitalize downtown Framingham. We established three objectives to accomplish this goal:

1. Understand the existing scope of knowledge.
2. Collect and analyze data on existing infrastructure, usage, and stakeholder opinion.
3. Determine and evaluate design improvements for multiple alternatives.

3.1. Objective #1: Understand Existing Scope of Knowledge

The first objective for our team was to learn about downtown Framingham and the current train station as well as to identify various stakeholders invested in the project. This was a preliminary objective as it helped us determine the limitations of our project; it also gave us a better understanding of who would be involved with and affected by our project.

3.1.1. Identify Current Station Amenities

After visiting the Framingham Commuter Rail station in the beginning stages of the project, current amenities found at the station were identified and evaluated (such as types of platforms and existence of bike lockers), which gave us a better understanding of the capabilities of the existing station. This allowed us to identify certain amenities the station lacked, which better informed our potential design options, ensuring that the station would be more accessible to all riders. We also preliminarily analyzed the popularity of different modes of transportation used to get to the station.

3.1.2. Identify Potential Stakeholders

We identified all parties involved with and impacted by the Framingham station. Stakeholders include passengers, TransitMatters, the MBTA, CSX Transportation, the City of Framingham, and local business owners and residents. Reviewing the future plans laid out by the MBTA and TransitMatters were pivotal to understanding how the station can be designed to satisfy the future plans. This was critical in understanding our limitations of the project as well as determining the criteria for scoring. Creating a design that is not favorable to all stakeholders makes the implementation of the project less favorable.

3.2. Objective #2: Analyze Existing Infrastructure, Usage, and Stakeholder Opinion

This objective — collecting and analyzing data on existing infrastructure, usage, and stakeholder opinion — was crucial in evaluating the current problems with the Framingham train station and brainstorming design criteria to make worthwhile improvements that would greatly benefit the station. Evaluations regarding current accessibility to the station and utilization of the Framingham-Worcester line were a large part of our findings. Additionally, gathering stakeholder opinion was very helpful in further shaping the potential designs.

3.2.1. Analyze Walkability Maps

From a study conducted by MIT researchers, we analyzed walkability maps surrounding the Framingham and Natick Center Commuter Rail stations. These maps give insight into the perceived and actual half-mile walks from the commuter rail stations, giving an indication of how walkable the area surrounding the Framingham station is. We compared these two stations to see if there was a difference in walkability between a station located slightly outside the downtown area (Framingham) and a station located in the heart of downtown (Natick Center).

3.2.2. Identify Current Bike Infrastructure

We also analyzed the existing bike path infrastructure located near the downtown Framingham station. This included identifying the current bike paths in the area and analyzing the actual and perceived bike network surrounding the Framingham station (which originates from the same MIT study mentioned earlier). We also identified and analyzed future bike paths that are currently planned or proposed for the surrounding area. Through these analyses, we determined whether or not these paths are in the most ideal locations around Framingham.

3.2.3. Evaluate Current Bus Access Issues

Investigating the bus routes and bus timetables for the City of Framingham allowed us to determine how effective the routes and stops are as well as the timing and frequency of the buses in relation to the train station and train schedules. Looking at these aspects of Framingham, it gave us a sense of how effective buses are as a means of public transportation to and from the train station, which allowed us to make modifications to our design recommendations for the future.

3.2.4. Determine Vehicle Patterns in Downtown Framingham

We also utilized StreetLight Data, a software that receives 40 billion mobile device location records worldwide each month, to determine the most popular mode of transportation to the Framingham Commuter Rail station. In conjunction with parcel and road network data, travel patterns of various modes of transportation are extrapolated, providing context as to how people move in and around different geographic locations (StreetLight Data, 2022). The data obtained from StreetLight are shown to be very accurate. Among vehicular movements, the data from StreetLight have been compared to data from the over 6,000 permanent vehicle counters across the U.S., resulting in an R^2 value of 0.98 (StreetLight Data, 2022). Statistically, the closer the R^2 value is to 1.0, the less variation there is between the independent and dependent variable, which, in this case, is the physical counter data and StreetLight data, respectively. High R^2 values are also seen for pedestrian and bicycle data when compared to similar data collected by agencies in San Francisco, which is regarded as highly comprehensive and accurate (StreetLight Data, 2022).

These data helped us determine how vehicles, bicyclists, and pedestrians moved into and around the downtown area. More specifically, turning movement counts at both the Route 135-Route 126 and Route 135-Bishop Street intersections were analyzed. In addition, parking data obtained from this software, while not the most accurate, gave us an indication of parking habits and patterns in the downtown Framingham area. Based on analyses of these data, various improvements to the station were implemented in the design options to make all modes of transportation to the downtown area and the commuter rail station more favorable.

Additionally, pedestrian crash data obtained through MassDOT were also analyzed at the streets near the Framingham station as well as at streets near the Natick Center station. Between these two areas, data were compared to help highlight the negative impacts the at-grade crossings in downtown Framingham can have on vehicles and pedestrians near commuter rail stations.

3.2.5. Evaluate Passenger Utilization on the Framingham-Worcester Line

Average ridership data from the MBTA was analyzed and provided context to the patterns of travel to and from the Framingham Commuter Rail station, which also gave us insight into peak travel times. Additionally, the types of tickets that the MBTA sells for the commuter rail were researched, providing relevant background information to help explain current ridership values. These ticket prices and all costs associated with traveling by train were discussed and subsequently compared to the costs associated with driving a vehicle from Framingham to Boston during rush hour. These analyses played a role in designing the station for its current capacity and daily ridership trends as well as for its future (likely increased) ridership.

3.2.6. Collect Stakeholder Opinion

We were able to obtain community input in multiple ways: interviewing Framingham residents; talking to people familiar with downtown Framingham; speaking with the mayor of Framingham, Charlie Sisitsky; and holding a forum in Framingham to present the design options of our project to the general public. These conversations had a direct impact on the direction of the project, design options, and ultimately deciding the best design criteria to revitalize downtown Framingham.

3.3. Objective #3: Determine and Evaluate Design Alternatives

This objective was completed after the previous two were done because the information found from the first two objectives were used for decision making on the design criteria to improve the station itself and access to the station. After speaking with many professionals in the transit field and in Framingham, along with our own independent research, we had to make decisions on how to improve the station and downtown Framingham. As a result of different design options, multiple options for train frequency timetables were created. Additionally, we analyzed grade separation and determined the positive and negative attributes associated with it.

3.3.1. Analyze Grade Separation

Analyzing the possibility of grade separation was a massive part of our project. We looked into case studies of grade separated passenger rail for inspiration on our design options. Factors that influenced our grade separation possibilities at the Framingham station included: the option to grade separate passenger rail, freight rail, or both; the potential slope required to elevate the tracks to the desired grade-separated height; and the length of the grade separation.

3.3.2. Develop Potential Timetables

Using the Future Visions Report by the MBTA (MBTA, 2020a) and the TransitMatters Regional Rail Proof of Concept Study (TransitMatters, 2019), potential timetables were created to satisfy 15-minute frequency to stations along the line. These timetables align with the idea of adopting a fully electrified rail system. Timetables for two- and four-track systems were developed for on- and off-peak hours. We created multiple timetables that reflected our ridership research, with an emphasis being placed on how to best serve Framingham-based commuters and the inclusion of new lines that access more communities and job opportunities.

3.3.3. Evaluate Accessibility

After we performed our analyses of the existing conditions of the station (including current accessibility to the station), we evaluated design criteria at the station, as well as in downtown Framingham, that would provide the best accessibility for all riders. We looked at possible new connections to the station in areas that previously had poor walking and biking connections to the station. Evaluating how riders arrived at the station also helped us make decisions on which criteria would be the most helpful to improve other forms of transportation. In order to create multimodal forms of transportation, we evaluated the current bus connections to the station, and looked into the timing of the bus stops at the train station and the timing of the train schedule.

Chapter 4: Findings

We performed ArcGIS data analyses around the station, analyzed train station case studies, researched accessibility in downtown, and conducted interviews with transit professionals and Framingham residents to determine the best options for the station and downtown Framingham. We investigated walkability and biking around the city, the current bus schedule, traffic safety issues in downtown, ridership, cost and logistics of riding the train to work, grade separation, zoning ordinances, and timetables for the Framingham-Worcester line.

4.1. Walkability Networks

A study performed in 2020 by a group of MIT students investigated the difference between the actual and perceived half-mile walking distance surrounding various commuter rail stations throughout Massachusetts. The perceived half-mile walk is the distance from the station that a pedestrian would reasonably discern to be half of a mile. This is based on factors such as the amount of straight-line walking, the number of intersections that must be crossed, the type of environment in which they are walking, among many others. Depending on the location of the station, the half-mile perceived walking distance can be very similar to the actual half-mile walking distance or much different (Sevtsuk et al., 2020).

The walkability networks surrounding Framingham station and Natick Center station were both analyzed in an effort to allow for comparisons between the two stations that are very close to one another geographically and differ slightly in terms of the respective station locations.

4.1.1. Walkability Around the Framingham Station

There are a few geographical features nearby the Framingham Commuter Rail station that cause negative effects on its surrounding walkability network. For example, Farm Pond exists to the northwest, the CSX North Framingham yard lies just to the northeast, and high-traffic State Route 135 runs parallel just to the south of the station. At the station, there are two parking lots on both sides of the tracks and another one on the south side of Waverly Street. This creates a station that is designed for riders to park and ride, rather than walk or use another form of transport. All of these factors combined create a walkability network that is unideal.

Framingham train station has a dense population with many places of employment close by. As of 2010, there were 4,786 jobs and 3,850 people within a half-mile walk of the station (Sevtsuk et al., 2020). However, the MIT study shows that in Framingham, the perceived walkability to the station is very poor, which can be seen in Figure 4.1 below (Sevtsuk et al., 2020).

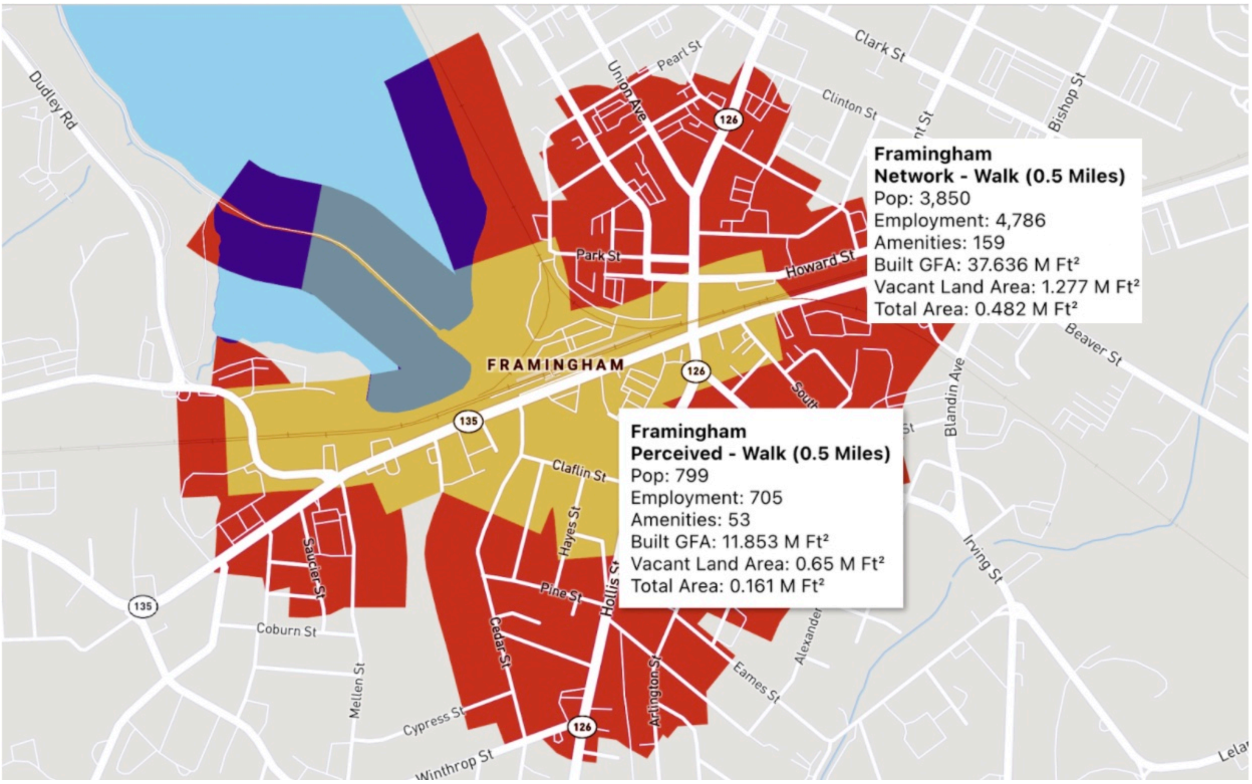


Figure 4.1. Framingham Walkability Map. Half-mile walk to the station is denoted by red and yellow, while perceived walkability is denoted solely by yellow. Statistics regarding the perceived and actual walk network are included (Sevtsuk et al., 2020).

The population in the perceived walk network is about 20.8 percent of the population in the half-mile walk network, and the employment encompasses 14.7 percent of the half-mile walk network jobs. The area of the perceived walk network is only 33.4 percent of the area of the actual half-mile walk network (Sevtsuk et al., 2020).

4.1.2. Walkability Around the Natick Station

As of 2010, there was a population of 3,542 people and 2,079 jobs within a half-mile walk to the Natick Center train station (Sevtsuk et al., 2020). According to the same MIT study mentioned in the previous section, the perceived half-mile walk network closely resembled the actual half-mile walk network (see Figure 4.2).

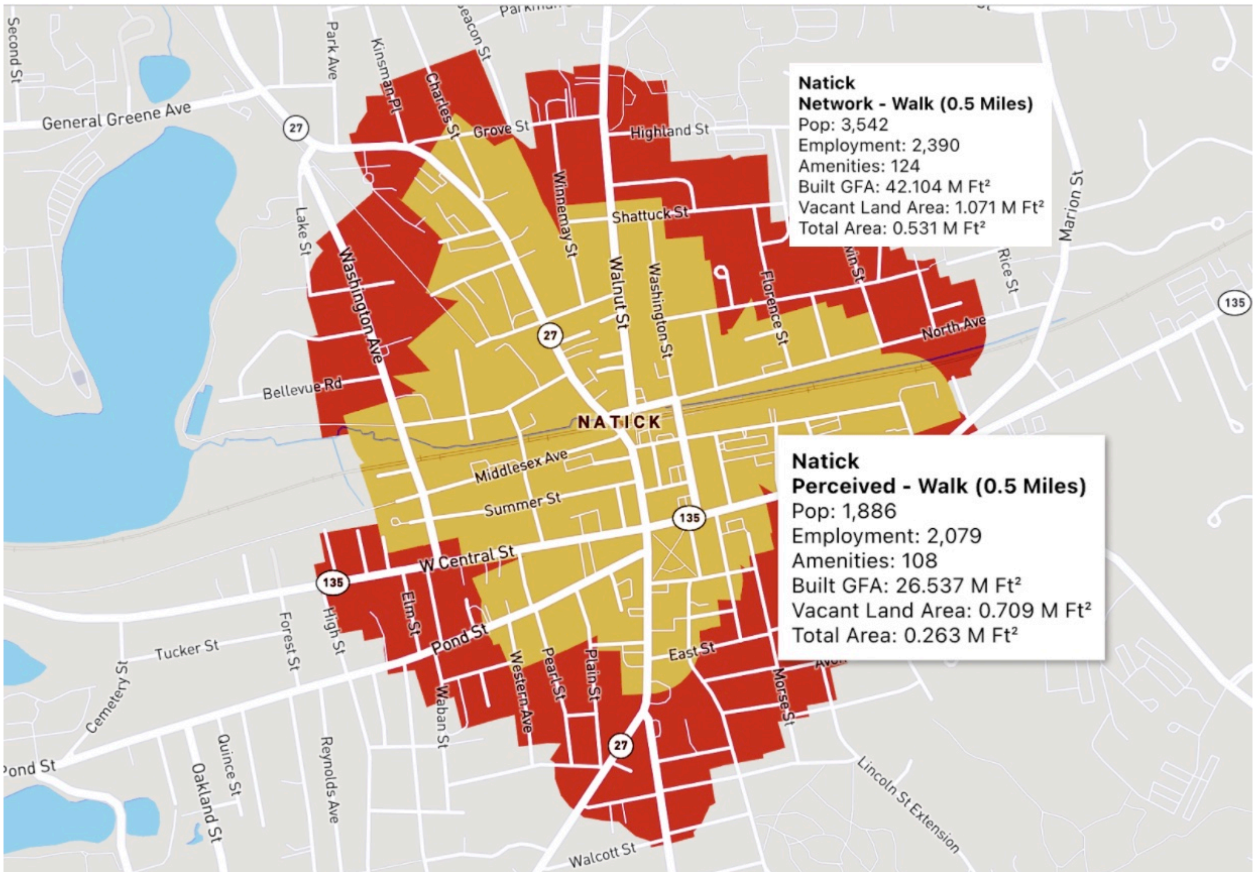


Figure 4.2. Natick Center Walkability Map. Half-mile walk to the station is denoted by red and yellow, while perceived walkability is denoted solely by yellow. Statistics regarding the perceived and actual walk network are included (Sevtsuk et al., 2020).

53.2 percent of the total population in the half-mile walk network exists in the actual half-mile walk network. Employment in the perceived walk network covers a larger portion; 87.0 percent of the jobs in the actual half-mile walk network exist in the perceived network. The area of the perceived walk network is approximately 50 percent of the total half-mile walk network (Sevtsuk et al., 2020).

4.1.3. Comparing Walkability Networks of Framingham and Natick

As seen in Figure 4.3 below, Framingham and Natick differ significantly in the portion of jobs, population, and area contained within the perceived half-mile walk network compared to the actual half-mile walk network. These statistics for Natick are higher in all three categories when compared to Framingham.

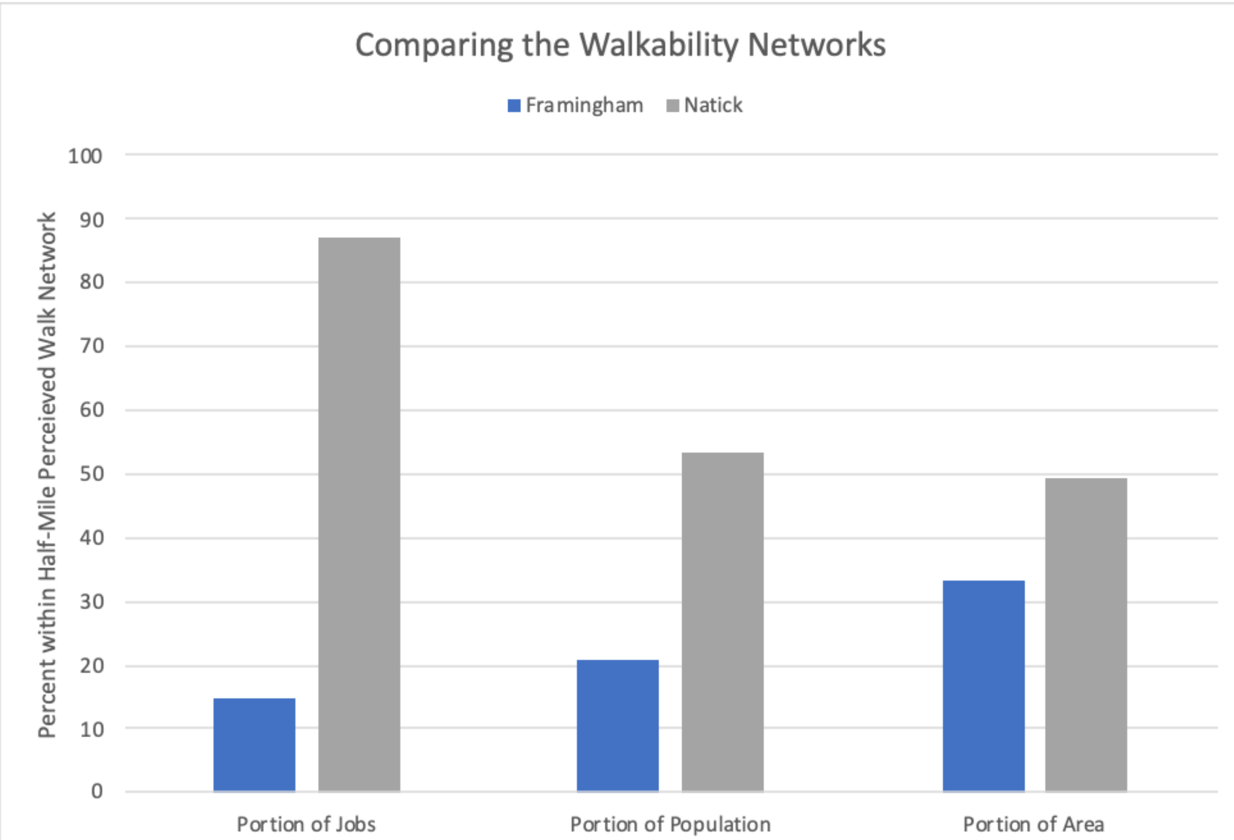


Figure 4.3. Comparing the Walkability Networks (Sevtsuk et al., 2020)

Like Framingham, Natick has Route 135 to the south; however, Natick has the added benefit of urban developments surrounding the station that provide a pleasant walk for commuters with fewer impediments to walking. The station at Natick is also below grade, so there are no grade crossings like the two found in Framingham. This allows for better flow of traffic in Natick, which is one less obstacle for pedestrians and bikers to worry about.

4.2. Bicycle Access

Framingham station itself has bike racks in the station and bike lockers in the north parking lot. Nearby the station, there are no separated or physically protected bicycle routes. These different types of bike lanes can be seen in Figure 4.4 below. A Class I bike lane is a separated pedestrian/bike usage path separated from the roadway. A Class II bike lane has a painted line in the roadway to signify bike-use only. A Class III bike lane is integrated with the roadway where bikes and traffic travel together. A Class IV bike lane is a bikeway separated from traffic for the exclusive use of bikes.

Figure 4.4. Bike Lane Classifications (Shearin, 2020)

The portion of Waverly Street (State Route 135) directly in front of the Framingham station has Class III bicycle lanes — painted markings within the roadway — but there is no larger bike network in downtown Framingham. Many side streets in the area do not experience a high volume of traffic, making it potentially accessible for bikers; however, the side streets do not reach the station and do not form a complete network on their own.

Building bicycle accommodations would be cheaper and faster than improving the bus system and creating the rail spur up toward Framingham State University (as discussed further in *Chapter 4.10. Potential Timetables for the Framingham-Worcester Line*). A separated bicycle lane network combined with bikeshare systems and high-quality bicycle parking would enable higher ridership on the trains and bring more people into Framingham's downtown without causing congestion (MassDOT, 2019).

Figure 4.5. BART Station Amenities (BART, 2021)

To encourage bicycle commutes, Bay Area Rapid Transit (BART) in California implemented bicycle accommodations — such as bikeshare, repair, rentals, and storage (both indoor and outdoor) — at their stations, as seen above in Figure 4.5. The bikeshare includes escooters, electric bikes, and bicycles specifically for people with disabilities (Rudick, 2019 & Bay Area, n.d.). These strategies would likely make bicycle commutes to Framingham station much easier, encouraging some residents to make the switch from driving, effectively decreasing congestion in the surrounding downtown area. Cargo bikes — which were found to deliver goods 60 percent faster than vans based on a study conducted in London — could also be implemented to decrease the congestion caused by delivery trucks (Aldred et al., 2021).

4.2.1. Bike Network Near Framingham Station

Looking at the Boston Transit Access report (Sevtsuk et al., 2020), riding a bicycle in Framingham offers access to more of the city (Figure 4.6). Around four times the number of jobs are within the 1.5-mile biking network than the half-mile walking network; over ten times more jobs are located in the perceived biking network than the perceived walking network (seen in *Chapter 4.1*). Notably, the biking network overlaps with that of West Natick.

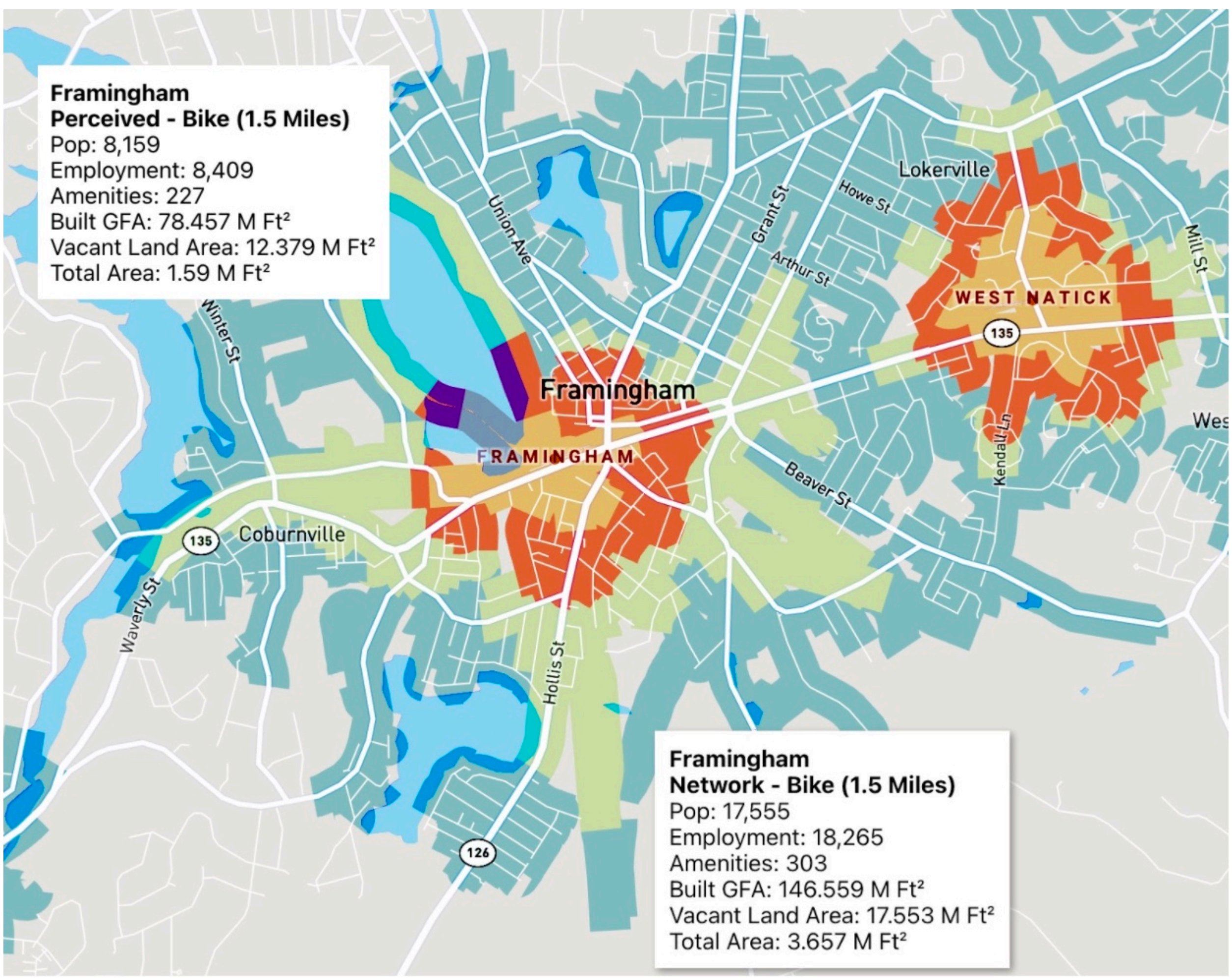


Figure 4.6. Walk Network (red), Perceived Bike Network (green), and Bike Network (cyan) in Framingham (Sevtsuk et al., 2020)

Compared to the perceived walk network, the perceived bike network encompasses 7,704 more jobs than the perceived walk network. It also has 7,360 more people living in the area than the perceived walk network (Sevtsuk et al., 2020). The actual 1.5-mile bike network almost doubles the population it encompasses compared to the perceived bike network, and it makes connections to surrounding towns, such as West Natick, possible (Figure 4.7).

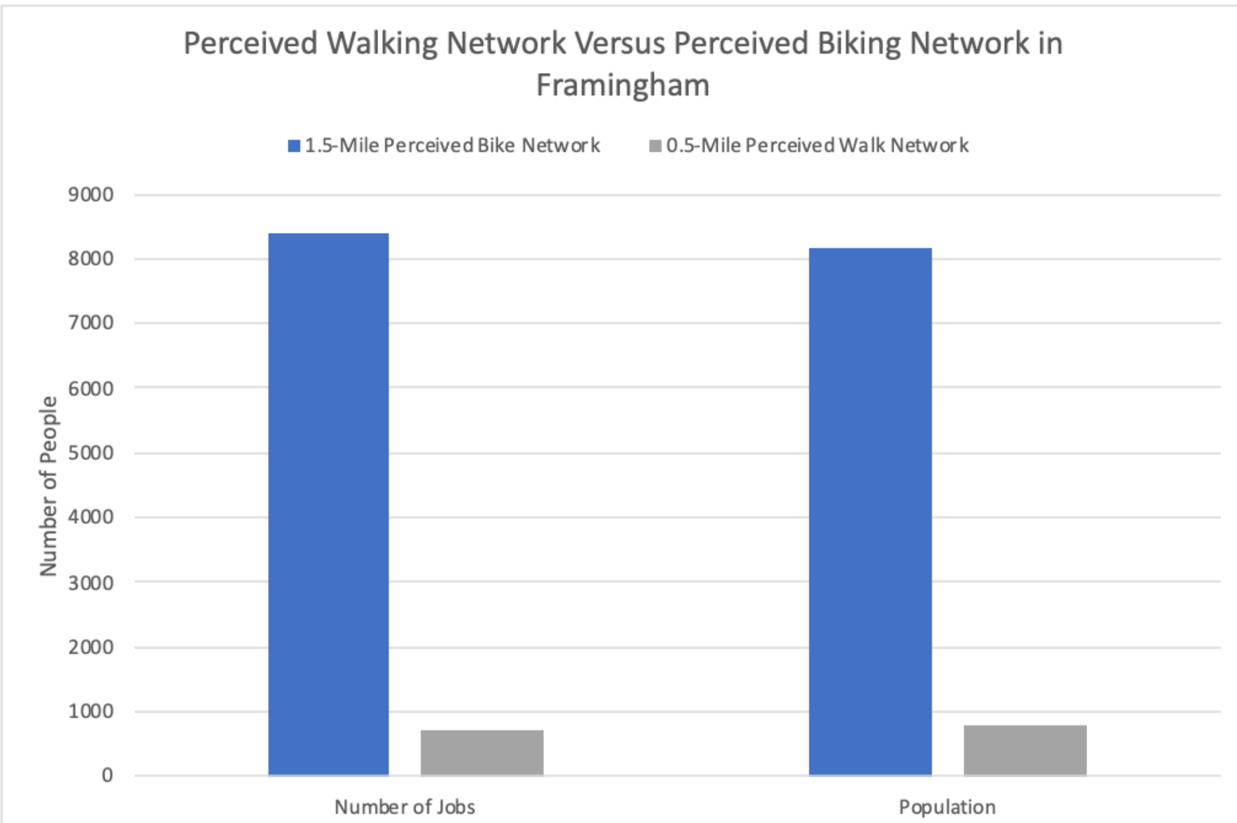


Figure 4.7. Perceived Walking Network Versus Perceived Biking Network in Framingham (Sevtsuk et al., 2020)

If the 1.5-mile bike network was made more accessible by bicycles, the opportunity for Framingham residents to commute to the station by bike would increase. Visitors and residents alike would also have another form of transportation to explore the city.

4.2.2. Future Bike Path Plans

There are plans to create recreational, separated (Class I) paths along some of the railway right-of-ways near the station. Along the tracks to the south and west, the Upper Charles Trail has been proposed, which details plans for a shared-use trail for walkers and bikers that extends 3.01 miles to the west and 1.61 miles to the south (geoDOT, 2021). The Bruce Freeman Trail, which is another shared-use trail, is planned to connect Framingham and Lowell. Though primarily recreational, both the Upper Charles and Bruce Freeman Trails can be integrated into the station design to provide comfortable walking and biking connections to the station, particularly from Central and North Framingham as well as Coburnville (which is west of Framingham).

There is also a shared-use trail planned that is proposed to travel northwest through Farm Pond and southeast, both along the Sudbury Aqueduct (Figure 4.8). Access to the northwest is currently blocked by a pump house on the path; from talking with individuals familiar with Framingham, there seems to be no plans or funding to build a boardwalk around it currently. Construction of the path on the aqueduct would be very beneficial to passengers who live on the other side of Farm Pond.

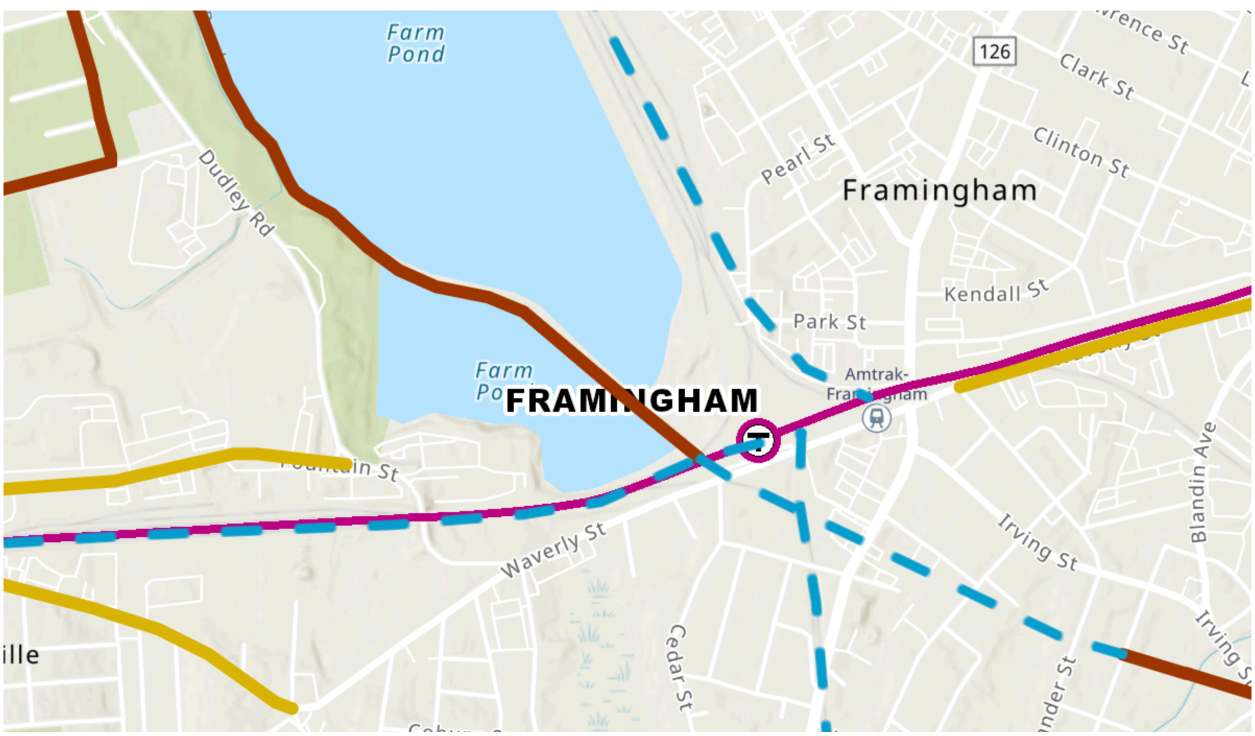


Figure 4.8. MassDOT Bicycle Facilities. Existing Class II (painted) bicycle lanes are yellow. Proposed Class I bicycle paths are shown with blue dashed lines, and existing Class I bicycle lanes are in red. Note: the map is incorrect. The Class I path through Farm Pond does not reach Framingham Station and there is no currently existing Class I path in the Southeast). The purple is the commuter rail line (geoDOT, 2021).

4.3. Bus Access Issues

The City of Framingham has a bus service that is operated by the MetroWest Regional Transit Authority (MWRTA). When looking at the map of MetroWest bus routes that travel in and around Framingham (Figure 4.9), riders can easily be confused. The map shows 15 different bus routes which overlap and are not placed on a geographically correct map, so it is unclear as to the destination of each route, the exact location of bus stops along the roads, the time taken for each journey, and the target community for the route.

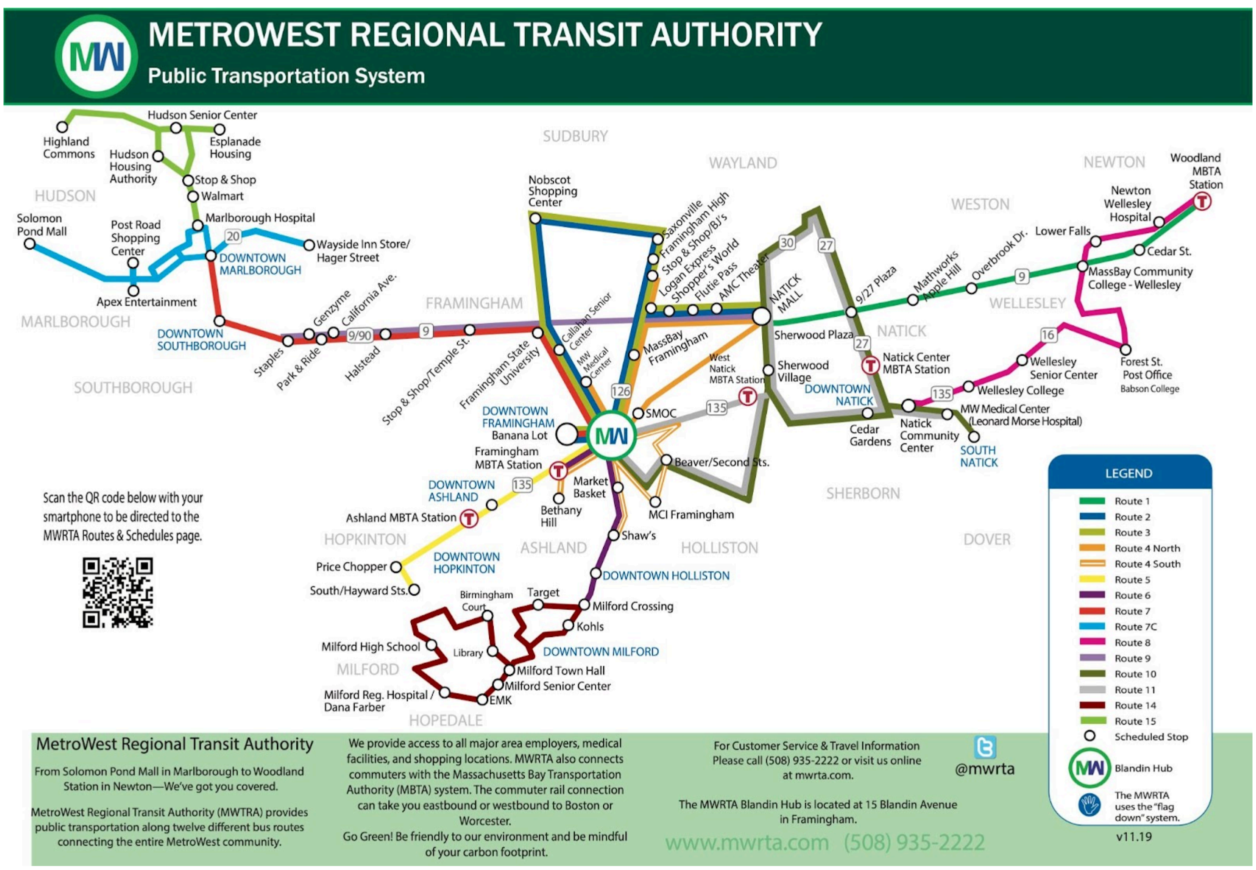


Figure 4.9. MWRTA System Map Depicting the Confusing Bus Routes (MWRTA, 2015)

Routes 4S, 5 and 6 serve the MBTA station to the south of the station; routes 2, 3 and 7 serve the parking lot to the north of the station. Of them, not one route has consistent and convenient times that correlate with the train schedule in Framingham (MWRTA, 2015). This alone immediately makes convenient transfers between the train station and the Blandin Hub — which is the bus hub in Framingham and is located just under a mile from the train station — impossible. The bus hub is about an 11-minute walk, seven-minute bus ride, five-minute bike ride, and four-minute drive to the train station (Google Maps, n.d.). The inconvenient scheduling is seen in Figures 4.10, which display the Framingham-to-Boston weekday morning schedule, and in Figure 4.11, which shows the weekday morning bus schedule for the 4S route which makes a stop at the station. Of the eight morning stops at the station, just three of them are within 15 minutes of a train going outbound to Boston (MWRTA, 2015).

Morning Schedule (AM)

Blandin Hub (15 Blandin Ave.)	6:10	6:52	7:35	8:17	9:00	9:45	10:30	11:15
MCI Framingham	6:13	6:55	7:38	8:20	9:03	9:48	10:33	11:18
Beaver/Second Sts.	6:18	7:00	7:43	8:26	9:08	9:53	10:38	11:23
Waverly St. (at N+1 Cyclery)	6:20	7:02	7:45	8:28	9:10	9:55	10:40	11:25
Framingham Commuter Rail Station	6:25	7:07	7:50	8:33	9:16	10:00	10:45	11:30
Bethany Hill*	6:30	7:12	7:55	8:37	9:21	10:05	10:50	11:35
Memorial House	6:33	7:15	7:58	8:40	9:24	10:08	10:53	11:38
Market Basket	6:38	7:20	8:02	8:44	9:28	10:12	10:57	11:42
Shaw's Supermarket	6:41	7:23	8:06	8:47	9:32	10:16	11:01	11:46
Waushakum/Arlington Sts.	6:46	7:28	8:11	8:53	9:37	10:21	11:06	11:51
Blandin Hub (15 Blandin Ave.)	6:49	7:31	8:14	8:56	9:40	10:25	11:10	11:55

Figure 4.10. Weekday Morning Bus Schedule for the 4S Route (MWRTA, 2015).

