Grand Junction Transportation Feasibility Study

A report produced by the Central Transportation Planning Staff for MassDOT

Grand Junction Transportation Feasibility Study

Final Report

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EXECUTIVE SUMMARY

The Central Transportation Planning Staff (CTPS) has completed an analysis of the feasibility of providing Massachusetts Bay Transportation Authority (MBTA) commuter rail service along the Grand Junction Railroad right-of-way (ROW), which is used by CSX local freight trains, by the MBTA for transferring equipment between the north-side and south-side commuter rail lines, and by Amtrak for transferring equipment for the Downeaster to and from the Southampton Street Yard. The Grand Junction ROW provides the closest and most direct connection between Boston's North and South stations, via Somerville, Cambridge, and Beacon Park Yard (in Allston). As a result of MassDOT's purchase of many CSX rail lines, and of the Grand Junction acquisition specifically, a proposal was made for some of the train service that is to be added to the MBTA Framingham/Worcester Line in the future to be routed via the Grand Junction to North Station, thereby allowing for new connections and destinations to be served, while also relieving congestion at South Station. The Grand Junction Transportation Feasibility Study was conducted in order to evaluate the feasibility, benefits, and impacts of this proposal.

This analysis examined the existing transit characteristics of MBTA Framingham/Worcester Line trains using the MBTA 2008–09 Systemwide Passenger Survey. CTPS collected traffic, pedestrian, and bike counts in the study area in order to understand the impacts on users of the various crossings of the Grand Junction ROW. Potential future service plans were developed for this study in order to test the ridership effects of changes in train frequency, train travel times though Cambridge and Somerville, and the potential construction of a commuter rail station near Cambridge's Kendall Square for a 2035 planning horizon year. Traffic and safety impacts at the six vehicular grade crossings and two pedestrian grade crossings along the branch were also evaluated. The study compares these impacts and ridership to a future "no-build" scenario in which all trains on the Framingham/Worcester Line terminate at South Station, as they do currently.

The analysis showed several benefits and burdens associated with this project.

Benefits

- A number of passengers (both in existing and future conditions) on the Framingham/Worcester Line would benefit by routing train service to North Station via Cambridge.
- It would improve train capacity and provide flexibility for train operations at South Station.
- It would provide an opportunity to serve a major employment center (Kendall Square) with more transit options.

- It would enable passengers to make a new connection between North Station markets and the Kendall Square market in Cambridge, a connection that is not currently served by a direct rapid transit service.

Burdens

- The proposed changes in commuter rail schedules to accommodate the shift of trains to North Station would reduce options for riders who would prefer going to the Back Bay or South Station areas.
- Additional train trips along the Grand Junction ROW would have an infrequent moderate impact on vehicular traffic and on pedestrian and bike trips at several grade crossings in Cambridge.
- Some commuter rail diesel locomotive emissions would be shifted from Boston to Cambridge.
- Utilizing this lightly used right-of-way and building a new station would require new capital investment.
- Operating and maintaining this service and a new station would increase the MBTA's operating costs.

Based on the findings of this analysis, MassDOT has determined that the greater density of trip demand in the Back Bay and Financial District make the South Station route more desirable for the majority of travelers on the Framingham/Worcester Line. Although the Cambridge-to-North-Station connection via the Grand Junction Railroad is a feasible approach to relieving track and platform congestion at South Station, MassDOT is also actively pursuing an expansion of the tracks and platforms at South Station. Therefore, MassDOT does not intend to actively pursue the implementation of Framingham/Worcester Line commuter rail service over the Grand Junction Railroad at this time.

1 BACKGROUND

1.1 OVERVIEW OF PROJECT

The Grand Junction Railroad right-of-way (ROW) provides the only rail connection east of Worcester between Boston's north-side commuter rail system (serving North Station) and the south-side commuter rail system (serving South Station). The Grand Junction runs from the Boston–Worcester main line in the vicinity of Beacon Park Yard in Allston, over the Charles River, and through Cambridge, Somerville, Charlestown, Everett, and Chelsea. Its alignment and grade crossings in Cambridge and Somerville are shown in Figure 1-1.

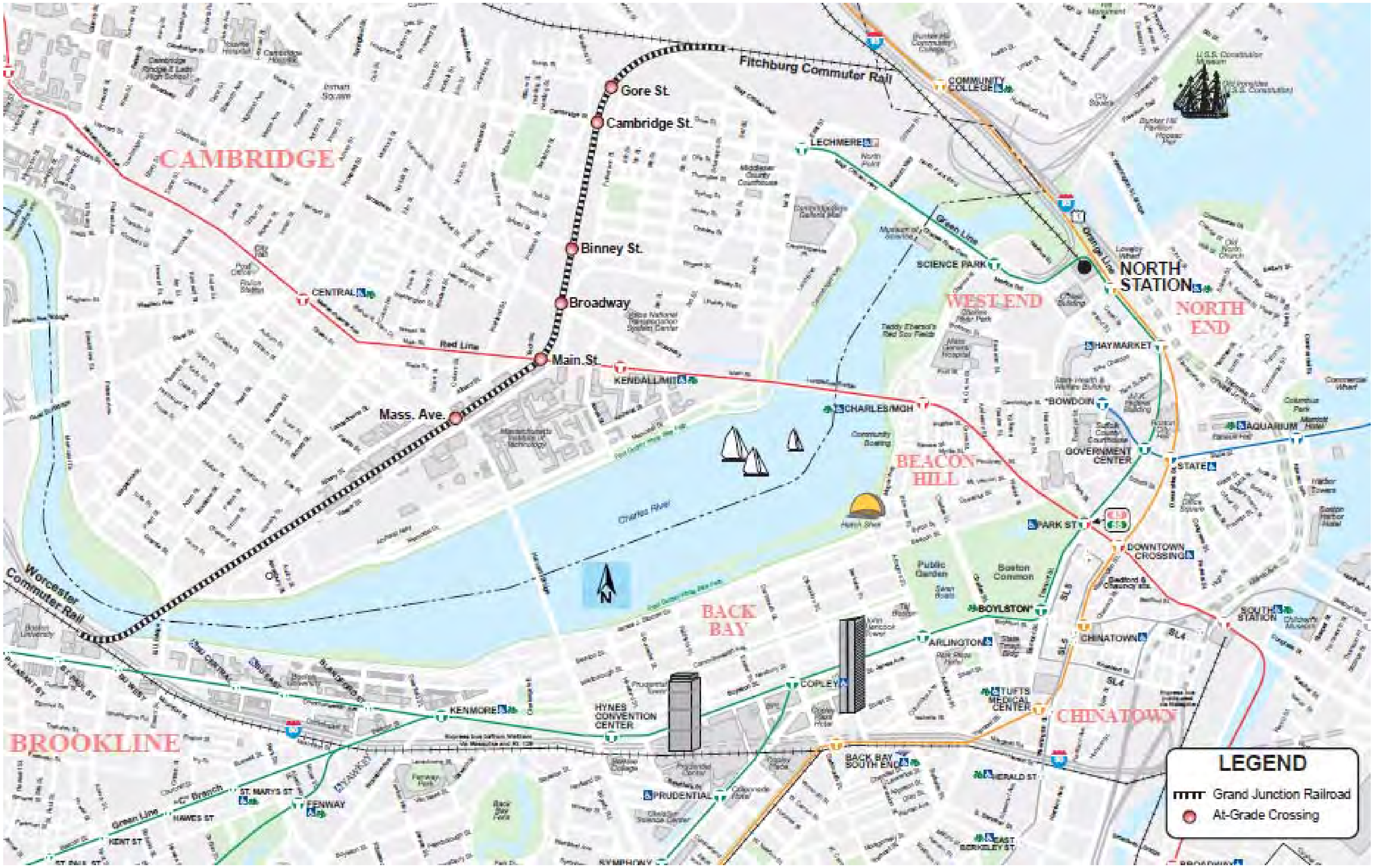
MassDOT owns the section of the Grand Junction ROW from Beacon Park Yard to its intersection with the Fitchburg main line near the MBTA Boston Engine Terminal to Chelsea. MassDOT purchased the Grand Junction Railroad from CSX Corporation in 2009, along with other former CSX rail rights-of-way in eastern Massachusetts, in the first phase of a two-phase transaction (the CSX properties acquired are shown in Figure 1-2). Associated projects related to the transaction include CSX's consolidation of its rail yard operations in Worcester and improvements to vertical clearance along the CSX line from the New York border to Westborough to allow for double-stack freight operations. When the second phase of the MassDOT-CSX transaction has been completed (anticipated to be in September 2012) with the purchase of the section of the CSX Boston Subdivision between Framingham and Worcester, MassDOT will own and control significant new transportation assets that can facilitate improved transportation services. Among other things, the purchase will allow for an increase in MBTA commuter rail service to communities along the Framingham/Worcester Line, since the MBTA will be able to use two tracks along the entire length of the line, and passenger trains will no longer be delayed by freight trains.

The commuter rail system in the Boston metropolitan area, like the systems in other cities across the United States, was originally built, owned, and operated by for-profit railroad corporations. These companies made most of their profits from the transport of freight, with passenger service costs often exceeding revenues. By the 1950s, losses from passenger service were threatening the overall viability of these railroads, and federal regulators were allowing the railroad operators to end passenger service unless public subsidies were provided. One of the reasons for the creation of the Massachusetts Bay Transportation Authority (MBTA) in 1964 was to provide an agency through which the state could provide operating subsidies for the commuter rail lines. The MBTA initially contracted with the railroad companies that were already operating the service and which continued to own the rolling stock and fixed facilities, including tracks and stations.

However, as the financial condition of these companies continued to deteriorate, tracks were not maintained to their former standards, resulting in slower trips and less reliable schedules.

Starting in the early 1970s, the MBTA began acquiring the rolling stock and fixed facilities (including the railroad lines themselves) from private railroad companies, which retained the right to operate freight service on the lines they sold. Public ownership of the railroad facilities helped to overcome objections, sometimes imposed by law, to investment of public funds in improvements to private property. It also allowed the MBTA to determine priorities for the upgrading of facilities and to modify train dispatching to give priority to passenger trains over freight trains. By the end of the 1970s, the MBTA had acquired all of the routes that were then being used for commuter rail service. However, commuter service on what is now the Framingham/Worcester Line was being operated only between Framingham and Boston, and the MBTA did not exercise an option to buy the tracks farther west.

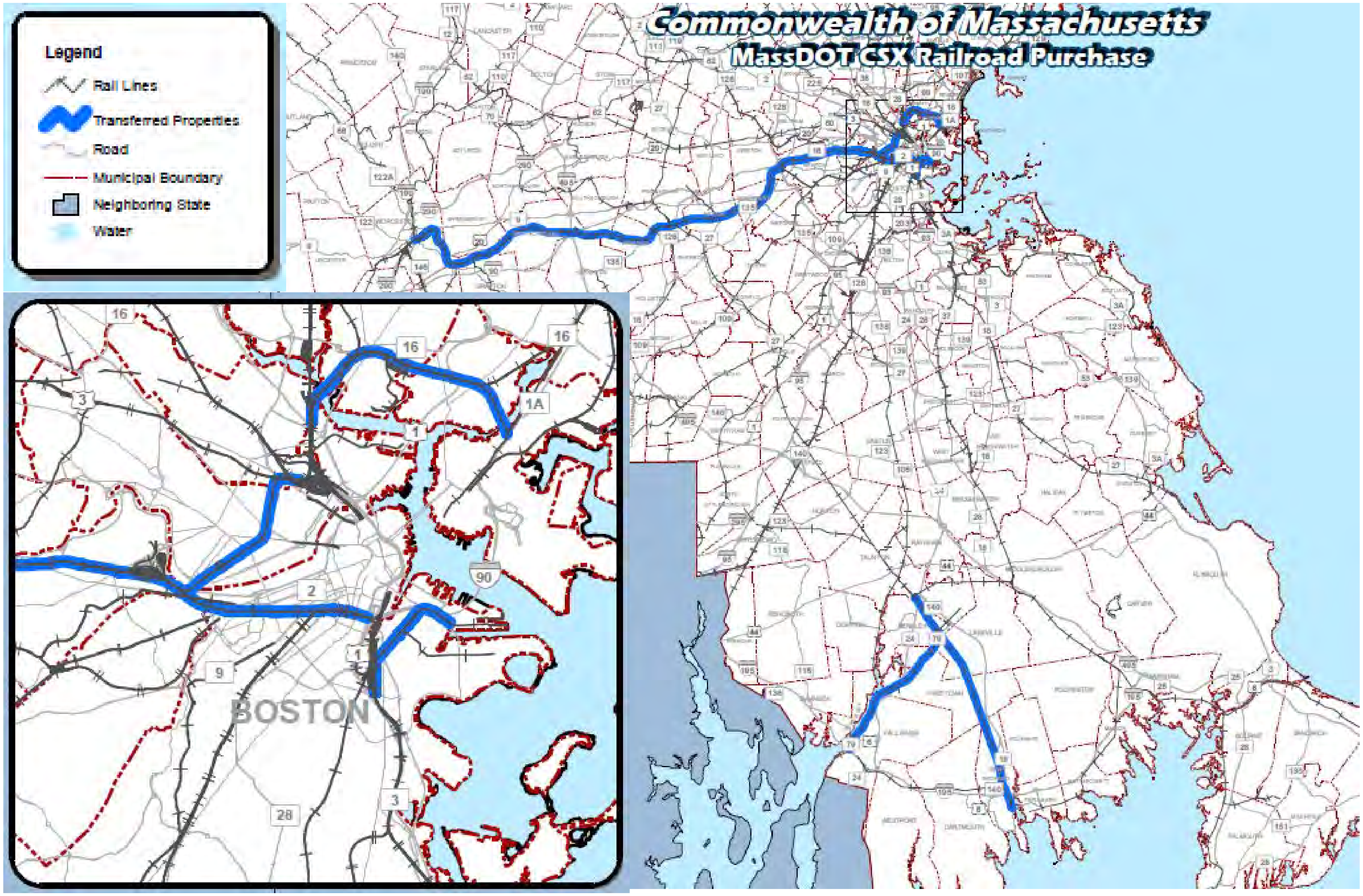
Commuter rail service to Worcester was restored on a limited basis in 1994 and was gradually expanded to include all-day service and several intermediate stations. The MBTA used the tracks by arrangement, first with Conrail, which owned them in 1994, and subsequently with CSX Corporation, which bought Conrail's New England operations in 1999. The MBTA funded the restoration of a second track between Westborough and Worcester, which had been removed several years earlier, but first Conrail and then CSX continued to control the dispatching of all passenger and freight trains on the entire line between Worcester and Boston. As passenger service frequency increased, there was increasing competition between passenger and freight trains for operating time slots on this line. In addition, track maintenance was scheduled by the private railroads for their convenience more than for the MBTA's convenience. Changes in the industrial base in the metropolitan Boston area made it feasible to relocate much of the rail freight operation on a different rail line east of Worcester. CSX was willing to do that and to turn over control of dispatching for the line to the MBTA on the condition that the MBTA buy the segments of the line that were not already in public ownership. That eventually resulted in an agreement between the MBTA and CSX for purchase of the Framingham/Worcester Line, as well as some other CSX lines, including the tracks from Boston to Fall River and New Bedford, on which the South Coast Rail commuter rail project is planned.



CTPS

FIGURE 1-1
Grand Junction Study Area

Grand Junction Transportation Study



CTPS

FIGURE 1-2
Property Acquired from CSX Railroad by Massachusetts

Grand Junction Transportation Study

1.2 PURPOSE AND NEED

Following the MBTA's acquisition of the Grand Junction ROW, a proposal was made for some of the additional train service planned for the MBTA Framingham/Worcester Line to be routed via the Grand Junction to North Station, thereby allowing for new connections and destinations to be served while also relieving congestion at South Station. The purposes of this project are:

- To better accommodate the high demand for travel between Boston from and Worcester and Metro-West and to better match trip origins with destinations
- To provide for more public transit access in Cambridge
- To reduce both local and regional traffic congestion
- To reduce fuel use and greenhouse gas emissions (consistent with the Global Warming Solutions Act)
- To help relieve track and platform congestion at South Station

It is important to note that the expansion of South Station would provide much-needed increased commuter rail capacity for many transportation priorities of the Commonwealth. MassDOT is actively pursuing this expansion; however, it is expected to be a very complex and expensive project, for which funding has not yet been identified. However, MassDOT has funding for preliminary engineering for South Station expansion, and is currently working toward this important milestone.

1.3 OBJECTIVES

The Grand Junction Transportation Feasibility Study is a review of the feasibility, benefits, and possible burdens of providing commuter rail service from the Framingham/Worcester Line to North Station via the Grand Junction, potentially with a stop in Cambridge. The objective of this study was to determine if MBTA commuter rail service from the Worcester Line via the Grand Junction to North Station is a viable transportation service that would generate sufficient ridership and increased mobility to offset any negative impacts, and if it would justify the cost of the project. Furthermore, the study would provide a preliminary assessment of impacts on vehicular traffic and on pedestrian and bicycle access at the grade crossings. The study's findings would guide the decisions about whether to pursue the use of the Grand Junction for MBTA commuter rail service, and, if so, how to do it.

This study is preliminary in nature, and is intended only to guide further discussion. This study evaluated the expected ridership for MBTA commuter rail service along the Grand Junction ROW based on a range of different modeling assumptions. Several potential future service plans have been developed in order to test the ridership effects of changes in frequency of rail transit, rail travel times (through Cambridge and Somerville), and the potential construction of a station near Kendall Square in Cambridge, for a 2035 planning horizon. Traffic and safety impacts at the six vehicular grade crossings and two pedestrian grade crossings along the branch in Cambridge and Somerville are also being evaluated. The study compared these impacts and transit demand to a future no-build scenario, in which all trains on the Worcester Line (the future western terminus for all trains on this line would be Worcester) would terminate at South Station, as they do currently. In order to conduct this study, MassDOT requested assistance from CTPS, which is the support staff to the Boston Region Metropolitan Planning Organization (MPO). The work scope for this work was approved on November 30, 2010, and the work was started in early 2011.

The findings of this analysis can be used to support MassDOT's decision making on the suitability of pursuing this service on the Grand Junction. The analysis also includes a review of other proposals for the corridor, including a potential section of the Urban Ring busway or a shared-use path.

1.4 PUBLIC PARTICIPATION

Public outreach for the project began in the winter of 2010–11, when MassDOT met with interested stakeholders, City of Cambridge officials, and neighborhood groups at individual meetings. A number of small meetings were held with groups that were recommended by the City staff and by Cambridge city councilor and state representative Tim Toomey. These meetings included the East Cambridge Planning Team, Central Square Business Association, Kendall Square Association, Cambridgeport Neighborhood Association, East Cambridge Business Association, and Area Four Coalition.

On June 16, 2011, MassDOT convened a large public meeting to discuss the project at the Morse School, in Cambridgeport. At this meeting, the general outline of the study was discussed. MassDOT presented how the study would progress over the coming months, and answered questions and heard concerns from residents. The next public meeting was held December 8, 2011, at the Kennedy-Longfellow School in East Cambridge. This meeting focused on the results of the ridership analysis that had been done as part of the study. Preliminary traffic and environmental findings were also discussed, and community input was heard in detail.

Overall, the public participation process on the Grand Junction project resulted in a robust discussion about the future of transit in eastern Massachusetts and the relative advantages and disadvantages of the Grand Junction proposal. Community members, organizational stakeholders, municipal staff, and elected officials were actively engaged, and MassDOT considered all input over the course of the study. All documents were posted on the project's website (http://mass.gov/massdot/grandjunction) and were distributed via an email list.

2 EXISTING CONDITIONS

2.1 STUDY AREA

This project has two distinct study areas: the first is the market area of current and potential transit users surrounding the Framingham/Worcester Line and the second is the area around the Grand Junction ROW. The two terminal MBTA commuter rail stations are South Station, where the current line terminates, and North Station, where a Framingham/Worcester commuter rail connection utilizing the Grand Junction would terminate. The majority of the destinations of potential users are around the two rail terminuses and in Cambridge.

2.2 FRAMINGHAM/WORCESTER LINE

The Framingham/Worcester Line is the third-longest commuter rail line among all of the MBTA's commuter rail lines. With 44 miles of tracks running through 12 towns and cities between Worcester and Boston, this line serves 17 stations (see Figure 2.1, below).

The line had about 6,700 daily inbound boardings in 2010 on weekdays (all ridership data in this report are for weekdays), which accounted for 12% of the total MBTA commuter rail inbound trips systemwide on a typical weekday that year. A breakdown of 2010 inbound station boardings is shown in Table 2-1, and outbound boardings are shown in Table 2-2.

FIGURE 2-1

Stations on the Framingham/Worcester Line

The three most heavily used stations on this line are Framingham, with 960 daily inbound boardings; Worcester, with 783 daily inbound boardings; and West Natick, with 717 daily inbound boardings. Six of the eight stations west of Wellesley Square have more than 400 daily inbound boardings. Inside Route 128/I-95, demand at the stations drops off significantly, averaging 200 to 300 daily inbound boardings at each of those four stations. Almost 78% of all inbound boarding occur in the AM peak period – 5,227 out of 6,728. South Station is the primary alighting station, accounting for almost 60% of alightings, while Back Bay accounts for 40% of inbound alightings.

2.2.1 SERVICE PLANS

Currently, the Framingham/Worcester Line operates 21 inbound trains to South Station on weekdays; 13 depart from Worcester and 8 leave from Framingham. There are 20 outbound trains per weekday. Table 2-3 shows the 2010 inbound and outbound daily schedules. The average trip time during the AM and PM peak periods from Worcester to South Station was 90 minutes. The inbound service plans for each trip follow one of three general formats:

- Departs Worcester, making stops at all stations
- Departs Worcester, skipping stations inside of Route 128/I-95
- Departs Framingham, making stops at all stations to the east

All trains stop at Back Bay and South Station to allow passenger to alight. Yawkey Station is currently only a part-time station, with only 8 of the 21 inbound trains stopping there to pick up or discharge passengers. However, the MBTA is pursuing a project to upgrade Yawkey Station to a full-time stop within a few years.

