SERVICE DEVELOPMENT PLAN

NH CAPITOL CORRIDOR

RAIL & TRANSIT ALTERNATIVES ANALYSIS (PARTS A&B)

STATE PROJECT NUMBERS 16317 AND 68067-A

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INTRODUCTION

The New Hampshire Department of Transportation, working in concert with its counterparts in Massachusetts, conducted a 21-month project supported by both the Federal Railroad Administration (FRA) and Federal Transit Administration (FTA). The New Hampshire Capitol Corridor (NHCC) Rail and Transit Study proceeded through 2013 and 2014 defining and evaluating opportunities to improve inter-city transit service in the 73-mile corridor between Boston, MA and Concord, NH.

Increasing transportation demand and growing concerns about mobility, economic development and quality of life have led the citizens and officials in New Hampshire and Massachusetts to explore options for new and improved transportation service along the northern end of the corridor. The NHCC Study evaluated a diverse set of rail and bus service options for improving connectivity along the corridor. These options would leverage existing transportation infrastructure, including railways owned by the Massachusetts Bay Transportation Authority (MBTA) and Pan Am Railways (PAR) as well as regional highways including U.S. Route 3, and I-93. A public-private partnership, supported by the State of New Hampshire, operates more than 80 weekday intercity and express bus trips between Concord, Manchester, Nashua and downtown Boston. The last permanent passenger rail service to Concord ceased operation in 1967[1].

Study activities included:

- Evaluating existing conditions: The study team engaged public and private stakeholders in New Hampshire and Massachusetts to understand the transportation and economic development problems they hope to address and the constraints they face in solving these problems. The team documented current and future conditions within the corridor to guide the development of alternatives that respond to current and future market conditions and infrastructure constraints.
- Developing alternatives: The study developed a mix of three intercity rail, six regional and commuter rail, and three bus service alternatives that respond to opportunities and constraints along the corridor to address stakeholder concerns.
- Evaluating alternatives: For each proposed service option, the study team estimated the cost to develop and operate the service, and projected future ridership. Parallel efforts evaluated how the service alternatives could be financed and managed and their impact on the environment, economic development, the existing transportation network, and the region's high quality of life.
- Recommendations: The alternatives were screened and refined to yield a mix of transportation service development options for New Hampshire and Massachusetts to consider for implementation. The recommended options include:
    - The most attractive of the three intercity rail service options, linking Boston and Concord with eight daily, 89-minute trips of making intermediate stops in Manchester, Manchester Airport, Nashua, Lowell and Woburn.

[1] There was short-lived demonstration train in 1980-81.

- A regional rail service that would extend MBTA commuter rail service 30 miles north from its current terminus in Lowell, MA to Manchester, NH.
- A Nashua commuter rail service that could potentially be implemented as a stepping stone towards regional service to Manchester.
- Several bus options aimed at increasing the frequency, speed and reliability of existing commuter bus services.

Organization of Joint FRA / FTA Study and the Service Development Plan

The unique nature of the corridor is reflected in the innovative combination of funding streams used to finance this study. The FTA and FRA jointly funded this study to ensure that the broadest possible universe of alternatives was considered to address the corridor's transportation issues. While these two funding streams supported one study, each agency designated the use of their funds for specific tasks and geographies. This Service Development Plan responds to the Federal Railroad Administration's desire to identify and implement corridor projects and programs that will:

- Serve as a catalyst for growth in regional economic productivity and expansion by stimulating domestic manufacturing, promoting local tourism, and driving commercial and residential development;
- Increase mobility by creating new choices for travelers in addition to flying or driving;
- Reduce national dependence on oil, and;
- Foster livable urban and rural communities.

In particular this project also lays the groundwork for the development of future intercity rail services north from Boston into New Hampshire and beyond.

A Passenger Rail Corridor Investment Plan (PRCIP) that consists of the preparation of a NEPA environmental review will become the foundation for potential future efforts including engineering design, environmental reviews, permitting and construction.

Service development planning is the technical analysis of new passenger rail (and related public transportation) services by progressively narrowing the set of reasonable alternatives that can best meet corridor needs. The Service Development Plan (SDP) lays out the overall scope and approach for the proposed service alternative as selected through the NEPA screening process. Among the primary objectives of the SDP are:

- Clearly demonstrate the Rationale for new or improved passenger rail service;
- Summarize analysis of the proposed new or improved passenger rail service and describe the alternative that would best address the Rationale and Purpose and Need as identified through the NEPA process;
- Demonstrate the operational and financial feasibility of the new service; and
- As applicable, describe how the implementation of the proposed Service Development Program may be divided into discrete phases.