Daily Schedule

Weekday schedule (modified service) (now)

FIRST TRIP 04:55 AM LAST TRIP 11:00 PM

Departs	Train	Destination	Trip Details
04:55 AM	500	South Station	
05:40 AM	502	South Station	
06:40 AM	504	South Station	
07:40 AM	506	South Station	
08:40 AM	508	South Station	
09:40 AM	510	South Station	
10:40 AM	512	South Station	
11:40 AM	514	South Station	

Figure 4.11. Weekday Morning Train Schedule for Framingham to Boston (MBTA, n.d. b)

The focus of this project is centered on the train station, rather than the rerouting of bus services and their schedules, so significant resources were not spent doing so. It is recognized, however, that an easy-to-use bus service is essential for train riders, so the revitalization of the Framingham bus service should be prioritized if improvements are made to the commuter rail station. This will require better coordination between the train and bus schedules to allow Framingham residents easier access to the station and to not have to wait upwards of 50 minutes (in some cases) to get on the train after taking the bus.

One consideration that could be made regarding improvement to the bus services is relocating the Blandin Hub closer to the station. Rather than having large parking lots around the station, some of this space could be used for the bus hub, in turn creating a multimodal transportation hub between the train station and the newly located bus hub. With this setup, the MWRTA could schedule stops in conjunction with the train schedule, which would allow bus riders to easily get to the station and have minimal waiting time for the train.

The newly located hub could also serve large businesses throughout Framingham, such as TJX, Bose, and Staples. More frequent bus service to these large businesses could provide a boost in rail ridership, providing ease of transportation to employees of these companies. Increased bus service could also serve as a substitute for a rail spur directed toward Framingham State University and northern parts of Framingham (as discussed further in *Chapter 4.9. Potential Timetables for the Framingham-Worcester Line*), which would be less costly than the construction fees required for this new spur.

4.4. Turning Movement Counts

As discussed in *Chapter 2.6. An In-Depth Explanation of the Problem*, there are two intersections that exist at-grade near the Framingham Commuter Rail station: the Route 135-Route 126 intersection and the Route 135-Bishop Street intersection. Turning movement counts — which is the determination of how many cars are making movements through an intersection during a specific window of time — were conducted at both intersections. This was done using the StreetLight Data portal (as discussed further in *Chapter 3.2.4. Determining Vehicle Patterns in Downtown Framingham*), which utilizes GPS locations of mobile devices to determine movements of pedestrians, cars, and other modes of transportation (StreetLight Data, 2022).

The average peak hours during weekday mornings and afternoons (as of 2019) were focused on as these would be the times where traffic is likely the densest. Based on the calculated data from StreetLight, the peak hours were 7:00 a.m. to 8:00 a.m. and 4:45 p.m. to 5:45 p.m. (StreetLight Data, 2022). It is important to note that the most important figures from each of these traffic movement counts is the amount of traffic passing through the northern leg of the intersection, as this is the part of both intersections where the commuter railroad crosses the roadway. For the Route 135-126 intersection, the westbound volumes are also important as the southern freight rail spur crosses through Route 135.

For the morning weekday commute at the Route 135-Route 126 intersection, 3,822 vehicles passed through during the one-hour window. 642 vehicles entered the intersection from the north, while 1,240 vehicles exited onto Route 126 north. In sum, 1,882 vehicles (25 percent) passed through the at-grade intersection with the railroad. During this same morning period, 1,559 vehicles entered the intersection from the westbound section while 620 vehicles exited. 2,179 vehicles crossed over the freight rail at-grade crossing, which accounts for 28.5 percent of the intersection's total morning peak hour traffic. The afternoon peak hour saw slightly higher figures. 1,155 vehicles entered the intersection while 1,012 vehicles exited the intersection from the northern part of Route 126; this totals to 2,167 vehicles passing over the rails or 25.6 percent of the traffic during this time period. The afternoon peak hour commute saw 579 vehicles enter and 1,756 vehicles exit from the westbound direction. 27.6 percent of the afternoon peak hour traffic enters or exits from this direction or 2,335 vehicles (Figure 4.12).

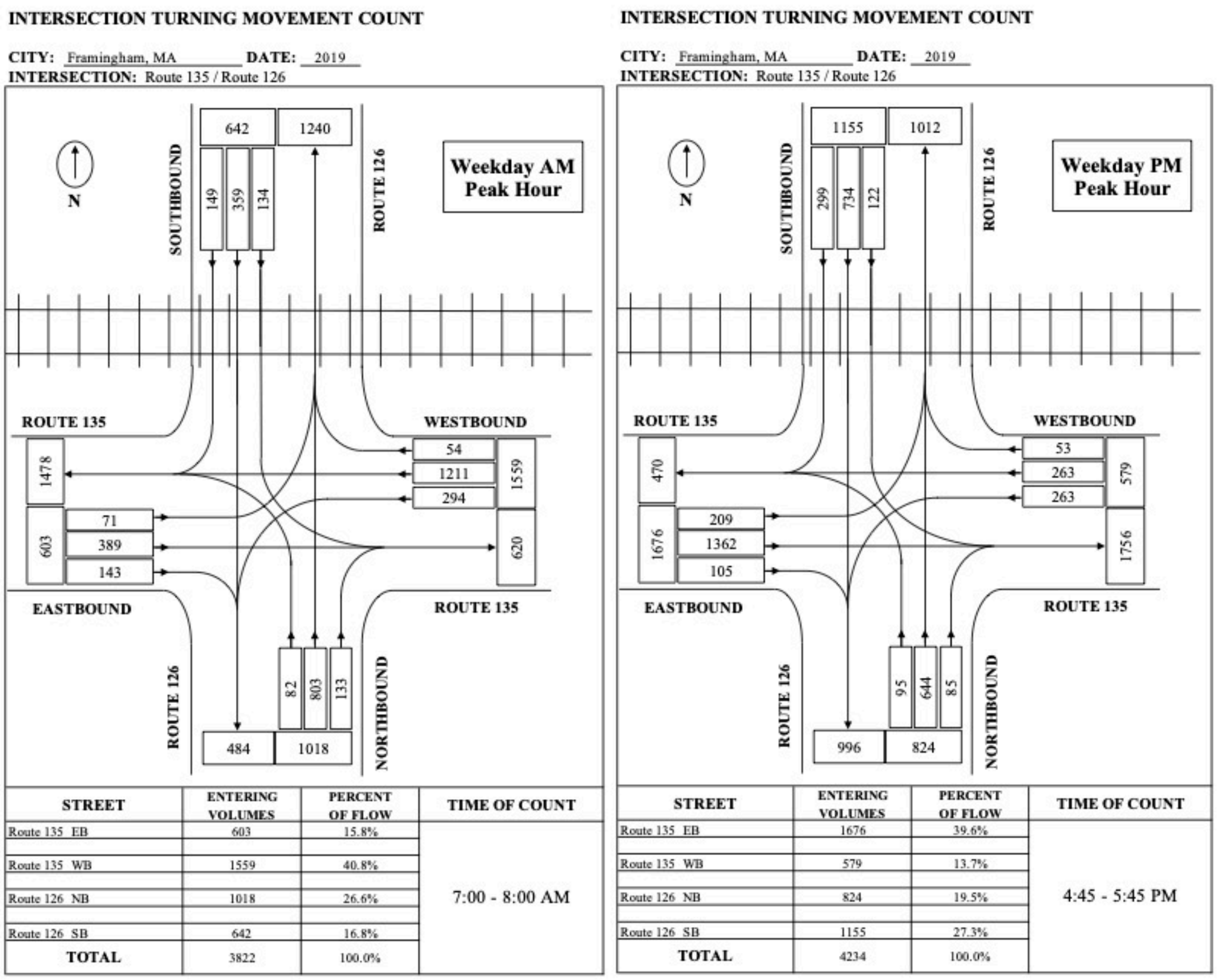


Figure 4.12. Route 135-Route 126 Intersection Turning Movement Counts. Counts are included for the morning and afternoon weekday peak hours (StreetLight Data, 2022).

At the Route 135-Bishop St. intersection during the morning peak hour commute, 3,623 vehicles passed through. 667 vehicles entered from the northern part of the street crossings while 1,155 vehicles exited. 1,822 total vehicles passed over the at-grade railroad, which accounts for 25.1 percent of the total traffic passing through the intersection during this hour. In the afternoon, 3,969 vehicles passed through, which is slightly higher compared to the morning hour. 1,076 vehicles entered the intersection while 929 vehicles exited from the northern portion, which totals to 2,005 vehicles (or 25.3 percent of the total traffic during this hour) passing through this part of the intersection (Figure 4.13).

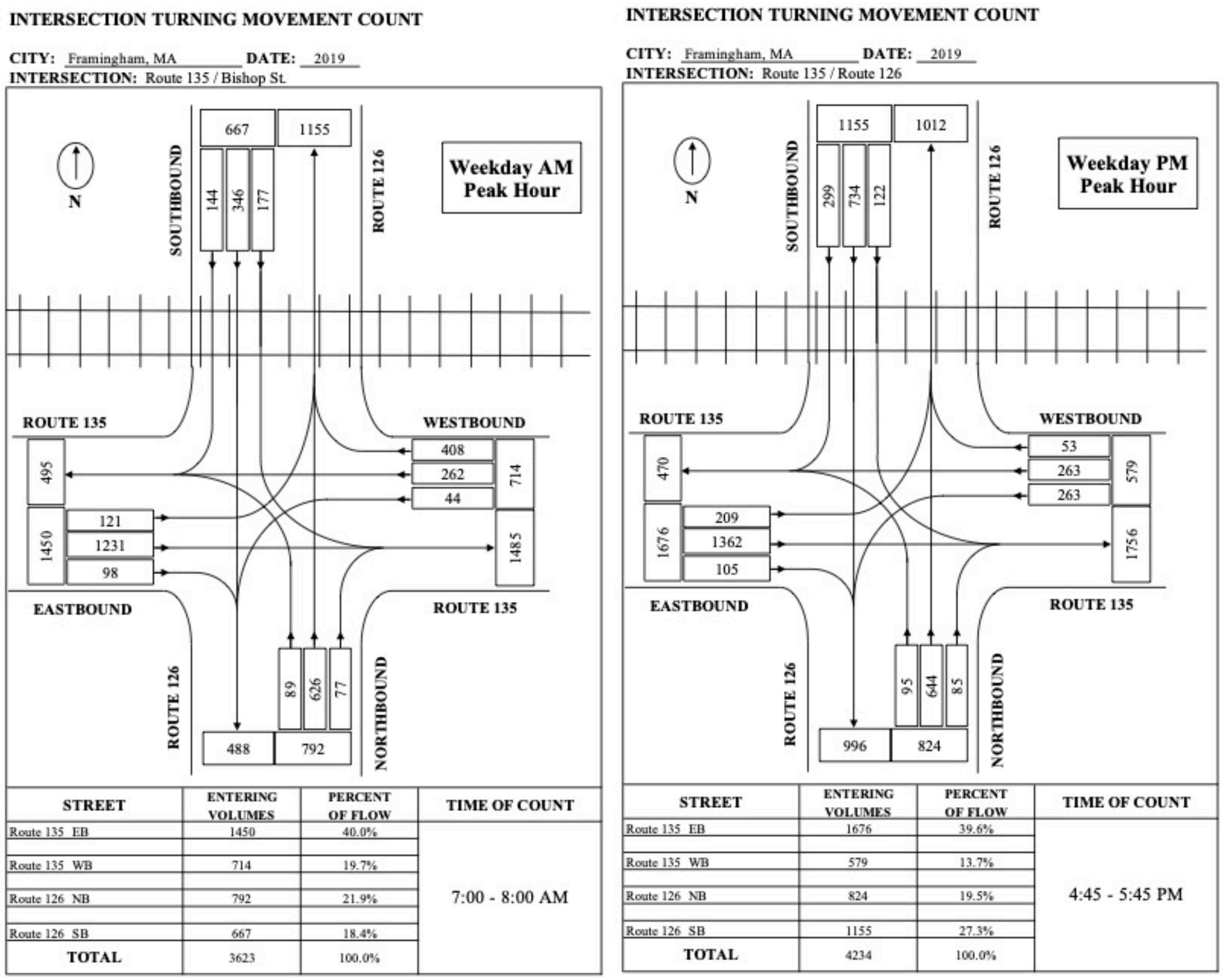


Figure 4.13. Route 135-Bishop Street Intersection Turning Movement Counts. Counts are included for the morning and afternoon weekday peak hours (StreetLight Data, 2022).

During the morning peak time from 6:30 a.m. to 8:45 a.m. (see Figure 4.25 in *Chapter 4.8. Average Ridership Values*) when ridership is highest for the train in Framingham (above 80 passengers boarding the train), the crossing guards go down at both intersections 11 times total, or 11 minutes of vehicular traffic being halted. When we visited the station, we timed the duration of the crossing guards blocking the roadways while trains passed through, which was found to be 60 seconds per train. The nighttime peak hours of 5:00 p.m. to 6:45 p.m. (which was calculated from Figure 4.26 in *Chapter 4.8. Average Ridership Values* when 80 or more passengers were deboarding the train) see 10 trains pass through, causing a delay of 10 total minutes during this timeframe. These intersections are interrupted often during these peak times, which causes a lot of congestion in downtown Framingham for drivers. With increased service likely to come in the future, this issue will only become worse.

4.5. Parking Study

Parking figures within the downtown Framingham area were also gathered through StreetLight Data portal. As mentioned in *Chapter 4.4. Turning Movement Counts*, this program utilizes GPS locations of mobile devices to determine movements of pedestrians, cars, and other modes of transportation (StreetLight Data, 2022). Specifically for the parking analysis conducted below, data collected from 2019 was averaged by each hour of the day.

To calculate the number of cars that were newly parked in downtown Framingham during any given hour, the number of cars exiting the downtown Framingham area during that period of time was subtracted from the number of cars entering the same geographical area during the same timeframe. The cumulative number of parked cars each hour on any given day was calculated to illustrate the total number of parked cars present in downtown Framingham during that given hour.

It is important to note that in Figure 4.14 and Figure 4.15, the number of parked cars do not "balance out." It can be seen in all the counts that the number of parked cars at the start of the 24-hour period is not equal to the number at the end. This is likely due to the number of parked cars for each individual hour being averaged from an entire year's worth of data, which will cause discrepancies when compiled into a single 24-hour cycle. This includes ending the 24-hour cycle with a negative number of parked cars. With this duly noted, it is important to view these graphs not too meticulously and to instead observe the general trends illustrated by the data.

In downtown Framingham, parking is very prominent with many people parking their car near their residences or their places of work. Throughout the day, the number of cars parked in the downtown area fluctuates, as shown in Figure 4.14.

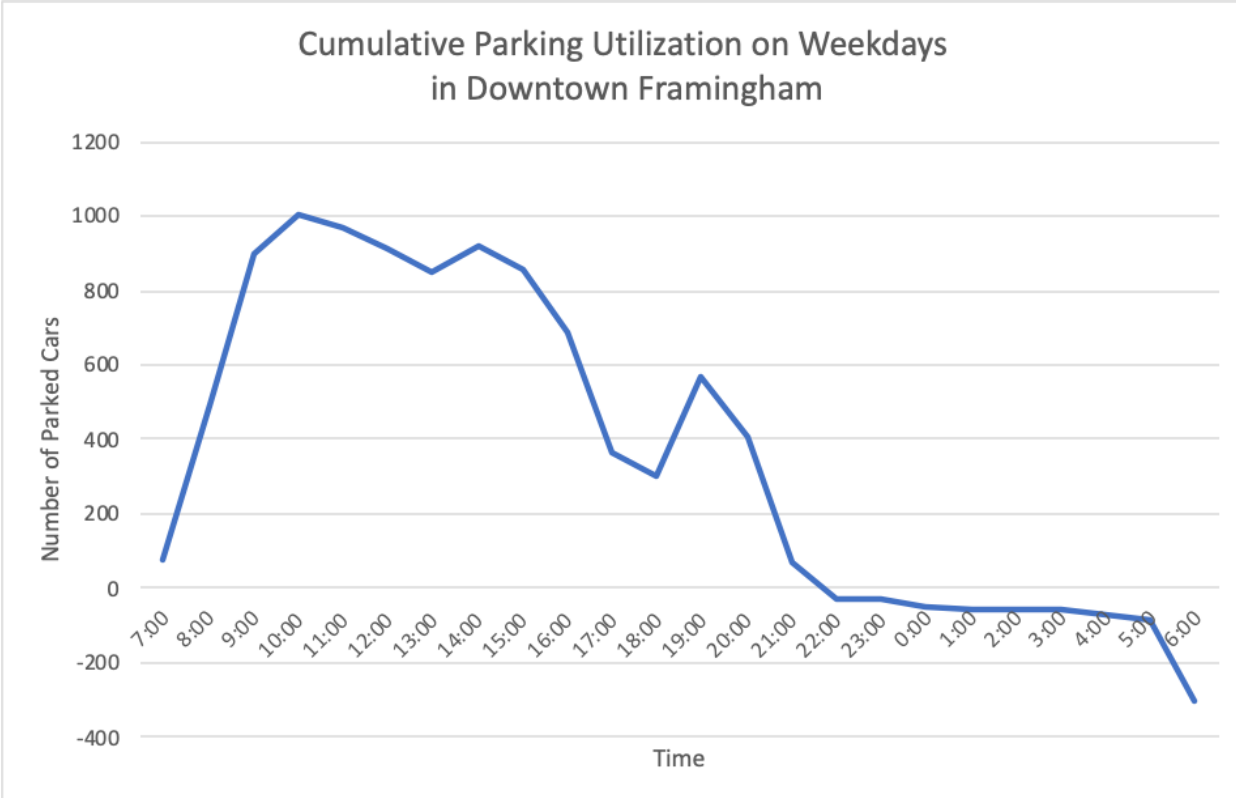


Figure 4.14. Cumulative Weekday Parking Utilization Estimates in Downtown Framingham

As shown above, 7:00 a.m. was the first hour of the day on a typical weekday that the total number of cars entering the area was greater than the number of cars exiting, indicating an increase in the total number of parked cars. The total number of parked cars in the downtown Framingham area peaked during the 10:00 a.m. hour with 1,004 cars. As the day wears on, the number of parked cars in the area decreases; a small increase in the number of parked cars is apparent among the 6:00 p.m. and 7:00 p.m. hours.

As seen below in Figure 4.15, the patterns for average downtown Framingham parking on Saturdays and Sundays is much different compared to that of the weekdays. 7:00 a.m., just like above, was the first hour after midnight of the 24-hour cycle where the total number of cars entering the downtown area exceeded the number of cars exiting. A peak of 1,134 cars is evidenced at the 10:00 a.m. hour, which is slightly higher than the weekday figures. Dissimilar to the weekday patterns, downtown Framingham parking experiences a large drop in parked cars between 1:00 p.m. and 5:00 p.m. whereas the weekday pattern, for the most part, stays consistent after the peak hour early in the morning. Both day patterns see a smaller secondary peak at 7:00 p.m. followed by a steady drop into the late-night and early-morning hours.

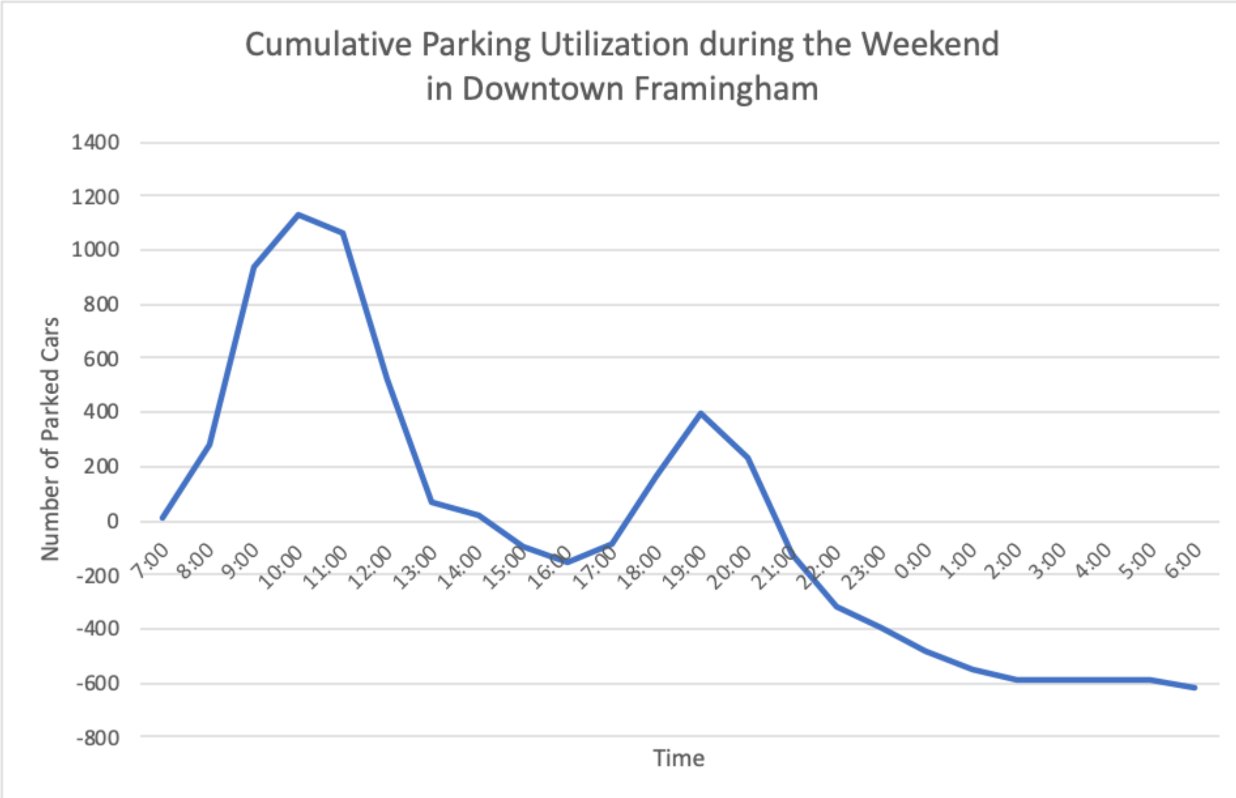


Figure 4.15. Cumulative Weekend Parking Utilization Estimates in Downtown Framingham

The parking figures displayed above may not be entirely accurate. The average parking counts determined for downtown Framingham appear to be underestimated. As stated earlier in this section, the main takeaway from these analyses is to get a sense of parking behaviors in these two locations, not necessarily paying close attention to the parking numbers themselves.

4.5. Traffic Safety Analysis

Analyzing crash data is important to understanding how traffic conditions are in a given location. MassDOT collects data annually regarding the number of vehicle, pedestrian, and bicycle crashes, as seen in *Chapters 4.6.1 and 4.6.2* below. The crash data for downtown Framingham as well as nearby the Natick Center station were both analyzed. This was done to allow for comparisons between the two stations as well as determine the severity of crashes in relation to a similar station since they are located two stops from each other on the Framingham-Worcester line.

4.6.1. Crash Data in Downtown Framingham

Downtown Framingham has multiple locations where there is high crash volume (Figure 4.16). On the most recently published MassDOT Top Crash Location Report (2017 data), Framingham had three of its intersections on the top 200 intersections list. One of these intersections was the Waverly Street and Bishop Street intersection, which also has the train passing through.

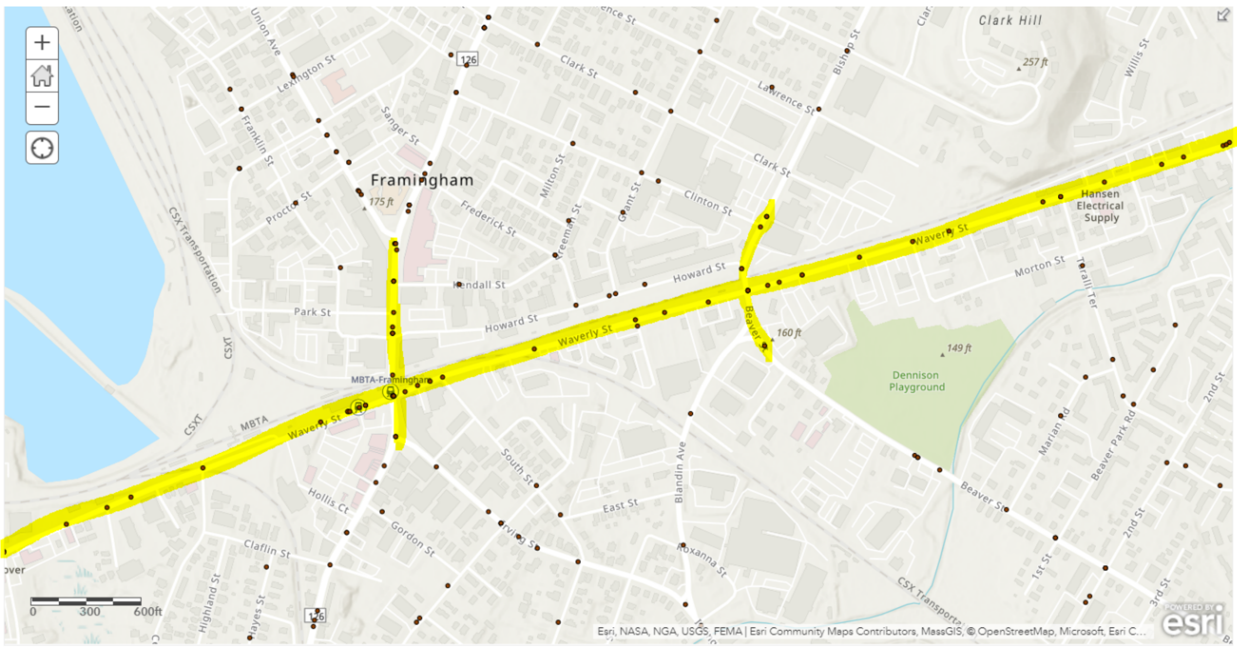


Figure 4.16. Vehicle Crashes Near the Framingham Station from 2020. The highlighted segments are two streets the train passes through (Route 126 and Bishop Street) as well as Waverly Street (Route 135) which runs parallel to the tracks (MassDOT, 2021).

In the 2015 MassDOT Top Crash Location Report, Framingham had a pedestrian-related crash cluster in the top 10 for the whole state (MassDOT, 2020). This cluster was not a top pedestrian-related crash cluster in the 2016 report or the most recent 2017 report; however, the number of crashes has increased by eight for this cluster between the 2015 and 2017 reports. In the 2015 report, the cluster showed 46 total crashes from 2006 to 2015, whereas the 2017 data showed 54 crashes from 2008 to 2017 (MassDOT, 2020). This cluster also has another smaller pedestrian crash cluster right next to it, both of which are close to the train station. The Route 135-Bishop Street intersection is in the larger cluster (Figure 4.17).

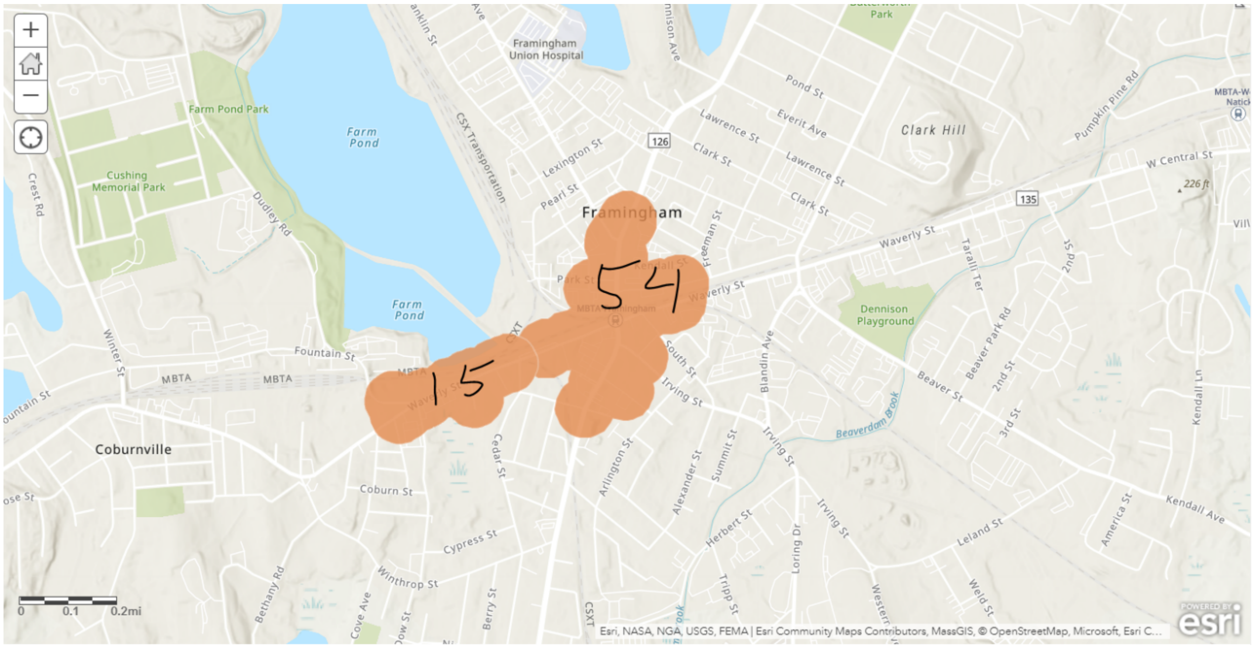


Figure 4.17. The Number of Pedestrian-Related Crashes by Cluster from 2008 to 2017 in Framingham. Made with ArcGIS (MassDOT, 2021).

Framingham's roads are relatively below the Massachusetts average annual average daily traffic (AADT) of 5,433 vehicles; however, the two intersections the train runs through are more congested and both have a higher AADT than the Massachusetts average (Figure 4.18). Route 135, Route 126, and Beaver Street experience some of the highest volumes of traffic in Framingham, which all are part of intersections with trains crossing through them.

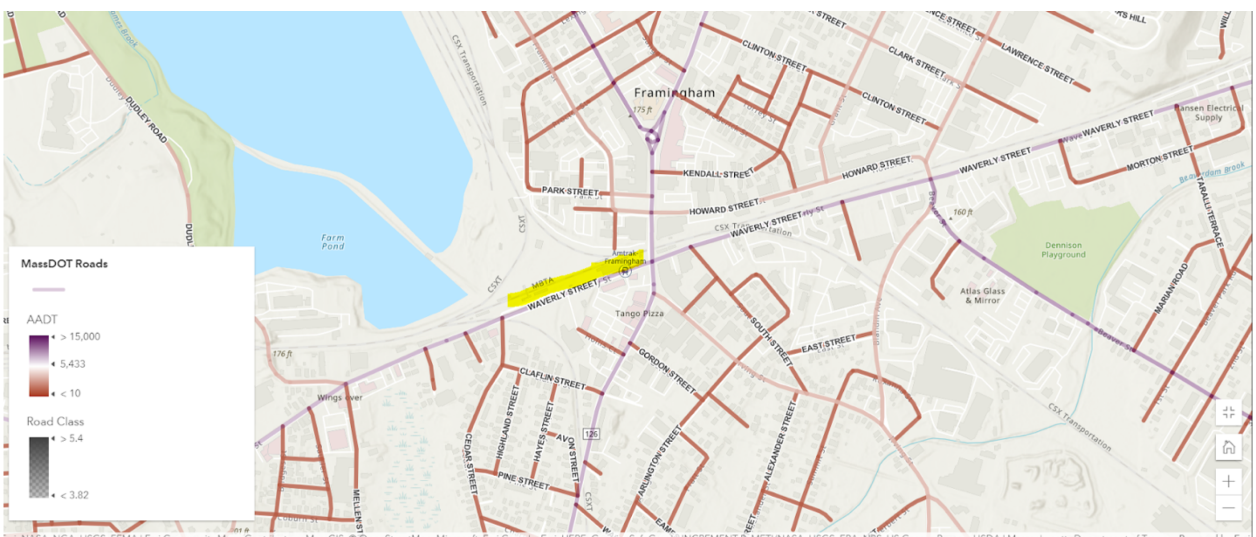


Figure 4.18. AADT for Road Segments Around Framingham Station. The station is highlighted yellow. Made with ArcGIS (MassDOT, 2021).

4.6.2 Crash Data in Natick, MA

Natick does not have a high crash volume around their train station (Figures 4.19 and 4.20), or anywhere in the town. It also does not have any locations on the MassDOT Top Crash Locations Report for overall crashes or pedestrian-related crashes. Although there are crashes reported in Natick, they do not meet the scale of crashes reported in Framingham. The AADT for the road segments in Natick are mostly lower than the Massachusetts average AADT of 5,433 for road segments (Figure 4.21). This is similar to Framingham, except for the two state highways running through Framingham's downtown and Beaver Street.

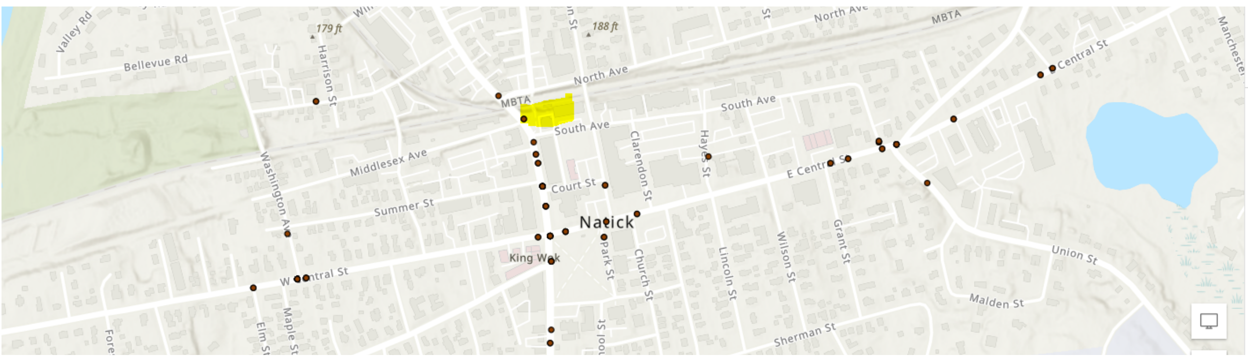


Figure 4.19. Vehicle Crashes Surrounding the Natick Center Station from 2020. The station is highlighted in yellow. Made with ArcGIS (MassDOT, 2021).

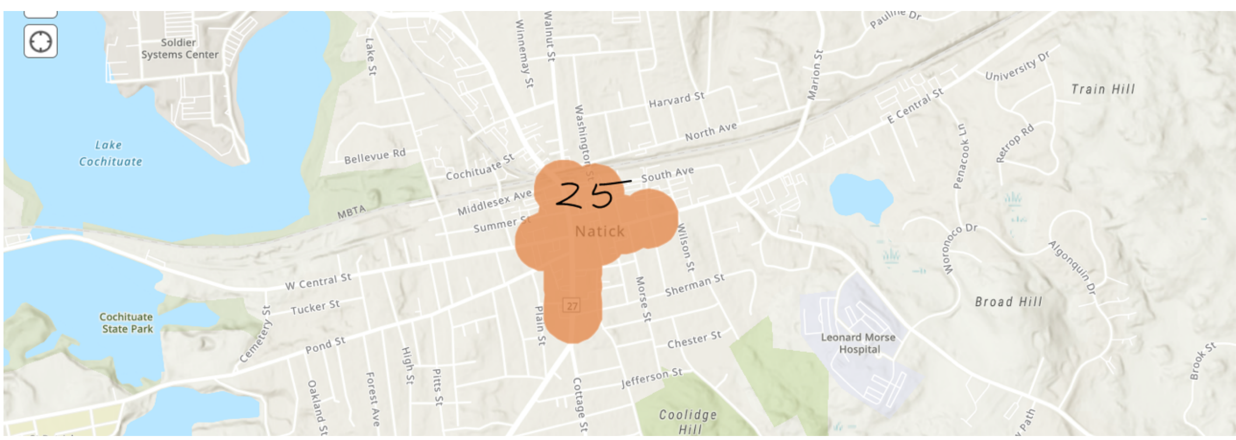


Figure 4.20. The Number of Pedestrian-Related Crashes by Cluster from 2008 to 2017 in Natick. Made with ArcGIS (MassDOT, 2021b).

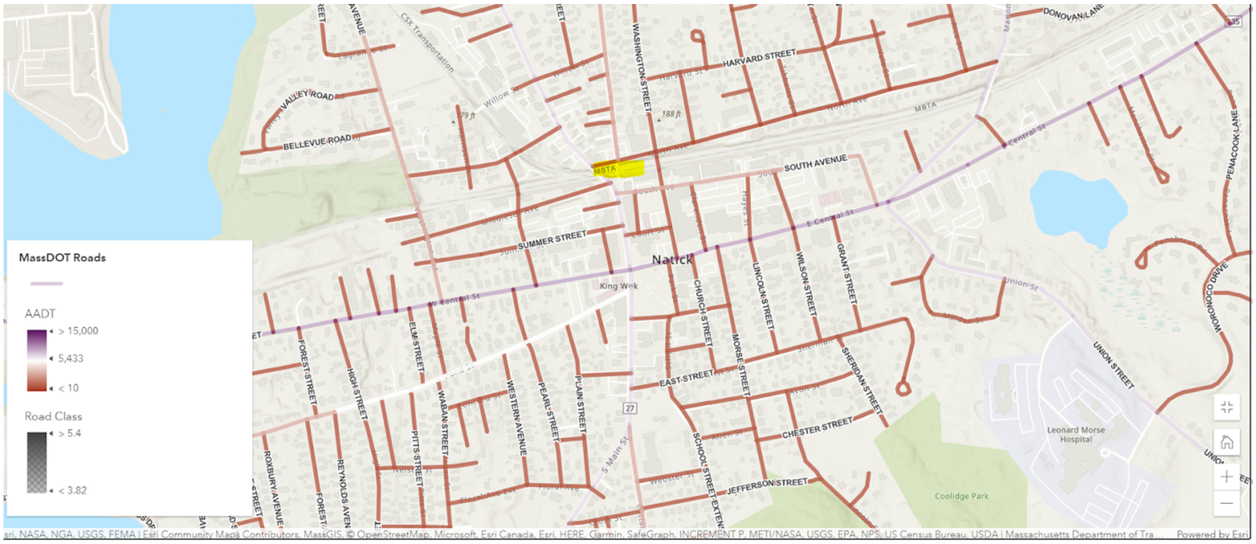


Figure 4.21. AADT for Road Segments Around Natick Center Station. The station is highlighted yellow. Made with ArcGIS (MassDOT, 2021).

4.7. Accessibility Near Framingham and Natick Stations

As seen in Figure 4.22 below, the majority of commuters riding the train drive alone to the Framingham station and park their car. Poor accessibility is a problem within downtown Framingham. Three parking lots are located near the station, allowing easy access for drivers as there is more than enough parking for the demand. This, however, only satisfies the need for one form of transportation.

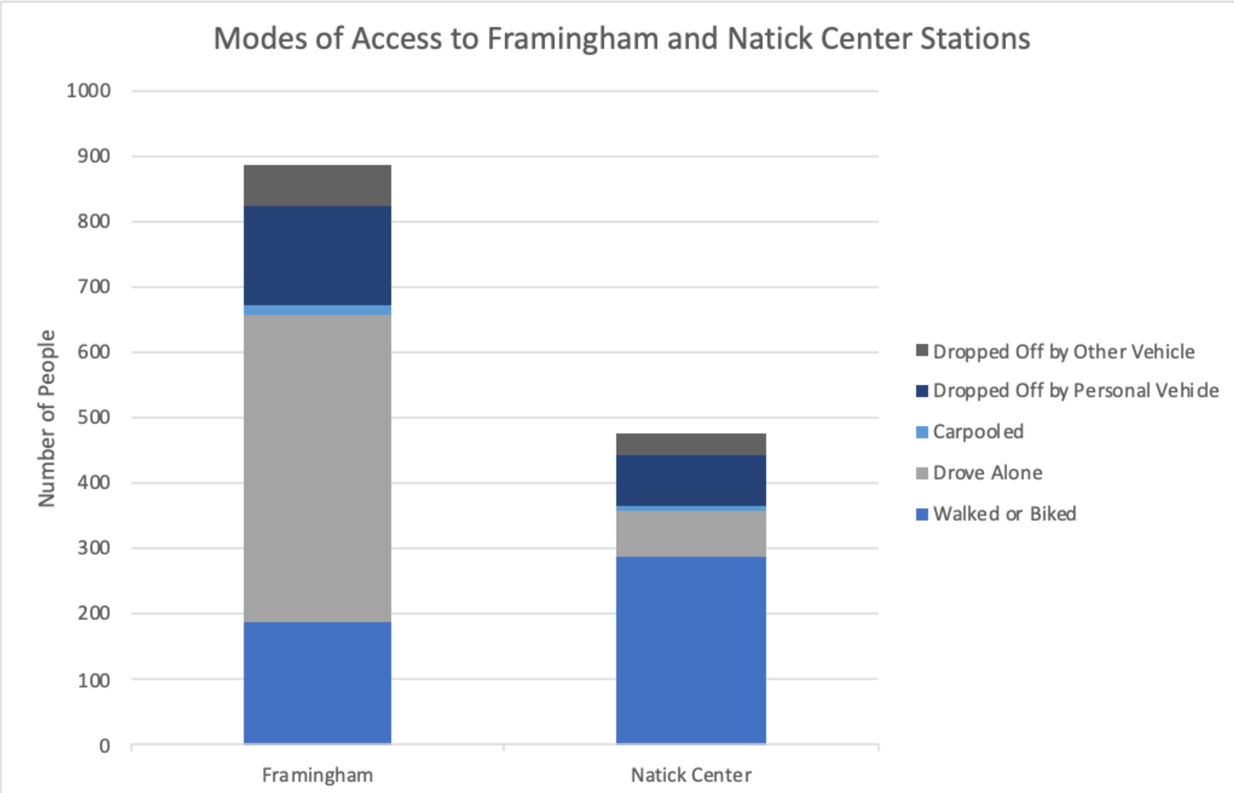


Figure 4.22. Mode of Access to Commuter Rail Stations. Uses 2012 passenger counts (Humphrey, 2012) and 2015-17 passenger surveys for access to the station (MBTA, 2018).