TABLE 2-1
2010 Daily Inbound Boardings for the Framingham/Worcester Line

Worcester Line								South Side		6483 = MBCR peak load count 11/08					
	Inbound (read down)														
	Daily		peak	AM		peak	MD		peak	PM		peak	NT		peak
station	ons	offs	load	ons	offs	load	ons	offs	load	ons	offs	load	ons	offs	load
Worcester	783	-	783	621	-	621	122	-	122	19	-	19	21	-	21
Grafton	498	3	1,278	395	2	1,014	77	0	199	12	0	32	13	0	34
Westboro	472	6	1,744	375	5	1,384	73	1	271	12	0	43	12	0	46
Southboro	483	8	2,219	383	7	1,760	75	1	345	9	0	52	16	0	62
Ashland	427	3	2,643	330	2	2,088	74	0	418	8	0	59	14	0	77
Framingham	960	20	3,583	743	16	2,815	167	3	582	17	0	77	33	0	109
W. Natick	717	16	4,284	555	13	3,357	125	3	705	13	0	89	24	0	133
Natick	524	9	4,799	406	7	3,755	91	1	795	9	0	99	18	0	150
Well. Sq.	428	20	5,207	331	16	4,071	72	3	864	10	0	108	15	0	165
Well. Hills	292	7	5,492	223	6	4,288	48	1	911	7	0	115	14	0	178
Well. Farms	305	7	5,790	233	6	4,516	51	1	960	7	0	122	14	0	192
Auburndale	222	10	6,002	178	8	4,685	44	2	1,003	-	-	122	-	-	192
W. Newton	242	6	6,238	194	5	4,874	48	1	1,050	-	-	122	-	-	192
Newtonville	265	20	6,483	212	17	5,070	53	3	1,099	-	-	122	-	-	192
Yawkey	20	302	6,201	12	262	4,820	1	14	1,086	5	14	113	3	13	182
Back Bay	90	2,423	3,868	35	1,900	2,955	3	402	687	41	46	108	11	74	119
S. Station	-	3,868	-	-	2,955	-	-	687	-	-	108	-	-	119	-
Total	6,728	6,728		5,227	5,227		1,124	1,124		169	169		208	208	

AM = 6:00AM to 9:00AM
MD = 9:00AM to 3:00PM
PM = 3:00PM to 6:00PM
NT = 6:00PM to 6:00AM

TABLE 2-2
2010 Daily Outbound Boardings for the Framingham/Worcester Line

Worcester Line								South Side		6483 = MBCR peak load count 11/08					
	Outbound (read up)														
	Daily		peak	AM		peak	MD		peak	PM		peak	NT		peak
station	ons	offs	load	ons	offs	load	ons	offs	load	ons	offs	load	ons	offs	load
Worcester	-	783	-	-	27	-	-	42	-	-	454	-	-	260	-
Grafton	3	498	783	0	17	27	0	27	42	2	289	454	1	165	260
Westboro	6	472	1,278	0	16	43	0	24	69	3	288	741	2	144	424
Southboro	8	483	1,744	0	16	59	0	24	93	5	295	1,026	3	147	566
Ashland	3	427	2,219	0	15	76	0	22	117	2	261	1,316	1	130	710
Framingham	20	960	2,643	1	33	90	1	49	139	11	586	1,576	7	292	839
W. Natick	16	717	3,583	0	24	122	1	36	187	9	438	2,150	6	218	1,124
Natick	9	524	4,284	0	18	146	0	27	223	5	320	2,579	3	160	1,336
Well. Sq.	20	428	4,799	1	15	164	1	20	249	12	275	2,894	7	119	1,492
Well. Hills	7	292	5,207	0	10	178	0	14	268	4	187	3,157	2	81	1,604
Well. Farms	7	305	5,492	0	10	187	0	14	282	4	196	3,340	2	84	1,683
Auburndale	10	222	5,790	-	-	197	0	12	296	6	146	3,532	3	64	1,765
W. Newton	6	242	6,002	-	-	197	0	13	308	4	159	3,672	2	69	1,825
Newtonville	20	265	6,238	-	-	197	1	19	321	13	177	3,827	6	69	1,892
Yawkey	302	20	6,483	-	-	197	19	2	339	189	14	3,992	94	4	1,955
Back Bay	2,423	90	6,201	91	39	197	126	6	322	1,481	28	3,817	725	17	1,865
S. Station	3,868	-	3,868	146	-	146	202	-	202	2,364	-	2,364	1,157	-	1,157
Total	6,728	6,728		240	240		352	352		4,114	4,114		2,022	2,022	

AM = 6:00AM to 9:00AM
MD = 9:00AM to 3:00PM
PM = 3:00PM to 6:00PM
NT = 6:00PM to 6:00AM

Inbound to South Station

Train No.	P500 A.M.	P502 A.M.	P504 A.M.	P506 A.M.	P508 A.M.	P510 A.M.	P512 A.M.	P514 A.M.	P516 A.M.	P518 A.M.	P520 P.M.	P522 P.M.	P524 P.M.	P526 P.M.	P528 P.M.	P530 P.M.	P532 P.M.	P534 P.M.	P536 P.M.	P538 A.M.	P540 A.M.
Worcester/Union Station	4 45	5 40	6 05	6 30	6 55	----	7 35	----	8 30	10 30	----	----	2 05	4 30	----	5 35	----	----	7 46	----	12 10
Grafton	5 00	5 54	6 19	6 44	7 09	----	7 49	----	8 43	10 43	----	----	2 18	4 43	----	5 48	----	----	7 59	----	f12 22
Westborough	5 06	5 59	6 24	6 49	7 14	----	7 54	----	8 47	10 47	----	----	2 22	4 47	----	5 52	----	----	8 03	----	f12 26
Southborough	5 16	6 08	6 33	6 58	7 23	----	8 03	----	8 56	10 56	----	----	2 31	4 56	----	6 01	----	----	8 12	----	f12 34
Ashland	5 23	6 13	6 38	7 03	7 28	----	8 08	----	9 00	11 00	----	----	2 35	5 00	----	6 05	----	----	8 16	----	f12 38
Framingham	5 35	6 25	6 50	7 15	7 40	8 00	8 19	8 40	9 11	11 11	12 20	2 09	2 46	5 11	5 40	6 16	6 43	7 45	8 27	12 31	f12 48
West Natick	5 40	6 31	6 55	7 20	7 46	8 05	8 24	8 45	9 16	11 16	12 25	2 14	2 51	5 16	5 45	6 21	6 48	7 50	----	f12 36	----
Natick	5 45	----	7 00	7 25	7 51	8 10	8 29	8 50	9 21	11 21	12 30	2 19	2 56	5 21	5 50	6 26	6 53	7 55	----	f12 40	----
Wellesley Square	5 51	----	7 06	7 31	----	8 16	8 35	8 56	9 27	11 27	12 35	2 24	3 02	5 27	5 56	6 32	6 59	8 01	----	f12 45	----
Wellesley Hills	5 55	----	7 10	7 35	----	8 20	8 39	9 00	9 31	11 31	12 39	2 28	3 06	5 31	6 00	6 36	7 03	8 05	----	f12 48	----
Wellesley Farms	5 58	----	7 13	7 38	----	8 23	8 42	9 03	9 34	11 34	12 42	2 31	3 09	5 34	6 03	6 39	7 06	8 08	----	f12 51	----
Auburndale	6 03	----	7 18	7 43	----	8 28	----	9 08	----	11 39	12 47	2 36	----	----	----	----	----	----	----	f12 55	----
West Newton	6 06	----	7 21	7 46	----	8 31	----	9 11	----	11 42	12 50	2 39	----	----	----	----	----	----	----	f12 58	----
Newtonville	6 10	----	7 25	7 50	----	8 35	----	9 15	----	11 45	12 53	2 42	----	----	----	----	----	----	----	f1 01	----
Yawkey	L6 20	L6 57	L7 35	L8 00	----	L8 45	----	----	----	----	L1 04	L2 52	----	----	****	L6 58	----	----	----	----	----
BACK BAY	L6 25	L7 02	L7 40	L8 05	L8 17	L8 50	L9 02	L9 29	L9 54	L11 59	L1 09	L2 57	L3 29	L5 59	L6 24	L7 03	L7 26	L8 28	L8 56	L1 17	L1 24
SOUTH STATION	6 31	7 08	7 46	8 11	8 23	8 56	9 08	9 35	10 00	12 05	1 15	3 03	3 35	6 05	6 30	7 09	7 32	8 34	9 02	1 23	1 30

**** Train P528 only stops at Yawkey Station at 6 19pm on weekday evenings when Red Sox home games are scheduled.

Outbound from South Station

Train No.	P501 A.M.	P503 A.M.	P505 A.M.	P507 A.M.	P509 A.M.	P511 A.M.	P513 P.M.	P515 P.M.	P517 P.M.	P519 P.M.	P521 P.M.	P523 P.M.	P525 P.M.	P527 P.M.	P529 P.M.	P531 P.M.	P533 P.M.	P535 P.M.	P537 P.M.	P539 P.M.
SOUTH STATION	4 00	6 50	6 59	7 29	8 50	11 00	12 10	1 00	2 40	4 05	4 27	5 00	5 15	5 35	6 15	6 30	7 15	8 20	10 20	11 25
BACK BAY	4 06	6 56	7 05	7 35	8 56	11 06	12 16	1 06	2 46	4 11	4 33	5 06	5 21	5 41	6 21	6 36	7 21	8 26	10 26	11 31
Yawkey	----	----	----	----	----	11 11	----	----	----	----	4 38	----	5 26	5 46	----	6 41	7 26	8 31	10 31	11 36
Newtonville	----	----	----	----	----	11 20	12 28	1 18	2 58	----	4 48	----	5 36	5 56	----	6 50	7 35	8 40	10 40	11 45
West Newton	----	----	----	----	----	11 24	12 32	1 21	3 01	----	4 52	----	5 40	6 00	----	6 54	7 39	8 44	10 44	11 49
Auburndale	----	----	----	----	----	11 27	12 35	1 24	3 04	----	4 55	----	5 43	6 03	----	6 57	7 42	8 47	10 47	11 52
Wellesley Farms	----	----	----	----	9 12	11 32	12 40	1 29	3 09	----	5 00	----	5 48	6 08	----	7 02	7 47	8 52	10 52	11 57
Wellesley Hills	----	----	7 24	7 55	9 15	11 35	12 43	1 32	3 12	----	5 03	----	5 51	6 11	----	7 05	7 50	8 55	10 55	12 00
Wellesley Square	----	L7 16	7 28	7 59	9 19	11 39	12 47	1 36	3 16	----	5 07	----	5 55	6 15	----	7 09	7 54	8 59	10 59	12 04
Natick	----	----	7 34	8 05	9 25	11 45	12 53	1 42	3 22	----	5 13	----	6 01	6 21	----	7 15	8 00	9 05	11 05	12 10
West Natick	----	7 25	L7 39	L8 10	9 30	L11 51	12 58	L1 47	3 27	4 36	L5 19	5 31	L 6 07	6 26	6 46	L7 22	8 06	9 11	11 11	L12 16
Framingham	4 40	7 30	7 45	8 16	9 35	11 57	1 03	1 53	3 33	4 42	5 25	5 37	6 13	6 31	6 52	7 28	8 11	9 16	11 16	12 21
Ashland	----	7 37	----	----	9 41	----	1 09	----	3 39	4 48	----	5 43	----	6 38	6 58	----	8 18	9 22	11 22	----
Southborough	----	7 42	----	----	9 46	----	1 14	----	3 44	4 53	----	5 48	----	6 43	7 03	----	8 23	9 27	11 27	----
Westborough	----	7 51	----	----	9 55	----	1 22	----	3 53	5 03	----	5 58	----	6 52	7 13	----	8 32	9 36	11 36	----
Grafton	L5 00	L7 59	----	----	L10 02	----	L1 27	----	L3 59	L5 09	----	L6 05	----	L6 58	L7 19	----	L8 38	L9 42	L11 42	----
Worcester/Union Station	5 19	8 14	----	----	10 16	----	1 41	----	4 13	5 24	----	6 20	----	7 13	7 34	----	8 52	9 56	11 56	----

Source: MBTA website, Nov. 2010, accurate through April 2012

2.2.2 TRANSIT MARKETS

Of the inbound passengers on the Framingham/Worcester Line, 40% get on the Line west of Framingham, 14% board in Framingham, and the remaining 46% board east of Framingham. Back Bay and South Station are the two largest destination stations, receiving about 2,400 and 3,900 daily inbound passengers, respectively.

According to the MBTA’s 2008–09 onboard survey, the largest destination location is the Boston neighborhood that includes the Financial District and the main downtown retail area, which attracts about 23.7% of the line’s total inbound ridership. Figure 2-2 is a map showing the MBTA neighborhoods near MBTA rapid transit stations. The second- and third-largest destination areas are the area near the Prudential Center and the Hancock Building, and the Boston Waterfront, with 11.6% and 8.7% of the total daily inbound ridership, respectively. The top 10 destination locations attract about 82% of the total daily inbound riders on the line. Table 2-4 lists the top 10 destination locations for riders on the line. Six of these destinations, which account for 63% of the riders, are in Boston Proper. The other four, accounting for 19% of the riders, are the South Boston Industrial Area, the Longwood Medical and Academic Area in Boston, the Kendall Square neighborhood in Cambridge, and the Fenway area in Boston. The riders with destinations other than the top 10 destinations make up 18% of the total daily inbound ridership.

TABLE 2-4
Top 10 Destination Locations
of Inbound Framingham/Worcester Line Riders

Destination Location	Closest Fram./Worc. Rail Station	Number of Riders	Percent of Riders
Boston: Financial-Retail	Between SS and NS	1,430	23.7%
Boston: Prudential/Hancock	SS	700	11.6%
Boston: Waterfront	Between SS and NS	530	8.7%
Boston: Back Bay	Back Bay	470	7.7%
Boston: South Boston Industrial	SS	380	6.2%
Boston: Gov’t Center	NS	360	5.9%
Boston: Longwood Medical Area	Yawkey	310	5.1%
Boston: Park Square	SS	300	4.9%
Cambridge: Kendall/MIT	NS	270	4.4%
Boston: Fenway	Yawkey	230	3.8%
Total Top 10 Destinations		**4,980**	**82%**

Notes: (1) Data are from MBTA 2010 onboard passenger survey. (2) Destination locations are shown in Attachment B. (3) SS indicates South Station and NS indicates North Station.

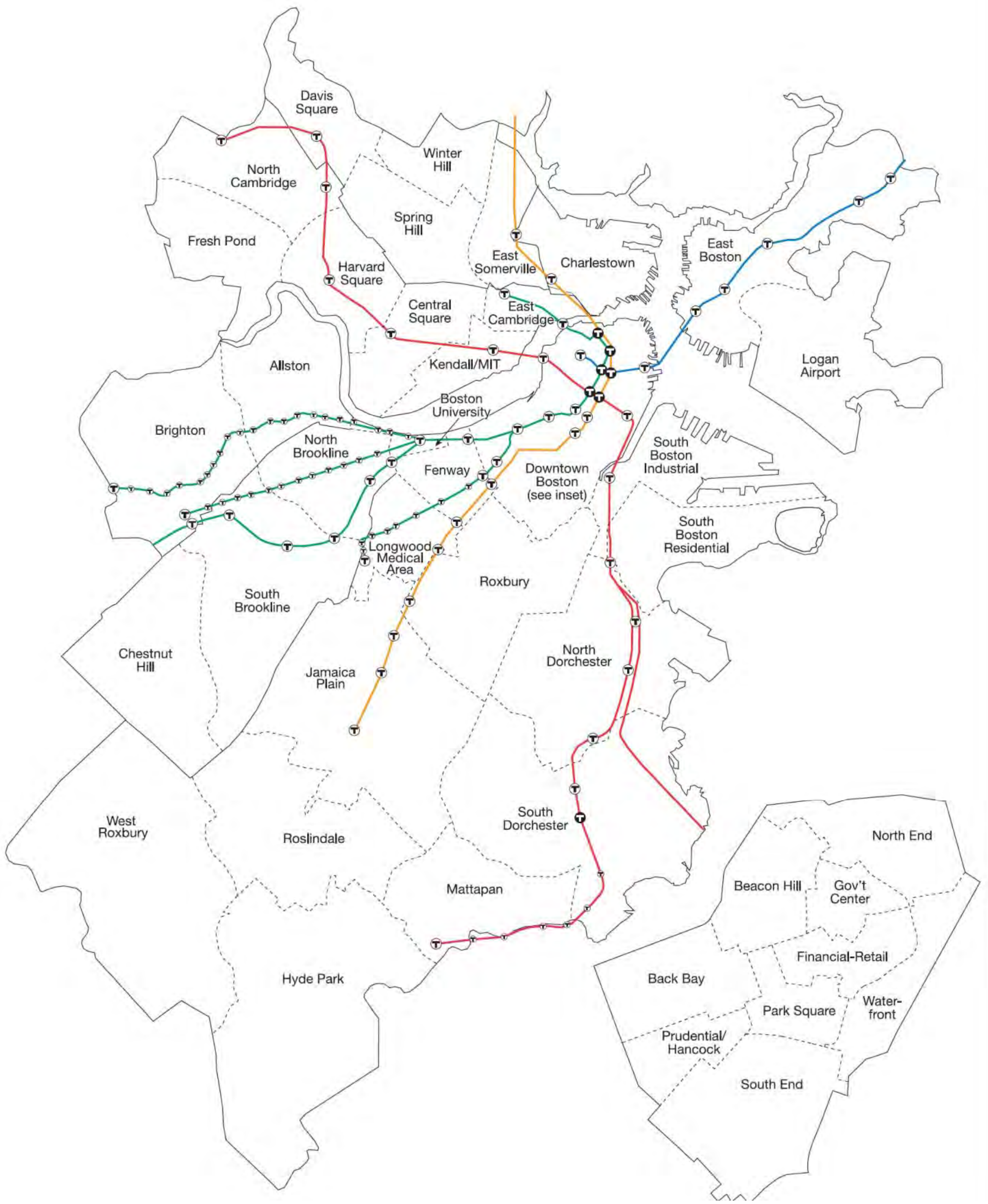


FIGURE 2-2
Neighborhood Map for Markets of Transit Riders

CTPS

Grand Junction Transportation Study

Based on the MBTA 2008–09 onboard survey, 6% of the Framingham/Worcester Line's daily inbound passengers are destined to a Cambridge neighborhood. The vast majority of Cambridge-bound trips have a destination near the Kendall Square neighborhood.

Table 2-5 presents the top five destinations in Cambridge of inbound Framingham/Worcester Line riders by neighborhood.

TABLE 2-5
Top Five Cambridge Destinations of Inbound Framingham/Worcester Line Riders

Destination Location	Number of Riders	Percent of Riders
Cambridge: Kendall/MIT	265	4.4%
Cambridge: Harvard Square	43	0.7%
Cambridge: Central Square	33	0.5%
Cambridge: East Cambridge	23	0.4%
Cambridge: Unspecified	13	0.2%
Total Cambridge Passengers	**377**	**6%**

Note: Data are from MBTA 2010 onboard passenger survey.

Table 2-6 shows the egress modes (the modes used to reach the final destination after alighting from commuter rail) of Framingham/Worcester Line riders and their top 10 destination locations. Of these passengers, 81% walk to their destinations. The destinations in downtown Boston near Back Bay Station and South Station have large shares of the walk egress mode.

Public transportation is the egress mode for 15% of the inbound passengers traveling to the top 10 destination locations. Transferring to the Red Line is the dominant egress mode for riders traveling to the Kendall Square neighborhood, serving about 85% of the trips to this area. Of the passengers going to the Longwood Medical and Academic Area, 45% use an egress mode other than walking or public transportation, likely indicating the use of private shuttles. The Longwood Medical and Academic Area has a large number of jobs, and many private shuttles transport workers to their final destinations there.

Based on the MBTA's 2008–09 onboard survey, there are about 1,330 daily trips on the north-side commuter rail lines that have destinations in Cambridge. These make up 8% of the total daily trips going to North Station on those lines. Table 2-7 shows the number and percentage of all north-side commuter rail riders traveling to each Cambridge neighborhood and the distribution of their egress modes. These passengers use various modes to reach their destinations, including rapid transit, private bus, walk, and commuter rail; the majority of the passengers use non-walk modes for their egress trips: 40% rapid transit, 31%

private bus, and 6% commuter rail. Only about 19% of the passengers traveling to Cambridge walk to their destinations. The Fitchburg Line is one of the lines feeding into North Station, and it also provides a transfer to the Red Line at Porter Square in Cambridge.

TABLE 2-6
Egress Modes of the Inbound Framingham/Worcester Line Riders and Their Top 10 Destination Locations

Destination Location	Walk	Public Transportation	Other Mode
Boston: Financial-Retail	94.6%	5.4%	0.0%
Boston: Prudential/Hancock	100.0%	0.0%	0.0%
Boston: Waterfront	98.9%	0.0%	1.1%
Boston: Back Bay	96.6%	0.0%	3.4%
Boston: South Boston Industrial	63.0%	36.0%	1.0%
Boston: Gov't Center	66.0%	33.0%	1.0%
Boston: Longwood Medical Area	33.0%	22.0%	45.0%
Boston: Park Square	76.0%	22.6%	1.4%
Cambridge: Kendall/MIT	10.0%	84.6%	5.4%
Boston: Fenway	79.7%	15.5%	4.8%
Overall	**81%**	**15%**	**4%**

Note: Data are from MBTA 2010 onboard passenger survey.

TABLE 2-7
Top Six Cambridge Destinations for of All North-Side Commuter Rail Riders

Destination Location	Number of Riders	Percent of Riders
Cambridge: Kendall/MIT	770	4.8%
Cambridge: Harvard Square	270	1.7%
Cambridge: East Cambridge	140	0.9%
Cambridge: Central Square	70	0.4%
Cambridge: North Cambridge	50	0.3%
Cambridge: Unspecified	30	0.2%
Total Cambridge Passengers	**1,330**	**8%**

Note: Data are from MBTA 2010 onboard passenger survey.

2.3 GRAND JUNCTION RIGHT-OF-WAY

The Grand Junction ROW provides the only rail connection east of Worcester between Boston's north-side commuter rail system (serving North Station) and south-side commuter rail system (serving South Station). The Grand Junction ROW is 8.5 miles long and runs from the Boston–Worcester main line in the vicinity of Beacon Park Yard in Allston, over the Charles River, and through Cambridge, Somerville, Charlestown, Everett, and Chelsea.

The segment of the line that is in Cambridge is two miles long and it also includes the Necco Spur and Long Siding, which is shown in Figure 2-3. The line follows a serpentine path past the MBTA's Boston Engine Terminal (BET) to serve industrial areas in Everett and Chelsea. The part of the Grand Junction tracks between Allston and the BET was the focus of this study. After it heads east from Beacon Park Yard in Allston, it heads north going over Storrow Drive and crosses the Charles River under the BU Bridge. After the Grand Junction ROW has crossed the Charles, it enters Cambridge. The Grand Junction ROW goes under Memorial Drive, passes the Necco Spur and Long Siding, which is just north of Memorial Drive, and then heads north to the passes its first pedestrian crossing, between Fort Washington Park and the Westgate Buildings, paralleling Vassar Street. After it crosses Massachusetts Avenue at grade, it continues past the Albany Garage and its second pedestrian crossing. There are five grade crossings from this point northward: Main Street, Broadway, Binney Street, Cambridge Street, and Gore Street.

2.3.1 LAND USES

The Grand Junction corridor passes through areas with various land uses. The Grand Junction corridor has historically been heavily industrial in nature, reflecting a past land use pattern that was dependent on the railroad for transportation services.

In 2008, the population of Cambridge was 105,600. The population within a half mile of the Grand Junction ROW accounts for about 34% of the city's population, or more than 34,000 people. This includes residents in the neighborhoods of Cambridgeport, Area Four, and East Cambridge. Cambridge is the municipality with the second-largest number of jobs in the Commonwealth; it contributed 104,000 jobs to the economy in 2010. The majority of these jobs are service oriented. More than 56,000 of them were within a half mile of the Grand Junction ROW. Employment sites along the Grand Junction ROW include the areas of Kendall Square, Cambridge Center, and MIT, and nearby employment centers such as University Park, portions of Central Square, business districts along Main and Cambridge streets, and various office, research and development, and industrial land uses along and near the tracks. Employment data show that this area has major destinations, which do not appear to be served well by transit, as shown in the transit market analysis. A commuter rail stop in the Kendall Square neighborhood would have the potential to serve a large job market.