This Service Development Plan focuses on the preferred intercity rail service option. In ten chapters it describes:

1. Project Rationale, Goals and Objectives
2. Existing Corridor Conditions
3. Review of Service Alternatives including all modes and a review of metrics applied to screen and refine the final service options
4. Market Analysis for the preferred intercity rail service
5. Service Design and Operations for the preferred intercity rail service
6. Infrastructure Requirements and Capital Costs for the preferred intercity rail service
7. Stations and Layover Facilities for the preferred intercity rail service
8. Projected Operating Costs and Revenues for the preferred intercity rail service
9. Public Benefits of the preferred intercity rail service
10. Implementation and Finance for the preferred intercity rail service

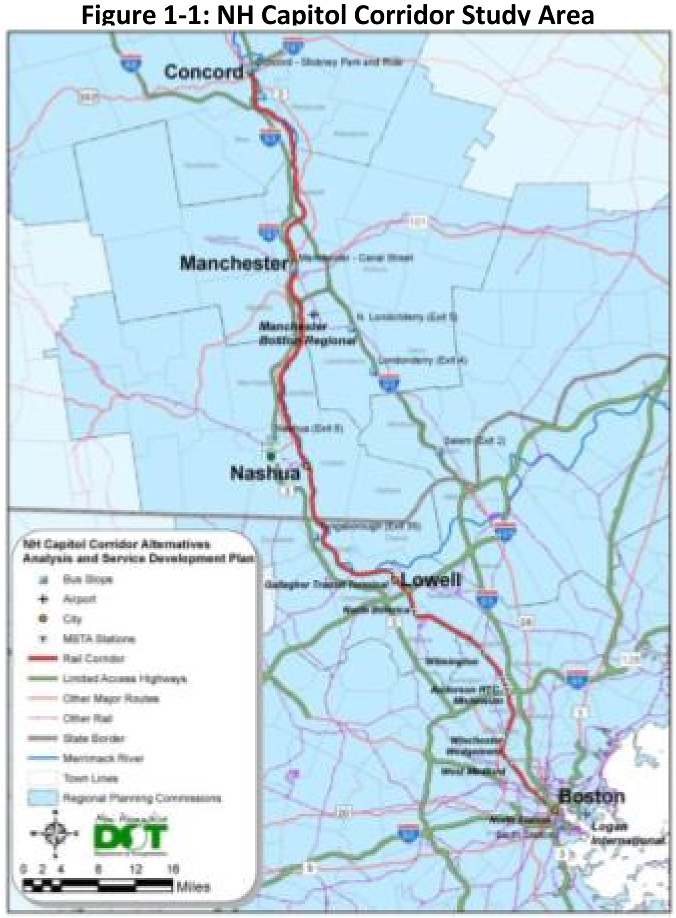
1.0 RATIONALE, GOALS AND OBJECTIVES

The fundamental starting point of any transportation planning effort is to identify the Rationale for improving transportation system service. To meet federal standards, this Rationale conforms to and supports the Purpose and Need Statement as mandated by the National Environmental Protection Act (NEPA)[2]. This Statement defines the public concern that provoked the need for the infrastructure investment studied in the environmental review process. The definition of the transportation problem, considers current and forecasted travel demand and capacity conditions. It also describes the transportation challenges and opportunities faced in the markets to be served by the proposed service. It also defines the goals and objectives the proposed service is intended to address.

1.1 Project Description

The New Hampshire Capitol Corridor Study is jointly funded by the Federal Railroad and Federal Transit Administrations. It was initiated by the New Hampshire Department of Transportation in cooperation with the Massachusetts Department of Transportation to explore and evaluate opportunities to improve public transportation service (intercity rail, commuter rail, express bus) along the 73-mile corridor between Boston, MA and Concord, NH. The corridor is presently served by express and intercity bus service between New Hampshire and Boston and by commuter rail and express bus service within Massachusetts.

Figure 1-1: NH Capitol Corridor Study Area



The most heavily used transit service in the corridor is the Massachusetts Bay Transportation Authority's (MBTA) commuter rail service, which runs 25 miles between Lowell and Boston and carries more than 17,000 passenger trips each weekday. Permanent passenger rail service has not been operated north of Lowell since 1967. A public-private partnership, supported by the State of New Hampshire, operates 80 weekday bus trips within the corridor between Manchester, Nashua and Boston. This service typically carries 1,800 passengers per day. A related private enterprise uses a state owned terminal to operate intercity bus service

[2] For more information on the NHCC Purpose and Need Statement the reader is referred to the *NHCC Project Purpose and Need Statement Technical Memorandum*.

between Concord and Boston that carries 150 passengers on typical day. Further south, several publicly operated express bus services link communities up and down the I-93 corridor in Massachusetts with downtown Boston. All together, the Massachusetts bus services carry 2,200 passengers on a typical day.