The parking lots also separate and disconnect the station from the relatively walkable downtown and the amenities within it. This also causes traffic problems for downtown Framingham since riders are driving to the station, causing more congestion for morning and afternoon commutes. The Natick station, however, has a much easier walk for residents in the area, reflecting a higher portion of commuters walking or biking to the station than Framingham. Because of this trend, roads in the surrounding area are less congested, and this is evident when looking at crash data (as seen in *Chapter 4.6. Crash Data*); Framingham has significantly more crashes in their downtown area than Natick. Framingham has had multiple locations on the MassDOT Top Crash Locations Report, and it must be addressed.

Despite the high population and job density around Framingham (as seen in Figures 4.23 and 4.24), 53 percent of commuters drive. Natick Center — which has significantly lower ridership, population, and job densities nearby — sees a greater portion of its commuters walk and bike to the station.

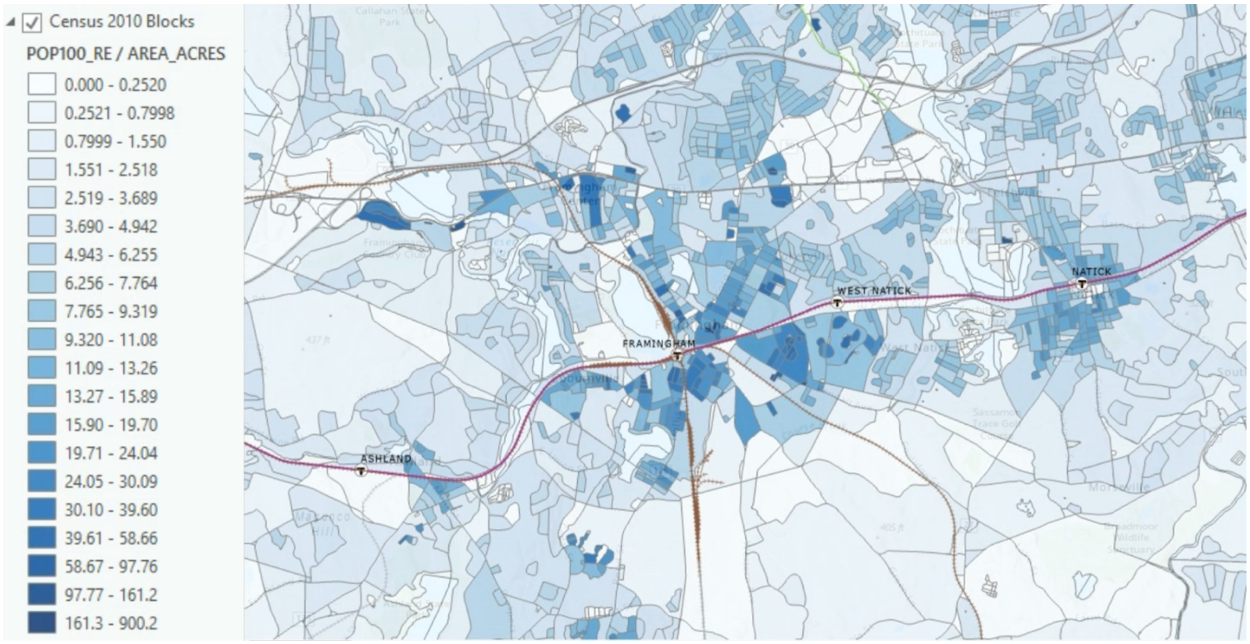


Figure 4.23. Population Densities Near Commuter Rail Stations. Measured in people per acre (US Census Bureau, 2019; MassGIS, 2019).

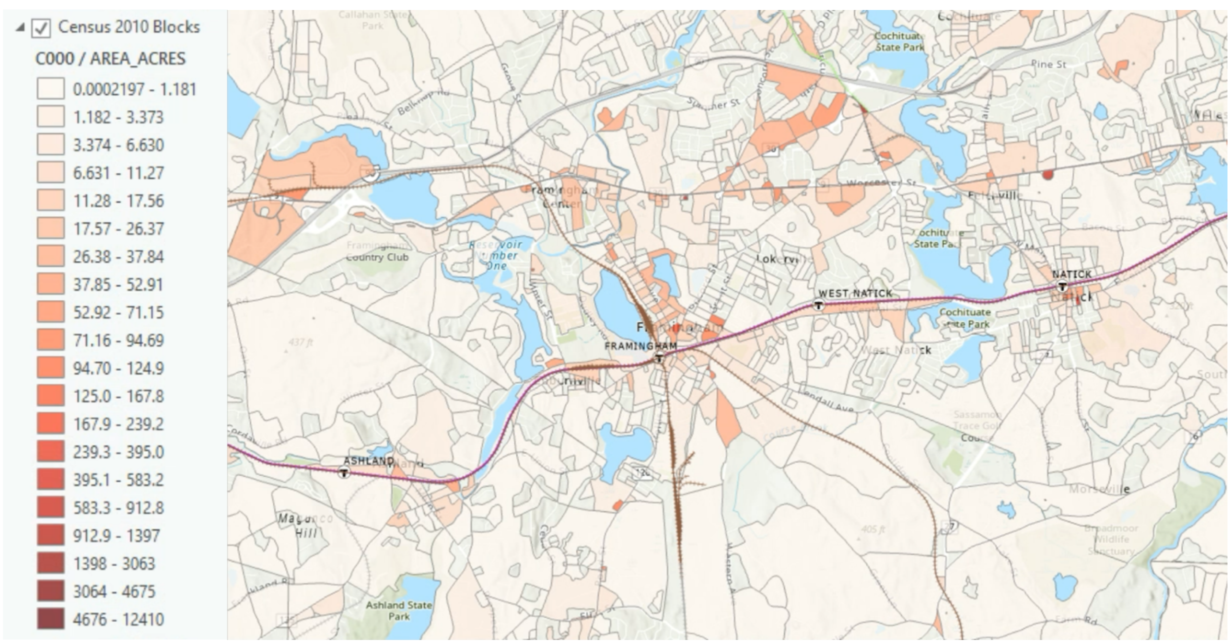


Figure 4.24. Job Densities Near Commuter Rail Stations. Measured in people per acre (US Census Bureau, 2018; MassGIS, 2019).

For Natick Center, this could be explained that three times more jobs and people are within a half-mile perceived walkshed than Framingham even though Framingham has more jobs and people overall near the station. It appears that Framingham has a lot of untapped potential for ridership near the station which could be realized by improving the station and access to the station. Another explanation could be derived from the placement of Framingham on the commuter rail line. As it exists, Framingham exists as an “end-of-the-line” destination, serving many commuters from smaller communities in the surrounding area. Many people likely either travel to Framingham or continue all the way to Worcester, mostly skipping the four stops in between. Stations east of Framingham, like Natick, serve dense clusters of people in smaller geographic areas due to their closer proximity to Boston.

4.8. Average Ridership Values

On a typical weekday in 2018 (pre-pandemic), the largest “average ons” (meaning average boardings) occurs in the period between 6:31 a.m. and 8:05 a.m. in which seven total trains pass through the station (Figure 4.25). The number of average ons is much lower throughout the rest of the day, with a steep decline right after this time period. After the 8:05 a.m. train, and up until (and including) the 4:31 p.m. train, average ons remain consistent between 20 to 30 people; after this, average ons drop to only a few, or, in some cases, no riders (MBTA, 2019). In the inbound direction between Framingham and Boston on a typical weekday, “average offs” — meaning average deboardings — are relatively few, typically ranging between 0 and 10 with a peak of 13 at 7:03 a.m. This data also reveals that 995 total daily average ons are standard for the inbound direction originating in Framingham; this is a 12.3 percent increase over similar data recorded in 2012. Average offs in the same direction with the same origin station were found to be 76 people in 2018 (MBTA, 2019).

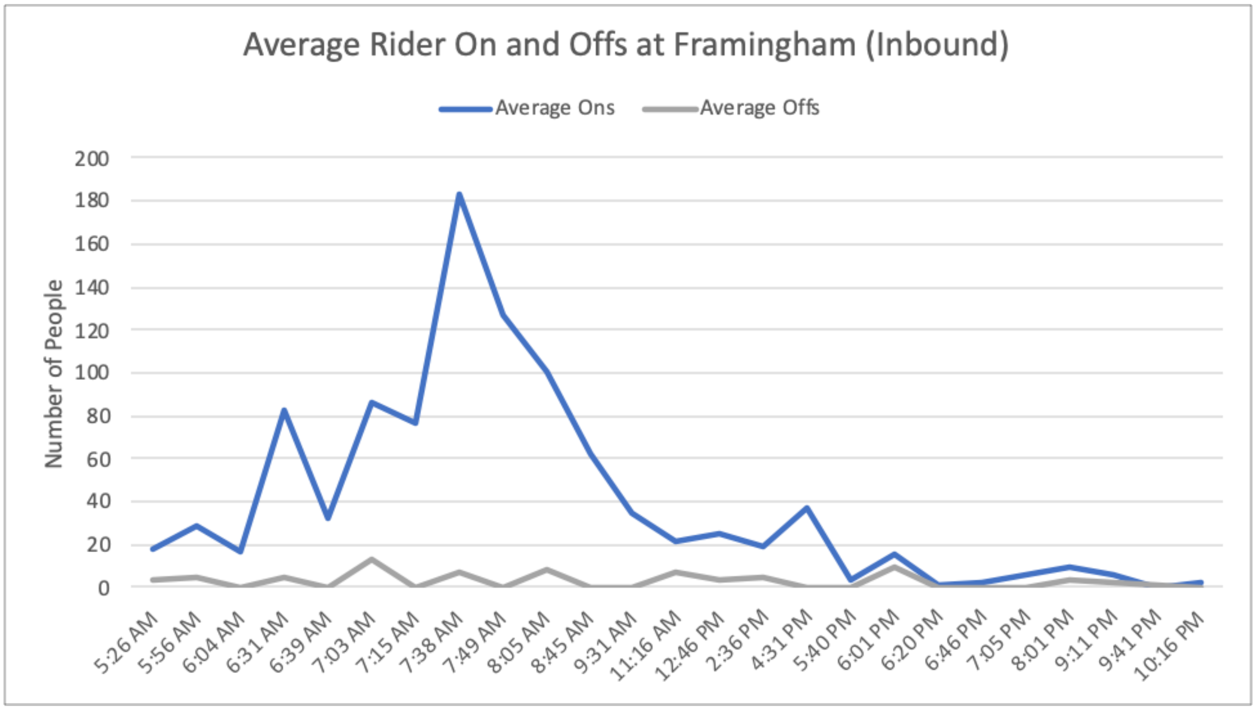


Figure 4.25. Average Ridership Per Train at Framingham in the Inbound Direction Toward Boston (MBTA, 2019)

The data for a typical weekday in 2018 originating in Boston traveling outbound to Framingham reveals a similar data pattern for the afternoon commute (Figure 4.26). Average ons and offs are relatively low during the morning hours. During the morning commute, consistently few average ons are recorded, peaking at nine riders at 9:35 a.m. Average offs during the morning hours range between zero and 26 riders; the peak occurs on the 7:53 a.m. train. During the afternoon commute, the outbound trains experience a similar spike in ridership to the inbound trains during the morning hours. Between 4:25 p.m. and 7:05 p.m., the highest activity is recorded on the outbound trains. During this time, the lowest number of average offs is 56 riders, with a peak of 263 riders at 5:43 p.m. Simultaneously, average ons exhibit a small boost, with a peak of 31 average ons at 5:43 p.m. After 7:05 p.m., average offs steadily decline to 11 by the last train of the night while average ons remain consistently few (between one and six riders). 1,158 total daily average offs are standard between Boston and Framingham in the outbound direction, which is a 35.3 percent increase over similar data collected in 2012. In the same direction and origin station, 135 total daily average ons were found in 2018 (MBTA, 2019).

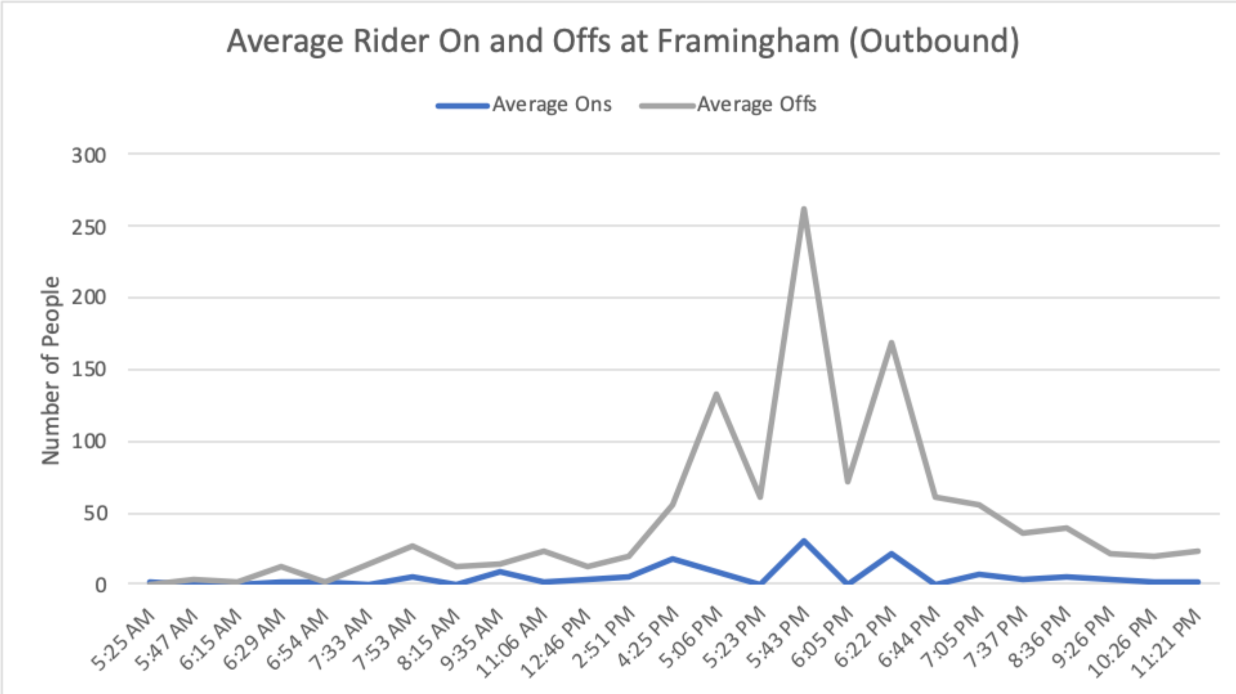


Figure 4.26. Average Ridership Per Train at Framingham in the Outbound Direction Toward Worcester (MBTA, 2019)

The average ridership on the Framingham-Worcester line reveals a logical trend: a spike in usage during daily rush hours. When looking at the ridership figures at Framingham station in the morning, the majority of riders are getting on the train to head toward Boston. Looking at outbound travel, the opposite relationship is true — the majority of passengers are deboarding at Framingham coming from anywhere east of the city. The spikes of ridership numbers are only centered around the rush hours (approximately 6:30 a.m. to 8:30 a.m. and 4:30 p.m. to 6:30 p.m.). Very few passengers in comparison are boarding or deboarding the train at any other times during the day in either direction. This reveals that the majority of the commuter rail's ridership from Framingham is commuters traveling to and from work.

Knowing this trend, it provides evidence that Framingham could easily become more of a transportation hub. The city lies halfway between Worcester and Boston and is an area where Boston commuters live. Because of this, there is great potential for Framingham to increase its local connections to provide more accessible commuting service via the commuter rail. Spurs toward Framingham State up to Northborough (as seen in *Chapter 4.10. Potential Timetables for the Framingham-Worcester Line*) could increase the locations on the commuter rail and increase ridership on the line. Additionally, if the train fares were lowered, Framingham would likely see an increase in ridership and revenue. When the $10.00 weekend pass was introduced in 2018, revenue increased from the previous year because far more people were riding the train on weekends (Buell, 2019).

Together, these improvements would effectively make Framingham more of a destination as a higher number of people would be traveling through during rush hours. With more people traveling through for work, it would be likely that the local downtown would benefit economically; restaurants and other offerings in the downtown would likely increase, driving the potential for Framingham to also be visited for leisure.

4.9. Cost of Riding the Train versus Driving

Taking the commuter rail from Framingham to Boston round-trip costs a passenger $19.50. Alternatively, a pass to take an unlimited number of rides solely on the commuter rail over the course of one calendar month costs $301.00 for the monthly *mTicket* (MBTA, n.d.). Alternatively, the monthly *CharlieTicket*, which provides the same benefits as the *mTicket*, includes transfers to MBTA buses (serving near Boston) and subways for $311.00 per month.

The price of the monthly pass is equivalent to about 15 round-trip tickets. A commuter traveling daily during the work week from Framingham to Boston on the train will do so approximately 21 times per month, at maximum. This was calculated from averaging the total number of weekdays in each month across all twelve months. It should be noted that 21 weekdays in a single month is on the higher end; some months, like February, simply have less days (and, therefore, less weekdays) while other months (like November and December) include a lot of days off for holidays. Additionally, employees are able to take vacations and sick days at any point throughout the year, resulting in a lower number of times they would be commuting for work.

Weekend rides on the commuter rail are significantly cheaper when compared to the work week. A weekend ticket, which allows for unlimited rides on all lines for a weekend, costs riders $10.00. This is $9.50 less than a round-trip ticket from Framingham to Boston during the work week. When the weekend pass was introduced in 2018, ridership massively increased on the weekends, and the ticket revenue increased 4.6 percent more from the previous year, despite lowering fares (Buell, 2019).

4.9.1. Transportation to and from Commuter Rail Stations

Depending on their proximity to the station, a train user can arrive at the Framingham station by using one of many different forms of transportation, such as driving, walking, biking, or taking the bus. Walking or biking to the station is free for the user. Driving, according to the IRS, costs $0.585 per mile on average (Miller, 2021) — which takes into account fuel prices as well as wear and tear on the vehicle; parking costs $4.00 per day on weekdays or $70.00 per month (MBTA, n.d.). Taking an MWRTA bus to the station costs $1.50 per ride, or $63.00 for 21 round trips.

After commuting approximately 50 minutes from Framingham to Boston (MBTA, n.d.), riders will either have to walk, bike, or take another form of transportation from the train station to their place of work. Walking will be no additional cost to the commuter; however, taking the bus or renting a bike in Boston (since bikes are not allowed on the train during peak hours) will increase monthly transportation expenses.

4.9.2. Commuting Cost Analysis

Based on the statistic that commuters will travel to and from work 21 times a month on average, they will effectively spend $14.33 per day on train tickets by buying an *mTicket* or $14.81 per day with a *CharlieTicket*.

For drivers, the distance from Framingham to Boston is approximately 23 miles; for a round-trip journey, a driver will travel 46 miles. By IRS standards (as mentioned in the previous section), operating a car costs $0.585 per mile driven (Miller, 2021). By this calculation, it costs the average driver $26.91 for each round trip, or $565.11 for the entire month. This statistic is almost double the $14.81 figure (calculated above) that commuters would spend traveling by train.

However, drivers are more likely to focus on the immediate costs associated with driving: fuel. The average gas price as of January 2022 in Massachusetts is $3.42 per gallon (American Automobile Association, n.d.). The average 2019 model year vehicle in the United States can travel 24.9 miles per gallon. For the average U.S. car to travel the distance from Framingham to Boston round-trip, $6.20 worth of gas is required (Waze, n.d). This statistic is 58 percent cheaper than the $14.81 per day cost associated with buying a *CharlieTicket* (MBTA, n.d. b). Commuting round trip 21 times per month from Framingham to Boston by car would cost approximately $130.20 in gas for the entire month. This is cheaper than riding the train by $180.80 per month.

Despite the apparent cost savings, parking in Boston is another large expense that would be incurred, which is, on average, $300.00 per month (MonthlyParking.org, 2021). Once this fee is added to the cost of gas (an immediate $430.20, or $865.11 based on IRS costs), driving by personal vehicle is much more of a financial burden than taking the train and any additional transportation required from South Station to their place of work (Table 4.1).

Table 4.1. Evaluation of Different Modes of Transportation Between Framingham and Boston

	Riding the Train Between Framingham and Boston		**Driving Personal Vehicle Between Framingham and Boston**	
Transportation Type	**mTicket**	**CharlieTicket**	**Perceived Cost of Driving and Parking (gas and parking only)**	**Actual Cost of Driving and Parking (IRS)**
Cost Per Month ($)	$301.00	$311.00	$430.20	$865.11
Benefits	Unlimited train rides to and from Framingham to Boston	Unlimited train rides to and from Framingham to Boston, and unlimited access to buses and subways	Can go to and from on your own time, and can park closer to your place of work	Can go to and from on your own time, and can park closer to your place of work

4.9.3. Commuting Cost Analysis: Time

Another cost incurred by commuters is the time it takes to travel. To drive from Framingham to Boston with no traffic takes about 23 minutes; however, for weekday commutes to work, that is never the case. Traveling in the morning rush hour to Boston from Framingham can take close to an hour, as shown in Figure 4.27 (Waze, n.d). As seen in *Chapter 2.7. TransitMatters: Regional Rail Proof of Concept Study* in Figure 2.10, taking the train will "cost" riders 39 to 55 minutes, depending on the Boston station to which they are traveling. While taking the train will provide commuters with, on average, a shorter commute, this mode of transportation is also much more reliably consistent as trains always have the right of way on the line. The time it takes to travel by vehicle will vary greatly, as congestion on the turnpike changes day to day (but is typically consistently high during the peak commuting hours).

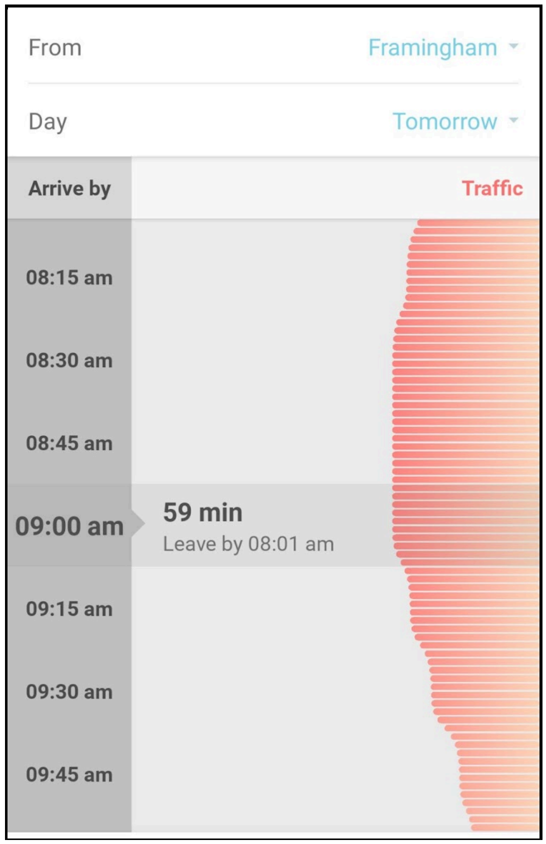


Figure 4.27. Estimated Travel Time for the Weekday Morning Commute from Framingham to Boston (Waze, n.d.)

<u>4.9.4. Commuting Alternative: Carpooling</u>

If two people that both live in Framingham were to carpool to work in Boston, the total cost of fuel and parking is immediately cut in half (assuming they park in a location that is within walking distance of their respective places of work). The two individuals would face an immediate monthly transportation cost of $215.10, which is cheaper than the *mTicket* by $85.90. This shared cost, however, does not take into account the wear and tear on the vehicle that is used for the commute or the potential maintenance costs that might be incurred.

Carpooling to work is more attractive because it is immediately cheaper; commuters will also likely not have to take another form of transportation or walk a far distance to their final destination. Riding the train into Boston typically requires a secondary form of transportation from the station to a place of work, which adds the cost of time and money, depending on the mode of transportation taken. Despite having to deal with rush-hour traffic on the highway, commuters are able to drive directly to their place of work, which saves time as the need for a secondary form of transportation is eliminated.

4.10. Community Input

From performing interviews with Framingham residents, and holding a forum in Framingham with many stakeholders in the city, everyone recognized traffic in Framingham is an issue (Figure 4.28). When we presented design possibilities to reduce congestion to these stakeholders such as grade separation, they were interested, but also concerned about logistics like funding and how large the grade separation would be. Discussions about making Framingham more accessible through other forms of transportation were viewed favorably, particularly in making effective bus connections in the city and building transit-oriented developments by modifying zoning.

Figure 4.28. Framingham Mayor Sisitsky and the WPI Train Team at the Forum in Framingham, MA. This took place on February 21, 2022.

4.11. Constraints of Grade Separation

As noted in *Chapter 2.5. Existing Conditions of the Station*, the Framingham Commuter Rail station is located slightly west of downtown, with its rail lines directly to the east cutting through two busy roadways. Grade separation, either of the rails or the roadways, would help resolve some of the traffic bottlenecks created by the frequent lowering of the crossing guards. Grade separation, however, is logistically and financially difficult to implement at the Framingham station due to the interlockings on either side of the station; the need to destroy and rebuild the station; and infrequent, but conflicting, freight rail service.

4.11.1. Cost of Grade Separation

One of the largest obstacles facing the proper implementation of grade separation at the Framingham Commuter Rail station is the cost. In general, grade separation is an extremely expensive endeavor, even for smaller projects. At Framingham, the ideal grade separation would occur over a mile-long section, stretching from slightly west of the station to the immediate east of the Route 135-Bishop Street intersection. This would enable complete grade separation in the downtown Framingham area, allowing for the two roadways — Route 126 and Bishop Street — to exist without rails crossing through them. From looking at other grade separation projects that have been implemented throughout the United States, costs range anywhere from just under $15 million to $200 million and beyond.

Regarding the potential costs more specifically, a few prominent examples stand out and give relevant context to how cost varies with the complexity of grade separation. On the lower end of the cost range, a newly constructed grade separation cost $14.7 million. This project — located in Lima, Ohio — was rather straightforward, consisting of elevating two freight railroads above a three-lane roadway with sidewalks. In terms of grade separation, this is as simple as it can get (as shown in Figure 4.29 below) and a bit below the needs of the Framingham station ("Railway Engineering Services", n.d.).

Figure 4.29. Completed Grade Separation in Lima, Ohio ("Railway Engineering Services", n.d.).

Many other recent examples, especially more complicated ones, exist in the state of California, which has recently been experiencing a surge in railroad development. Many of these projects have been occurring on commuter rail lines operated by Caltrain, the commuter rail line serving areas near San Francisco, CA. Caltrain is notorious for over-engineering structures which heighten costs of their projects (Clem, 2021). Redwood City, California is currently planning for a potentially massive grade separation project. This would consist of many grade separations across multiple minor street crossings and would overall be a project with a scope much beyond that of Framingham. Looking at some of the individual grade separations for this project, there are a few variations that are comparable to the needs of Framingham.

Along the rail corridor in Redwood City, the tracks cross Whipple Avenue — a roadway similar to Routes 126 and 135 in Framingham, MA — at grade and are subject to bottlenecks when the crossing guards are down as trains pass. Based on a study conducted in 2009, the complete grade separation of this intersection alone would cost anywhere between $150 and $300 million; adjusted for inflation since 2009, the costs could be approximately $200 to $400 million today. The reason for such a large price range is due to the different design options that are possible: such as roadways completely over or under the railway; roadway shifted down a little and railway shifted up a little; or roadway shifted up a little and railway shifted down a little. Caltrain's tendency to over engineer, as mentioned earlier, also adds to the heightened costs (Figure 4.30) (Clem, 2021).

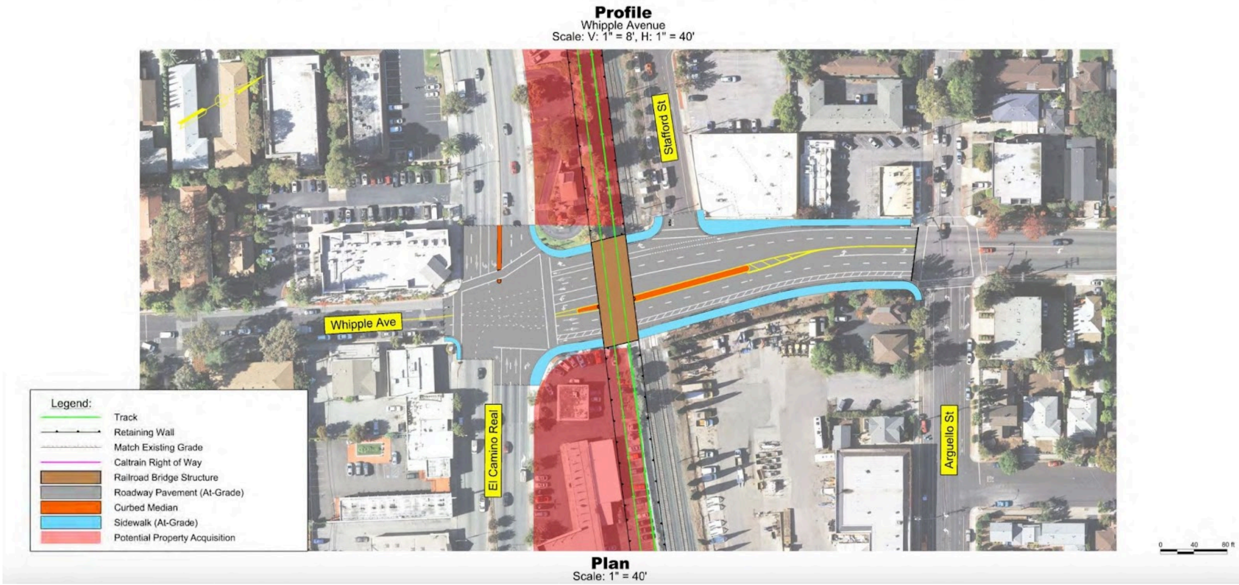


Figure 4.30. Potential Grade Separation at Whipple Avenue. This option shows the railroad being moved upwards with the roadway remaining at the same grade ("Redwood City", 2020).

Another example of grade separation in Redwood City involves grade separating the railroad above the street crossings between Whipple Avenue (mentioned previously) and Maple Street. This stretch is approximately one mile and would include the Redwood City Commuter Rail station — a situation extremely similar to the one found in Framingham (Figure 4.31). The cost of this project was estimated to be $500 million in 2009, which would be approximately $650 million today ("REPORT", 2018).

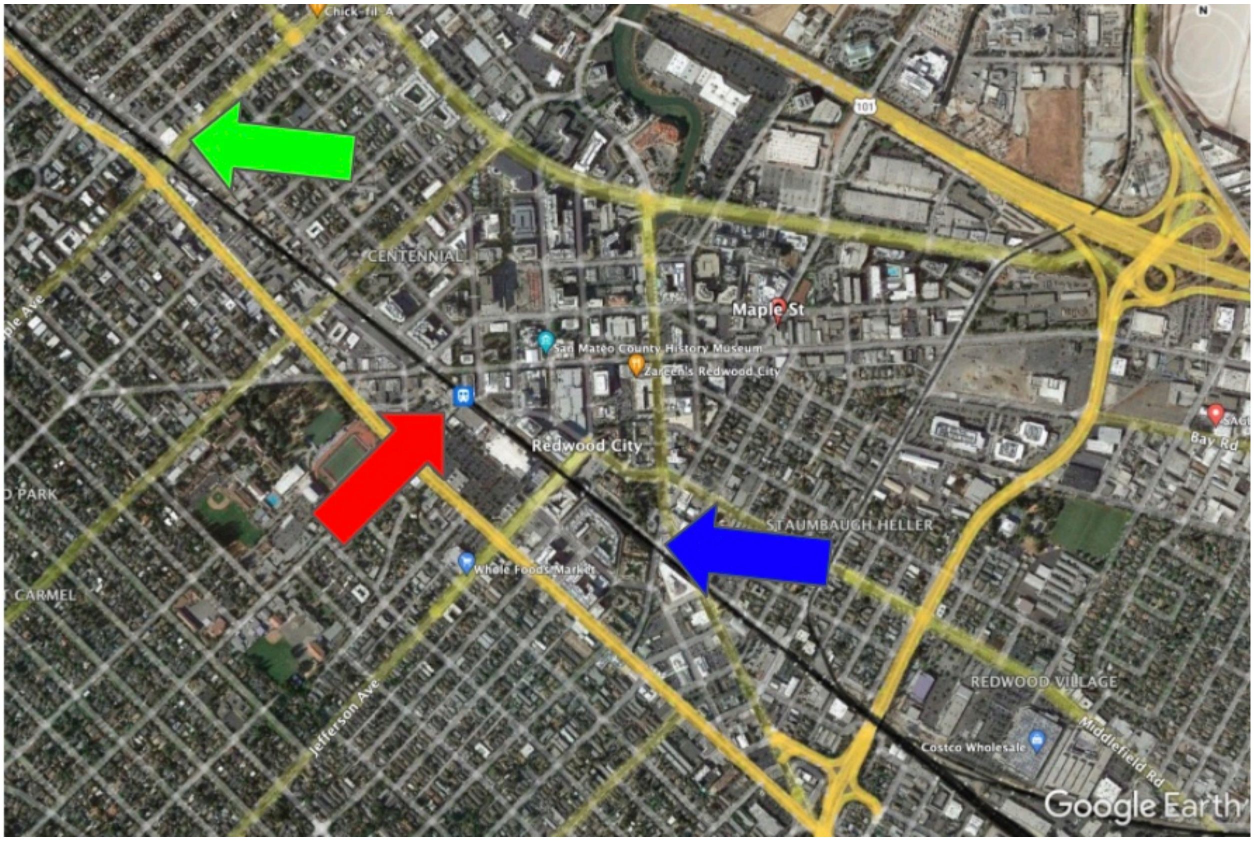


Figure 4.31. Potential Grade Separation Locations in Redwood City. The green arrow points at Whipple Avenue, the blue arrow points at Maple Street, and the red arrow points at Redwood City station ("REPORT", 2018).

4.11.2. Interlockings

The Framingham Commuter Rail station is located between two interlockings, control point 21 (CP 21) just to the east of the station and control point 22 (CP 22) just to the west. These interlockings cover small zones of railroad track where a computer system analyzes train movements in these areas and ensures that trains move through them in a manner that prevents crashing; essentially, the system makes sure only one train moves through the interlocking at a time. CP 21 covers the entire area occupied by the two branches of rails that split off from the main east-west rail line. This section exists over a fairly substantial area, as shown below in Figure 4.32, and crosses through Route 126, which is extremely close to the Route 126-Route 135 intersection.

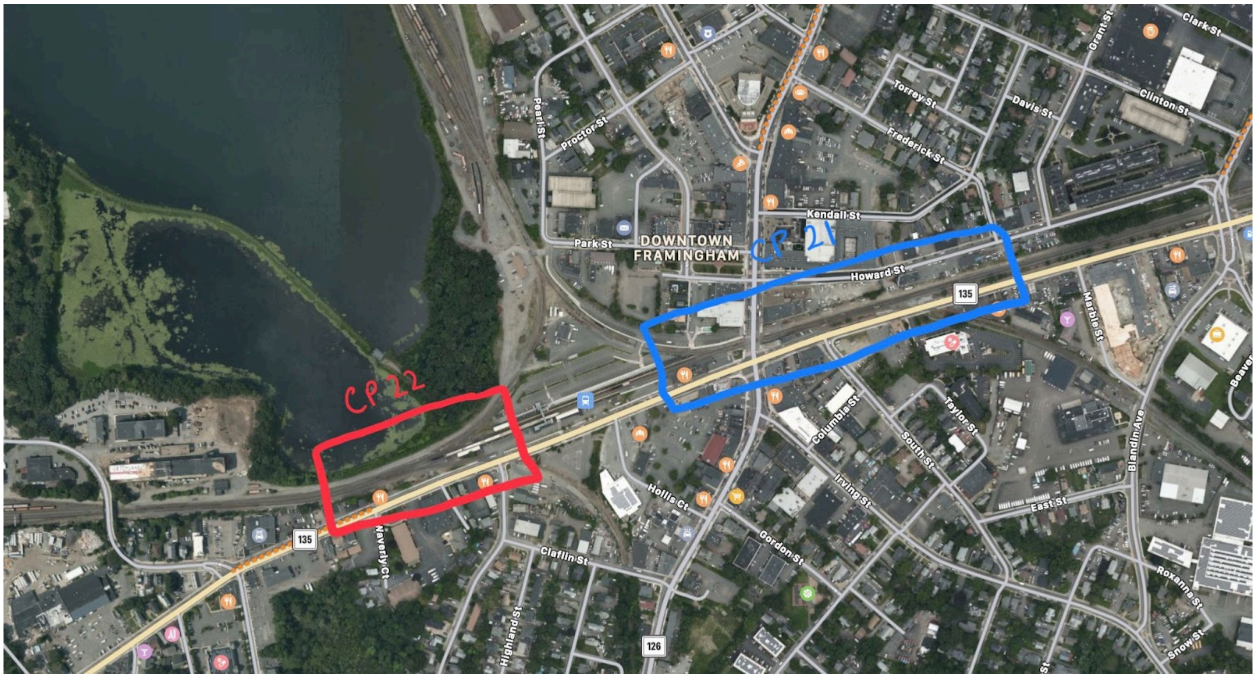


Figure 4.32. Approximate Locations of CP 21 and CP 22 (Google Earth)

The branching that occurs at this control point is essential to freight rail service. While infrequent, freight rail travels south through the CP 21 interlocking three times a day at maximum. Freight trains rarely travel east toward Boston or North at CP 21. Essentially, all regular freight traffic travels between Worcester and north of CP 22 (once a day at maximum) as well as between Worcester and south of CP 21 (three times a day at maximum).

Removing either of these interlockings or grade separating the rails would cause disruptions to freight rail service. An entirely new configuration would need to be constructed if the route of grade separation was taken as the limited freight rail service needs to move north or south through this area.

4.11.3. Elevations of Grade Separation

Another major logistical hurdle facing proper implementation of grade separation is the existence of bridges slightly west of the existing station. Fountain Street, which is a road that goes over the railroad tracks, is located approximately 1,500 feet west of the station measured from the western-most edge of the station. This provides limited space to elevate the tracks to an appropriate grade-separated height (which is approximately 24 feet from the base of the road to the top of the railroad track). Freight trains require a much shallower grade of 1.5 percent compared to the grade required for EMUs or electric multiple units (four percent) (Regional Transit Design Denver, 2009). This means that to change the vertical elevation of the rails by 24 feet, freight trains would require at least 1,600 feet of horizontal distance, not counting the curves required to transition to a 1.5 percent grade from a zero percent grade. Comparatively, using the standard grade of electric trains, at least 600 feet of horizontal distance would be necessary at a four percent grade, or, based on requiring 90 feet per degree change at 50 MPH, 960 feet if starting and ending at a zero percent grade with a four percent grade in the middle, which would be more feasible (Regional Transit Design Denver, 2009).

Notably, station platforms can be built with up to a 0.75 percent grade in their design (MBTA, 1996).

4.11.4. Modified Forms of Grade Separation

Two obvious alternatives to raising the tracks above the road crossings in downtown Framingham would involve lowering the roads beneath the tracks or lowering the tracks beneath the roads. Both of these options are likely very infeasible due to a number of reasons.

One main issue surrounding either option is the impact of flooding. Obviously, placing a road or track at a lower elevation will inherently put it at a higher risk of flooding during a rain event. Drainage typically becomes a major issue for these lower points and is something that, even with dedicated effort to combat the issue, is something that will happen regardless. At the Natick Center station, which is elevated below the surrounding roads, drainage has become a major issue that is prominent during any rain event, resorting to pumping stormwater to prevent any long-lasting problems. Especially with Farm Pond so close by to the Framingham station, groundwater elevations would be a big point of concern since the area would be naturally prone to flooding in addition to during storms. Another issue plaguing any type of lowering of the tracks or roads would be locating and moving existing utilities, such as electric and sewer.

Lowering the roads beneath the tracks is possible but infeasible for the reasons stated above. Additionally, this idea was explored in the 2009 BETA study and it was determined that there are many logistical problems with the proposed designs. In either case, complete grade separation is not achieved as some vehicle traffic would be diverted at grade over the tracks. With this configuration, most through traffic utilizing Route 126 would travel underneath the tracks but turning traffic would be directed over the tracks. Pedestrian crossings would also be eliminated across Route 126 at Howard Street and Irving Street.

4.11.5. Effects on Downtown Framingham

The at-grade crossings in Framingham have been a major issue facing circulation in the downtown area where the train station and the majority of the city's retail businesses are located. While grade separating the Route 135-Route 126 intersection would certainly alleviate congestion and increase access to local businesses in the area, it would also increase the perceived walkability in the area. Framingham residents have told us repeatedly that the train crossing at the two intersections is a huge problem and morning traffic is terrible. As seen in *Chapter 4.2.1. Crash Data in Downtown Framingham*, these two intersections are serious problems because of the number of crashes that occur.