2.3.2 HISTORY OF THE GRAND JUNCTION

The Grand Junction railroad was one of the first north-south rail connections in the Boston metropolitan area. Opened in 1855 by the Grand Junction and Depot Company, the line followed a serpentine alignment weaving through the newly industrialized areas of Cambridgeport, East Cambridge, Charlestown, Everett, and Chelsea, ending at the piers of East Boston. In the latter half of the 19th century, Cambridge had an extensive network of rail spurs, sidings, and street trackage serving warehouses and factories. The main line included as many as four or five tracks in places, while the spurs and street trackage branched out to locations several blocks from the main line. Several firms provided a significant source of freight revenue, including Boston Woven Hose and Rubber Company (rubber goods, hose, tires, and belts; at the current "One Kendall Square"); North Packing and Provision Company (meats); John Reardon and Sons (soap); and Norcross Brothers (stonecutters).

The Grand Junction Railroad (RR) initially provided freight connections between the south-side Boston and Worcester RR and the four north-side lines that were eventually merged into the Boston and Maine RR. The Boston and Worcester RR became the Boston and Albany RR (B&A), and the Grand Junction RR itself was bought by the B&A in 1869. By 1900, the B&A was leased to and operated by its new parent company, the New York Central System. Corporate consolidations in the railroad industry have included the Grand Junction Railroad's changing owners from the New York Central to Penn Central to Conrail, and now to CSX Corporation.

The New England economy shifted from a manufacturing base to a technology and service base during the latter half of the 20th century, decreasing the importance of the line for local freight service. For example, between Main Street and Binney Street in Cambridge, manufacturing facilities have been replaced by offices and research-and-development facilities such as Technology Square, One Kendall Square, and Cambridge Center. MIT has purchased and redeveloped or demolished many of the industrial buildings between Memorial Drive and Main Street. Today there are no freight rail customers along the Grand Junction in Cambridge.

After the Massachusetts Bay Transportation Authority (MBTA) took over Boston-area commuter rail services from the Boston and Maine RR and the Penn Central RR, the Grand Junction RR gained new importance. Beginning in 1977, a single commuter rail operator was contracted by the MBTA. The Boston and Maine RR was the contractor until 1987, when Amtrak won the contract and operated it through 2003, at which time the Massachusetts Bay Commuter Railroad became the contractor. One result of this switch to a single regional operation was that this single operator needed to move equipment regularly between north-side and south-side operations. In 2001, Amtrak started its Downeaster service between North Station and Portland, Maine, necessitating the moving of passenger equipment between North Station and the Amtrak maintenance facility at Southampton Street.

Currently, the Grand Junction line remains the only north-south rail connection east of Worcester. On a typical weekday, four to six freight trains run through the corridor, and there are occasional trains on weekends. MassDOT purchased the Grand Junction ROW from CSX Corporation in 2009, along with other CSX rail rights-of-way in eastern Massachusetts in the first phase of a two-phase transaction.

2.3.3 GRAND JUNCTION INFRASTRUCTURE

The Grand Junction Railroad is generally a signal-less single-track line with one active siding (called the "Long Siding") and one inactive spur (the Necco Spur), both of which are shown in Figure 2-3. The Long Siding is a second track splitting off from the Grand Junction ROW just north of Memorial Drive and paralleling the mainline for a short distance, which allows for trains to pass each other along the Grand Junction ROW. The Necco Spur, a side track that once brought sugar to the old Necco Candy factory in Cambridgeport, is no longer in use. Between Allston and North Station, the Grand Junction Railroad includes eight grade crossings (shown in Table 2-8) and four grade-separated structures. There are five important structures along the ROW:

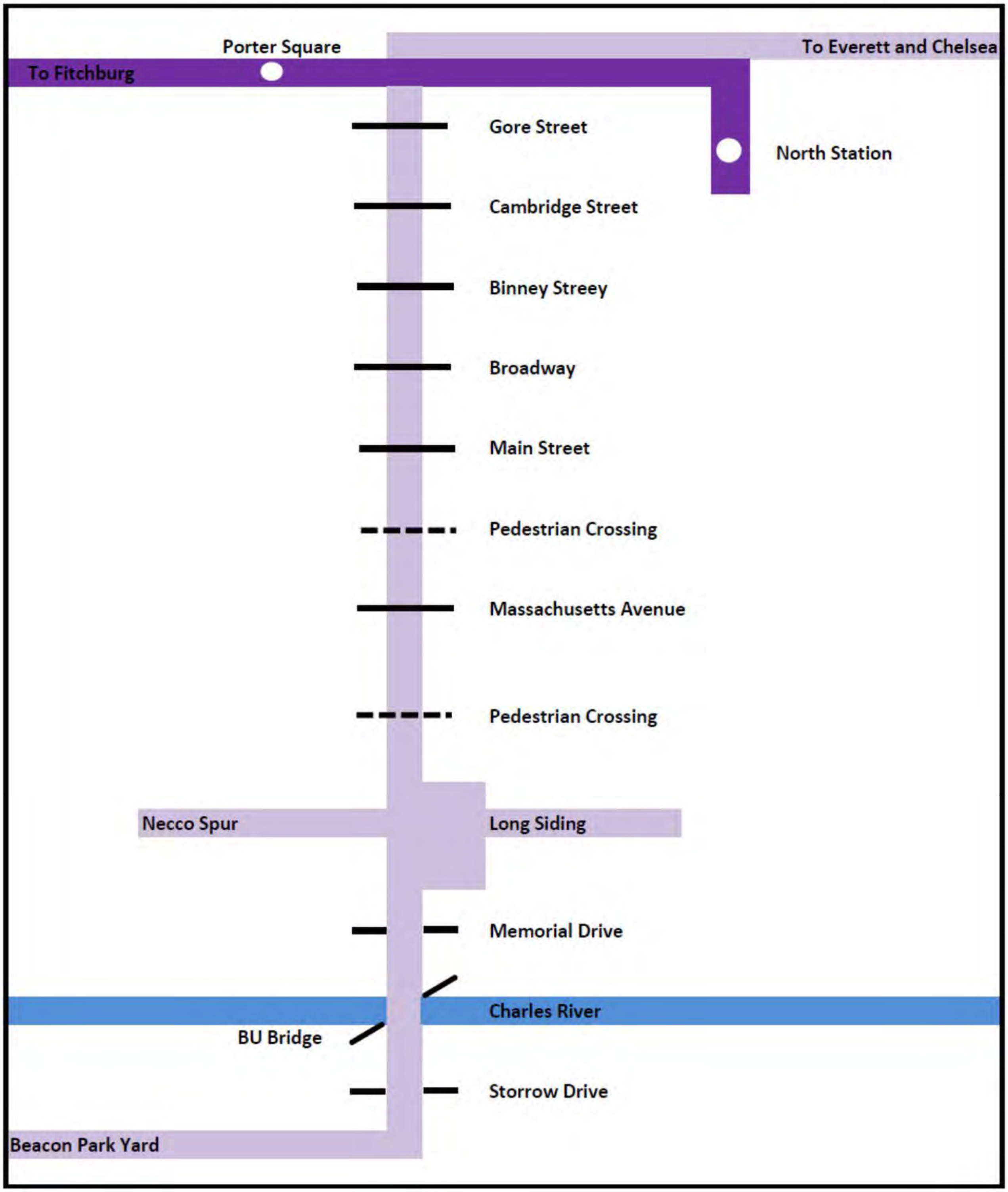
- Railroad bridge over the Charles River
- Memorial Drive bridge over tracks
- MIT building over ROW
- Pedestrian bridge over tracks connecting MIT properties
- Utility bridge over tracks connecting MIT properties

The track speed is limited to 10 mph from Allston to Chelsea. All grade crossings are protected by flashing lights and audible warnings. The street crossings in Cambridge, at Cambridge Street and Gore Street, and the two pedestrian crossings, in Cambridge all include gate arms.

2.3.4 GRAND JUNCTION OPERATIONS

The segment of the Grand Junction between the MBTA's Framingham/Worcester Line in Allston and the Fitchburg Line in Somerville is known as the Grand Junction Running Track. It is usually used for one round-trip a day by a CSX Transportation (the operating company for CSX Corporation) freight train going to and from the New England Produce Center in Chelsea, and for one round-trip a day by the MBTA to move commuter rail equipment to and from the Boston Engine Terminal (BET) on the border of Charlestown and Somerville. It is also used as needed to transfer additional MBTA commuter rail equipment between the north-side and south-side lines and Amtrak Downeaster equipment from North Station to the Southampton Street maintenance facility near South Station.

On a typical day, the total number of trains would be at most three in each direction. These train trips most often take place in the evening or at night, but can occur at any time of day. In recent years, the maximum speed limit for trains on the Grand



CTPS	**FIGURE 2-3** **Grade Crossings Along the Grand Junction Right-of-Way in Boston and Cambridge**	*Grand Junction Transportation Study*

Junction line has been 10 mph, and historically it did not exceed 15 mph. Quiet zones have not been established at any of the grade crossings on the line, so by federal regulation train horns must be sounded at each one.

2.3.5 ACTIVITY AT THE GRADE CROSSINGS

The eight grade crossings along the Grand Junction ROW serve a number of autos, pedestrians, and bicyclists. Table 2-9 shows the existing AM peak-hour traffic for the six at-grade roadway crossings that would be affected by establishing commuter rail service on the Grand Junction ROW. Table 2-10 shows the PM peak-hour traffic volumes for the same locations. Massachusetts Avenue and Broadway have the highest traffic volumes in both the AM and PM peak hours. Table 2-9 shows that over 6,000 vehicles cross one of the grade crossings during the AM peak hour and also during the PM peak hour. Figures 2-4 and 2-5 show the traffic by turning movement for the AM and PM peak hours, respectively. These 6,000 vehicles in each of the peak hours include buses serving eight major bus routes, shown in Table 2-10. The bus routes serve approximately 2,490 riders in the AM peak hour, with bus Route 1 carrying the largest ridership over these grade crossings, 1,479 riders.

There is also significant pedestrian and bicycle activity during the AM and PM peak hours, as shown in Table 2-11. In addition to having some of the heaviest vehicular traffic in Cambridge, Massachusetts Avenue and Broadway have the greatest number of pedestrians and bicyclists in both time periods. The pedestrian activity is about 2.5 times that of the bicycle travel across the grade crossings, with slightly more activity occurring in the PM than in the AM peak hour. The pedestrian traffic at the grade crossings is shown in Figures 2-6 and 2-7. The bicycle traffic at the grade crossings is shown in Figures 2-8 and 2-9.

TABLE 2-8
Grand Junction Grade Crossings and Capacity of the Infrastructure

Location	Mode	Capacity		Safety Features
		Roadway	Sidewalk	
Gore Street	Road	2 lanes	2 sidewalks	Flashing Signal and Gates
Cambridge Street	Road	2 lanes	2 sidewalks	Flashing Signal and Gates
Binney Street	Road	2 lanes	2 sidewalks	Flashing signals only
Broadway	Road	4 lanes	2 sidewalks	Flashing signals only
Main Street	Road	2 lanes	2 sidewalks	Flashing signals only
South of Main Street	Pedestrian	None	1 walkway	Flashing signal and gates
Massachusetts Avenue	Road	4 lanes	2 sidewalks	Flashing signals only
Fort Washington Park	Pedestrian	None	1 walkway	Flashing signal and gates

TABLE 2-9
Existing Motor Vehicle Traffic Volumes at Grade Crossings in Cambridge

Location	AM Peak Hour			PM Peak Hour		
	Eastbound	Westbound	Total	Eastbound	Westbound	Total
Mass. Avenue	820	730	1,550	685	800	1,485
Main Street	475	435	910	400	460	860
Broadway	790	735	1,525	830	780	1,610
Binney Street	165	125	290	180	140	320
Cambridge Street	420	570	990	450	600	1,050
Gore Street	650	180	830	690	190	880
Total	3,320	2,775	6,095	3,235	2,970	6,205

Note: Traffic counts conducted by CTPS during the spring of 2011.

2.3.6 SAFETY CONSIDERATIONS

Though most of the right-of-way is fenced off, there are many places where pedestrians can gain access. These include all eight grade crossings and other openings in the fence in Cambridge, such as at Pacific Street and the unfenced section along Waverly Street. It is very easy for pedestrians to trespass within the right-of-way. With only a few trains per day and the low operating speed, there is little to discourage this behavior. The low speed and frequent stops reduce the risk of train-vehicle and train-pedestrian conflicts, although such conflicts do occasionally occur.

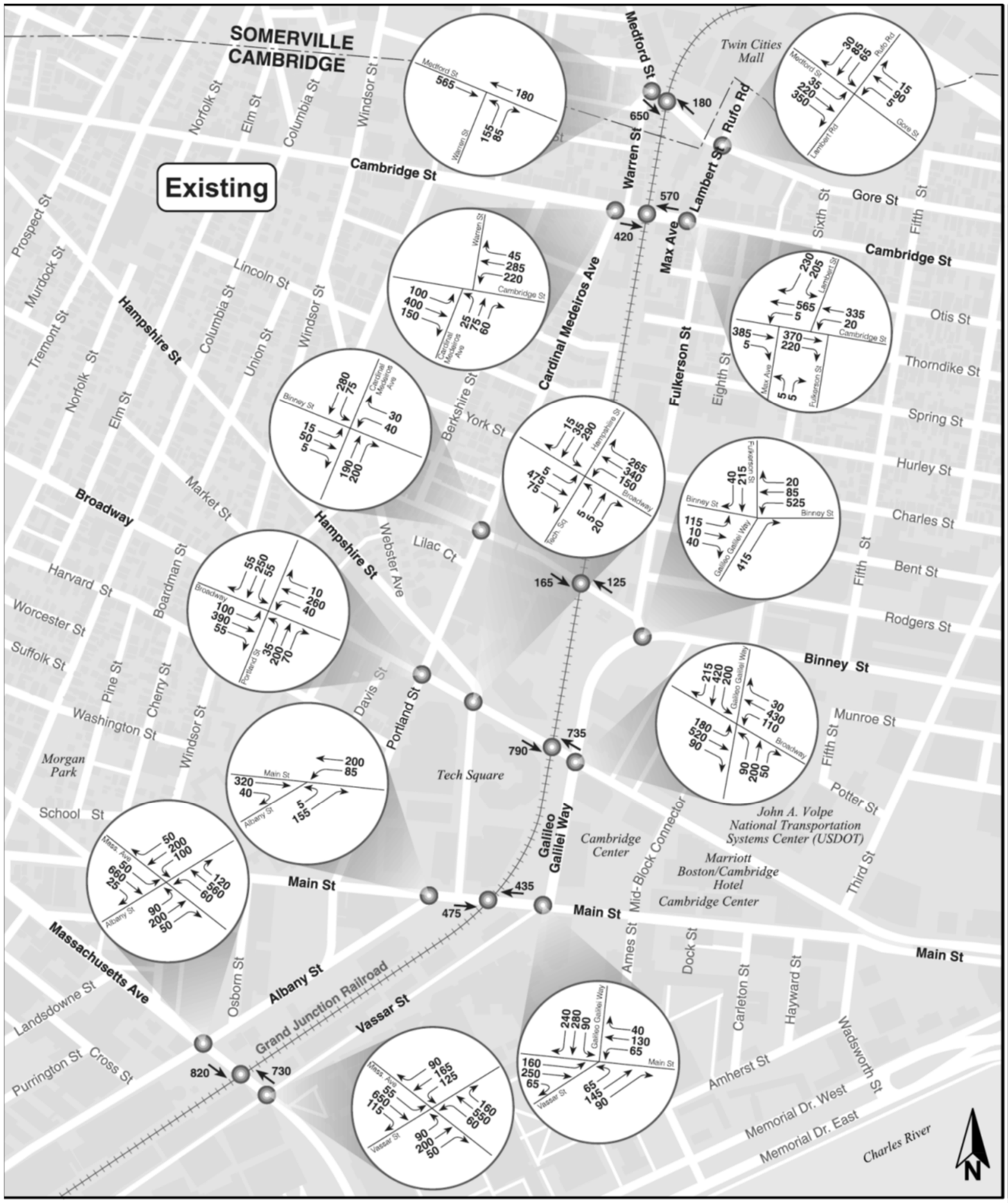


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FIGURE 2-4
Existing AM Peak Hour Vehicular Traffic at Grade Crossings

Grand Junction Transportation Study

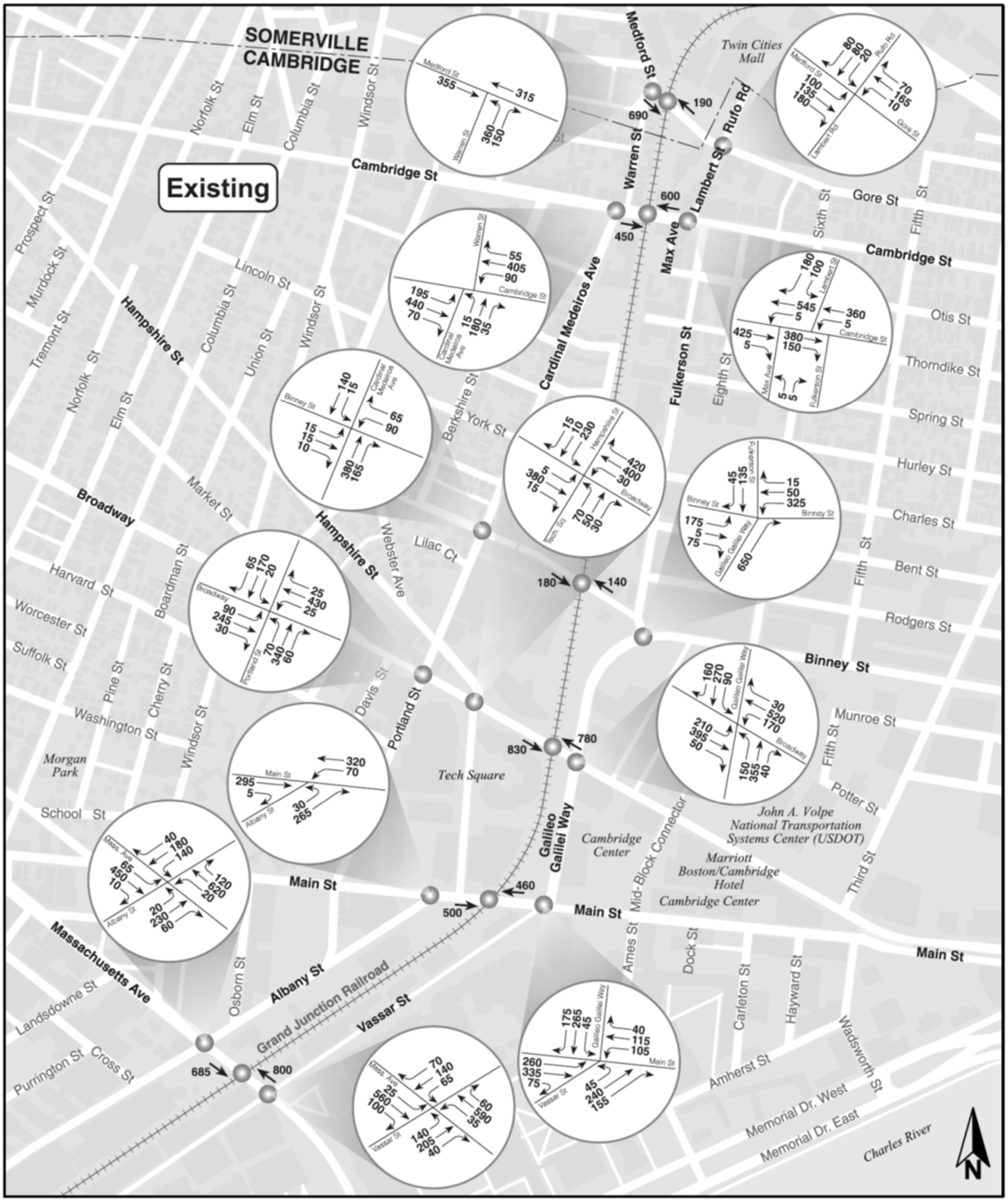

FIGURE 2-5
Existing PM Peak Hour Vehicular Traffic at Grade Crossings

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Grand Junction Transportation Study

Table 2-10
Existing Bus Routes at Grade Crossings

Bus Route	Daily Riders	AM Peak Hr Riders	AM Peak Hr Headway (mins)	# of One-way Trips in AM Peak Hour
1	12,325	1,479	8.5	7.1
CT1 (701)	2,014	242	20	3
CT2 (747)	1,253	150	20	3
64	1,268	152	23	2.6
68	520	62	30	2
69	2,985	358	14	4.3
85	397	48	30	2
EZ	tbd	tbd	10	6
Total	20,762	2,491	na	30.0

Note: MBTA AM peak is from 6:30 to 9:00 am.

TABLE 2-11
Existing Pedestrians and Bicycle Traffic at Grade Crossings

	AM Peak Hour			PM Peak Hour		
Location	Pedestrians	Bicyclists	Total	Pedestrians	Bicyclists	Total
Fort Washington Park	31	17	48	46	29	75
Mass. Avenue	482	275	757	836	356	1,192
Albany Garage	113	-	113	149	-	149
Main Street	710	111	821	777	135	912
Broadway	662	345	1,007	824	317	1,141
Binney Street	111	32	143	145	22	167
Cambridge Street	204	95	299	289	85	374
Gore Street	78	50	128	93	48	141
Total	2,391	925	3,316	3,159	992	4,151

Note: Pedestrian and bike counts conducted by CTPS during the spring of 2011.

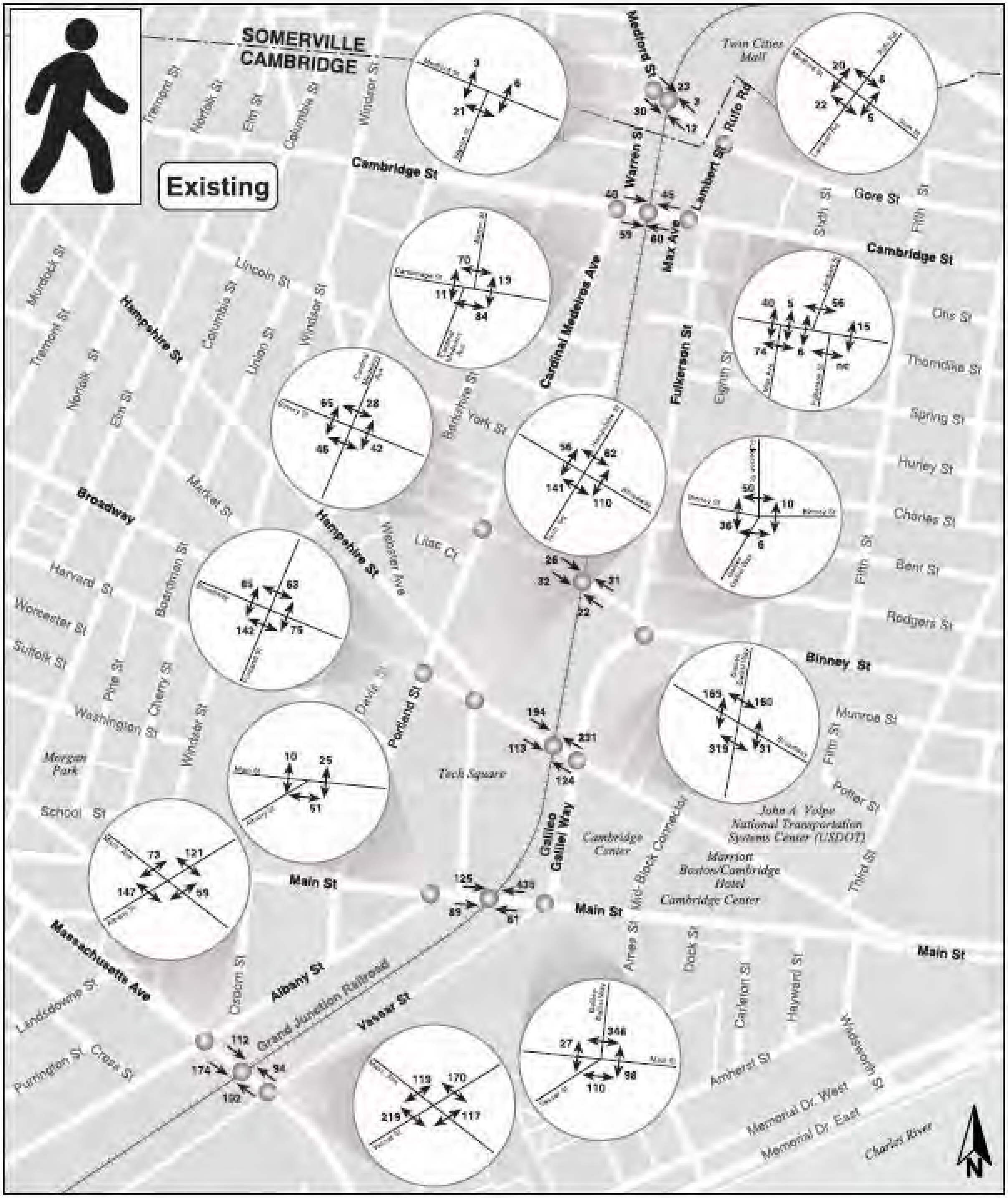

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FIGURE 2-6
Existing AM PedestrianTraffic at Grade Crossings

Grand Junction Transportation Study

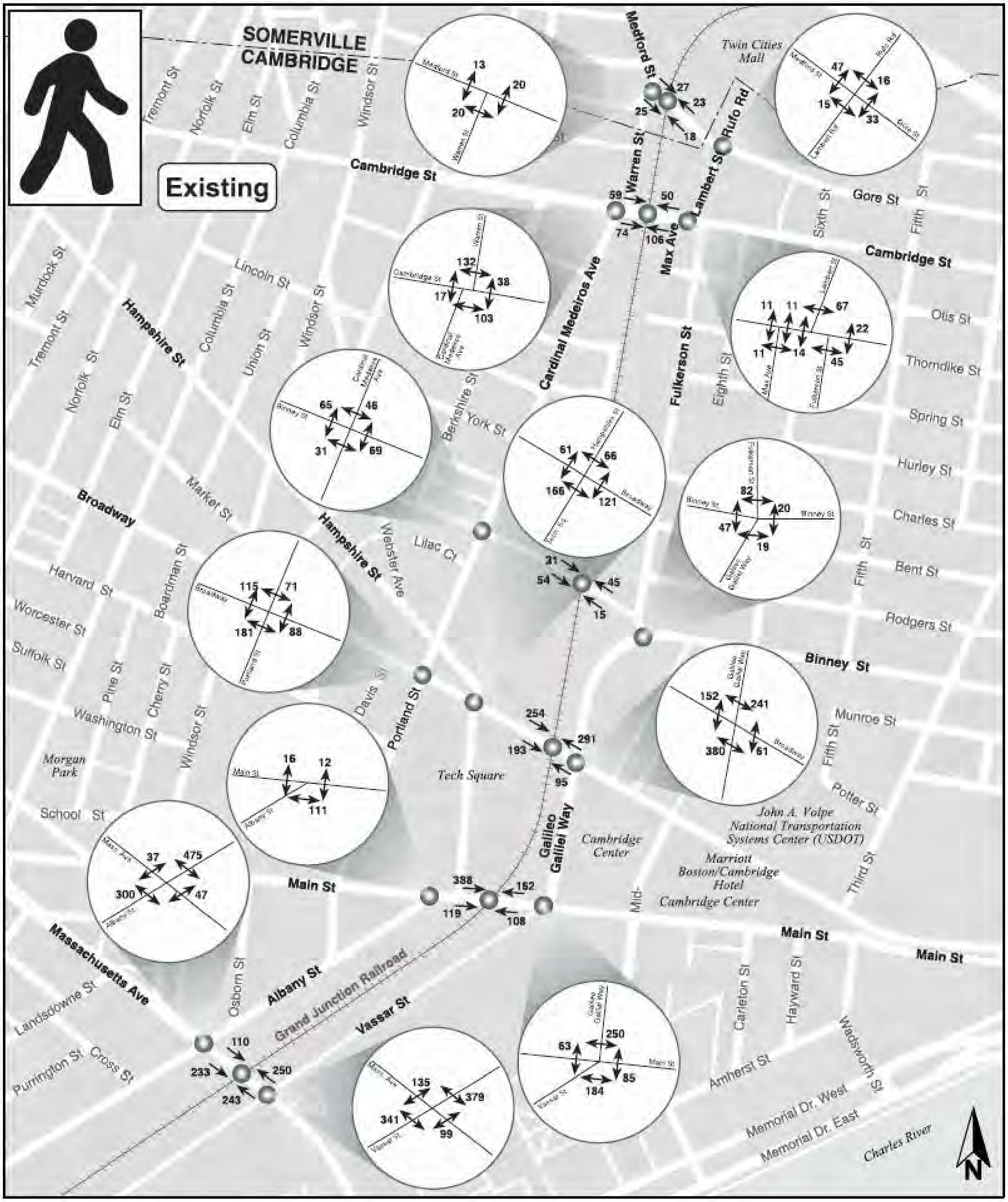

FIGURE 2-7
Existing PM PedestrianTraffic at Grade Crossings

Grand Junction Transportation Study

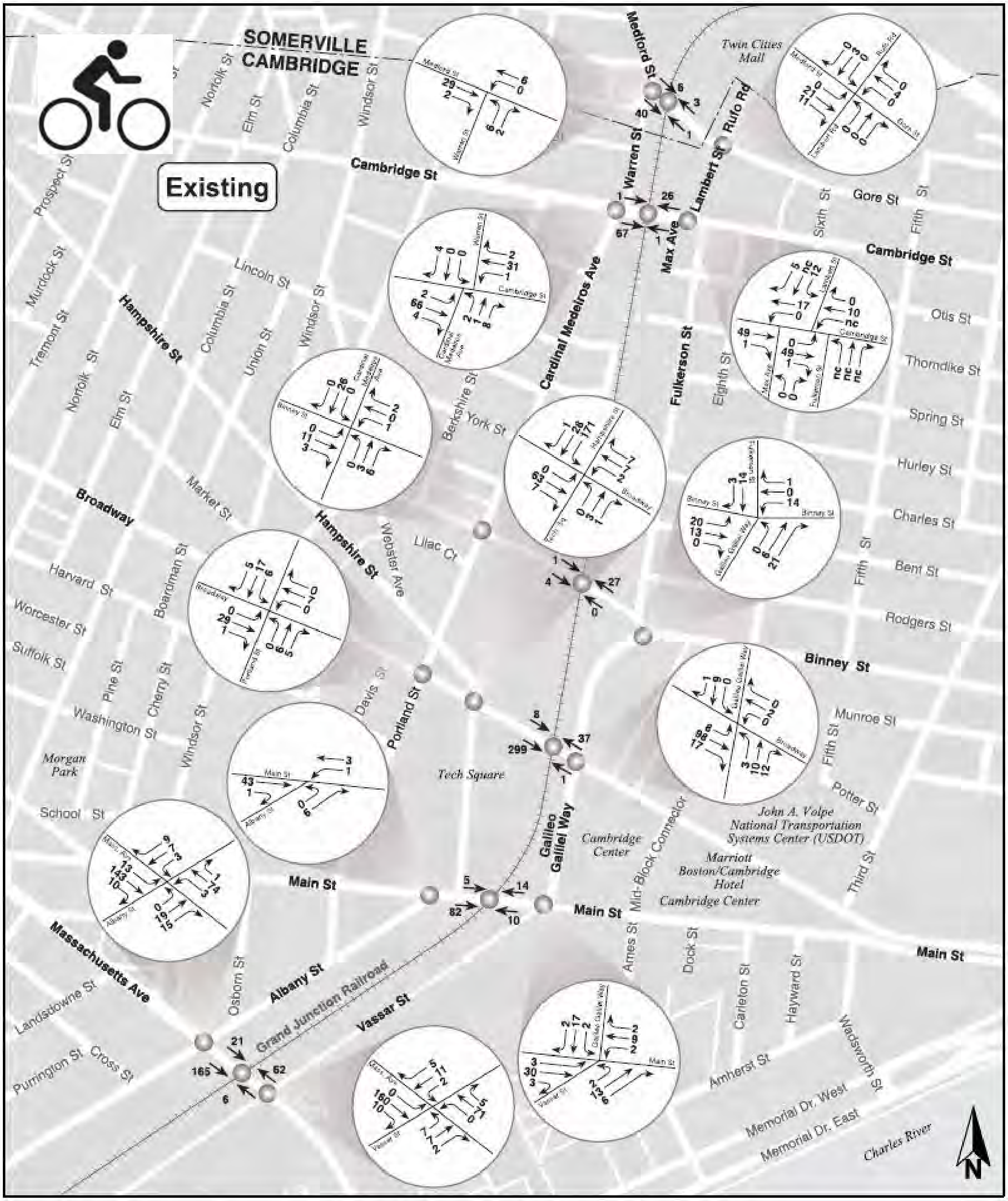

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FIGURE 2-8
Existing AM BicycleTraffic at Grade Crossings

Grand Junction Transportation Study

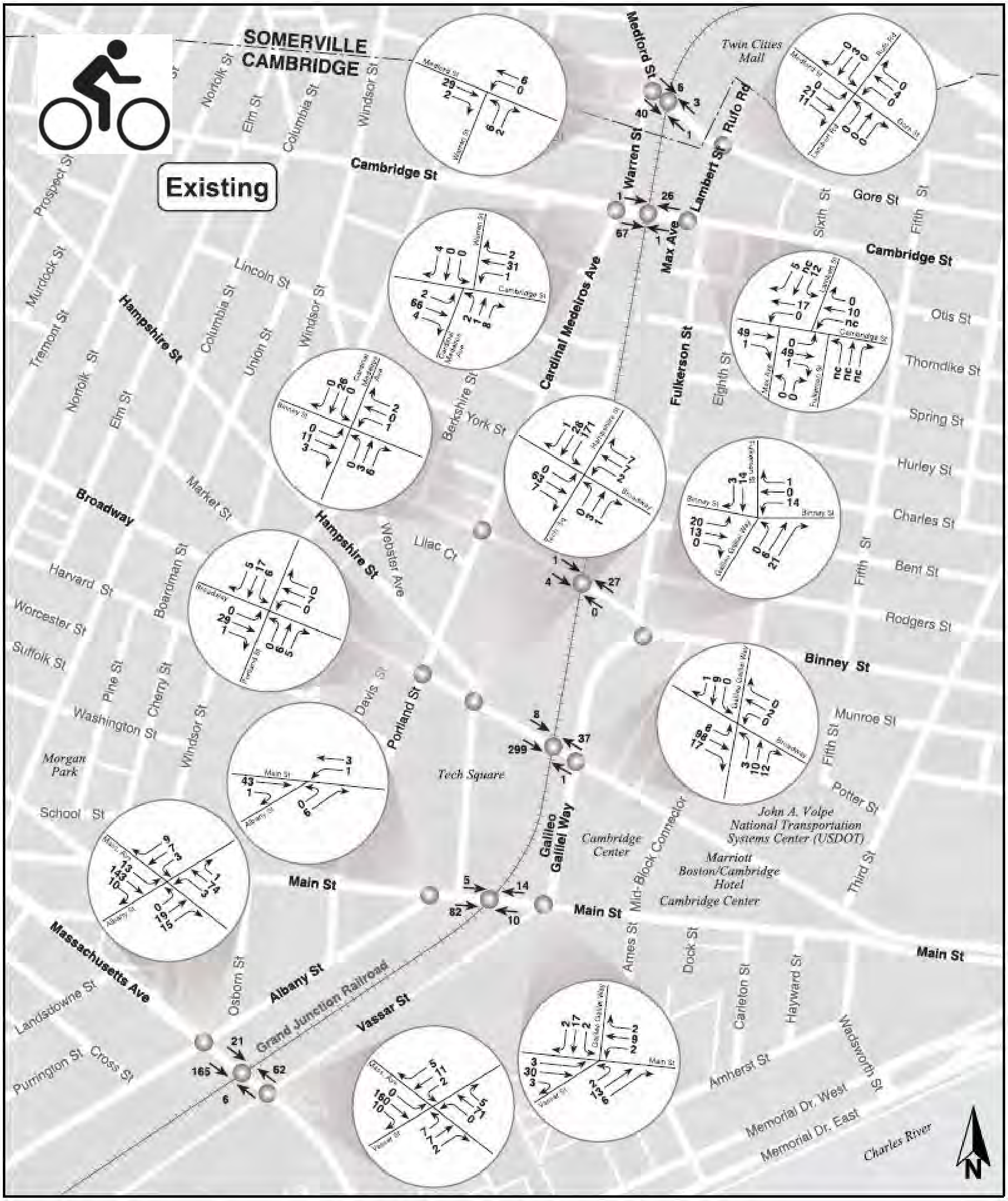

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FIGURE 2-9
Existing PM BicycleTraffic at Grade Crossings

Grand Junction Transportation Study

3 FUTURE YEAR METHODOLOGY

3.1 METHODOLOGY

The MPO's regional travel demand model set, which the Central Transportation Planning Staff (CTPS) uses for forecasting travel demand, is based on procedures and data that have evolved over many years. The regional model set is of the same type as those used in most large urban areas in North America. It uses the best computer models, transportation networks, and input data available to CTPS at this time. The model set is used to simulate existing travel conditions and to forecast future-year travel on the entire transportation system, spanning most of eastern Massachusetts, for the transit, auto, and walk-bike modes.

3.1.1 MAJOR FEATURES

The model set simulates the modes and routes of trips from a unit of geography called a transportation analysis zone (TAZ). The flows of person-trips are estimated for a base year and future year between each TAZ in the model area. Population, households, employment, and auto ownership are the factors used to develop the number of trips produced in or attracted to a TAZ on the demand side. On the supply side, highway and transit levels of service, walking and biking paths, downtown parking costs, auto operating costs, and transit fares are used to help estimate flows between TAZs and the mode that trips are likely to use. These inputs are continuously updated so that the model set simulates current travel patterns with as much accuracy as possible. The regional model set has been used in a number of recent studies, such as the Green Line Extension to Medford and Somerville, and for the Long-Range Transportation Plan (LRTP) and the South Coast Rail Final Environmental Impact Report (FEIR).

Some important features of the model set are listed below.

- The model area encompasses 164 cities and towns in eastern Massachusetts, as shown in Figure 3-1. The modeled area is divided into 2,727 internal TAZs, as shown in Figure 3-2, for the Boston-Cambridge area. There are 124 external stations around the periphery of the modeled area that allow for travel between the modeled area and adjacent areas of Massachusetts, New Hampshire, and Rhode Island.

- The model set was estimated using data from a Household Travel Survey, External Cordon Survey, several Transit Passenger Surveys, data from the 2000 U.S. Census, an employment database for the region, and a vast database of ground counts of transit ridership and traffic volume data collected over the last decade.
- The transportation system is broken down into three primary modes. The transit mode consists of all of the MBTA rail and bus lines, commuter boat services, and private express bus carriers. The auto mode includes all of the express highways, principle arterials, many minor arterials, and local roadways. Walk and bike trips are also examined, and are represented in the nonmotorized mode. The nonmotorized mode is represented as a network of roadways, bike trails, and major walking paths.
- The model is set up to examine travel on an average weekday in the spring, over four time periods, for the year being examined. The base year is 2010, and the forecast year is 2035.

The model set is based on the traditional four-step urban transportation-planning process of trip generation, trip distribution, mode choice, and trip assignment, with a fifth step added – a vehicle ownership model that was used to expand the capability of the four-step process. This process is used to estimate the daily transit ridership, nonmotorized activity, and highway traffic volumes, based on changes to the transportation system. The model set takes into consideration data on service frequency (how often trains and buses arrive at any given transit stop), routing, travel time, and fares for all transit services. The highway network includes all of the express highways and principle arterial roadways, as well as many of the minor arterials and local roadways. Results from the computer model provide detailed information relating to transit ridership demand. Estimates of passenger boardings on all of the existing and proposed transit lines can be obtained from the model output. A schematic representation of the modeling process is shown in Figure 3-3.

3.1.2 THE FIVE-STEP MODEL

1. Vehicle ownership: Household auto ownership is an input to trip generation and mode choice. It is forecast using a logit model developed with the Household Travel Survey and 2000 U.S. Census data. The model is integrated with the trip production procedures. These models estimate the probability of a household owning a certain number of vehicles as a function of income, household size, workers per household, household density, employment density, household location, and transit walk-access factors.

2. Trip generation: In the first step, the total number of trips produced by the residents in the model area is calculated using demographic and socioeconomic data. Similarly, the numbers of trips attracted by different types of land use, such as employment centers, schools, hospitals, and shopping

centers, are estimated using land use data and trip generation rates obtained from travel surveys. All of these calculations are performed at the TAZ level.

3. Trip distribution: In the second step, the model determines how the trips produced and attracted would be matched throughout the region. Trips are distributed based on transit and highway travel times between TAZs and the relative attractiveness of each TAZ. The attractiveness of a TAZ is influenced by factors such as the number and type of jobs available, which are related to the size (number of employees) of schools, hospitals, and shopping centers.

4. Mode choice: Once the total number of trips between all combinations of TAZs is determined, the mode-choice step splits the total trips among the available modes of travel. The modes of travel are walk, auto, and transit. To determine what proportions of trips each mode receives, the model takes into account the travel times, number of transfers required, and costs associated with these options. Some of the other variables used in the mode choice are auto ownership rates, household size, and income.

5. Assignment: After estimating the number of trips by mode for all possible TAZ combinations, the model assigns them to their respective transportation networks. Reports showing the transit and highway usage can be produced, as well as the impact of these modes on regional air quality.

3.1.3 MODEL APPLICATION

The model set is calibrated to existing conditions. Calibration involves making sure the usage for all modes of transportation match or approximates the count or survey information whenever possible. Once calibration is complete for the existing conditions, the model set is used to develop a no-build scenario for the 2035 forecast year. The forecast year analysis uses inputs such as the projected population and employment by TAZ produced by the Metropolitan Area Planning Council (MAPC) and the Boston Region MPO's assumptions about what the transportation infrastructure would exist in 2035. The build and no-build scenarios use the same set of population and employment forecasts. The ridership forecasts are first developed for a no-build forecast year that assumes that there will be no transit improvements in the Grand Junction corridor. The transportation network is updated to reflect the project improvements and the model is re-run for the various build options. The outputs of these model runs can then be compared to the no-build scenario to see what changes in travel patterns occur to the transportation system.

3.1.4 FUTURE LAND USE ASSUMPTIONS

MAPC produced projections of population, households, and employment by sector at the TAZ level in support of the Boston Region MPO's current Long-Range Transportation Plan, *Paths to a Sustainable Region*. This land use is consistent with the MetroFuture land use projections produced by MAPC that involved extensive outreach and feedback from the communities. The three employment sectors are basic, retail, and service. MAPC worked with the communities to decide where the growth would occur. These projections conform to the regional totals for population and employment growth issued by MassDOT in December 2010. Population, households, and employment in future years were estimated by MassDOT at the state level, and then the projected total growth was allocated to the state's 13 regional planning agency districts. To be consistent with the Boston Region MPO travel demand model set and the LRTP, the Grand Junction study used the same assumptions.

In 2010, the city of Cambridge had a total population of about 105,600 and employment of about 104,000. The projected population and employment in 2035 are 123,000 and 120,000. Population and employment are projected to increase 16% and 15%, respectively, between 2010 and 2035. The employment and population changes in Cambridge are shown in Table 3.1.

TABLE 3-1
Population and Employment Change in Cambridge

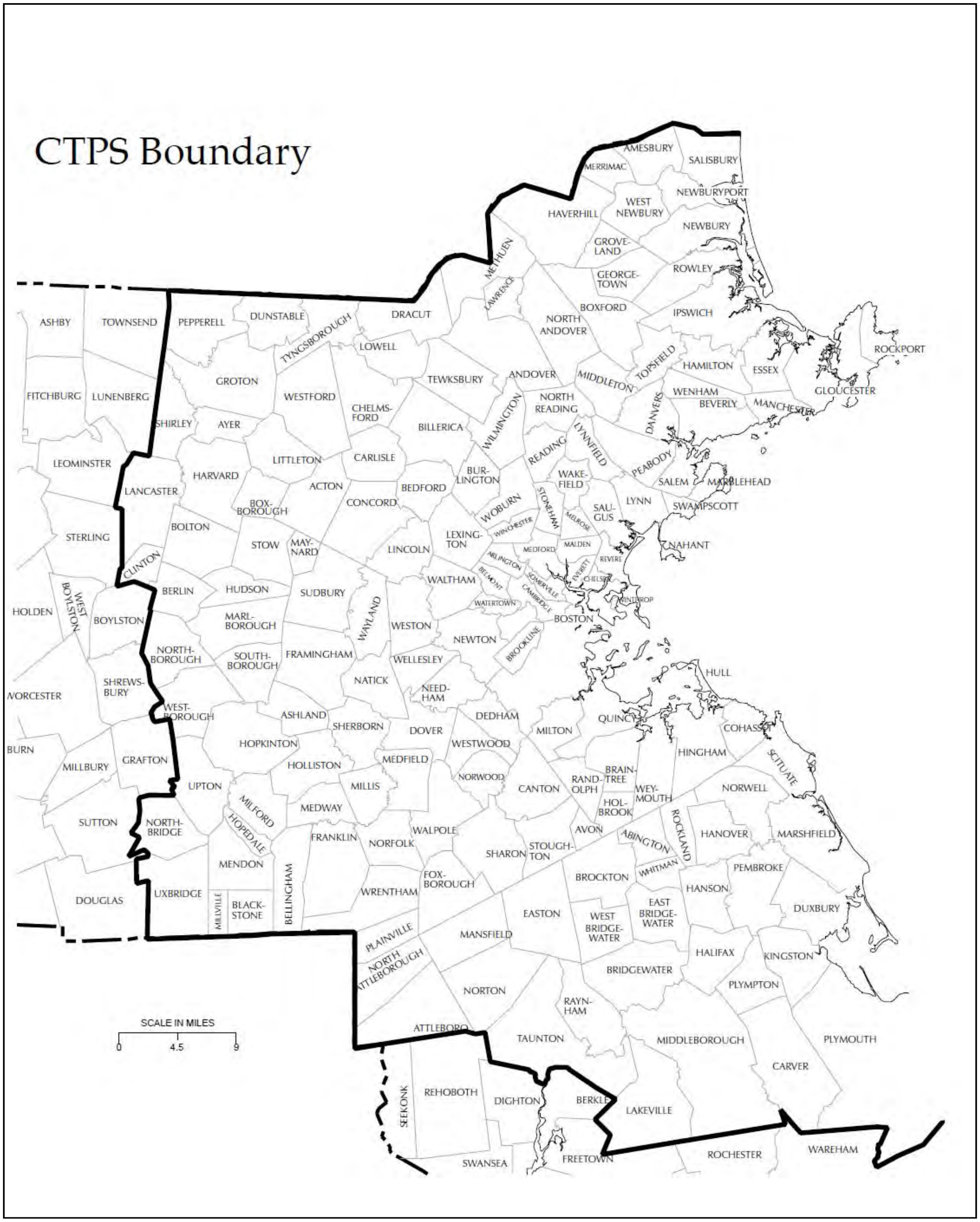
Cambridge	2009	2035	Change	Ratio
Population	105,600	123,000	17,400	16%
Employment	104,000	120,000	16,000	15%

Note: 2008 data are from CTPS and 2035 data are from MAPC.