Without addressing the grade separation, the increased train service that is likely to come in the future would compound pedestrian and vehicular access issues at Route 135-Route 126 and Route 126-Bishop Street intersections. Grade separating the railroads may marginally improve train service; however, it will massively improve traffic and pedestrian flow in the area. This would also enable the reconstruction of those intersections to provide safe accommodations for all modes of transportation, which could decrease the number of car crashes in the area. Pedestrians and bicyclists alike would have newly dedicated and safer routes across Framingham, which would also increase access to the station and local business.

There are other political, social, and aesthetic concerns to address regarding elevating the tracks other than the inevitably massive cost and disruption of this project. While the existing station and tracks form a barrier between north and south Framingham as well as Farm Pond, an elevated train track would drastically change the landscape of the area. A minimalistic and open structure with commerce underneath and new pedestrian connections nearby could help reconnect these parts of the city and be less of an obstruction than commonly thought.

4.12. Issues with Zoning

In Framingham's Zoning Ordinances, the Framingham Planning Board states they want to reduce congestion, consolidate parking and encourage multiple forms of transportation (Framingham Planning Board, 2021); however, their parking requirements do not reflect this.

For example, off-street parking at residential buildings within the central business zone that the train station is in requires (as seen in Table 4.2) one space per one bedroom, 1.5 spaces per two bedrooms, and two spaces per three bedrooms.

Table 4.2. Minimum Off-Street Parking Spaces for Residential Structures in Framingham (Framingham Planning Board, 2021)

Unit Type	**Minimum Spaces Per Units**
Studio	0.5
One bedroom	1
Two bedroom	1.5
Three bedroom	2

However, outside of the Central Business zone, areas within a mile of the existing station — which is distance that could easily be walked or biked — require the following: one parking space per apartment; two parking spaces per single-family house (and an extra one for every room rented); and one parking spot for every two employees. Low-income individuals will pay additional rent for a parking spot when they might not be able to afford a car in the first place. Additionally, businesses have to pay for parking that their employees might share or not utilize.

For businesses, parking drives up costs for no benefit. An office, mall, and nightclub can exist right next to each other, each requiring their own massive parking lots. When workers are at the office on weekdays, the parking at the mall and nightclub will be empty. When people are at the mall on the weekends, the parking at the nightclub and the office will be empty. At night, the mall and office parking will be empty. Rather than having three separate massive parking lots, they could just share one and have additional businesses and residences in the saved space, not to mention increase tax revenue for the city and decrease costs for businesses. Alternatively, they could even improve transit connections to enable people to travel without taking up parking. But no such consideration is in the zoning ordinance — massive private parking requirements are required for new developments that will often lie empty.

This seems to be counterproductive to provide this many parking spots per bedroom, while encouraging more forms of transportation. Boston, which is well known for its great public transportation, has parking requirements for residential buildings based on the Floor-to-Area Ratio (FAR) (Boston Redevelopment Authority, 2021). FAR is the ratio of the area of the building's floor area to the area of the lot the building is on. The parking requirement by FAR in Boston can be seen in Table 4.3. Additionally, Boston has removed parking requirements for affordable housing (Dimiceli, 2022).

Table 4.3 Minimum Off-Street Parking Spaces for Residential Structures in Boston (Boston Redevelopment Authority, 2021)

Maximum Floor Area Ratio of the Lot	The Minimum Number of Spaces Required for Each Unit
0.3 or 0.5	1.0 space
0.8 or 1.0	0.9 space
2.0	0.7 space
3.0	0.6 space
4.0	0.5 space
5.0	0.4 space

This method allows for more efficient land use and dense living because the number of parking spaces is determined not only by the number of units in the building but also by the area the building takes up. This makes for the most efficient use of the land because buildings with a higher FAR cannot have as many parking spaces per unit. This encourages more high-rise buildings, which take up less space and can house more people, creating more population density. Building owners do not want to pay for more parking, so by making large high-rise buildings with a high FAR, this will decrease the required parking spaces (Boston Redevelopment Authority, 2021).

Other regulations — such as density, height and setback requirements — decrease the buildable area of parcels. These regulations prevent building dense, vibrant storefronts and mixed-use developments that bring vitality to downtowns like Boston, Massachusetts and Berlin, Germany.

Essentially, the zoning ordinance recognizes the benefits of decreasing congestion, consolidating parking, and enabling multimodal transportation, but its regulations promote the exact opposite. They actively discourage travel aside from a car and make thriving downtowns (like those found in Boston and Berlin) illegal.

4.13. Potential Timetables for the Framingham-Worcester Line

As discussed in *Chapter 2.8 MBTA Future Visions*, the FCMB (Fiscal Control and Management Board) of the MBTA unanimously adopted resolutions to convert the MBTA commuter rail from diesel to electric, providing all-day clock face 15-minute service — which is easily memorable by riders — across the entire system (MBTA, 2020).

As it exists today, the Framingham-Worcester line serves the region's population, especially daily commuters, traveling into downtown Boston; this line provides these individuals with many important connections, such as buses to cities surrounding Boston and the planned West Station. As seen below (Figure 4.33), the existing Framingham-Worcester line is expansive, containing 18 stops along its over-40-mile stretch.

Figure 4.33. Stops Along the Framingham-Worcester Commuter Rail Line. Station names in brackets indicate that the station does not currently exist but has been proposed.

As shown above, the Framingham-Worcester line extends from Worcester, MA to South Station in Boston. Seen in Figure 4.34 below, South Station, Back Bay and Lansdowne have large numbers of jobs and residential populations, making Boston the key employment hub along the rail line. Most riders travel from stations outside Boston to inner Boston stations for work in the morning and return back home in the evening. In the near future, this paradigm is unlikely to change.

Outside of Boston and Worcester, the two termini of the passenger rail line, Framingham has both the highest population and jobs within a half-mile walk of the station, albeit by a small margin.

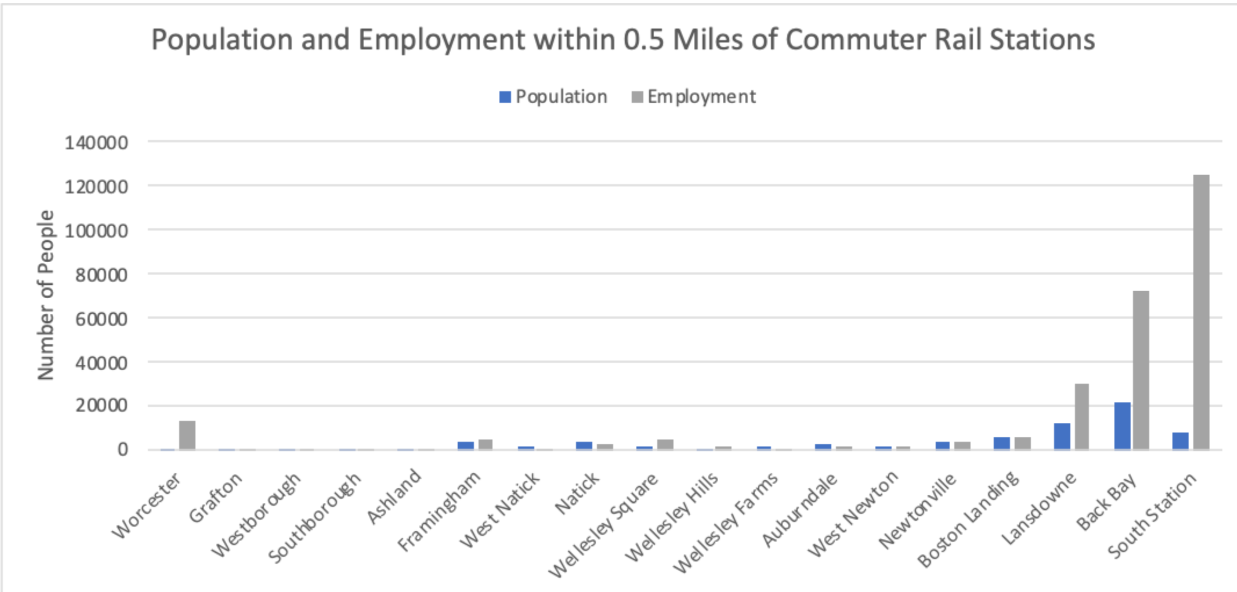


Figure 4.34. Half-mile Walkshed Around Each Station on the Framingham-Worcester Line (Sevtsuk et al., 2020)

The Framingham-Worcester line contains a dense urban core near Boston to which it can provide high-frequency service and also includes Worcester, a gateway city. Within the urban core close to Boston, frequent service is important because this line serves short trips within the city. For Framingham and Worcester, fast service is more important than frequent service since journey time is higher and ridership does not justify running frequent service compared to within Boston. See *Appendix C: Frequency and Speed Analysis for All Stations on the Framingham-Worcester Line* for a more in-depth analysis of all stations on the rail line.

Providing frequent service comes in the form of express trains. During the morning commute, there are currently seven trains that pass through the station between 6:31 a.m. and 8:05 a.m. This means the frequency is about one train for every 13 minutes during this timeframe. This is a high frequency for a morning commute, but currently there are only local trains going out of Framingham. Express trains would offer commuters a quicker ride to their place of work.

For Framingham, an express diesel train would reduce travel time to South Station by about 30 percent compared to a local diesel train; with electrified trains, the electric express would reduce travel time by about 40 percent compared to the electric local. This is much more favorable to riders because this saves them time getting to work and will also afford them more time to themselves after work. Having an express train during the rush hours would make the train a very favorable option as it would transport commuters to destinations of interest quickly and would bypass the headache that is rush-hour highway traffic. While most important during rush hours, express trains, due to their high time-savings, should be run all day.

In all scenarios listed below (Figures 4.30, 4.31, 4.32, and 4.33), there is a red line and a purple line. The red line represents local train service, which is a train that stops at all train stations along the line. Alternatively, the purple line indicates express service, which is a train that skips many stops along the line — typically only servicing stops with high ridership or population density — in an effort to provide faster travel times between prominent locations.

Each scenario also depicts a spur on the red line from Framingham that leads to Framingham State and beyond. Currently, the rail infrastructure for this line only partially exists, so it would need to be built out to allow for service. In any case, service, as described, can occur on the remainder of the red line with or without this infrastructure being in place.

Note that East-West rail to Western Massachusetts could be implemented as an extension of the purple line in all scenarios. Irregular Amtrak service, which currently passes through once daily, would have sufficient space between local and express trains for all scenarios in their respective timetables.

4.12.1. Timetable Possibilities with a Two-Track Station

Regarding timetable possibilities with a two-track station, potential train schedules are divided into Service Pattern 1 and Service Pattern 2, with slight differences noted between them (as discussed later).

The red line in Service Pattern 1 (shown in Figure 4.35 below) can be run from Boston to Framingham with three train sets for 15-minute frequency. To provide service to Framingham State and beyond, four trainsets would be required. The purple line will require four train sets for

15-minute frequency. These express trains, as mentioned previously, would make limited stops between Framingham and Boston, similar to what TransitMatters' timetable (shown in *Chapter 2.7 TransitMatters: Regional Proof of Concept Study*) proposes.

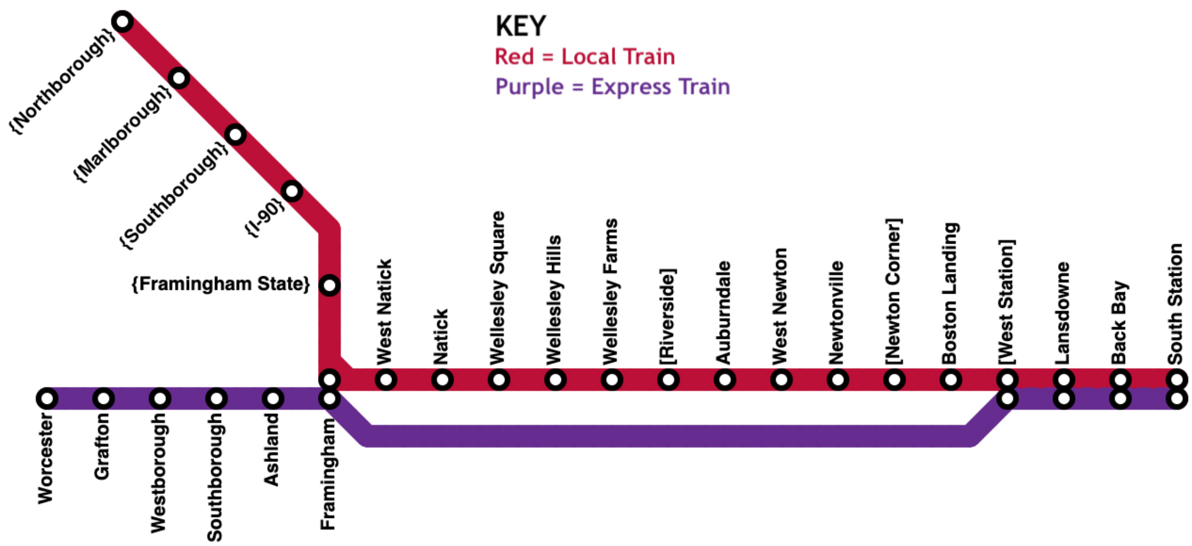


Figure 4.35. Two-Track Station Service Pattern 1 Map. Station names in square brackets indicate that the station does not currently exist but has been proposed by either TransitMatters or the MBTA. Stations in curly brackets are suggested by us.

For this timetable option, a two-track station is adequate for alternating local and express trains, providing frequent service to Framingham. This enables a 25-minute journey from Framingham to Boston, a 20-minute journey between Framingham and Worcester, and, from the perspective of Framingham, service every 15 minutes to any station on the train line.

Both the express and local trains make all stops between the proposed West Station and South Station. If these trains each run at a 15-minute peak hour frequency, they can provide 7.5-minute service frequency for stops within Boston. The disadvantage is that transfers at Framingham between locals and express trains are less smooth and involve 7.5 minutes of waiting time at peak hour, and possibly more at off-peak hours.

Service Pattern 2 (shown below in Figure 4.36) is very similar to Service Pattern 1, but there are a few minor differences; West Natick, Natick Center and Wellesley Square would receive express service, which would take approximately 40 percent less time than a local train. Because of these added stops, Framingham would receive an estimated four-to-five-minute slower express service to Boston — taking 24 minutes instead of 20 (as inferred from Regional Proof of Concept Study discussed in *Chapter 2.7*) (TransitMatters, 2019), but assuming each line is run at a 15-minute frequency, the stations from Wellesley Square to Framingham would receive approximate 7.5-minute service frequency.

The suggestion of added stops in between Framingham and West Station for the express line in Service Pattern 2 is based on ridership today. However, the express could stop at, for example, Boston Landing and Newton Corner depending on future ridership, job and population hotspots.

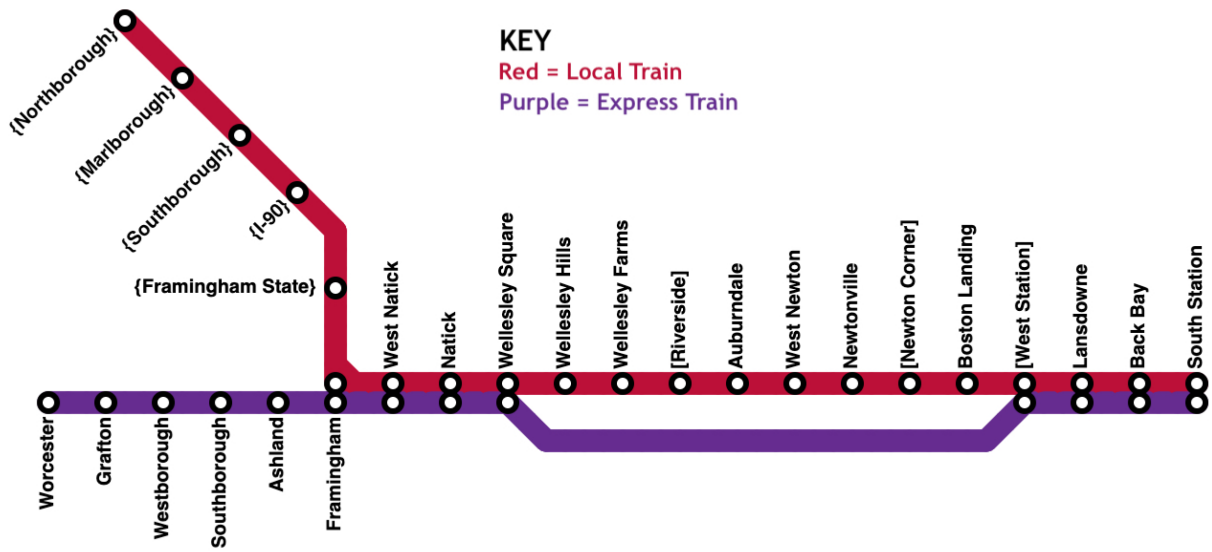


Figure 4.36. Two-Track Station Service Pattern 2 Map. Station names in square brackets indicate that the station does not currently exist but has been proposed by either TransitMatters or the MBTA. Stations in curly brackets are suggested by us.

Service Pattern 2 contains more stops compared to Service Pattern 1. This enables higher-frequency trains between Wellesley Square and Framingham for local traffic and decreases the travel time between Wellesley Square and South Station by 10 minutes (or 40 percent), though adding four minutes (or 20 percent) to express travel time from Framingham. These numbers may change depending on whether the express train stops at stations like Boston Landing and Newton Corner as well. There is no need to decide which service pattern should be used yet.

Future land use and ridership should determine which service pattern — or which combination of service patterns — would maximize access and ridership.

Within Service Patterns 1 and 2, there is a tradeoff to be made with scheduling when it comes to providing either rapid transit among the stations closest to Boston or timed transfers at Framingham station:

1. Rapid transit within Boston: If red local and purple express trains are staggered and run at 15-minute frequencies each, South Station to West Station could receive 7.5-minute service and provide rapid transit along that corridor. Additionally, within Service Pattern 2, Wellesley Square to Framingham could receive approximately 7.5-minute service as well. However, passengers from Worcester to a stop such as Newtonville or Boston Landing would have to transfer from the purple express to the red local with a 7.5-minute wait, and passengers from Framingham State to Boston would have to wait 7.5 minutes to transfer to an express.
2. Timed transfer at Framingham: Framingham station can either be set up to have cross-platform transfers, where local and express trains simultaneously arrive and depart at Framingham station. That would enable passengers to transfer by simply walking across the platform from one train to the other without any delay, allowing passengers from Framingham State to travel to Boston 7.5 minutes faster and passengers from Worcester to travel 7.5 minutes faster to stops in Newton. It would also enable consistent bus service to serve the trains on a 15-minute schedule. However, in such a scenario, the stations between West Station and Boston as well as Framingham to Wellesley Square would not receive 7.5-minute service.

Given the massive ridership, population densities, and job densities in Boston, we tentatively recommend Service Pattern 1 so that the trains are staggered to optimize service within Boston, despite the loss of the cross-platform transfer at Framingham.

Providing rapid transit within Boston has an unintended potential benefit to Framingham. Since passengers from Framingham State to Boston as well as Worcester to Newton have to wait for 7.5 minutes to transfer, they could make quick stops at nearby stores and cafes while waiting for their train, ultimately improving local business revenue within the station and potentially in the surrounding area.

4.12.2. Timetable Possibility with a Four-Track Station

This option combines the best of Scenario Patterns 1 and 2 (shown in Figure 4.37), providing a cross-platform transfer at Framingham; 7.5-minute service at peak hour in Boston and between Wellesley Square and Framingham; and express service for all the stations that need it most. The red local and purple express lines would require four trainsets to provide 15-minute frequencies at peak hour, and a third blue super express line (which can be extended to Western Massachusetts as part of the East-West rail project) can be run at 15-minute frequencies as well with four train sets, though ridership will likely justify a lower frequency. In that case, irregular Amtrak trains can also take the place of the blue express line. The purple express can make stops in Natick Center or Newton to provide approximate 7.5-minute frequencies there as well. Note that stops can be added or removed on the purple and blue lines depending on future population, job growth, and commuting patterns.

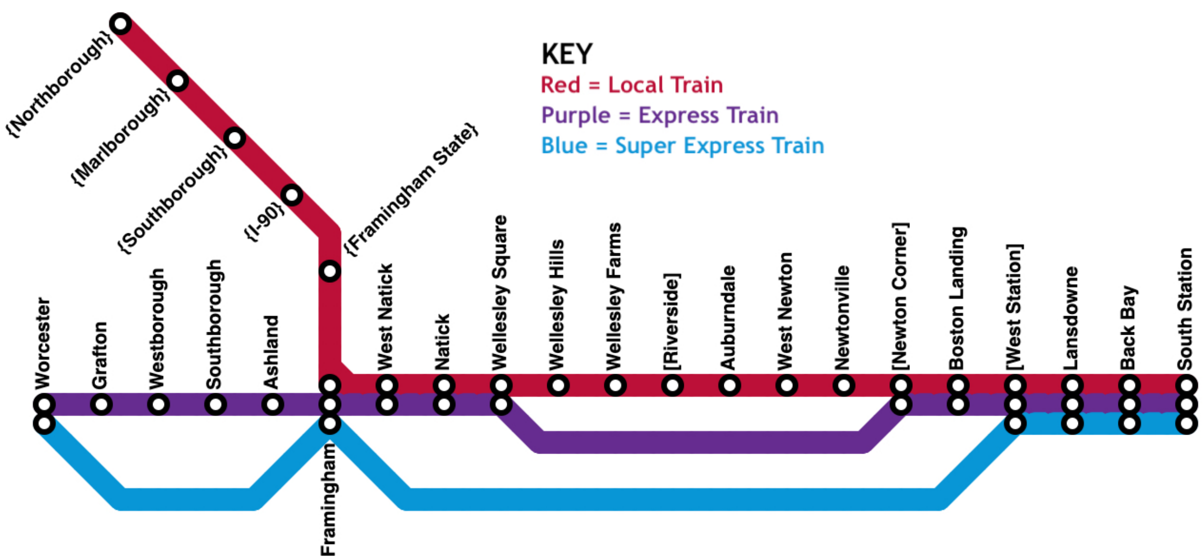


Figure 4.37. Four-Track Station Service Pattern Map. Station names in square brackets indicate that the station does not currently exist but has been proposed by either TransitMatters or the MBTA. Stations in curly brackets are suggested by us.

The four-track station service pattern provides 7.5-minute frequency both within Boston and between Wellesley Square and Framingham. Framingham and Worcester each get fast service from a blue super express service that simultaneously provides a cross-platform transfer between the red local and blue super express lines. This also enables passengers from Worcester to travel to Newton quickly and passengers from Framingham State to transfer to the express train without delay. The only disadvantage is that passengers transferring at Framingham between train lines would be less likely to stop at local businesses, and passengers from stations between Worcester and Framingham (such as Grafton and Ashland) would have to wait approximately 7.5 minutes at Framingham to transfer to stations on the red local line.

The main constraint to scheduling with this four-track service pattern is the capacity for trains at South Station. Currently, South Station is equipped to handle eight trains per hour per direction (tph/d). The best practice for scheduling out of stub-end terminals is for each line to have dedicated platforms at the terminals for ease of riders and to prevent scheduling issues across multiple train lines in the case of delayed trains. Assuming electrification and the use of EMUs, each platform can accommodate four tph/d, and there are two platforms available at South Station for sole use of the Framingham-Worcester line (TransitMatters, 2019). The reason for this is that trains require time to turn around; in order to reverse the train, the train operator has to physically move to the opposite side of the train.

There are four ways to accommodate this schedule of running three service patterns:

1. <u>Alternating the express and super express</u>: The red local line would run every 15 minutes (4 tph/d), and the purple express and blue superexpress would each run every half an hour (2 tph/d each). However, stops between Worcester and Framingham would receive less service. This may be a confusing service pattern for riders, and we do not recommend it.
2. <u>Sharing a third platform with Amtrak trains</u>: Assuming the red local and purple express trains each run at 15-minute frequencies (4 tph/d), it is possible for super-express trains running at 30-minute frequencies (2 tph/d) to share a platform with Amtrak trains with relatively minimal interference to scheduling, particularly given optimizations to South Station capacity as suggested by TransitMatters, but this does introduce dependency between Framingham/Worcester and Northeast Corridor trains that would not otherwise exist; a schedule change on one line could affect the other line.
3. <u>Reverse trains faster</u>: The main reason trains take so long to reverse at South Station is because the conductor has to walk outside to the opposite end of the train.

Hydraulic brakes, which are utilized on the trains, also require a brake test. Instead, however, additional train conductors can be waiting at the platform and can immediately perform the brake test and turn the train around, which would increase capacity at South Station.

4. Build the North-South rail link: Trains would not have to turn around if they simply went through the proposed North-South rail link. If the red local and the purple express went through the rail link, that would free up enough capacity at South Station for the other line(s).

4.12.3. Timetable Possibility for Extreme Off-Peak/Minimum Service

At extreme off-peak hours, such as after midnight or on holidays, this schedule (seen in Figure 4.38) may be desirable to provide minimal service to all stations along the line accessible by all passengers.

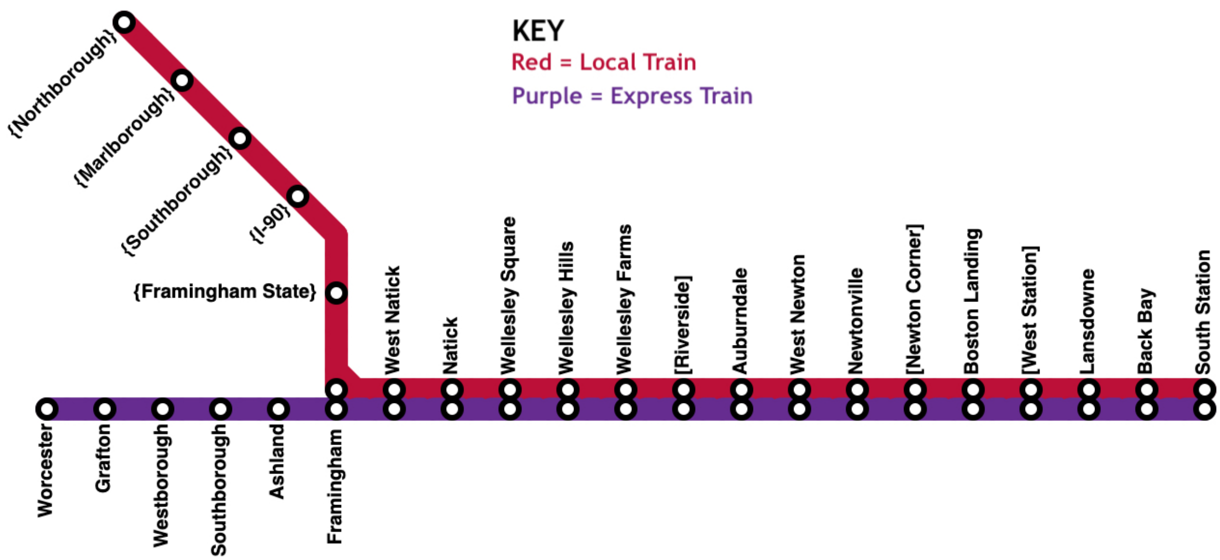


Figure 4.38. Minimum Service Pattern Map. Station names in square brackets indicate that the station does not currently exist but has been proposed by either TransitMatters or the MBTA. Stations in curly brackets are suggested by us.

Chapter 5: Design Options & Recommendations

An important component of a design project like this is presenting and evaluating the benefits and drawbacks of various designs. To create these designs, we relied on a lot of the knowledge we learned in *Chapter 2. Background* and the analyses we conducted in *Chapter 4. Findings*. Additionally, in terms of the technical aspects of the station design, we heavily relied on design guides.

Specifically, for the "Basic Design" (seen in *Chapter 5.2*), the Massachusetts Bay Transportation Authority (MBTA) Commuter Rail Design Standards Manual: Stations and Parking was heavily used for dimensions such as station platform height, staircase and ramp dimensions, and distances between platform and railroad track (MBTA, 1996).

The second, long-term design option was influenced by the Regional Transportation District (RTD) Commuter Rail Design Criteria to provide design guidelines for Electric Multiple Units (EMUs) or electric trains, for which the MBTA does not currently have design guidelines. It is notable that both rail design manuals might be conservative as neither of them will perfectly apply to EMUs that the MBTA will purchase in the future.

As noted in *Chapter 2.7*, TransitMatters notes that the MBTA follows outdated speed limits on their railroads, meaning that trains run slower on certain sections of track that could handle faster-traveling trains due to outdated regulations (TransitMatters, 2019). Additionally, the design manuals conflict. For example, the RTD Design Criteria require wider platforms than the MBTA Design Standards, and the MBTA standards sometimes follow older federal standards that have since changed (Regional Transit Division Denver, 2009; MBTA, 1996). Therefore, these guides are solely for an initial design to imagine what the layout would look like and would require more detailed engineering based on the EMUs that the MBTA intend to purchase.

Throughout this chapter, we will briefly document some of the design options we evaluated but determined were infeasible. We will also provide thorough descriptions of the two designs we evaluated and deemed plausible options. We will explain the benefits and drawbacks of choices made within each of the designs to provide fair analyses of both.

Chapter 5.1. Designs Not Considered for Evaluation

Before evaluating any potential design options, we created a list of all possible designs that could improve the Framingham Commuter Rail station. Originally, five options were considered; however, it was determined that, for the sake of simplicity, only two would be closely evaluated (as seen in *Chapters 5.2 and 5.3* below).

1. "Basic Design" consisting of minor improvements to connections within and to the station.
2. "Grade Separating Both Passenger and Freight Rail" which calls for the elevation of both passenger and freight rails 28 feet above the ground below.
3. "Expansion of the Existing Station" that involves adding additional tracks and reconfiguring the existing station.
4. "Elevated Passenger in Place" in which the station would be located in its current location but elevated above the ground.
5. "Long-Term Design" that consists of demolishing the existing station and rebuilding it elevated in the air on the east side of the Route 135-Route 126 intersection.

The two options evaluated in-depth in the following sections are two extremes of the many possibilities for improvement at the Framingham Commuter Rail station. On one end, the design option discussed in *Chapter 5.2* majorly focuses on minor improvements to the station, such as high-level platforms and the inclusion of a small bus drop-off area. Complete grade separation — which is a very costly, large-scale project that will require a lot of coordinated efforts for more thoughtful design and implementation — exists on the opposite end of the design spectrum, as discussed in *Chapter 5.3*.

Chapter 5.1.1. Grade Separating Both Passenger and Freight Rail

One design option that was decided against included grade separation of both passenger and heavy freight rail. Compared to the four percent slopes possible by electric rail (Regional Transit Division Denver, 2009), freight rail requires a shallower elevation of 1.5 percent to successfully elevate to the grade-separated height, requiring much longer elevated structure (MBTA, 1996).

Heavy freight trains travel at much slower speeds and are much heavier, so the bridge created for grade separation would have to be much stronger to withstand the weight of the cars, requiring larger foundations, more materials, and thicker or more frequent supports. The materials required for this would need to be of better quality, which would also make grade separation in this case much more costly.

There are ways of making freight climb four percent grades. Using basic physics (potential and kinetic energy calculations not counting friction), a train traveling at 26.8 MPH can travel uphill to a height of 24 feet with its engine off, assuming no friction (see Appendix B). Additionally, a long freight train could travel uphill on a four percent grade for 675 feet if it is more than 1,800 feet long and the rest of the train is on flat track because the train in its entirety would be traversing an average 1.5 percent grade. Perhaps more simply, using light freight — meaning filling up freight cars with less materials — might be an easier alternative, since there would be no need for complex grade considerations or extra structural support (Clem, 2009).

The complex geometry of the wye intersection near the existing Framingham station also makes the grade separation of freight rail extremely difficult. As seen in Figure 5.2 below, the tracks surrounding the Framingham station to the north form a triangular shape, creating two interlockings (the points where the tracks in different directions join each other) on either side of the station. Grade separating the station in this location is difficult as all the tracks would need to be elevated — providing for a much more expensive project — or a combination of tracks on the ground and elevated tracks would have to be designed, which might be very complicated engineering.

As it stands today, freight trains typically do not travel east toward Boston, so there is little need for heavy freight infrastructure in that direction (Personal Communication with Jay Flynn, 2022). Most freight trains currently travel north, south, and west, as seen in Figure 5.1 below.

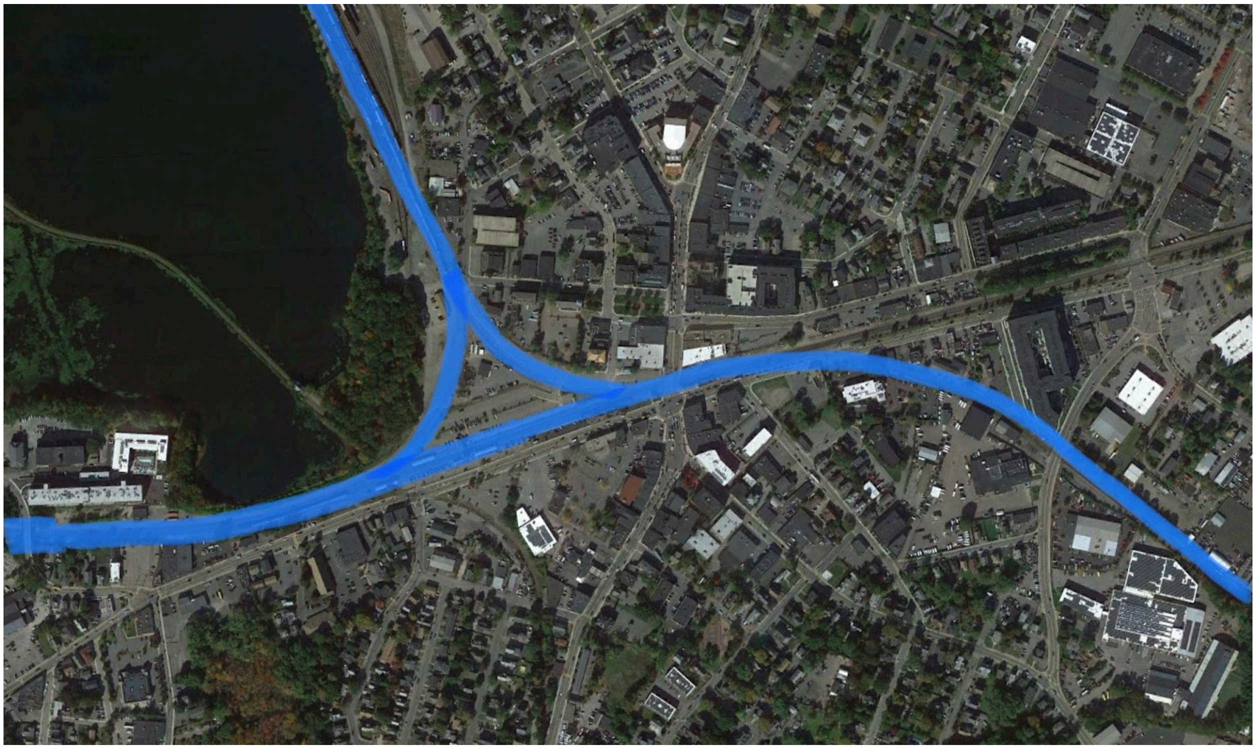


Figure 5.1. Common Current Routes of Freight Trains

Freight trains in Framingham only travel through the wye-intersection three times a day at maximum and typically are at non-peak travel hours (Personal Communication with Jay Flynn, 2022). With this information noted, it would be pointless for freight rail to be elevated in addition to passenger rail as complex geometry would need to be designed around and costs would be exorbitantly high for such little use. Freight trains can easily use the existing, at-grade infrastructure to travel north and south along the existing spurs, and due to their low frequency, they would provide minimal interruptions to the vehicular traffic in downtown Framingham.

Chapter 5.1.2. Expansion of the Existing Station

Another design option considered expanding the existing station to include four tracks, which would enable express and local service along the line with easy transfers at Framingham. This option was eventually ruled out because of a few reasons.

Firstly, the station would remain at grade, meaning the vehicular congestion in downtown Framingham would continue to exist and likely get worse, as increased train service triggers the grade crossing barriers and prevents downtown local travel. This design option, while greatly benefiting the frequency and capacity of trains on the line, would have detrimental impacts to the flow of downtown, greatly impacting businesses and hindering the economic expansion of Framingham.

Additionally, expanding the number of tracks at the existing station would require removal and relocation of many parking spaces in the north and south parking lots. It would also require the station to be completely reconfigured as the existing platforms are single-sided, meaning they are not designed to service tracks on either side (like a central platform would), and tracks would need to be rearranged around the historic train station.

In the case that a spur line toward Framingham State University is constructed, it would also make passenger transfers inconvenient. The location of the existing station would make it impossible for trains to stop at the current station and then travel north. Passengers wishing to travel northward to Framingham State would have to walk across the existing parking lot to a secondary station that would service trains traveling solely along the spur. This new station would have to be erected on part of the complicated rail intersection as seen in Figure 5.2 below.

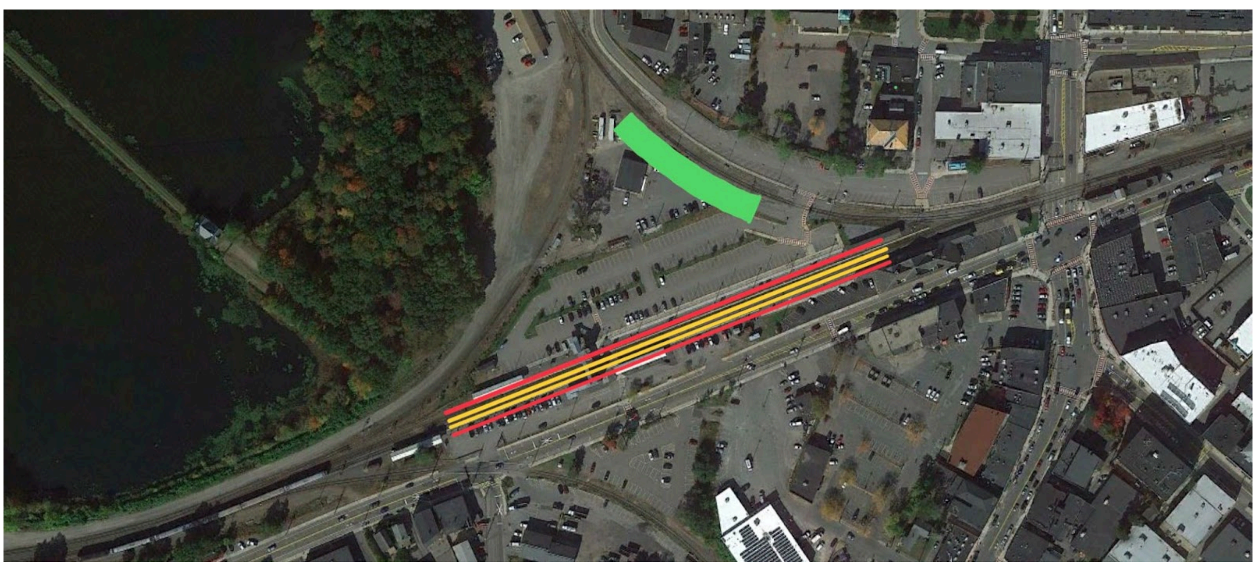


Figure 5.2. Potential Existing Four-Track Station Layout. The yellow lines represent the existing tracks while the red lines represent potential additional tracks. The green rectangle represents the secondary station for the potential Framingham State spur.

Additionally, if the northward spur is used for passenger rail from Boston to Framingham State, there would be serious operational conflicts for the train system.

As shown in Figure 5.3 below, if the tracks are not grade-separated, there will be a continuous conflict at the intersection: westbound trains to Worcester and eastbound trains from Framingham State to Boston cannot travel simultaneously through the intersection. As mentioned in *Section 4.11.2. Interlockings*, only one train can be in the interlocking at a time, and this could cause operational conflicts. While this could be addressed through scheduling, it still introduces a dependency between the lines.

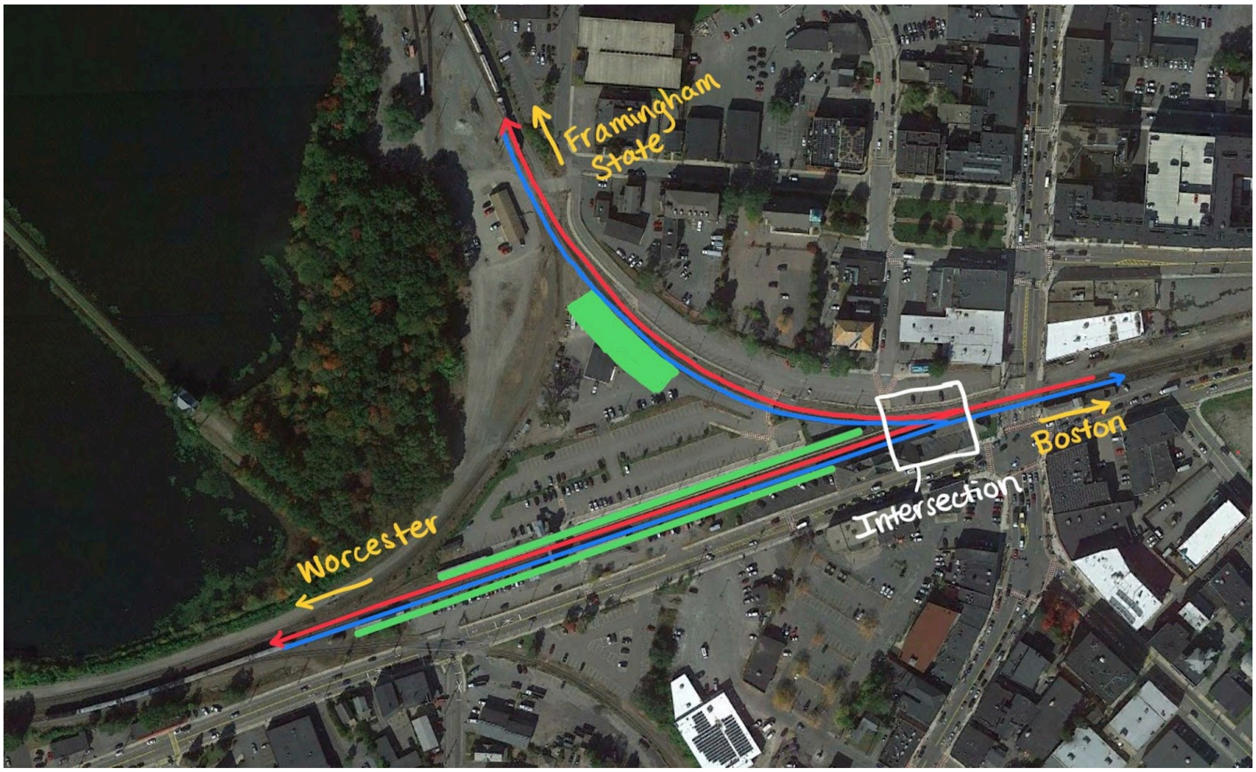


Figure 5.3. Operational Conflicts of Railroad Tracks. Red lines represent westbound tracks, blue lines represent eastward tracks, and green represents station platforms.