The 10 TAZs with the greatest population and employment change are shown in Table 3.2. The three TAZs with the greatest projected population growth are in the Grand Junction corridor: TAZ 625 near the Lechmere Green Line station and TAZs 638 and 637 near the Kendall/MIT Red Line station. The projected population increase in these top 10 TAZs accounts for 63% of the total change in Cambridge between 2008 and 2035.

Figure 3.4 displays the projected population change in Cambridge between 2010 and 2035. In the regional travel model sets, employment is one of the most important factors for determining the number of trips attracted to a TAZ. Trips are attracted to different types of land use, such as employment centers, schools, hospitals, shopping centers, and so on. Thus, types of trips include work trips, school trips, and shopping trips.

Employment change in Cambridge between 2008 and 2035 exhibits a distribution pattern similar to that of population change. The areas with the greatest employment increases are near the rapid transit stations of Lechmere, Kendall/MIT, and Alewife: TAZ numbers 625, 637, 655, 643, and 728 (see Figure 3.5). The employment change analysis used three categories: basic, retail, and service. Virtually all of the projected employment growth is in the service sector.



CTPS

FIGURE 3-1
Travel Demand Model Area

Grand Junction Transportation Study

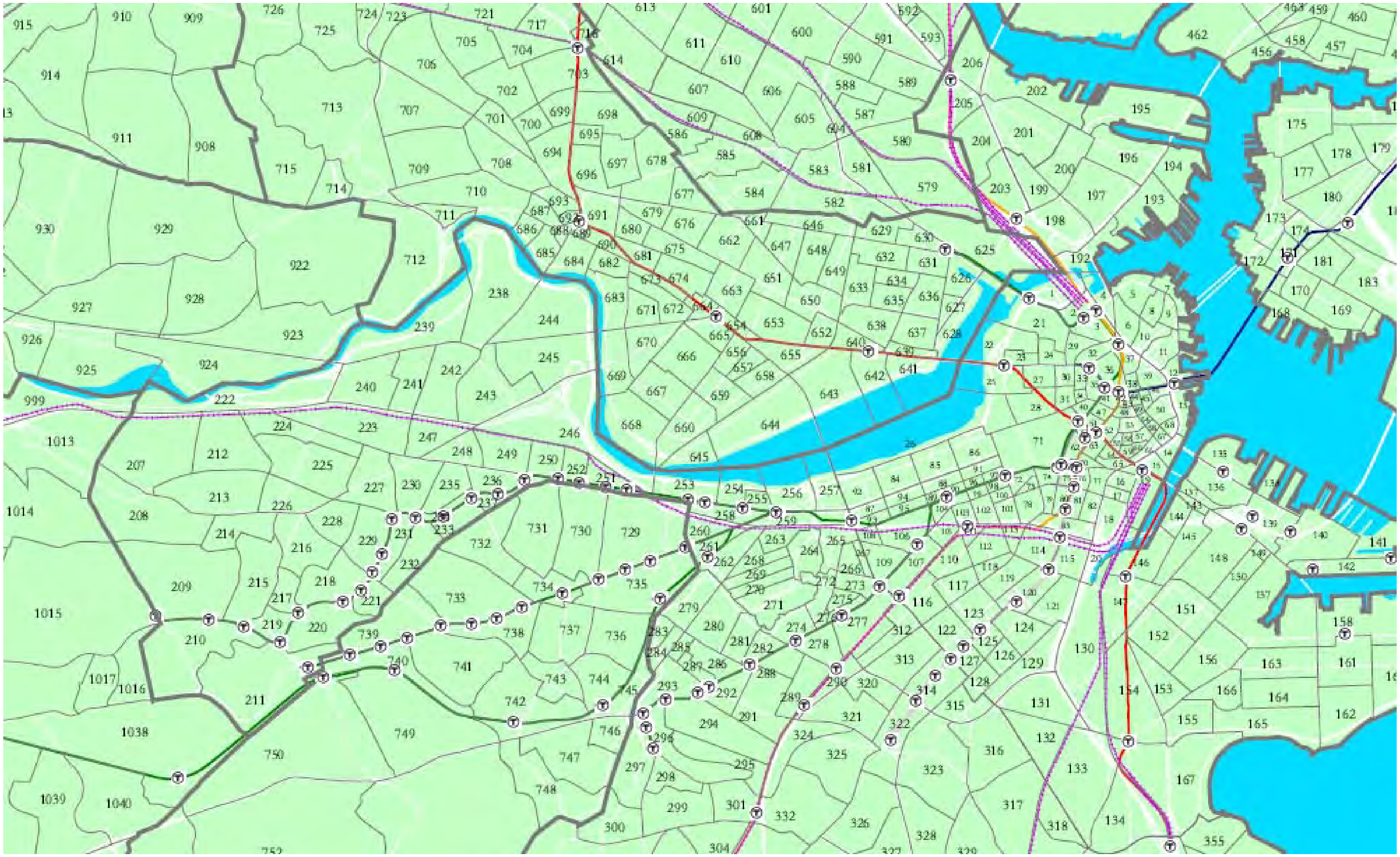


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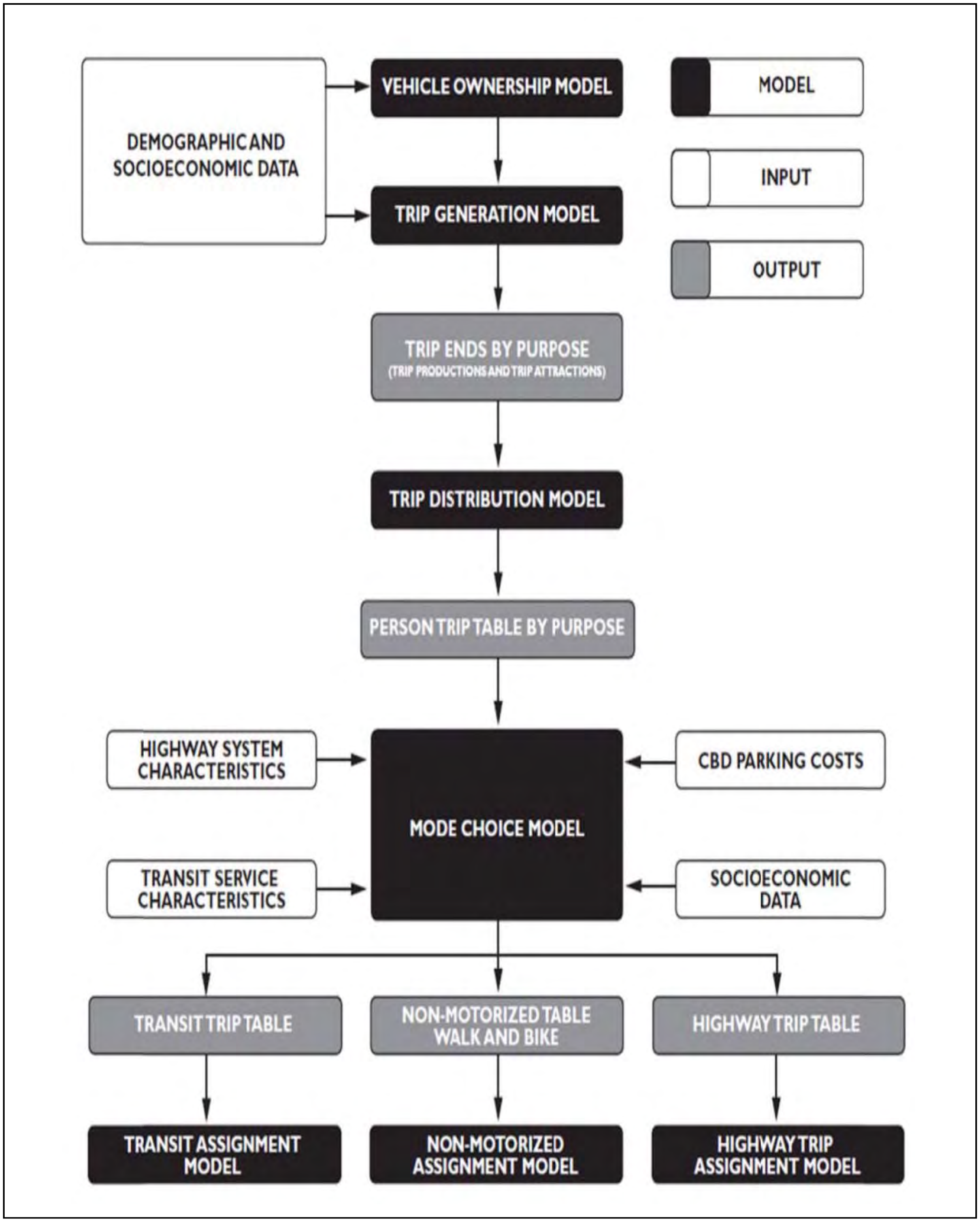
FIGURE 3-2
Travel Demand Model Set TAZs in Study Area

Grand Junction Transportation Study



CTPS

FIGURE 3-3
Travel Demand Model Set Flowchart

Grand Junction Transportation Study

TABLE 3.2
Cambridge TAZs with the Greatest Population and Employment Change

TAZ	Population Change	TAZ	Employment Change
625	3,350	625	3,860
638	2,000	637	2,370
727	1,230	655	2,090
637	1,000	643	1,530
636	560	728	1,230
728	550	697	1,010
725	530	696	990
726	520	642	920
659	490	636	780
724	470	633	770
Total	**10,630**	**Total**	**15,530**

Note: 2008 data are from CTPS and 2035 data are from MAPC.

3.1.5 FUTURE TRANSPORTATION PROJECTS

The future year analysis builds on the Long-Range Transportation Plan (LRTP) of the Boston Region Metropolitan Planning Organization (MPO). The document is located on the Boston Region MPO website: http://www.ctps.org/bostonmpo/3_programs/1_transportation_plan/plan.html.

The fiscally constrained LRTP identified several highway and transit projects in the region that were included in the analysis of the 2035 horizon year. Some examples of projects that were included in the LRTP and in the analysis are listed below.

Highway Projects

- Sullivan Square/Rutherford Avenue (Boston)
- Middlesex Turnpike Improvements, Phase III (Bedford, Burlington, and Billerica)
- I-93/Route 3 Interchange – Braintree Split (Braintree)
- I-93/I-95 Interchange (Canton)
- I-93/I-95 Interchange (Reading and Woburn)
- Montvale Avenue (Woburn)
- New Boston Street Bridge (Woburn)
- Route 1 Improvements (Malden and Revere)

Transit Projects

- Green Line Extension to Mystic Valley Parkway and Union Square (Cambridge, Medford, and Somerville)
- Beverly and Salem Parking Garages
- Parking Expansion – 1,000 New Parking Spaces (various locations)
- Assembly Square Orange Line Station (Somerville)

The Commonwealth of Massachusetts, with the acquisition of CSX Transportation's right-of-way (ROW) and the potential of track expansion at South Station, expressed a desire to increase the number of trains using the Worcester Line in the future. To reflect these potential improvements in the future no-build scenario, CTPS worked with the MBTA to develop future-year service plans for the Worcester Line that would increase the number of inbound trains from 21 to 30, a 46.3% increase in the year 2035 from the 2010 base year. This was due to an assumption of improved operations on the line, increased capacity at South Station, and additional train sets available in 2035. One of the operational improvements would allow all trains to terminate in Worcester, compared to the current split between Framingham and Worcester.

There are two proposed transportation projects that are not included in this analysis, but they could share the Grand Junction ROW with additional Worcester commuter rail service. They are the Urban Ring Circumferential Transit Service and the Mixed-Use Path (Rail-with-Trail); the latter would utilize parts of the Grand Junction ROW for walking and biking trails.

Urban Ring

The Urban Ring is a proposed major new bus rapid transit (BRT) system that would run in a roughly circular corridor serving employment centers, residential neighborhoods, and major educational and medical institutions in Boston, Brookline, Cambridge, Chelsea, Everett, Medford, and Somerville. This project, as envisioned, would involve creating an exclusive bus lane along the Grand Junction ROW in Cambridge. The project would utilize the Grand Junction ROW, which would be shared between four modes: bus rapid transit, a mixed-use path, local roads, and commuter rail. A more detailed description of the project and a map can be accessed at the following website: https://www.massdot.state.ma.us/theurbanring/.

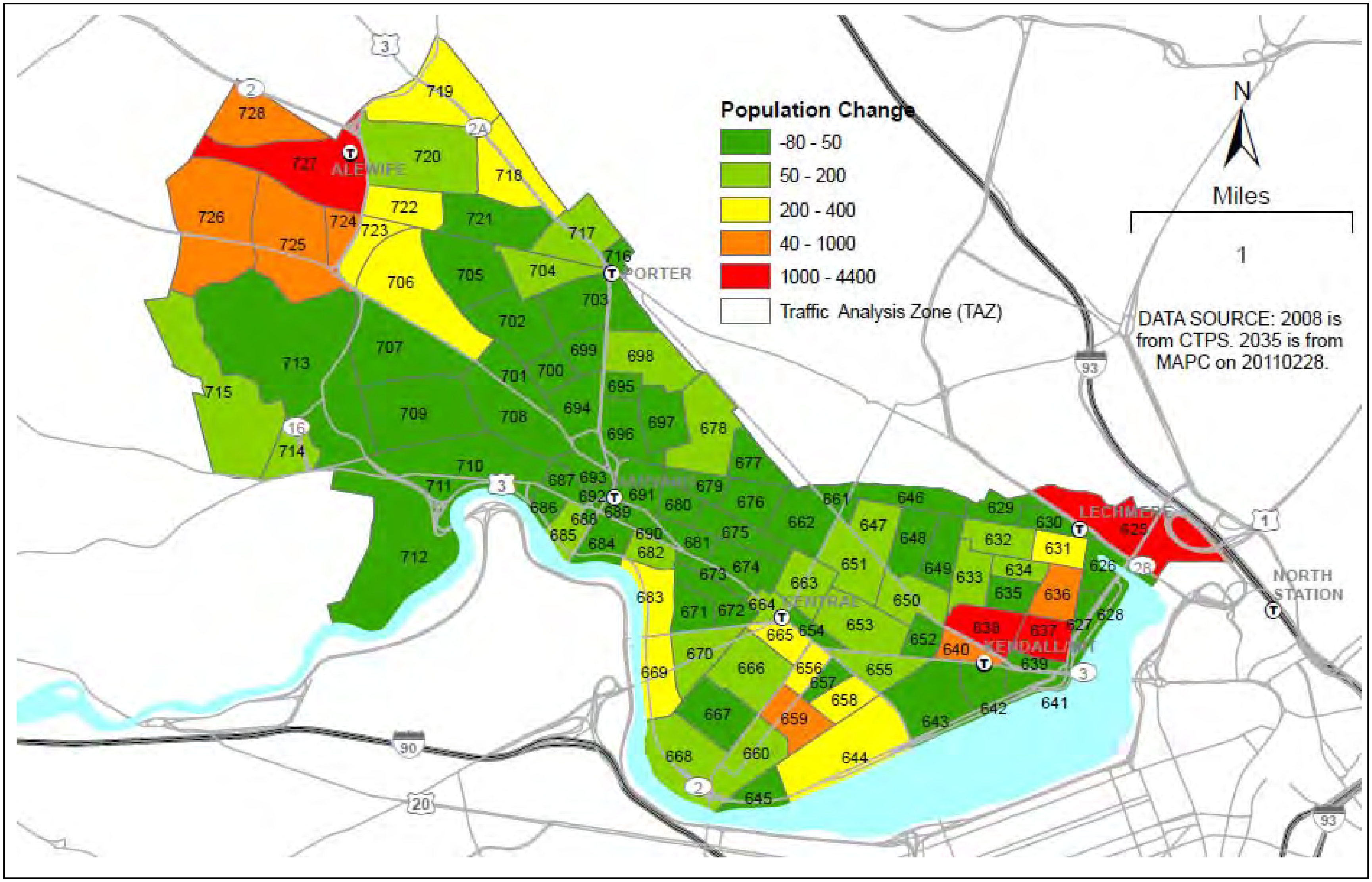


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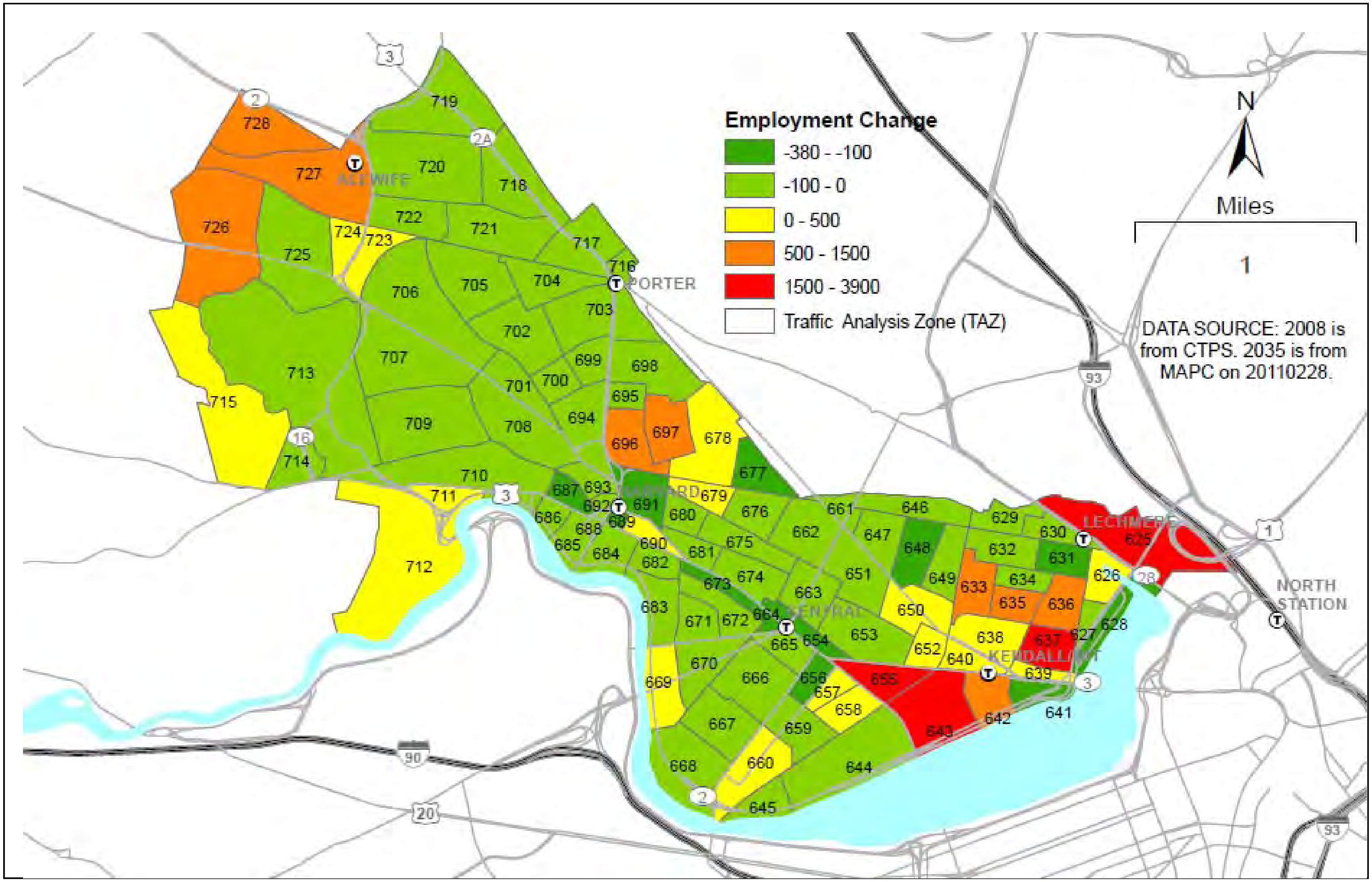
FIGURE 3-4
Population Change in Cambridge Between 2010 and 2035

Grand Junction Transportation Study



CTPS

FIGURE 3-5
Employment Change in Cambridge Between 2009 and 2035

Grand Junction Transportation Study

On January 22, 2010, the Massachusetts Department of Transportation (MassDOT) notified the Executive Office of Energy and Environmental Affairs that it was suspending further environmental review for the Urban Ring, Phase 2, project. This decision was made in the context of the challenging environment for funding MBTA expansion projects. The Boston Region MPO was unable to fit any portion of the project into the latest version of its Long-Range Transportation Plan (the fiscally constrained 20-year planning document, inclusion in which is a prerequisite for the receipt of federal transportation funds). The cost to the MBTA of building and operating the Urban Ring prevented it from being included in the LRTP and from being included in this analysis. The use of the Grand Junction ROW by Framingham/ Worcester Line commuter rail trains would not preclude the Urban Ring project from advancing at some future time.

Grand Junction Mixed-Use Path (Rail-with-Trail)

The use of the Grand Junction corridor as a mixed-use path was envisioned by the Cambridge Green Ribbon Open Space Committee in its 2001 study of possible new parks and open space in the city, and was identified as a top priority. The 2001 Eastern Cambridge Planning Study also recommended the creation of the path along the Grand Junction as an infrastructure project to enhance non-auto mobility. The City of Cambridge has undertaken a feasibility study to determine whether it is possible to create a rail-with-trail (RWT) along this corridor. An RWT would enable the railroad to continue its services, with a separated trail functioning parallel to the rail service. The proposed Grand Junction RWT would serve pedestrians, bicyclists, joggers, and others as a recreational and transportation route, linking various Cambridge neighborhoods and other recreational facilities and serving major employment and university centers. The City of Cambridge published *The Grand Junction Rail-with-Trail Feasibility Study* in 2006. New commuter rail service along the Grand Junction line would not preclude developing the rail-with-trail at some later point.

3.2 TRANSIT SYSTEM ANALYSIS

The future 2035 no-build scenario was compared to the existing conditions for 2010, and the changes were examined using a variety of metrics. The metrics that are presented below include linked and unlinked transit trip by mode, and mode of access for Framingham/ Worcester Line stations. A linked transit trip represents a person-trip from an origin to a destination regardless of the number of transit modes taken. An unlinked transit trip represents boardings for each transit mode separately. One linked transit trip can include multiple transfers to other transit modes, resulting in multiple unlinked transit trips taken to reach a destination.