Ultimately, it was determined that expanding the existing station provided too many drawbacks for it to feasibly be considered. Essentially, the existing station can have minor improvements, or should be replaced entirely, as described in *Chapters 5.2 or 5.3*.

Chapter 5.1.3. Elevated Passenger Rail in Place

This design option considered the possibility of grade-separating the existing Framingham Commuter Rail station but keeping it in the location it is in currently. This option was quickly determined to be infeasible due to many of the reasons discussed in the previous section. Every grade-separated station design we considered would include four tracks to allow for easy cross-platform transfers between lines. As mentioned in the previous section, the complex geometry of the wye intersection would make this impossible, completely defeating the purpose of the four-track station.

Since the station that currently exists would need to be demolished, there is no reason to grade separate the station in its existing location if it will cause many issues with cross-platform transfers. This option was quickly deemed infeasible as the station should be moved to its most ideal location if the existing station is being demolished anyways.

Chapter 5.2. Design Option #1: Basic Design

The first design option — known as the "Basic Design" — mainly proposes accessibility improvements around the Framingham train station and within downtown Framingham. Because a lot of this design recommends relatively minor improvements in comparison to the long-term design (as seen in *Chapter 5.3*), the intention of this design option is to provide a cheaper, short-term alternative to the large changes seen in the later design while attempting to greatly improve ease of transportation and vehicular circulation given the current infrastructure.

As part of this design, it is recommended that the current two-track station be maintained with minor improvements being made to greatly improve train efficiency and access directly within the station; this means that the station would be located in the same place as it currently is and would remain at grade. A rendering of the potential station and parking lot design can be seen in Figure 5.4.

Figure 5.4. Aerial View of Design Option 1

Most notably, high-level platforms are recommended to be constructed, spanning the entire length of the existing station. This is to provide for efficient boarding at every entrance along the entire length of the train, shortening the amount of time the train has to stop at the station. It also provides an accessibility benefit as climbing up steep train steps at a train car entrance would not be required by passengers, which would also cut down on the station stop time. These platforms need to be four feet high, approximately 750 feet long, and 18.5 feet wide. The centerline of the railroad tracks should be 8.5 feet from the edge of the station platform (MBTA, 1996).

Updated canopies, following a design similar to those found at the newly constructed Boston Landing station on the Framingham-Worcester line, are proposed to be installed to provide protection for those waiting. These are different from the canopies currently found at the station (Figure 5.5).

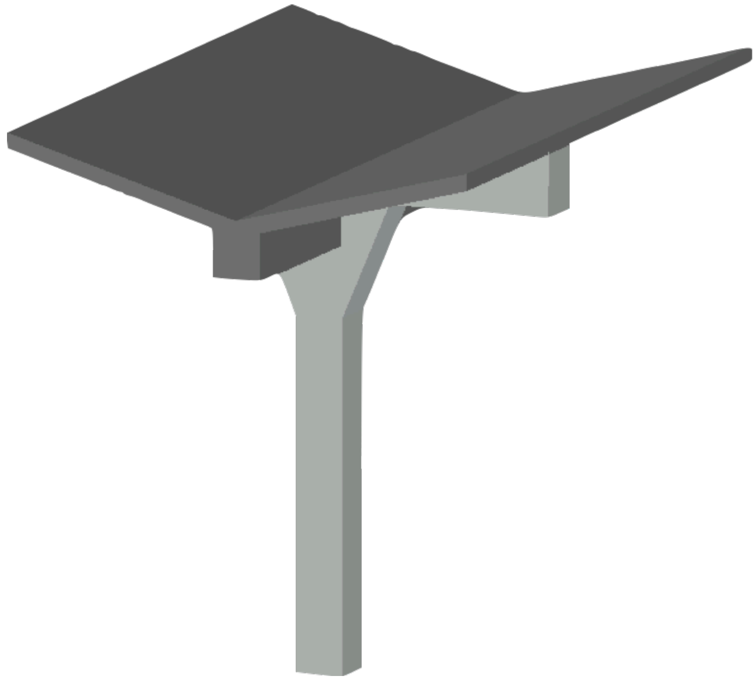


Figure 5.5. Design of Canopy Covering

The canopies are suggested to be 14 feet tall and 14.5 feet wide. The roof pieces are suggested to be pitched upwards at an approximately 17-degree pitch. The new canopies should be shaped more like a "Y" compared to the existing ones, allowing for water to drain into the centerline of the canopy and down through drainage pipes alongside support columns for the structure. Passengers would not need to worry about being drenched by excess runoff during storms as most of the rainfall would be caught by the canopy and properly drained. With the current design, water drains off the sides of the canopy, offering a greater chance for waiting passengers to be covered in water when they move in and out of the protection it offers.

Access points, in the form of ramps and staircases, to enable passengers to get up to the station platform are recommended to exist in three pairs on either side of the station. All six staircases would follow the same design as seen in Figure 5.6. Staircases need to be four feet high and 10 feet wide. Railings need to be 1.5 inches in diameter and should be located 34 and 19 inches from the base of each staircase. Each landing of the staircase should rise 6 inches from the previous one.

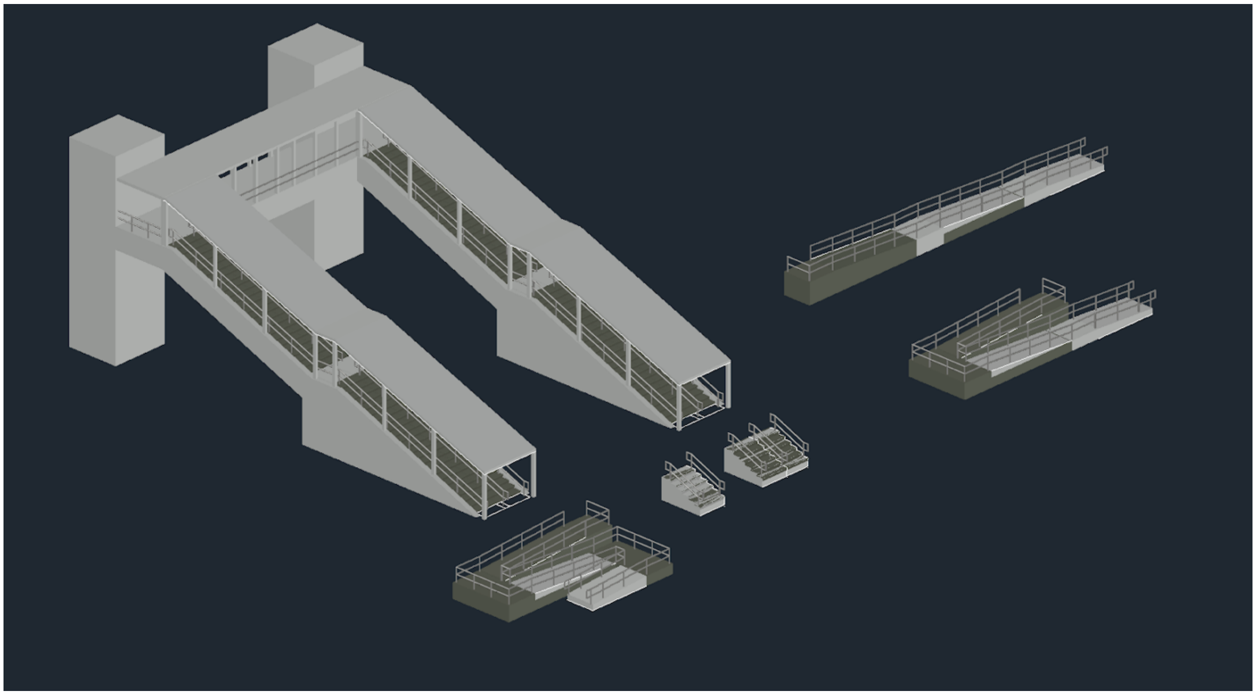


Figure 5.6. Designs of Ramps and Staircases

Access between the two platforms of the station is recommended to be connected by the bridge already found at the station, as seen in the above figure. However, this would need to be modified to ensure that the staircases and elevators of this bridge service the two high-level platforms as opposed to the ground level of the parking lot as it currently exists.

Chapter 5.2.1. Walking and Biking Improvements

Improvements should be made to the overall walkability and bikeability of downtown Framingham, especially in the area closest to the station. As seen in Figure 5.7 below, many new walking and biking paths are proposed to provide for better non-vehicle connections within the downtown area.

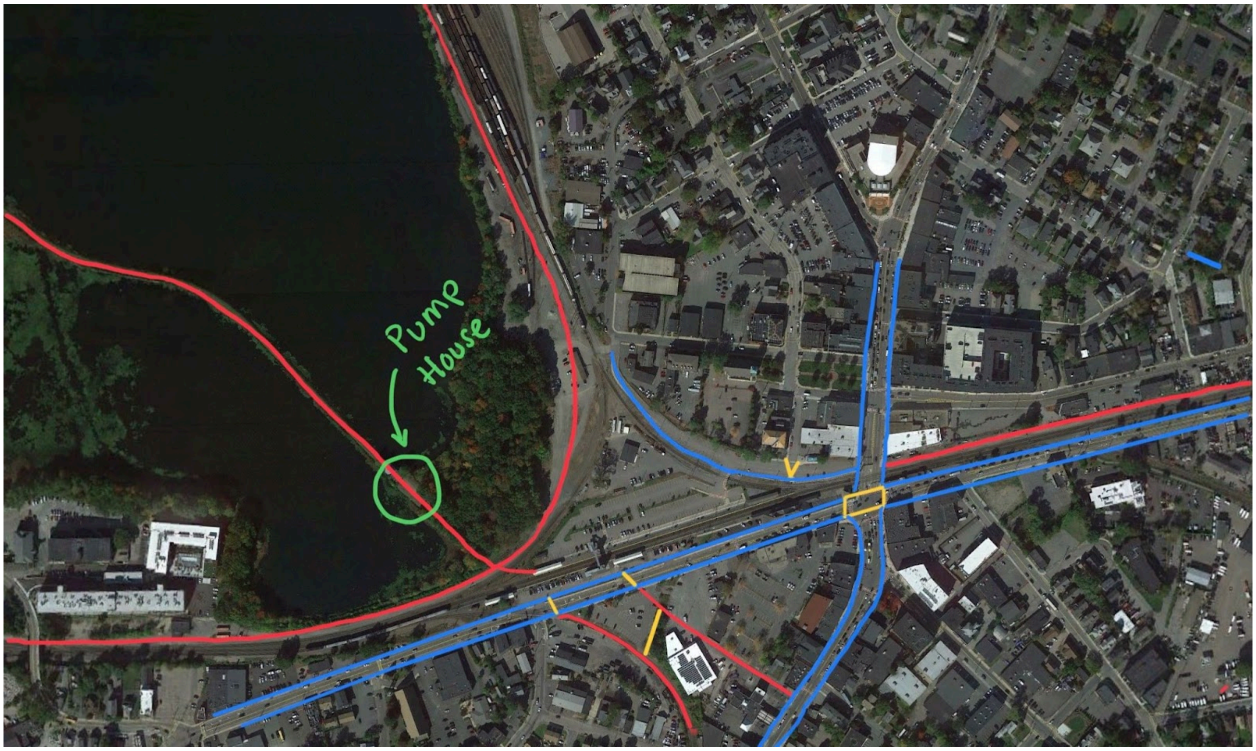


Figure 5.7. Current and Future Biking and Walking Paths. Blue lines indicate existing sidewalks. Red lines indicate potential walking/biking paths. Yellow lines indicated crosswalks (Google Maps, n.d.).

A shared-use path for walkers and bikers needs to be added along the Sudbury aqueduct to better connect northwestern Framingham to the commuter rail station. The pump house (indicated by the green circle in Figure 5.7) should be removed to make this connection possible. Additionally, pathways toward the immediate west along the railroad tracks are proposed to connect some of the new apartment developments in that area. Pathways northward (as proposed in the MAPC Trail Map (Un, 2010) alongside the rails will be added to better serve North Framingham. Looking south, paths should be implemented alongside the existing rail spurs to reach communities on the southern side of the station. Paths should also be added along the rails located east of the station. Sidewalks along Route 135 and Route 126 are major walking corridors that lead to the Framingham station currently.

To encourage use of these new paths (especially for bikers), the following improvements should be made:

1. Adding secure bike locks and bike lockers (including indoor spaces for bike parking) with charging capabilities for e-bikes across the city and, most especially, at the station.
2. Implementing a bike-share program, including bicycles accessible to people with disabilities, e-bikes, and cargo bikes (Rudick, 2019).
3. Making bike stores, repair shops, rentals, repair tools readily available at the station (Bay Area, n.d.), both by repurposing parts of the train station and by encouraging and implementing these services throughout Framingham.
4. Permitting bikes on the commuter rail, especially during peak hours, unless absolutely unfeasible.
5. Educating businesses and deliveries and supporting pilots to use e-cargo bikes.

The addition of these amenities around the station and within downtown Framingham, along with the added paths as described earlier, would make biking a more favorable option, encouraging more residents to use this mode of transportation in place of a vehicle if they live reasonably close to the station. Additionally, residents of Coburnville — a large neighborhood on the outskirts of Framingham — might be more inclined to bike to the station and the downtown as well if the path and other amenities are extended along the train line to there, potentially increasing usage of the station and ridership on the Framingham-Worcester line, and visitors to the downtown.

Chapter 5.2.2. Bus Improvements

Included in this design, as seen previously in Figure 5.4, a small busway is recommended, being incorporated into the modified northern parking lot design. A closer look at this area can be seen below in Figure 5.8.

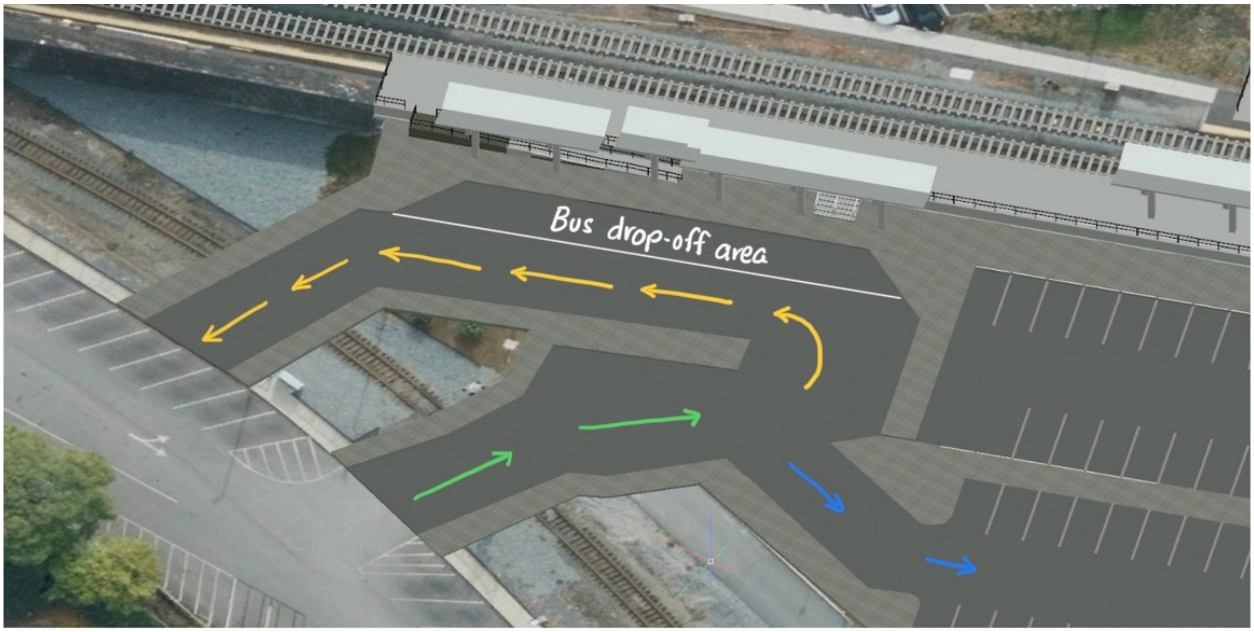


Figure 5.8. Close-up Aerial View of Bus Circle. Green arrows indicate shared use between vehicles and buses; yellow arrows indicate bus flow; and blue arrows indicate vehicle flow.

Vehicles looking to park and buses picking up and dropping off passengers would share an entrance while buses would have a dedicated exit onto Franklin Street. Buses would go to the left toward the bus circle while vehicles would go right toward the parking lot. Buses would have plenty of room to make the tight turn, as the turning radius of a standard bus requires 21.5 feet; buses would have a total of 66 feet to turn around (MBTA, 1996). Approximately two buses would be able to simultaneously pick up and drop off passengers. It is important to note that this would not have the capacity to replace the Blandin Hub that is located near the station; the implementation of this pick up and drop off area for buses is simply to provide more convenient connections between buses and trains. Since the scope of this project is not focused on bus scheduling, careful thought was not dedicated to proposing alternatives; however, it is recommended that bus and train schedules more closely align to create a multimodal hub at Framingham station.

Located on the sidewalk in front of the bus area, canopies in the same style as the ones found on the train station platform are recommended. Bus passengers would wait under these canopies on a raised sidewalk that extends the entire length of the station. This waiting area would also be serviced by a ramp and staircase leading up to the station platform.

Chapter 5.2.3. Effects on Vehicles

Because grade separation is not included in this design option, the bottlenecks caused by the at-grade rail crossings at Route 135-Route 126 and Route 135-Bishop Street intersections would not be eliminated; however, because of the emphasis on making Framingham station a multimodal transportation hub as part of this option, the congestion may naturally lessen as individuals in the local community opt to walk, bike, or take the bus to the station.

Even with this in mind, it is likely that train service frequency would increase whether or not improvements are made to the station. 15-minute service frequency with a two-track station is not as likely, but it is expected that trains will stop at Framingham more often in the future. Because of this, crossing guards will come down more often at the intersections mentioned previously, especially during peak commute times, meaning that vehicle congestion in the downtown area will be negatively affected. This will not be advantageous for businesses located downtown as vehicle congestion may turn away potential customers; however, with the improvements to other forms of transportation, this may not be as much of a concern.

Because of the added bus pick up and drop off area in the northern parking lot at the station, the total number of parking spaces available to commuters will be decreased. Today, 167 spaces can be found at the Framingham train station. The bus circle will take the place of 14 spaces, leaving 153 spaces for vehicles to park.

Chapter 5.2.4. Necessary Zoning Changes for Better Developments

Zoning ordinances must be reviewed to allow for transit-oriented developments close to the station, and closer to the street. The current large parking lots around the station take up a lot of space and could be repurposed into commercial buildings, residential buildings, or a parking garage which would take up less space than a parking lot. The parking requirements, height, density and setback regulations near the station makes it more difficult to build developments and commerce around the station. New developments require large parking lots regardless of the mode of travel people actually use and existing public parking, require empty space on property edges, and prohibit intensive developments that would provide more jobs or house more people.

To enable economic growth from the train station, we recommend a zoning overlay district applying for a mile walkshed around the train station that reduces or eliminates these requirements in order to decrease congestion, encourage new developments, and enable more forms of transportation for Framingham's Zoning Ordinance to meet its stated goals. Framingham can consider adopting ordinances like Boston's parking requirements for residential buildings that are based on the Floor-Area Ratio (FAR) (as mentioned in *Chapter 4.12*) and number of units per building in a way that encourages high rise buildings — they take up less space and have more housing and jobs. High rise buildings also provide larger tax revenues in a smaller area. Boston has also removed parking requirements for certain developments, such as affordable housing.

Chapter 5.2.5. Fare Policy

As found in *Chapter 4.9.2*, costs of travel by train are expensive. While the cost of travel by car from Framingham to Boston is $26.91 after accounting for gas and maintenance costs, the perceived cost to a car owner may be just the cost of gas, which is $6.20. To encourage travel by public transit, a round-trip ticket (which would only be valid for one person) should be at most the cost of gas for a similar car journey. In that case, a one-way ticket from Framingham to Boston should cost at most $3.10. Additionally, transfers to the MWRTA, other MBTA services, and future bikeshare (if implemented) should be free or discounted.

Chapter 5.3. Design Option #2: Long-Term Design

This design option is much more involved than the design option described in *Chapter 5.2*. Known as the "Long-Term Design," this option involves grade separation, which is a concept that was thoroughly investigated in *Chapter 4.11*. This design is intended to provide Framingham with an opportunity to completely transform its downtown area, mostly by eliminating its two at-grade rail crossings and hopefully encouraging more tourism with the train frequencies and transfers possible by the proposed station design.

A rendering of this design option can be seen in Figure 5.9 below. As noted, a number of differences from the previous design option (as discussed in *Chapter 5.2*) are present and will be discussed more in-depth in the coming sections.

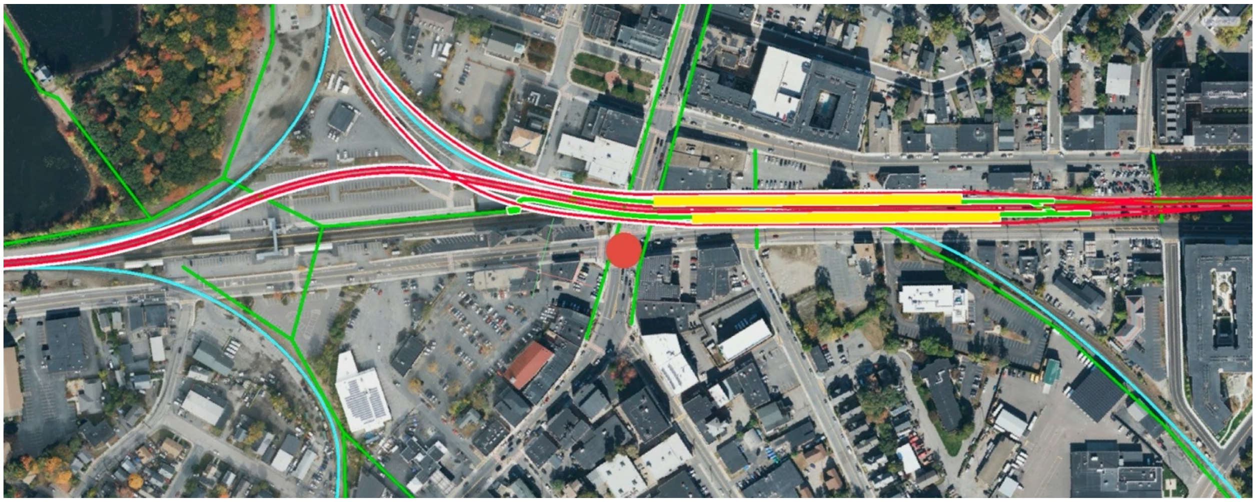


Figure 5.9: Design Plans of Station and Grade Separation. Green shows paths (thicker if above-grade), yellow indicates platforms, red indicates passenger tracks, and cyan indicates freight tracks.

Chapter 5.3.1. Station Location

In the case of the grade separation, the existing station west of Route 126 will be destroyed. A new station should be placed east of Route 126 street to minimize cost, enable efficient train operations and maximize access. This requires less elevated structures as the tracks will be able to descend immediately to ground level west of Concord Street rather than stay in the air for the station layout. Trains going north to Framingham State on the spur will be able to use a single station or shared platforms with trains going to Worcester (as discussed more in-depth in *Chapter 5.3.4*). The station would also be located directly in the heart of downtown (Figure 5.10), which is closer to greater amounts of businesses and residents — a much more desirable location than the current one next to Farm Pond. Moving the station also makes the train station closer to the Blandin Hub, allowing for easier connections from the buses and trains, creating a multimodal transportation system.

Figure 5.10. Proposed New Location for the Elevated Train Station. This shows a new apartment building on the right side as well.

Chapter 5.3.2. Grade Separation Profile

The clearance for freight trains is 22.5 feet, and the clearance for passenger rail is 18 feet. Tracks that travel above ground-level freight rail tracks need to be elevated 24 feet in the air to account for the clearance requirements as well as approximate thicknesses (which may vary due to materials utilized) of support structures. In the same scenario but with passenger rails on the ground, the elevated tracks must be constructed approximately 19 feet in the air (Figure 5.11).

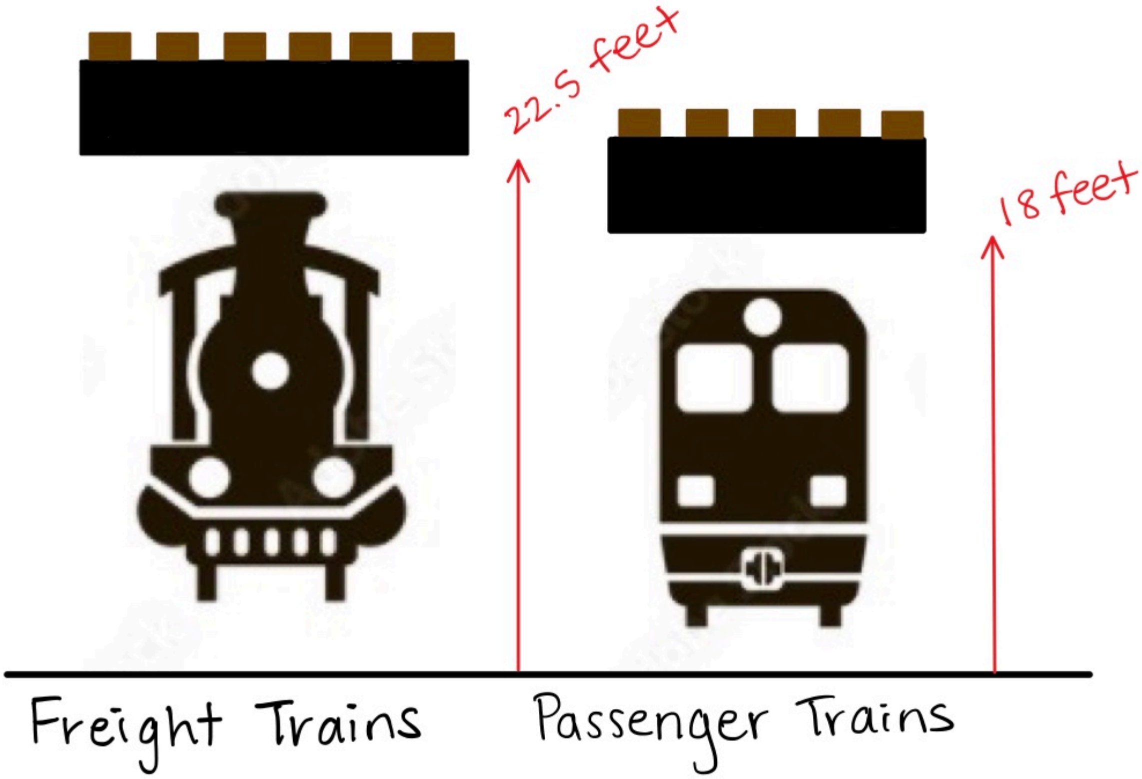


Figure 5.11. Comparing Elevated Rail Heights for Freight and Passenger Trains

The elevation of the tracks would occur between slightly west of the Route 135-Route 126 intersection and slightly east of the Route 135-Bishop Street intersection. Starting from the west, the grade separation would begin ascending near Control Point 21 (the railway intersection crossing Route 135 slightly south of the existing station); remain at an elevated, zero-percent slope from the Route 135-Route 126 intersection to the Route 135-Bishop Street intersection; and then begin its descent (Figure 5.12).

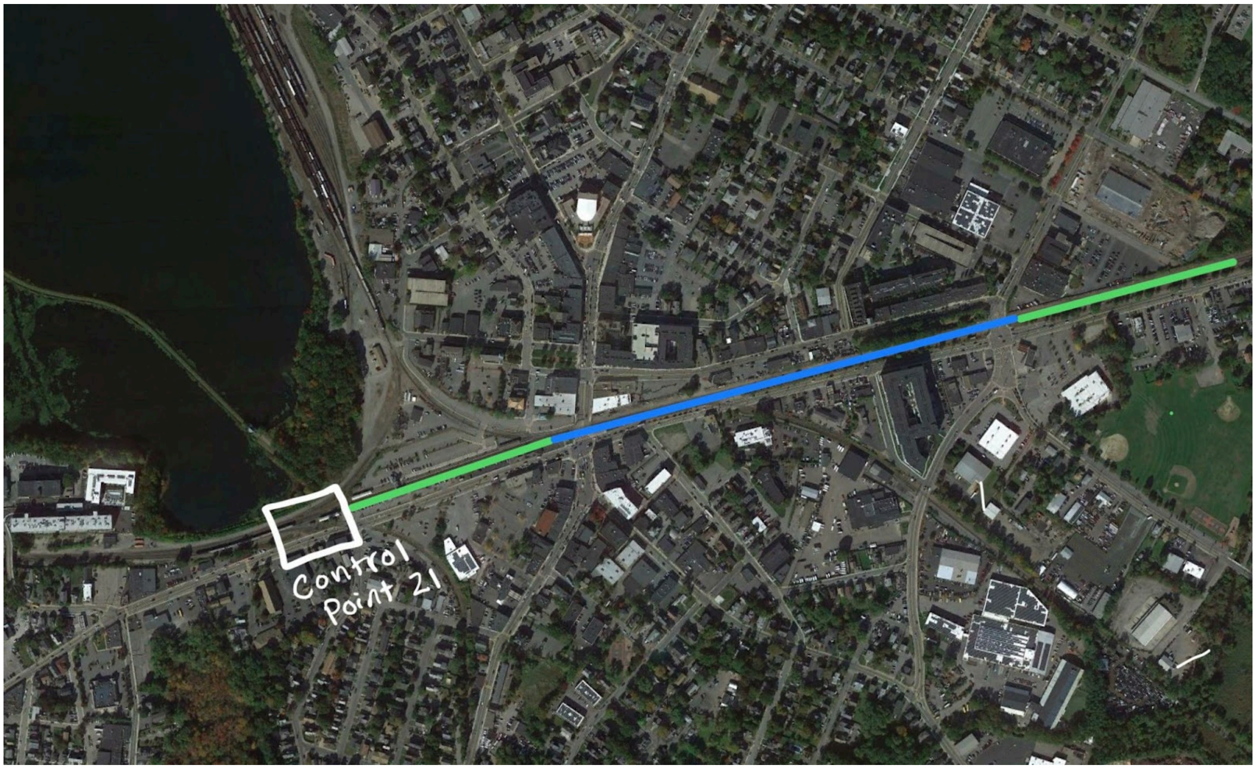


Figure 5.12. Grade Separation Layout. Green lines indicate 1,000-foot track elevation sections and blue lines represent elevated, zero-percent slope track sections.

The tracks should rise to a height of 24 feet over a 1,000-foot distance as seen in Figure 5.13. As an initial design, the first 360 feet of that would be a curve transitioning the tracks from a zero percent slope to a four percent slope (designed for 50 MPH) and the rest of the slope would be flattened from four percent to zero percent, descending down to a height of 16.8 feet over 840 feet longitudinally (designed for 65 MPH). It follows vertical curve requirements according to RTD design standards, which permits a maximum of a one percent grade change over 90 feet at 50 MPH (Regional Transit Division Denver, 2009). The slope can be made more gradual than this to increase permissible speeds, particularly as the train accelerates down the slope; however, this would increase costs.

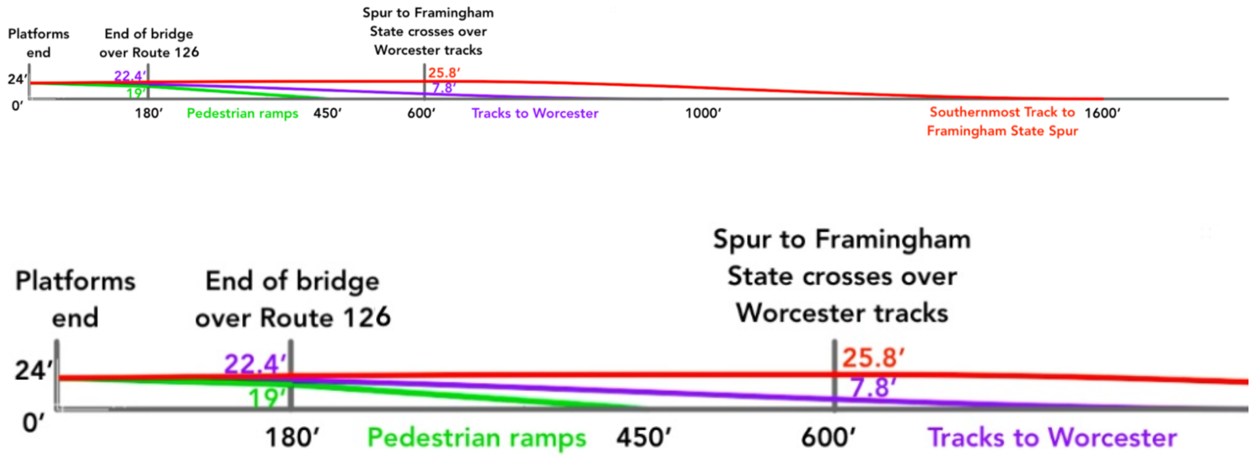


Figure 5.13. Elevation of Tracks Going West from Grade Separation (cross-sectional view). The top picture illustrates the entire elevation of the track while the bottom picture focuses in on the more complicated layouts of track toward the upper end of the elevation.

As shown in Figure 5.13, The southernmost track curves up to the north in the direction of Framingham State University while the westbound local travels on it. It will rise up for four feet to go over the tracks going to Worcester and then descend down to be at-grade, avoiding operational conflicts and enabling cross-platform transfers.

This design ensures that there are no conflicts between train tracks and that cross-platform transfers occur between local and express trains as described in *Chapter 4.13. Potential Timetables for the Framingham-Worcester Line*. Note that west of the station, there are no switches to transfer between different platforms, as they would either require the construction of additional ramps (which would be costly) or prevent a grade-separated seamless pedestrian connection from paths to the station.

<u>**Chapter 5.3.3. Walking, Biking, Bus, and Vehicle Connections**</u>

The grade-separated designs enable better walking, biking and bus connections. As seen in Figure 5.7 in *Chapter 5.2.1*, similar walking and biking paths are recommended to provide connections to many different areas of downtown Framingham. However, with this design option involving a different location of the station, slight modifications will have to be made, as seen in Figure 5.14 below.

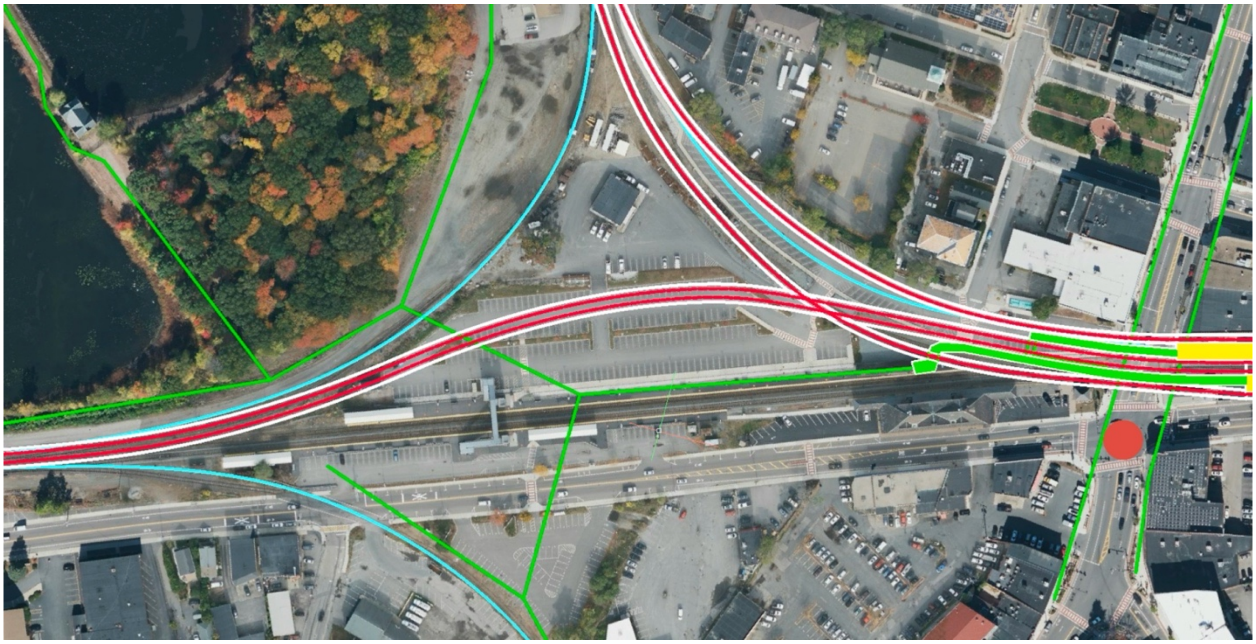


Figure 5.14. Walking and Biking Connections Around the Station. Thick green indicates the ramps to the station.

Most importantly, pedestrian pathways are grade-separated as well (shown in thick green in Figure 5.14), making an easy walk up the station that is also ADA accessible (maximum slope of eight percent with five-foot flat portions or landings spaced 30 feet apart along the slope) (MBTA, 1996), with a resulting average grade of 6.86 percent.

Just like with the first design option, a pathway along the Sudbury Aqueduct is recommended as well as new pathways along the existing rail lines. The existing walking and biking path toward Blandin Hub would be maintained. The sidewalks on Route 135 in front of the proposed station would serve as walking connections while the separated bike lanes on Route 135 in front of the proposed station would serve bicycles.

Additionally, grade-separation enables new neighborhood connections — pedestrians can walk straight under the tracks at any point between Concord Street and Bishop Street. This would reconnect the area and enable more pedestrian access to downtown. Collaboration with nearby businesses is necessary for this, but that should be very feasible, given that more pedestrians would be a benefit for the businesses. For example, Marble and Grant Street can be reconnected to form a seamless walking and biking route, and this path is marked on previously shown plans (building a roadway is possible but would require much more private land, increase costs, and decrease developable area underneath the station).

Figure 5.15. Grade-Separated Track Layout on East Side of Station. Green lines show paths, red lines show tracks. The thick green paths are elevated ramps from the ground to the station. The green line to the bottom-right corner goes southeast to the MWRTA bus hub. The green line in the top-right corner connects Marble and Grant street with a pedestrian walkway.

Buses for the proposed station would drop off and pick-up passengers at the Blandin Hub (current MWRTA bus hub), which is located close by and is served by a walking and biking path, as mentioned earlier. Transfers between buses and trains would be relatively easy as passengers would only need to take less than five minutes to walk from the station to the bus station or vice-versa. Passengers can also use bus stops on Bishop Street, Concord, and Waverley street for a faster transfer.

Vehicles would greatly benefit from the grade-separated design. Drivers would no longer have to worry about the crossing guards coming down at the Route 126 and Bishop Street intersections. This will lead to better circulation on the roads and help solve Framingham's congestion problem, especially in morning and evening peak hours. These two intersections, which both have high crash numbers, could see a decrease in the number of crashes with better circulation.

Chapter 5.3.4. Four Track Station

Grade separation enables more frequent train service that will benefit downtown Framingham, and the train station design should enable efficient service by local and express trains as well as trains traveling north along the spur toward Framingham State. A four-track station with two island platforms enables up to four trains to stop simultaneously at Framingham. This can enable instantaneous cross-platform transfers between local trains and express trains; passengers simply cross the platform or change platforms to get on a new train. This also adds more space for irregular Amtrak trains to stop at Framingham. Because of this setup, train operations are therefore smoother and less constrained, with easier transfers and extremely short waiting times.