The results of the modeling of the transit system results are shown in Table 3-3. Linked transit trips increase by 22.6%, from the 985,700 that existed in 2010, to 1,208,800, in 2035. This increase is due to growth in population and employment in the region by 2035, in addition to some additional transit services, such as the Green Line extension and additional trains on the Framingham/Worcester Line. (The additional transit service was described in the previous section.) Unlinked transit trips by sub-mode increase by 28.3%. The modes that experience the greatest increase in demand are the commuter rail and local buses, which grow by 30%.

Daily boardings on the Framingham/Worcester Line increase between 2010 and 2035 by 34.3%. This increase is a result of projected demographic growth in the region and improved frequency of train service. The increase of linked transit trips on the Framingham/Worcester Line is primarily associated with trips that consist of driving to the stations and parking. The parking mode increased by 40.6%, while walk trips and drop-offs increased by 25.6% and 29.1%, respectively. The access mode “Other” includes transit trips, and accounts for just 14% of the total means of access to a train station.

TABLE 3-3
Transit System Summary

Daily	2010 Existing	2035 No-Build	Change Absolute	Change Percent
Linked Transit Trips in eastern MA	985,700	1,208,800	223,100	22.6%
Unlinked Transit Trips in eastern MA	1,182,400	1,516,700	334,300	28.3%
Commuter Rail	104,900	137,400	32,500	31.0%
Rapid Transit	692,400	882,200	189,800	27.4%
Local Bus	355,500	462,200	106,700	30.0%
Express Bus	25,200	30,400	5,200	20.6%
Ferry	4,400	4,500	100	2.3%
Worcester Commuter Rail Service	41	60	19	46.3%
Inbound	21	30	9	42.9%
Outbound	20	30	10	50.0%
Total Boardings on Worcester Commuter Rail	13,400	18,000	4,600	34.3%
Inbound	6,700	9,000	2,300	34.3%
Outbound	6,700	9,000	2,300	34.3%
Mode of Access for Inbound Worcester Service	6,700	9,000	2,300	34.3%
Walking	1,760	2,210	450	25.6%
Parking	3,870	5,440	1,570	40.6%
Drop-offs	860	1,110	250	29.1%
Other	210	240	30	14.3%

Source: CTPS Travel Demand Model Set

Parking utilization is an important factor in this analysis; a summary of the finding is shown in Table 3.4. Due to the demand associated with increased frequency on the line in 2035 and demographic growth, the parking utilization increases from 32% in 2009 to 98% in 2035. This parking constraint potentially limits the number of people who might want to use this commuter rail line to take advantage of improved transit service and connections along the Worcester Line.

Station	Distance	2009									2035 No-Build							
		Daily		AM Pk 3 Hrs							Daily		AM Pk 3 Hrs					
		ons	offs	ons	offs	Available Parking	Parking Used	Parking Utilization	Unused Parking	Calculated Drive Access	ons	offs	ons	offs	Available Parking	Parking Used	Parking Utilization	Unused Parking
Worcester	44.3	780		620		500	235	47%	265	406	1,050		830		500	544	109%	(44)
Grafton	36.4	500		400		370	198	54%	172	319	640	10	510	10	370	407	110%	(37)
Westboro	32.0	470	10	370	10	440	352	80%	88	285	790	10	620	10	440	477	109%	(37)
Southboro	26.0	480	10	380	10	360	226	63%	134	272	690	10	550	10	360	394	110%	(34)
Ashland	25.3	430		330		670	198	30%	472	287	980	10	750	10	670	653	97%	18
Framingham	21.4	960	20	740	20	310	127	41%	183	488	1,090	20	840	20	310	344	111%	(34)
W. Natick	20.1	720	20	560	10	180	130	72%	50	241	960	20	750	20	180	210	117%	(30)
Natick	17.7	520	10	410	10	70	48	69%	22	115	550	10	430	10	70	78	111%	(8)
Well. Sq.	14.7	430	10	330	10	300	192	64%	108	174	520	20	400	20	300	211	70%	89
Well. Hills	13.5	300	10	220	10	70	65	93%	5	76	330	10	240	10	70	83	118%	(13)
Well. Farms	12.5	300	10	230	10	200	119	60%	81	142	350	10	270	10	200	167	84%	33
Auburndale	10.2	220	10	180	10	120	107	89%	13	96	250	10	200	10	120	107	89%	13
W. Newton	9.1	240	10	190		190	139	73%	51	80	290	10	230	10	190	97	51%	93
Newtonville	8.1	270	20	210	20	100	24	24%	76	43	310	20	240	20	100	49	49%	51
Yawkey	2.4	20	300	10	260	0	0	0%	-	0	70	450	40	300	0	0	0%	-
Back Bay	1.0	90	2,430	30	1,880	0	0	0%	-	0	130	3,210	40	2,470	0	0	0%	-
S. Station		-	3,860		2,950	0	0	0%	-	0	-	5,170		4,000	0	0	0%	-
Total	na	6,730	6,730	5,210	5,210	3,880	2,160	32%	1,720	3,026	9,000	9,000	6,940	6,940	3,880	3,821	98%	59

Note: The number of Worcester daily inbound trains is expected to increase from21 in 2009 to 30 in the year 2035.

CTPS

TABLE 3-4
Parking Demand Between 2009 and 2035

Grand Junction Transportation Study

The objective of this study was not to look at expanding parking options at the various stations, but to examine how future train service could provide opportunities to existing and future markets via the Grand Junction ROW.

3.3 HIGHWAY SYSTEM ANALYSIS

The existing railroad crosses six streets (listed from the south to the north) in the East Cambridge area: Massachusetts Avenue, Main Street, Broadway, Binney Street, Cambridge Street, and Gore Street/Medford Street. Drivers and their passengers using these roadways could be impacted by the gate-down time associated with the various service plans. The gate-down time creates traffic queues to form on each approach to the grade crossing. The queue length and delay are highly correlated to the roadway traffic volumes and the operations and settings of its adjacent intersections.

Intersections in the Study Area

The study area for the traffic analysis includes the six crossing locations and at least one intersection upstream and at least one downstream of the crossing locations. Synchro[1] was used to assist with the analyses based on the information provided by the City of Cambridge and data collected in the field. The results of the travel demand model were used as input in the Synchro model and processed to estimate delay and queue length.

Table 3.5 shows the location, traffic operations, and pedestrian signal settings of the intersections included in the study network. The traffic signals on Massachusetts Avenue, Main Street, and Broadway all operate at 90-second cycles and are synchronized and coordinated in the east-west direction. The settings appear to be suitable for the traffic volumes and patterns in the area. The Synchro analysis indicates that these signalized intersections currently operate at an acceptable level of service of C or better.

Total Vehicle Delay

The estimation focuses on the impact on traffic on both sides of the six train crossing locations during the peak hour of traffic in the morning and the peak hour in the evening. If there is a signalized intersection immediately adjacent to a crossing location, the signal is assumed to be interconnected with the gate signal in the 2035 build scenario, so that traffic would be stopped at the signalized intersection. For these locations, the delays were estimated at the adjacent signalized intersection instead of at the gate location.

[1] Synchro is a traffic simulation software package used in this analysis.

In brief, the vehicle delay estimation involved the following steps:

- Estimate and balance the existing AM and PM peak-hour traffic volumes at the crossing locations and the adjacent intersections in the study area.
- Construct and calibrate the base-year Synchro traffic model.
- Obtain growth rates from the AM and PM peak-period models and estimate the future 2035 peak-hour traffic volumes for the study area.
- Construct the 2035 no-build scenario, for the least impact and the most impact on traffic.
- Obtain average vehicle delays at the adjacent intersections using Synchro models.
- Estimate gate-down time for each of the proposed scenarios.
- Estimate 95th percentile arrival rates at each crossing location based on the estimated gate-down time and the projected traffic volumes.
- Estimate the average vehicle delay at each crossing location based on the estimated 95th percentile arrival rates.
- Estimate the total vehicle delay from all vehicles impacted by the gate-down time based on the average vehicle delay and the projected traffic volumes for all of the selected locations on both sides of the gates.

Time for Processing Queues as a Result of the Gate-Down Time

To understand the extent of the impact on traffic at individual crossing locations when a train goes through the area, staff also estimated the potential queue build-ups under heavy traffic conditions (95th percentile queues) and the time needed to process the built-up queues. The processing time can also be regarded as the potential maximum delay that a driver could encounter if he or she happens to arrive at the back of the 95th percentile queue when the gate comes down.

The time that the gate is down is assumed to be 63 seconds if the train does not need to stop at any new commuter rail station, and 89 seconds if the train has to stop at a new commuter rail station (the latter situation occurs, for example, between Massachusetts Avenue and Main Street); the details of the alternatives are described in Chapter 4. Staff used the scenario of a train running at a maximum of 30 mph with no stops as the least-impact case (the lower bound of the estimation), and the scenario of a train running at 15 mph with a stop as the most-impact case (the upper bound of the estimation). The traffic arrival rates are based on the projected AM and PM peak-hour traffic volumes for year 2035, shown in Figures 2-4 and 2-5.

The process of estimating the time it would take to process queues includes the following steps:

- Estimate the 95th percentile queues at the gate locations during the time the gate is down.

- Estimate the queues at the adjacent signalized intersections by deducting the potential storage of the queues in the roadway section between the intersection and its adjacent gate location.
- Estimate additional traffic arrivals during the queue discharge period.
- Estimate the number of signal cycles needed to process the queues at the signalized intersections.
- Estimate the total time needed to process the traffic queues after a train's arrival.

3.4 PEDESTRIAN AND BIKE ANALYSIS

The pedestrian and bike counts, conducted in May of 2010 for each of the grade crossings, were expanded to 2035 projections based on the percent increase identified in the nonmotorized mode (walking and bike trips) reported in the regional model set. Based on the gate-down time, each person crossing one of the grade crossings would experience some form of delay depending on the alternative being considered. This delay was summed for all pedestrians and bicyclists at each of the grade crossings to develop a metric of the total delay experienced by people walking or biking due to the gate-down time.

4 ALTERNATIVES

4.1 SERVICE PLANS

The objective in defining the service plans for the alternatives was to determine the benefits, impacts, and costs of different service profiles for Framingham/Worcester trains serving North Station in 2035 via the Grand Junction ROW. To identify a feasible service plan, several alternatives were examined in order to understand the demand for the destinations of North Station and Kendall Square neighborhoods, assuming different train frequencies, different train speeds, and different station scenarios (in this case, with or without a Kendall Square station).

The frequencies were important for determining how the number of trains serving North Station would affect demand. More frequent service means less wait time. Train speed was important for gauging the impact of travel time on demand and gate-down time on traffic conditions. A potential new station in Cambridge near Kendall Square was examined separately in order to understand the demand for that neighborhood.

This approach resulted in eight alternatives, which were variations of three service variables: frequency, speed, and a new station. The alternatives considered are shown in Table 4-1. The lower-bound speed estimate was 15 mph, and the upper-bound speed was 30 mph. The lower-bound frequency considered in this analysis was 6 trips daily one-way to North Station, and the upper-bound estimate was 12 trips daily to North Station. Four alternatives assumed that there would be no new station in Cambridge, while four assumed that there would be a new station near Kendall Square.

4.2 SERVICE PLAN ASSUMPTIONS

To develop the service plans, a number of assumptions about operations, infrastructure, and compatibility with other modes were considered. CTPS developed hypothetical schedules with assistance from the MBTA for commuter rail service between Worcester and North Station via the Grand Junction track through Boston, Cambridge, and Somerville. The assumptions and constraints are described below.

Variable	Service Plans	1	2	3	4	5	6	7	8
Speed	15 mph	✓	✓			✓	✓		
	30 mph			✓	✓			✓	✓
Frequency	6 trains/day	✓		✓		✓		✓	
	12 trains/day		✓		✓		✓		✓
Station	Yes	✓	✓	✓	✓				
	No					✓	✓	✓	✓

TABLE 4-1
Service Plan Assumptions for 2035 Alternatives

4.2.1 BEACON PARK YARD AND GRAND JUNCTION TRACK LAYOUT

All scenarios assume that the Beacon Park Yard would be vacated by CSX Transportation prior to the implementation of Grand Junction service, and that any further CSX freight service between Worcester and Boston would be conducted in a manner that would not conflict with the hypothetical commuter rail schedules. All scenarios further assume that a new direct-track connection would be provided between the Grand Junction and the Fitchburg Route Main Line at the location where they currently cross in East Somerville (Swift Interlocking), and that automatic protection devices at all grade crossings of streets on the Grand Junction would be adequate to allow trains to cross the streets without slowing down or stopping.

At present, the Framingham/Worcester Line is entirely double-tracked except for a distance of 1.7 miles along the south side of Beacon Park Yard, where there is only one main track for commuter rail use. The junctions between the eastern and western limits of yard tracks and the single-track main line section are identified by the Massachusetts Bay Commuter Railroad Company (MBCR, the MBTA's contractor for commuter rail service) as CP-3 and CP-4. The Grand Junction does not connect directly with the main track. To get from one to the other at present, it is necessary to use intermediate yard tracks, which, it was assumed, would be upgraded in order to accommodate regular passenger rail service. The analysis assumed that there would be no substantial changes to the Grand Junction ROW, and that it would continue to operate with one track except for some sidings (pullouts for passing).

4.2.2 ASSUMED SPEED LIMITS ON THE GRAND JUNCTION RAILROAD

The alternatives analysis assumes two speeds at which the train would travel through Cambridge, in order to gauge whether demand would be sensitive to changes in the travel time differences and to enable an assessment of impacts of gate closure time on study area traffic, pedestrians, and bicyclists. The low-speed alternative for Grand Junction service assumes that eastbound trains going to the Grand Junction would diverge from the main line at CP-4 and use the present yard Track 1 to reach the series of tracks connecting to the Grand Junction Running Track. It is also assumed that all switches would be set up or controlled in a way that would not require the train crews to stop to line them up. The higher-speed alternatives assume that a second main track would be built or adapted from existing yard tracks between CP-3 and CP-4, and that direct connections would be installed between the Grand Junction line and both main tracks near the point where the Grand Junction now diverges from the yard tracks.

Under the low-speed alternatives, it was assumed that the Grand Junction Running Track and the yard tracks that connect it with the main line would be maintained to Federal Railroad Administration (FRA) Class 1 standards. These are the minimum standards at which passenger trains are permitted and they allow a maximum speed of 10 to 15 mph, with 15mph being used as the lower bound of speed for this analysis.

Under the higher-speed alternatives, it was assumed that the Grand Junction Running Track would be maintained to FRA Class 3 standards. These standards would result in a maximum passenger train speed of 30 mph in the Grand Junction corridor, which is a dense urban area with several grade crossings. The travel time savings to several destinations, with and without a stop at Kendall Square, is shown in Table 4-2.

4.2.3 ASSUMED LOCATION OF A STATION SERVING THE KENDALL SQUARE AREA

For purposes of analysis, a station serving the Kendall Square area of Cambridge was assumed to be located between the Massachusetts Avenue and Main Street grade crossings. This is the only location that would have enough distance between crossings for a platform that would accommodate the trains that might be run on the line and that would also be within a reasonable walking distance of Kendall Square. A stop there would add about two minutes to trips times to and from North Station compared with non-stop operation. The two minutes are due to two factors – train travel time and “dwell” time in the station, which is the amount of time that the train is stopped in the station for passengers to alight and board. The additional train travel time is the time the train would need for slowing down, stopping, and accelerating to get back up to the operating speed of that alternative.

4.2.4 STRATEGY FOR SYNCHRONIZING TRAIN SCHEDULES TO NORTH STATION

There are many potential strategies for scheduling Grand Junction service. For purposes of analysis, an attempt was made to add this service to the Framingham/Worcester Line schedules that were in effect in the winter of 2011, with minimal alteration of those schedules. The 2035 no-build analysis added several trips to the existing schedules, increasing the total from 21 to 30 inbound trains daily. The more frequent the service, the less time people need to wait for a train. The objectives in developing the different service plans for the Grand Junction service through Cambridge was to hold the overall service levels on the Framingham/Worcester Line constant, and develop two different service levels for the Grand Junction service through Cambridge that show how sensitive demand would be to frequency of service.

North Station currently has 10 tracks. With the current schedules on north-side lines, there should always be at least one unoccupied track at times when the Framingham/Worcester trains would need to be in the station under the hypothetical study schedule. However, some changes might be needed in the practice of storing equipment in the station between trips.

	Worcester to North Station		Worcester to Kendall		Worcester to South Station
	Existing via Orange Line	Grand Junction	Existing via Red Line	Grand Junction	Existing
Travel Time	1:37	1:28-1:35	1:44	1:18-1:20	1:30
Savings		2 – 9 mins.		24 – 26 mins.	

CTPS

TABLE 4-2
Travel Time Comparison of New Service with Current

North Station is not at capacity but has limitations based on the schedules of trains arriving and departing, which limits the potential for inserting many additional trips from the Framingham/Worcester Line. The service plan analysis identified that between one and two inbound trips arriving at North Station during the AM peak hour or departing in the PM peak hour could be accommodated by the proposed schedules. On a daily basis, the lower-bound frequency assumption was that 6 inbound trains out of 30 trains on the Framingham/Worcester Line could be diverted to North Station. The upper-bound estimate was that 12 inbound trains (out of the same total 30 trains on the Framingham/Worcester Line) could be diverted to North Station.

4.2.5 CONSTRAINTS OF WORCESTER LAYOVER FACILITY

The layover facility at Worcester has capacity for only four train sets, and there is no room for expansion there. To provide the present service between Worcester and South Station, four trains sets are kept overnight at the Worcester facility and two others are sent out from South Station at 4:00 AM coupled together. For purposes of analysis, it was assumed that the two train sets required for the 2035 no-build operations and North Station service would also have to be based in Boston and run out to Worcester early in the morning.

Track constraints at Worcester were assumed to require that these two train sets be run separately. Although both could start from either North Station or South Station, it was assumed that the first one would leave South Station at 5:26 AM and that the second would leave North Station at around 5:50 AM. The removal of the single-track constraint near Beacon Park Yard and the use of two tracks for the length of the line would provide additional operational flexibility that would allow these trains to depart later and operate as revenue trains (trains that carry passengers). At present, four trains are scheduled to leave South Station on various routes before 5:26, but the earliest departure from North Station on any route is at 5:45. Operating trains only when the stations would be open anyway would avoid the costs of extra station staffing time.

4.2.6 CONSTRAINTS OF SHARING TRACKS WITH FITCHBURG LINE TRAINS

Framingham/Worcester trains would use the Fitchburg Line tracks between Swift Interlocking and North Station. The hypothetical Framingham/Worcester Line service schedules would be compatible with the current Fitchburg Line schedules, but might require some adjustments of a few minutes in arrival or departure times of either the Framingham/Worcester Line trains or the Fitchburg Line trains.

4.2.7 GATE-DOWN TIME

For purposes of analysis, it was assumed that with tracks upgraded to a maximum of 30 mph, each train would cause traffic to stop for approximately 63 seconds at each grade crossing, with the exception of the crossings immediately adjacent to the proposed station. Given the proposed station at Kendall Square, northbound trains would block Main Street and southbound trains would block Massachusetts Avenue for approximately 82 seconds due to the slower speeds associated with start-up and acceleration, as described below. These times assume a maximum train length of eight cars at 85 feet each and one engine at 65 feet, for a total length of 745 feet.

While approaching and passing over the crossings, trains would be traveling at 30 mph in the higher-speed alternative (with the exception of Main Street and Massachusetts Avenue, where speeds would be lower due to start-up and acceleration). Gates would be timed to be fully closed by the time an approaching train traveling 30 mph reaches normal (nonemergency) braking distance from the crossing, or about 700 feet. Based on some observations of comparable crossings, flashers activate about 5 seconds before gates start to descend, and gates take about 12 seconds to be fully lowered. After a train has passed over a crossing, it takes about 12 seconds for the gates to open completely and allow traffic to pass through. From the time the gates are fully closed, it takes a train approximately 16 seconds to reach the near side of a crossing, and about 18 seconds to get completely across. In summary, the total crossing obstruction observed by drivers will be as shown in Table 4-3

The assumed location of a station serving the Kendall Square area is between Massachusetts Avenue and Main Street. Trains stopping at this station in either direction would be able to decelerate from 30 mph without changing the 63-second obstruction time for the crossing before the station. Crossing protection is assumed to be wired so that gates remain open while a train is stopped at the station.

TABLE 4-3
Sources of Gate-Down Time

Action	Obstruction Time
Flashing lights activate	5 seconds
Gates closing	12 seconds
Train reaches crossing	16 seconds
Train occupies crossing	18 seconds
Gates opening	12 seconds
Total time	63 seconds

When the train is ready to proceed, the crossing protection is activated by the engineer, but the train does not move until the gates are observed to be closed. The train is still accelerating when it reaches the crossing and will have reached a speed of 20–25 mph. The additional time, compared with approaching a crossing at 30 mph with a fully closed gate, would be about 18 to 20 seconds, necessitating a total obstruction time of 81 to 83 seconds for northbound trains at Main Street or southbound trains at Massachusetts Avenue. The longer period, 83 seconds, was assumed for the purposes of analysis.

5 RESULTS

5.1 OVERVIEW

Two alternatives were selected to simplify the analysis and to represent the upper-bound and lower-bound alternatives, which are defined below. The lower-bound alternative produced the least transit demand, as well as the lowest bike, pedestrian, and traffic impacts, in addition to the other metrics being discussed. The upper-bound alternative produced the greatest transit demand, and the greatest impact on bike and pedestrian activity and on vehicular traffic. These two alternatives provide the clearest distinctions and the most relevant information on the travel demand analysis, so the summary of results focuses on these two alternatives in order to simplify the analysis and presentation of results. The analysis looked at daily summaries of transit ridership, as well as peak-hour impacts to traffic, pedestrians, and bicyclists.

5.2 TRANSIT SUMMARY

A summary of the service assumptions and ridership results is presented in Table 5-1. The lower-bound alternative that produced the least transit demand had the lowest train speed (15 mph), was the least frequent (6 daily inbound trains to North Station), and did not include a new station near Kendall Square. The upper-bound alternative that produced the greatest transit demand had the fastest speed (30 mph), was the most frequent (12 daily inbound trains to North Station), and included a new station near Kendall Square.

The lower-bound alternative produced the least transit demand as a result of three factors – the additional travel time caused by the slower speeds, less frequent service, and less transit connectivity due to not having a Kendall/MIT station on the commuter rail line – that resulted in fewer transit riders. The lower-bound alternative also had the greatest impact on the grade crossings and on the traffic, pedestrians, and bicyclists at these crossings, for any given train passing as a result of the slower speeds that caused the gate-down time at the grade crossing to be greatest. However, the overall impact on the grade crossings was less than in the upper-bound alternative because there were fewer train passings (6 versus 12) than in the upper-bound alternative.

The upper-bound alternative produced the greatest transit demand as a result of three factors: the faster travel time caused by the faster speeds, more frequent service, and more transit connectivity due to having a Kendall/MIT station on the rail line. The upper-bound alternative also had the least impact on the grade crossings for each train passing as a result of the faster speeds that allow the gate-down time at the grade crossing to be shorter. However, the overall impact on the grade crossings was greater because there were more train passings (12 versus 6) than the upper-bound alternative.