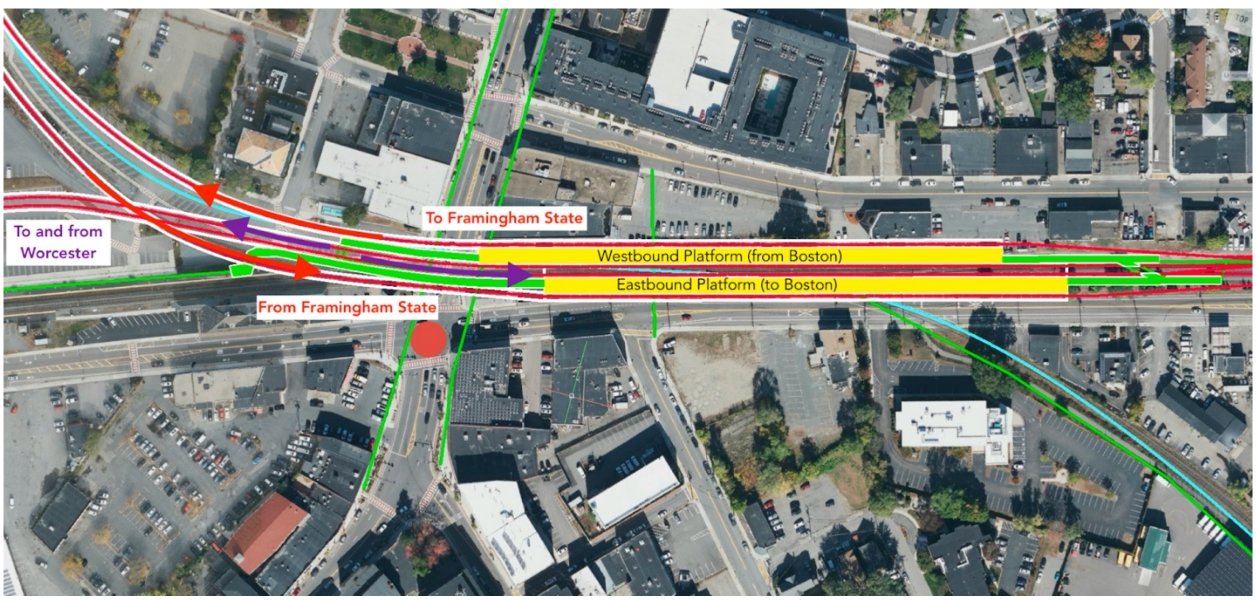


Figure 5.16. Platform Diagram for Four-Track Station. This shows passenger train operation.

The right-of-way of the train line, while wide enough for four tracks, is not wide enough for the four-track station because of the additional width of the platforms. However, the station can be elevated and hang over Route 135 below without interruption to the current street layout or flow of traffic. Additionally, with the exception of the historic train station, the buildings nearby are shorter than the grade separation. It is likely simpler to just build the station with the southernmost track overhanging over Route 135, but, if necessary, nearby properties are short enough that the station can be built using air rights above them without requiring a single building to be destroyed.

In this design, there also will be a spur to the north of Framingham that provides service to Framingham State University; the I-90 area (which is home to the headquarters of many large companies); and towns further north, such as Southborough, Marlborough, and Northborough. The four-track station design that is recommended as part of this design option would make this spur line much more operationally efficient, as easy cross-platform transfers would be possible. This aspect of this design option would have to be constructed after the Framingham station is rebuilt because it is a large-scale project which would require fixing current and creating new tracks as well as erecting new stations along the spur.

Moving the station to the east will make it easier for trains to go north on the spur because it enables wider horizontal curves. Tighter curves decrease the speed trains can travel along the curve. This is important as over the 800-foot length of the platform, using an acceleration value of one-tenth of the force of gravity, the trains can accelerate to 50 MPH, so the curves as drawn already may constrain the maximum speed of the train (Regional Transit Division Denver, 2009). As discussed in *Chapter 5.1.2.*, it is feasible to erect a separate station along the spur line near the existing Framingham train station to provide service on that line; however, cross-platform transfers are much more convenient and would take less space.

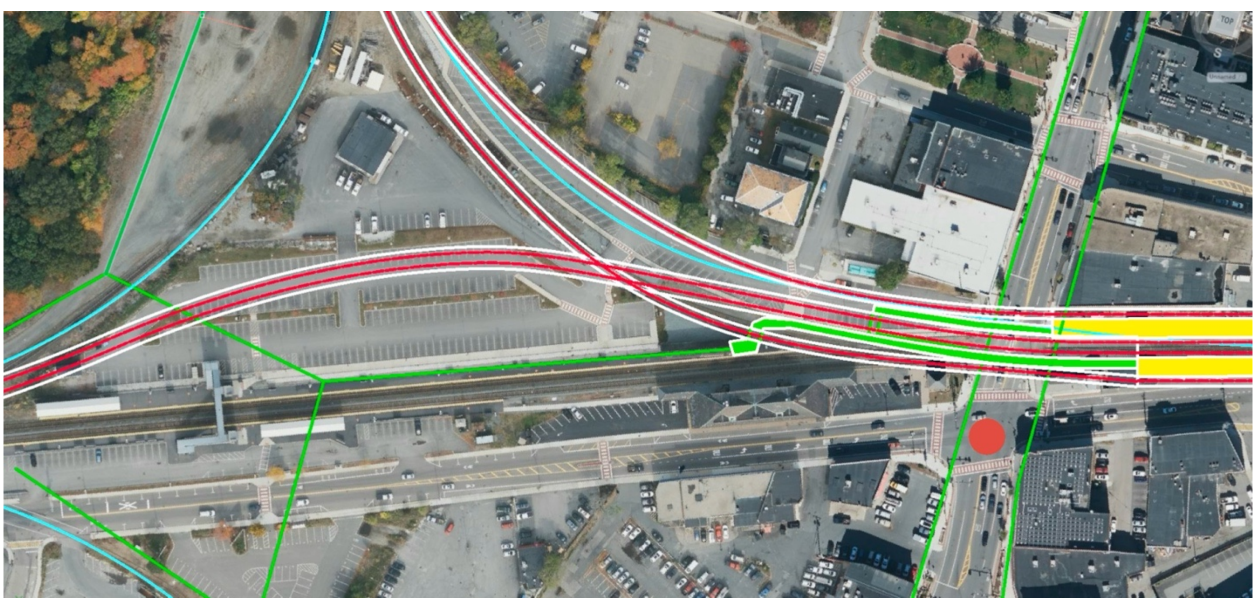


Figure 5.17. Track Layout for Design Option 2

The current location of the station does not provide enough room for tracks to successfully curve toward the northern spur while maintaining the station in its entirety. Due to the proximity of Farm Pond, there is not enough room on the western side of the station to safely curve tracks to serve the northern spur. Because the intention of this design option is to build a four-track station in order to provide cross-platform transfers, moving the station east is the only way to enable this.

Chapter 5.3.5. Grade Separation Considerations

The second design option is a much more intricate design than the first because it is not only built for improvements in the short-term, but also for the far-fetched future of Framingham. The proposed station is intended serve a growing and changing city over a long lifespan without needing to be rebuilt again. This design recommends implementing everything in the first design option. It also prepares the station for increased service and to improve traffic flow in downtown Framingham. Grade separation of the train station and the tracks that run through downtown Framingham will be implemented at the Route 135-Route 126 and Route 135-Bishop Street intersections for passenger rail only. Level boarding would also be installed in the new station. Also, since the station is being grade separated, the current station will have to be destroyed, and it will be moved about a quarter of a mile eastwards in between the Route 126 and Bishop Street intersections. Moving the station east makes it closer to Framingham's downtown area, allowing for a better connection between the train station and the heart of the city. Also, as seen in Figure 5.10, there is a new apartment complex right next to the proposed new location. We envision having multiple buildings like this around the station, providing the opportunity for many transit-oriented developments.

Chapter 5.3.6. Potentially Redirecting Freight Train Traffic

If the existing freight tracks are maintained under the elevated station, it will occupy valuable real estate under the proposed grade-separated station and in the downtown and continue causing irregular traffic impacts. It would be desirable to redirect freight to avoid downtown. To do this, Control Point 21 can be removed, and freight trains can be redirected on a lengthier route as depicted in Figure 5.18. New track would need to be constructed mostly on freight-owned property (shown in light green), but with fragments of other properties as well.

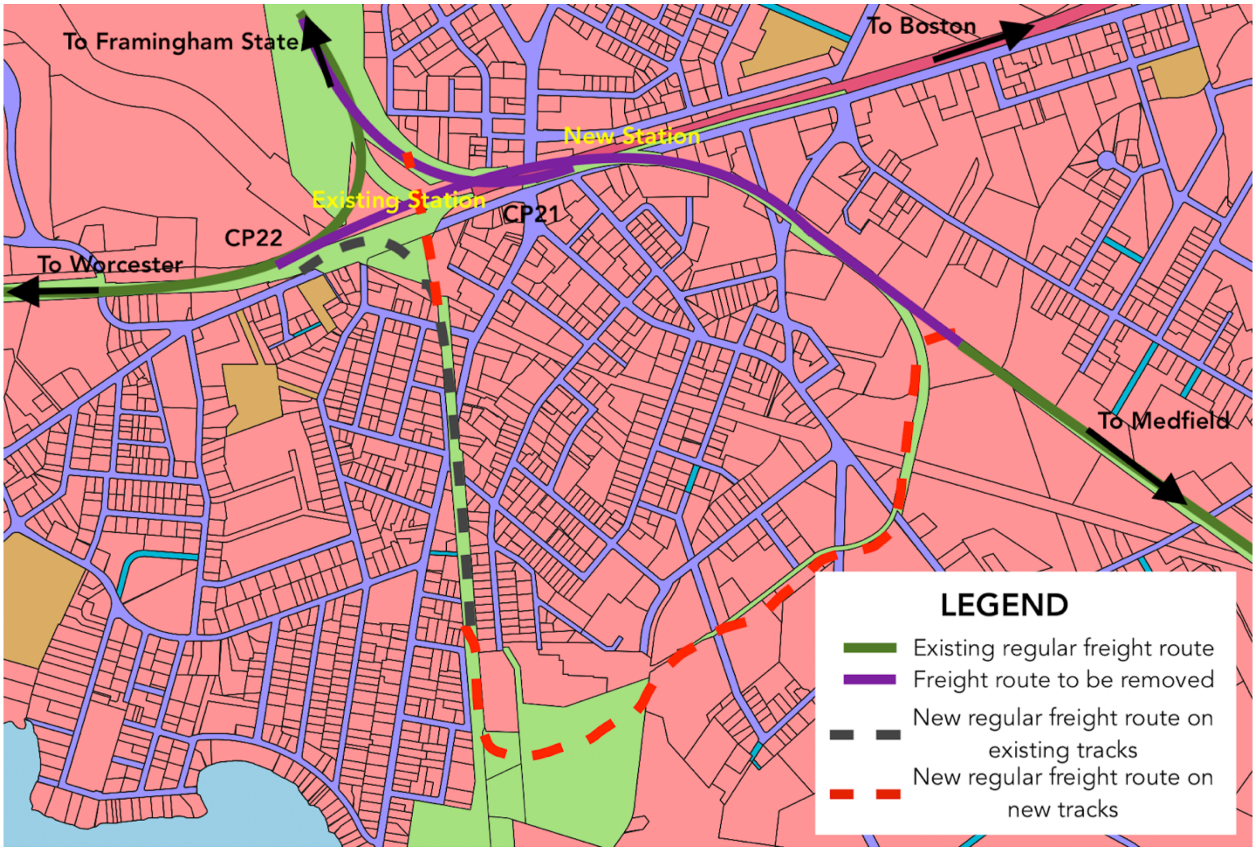


Figure 5.18. Framingham Freight Parcels (in light green). Based on data from the Framingham Property Viewer with annotations (MapGeo, 2021).

However, such a design would force the freight railroad tracks to go under the Framingham-Worcester line tracks west of Route 126, requiring a larger elevated support structure since the rail tracks would need to be elevated for a longer distance. Additional costs would be incurred from the construction of the new freight rail tracks. As the table below shows, both in terms of cost and politics, it is much better to keep freight tracks as is rather than redirect it despite the loss of real estate around the grade crossing of freight at the Route 135-Route 126 intersection.

Table 5.1. Benefits and Drawbacks of Redirecting Freight Train Traffic

	Keeping freight routes as they exist today	**Redirecting north/south freight rails**	**More advantageous?**
Potential Costs	No new freight tracks required. All tracks but one descend to ground level immediately west of the grade separation; the southernmost track has to curve over the others to go northward.	New freight tracks, layouts, and parcels required. Two tracks must remain elevated while other two tracks descend to ground level immediately on west side of grade separation.	Keeping
Location of Freight Tracks	Freight tracks run through Route 135 in multiple locations and through Route 135-Route 126 intersection.	No interruptions through the heart of downtown; would still cross through Route 135 near the existing station.	Redirecting
Potential Political Issues	Less impact on, negotiation with, and pushback from freight rail companies and other private property owners.	More impact on, negotiation with, and pushback from freight rail companies and other private property owners.	Keeping

Though redirecting freight is feasible, we recommend retaining freight routes, including a single-track from north of Framingham to the south, which would decrease the amount of developable area underneath the station for commerce, bus stops, and pedestrians. It also retains more grade crossings, but it is expensive to redesign freight and would require cooperation with freight companies and other private entities as well. However, this would enable other areas near the station to much more favorably be redeveloped.

Chapter 6: Conclusion

Framingham is a city that has the opportunity to become an economic powerhouse, but they need to take action to make their city more accessible and make more convenient forms of transportation. With electrified rail service coming, Framingham must take advantage of this by having the capacity for increased service while keeping road congestion at a minimum. Elevated tracks would alleviate congestion in downtown and create an opportunity to move the station to a more central and populated location. This combination increases the accessibility to the station via walking and biking along with encouraging other forms of transportation besides driving by providing the necessary amenities and routes. Freed up space from grade separation and repurposing large parking lots, along with new zoning regulations would allow for more transit-oriented development. All this in combination would help Framingham become more accessible, alleviate congestion in downtown, provide convenient transportation options to residents, and help Framingham make the jump from the town they were just a few years ago to become an economic powerhouse of a city.

References

Aldred, R., Collignon, N., Itova, I., & Verlinghieri, E. (2021, August). *The promise of low-carbon freight*. Possible. https://static1.squarespace.com/static/5d30896202a18c0001b49180/t/61091edc3acfda2f4af7d97f/1627987694676/The+Promise+of+Low-Carbon+Freight.pdf

American Automobile Association. (n.d.). *Massachusetts average gas prices*. AAA Gas Prices. Retrieved October 25, 2021, from https://gasprices.aaa.com/?state=MA.

American Structurepoint. (n.d.). *Railway Engineering Services: Projects: Vine St. Railroad Grade Separation*. Retrieved December 13, 2021, from https://www.structurepoint.com/engineering-and-infrastructure/project/vine-street-railroad-grade-separation.

BART. (2021, November 5). *BART Bike Stations*. BART. https://bikehub.com/bart/

Bay Area Rapid Transit. (n.d.). *Bikes on bart*. Bay Area Rapid Transit. Retrieved January 30, 2022, from https://www.bart.gov/guide/bikes

Boston Redevelopment Authority. (2021, November). Zoning Code. Retrieved February 2, 2022, from https://library.municode.com/ma/boston/codes/redevelopment_authority?nodeId=ART23OREPA_S23-1REUS

Buell, S. (2019, January 2). *The $10 weekend commuter rail passes are coming back*. Boston Magazine. Retrieved January 30, 2022, from https://www.bostonmagazine.com/news/2019/01/02/commuter-rail-weekend-passes-back/

Clem. (2009, August 9). The Effect Of Heavy Freight [web log]. Retrieved February 20, 2022, from https://caltrain-hsr.blogspot.com/2009/08/effect-of-heavy-freight.html.

Clem. (2021, May 9). *The exploding cost of grade separations*. The Exploding Cost of Grade Separations. Retrieved January 26, 2022, from https://caltrain-hsr.blogspot.com/2021/05/the-exploding-cost-of-grade-separations.html

Clem. (2020, December 15). Redwood City Grade Seps: We Must Do Better [web log]. Retrieved October 2021, from https://caltrain-hsr.blogspot.com/2020/12/redwood-city-grade-seps-we-must-do.html.

City of Framingham, Massachusetts. (2021). *Real Property Assessment Data*. Patriot Properties Framingham webpro. Retrieved March 2, 2022, from http://framingham.patriotproperties.com/default.asp

DeCosta-Klipa, N. (2019, November 4). *The MBTA is backing a long-term plan for the commuter rail. Here's where they want to start*. Boston.com. Retrieved October 2021, from https://www.boston.com/news/local-news/2019/11/04/mbta-commuter-rail-plan/

Dimiceli, V. (2022, January 1). Boston to eliminate parking requirements to spur below-market residential development. *New York Real Estate News*. Retrieved January 2022, from https://therealdeal.com/2022/01/01/boston-to-eliminate-parking-requirements-to-spur-below-market-residential-development/.

Dimino, R., Nally, T., & Carlson, K. (2018). *The Transportation Dividend*. Boston: A Better City. Retrieved from https://www.abettercity.org/assets/images/Transportation%20Dividend%20-%20FINAL%20-%20012918.pdf.

Framingham Master Plan. City of Framingham, MA. (2021). Retrieved March 3, 2022, from https://www.framinghamma.gov/294/Framingham-Master-Plan

Framingham Planning Board. (2021, February). Framingham Zoning Ordinances. City of Framingham, MA Official Website | Official Website. Retrieved February 2, 2022, from https://framinghamma.gov/

geoDOT. (2021). (rep.). *Bike Inventory 2020*. massDOT. Retrieved November 11, 2021, from https://geo-massdot.opendata.arcgis.com/datasets/MassDOT::bike-inventory-2020/about.

Google Maps (n.d.). *Google Maps*. Retrieved 11 October 2021, from https://www.google.com/maps.

History of Framingham. City of Framingham, MA. (2021). Retrieved October 11, 2021, from https://www.framinghamma.gov/1182/History-of-Framingham.

Humphrey, T. J. (2012, December 21). *Introduction*. MBTA Commuter Rail Passenger Count ResultsMBTA Commuter Rail Passenger Count Results. Retrieved October 11, 2021, from https://www.ctps.org/data/html/studies/transit/2012_MBTA_Commuter_Rail_Passenger_Counts/MBTA_Commuter_Rail_Passenger_Count_Results.html.

Jessen, K. (2021). *MWRTA to Oversee Framingham Commuter Rail Station | MassDOT Blog*. Blog.mass.gov. Retrieved 11 October 2021, from https://blog.mass.gov/transportation/mbta/mwrta-to-oversee-framingham-commuter-rail-station/.

MapGeo. (2021) Framinghamma.mapgeo.io. Retrieved 11 October 2021, from https://framinghamma.mapgeo.io/datasets/properties.

MassDOT. (2021) *East – West Passenger Rail Study*. Mass.gov. Retrieved 11 October 2021, from https://www.mass.gov/doc/chapter-3-existing-conditions/download.

MassDOT. (2021a, March 11). Layer: Vehicle (ID: 1). Retrieved November 15, 2022, from https://gis.impact.dot.state.ma.us/arcgis/rest/services/MassDOT/MASSDOT_ODP_OPEN_2020/FeatureServer/1

MassDOT. (2021b, December 13). Layer: 2008-2017 HSIP pedestrian cluster (ID: 11). Retrieved November 15, 2022, from https://gis.massdot.state.ma.us/arcgis/rest/services/Roads/CrashClusters_ODP/FeatureServer/11

MassDOT. (2021c, May 25). MassDOTRoads_gdb (FeatureServer). Retrieved November 21, 2022, from https://services1.arcgis.com/hGdibHYSPO59RG1h/arcgis/rest/services/MassDOTRoads_gdb/FeatureServer

MassDOT. (2020). *Top high crash location reports by year*. Mass.gov. Retrieved October 28, 2021, from https://www.mass.gov/lists/top-high-crash-location-reports-by-year.

MassDOT. (2019). *Municipal Resource Guide for Bikeability.* Mass.gov. Retrieved January 30, 2022, from https://www.mass.gov/files/documents/2019/06/13/2019_Municipal_Resource_Guide_for_Bikeability.pdf.

MassGIS (Bureau of Geographic Information). (2019). Commonwealth of Massachusetts EOTSS.

MBTA. (2018). *2015-17 MBTA systemwide passenger survey*. 2015-2017 MBTA Systemwide Passenger Survey. Retrieved October 5, 2021, from https://www.bostonmpo.org/dv/mbtasurvey2018/index.html#navButton.

MBTA. (1996). *Commuter Rail Design Standards Manual.* Retrieved Feburary 23, 2022, from https://www.mbta.com/engineering/design-standards-and-guidelines

MBTA. (2021a). *MBTA Commuter Rail Fares*. Retrieved October 12, 2021, from https://www.mbta.com/fares/commuter-rail-fares.

MBTA. (2019, August 28). *MBTA Commuter Rail Ridership by Trip, Season, Route/Line, and Stop*. Retrieved November 11, 2021, from https://mbta-massdot.opendata.arcgis.com/datasets/mbta-commuter-rail-ridership-by-trip-season-route-line-and-stop/explore?filters=eyJzdG9wX25hbWUiOlsiRnJhbWluZ2hhbSJdfQ%3D%3D.

MBTA. (n.d. a). *Fares Overview*. MBTA. Retrieved December 14, 2021, from https://www.mbta.com/fares

MBTA (n.d. b). *Framingham*. MBTA. https://www.mbta.com/stops/place-WML-0214

MBTA. (2021c). *Framingham/Worcester Line*. Retrieved 12 October 2021, from https://www.mbta.com/schedules/CR-Worcester/timetable.

MBTA. (2020, June 15). *New 5-Day flex pass pilot for Commuter Rail begins July 1*. MBTA. Retrieved January 20, 2022, from https://www.mbta.com/news/2020-06-15/new-5-day-flex-pass-pilot-commuter-rail-begins-july-1

MBTA. (2021b). *Schedule & Maps*. Retrieved 12 October 2021, from https://www.mbta.com/schedules/CR-Worcester/line.

MBTA. (n.d. c). *Trip planner*. Retrieved October 25, 2021, from https://www.mbta.com/trip-planner?_utf8=%E2%9C%93&plan%5Bfrom%5D=Framingham&plan%5Bfrom_latitude%5D=42.276108&plan%5Bfrom_longitude%5D=-71.420055&plan%5Bto%5D=Boston%2C%2BMA%2C%2BUSA&plan%5Bto_latitude%5D=42.3600825&plan%5Bto_longitude%5D=-71.0588801&plan%5Btime%5D=depart&plan%5Bdate_time%5D%5Bhour%5D=10&plan%5Bdate_time%5D%5Bminute%5D=30&plan%5Bdate_time%5D%5Bam_pm%5D=AM&plan%5Bdate_time%5D%5Bmonth%5D=10&plan%5Bdate_time%5D%5Bday%5D=25&plan%5Bdate_time%5D%5Byear%5D=2021&plan%5Bmodes%5D%5Bsubway%5D=false&plan%5Bmodes%5D%5Bcommuter_rail%5D=true&plan%5Bmodes%5D%5Bbus%5D=false&plan%5Bmodes%5D%5Bferry%5D=false&plan%5Boptimize_for%5D=best_route#plan_result_focus.

MBTA. (2020a). *Rail vision*. MBTA. Retrieved January 28, 2022, from https://www.mbta.com/projects/rail-vision#alternatives

MBTA. (2020b). *Rail Vision Alternative 6*. MBTA Rail Vision. Retrieved from https://cdn.mbta.com/sites/default/files/2019-10/rail-vision-alternative6-oct2019-accessible.pdf

Miller, S. (2021, December 22). *IRS raises standard mileage rate for 2022*. SHRM. Retrieved January 27, 2022, from https://www.shrm.org/resourcesandtools/hr-topics/benefits/pages/irs-raises-standard-mileage-rate-for-2022.aspx

MonthlyParking. (2021, August 19). *Boston Monthly Parking: Tips and Resources*. MonthlyParking.org. Retrieved October 24, 2021, from https://monthlyparking.org/boston-monthly-parking/.

Mufti, S., & Leonard, N. (2013). *A guide to the MBTA commuter rail*. Boston.com. Retrieved October 11, 2021, from https://www.boston.com/uncategorized/noprimarytagmatch/2013/12/20/a-guide-to-the-mbta-commuter-rail/.

MWRTA. (2015). *Fixed routes*. MWRTA. Retrieved January 12, 2022, from https://www.mwrta.com/routes/fixed-routes

Redwood City. (2020). *Redwood City Grade Separation Planning Study*. Redwood City. Retrieved from https://www.redwoodcity.org/city-hall/current-projects/infrastructure-projects?id=140

Redwood City Grade Seps: We Must Do Better. (2020). [Blog]. Retrieved October 12, 2021, from https://caltrain-hsr.blogspot.com/2020/12/redwood-city-grade-seps-we-must-do.html.

Report to the Honorable Mayor and City Council From the City Manager. (2018, October 1). Retrieved December 13, 2021, from https://www.redwoodcity.org/home/showdocument?id=16972.

Rudick, R. (2019, May 13). Oakland Adds Bike Share for People with Disabilities [web log]. Retrieved January 30, 2022, from https://sf.streetsblog.org/2019/05/13/oakland-adds-bike-share-for-people-with-disabilities/.

Regional Transit Division Denver. (2009, April). *RTD Commuter Rail Design Criteria.* Retrieved Feburary 23, 2022, from https://www.rtd-denver.com/sites/default/files/files/2018-08/RTD-Commuter-Rail-Design-Criteria-Revised-040109.pdf

Sevtsuk, A., Morgan, R., & Fayad, S. (2020). Greater Boston Transit Access. Retrieved December 9, 2021, from http://boston.transit-access.com/.

Shearin, J. (2020, August 20). *Which is safest? A quick guide to bike boulevards, trails and Bike Lanes*. Walk. Retrieved January 26, 2022, from https://walkbikecupertino.org/index.php/2019/07/19/quick-guide-to-the-different-classes-of-bike-lanes/

South Station. (2021). *Railway History — South Station*. Retrieved October 11, 2021, from https://www.south-station.net/railway-history.

StreetLight Data. (2022, February 4). *Transportation Analytics On Demand*. StreetLight. https://www.streetlightdata.com/

TransitMatters. (2019). *Regional Rail Proof of Concept*. Retrieved 11 October 2021, from http://transitmatters.org/regional-rail

Un, K. (2010). *Oversupply: Parking Taking up Valuable Space – MAPC*. MAPC. Retrieved October 11, 2021, from https://www.mapc.org/resource-library/oversupply-parking-taking-up-valuable-space/.

U.S. Census Bureau. (2019). Census.gov. Retrieved October 11, 2021, from https://www.census.gov/.

U.S. Census Bureau. (2018). *LEHD Origin-Destination Employment Statistics Data (2002-2018).* Washington, DC: U.S. Census Bureau, Longitudinal-Employer Household Dynamics Program, Retrieved September 10, 2021, from https://lehd.ces.census.gov/data/#lodes.

Waze. (n.d.). *Driving Directions, live traffic & road conditions updates*. Waze. Retrieved October 24, 2021, from https://www.waze.com/live-map?utm_source=waze_website&utm_campaign=waze_website&utm_medium=website_menu.

Wikipedia contributors. (2021, October 5). *Framingham station*. Wikipedia. https://en.wikipedia.org/wiki/Framingham_station#/media/File:Framingham_stations_map.svg

Appendix A: Frequency and Speed Analysis for All Stations on the Framingham-Worcester Line

Table A1. Frequency and Speed Analysis for All Stations on the Framingham-Worcester line. Stations in bold have medium to very high ridership; stations in gray do not exist yet.

Stations	Ridership (MBTA, 2019)	Primary mode of access to station (MBTA, 2018)	Importance of high frequency for residents	Importance of speed for residents
South Station ***Back Bay*** ***Lansdowne*** *West Station* ***Boston Landing***	*Very High-Medium*	*Walking/Biking*	*High, enables short-distance, all-day trips.*	*Low, residents make mostly short-distance trips. Express trains are undesirable as they may skip important stops.*
Newton Corner	*Not Built*	*Unknown*	*Same as below*	*Same as below*
Newtonville *West Newton* *Auburndale*	*Low*	*Walking/Biking*	*High, enables short-distance, all-day trips, but ridership might not justify frequency.*	*Low, residents make mostly short-distance trips. Express trains are undesirable as they may skip important stops.*
Riverside	*Not Built*	*Unknown*	*Same as above*	*Same as above*
Wellesley Farms *Wellesley Hills* ***Wellesley Square***	*Low-Medium*	*Equal Walking/Biking and Driving Alone*	*Medium, enables short-distance, all-day trips, but ridership might not justify frequency.*	*Medium to High. Wellesley Square journey times to Boston would be significantly shortened by 10 minutes or by nearly 40%. Wellesley Farms and Wellesley Hills have low ridership and might not be worth express service.*
Natick Center ***West Natick***	*Medium*	*Walking/Biking*	*Medium. Long intercity journey times to Boston, but there is some*	*High, journey times from Natick Center to Boston would be significantly shortened*

			potential for short trips, perhaps to Framingham.	*by 12 minutes or by 40%.*
Framingham	*High*	*Driving Alone*	*Medium. Frequency is less important, but there is some potential for short trips.*	*High, journey times from Framingham to Boston would be significantly shortened by 13 minutes or by 40%.*
Ashland *Southborough* ***Westborough*** *Grafton*	*Low/ Medium*	*Driving Alone*	*Low, insufficient ridership.*	*High, express service to Boston important.*
Worcester	*High*	*Driving Alone and Personal Vehicle Dropoffs*	*Low, insufficient ridership and mainly long-distance trips.*	*High. Express trains decrease travel time to South Station by 13 minutes or 21%.*

Table A1 above assesses the ridership and mode of access to each station, as well as the importance of frequency and speed for residents. It makes two assumptions: most travel is from more residential areas to job centers (mainly to Boston, but a bit to Framingham and Worcester as well) and that frequency is more important for short trips while speed is more important for long trips. The time improvement for an express was calculated from the TransitMatters Regional Rail Report assuming electrified service is implemented (TransitMatters, 2019).

The ridership for each station was categorized between very low and very high depending on the percentage ridership for each station compared to the whole line (MBTA, 2019). Stations with less than one percent ridership were considered to have very low ridership, while stations with above 10 percent of the line's ridership were considered to have very high ridership, as seen in Table A2.

Table A2: Ridership Criteria to Classify Stations.

Ridership as percentage of line	Ridership category
0-1	Very Low
1-3	Low
3-5	Medium
5-10	High
10-40	Very High

The primary mode of access to the station was found from MBTA rider census data (MBTA, 2018).

Appendix B: Velocity Calculation for Trains Traveling Uphill to a Height of 24 Feet with Engine Off

*Note: Assuming no friction

m = mass g = gravity h = height v = velocity

$$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$$

Potential Energy (mgh); Kinetic Energy ($\frac{1}{2}mv^2$)

$g = 32.2\ ft/s^2$

$h = 24\ ft$

$$gh = \frac{1}{2}v^2$$

$$v = \sqrt{2gh} = \sqrt{2(32.2\ ft/s^2)(24\ ft)} = 39.31\ ft/s = 26.8\ mph$$

Appendix C: Proposal

Major Qualifying Project Proposal

Framingham, MA Commuter Rail Station

Braden Ballard, Joseph Coutcher,

John Parenteau, Tarang Shah, and Maximilian Storch

in collaboration with TransitMatters

Advised by Professor Suzanne LePage

Capstone Design Statement

Worcester Polytechnic Institute (WPI) requires all students to complete a capstone design project, which is known as the Major Qualifying Project (MQP), as part of their graduation requirements. This project will meet the capstone design requirement by providing a new design to the current Framingham, Massachusetts commuter rail station which will improve multimodal access to the station, support increased transit ridership, increase the speed of trains traveling through the station and the downtown area, and enable more frequent service to more destinations; together, these improvements will support improvements to downtown Framingham. The current station is located in the western portion of downtown Framingham, which is at grade and contains mini-high small, raised platforms from the larger platforms at grade. Our project will look to evaluate different design criteria and to determine which improvements would be the most beneficial for the station, current and future riders, and the city.

Constraints associated with this project include:

1. **Economic constraints:**

   When considering different design criteria, it is also important to keep in mind the cost that is associated with the project. We could propose multiple different improvements to the station and make it the most ideal station possible, but if the cost is not feasible, the project will not be taken seriously by the major public stakeholders.

2. **Social Constraints:**

   Construction along the rail line might impact rail service as well as vehicular and pedestrian circulation, causing delays for passengers, visitors and residents alike. Interrupting service at this station for an extended period of time may cause an unfavorable outlook on the project by the local community and communities along the rail line.

3. **Political implications:**

   The proposal for a redesign of Framingham Station must have political backing from the City and State government. Both City and State governments must ultimately make the decision that the project is beneficial enough to complete, and worthy of priority status.

4. **Environmental constraints:**

There may be negative environmental effects from the construction of the proposed design, for example, on nearby Farm Pond and for nearby residents. On the other hand, improved train service and multimodal transportation across downtown enables environmentally friendly travel with fewer emissions.

5. **Constructability:**

Ideally, the station can be placed within existing right-of-way, but some private property may need to be bought or some roadway area may need to be repurposed by the city in order to construct certain design alternatives. Land is also important to consider the potential of redevelopment with the new station.

Table of Contents

Capstone Design Statement 123

Table of Contents 125

Chapter 1: Introduction 126

An Overview of the Problem 129

Goal Statement 130

Objectives 130

Chapter 2: Background 131

History of Framingham 131

History of the Framingham-Worcester Rail 131

Existing Conditions of the Framingham-Worcester Rail 131

Existing Conditions of the Station 135

An In-Depth Explanation of the Problem 137

TransitMatters: Regional Rail Proof of Concept Study 140

Case Study on Grade Separation: Redwood City, CA Station 143

2009 BETA Study 152

Framingham Master Plan 153

The Transportation Dividend 153

Millbrae Station Area Specific Plan (MSASP) 155

Chapter 3: Methods 156

Community Input 156

Stakeholder Analysis 156

Identify Station Amenities 156

Identifying Existing Bike Paths and Plans 156

Bus Routes 157

Parking Study 157

Analyze StreetLight Data 157

Environmental Impact Report (EIR) 157

Commuter Rail Ticket Sales 158

Gantt Chart 159

Chapter 1: Introduction

The Framingham-Worcester commuter rail is a 44.2-mile passenger rail line operated by the Massachusetts Bay Transportation Authority (MBTA) that connects Boston and Worcester, MA, serving 20 train stations and connecting New England's two largest cities. Though it is the fastest mode of public transit between these cities, it is relatively slow, taking 1.5 hours when a private car can travel the same distance in under an hour. Improving the speed and frequency of public transit is important to support the daily needs of residents, and TransitMatters, a non-profit organization that is dedicated to improving public transportation — specifically rail — within the Boston and Greater Boston areas, performs analyses to identify ways to make transit faster, more frequent and more accessible. A crucial station along the line is in Framingham, MA, which is a city located in Massachusetts approximately 20 miles west of Boston, Massachusetts and 172 miles from New York City (Figure 1). Trains at Framingham travel slowly to approach and leave the station due to at-grade crossings and increasing train service along the Framingham-Worcester line might further hamper downtown travel. Improving the station would enable faster travel by all modes of transportation in Framingham and might revitalize the downtown area.

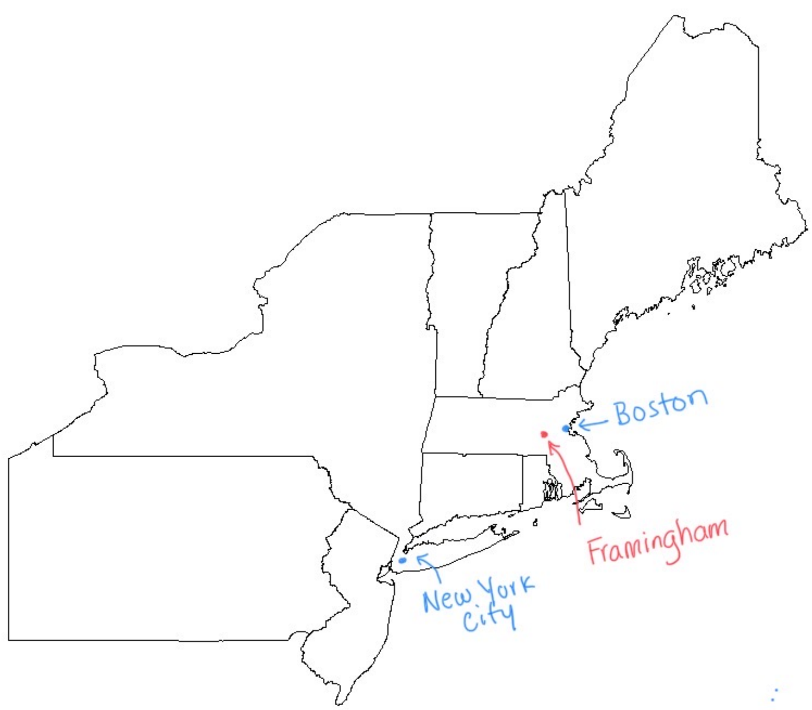


Figure 1: Map of the Northeast United States.

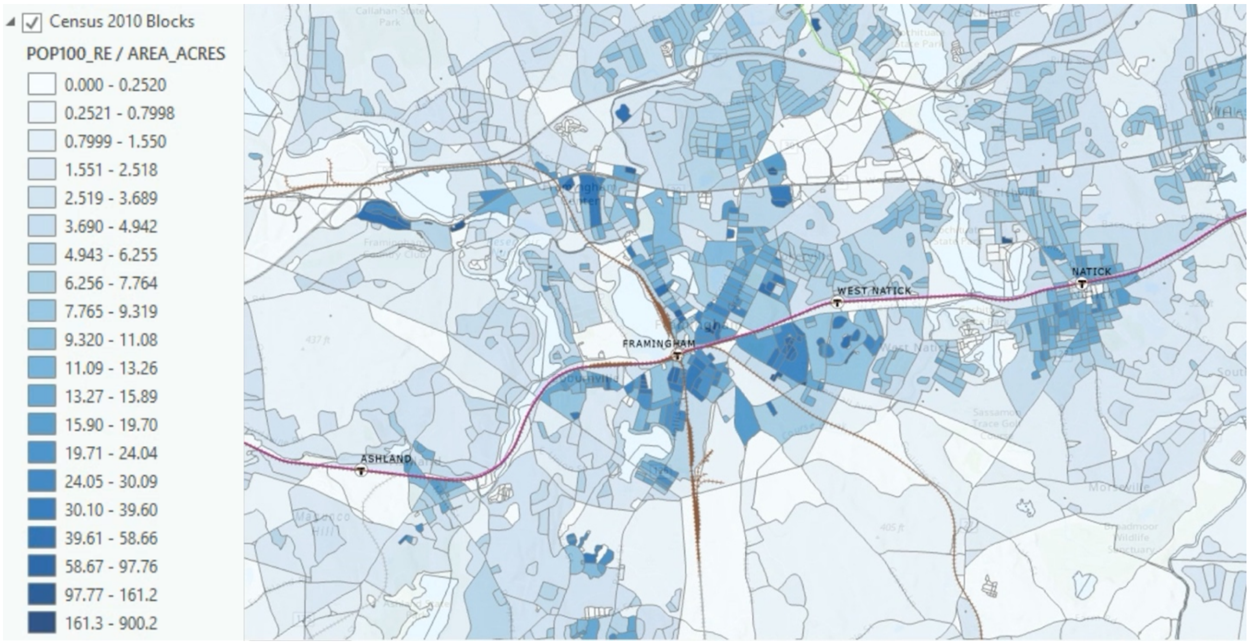


Figure 2: Population Density near commuter rail stations in people per acre in 2010 (US Census Bureau, 2019, MassGIS).

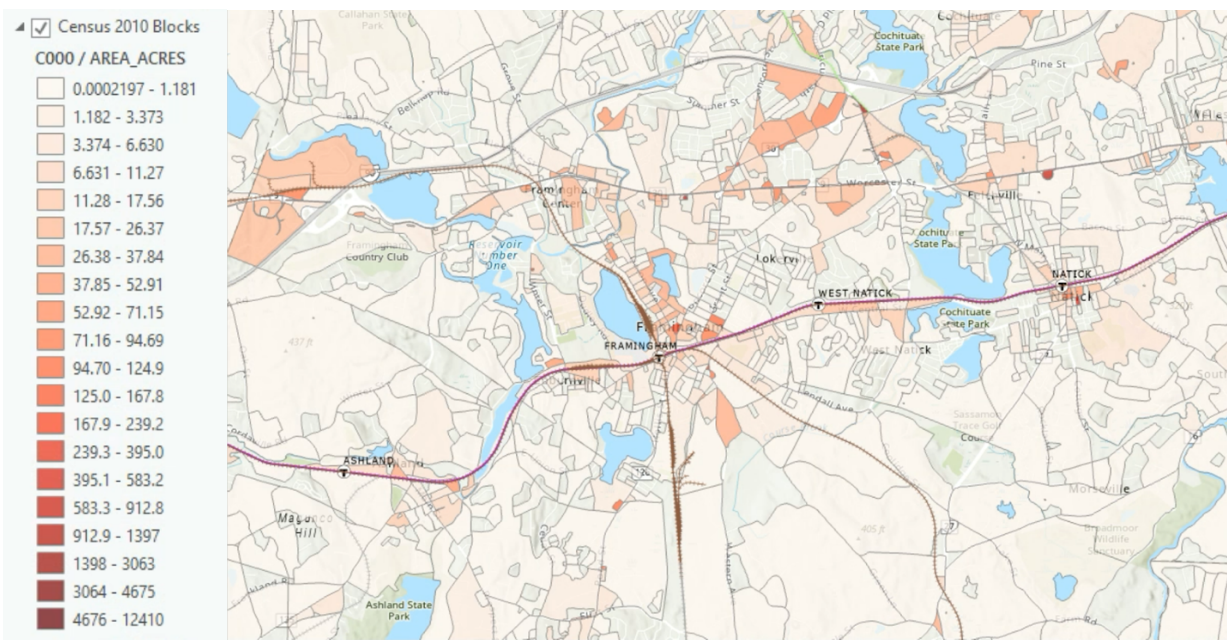


Figure 3: Job density near commuter rail stations in people per acre (US Census Bureau, 2018, MassGIS).

Currently, Framingham is the home to just over 72,000 residents as well as multiple manufacturing and management companies. Bose, Staples, T.J. Maxx (and many others) operate manufacturing plants or base their headquarters directly out of Framingham. The most popular employment sectors currently in the city exist in the medical, education, bio-technical, and retail fields (“City Information”, 2021). The census blocks within a half-mile of the station are the most densely populated area near a train station on the line outside of Boston and Worcester (Figure 2, Figure 3).

Framingham has the highest ridership of any station on the line outside of Worcester and Boston, with an estimated 886 weekday boardings in Winter/Spring 2012, as visible in Figure 4. However, despite the high population and job density around Framingham, 53% of commuters drive, as opposed to West Natick and Natick Center, both of which have far more people walking and biking to the station, despite having significantly lower ridership and having lower population and job densities near the station (Figure 2, Figure 3). It appears that Framingham has a lot of untapped potential for ridership near the station, which could be realized by improving the station.

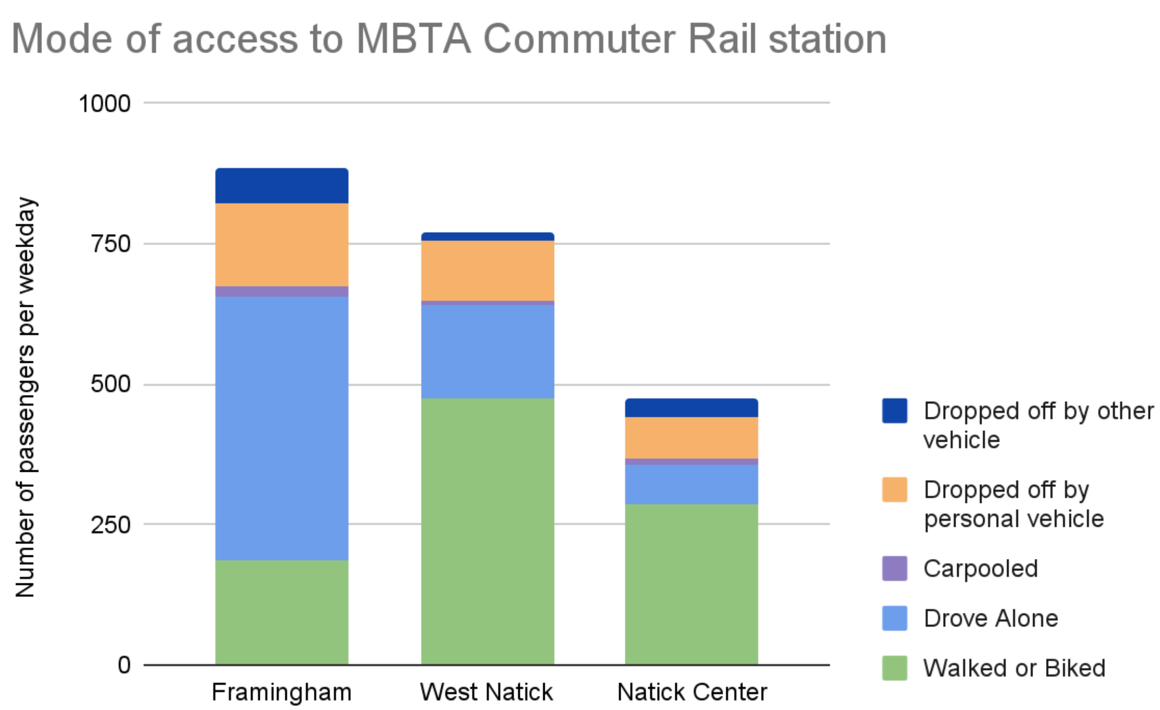


Figure 4: Mode of access to commuter rail station. Uses 2012 passenger counts (Humphrey, 2012) and 2015-17 passenger surveys for access to the station (MBTA, 2018).

Improving the commuter rail (as well as the abundant network of rails within Massachusetts) is always on the radar of TransitMatters. Equity, in terms of mobility and economic opportunity, are at the forefront of TransitMatters' vision for the future of rail and bus services. This is especially evident when overviewing their five major goals that define its scope of work: an expanded bus service to 24 hours, 7 days a week; more equitable transit fares; a reinvented and revitalized commuter rail system; a redesigned bus network; and the introduction of mobility hubs. Regarding their third goal, they believe the keys to creating a functional, high-speed, and efficient commuter rail system include system-wide electrification, high-level platforms, improved infrastructure to relieve bottlenecks, frequent all-day service, and free transfers.

With their commitment to improve the commuter rail systems in the Greater Boston area, their knowledge and vision perfectly aligns with the improvements needed at the Framingham commuter rail station to make it more efficient and accessible by the local population. TransitMatters will be assisting with our project by overseeing our progress and acting as mentors. Specifically, their relationship to us and the project will include helping to target our action items, contextualizing the Framingham station, and answering any questions regarding improvements and accessibility within and around the station.

An Overview of the Problem

The Framingham-Worcester line travels through areas where there is a high volume of people that travel in and out of Boston. With Framingham being located halfway between Worcester and Boston it has the potential to serve as a large hub for rail service. Commuting into Boston already poses a large problem to drivers as Massachusetts Interstate 90 (I-90) suffers from slow-moving backups during rush hours; impending construction will only worsen this. Commuter rail service takes more than double the time of driving to travel between Worcester and Boston due to the frequent number of stops and speed caps to which the MBTA's diesel trains must adhere. Commuter rail speeds immediately east of the Framingham station are currently limited by two at-grade road crossings with crossing guards. While an increase in speed and train frequency is necessary for increased ridership, poor access to and within the station limit the ridership to the station, as well as the ability for increased service to revitalize downtown Framingham.

Goal Statement

Design a more accessible station enabling the MBTA to provide increased service that will help improve downtown Framingham.

Objectives

With some key problems identified in the current train station setup at Framingham, it is important to outline some of the objectives that will guide our process in satisfying our overall goal for this project.

1. Understand scope of knowledge
    1. Train station case studies (particularly for CalTrain), which provide example features and layouts.
    2. TransitMatters reports, which propose higher frequency and higher speeds for commuter rail.
2. Collect data on existing infrastructure and usage
    1. Site Visits to understand the current layout of the station and its relationship to the rest of the downtown.
    2. GIS data and property information to see where people live and work near the station.
    3. Streetlight Travel Data on how and from where people travel to the station.
3. Analyze data
    1. Analyze populations and travel patterns to downtown Framingham and to the Framingham train station to understand how a new train station can support multimodal transportation.
4. Design improvements (multiple alternatives), with different combinations of:
    1. Station layout and location.
    2. Access to station by different modes of travel
    3. Grade separation
    4. Station features and amenities, such as high platforms.

Chapter 2: Background

History of Framingham

After the American Revolutionary War, with such a convenient location halfway between the two largest cities in New England — Boston and Worcester — Framingham became a major stop for one of the earliest forms of transportation, stagecoach ("History of Framingham", 2021). Framingham was a popular spot to make repairs to carts, or switch horses, and this allowed for more people to explore the city, which brought in more customers for Framingham businesses, causing the Framingham economy to thrive. In the late 1800s, a station for the steam engine train was created in Framingham. Framingham saw a massive growth in its economy, population, and development due to the influx of people coming to and from the city on the rail ("History of Framingham", 2021). The city that started out with just a small corn mill has turned into a major manufacturing hub for cotton products, footwear, light bulbs, and many other products.

History of the Framingham-Worcester Rail

The Framingham-Worcester rail has a long history, originating in the early 1800s. With the onset of the 1900s, it became evident that Worcester, one of the most central towns in Massachusetts, would become the point of division regarding how each half of the east-west rail line in Massachusetts would be developed further. East of Worcester saw a boom in commuter development; westward saw a continuation of intercity service with no other major developments. Amtrak, founded in 1971, immediately took over service west of Worcester while the Massachusetts Bay Transportation Authority (MBTA) began overseeing the line east of Worcester ("Railway History — South Station", 2021). The MBTA and Amtrak swapped ownership over the commuter rail twice, once in 1987 and again in 2003. In 1994, rush hour trains returned between Worcester and Framingham after service was discontinued in 1975; this service was further expanded in 1996 (Mufti & Leonard, 2013).

Existing Conditions of the Framingham-Worcester Rail

As it currently stands, the Framingham-Worcester Rail is owned and operated by the MBTA. Previously, CSX Transportation — a freight railroad company — owned the Worcester-Framingham line and had priority access to the line, inhibiting the expansion of passenger rail service. The year 2012 saw an acquisition of the line by the MBTA, allowing for passenger service to expand as well as infrastructure improvements along the entirety of the rail to be made ("East – West Passenger Rail Study", 2021).

According to pre-pandemic data, the line is MBTA's second-busiest line with over 18,000 weekday riders on average. The commuter portion (the portion MBTA owns) lies between Worcester and Boston, Massachusetts — the state's two biggest cities. The line provides service at 20 stops which include suburbs and smaller towns as shown in Figure 5, but a majority of its weekday rider-base is going to work in Boston ("Regional Rail Proof of Concept", 2019). Fares can cost riders anywhere between \$2.40 and \$13.25 depending on the distance traveled, and unlimited access to the commuter rail for a weekend can be purchased for \$10.00. Monthly commuter rail passes will cost riders anywhere in the range from \$80.00 to \$426.00 depending on preference of access to different services and rail lines ("MBTA Commuter Rail Fares", 2021).

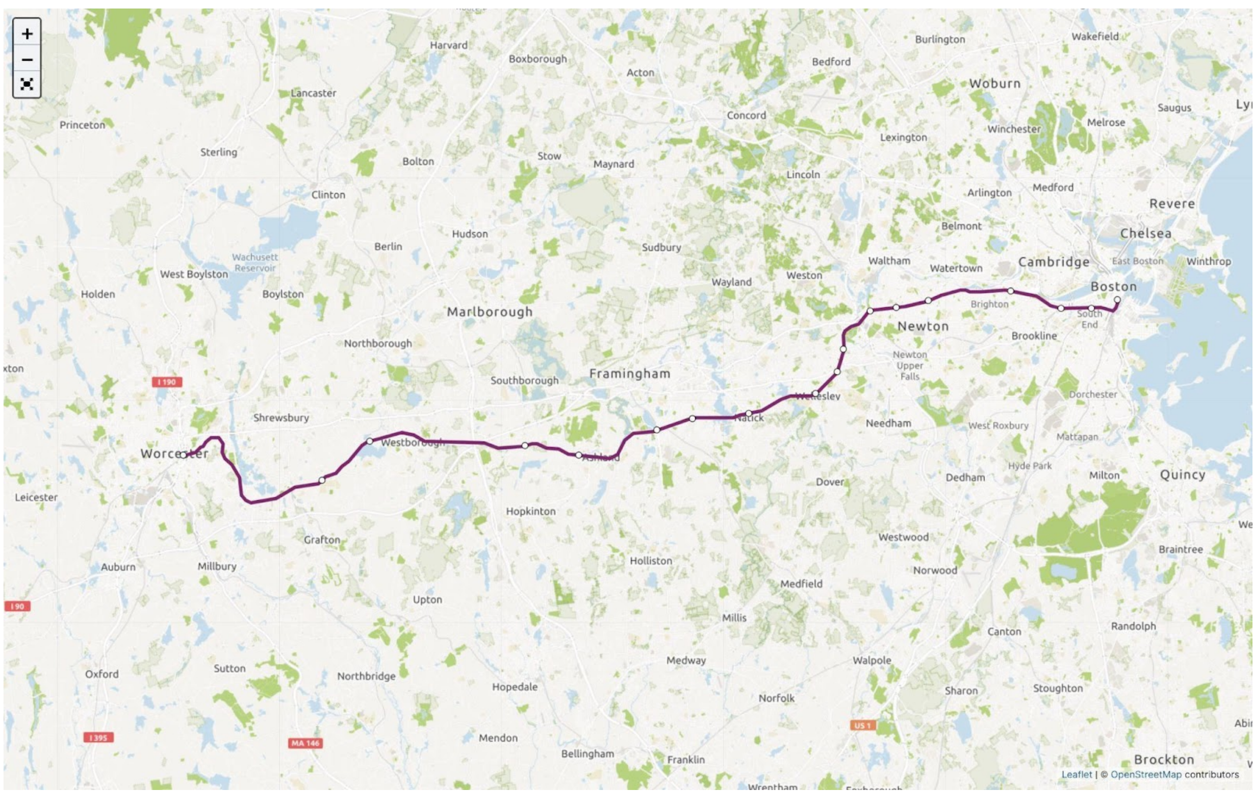


Figure 5: A map depicting the route of the Framingham-Worcester rail line ("Schedule & Maps", 2021).

The Framingham-Worcester line does not encounter many geographical hurdles along its route. The landscape between Worcester and Boston is relatively flat with zero slopes greater than one percent grade present. 21 sharp turns (defined as horizontal curves greater than approximately two degrees) exist between the two cities, causing trains to slow down in order to safely traverse these sections. Trains are able to travel as fast as 79 miles per hour, but only 11 percent of the commute is spent traveling at this speed due to the number of stops and sharp turns, such that trains that stop at all stations take 1.5 hours to travel 44 miles. The entire rail line, however, is double-tracked, meaning two trains can travel simultaneously without fear of collision ("East – West Passenger Rail Study", 2021).

Pre-pandemic, the Framingham-Worcester line provided irregular service concentrated at peak hours, including trains that stopped at all stops and trains that skipped stops (as shown in Figure 6). All trains — except a single morning train to Boston and a single evening train to Worcester — stopped at Framingham. Trains ran approximately every two hours on weekends, stopping at all stations.

Now, during the work week, trains currently depart from either Boston or Worcester approximately every hour on the hour, which is a more consistent and frequent schedule than before (Figure 7). Though some trains from Boston turn around at Framingham and some skip stops east of Framingham to provide faster Boston-Worcester service, all trains stop at Framingham. An increase in service is seen during the afternoon as trains depart Boston approximately every half hour starting around 3:00 p.m. until 11:00 p.m. Weekend service is similar to pre-pandemic service, except it starts earlier ("Framingham/Worcester Line", 2021).

Amtrak runs a train daily in each direction on the Framingham-Worcester commuter rail line to provide train service between Boston and Chicago, stopping at South Station (Boston), Framingham and Worcester.

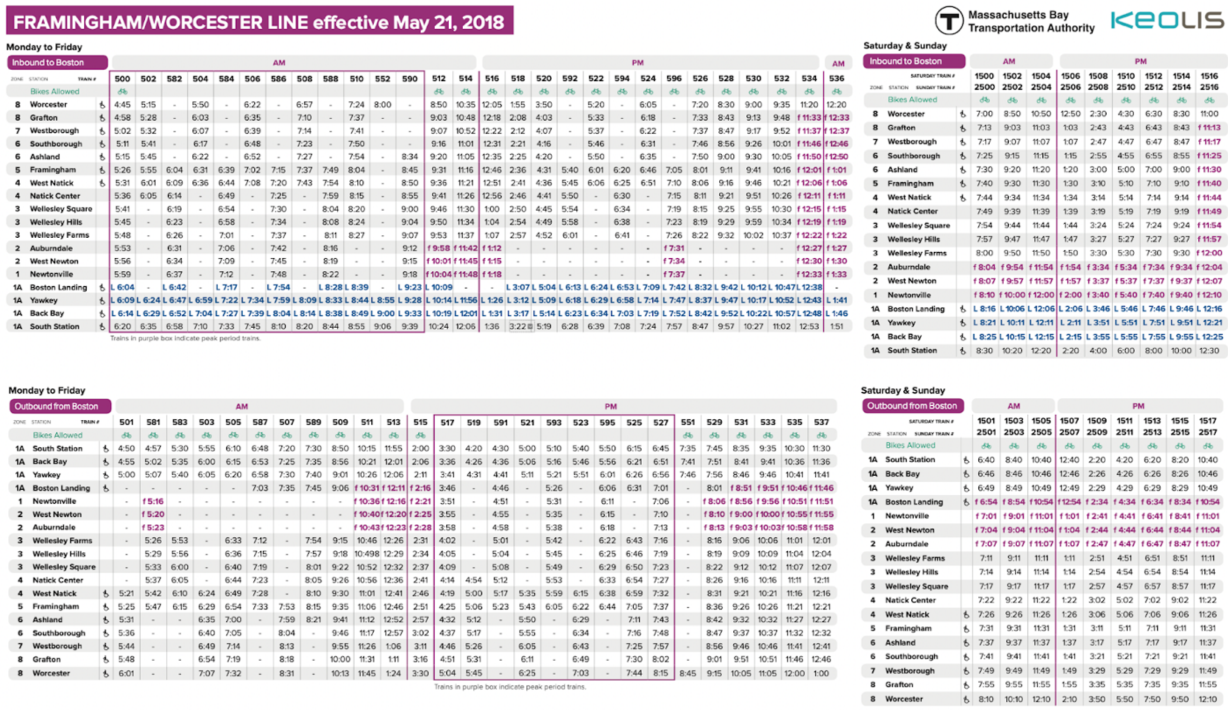


Figure 6: Summer Schedule (pre-pandemic) effective from May 21, 2018 to an unknown date ("Framingham/Worcester Line", 2021).

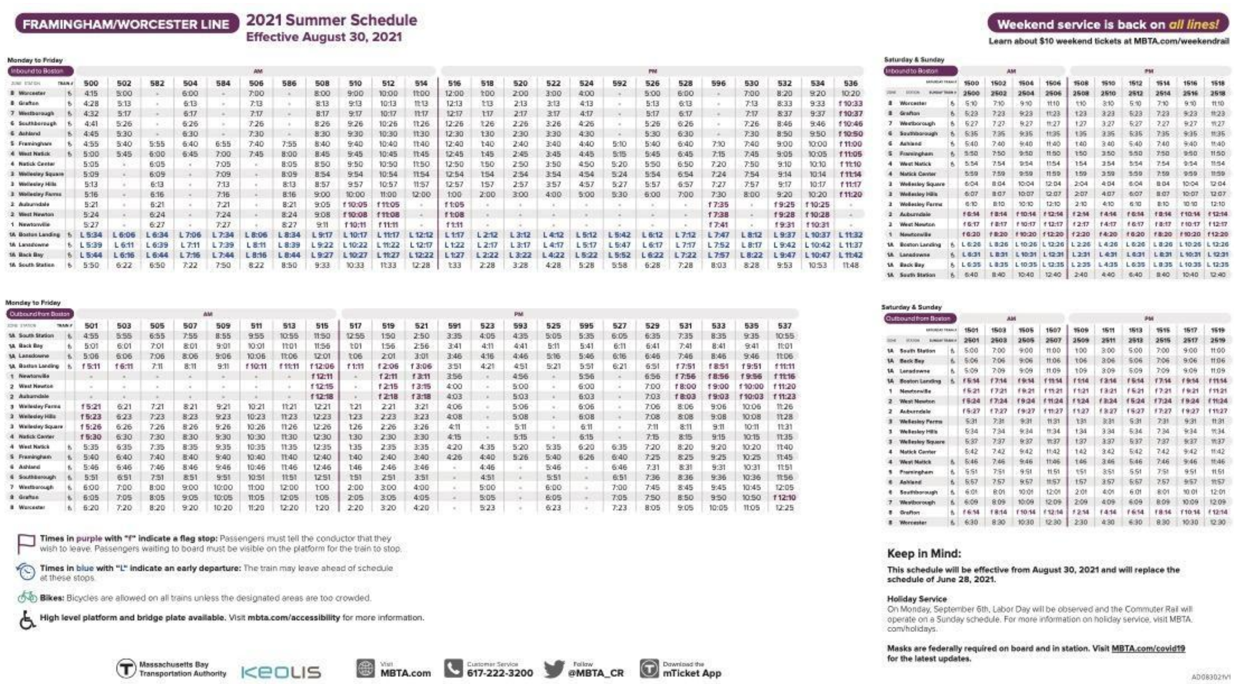


Figure 7: 2021 Summer Schedule from August 30, 2021 to Oct 10, 2021 ("Framingham/Worcester Line", 2021).

Existing Conditions of the Station

Framingham station is currently a two-track station with platforms oriented along the railway line going east-west, with side platforms on either side. The trains going west to Worcester stop at the Framingham platform to the North, and the trains going east to Boston stop at the Framingham platform to the South. The platforms are connected by a pedestrian bridge over the tracks, which also includes two elevators for wheelchair accessibility. While the historical train station is still present, it is in use as a restaurant and is neither owned by freight rail companies nor the MBTA (“Framingham Master Plan”, 2020).

There are bike racks along the platforms and bike lockers at the Westbound platform (Figure 8). The station is parallel to Waverly St. (State Highway 135) and is located next to a grade crossing at Irving St. (State Highway 126). There are parking lots to the North and South of the station. The South parking lot is long and narrow, and the North parking lot is much larger. Both combined have 167 parking spaces (Jessen, 2016).

Figure 8: Annotated map of the Framingham Commuter Rail station.

Currently, the station is managed by the MWRTA (MetroWest Regional Transit Authority) that runs buses that serve the station, and the MWRTA receives parking revenue to pay for bus shelters (Jessen, 2016). This allows the MBTA to save money on managing the station, and the MWRTA can use FTA (Federal Transit Administration) funds to maintain the station. However, with the exception of some of the North parking lot, the station is largely owned by the "Georgetown & High Line Railway" (see Figure 5). Further investigation is needed regarding the agreement between MBTA and freight rail companies regarding use of the station (MapGeo, 2021).

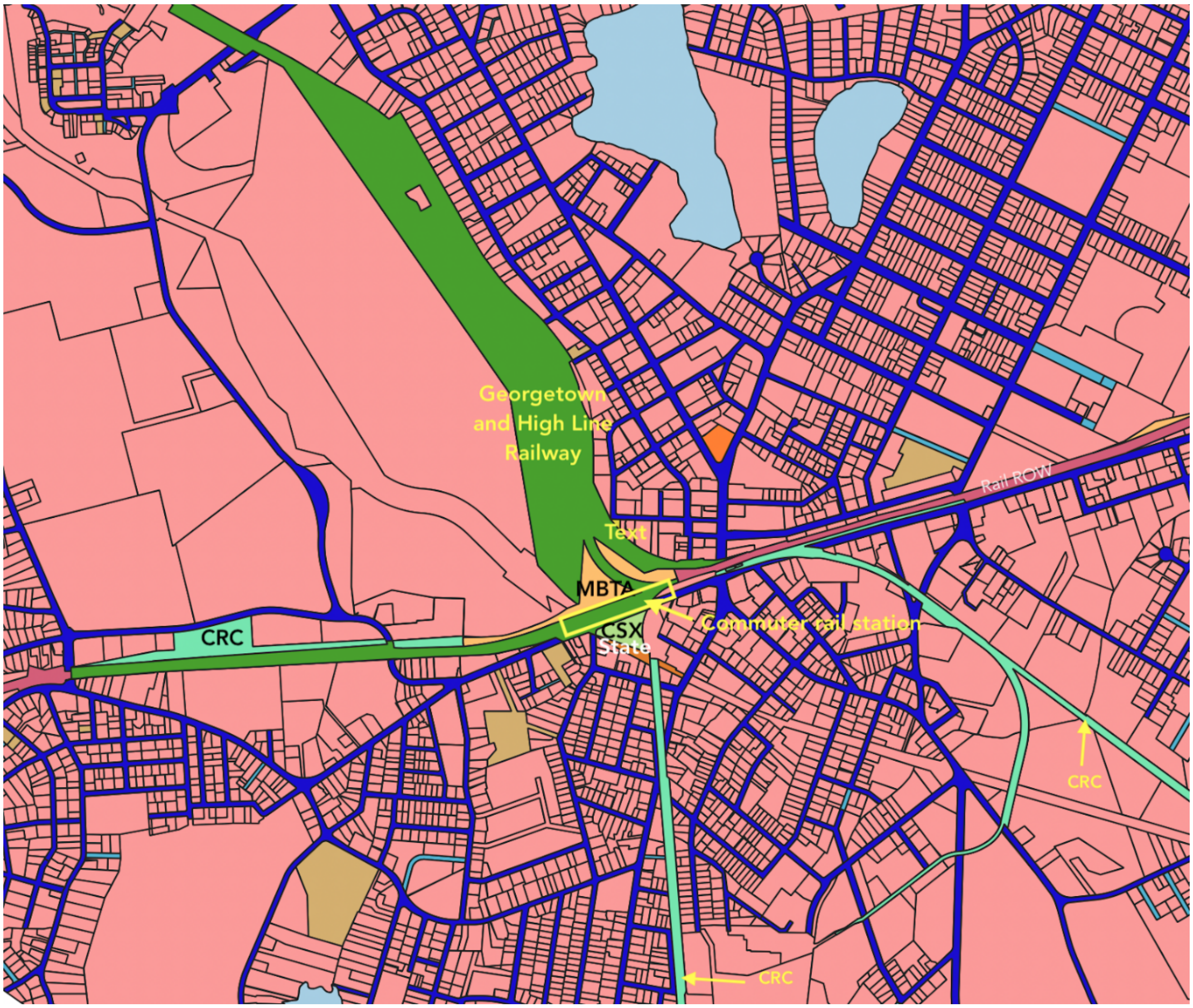


Figure 9: Map of Framingham based on data from the Framingham Property Viewer (MapGeo, 2021).

The green areas in Figure 5 show the Georgetown and High Line railway properties. The CRC, or Consolidated Rail Corporation owns the properties in Cyan, and CSX property in light green. MBTA properties are labeled in light ochre, and the commuter rail station (approximate and not including parking) is labeled with a yellow box. The state owns a small parcel of land just south of the commuter rail station. Please note that the Georgetown and High Line railway, CRC and CSX all have the same ownership address, so despite the different names, they are probably all the same entity.

An In-Depth Explanation of the Problem

Plans are currently being laid out for a major construction project on Interstate 90 near Allston, which will create many bottlenecks and slow down vehicle traffic considerably. The construction that will take place on I-90 is assumed to be a 6-to-10-year process; therefore, an alternative use of transportation becomes highly valuable to city-goers and commuters. One of the most efficient forms of public transportation is trains, but in order for that to be true, the train station must be accessible and easy to get to. The City of Framingham's Master Land Use Plan outlined a recent evaluation of current bus routes and their efficiency. It also discussed some future plans, which included servicing some of the most critical points in the city, including the train station ("Framingham Master Plan", 2020). The Master Plan also says Framingham is committed to accommodating other forms of transportation to bus stations and the train station, such as walking and biking, by creating more paths and sidewalks to these transportation hubs ("Framingham Master Plan", 2020). Not having a convenient way of getting to the train station makes the option of traveling by train less favorable, contributing to more traffic on I-90. This will cause even more headaches for commuters attempting to get into the city by car during the Allston construction.

The Framingham station itself suffers from a problem faced by many rail networks around the globe: at-grade road crossings. The Framingham commuter rail station sits directly adjacent to the busy Route 126-Route 135 intersection (circled in red in Figure 10); a half-mile east from the station is the Bishop Street-Route 135 intersection (circled in blue in Figure 10). These at-grade crossings cause trains to forcibly slow down when leaving or entering Framingham station anywhere east of the station. Road traffic is also affected as, very obviously, traffic cannot cross the rails while a train is occupying the intersection. Additionally, upon observation, it became quickly apparent that pedestrians like to walk alongside the tracks, which causes train conductors to slow down even more for fear of hitting them. The at-grade crossings do nothing but hinder rail efficiency as well as create large vehicle bottlenecks in the busy corridors nearby the station.

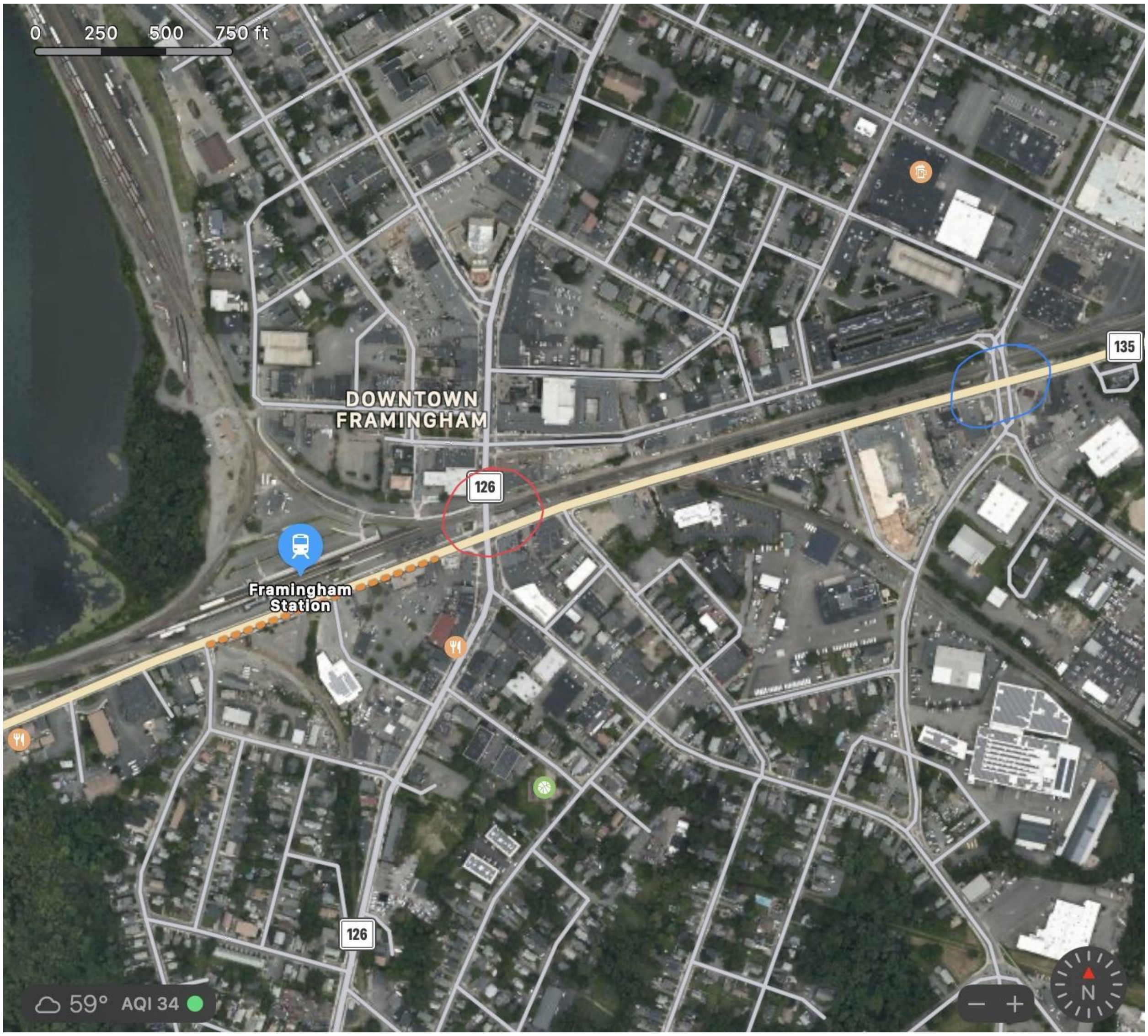


Figure 10: Map of downtown Framingham with the at-grade crossings circled (Apple Maps).

A large accessibility problem in terms of its station layout is also found at Framingham station. With its current setup, there are two different platform levels — one that is at the level of a train car and one that is at street level (see Figure 11). Boarding time and accessibility are largely affected by this design. For example, those who are disabled are likely not able to board from the street-level platform because they will be unable to climb up the steep steps up to the train. All of these passengers would need to enter from the small high-level platform, which would take a considerable amount of time since the high-level platform only serves one or two train car entrances. This vastly increases the time spent at the station, wasting precious minutes that could have been spent traveling.

Figure 11: Picture of the Framingham station with its small high-level platform (Google Maps).

The Framingham station is currently set up in favor of commuters parking their car at the station and then boarding a train. The infrastructure surrounding the station does not lend itself well to arriving at the station via an alternative transportation method. A bus stop currently exists on the street in front of the station. The pick-up and drop-off area for individuals using rideshare services exists in front of the station, although it is very small with a less-than-ideal setup. Bicyclists have access to storage lockers at the station, but their travel to the station is a bit complicated. Dedicated bike lanes are not present on Route 135 in front of the station, and bikes are encouraged to share the road with vehicles. There are also no other pedestrian and bicycle lanes nearby that lead to the station from other densely populated areas of Framingham.

TransitMatters: Regional Rail Proof of Concept Study

TransitMatters is a non-profit organization that works to support transportation around the Boston area by advocating for and advancing the best proven practices. They do this work with the vision of making an equitable, sustainable, and reliable public transportation system accessible to everyone in Metropolitan Boston (TransitMatters, 2021). One high impact, low-cost initiative they advocate for is modernizing the commuter rail system. TransitMatters believes the regional rail system should provide frequent, all-day service with elements such as level-boarding, systemwide electrification, and free transfers (“Regional Rail Proof of Concept”, 2019). This high level of service on the Framingham-Worcester line could be critical to alleviate congestion with the future construction plans on I-90, and it would be an equitable solution for users with flexible work schedules.

Many changes would need to be made by the MBTA that are outlined by TransitMatters. At its core, TransitMatters believes that logical timetable adjustments are the key to creating a more efficient rail network, especially on the commuter rail. In order to do so, various infrastructure improvements would need to be made to ensure that trains are traveling optimally. To start, the speeds of trains would need to increase. Currently, trains are capped at a travel speed of 60 MPH despite the line being able to support 90 MPH to 100 MPH travel speeds. Many of the straight portions of track would be able to accommodate these higher speeds. Curves throughout the network would need to be redesigned to allow for trains to travel more quickly through them. Overall, though, the speed caps would need to be increased in order to provide the most efficient service. Electrifying the rail would also support this initiative, but it is unlikely to occur anytime soon ("Regional Rail Proof of Concept", 2019).

Other improvements aimed at increasing efficiency would include high-level platforms at all stations on the commuter rail line and the construction of a third track. As discussed in the "An In-depth Explanation of the Problem" section, high-level platforms would naturally increase the efficiency of the boarding and deboarding at each station along the line. This would cut down on the amount of time the train sits idle at the station, therefore increasing the frequency of trains traveling down the line. A third track would not need to stretch the entire length from Worcester to Boston; rather, it would begin near Framingham and end near Wellesley. A third track would increase the efficiency of the line dramatically as it would allow trains to overtake one another, especially if local and express trains are both run on the commuter rail. However, this would be a high-cost project with many logistical issues realigning the tracks and the stations ("Regional Rail Proof of Concept", 2019).

Through the plans suggested by TransitMatters, the Framingham-Worcester line can achieve four local trains per hour in both directions. TransitMatters also suggests introducing local and express service, utilizing the potential third rail to help with this initiative. Essentially, local trains would travel between South Station and Framingham while express trains would travel the entire length. Express trains would notably not stop at any station between West Station and Framingham (see Figure 12 for TransitMatters' suggested timetable). On the contrary, local trains would stop at every station between these two points, but, again, trains would turn around at Framingham. Due to this method of scheduling, the Framingham station would essentially become a hub for transfers between local and express service. Additionally, with the desire to increase train speeds and overall efficiency on the commuter line, express trains would be able to travel between South Station and Worcester in 45 minutes — less than half the time it currently takes ("Regional Rail Proof of Concept", 2019).

Travel Times

FRAMINGHAM/WORCESTER			
Station	**Local**	**Express**	Current
South Station	**0:00**	**0:00**	0:00
Back Bay	0:03	0:03	0:06
Lansdowne	0:05	0:05	0:11
West Station	0:08	0:07	--
Boston Landing	0:10	(0:08)	0:16
Newton Corner	0:13	(0:10)	--
Newtonville	0:15	(0:11)	0:21
West Newton	0:17	(0:12)	0:25
Auburndale	0:19	(0:12)	0:28
Wellesley Farms	0:22	(0:14)	0:32
Wellesley Hills	0:24	(0:15)	0:35
Wellesley Square	0:26	(0:16)	0:39
Natick Center	0:30	(0:18)	0:44
West Natick	0:32	(0:19)	0:49
Framingham	**0:35**	**0:21**	0:55
Ashland	(0:38)	0:25	1:02
Southborough	(0:42)	0:29	1:07
Westborough	(0:46)	0:33	1:16
Grafton	(0:51)	0:38	1:21
Worcester	**(0:57)**	**0:45**	1:34

Times in parentheses on the express trains indicate the time at which the train will pass a station without stopping; on the local trains they indicate the time the train would serve the station if it kept running local to Worcester.

Figure 12: Proposed timetable between Framingham and Worcester, assuming overtake facilities in Wellesley ("Regional Rail Proof of Concept", 2019).

Case Study on Grade Separation: Redwood City, CA Station

Between San Francisco and San Jose, California lies an approximately 50 mile stretch of rail operated by Caltrain. Redwood City is situated halfway between these two cities. This system provides many similarities to the Framingham-Worcester line as they both are similar in length, provide service between a major and moderately sized city, and have a station mid-way between their two noteworthy destinations that has the potential to serve as a transfer hub between local and express trains and potential for a reactivated spur line. Framingham and Redwood City share many similarities, offering increasingly growing populations and downtown areas. They also share a similar issue when it comes to increasing trains-per-hour: at-grade rail crossings.

The Redwood City station finds itself in a more precarious situation compared to Framingham. Its station is sandwiched directly between two cross-streets that serve higher-traffic corridors parallel to the station. Additionally, there are five smaller cross-streets on either side of the station. Framingham finds itself directly adjacent to Route 126, a cross-street that sees a significant amount of throughput, and proximal to another cross-street a few hundred feet down the line. Framingham is obviously a less complicated scenario in comparison to Redwood's situation (Redwood City, 2020).

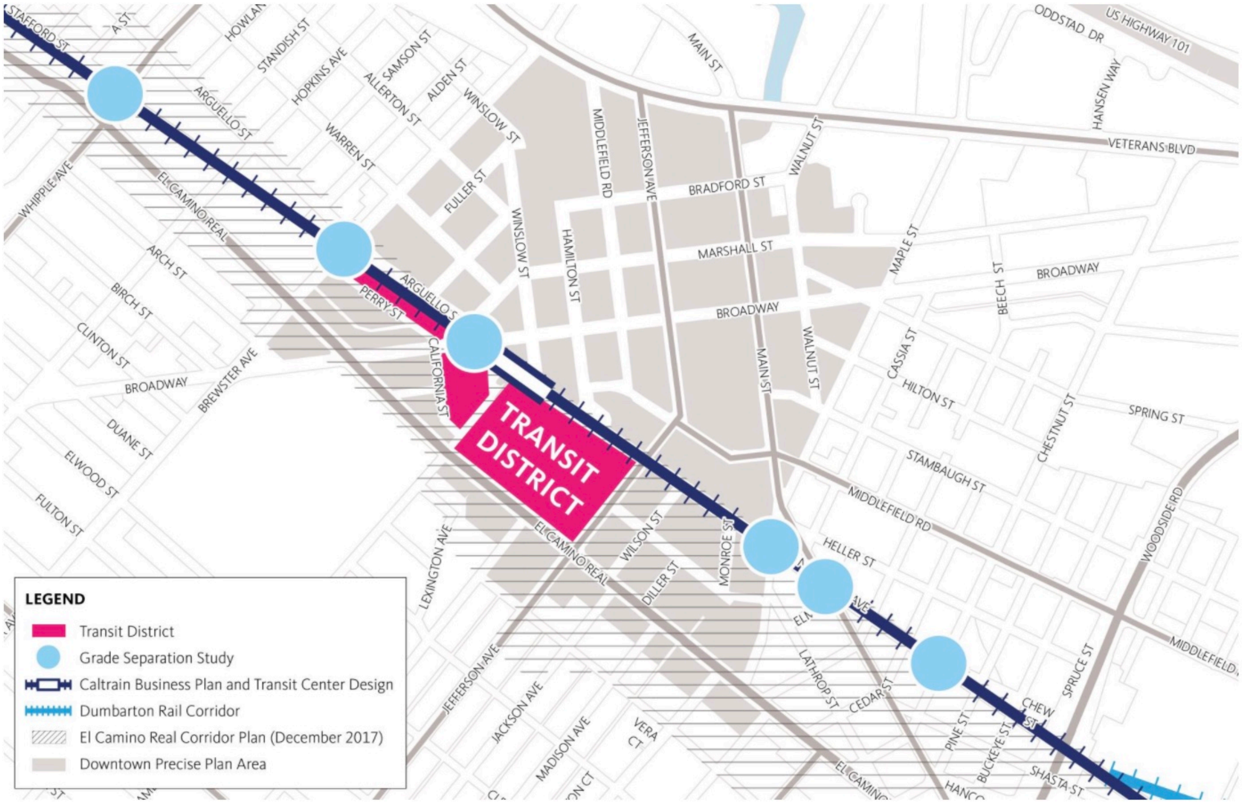


Figure 13: Aerial view of the Redwood City rail station and its surrounding road networks, including identifiers for the various existing at-grade crossings (Redwood City, 2020).

In all cases of separating grades, roadways underneath bridge structures with rails passing above need a 24-foot distance from the base of the road to the top of the rail. This ensures that cars have enough headway to pass under the bridge while also providing enough room for the physical steel bridge beam. Additionally, each scenario will include an elevated station containing four rails with central platforms (Redwood City, 2020).

The current planning proposals offer four different scenarios regarding the two streets directly adjacent to and crossing underneath the Redwood Station — Brewster Avenue to the north and Broadway to the south (Redwood City, 2020).

In the first suggestion, Brewster Avenue would remain at its current grade with the station being elevated to provide a 15’-6” clearance between the road and the underside of the bridge structure. The design also includes a bike/pedestrian ramp directly from the sidewalk within the tunnel up to the station above. Broadway would similarly remain at-grade and pass underneath the rails above with a 15’-6” clearance. A bike/pedestrian ramp with direct access to the sidewalk below in the tunnel is also included (Redwood City, 2020).