The demand for the new service shifted to varying degrees from four transportation sources: auto diversions, the Fitchburg Line, private buses, and drive access to a rapid transit line (rapid transit is referred to as “Other transit” in Table 5-1). The lower-bound alternative produced 300 more daily boardings (150 each way) relative to the no-build scenario, for a total of 18,300 boardings, compared to the upper-bound alternative, which had 600 new daily boardings (300 each way) for a total of 18,600 boardings on the Worcester Line. By a slim majority, most of these new daily boardings were auto diversions – 100 out of 300 for the lower-bound alternative and 250 out of 600 for the upper-bound alternative. The remainder of the new boardings came from the Fitchburg Line. private bus service, and other transit modes.

With the new train service to North Station, the lower-bound estimate of demand indicated that there would be 2,700 new people traveling to North Station. The upper-bound estimate was that 5,600 additional people would travel to North Station. Not all of these people had destinations at or around North Station or the Kendall Square area. In the lower-bound alternative, 52% of the 2,700 additional travelers had some other destination and were using the transit system at North Station to complete the final leg of their trips. The upper-bound estimate indicated that over 64% of the 5,600 riders going to North Station ended up in some market other than the North Station or the Kendall Square areas. This shows that people are interested in using commuter rail to get into Boston, even if North Station is not their final destination. In this case, the primary alternative markets are the Financial District, Seaport District, and Longwood Medical and Academic Area.

Of the 2,700 commuter rail riders on the new service to North Station in the lower-bound alternative, only 1,300 had a destination in the Kendall Square or North Station neighborhoods; the other 1,400 had destinations in other locations, such as Haymarket or the Financial District. Given the split in service, differing frequencies, and differing departure times, about 900 trips destined to the Kendall Square area or North Station neighborhoods would still be on the South Station–bound trains in the lower-bound alternative. This would account for 2,200 boardings that would have a destination in either the Kendall Square or North Station neighborhoods.

Daily	2035 No-Build	2035 (Lower Bound)	Delta	2035 (Upper Bound)	Delta
Total Trains	30	30	na	30	na
Trains to N.Station	na	6	6	12	12
% of Total Trains Going to N.Station	na	20%	20%	40%	40%
Trains to S. Station	30	24	-6	18	-12
% of Total Trains Going to S.Station	100%	80%	na	60%	na
Total Boardings	18,000	18,300	300	18,600	600
Inbound Boardings Total	9,000	9,150	150	9,300	300
Outbound Boardings Total	9,000	9,150	150	9,300	300
Boardings for Trains to/from N.Station	na	2,700	2,700	5,600	5,600
% of Total Boardings	na	15%	na	30%	na
Inbound Boardings to N.Station	na	1,350	1,350	2,800	2,800
Outbound Boardings from N.Station	na	1,350	1,350	2,800	2,800
Boardings for Trains to/from S.Station	18,000	15,600	-2,400	13,000	-5,000
% of Total Boardings	100%	85%	na	70%	na
Inbound Boardings to S.Station	9,000	7,800	-1,200	6,500	-1,300
Outbound Boardings from S.Station	9,000	7,800	-1,200	6,500	-1,300
Sources of Change in Worcester Ridership	na	300	300	600	600
Auto Diversions	na	100	100	250	250
% of Change	na	33%	33%	42%	42%
Fitchburg Commuter Rail	na	90	90	170	170
% of Change	na	30%	30%	28%	28%
Private Buses	na	50	50	90	90
% of Change	na	17%	17%	20%	20%
Other Transit	na	60	60	90	90
% of Change	na	20%	20%	15%	15%
Markets Served by N.Station Trains	na	2,700	na	5,600	na
Kendall/MIT and N.Station Markets	na	1,300	na	2,000	na
% of Total Boardings	na	48%	na	36%	na
Other Markets	na	1,400	na	3,600	na
% of Total Boardings	na	52%	na	64%	na
Total Trips to-from Kendall/MIT and N.Station Market Area	2,160	2,200	40	2,400	240
% of Total Boardings	12%	12%	0%	13%	1%
Trips Destined to-from Kendall/MIT Area	900	900	0	1,100	200
% of Total Worcester Boardings	5%	5%	0%	6%	1%
Trips Destined to-from North Station area on Train	1,260	1,300	40	1,300	40
% of Total Worcester Boardings	7%	7%	0%	7%	0%
Total Boardings at New Station	na	na	na	500	500

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TABLE 5-1
Transit System Summary

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Of the 5,600 commuter rail riders on the new service to Cambridge and North Station in the upper-bound alternative, only 2,000 had a destination in the Kendal/MIT or North Station neighborhoods. The other 3,600 had destinations in other locations, such as Haymarket or the Financial District. Given the split in service, differing frequencies, and differing departure times, about 400 trips destined to the Kendall Square area or North Station neighborhoods would still be on the South Station–bound trains in the lower-bound alternative. These estimates account for 2,400 boardings that had a destination in either the Kendall Square or North Station neighborhoods. The new Kendall/MIT station would generate 500 boardings daily and an equal number of alightings: 100 trips between the Kendall Square and the North Station neighborhoods, and 400 trips between the Kendall Square area and points west on the Framingham/Worcester Line.

5.3 BIKE AND PEDESTRIAN ACTIVITY AT GRADE CROSSINGS

As indicated in chapter 4, the through trains would block the intersections from a lower-bound estimate of 63 seconds for train service going 30 mph, to an upper-bound estimate of 89 seconds for the slower trains. going 15 mph, and stopping at a new station. The estimate of total of delay is based on the time it takes for the train to actuate the signals and gate to come down, traverse the grade crossing, and finally actuate the gate to rise. The station would be positioned so that trains would not block intersections while stopped. However, the deceleration of trains approaching the proposed station, and the additional wait for the subsequent closing of the gates on either side of the station would add additional gate time. The frequency of trips dictates how many trains would generate delays. The lower-bound alternative (6 trains to North Station) would generate about one trip each way across the grade crossings during the AM peak hour and the PM peak hour. The upper-bound alternative (12 trains to North Station) would generate under two trips each way across the grade crossings during each peak hour.

Table 5-2 contains the results of the pedestrian and bicycle analysis for the eight pedestrian and bike grade crossings. In the AM peak hour, 60 to 76 pedestrians would be impacted, resulting in a net delay of 32 to 52 minutes for these individuals. There are 26 to 32 bicyclists experiencing delays in the AM peak hour, resulting in 14 to 22 minutes of delay. In the PM peak hour, there are 37 to 94 pedestrians affected, resulting in 19 to 62 minutes of delay. There are 14 to 36 bicyclists experiencing delays in the AM peak hour, resulting in 7 to 25 minutes of delay. The maximum delay at the grade crossings for pedestrian and bicyclists in the lower-bound alternative in the peak hour would be about 63 seconds, and in the upper-bound alternative it would be about 89 seconds. However, the pedestrians and bicyclists are assumed to arrive at the gate at randomly distributed times during this interval.

AM Peak-Hour Total Pedestrian/Bicyclist Delayed

Crossing #	Impact Locations	Traffic Operation	Pedestrian 2009 Base	Pedestrian 2035 No-build	Pedestrian 2035 Lower Bound	Pedestrian 2035 Upper Bound	Bicyclist 2009 Base	Bicyclist 2035 No-build	Bicyclist 2035 Lower Bound	Bicyclist 2035 Upper Bound
1	George Washington Park	Traffic Signal	31	36	2	2	17	20	2	2
2	Massachusetts Ave.	Traffic Signal	482	564	12	16	275	316	6	8
3	Albany Garage	Gate Signal	113	132	4	4	-	-	-	-
4	Main St.	Traffic Signal	710	831	16	22	111	128	4	4
5	Broadway	Traffic Signal	662	775	14	18	345	397	8	10
6	Binney St.	Traffic Signal	111	130	4	4	32	37	2	2
7	Cambridge St.	Gate Signal	204	239	6	6	95	109	2	4
8	Gore St.	Gate Signal	78	91	2	4	50	58	2	2
	Total Delay in Persons				**60**	**76**			**26**	**32**
	Total Delay in Time (Minutes)				**32**	**52**			**14**	**22**

Note: The Least-Impact Scenario is the alternative of 30 mph train speed without a stop, one inbound and one outbound trains around 8:00-9:00 AM.
The Most-Impact Scenario is the alternative of 15 mph train speed with a stop, one inbound and one outbound trains around 8:00-9:00 AM.

PM Peak-Hour Total Pedestrian/Bicyclist Delayed

Crossing #	Impact Locations	Traffic Operation	Pedestrian 2009 Base	Pedestrian 2035 No-build	Pedestrian 2035 Lower Bound	Pedestrian 2035 Upper Bound	Bicyclist 2009 Base	Bicyclist 2035 No-build	Bicyclist 2035 Lower Bound	Bicyclist 2035 Upper Bound
1	George Washington Park	Traffic Signal	46	54	1	2	29	33	1	2
2	Massachusetts Ave.	Traffic Signal	836	978	9	26	356	409	4	12
3	Albany Garage	Gate Signal	149	174	2	4	-	-	-	-
4	Main St.	Traffic Signal	777	909	9	24	135	155	2	4
5	Broadway	Traffic Signal	824	964	9	22	317	365	4	10
6	Binney St.	Traffic Signal	145	170	2	4	22	25	1	2
7	Cambridge St.	Gate Signal	289	338	4	8	85	98	1	4
8	Gore St.	Gate Signal	93	109	1	4	48	55	1	2
	Total Delay in Persons				**37**	**94**			**14**	**36**
	Total Delay in Time (Minutes)				**19**	**62**			**7**	**25**

Note: The Least-Impact Scenario is the alternative of 30 mph train speed without a stop, one outbound trains around 5:00-6:00 PM.
The Most-Impact Scenario is the alternative of 15 mph train speed with a stop, one inbound and one outbound trains around 5:00-6:00 PM.

Therefore, the average delay for each pedestrian and bicycle would be about half of the maximum time, or 32 to 45 seconds. This delay would occur 1 to 2 times per hour during the AM and PM peak hour for trains going inbound and outbound.

5.4 TRAFFIC IMPACTS AT GRADE CROSSINGS

Table 5-3 shows the 12 locations included in this estimation of vehicle delays for the no-build scenario, and the traffic impact of the lower-bound and upper-bound scenarios, based on the projected 2035 traffic volumes in the AM (7:00 to 8:00) peak hour. The total vehicle delays for each peak hour are estimated from average vehicle delays (ranging from a few seconds to about half a minute depending on the locations and traffic operations) and the projected traffic volumes at the estimated locations.[2] As estimated, the least-impact scenario would add about 9.2 vehicle-hours of delay during each AM peak hour and the most-impact scenario would add a total delay of about 13.0 vehicle-hours during each AM peak hour to the amount of delay that traffic would experience during the no-build scenario for all traffic entering the six track-crossing locations. In other words, the proposed service scenarios could cause additional delay of about 9.2 to 13.0 vehicle-hours for the traffic going through the crossing locations during the AM peak hour. In the 2035 no-build scenario, the average vehicle would experience about 16.5 seconds of delay when the gate is down. This would increase in the lower- and upper-bound alternatives, respectively, to between 18 and 19 seconds, approximately one to two times per hour in the peak periods.

Table 5-4 shows the same estimation for traffic in the PM (5:00 to 6:00) peak hour at the crossing locations based on projected 2035 traffic volumes. As estimated, the proposed service scenarios could cause total additional delay of about 3.7 to 9.8 vehicle-hours for the traffic entering the crossing locations during the PM peak hour. The PM estimation has a lower-bound delay (3.7 vehicle-hours) that is much less than the AM estimation, as the lower-bound scenario has only one scheduled train to North Station in the PM peak hour, while the upper-bound alternative has two scheduled trains in both the AM and the PM peak hour.

Figure 5-1 shows the estimated time needed to process the 95th percentile traffic queues at the six crossing locations in the AM peak hour. The central vertical line can be regarded as the train track. The horizontal bars represent the time needed to process the queues (potential maximum delay to a driver). As shown, most of these locations would need about 3 to 4 minutes to process the 95th percentile queues, except for the locations at Binney Street and Medford Street. Presumably it would require two to three signal cycles, averaging 30 to 90 seconds, for the intersections at Massachusetts Avenue, Main Street, and Broadway to process the 95th percentile queues.

[2] Vehicle delay = average delay per vehicle multiplied by the number of entry vehicles

Figure 5-2 shows the same estimation for the six crossing locations in the PM peak hour. Overall, most of these locations are estimated to encounter somewhat less delay in the PM peak hour than in the AM peak hour. They are estimated to be 2.5 to 3.5 minutes for most of the locations, except at Binney Street (about 1.5 to 2 minutes). It would still require two to three signal cycles to process the 95th percentile queues at the existing signalized intersections.

AM Peak-Hour Total Delay (hours)				Total Delay in Hours			Change in Delay	
Gate #	Impact Locations	Traffic Operation	2035 Traffic Projection (Vehicles)	2035 No-Build Base Case	2035 Lower Bound Case	2035 Upper Bound Impact Case	Lower Bound Impacts from 2035 NB	Upper Bound Impacts from 2035 NB
1	Mass Ave. at Vassar St.	Traffic Signal	2,689	12.55	13.89	14.42	1.34	1.87
	Mass Ave. at Albany St.	Traffic Signal	2,386	13.85	15.64	16.44	1.79	2.59
2	Main St. at Vassar St.	Traffic Signal	1,886	8.70	9.32	9.53	0.63	0.84
	Main St. EB @ Gate	Gate Signal	553	-	0.43	0.77	0.43	0.77
3	Broadway at Galileo Galilei Way	Traffic Signal	2,951	13.77	15.08	15.49	1.31	1.72
	Broadway at Hampshire St.	Traffic Signal	1,956	13.09	14.67	14.99	1.58	1.90
4	Binney St. at Fulkerson St.	Traffic Signal	1,705	11.89	11.99	12.06	0.09	0.17
	Binney St. EB @ Gate	Gate Signal	192	-	0.14	0.22	0.14	0.22
5	Cambridge St. WB @ Gate	Gate Signal	664	-	0.53	0.85	0.53	0.85
	Cambridge St. EB @ Gate	Gate Signal	489	-	0.37	0.60	0.37	0.60
6	Medford St./Gore St. at Rufo Rd.	Traffic Signal	1,042	5.18	5.56	5.64	0.38	0.46
	Medford St. EB @ Gate	Gate Signal	757	-	0.61	0.99	0.61	0.99
Total Delay for 12 locations (veh-hr)				79.04	88.24	92.02	9.20	12.99

Note: Lower Bound Traffic Impact Case - 30 mph train speed with no stop, one inbound and one outbound trains around 8:00-9:00 AM

Upper Bound Traffic Impact Case - 15 mph train speed with a stop, one inbound and one outbound trains around 8:00-9:00 AM

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TABLE 5.3
Total Vehicle Delay in the AM Peak Hour

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PM Peak-Hour Total Delay (hours)				Total Delay in Hours			Change in Delay	
Gate #	Impact Locations	Traffic Operation	2035 Traffic Projection (Vehicles)	2035 No-Build Base Case	2035 Lower Bound Impact Case	2035 Upper Bound Impact Case	Lower Bound Impacts from 2035 NB	Upper Bound Impacts from 2035 NB
1	Mass Ave. at Vassar St.	Traffic Signal	2,341	9.49	9.88	10.53	0.39	1.04
	Mass Ave. at Albany St.	Traffic Signal	2,254	10.90	11.33	12.15	0.44	1.25
2	Main St. at Vassar St.	Traffic Signal	2,139	9.15	9.39	9.86	0.24	0.71
	Main St. EB @ Gate	Gate Signal	773	-	0.32	1.14	0.32	1.14
3	Broadway at Galileo Galilei Way	Traffic Signal	2,813	17.12	17.58	18.21	0.47	1.09
	Broadway at Hampshire St.	Traffic Signal	1,908	18.92	19.67	20.14	0.74	1.22
4	Binney St. at Fulkerson St.	Traffic Signal	1,701	11.95	12.14	12.38	0.19	0.43
	Binney St. EB @ Gate	Gate Signal	294	-	0.11	0.35	0.11	0.35
5	Cambridge St. WB @ Gate	Gate Signal	634	-	0.25	0.81	0.25	0.81
	Cambridge St. EB @ Gate	Gate Signal	496	-	0.19	0.61	0.19	0.61
6	Medford St./Gore St. at Rufo Rd.	Traffic Signal	969	4.87	5.00	5.33	0.13	0.46
	Medford St. EB @ Gate	Gate Signal	553	-	0.21	0.69	0.21	0.69
Total Delay for 12 Locations (veh-hr)			16,875	82.40	86.08	92.20	3.68	9.80

Note: Lower Bound Traffic Impact Case- 30 mph train speed with no stop, only one outbound train around 5:00-6:00 PM
Upper Bound Traffic Impact Case - 15 mph train speed with a stop, one inbound and one outbound trains around 5:00-6:00 PM

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TABLE 5.4
Total Vehicle Delay in the PM Peak Hour

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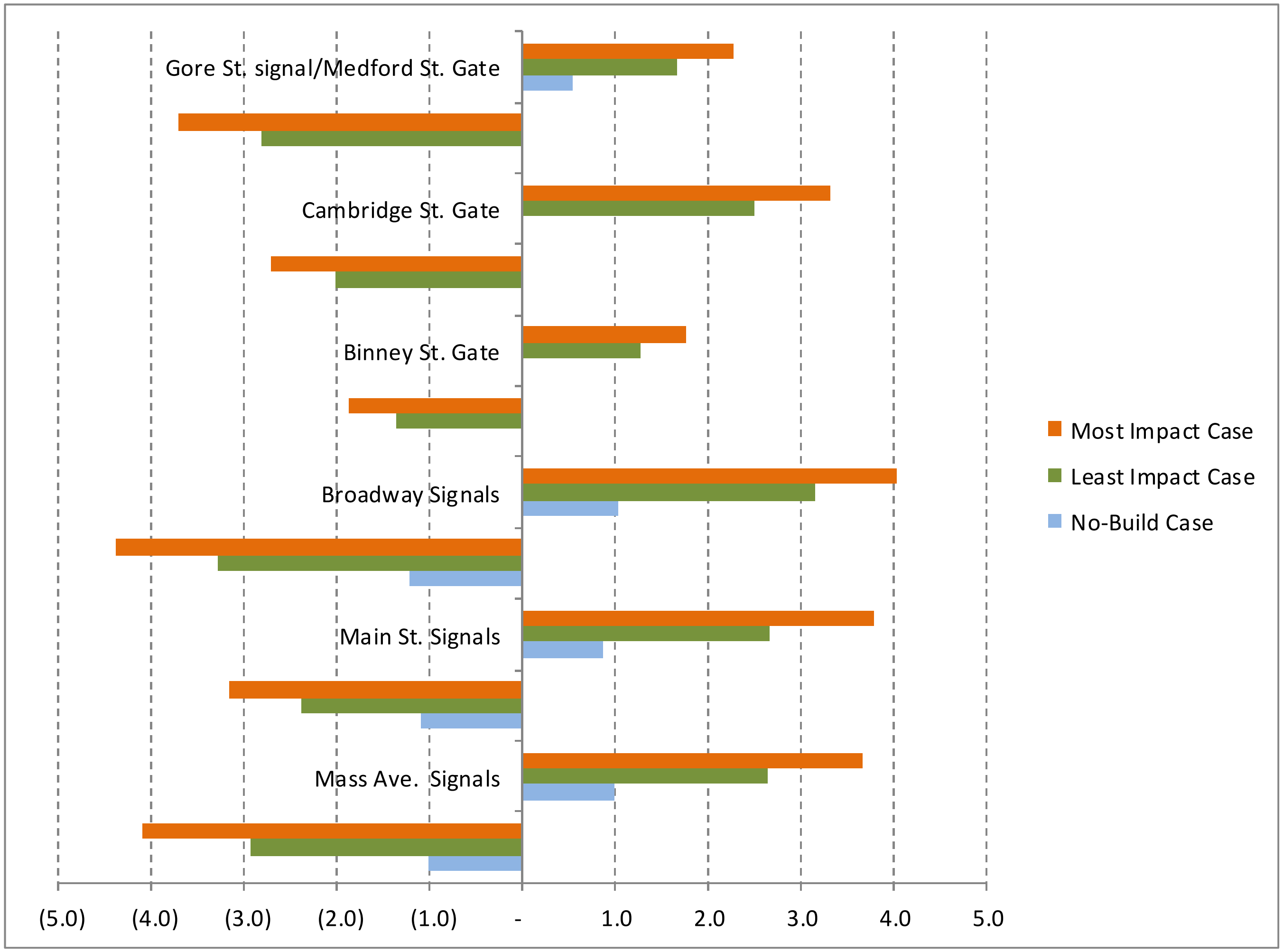

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FIGURE 5.1
Maximum Delay (in Minutes) Caused by Gate Downtime in the AM Peak Hour

Grand Junction Transportation Study

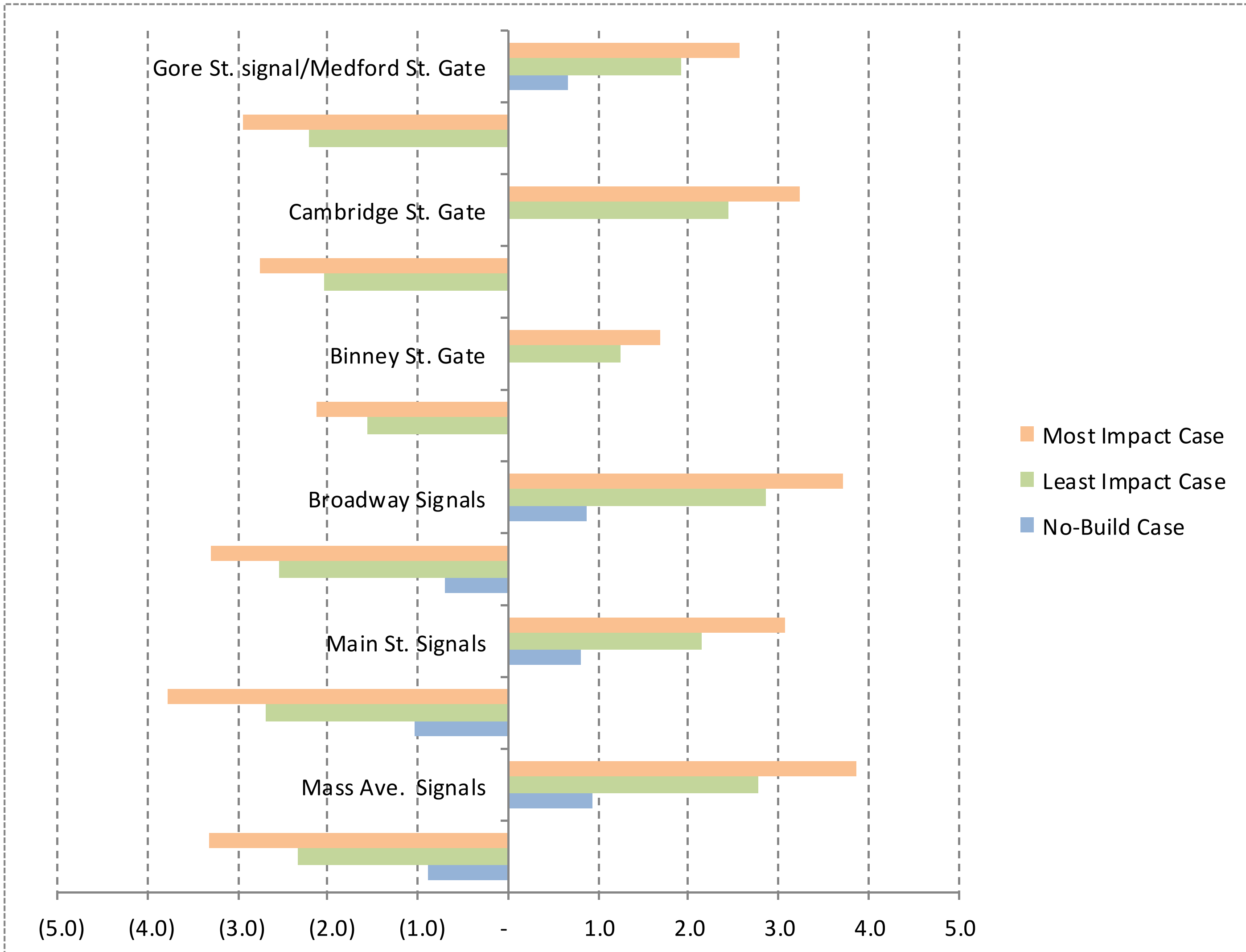

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FIGURE 5.2
Maximum Delay (in Minutes) Caused by Gate Downtime in the PM Peak Hour

Grand Junction Transportation Study

5.5 AIR QUALITY ANALYSIS

Table 5-5 presents the results of the air quality analysis. The lower-bound estimate is the one that produces the lowest transit demand – slow speed (15 mph), least-frequent service, and no new station in Cambridge – that that results in the fewest auto diversions. The upper-bound estimate is the one that produce the greatest transit demand – fastest speed (30 mph), most-frequent service, and including a new station in the Kendall Square/MIT area – and that results in the greatest number of auto diversions.