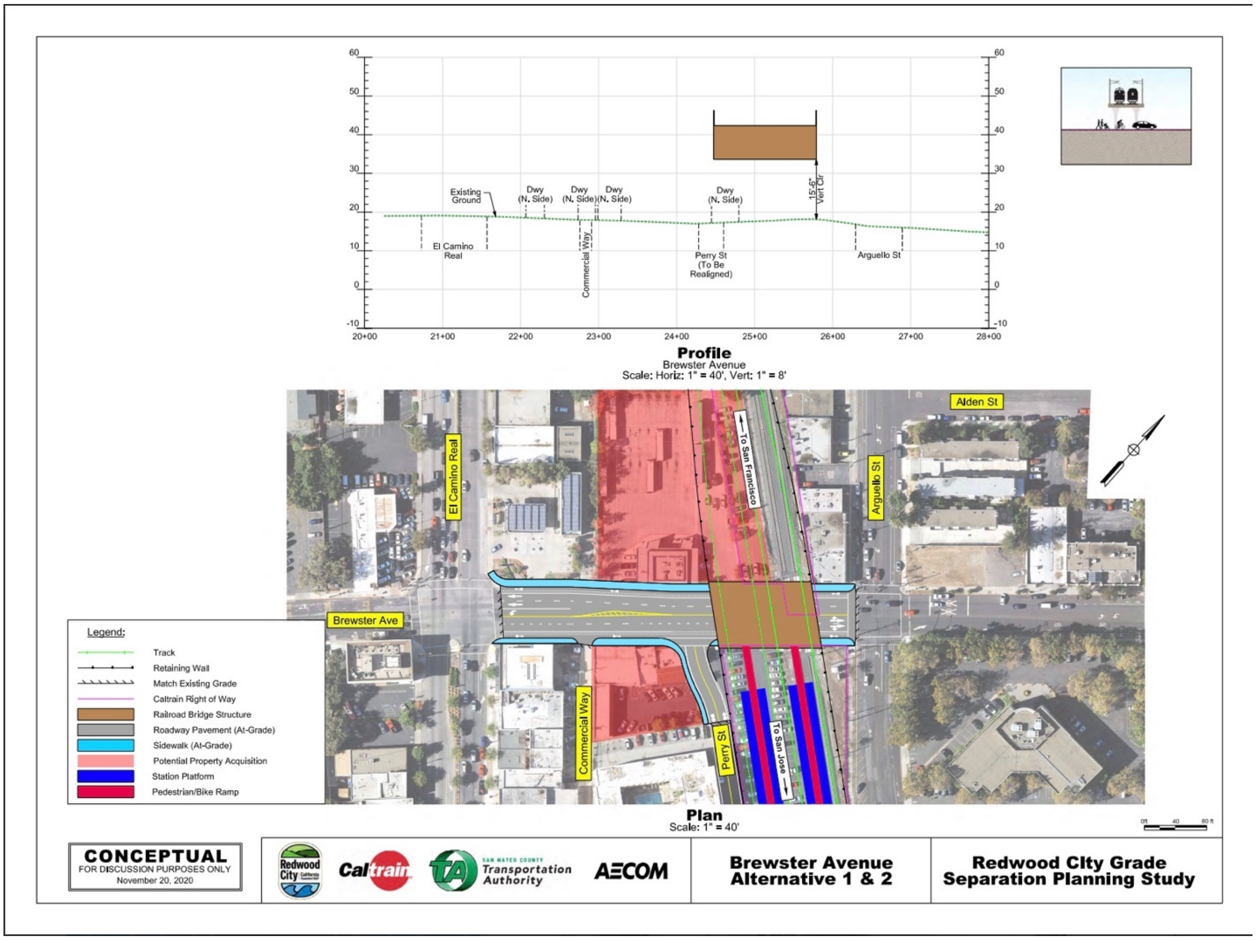


Figure 14: Visual depiction of modifications to Brewster Avenue for design alternatives 1 and 2 (Redwood City, 2020).

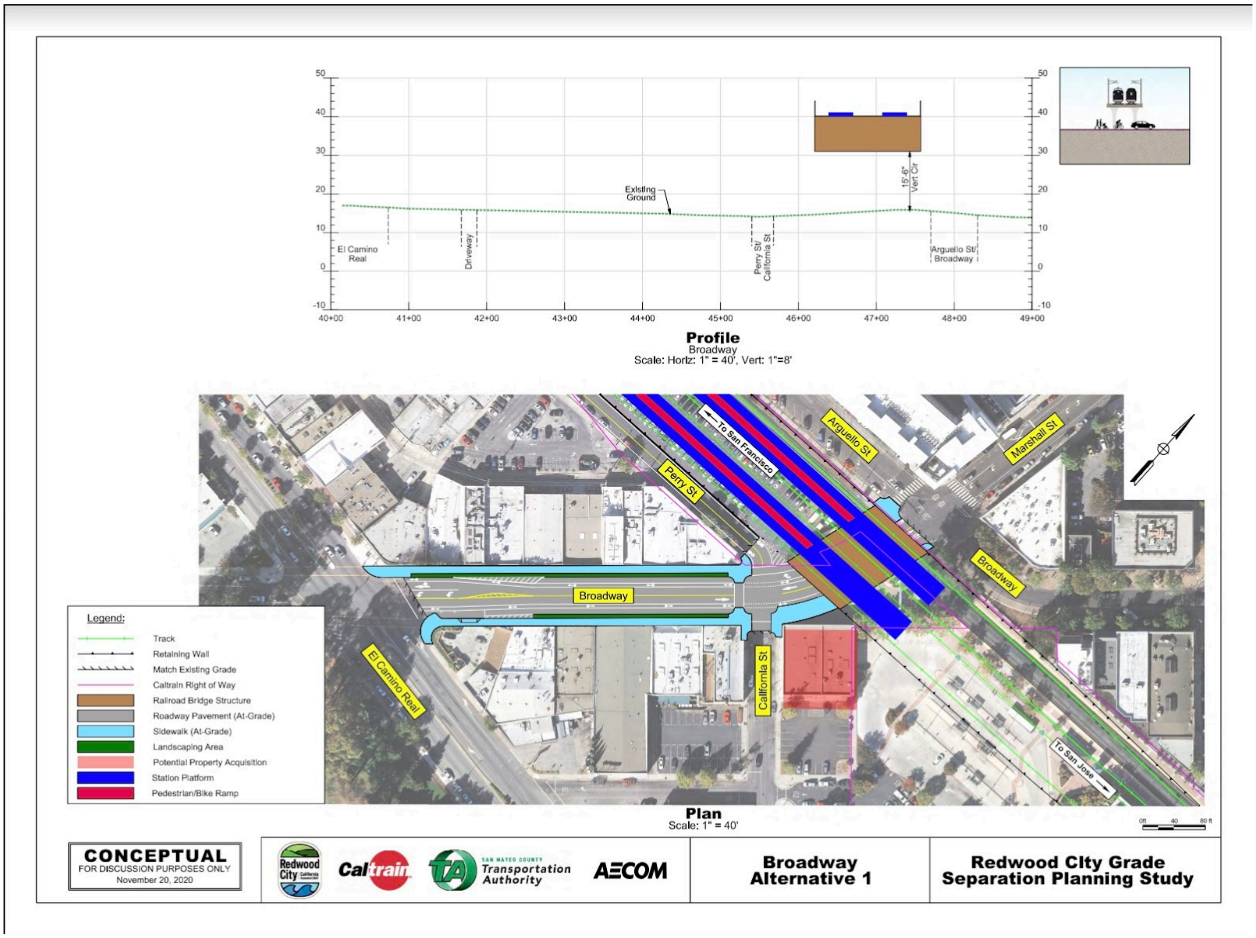


Figure 15: Visual depiction of modifications to Broadway Avenue for design alternative 1 (Redwood City, 2020).

The second suggestion contains minimal changes for Brewster Avenue, with its only change being an increase in road clearance to 17'-1". Broadway would undergo much greater changes, consisting of moving Broadway and the intersection immediately next to the station slightly below its existing grade. An approximate four-foot vertical change in grade would take place at its most extreme points with a maximum of 3% grades connecting the roads from its new to existing grades. A 15'-6" clearance would be implemented at the Broadway crossing. The bike/pedestrian ramps at either street would be maintained (Redwood City, 2020).

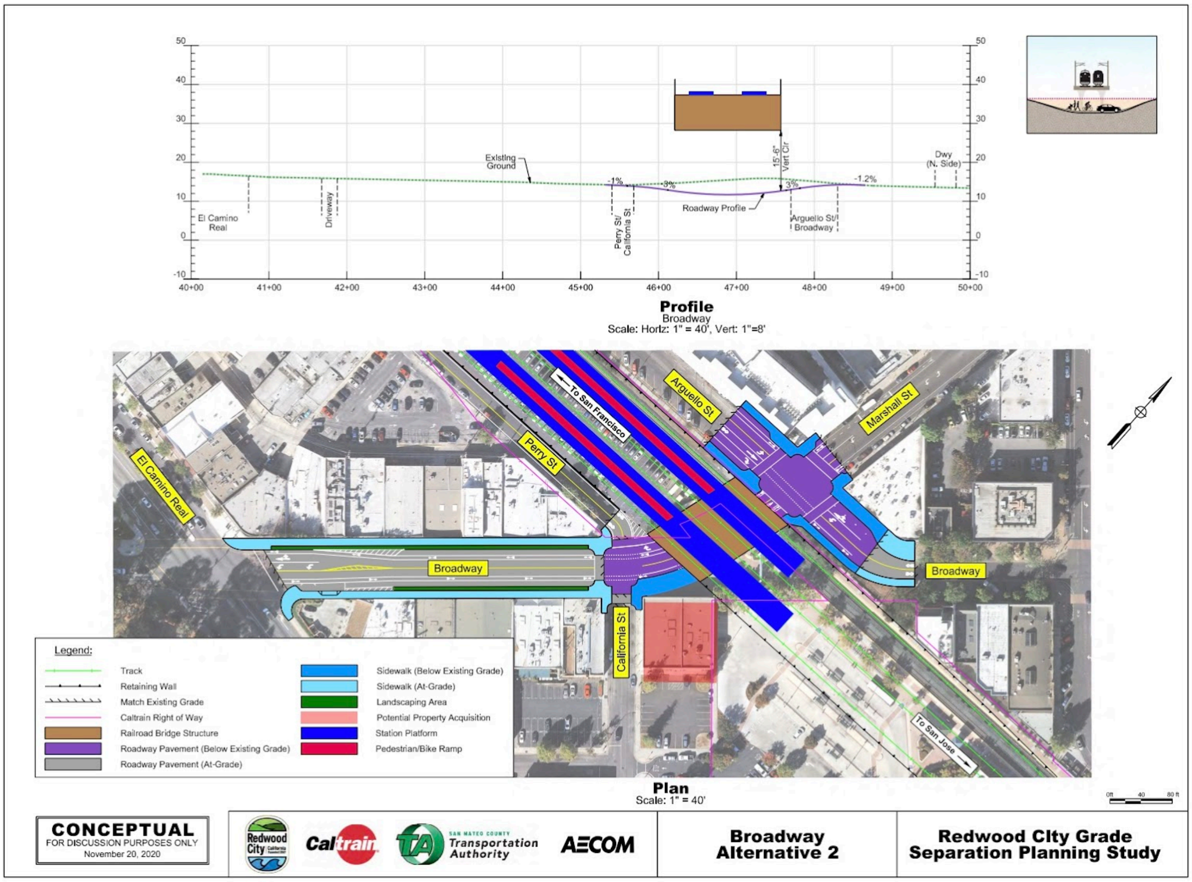


Figure 16: Visual depiction of modifications to Broadway Avenue for design alternative 2 (Redwood City, 2020).

The third alternative suggests grade changes for Brewster Avenue but the complete elimination of the crossing at Broadway. Brewster Avenue would be moved below grade by approximately nine feet directly underneath the station. 6.5% grades (at the most extreme) will be used to bring the road from the existing grades below the station and back up to the other side. The bike/pedestrian ramps at Brewster Avenue would be maintained. Regarding Broadway, a landscaping planter would cut off the existing crossing underneath the station. Perry Street, which runs directly parallel to the station, as well as California Street, would serve as outlets to this newly shortened section of Broadway. New bike/pedestrian ramps would be built on either side of the rail tracks, which would connect to the sidewalks on the sides of the station (Redwood City, 2020).

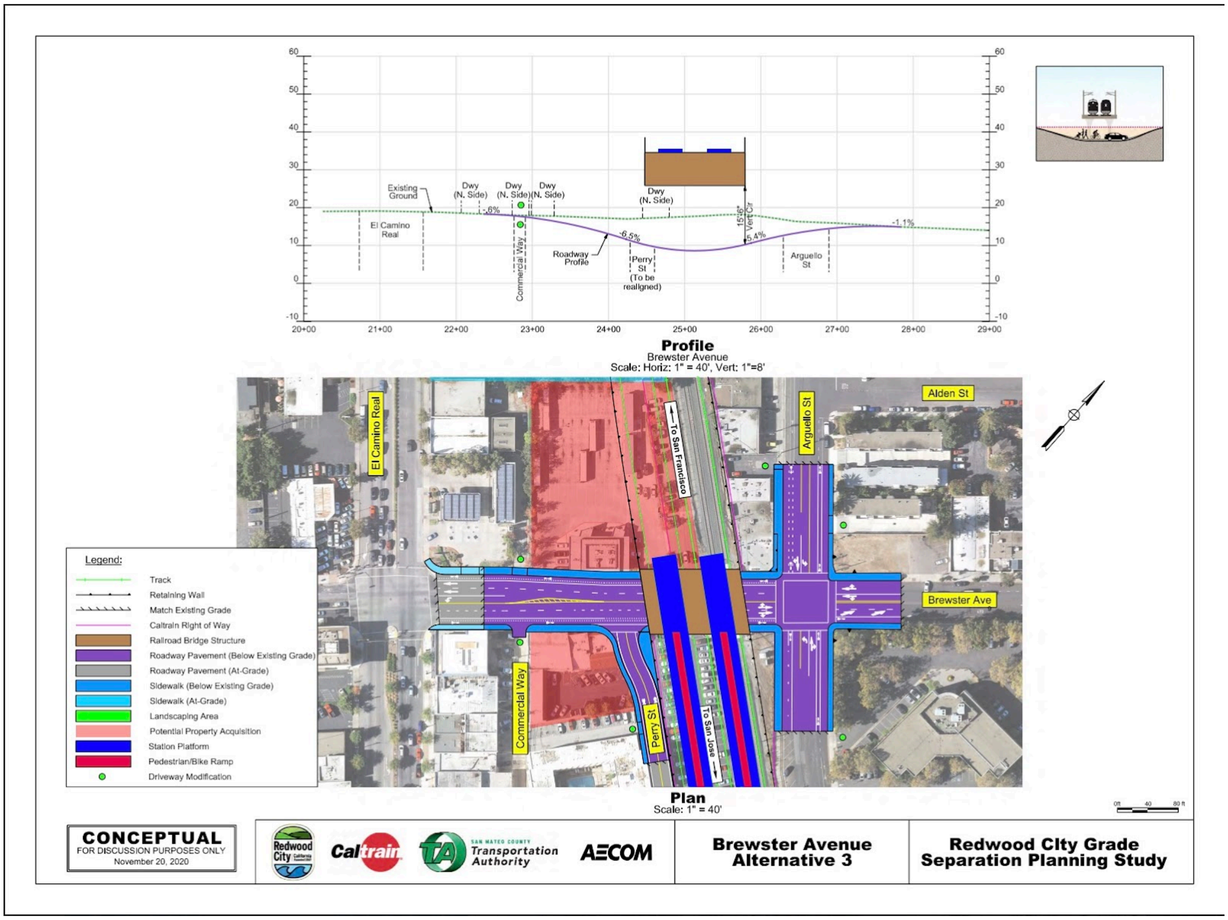


Figure 17: Visual depiction of modifications to Brewster Avenue for design alternative 3 (Redwood City, 2020).

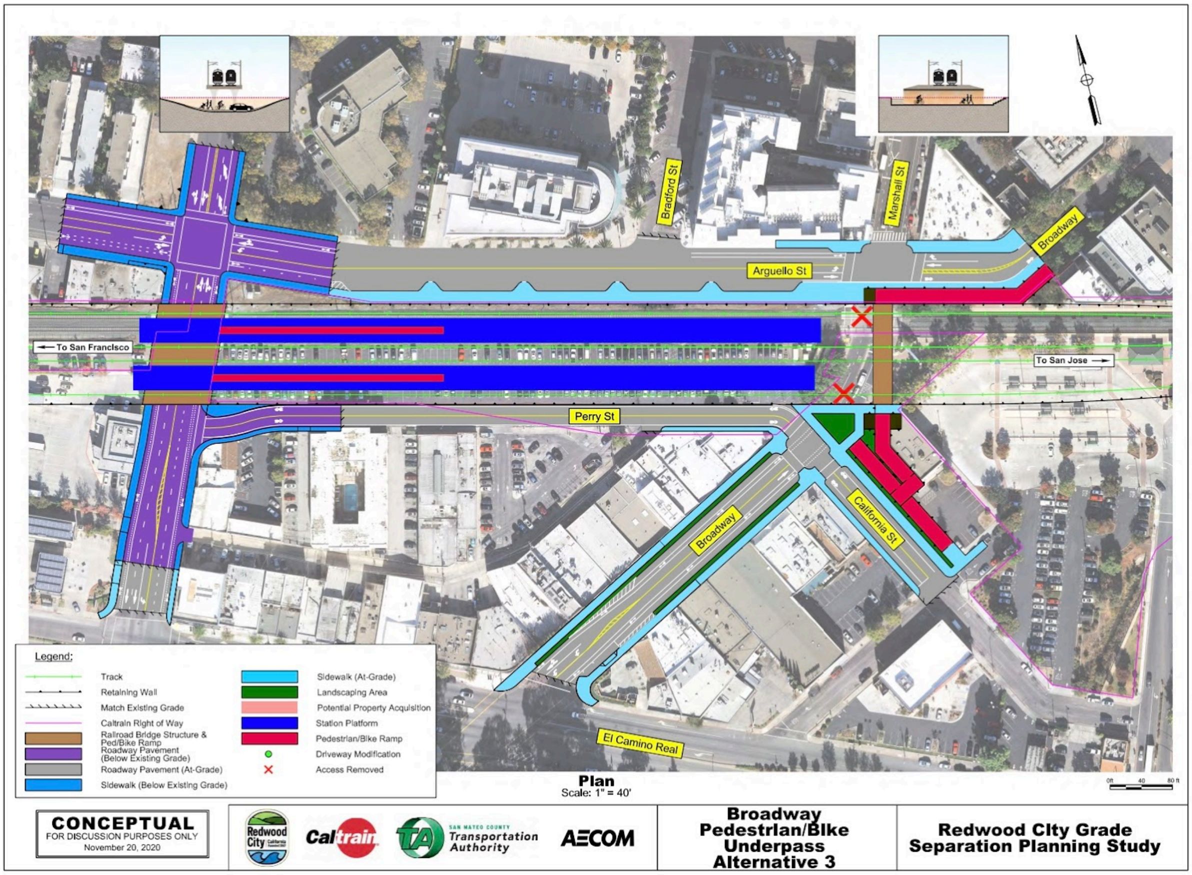


Figure 18: Visual depiction of modifications to Broadway Avenue for design alternative 3 (Redwood City, 2020).

A separate variation of the third alternative would see the same grade changes to Brewster Avenue as described in the previous paragraph but would also include more extreme grade variations for Broadway, effectively keeping the underpass on that side of the station. A maximum of 8.5% grades would be used to connect the newly lowered Broadway approximately 16 feet below its existing grade. A 15’-6” clearance height would be maintained at the Broadway crossing. Additionally, the typical bike/pedestrian ramps that extend from the tunnel directly up to the station platform would be implemented (Redwood City, 2020).

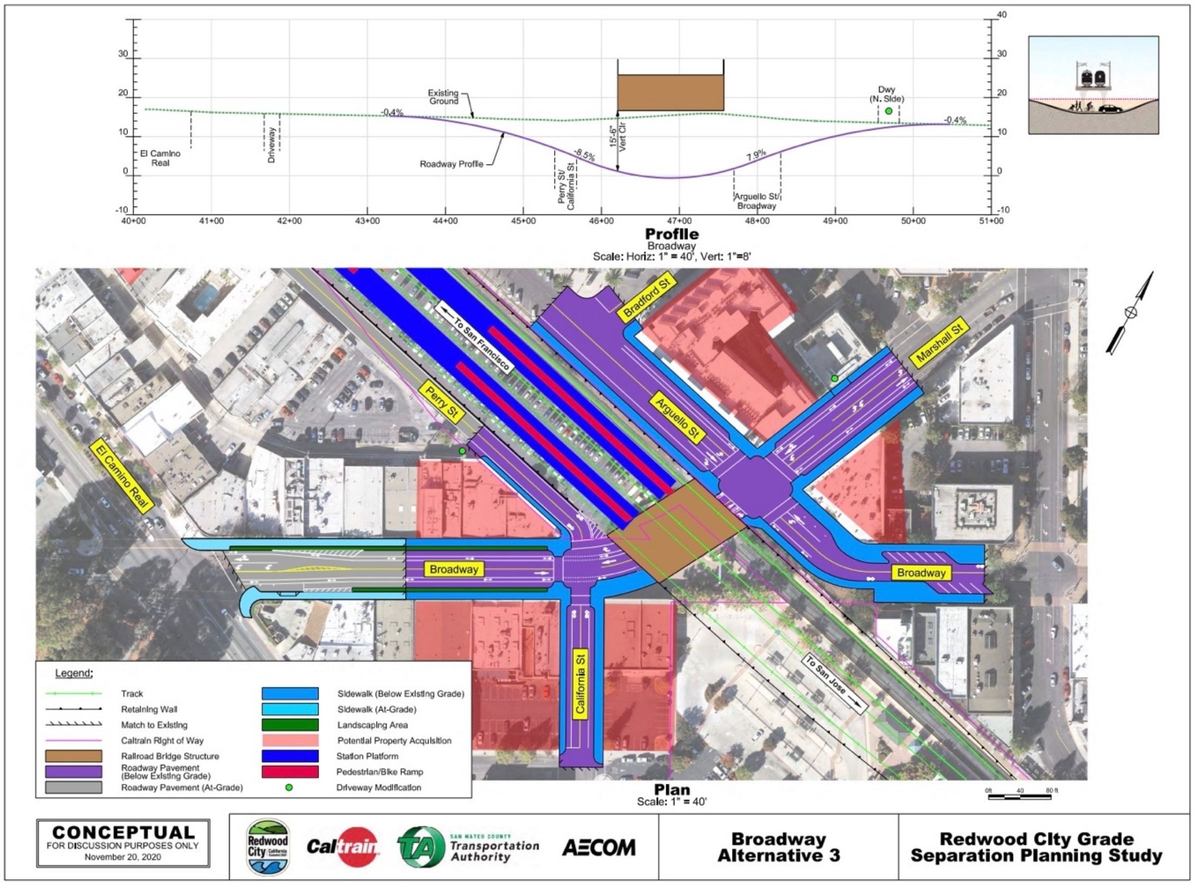


Figure 19: Visual depiction of modifications to Broadway Avenue for a different variation of design alternative 3 (Redwood City, 2020).

The final proposed alternative would see the removal of both crossings. Both Brewster Avenue and Broadway would be diverted into one another via Perry Street. Additionally, bike/pedestrian paths would not be constructed in any fashion.

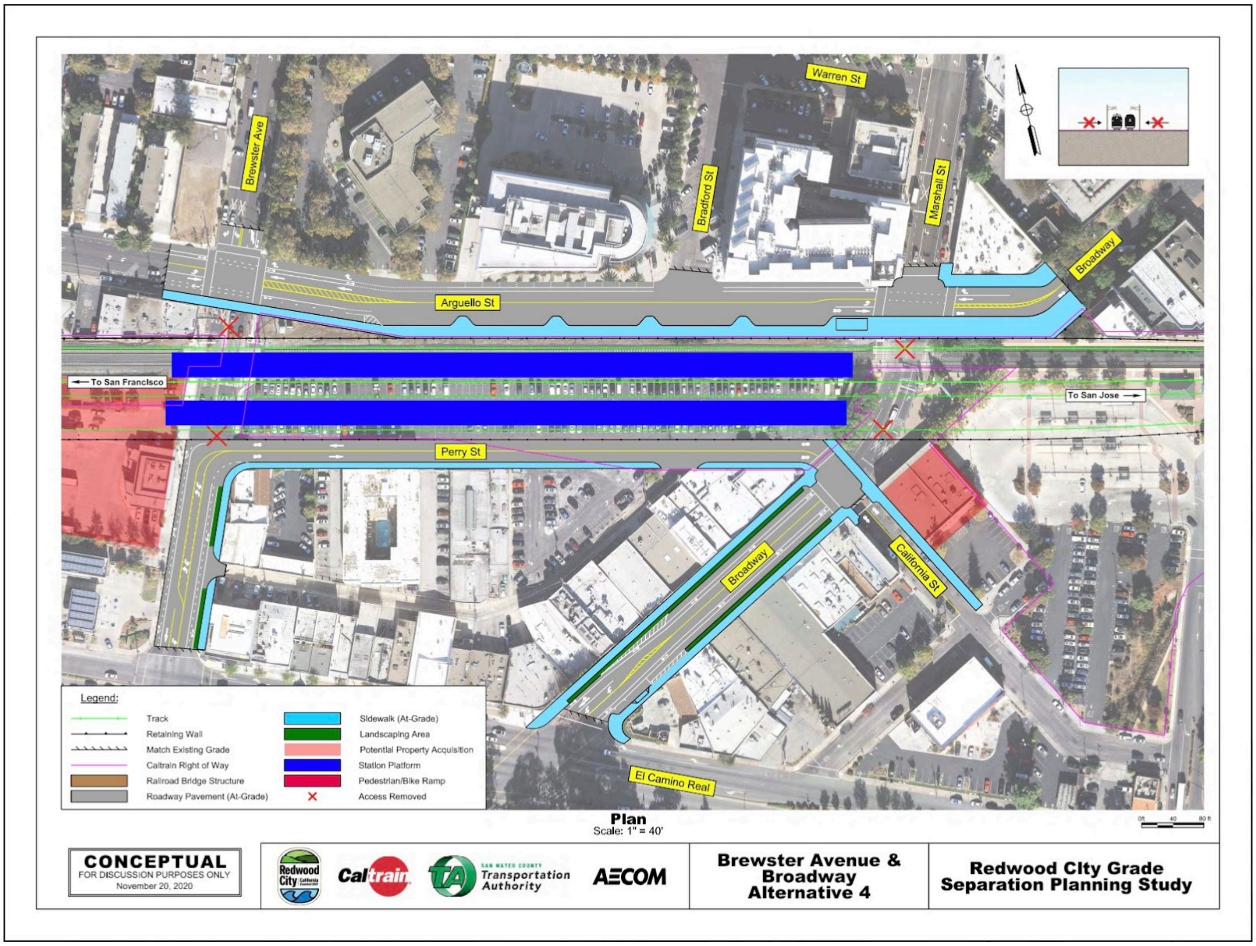


Figure 20: Visual depiction of modifications to Broadway and Brewster Avenues for design alternative 4 (Redwood City, 2020).

In a blog post designated for discussion on the proposed alternatives of the Redwood City station in terms of its grade separation, a few key issues were highlighted. The thickness of the steel bridge beams was quickly pointed out as being excessive. A recently completed rail bridge crossing design in San Bruno, California utilized 5.5-foot bridge depths for an approximately 85-foot span — approximately 11 feet longer than the span proposed at Redwood City. The elevated Redwood City station is proposed to be built on an embankment. For each additional foot of bridge depth, an additional vertical foot of embankment must be added, effectively increasing costs and labor. The proposed 9-to-17-foot bridge depths for Redwood City are excessive, and therefore increase costs and labor ("Redwood City Grade Seps: We Must Do Better", 2020).

An additional criticism of the Redwood City alternatives was specifically targeted at the fourth suggestion. This option removes both road crossings immediately adjacent to the station. With no bike/pedestrian paths being built in this scenario, there is no clearly designed way for pedestrians or bicyclists to get to the top of the station ("Redwood City Grade Seps: We Must Do Better", 2020).

2009 BETA Study

The 2009 Final Report of the Downtown Study Framingham by BETA Group, Inc. assesses existing land use and transportation in downtown Framingham, particularly the intersection of State Highways 135 and 126 at the train station.

It is a notably car-centric study, with minor consideration of pedestrian and transit needs despite mentioning a "high volume of pedestrian activity." The study recommends an increase in car parking despite documenting low parking utilization, in part with extremely generalized parking requirement calculations that aren't true for a dense urban environment such as Downtown Framingham where people may not require cars. It assumes an increase in traffic volumes even though "traffic volumes have remained stable or even declined slightly" historically and assumes that any land use redevelopment will automatically increase traffic when a new development could be designed to prioritize pedestrian access. Additionally, the study does not consider that increasing parking leads to more driving and less walking in a self-fulfilling prophecy (Un, 2010).

However, with these caveats, the study has extremely detailed and useful information and insights, including traffic and parking counts.

It includes the following data and analyses:

1. Land use in the area, including FAR (Floor-to-Area ratio calculations)
2. Underground utilities: electric, gas, telecommunication, water, storm drain and sewer near the railway station.
3. Number of parking spaces within downtown, classified by area, on-street, off-street and by ownership (town, public or private).
4. Traffic Volume Forecasts (which appears to have flawed assumptions as noted previously).

5. Level of Service Analyses, which assesses car delay at intersections, including delays due to grade crossings with the rail line(s).
6. Areas of and parking demands for different land use types.
7. Key properties for redevelopment around the commuter rail station, including CSX-owned properties, and key buildings to be retained beyond redevelopment.
8. Land use implication of the Residential, Cultural and Mixed-use "Urban Design and Development strategies" around the train station, and how they would interact with various alternatives for grade-separating State Highways 135 and 126.
9. Existing utilization of area and long-term build-out calculations.

Framingham Master Plan 2020

The Framingham Master Land Use Plan states their vision for Framingham is to be "the heart of MetroWest Boston that is culturally vibrant and provides members of the community access to affordable and diverse housing options, educate opportunities for all, transportation that is efficient and easy to utilize, supportive of all businesses that choose to locate in Framingham, safe and attractive neighborhoods and villages, cultural and historical resources, and a community representing its people" ("Framingham Master Plan", 2020). This vision the city has clearly does not just want good public transportation, but, rather, they are looking to make Framingham a more attractive place to live and visit. The city speaks about supporting all businesses in Framingham, and a great way to make those businesses flourish is to physically bring more people to the city. This is also justification for improving the rail service in Framingham; more access means more economical opportunity.

The Transportation Dividend

A 2018 study, known as the Transportation Dividend, analyzed the existing conditions of the Massachusetts Bay Transportation Authority (MBTA) rail system in Boston and discussed its impact on the local economy. A brief look at the study reveals that the rail network found within Boston (known colloquially as the T) has a substantially positive impact on the city's economy. To put it into terms of a statistic, the MBTA's annual operation provides the city with $11.4 billion in economic benefit, which is considerable when compared to its $2 billion operating budget. This figure was calculated based on what infrastructure, travel costs, and travel time increases would be required for all 1.3 million weekday MBTA users to successfully travel in and around Boston without the MBTA's services. The MBTA has seen a 6.7% reduction in daily car trips, $640 million annually in vehicle crash savings, and $3.6 billion in savings annually in terms of travel costs, which is a result of decreased gas, tolls, car maintenance, and car insurance costs for T users. Boston is known nationally as one of the most congested cities and would be unable to function without the MBTA's services, specifically the T. The city is able to move so many people around the city because of the vast network of rails underground, which also allows the city to produce six times more GDP than the national average (Dimino et al., 2018).

Accessibility to the stations is also an extremely integral piece of why the T propels the city of Boston to such economic heights. Within Metropolitan Boston, 25% of the region's households and 37% of the region's jobs exist within a half-mile radius of one of the 268 rapid transit or commuter rail stations. Not only does this provide residents and employees with an extremely convenient alternative mode of transportation to vehicles, it also increases property values, resulting in $160 million in additional property tax revenues (Dimino et al., 2018).

As the MBTA looks into the future, they have three main investment strategies they can choose from. First, the organization could look into spending $7.3 billion to bring the system up to a "State of Good Repair." This would provide much needed enhancements and efficiency improvements to the rail and bus networks. It is projected that $400 million in additional yearly revenue would be achieved from these modifications. Secondly, giving attention to the rail lines that see the most use within Boston would be considered a step above the previous spending strategy. The changes to these lines would see actual improvements over the existing infrastructure, not just fixing the line to operate at an acceptable level of performance. Such changes are already in the works, such as new fleets on the red and orange lines in addition to signal improvements and the construction of additional maintenance facilities. The orange line will see a 30% increase in service while the red line will see a 50% increase. The green and silver lines have been identified as the next rails that would need to see improvements made to the same degree as they are both traveled on frequently by passengers. The last spending method would see investment in various service enhancements that would transform the entire MBTA system. Creating infill stations (stations between two existing stations), reimagining the commuter rail, making bus transit more rapid, and utilizing ferries are a few of the many changes this spending method would bring (Dimino et al., 2018).

Overall, it is clear how impactful a successful transit system can have on a city in terms of use and economic implications. Rail is an important transportation method with real, far-reaching impacts on its surrounding community and economy.

Millbrae Station Area Specific Plan (MSASP)

This Environmental Impact Report for Millbrae, a station on the Caltrain, assesses the environmental impact of new developments around the train station. It provides a detailed list of environmental impacts and mitigation strategies for alternatives, such as noise, transportation circulation and air quality. For example, it includes increased exposure to air pollution due to new developments as well as how bringing more people into such an area would increase exposure to certain pollutants. This is relevant to our project, which would need to consider the effect of improved train service and related new developments to the neighborhood.

Chapter 3: Methods

Important with any large project, outlining a list of tasks that need to be completed is helpful. Below is a list of tasks sorted by our objectives, that must be completed before moving onto the design phase of our project with a description of what we will do regarding each one:

Objective 1 Methods (Understand scope of knowledge):

Community Input

Obtaining community input on the station will help determine what residents and business owners hope to see at the new station. This information can be gained from Framingham city planners; as well as, talking to any other local representatives about what can possibly be constructed.

Stakeholder Analysis

We will identify all parties involved and impacted by the Framingham station. Some of the stakeholders are passengers, the MBTA, CSX Transportation, and the City of Framingham. Data can be taken from the MBTA system-wide survey regarding trip frequencies, rider data, access modes, and more.

Objective 2 Methods (Collect data on existing infrastructure and usage):

Identify Station Amenities

By identifying the station's current amenities, we will be able to get a better understanding of what the station is capable of. This will allow us to brainstorm possible additions that could help the station in terms of making it more accessible to riders and for users to have a better overall experience. Benefits from this could include easier station access and increased ridership.

Identifying Existing Bike Paths and Plans

Looking into the existing bike paths around the station will allow us to examine the current accessibility of the station by bike. This will help in determining if the bike paths are in the most ideal locations around Framingham, and we will be able to determine if there should be more paths created that are not in any future plans Framingham might have for bike paths.

Bus Routes

Having the bus routes and stops for the city of Framingham will be very helpful as it will allow us to determine how effective the routes and stops are as well as the timing and frequency of the buses. Buses are the more local method of public transportation, so they will play a key role in analyzing the effectiveness of them and how they impact riders of the train.

Parking Study

A parking study would help evaluate the current parking situation for the station. This will allow us to evaluate the effectiveness of the current parking around the station and if there would be a better use of the land where the parking currently is. This can be done by visiting the station and examining the parking on a typical workday.

Objective 3 Methods (Analyze data):

Analyze StreetLight Data

StreetLight Data uses mobile devices, or anything with a GPS, to gather location records to identify travel patterns. This will be useful to us because it will allow us to track traffic in and out of downtown Framingham. StreetLight Data will also be able to give us the method of transportation on how users arrive downtown. This data will help us in determining which necessary improvements are needed to make all forms of transportation to the city more favorable. We will send a request to StreetLight Data to obtain the data for the area.

Environmental Impact Report (EIR)

Using the EIR from the Caltrain project can lead the group to accessing what aspects of the project have negative and positive effects on the environment. The EIR provides information as to what design and construction tactics can be used or avoided.

Commuter Rail Ticket Sales

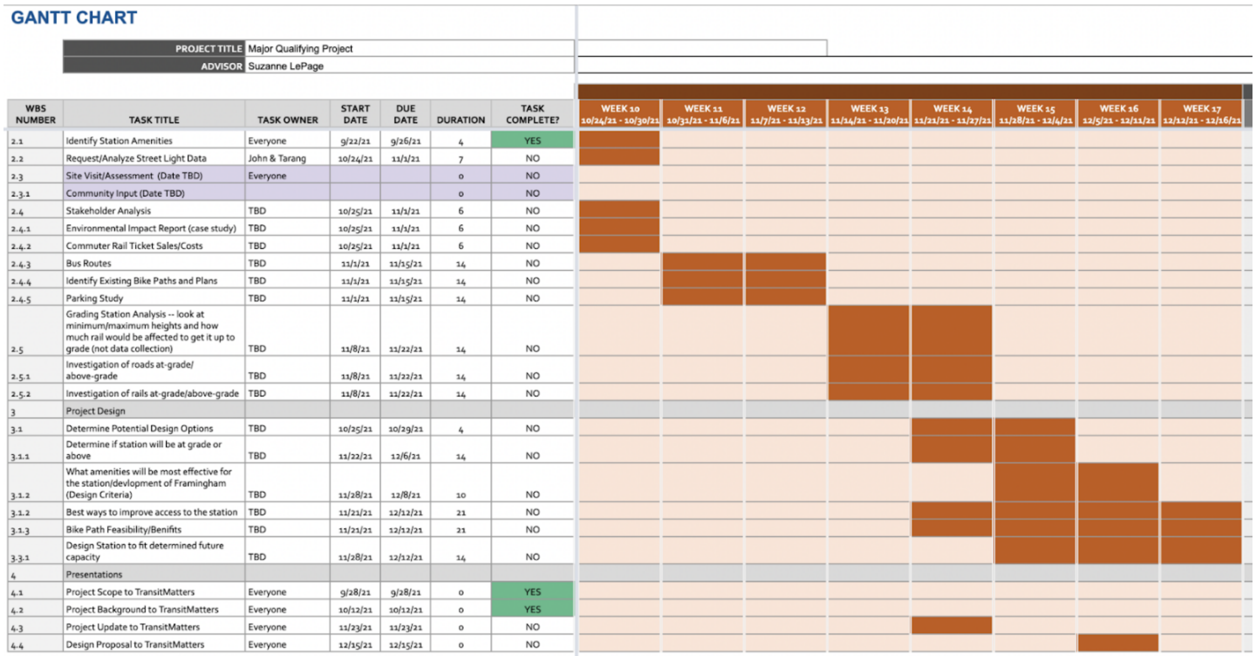
Getting commuter rail ticket sales will provide the number of riders boarding the train from the Framingham station. Along with StreetLight Data, this will allow us to examine the number of people riding the train from the Framingham station. This could also allow us to see the busiest days and times for the station. This will assist us when designing the station to plan for the current capacity.

Objective 4 Methods (Design Improvements):

Grading Station Analysis

Analyzing whether or not the station should be at grade or not is imperative to this design; it would be a massive project if it were to be elevated, but the payoff has great potential. Performing an in-depth investigation into whether or not raising the station is a key step in determining a potential design of a new station. This will be done by examining case studies and forming a method of evaluation (such as a rubric) to determine if it will be worth it. It is important to note the train runs through two intersections in downtown Framingham, so this would change the flow of traffic as well.

Gantt Chart:



GANTT CHART

PROJECT TITLE Major Qualifying Project
ADVISOR Suzanne LePage

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	TASK COMPLETE?
2.1	Identify Station Amenities	Everyone	9/22/21	9/26/21	4	YES
2.2	Request/Analyze Street Light Data	John & Tarang	10/24/21	11/1/21	7	NO
2.3	Site Visit/Assessment (Date TBD)	Everyone			0	NO
2.3.1	Community Input (Date TBD)				0	NO
2.4	Stakeholder Analysis	TBD	10/25/21	11/1/21	6	NO
2.4.1	Environmental Impact Report (case study)	TBD	10/25/21	11/1/21	6	NO
2.4.2	Commuter Rail Ticket Sales/Costs	TBD	10/25/21	11/1/21	6	NO
2.4.3	Bus Routes	TBD	11/1/21	11/15/21	14	NO
2.4.4	Identify Existing Bike Paths and Plans	TBD	11/1/21	11/15/21	14	NO
2.4.5	Parking Study	TBD	11/1/21	11/15/21	14	NO
2.5	Grading Station Analysis -- look at minimum/maximum heights and how much rail would be affected to get it up to grade (not data collection)	TBD	11/8/21	11/22/21	14	NO
2.5.1	Investigation of roads at-grade/ above-grade	TBD	11/8/21	11/22/21	14	NO
2.5.2	Investigation of rails at-grade/above-grade	TBD	11/8/21	11/22/21	14	NO
3	Project Design					
3.1	Determine Potential Design Options	TBD	10/25/21	10/29/21	4	NO
3.1.1	Determine if station will be at grade or above	TBD	11/22/21	12/6/21	14	NO
3.1.2	What amenities will be most effective for the station/devlopment of Framingham (Design Criteria)	TBD	11/28/21	12/8/21	10	NO
3.1.2	Best ways to improve access to the station	TBD	11/21/21	12/12/21	21	NO
3.1.3	Bike Path Feasibility/Benifits	TBD	11/21/21	12/12/21	21	NO
3.3.1	Design Station to fit determined future capacity	TBD	11/28/21	12/12/21	14	NO
4	Presentations					
4.1	Project Scope to TransitMatters	Everyone	9/28/21	9/28/21	0	YES
4.2	Project Background to TransitMatters	Everyone	10/12/21	10/12/21	0	YES
4.3	Project Update to TransitMatters	Everyone	11/23/21	11/23/21	0	NO
4.4	Design Proposal to TransitMatters	Everyone	12/15/21	12/15/21	0	NO

Figure 21: B-Term Gantt Chart.