The top part of the table presents emission reductions associated with auto diversions. The lower-bound estimate generates 100 auto diversions. This result produces a reduction of approximately 2,340 vehicle-miles of travel (VMT) relative to the no-build scenario. This daily VMT reduction reduces volatile organic compounds (VOCs) by 0.4 kg, nitrogen oxides (NOx) by 0.4 kg, carbon monoxide (CO) by 19.6 kg, and carbon dioxide ($CO_{2)}$ by 1,332.4 kg. The upper-bound estimate generates 250 auto diversions. This result produces a daily reduction of approximately 5,850 vehicle-miles of travel (VMT) relative to the no-build scenario. This daily VMT reduction for the upper-bound alternative reduces VOC by 1.1 kg, NOx by 0.9 kg, CO by 49.1 kg, and CO_2 by 3,331.0 kg.

The middle part of the table examines what the Worcester Line diesel locomotive emissions from Allston to North Station would be based on some South Station–bound trains being rerouted to North Station. Having some of the trains go to North Station would increases the daily two-way train mileage slightly, from 4.8 to 9.6 miles per day, which has a minimal impact on operating costs but does lead to greater emissions, especially in Cambridge. The pollutants increasing the most are CO_2, CO, and NOx. There is no noticeable change in the levels of VOC and PM10 (particulate matter up 10 micrometers in size). Locomotive emission rates for PM10 and VOC are relatively small when compared to the other pollutants.

The bottom section of Table 5-5 presents the cumulative regional air quality benefits and burdens of the lower-bound and upper-bound alternatives. All pollutants except NOx are reduced. NOx is more affected by an increase in diesel locomotive mileage than by a decrease in auto vehicle-miles travelled. VOC is reduced by 0.4 to 1.1 kg, CO is reduced by -19.2 to 48.3 kg, CO_2 is reduced by 1,175.5 to 3017.1 kg, and PM10 is reduced by 0.1 kg. NOx increases by 0.2 to 0.1 kg due to the additional train revenue miles. This analysis showed very small changes, but it is important to note that this was done on a regional scale. There would be a geographic shift in the distribution of these pollutants at the local level, with slightly lower levels of emissions in the Fenway, Back Bay, and Chinatown neighborhoods, and slightly increased levels in Cambridge. However, the amount of emissions in question is very low relative to the overall levels of emissions from all sources in these local areas.

Daily Mobile Emission Sources in 2035	Emissions by Pollutant				
	VOC	NOx	CO	CO2	PM 10
WGJ Auto Vehicle Emissions					
Lower Bound Scenario					
Auto diversions	-100.0	-100.0	-100.0	-100.0	-100.0
Auto VMT reduced	-2,340.0	-2,340.0	-2,340.0	-2,340.0	-2,340.0
Auto emissions (kg/daily)	**-0.4**	**-0.4**	**-19.6**	**-1,332.4**	**-0.1**
Upper Bound Scenario					
Auto diversions	-250.0	-250.0	-250.0	-250.0	-250.0
Auto VMT reduced	-5,850.0	-5,850.0	-5,850.0	-5,850.0	-5,850.0
Auto emissions (kg/daily)	**-1.1**	**-0.9**	**-49.1**	**-3,331.0**	**-0.2**

Note: The emissions reductions are a result of people switching from the auto mode to transit, which causes a small decline in vehicle miles traveled and improves roadway speeds. There is also some reduction in speeds and an increase in idling along roadways impacted by the gate downtime.

WGJ Locomotive Emissions					
2035 CR emission factor (gr/mile)	2.2	105.6	85.1	32,694.4	1.6
Lower Bound Scenario					
CR train mileage - No-build	2,658.0	2,658.0	2,658.0	2,658.0	2,658.0
CR train mileage - Build	2,662.8	2,662.8	2,662.8	2,662.8	2,662.8
CR train mileage - delta	4.8	4.8	4.8	4.8	4.8
Worcester CR line emissions (kg/daily)	**0.0**	**0.5**	**0.4**	**156.9**	**0.0**
Upper Bound Scenario					
CR train mileage - No-build	2,658.0	2,658.0	2,658.0	2,658.0	2,658.0
CR train mileage - Build	2,667.6	2,667.6	2,667.6	2,667.6	2,667.6
CR train mileage - delta	9.6	9.6	9.6	9.6	9.6
Worcester CR line emissions (kg/daily)	**0.0**	**1.0**	**0.8**	**313.9**	**0.0**

Total Daily Emissions from Mobile Sources					
Lower Bound Scenario					
Total emissions (kg)	**-0.4**	**0.2**	**-19.2**	**-1,175.5**	**-0.1**
Upper Bound Scenario					
Total emissions (kg)	**-1.1**	**0.1**	**-48.3**	**-3,017.1**	**-0.1**

5.6 BUS ROUTES IMPACTED BY TRAIN SERVICE

Table 5-6 identifies the eight potential bus routes that traverse one or more of the grade crossings that could be impacted by the gate-down time if more trains were to go through Cambridge. Collectively these bus routes carry 20,800 daily riders, of whom almost 2,500 travel in the AM peak hour. Of the eight bus routes, Route 1 has the greatest demand, with 12,300 daily riders, including almost 1,500 in the AM peak hour. The specific impacts to bus routes were not separated from the impacts to general traffic that were discussed above. Buses would experience delay comparable to that of autos (described in Section 5.5), but with a greater number of people per vehicle, there would be a larger number of person-hours lost to delay.

5.7 TD GARDEN EVENTS

In response to comments received at the public meetings, the potential benefits to Framingham/Worcester Line markets of having trains go to North Station and potentially serve TD Garden events was examined. The analysis attempted to quantify the total demand for an event, how many would come from Framingham/Worcester Line commuter rail markets, and finally how many of those people might take the proposed service to North Station. Table 5-7 contains the analysis of arena events.

The events fall into four categories, represented by the column headings: basketball, hockey, concerts, and "other." Collectively these events attract about 3.5 million attendees annually. This was expanded by 5% to arrive at a 2035 attendance estimate. Using the Boston Region MPO regional travel demand model set, it is estimated that 20% of all recreational trips destined to the North Station area could come from Worcester commuter rail markets, irrespective of transportation mode, in 2035. For the upper-bound alternative, the total market of the new commuter rail line could draw from around 735,000 people. If we assume a 25% transit mode share, this would lead to potentially 183,900 annual transit trips that could benefit by having a one-seat ride to North Station and Garden events. If the average one-way auto trip length is 18 miles, this project could reduce vehicle-miles traveled annually by 1.3 million, or 7,800 miles per event. The benefit of a new transit connection would improve transit use to TD Garden events by about 5%.

Bus Route	Daily Riders	AM Peak Hr Riders	AM Peak Hr Headway (mins)	# of One-way Trips in AM Peak Hour
1	12,325	1,479	8.5	7.1
CT1 (701)	2,014	242	20	3
CT2 (747)	1,253	150	20	3
64	1,268	152	23	2.6
68	520	62	30	2
69	2,985	358	14	4.3
85	397	48	30	2
EZ	tbd	tbd	10	6
Total	20,762	2,491	na	30.0

Note: MBTA AM peak is from 6:30 to 9:00 am.

Estimate of Garden Activity

Month	No. of Events	Basketball	Hockey	Concert	Other Events
May-11	12	2	8	2	
Jun-11	12		3	9	
Jul-11	8			8	
Aug-11	3			3	
Sep-11	8		4	4	
Oct-11	18	3	9	6	
Nov-11	20	6	10	4	
Dec-11	16	8	7	1	
Jan-12	24	14	10		
Feb-12	21	10	11		
Mar-12	20	9	11		
Apr-12	7	5	2		
Annual Events	169	57	75	37	
Audience per Event		18,624	17,565	19,580	
Annual Audience		1,061,568	1,317,375	724,460	400,000
Annual Total					3,503,403

Note: 1. Seating capacity for hockey, basketball and concert is 17,565, 18,624, and 19,580 respectively .
2. It is assumed the occupancy rate for basketball game, hockey game and concert is 100%.
3. The TD Garden website says "the TD Garden hosts well over 3.5 million people each year". This is why the audience for o
is assumed to be 400,000.

Assumptions Used to Estimate Garden Trip Making by Mode

Distribution of Demand Coming in from Worcester area		Estimate
2009 Base	Annual Garden Trips	3,503,400
	20% of all trips destined to core come from Worcester CR corridor	700,700
	20% Transit mode share for trips coming into Boston	140,100
	Annual Two Way Transit Trips	280,200
	Average Trip Length = 18 miles	
	Annual VMT Saved Due to Transit	5,043,600
2035 No-build	Annual Garden Trips, out to 2035 with a 5% increase	3,678,600
	20% of all trips destined to core come from Worcester CR corridor	735,700
	20% Transit mode share for trips coming into Boston	147,100
	Two Way Transit Trips	294,200
	Average Trip Length = 18 miles	
	Annual Potential VMT Saved Due to Transit	5,295,600
2035 Upper Bound	Garden Trips in 2035	3,678,600
	20% of all trips destined to core come from Worcester CR corridor	735,700
	25% Transit mode share for trips coming into Boston	183,900
	Two Way Transit Trips	367,800
	Average Trip Length = 18 miles	
	Annual Potential VMT Saved Due to Transit	6,620,400
	Delta with 2035 No-build	1,324,800
	Potential VMT Saved Per Event	7,800

5.8 TRAVEL TIME ANALYSES

Table 5-8 contains the analysis of travel time benefits and burdens for the AM peak hour of the upper-bound alternative. The upper-bound alternative was chosen to compare how the alternative with the best transit demand would fare against the alternative with the least traffic impact. Travel times benefits and delays were calculated for:

- Autos at grade crossings
- Pedestrians and bicyclists at grade crossings
- Trips with destinations in the North Station and Kendall Square neighborhoods
- Other riders not destined to the North Station or Kendall Square area
- Auto diversions,
- Wait times for South Station riders with less frequent commuter rail service to South Station

All of these benefits and delays were summarized to try to understand the net travel time benefit or burden of this project for the upper-bound alternative in the AM peak hour for 2035.

The results showed that 524 vehicles would experience delays due to the gate-down time at the grade crossings and the queues that are associated with intersections near the crossings. This resulted in 4.3 hours of delay for traffic in Cambridge and Somerville. There would be 76 pedestrians impacted by the gate-down time at the grade crossings, which would result 0.9 hours of delay, and 32 bicyclists would be affected, with 0.4 hours of delay. Extending service to North Station via a new station in the Kendall Square area would benefit up to 160 new transit riders (32% of the 500 daily boardings using the new station, shown Table 5.1) destined to the Kendall Square neighborhood, resulting in a savings of 40 hours. There would be 480 commuter rail riders benefiting from having some trains go to North Station. This would result in 72 hours of savings. The trains going to North Station would include a significant number of riders who did not have a destination at or around the Kendall Square or North Station area. Approximately 576 rail riders (16% of the 3,600 daily riders destined to other markets, shown in Table 5.1) would experience an increased travel time due to being on a train going to North Station instead of South Station, resulting in 57.6 hours of delay. The proposed project would generate auto diversions, and these trips would have a travel time savings. Of the 250 auto diversions daily, 80 would occur in the AM peak hour and would produce 20 hours of savings. With fewer trains going to South Station from Worcester, the riders that currently benefit from this service would now have longer wait times between trains. Over 1,000 commuter rail riders at South Station would individually experience between 3 and 4 minutes of wait time per trip due to fewer trains going to South Station, causing 63.6 hours of delay. Collectively this analysis shows that there would be 132 hours of savings for some markets and 127 hours of delays for other markets. The cumulative results are small, but there is a wide range of savings and delays that impact different markets.

Market of Benefits/Delays	Reason	Number of People Impacted	Hours	
			Savings	Delay
Auto Passenger Delay	Gate Down Time	524	na	4.3
Pedestrian Delay	Gate Down Time	76	na	0.9
Bicyclist Delay	Gate Down Time	32	na	0.4
N.Station Riders to Kendall/MIT Benefits	New Station	160	40.0	na
N.Station Riders to N.Station Benefits	New terminus	480	72.0	na
Other Riders to N.Station Delay	N.Station terminus but not destination	576	na	57.6
Auto Diversions to N.Station Benefits	New terminus	80	20.0	na
Wait Time Delays for Riders to S.Station	Headways worst for S.Station	1040	na	63.6
Total			**132**	**127**
Net Benefits / Burden in Travel Time				**5**

CTPS

TABLE 5-8
AM Peak Period Travel Time Benefits and Delays

5.9 CAPITAL COSTS

The following estimates of capital cost requirements for implementation of commuter rail service on the Grand Junction line from Allston to North Station are based on a combination of reported amounts of recent construction contracts for comparable facilities, and unit costs used in recent past studies of other potential commuter rail projects in the Boston area. They are not based on detailed engineering studies of the Grand Junction line itself and represent only an approximation for general planning work.

5.9.1 Track, Signal Work, Crossing Protection, and Switches

Necessary work on the Grand Junction line is assumed to include replacement of the rails, installation of signals, installation of four-quadrant gates and new flashing lights at all at-grade crossings of streets, and upgrading of crossing surfaces. Most of the ties along this corridor have already been replaced. The regular maintenance cost is 13.0 million dollars.

Passenger service would require reconfiguration of the track connections between the south end of the Grand Junction line and the Worcester Line in Allston, and between the Grand Junction line and the Fitchburg Line in Somerville. For purposes of cost estimation, the connection in Somerville is assumed to be included in the Green Line Somerville/Medford extension project.

Table 5-9 presents an itemized list of capital costs for the proposed project. The total cost without a new station would be $30 million for the upper-bound alternative and about $21 million for the lower-bound alternative, with the major difference being $7.5 million for the construction of a new station, including its 1.5 design and permitting. The track work cost would be comparable for both alternatives – $2.5 million for signals, $0.5 million for linking the traffic signals and gates, and $3.5 million for work at the Beacon Park Yard junction. It would cost about $16 million dollars for design and allow for project contingencies.

5.9.2 New Station

Service options analyzed for the Grand Junction line include operation with no intermediate stops on the line, and operation with one intermediate stop in the vicinity of Kendall Square. A station would include shelters, platforms, ramps, and signage. Based on recent contract costs for stations at new locations on the MBTA commuter rail system, and assuming that a station in the Kendall Square area would have one platform serving one track for inbound and outbound trains to share, the cost of such a station would be about $7.50 million.

5.9.4 Track Bridges

There are two railroad bridges on the Grand Junction line, carrying the track across Soldiers Field Road in Allston, and across the Charles River between Allston and Cambridge. If engineering studies determine that either or both of these bridges must be substantially rehabilitated or replaced for passenger service, this could add greatly to the capital cost. However, the condition and needs of these bridges are currently unknown, so these costs are not included in the costs estimates shown in Table 5.9.

5.9.5 Rolling Stock

It is very likely that the MBTA would have sufficient rolling stock to operate the improved frequencies in the 2035 no-build scenario in addition to the scenarios being tested. The scenarios examined in this study do not add additional service; they just shift the destination of some train sets from the south side to the north side. Based on these assumptions, no rolling stock capital costs were included.

5.10 OPERATING COSTS

The commuter rail system is currently operated for the MBTA by the Massachusetts Bay Commuter Railroad Company (MBCR) under a fixed-price contract. It is up to MBCR how to allocate the funds they are paid under the contract in order to operate the schedules specified by the MBTA. The only operating cost items not included in the contract are diesel fuel, which is supplied by the MBTA, and charges for dispatching services that the MBTA pays to parties other than MBCR.

The estimated running time for Worcester Line trains would be the same going to either North Station or South Station, so if it is assumed that any trains going to North Station would be diverted from South Station, the operating cost using the car-hour formulas would not change. However, the MBTA (or one of its contractors) would be responsible for the maintenance of an additional commuter rail station in the Kendall Square area of Cambridge. There would be only minor additional operational costs associated with the service to North Station.

Regular Maintenance Program	*Cost ($ Millions)*	North Station Service with Kendall Station	*Incremental Cost ($ Millions)*
Track Work		Track Work	
Rail Upgrades	$2.5	Signals	$2.5
Signals	$2.5	Traffic Signal Link	$0.5
		Beacon Park Junction	$3.5
Crossings			
Gates, Protection	$3.5		
Crossing Surfaces	$1.5		
		Station Construction	$7.5
Design & Contingency	$3.0	Design & Contingency	$16.0
TOTAL	**$13.0**	**TOTAL**	**$30.0**

CTPS

TABLE 5-9
Capital Costs of Rail Service Along Grand Junction ROW

6 CONCLUSIONS

6.1 OVERVIEW OF PROJECT

The Grand Junction ROW acquisition would provide the opportunity to route some additional MBTA Framingham/Worcester Line trains via the Grand Junction ROW, potentially with a stop in Cambridge, to North Station, thereby allowing for new connections and destinations to be served while also relieving congestion at South Station. This study was undertaken to evaluate the effectiveness of the proposed service in achieving the following goals:

- To better accommodate the high demand for travel between Boston and Worcester and between Boston and MetroWest, and to better match trip origins with destinations
- To provide for more public transit access in Cambridge
- To reduce both local and regional traffic congestion
- To reduce fuel use and greenhouse gas emissions (consistent with the Global Warming Solutions Act)
- To help relieve track and platform congestion at South Station

More specifically, this study examined the feasibility, benefits, and negative impacts of the proposed service using several metrics, including transit use; pedestrian, bicycle, and traffic impacts at the grade crossings; air quality; capital costs; and travel time. It considered whether the proposal would be a viable transportation service generating sufficient ridership and increased mobility to offset any negative impacts justify the cost of the project. This study is preliminary in nature, and is intended only to guide further discussion.

6.2 KEY FINDINGS

The analysis showed several benefits and burdens associated with this project:

Benefits

- A number of passengers (both in existing and future conditions) on the Framingham/Worcester Line would benefit by routing train service to North Station via Cambridge.
- It would improve train capacity and provide for greater flexibility of train operations at South Station.
- It would provide an opportunity to serve a major employment center (Kendall Square, in Cambridge) with more transit options.
- It would allow for passengers to make "reverse" trips – trips in the off-peak direction (against the normal peak-period direction) – from North Station markets to the markets in Cambridge that are currently underserved by rapid transit.

Burdens

- The proposed changes in commuter rail schedules to accommodate the shift of trains to North Station would reduce options for the majority of riders, who would choose to continue going to the South Station area.
- Additional train trips along the Grand Junction ROW would have occasional, moderate negative impacts on vehicular traffic, pedestrians, and bicyclists at several grade crossings in Cambridge.
- Some commuter rail diesel locomotive emissions would be shifted from Boston to Cambridge.
- Utilizing this new right-of-way and possibly building a new station would involve significant capital costs.
- Maintaining a new station would increase the MBTA's operating costs.

6.3 NEXT STEPS

Based on the findings of this study, MassDOT has determined that the greater density of trip demand in the Back Bay and Financial District make the South Station route more desirable for the majority of travelers on the Framingham/Worcester Line. Although the Cambridge-to-North Station connection via the Grand Junction Railroad is a feasible approach to relieving track and platform congestion at South Station, MassDOT is actively pursuing an expansion of the tracks and platforms at South Station. Therefore, MassDOT does not intend to actively pursue the implementation of Framingham/Worcester Line commuter rail service over the Grand Junction Railroad at this time.

This feasibility study will provide the groundwork and opportunity for people to appreciate and discuss the benefits and burdens of this project.

There are six key next steps related to this study:

1) Finalize the CSX track purchase
2) Implement safety and operational improvements to existing service
3) Study and advance South Station expansion
4) Plan for continued utilization of the Framingham/Worcester Line and the increasing demand on its parking facilities
5) Continue to study other transportation uses for the Grand Junction ROW
6) Conduct a more detailed environmental and engineering study of this project, if it advances

Nevertheless, MassDOT does not plan to take further action directly related to the Grand Junction corridor and the expansion of service on the Framingham/Worcester Line at this time. The purchase of the Grand Junction ROW and other ROWs from CSX will provide MassDOT greater flexibility and allow for more efficient control in dispatching and operating train service along this and other corridors in the commonwealth. The contractual process for acquiring the ROWs will hopefully be completed in the fall of 2012.

The Grand Junction ROW will undergo some track safety and operational improvements. This work will include continuously welded track, new signals, new gates, and signal improvements to improve operations of the existing infrequent train service along this corridor.

In order to alleviate the limitations on expansion and improvement of track usage and operations at South Station, MassDOT is continuing to work with the U.S. Postal Service to acquire the processing facility adjacent to South Station.

Several recent transportation studies have highlighted the existing limitations at South Station and the associated limitations on the expansion of local, regional, and Northeast Corridor rail service. In order to realize the cumulative 50 percent increase in Amtrak high-speed and intercity passenger service outlined in the Northeast Corridor Plan, South Station and its support facilities need to be expanded and improved. In addition to this, the Commonwealth of Massachusetts is planning a number of major commuter rail expansion projects, and greater capacity at South Station is also a prerequisite for the full realization of these plans. MassDOT is actively engaged in the South Station Expansion Planning Study using funding from the Federal Railroad Administration.

There has been discussion about increasing the number of trains serving Framingham and Worcester. If this service improvement proceeds, with or without South Station being expanded, it would be important to find out if park-and-ride access at the stations along this commuter rail line would be constrained by the number of parking spaces available and if that would limit the ability to attract new transit riders.