For purposes of this study, the Capitol Corridor is defined as the area that includes the Nashua Regional Planning Commission (RPC), the Rockingham Planning Commission, the Southern New Hampshire Planning Commission, the Merrimack Valley Planning Commission, the Northern Middlesex Council of Governments, and the Boston Region Metropolitan Planning Organization (MPO).

Study Corridor Dynamics

Metropolitan Boston, like most large American cities, has been continuously extending its reach and geographic scope for decades. With a 20th Century highway network and 21st Century communication links, the economies of Boston, Nashua, Manchester and Concord have never been more closely intertwined. Boston's zone of influence first moved beyond I-95/Route 128, then I-495 in Massachusetts, and now clearly extends into southern New Hampshire. It can be expected to continue expanding northward, in addition to westward and southward.

The expansion of the metropolitan area and the Boston commuter-shed has contributed to congestion in the Capitol Corridor, especially near Boston and particularly on I-93. This congestion results partly from the fact that Route 3 loses its freeway functionality south of I-95/Route 128, which negatively impacts traffic flow on the Lowell-Nashua-Manchester side of the corridor.

The congestion resulting from heavy north-south travel along corridor is exacerbated by sprawl-type suburban residential development patterns throughout parts of southern New Hampshire. Sprawl-type development contributes to increased vehicle miles travelled (VMTs) throughout the corridor. Denser development patterns do exist within the corridor, particularly in Nashua, Manchester and Concord.

Business development and job creation in the northern two thirds of the corridor has not kept pace with residential growth, especially in the high-technology sectors that are flourishing in the southern third. This residential/employment disconnect exacerbates the transportation issues that are driving the Capitol Corridor study.

The existing express and intercity bus services are not attractive to an especially broad market and employ a park and ride strategy with a focus mainly on collecting passengers at parking lots built near freeway interchanges. This is not a strategy that tends to promote the dense, sustainable development that leads to reductions in VMT.

Project History and Planning Context

Passenger rail service in the corridor started 175 years ago when a train from Boston first pulled into Nashua. Freight service on the line has run continuously since that time. Regular passenger rail service between Concord, NH and Boston, MA ended in 1967, with the exception of a brief restoration of service during a 1980-81 demonstration project. As the region has grown, traffic congestion on the main highway arteries has increased with adverse impacts on travel time and reliability for automobile and bus travel. Consequently, public interest in passenger rail service has grown as trains are insulated from highway congestion as well as concerns about air quality and sprawl. Since the 1980s, numerous studies and plans have supported the return of passenger rail service and expanded transit options in this corridor.

- In 1984, the MBTA and the Boston and Maine Railroad studied an extension of commuter rail service to Nashua's newly opened Pheasant Lane Mall. In the early 1990's the NHDOT Commissioner Charles O'Leary and Congressman Dick Swett asked the MBTA to consider extending its commuter rail service into Nashua.
- In 2006, the Community Advisory Committee to the New Hampshire DOT Commissioner recommended expanded passenger rail as one of the five "initial action items" in its final report, a component of the State's long-range transportation plan.
- In 2007, New Hampshire invested $35 million in new express bus services for travel from Greater Manchester and Nashua to Boston. NHDOT has also supported private bus service from Concord to Boston with purchase of buses and construction of a new bus terminal in Concord.
- In 2007, the New Hampshire legislature created the New Hampshire Rail Transit Authority with a charge to establish passenger rail service in New Hampshire.
- In 2009, the New Hampshire Climate Action Plan, prepared by the New Hampshire Climate Change Policy Task Force, recommended expanded passenger service as part of a balanced transportation system.

Previous Corridor Planning

- In 2003, the state departments of transportation from New Hampshire, Vermont and Massachusetts commissioned a feasibility study for the Boston to Montreal rail corridor: *Boston to Montreal High-Speed Rail Planning and Feasibility Study Phase I: Final Report.* The study describes existing conditions, including within the Boston, MA to Concord, NH portion of the study corridor, and presents a ridership analysis of stations in the corridor. The study found that "further study of associated operational, engineering and cost/revenue factors is warranted".
- In 2004, NHDOT developed a *Lowell, MA to Nashua, NH Commuter Rail Extension Project Environmental Assessment* (2004), in anticipation of extending MBTA commuter rail service to New Hampshire.
- The 2010 *New Hampshire Capitol Corridor Project Overview,* a white paper prepared for Amtrak detailed the corridor's state of readiness to function as part of the federal High Speed and Intercity Passenger Rail (HSIPR) program.
- Also in 2010, NHRTA commissioned *Economic Impact of Passenger Rail Expansion along the New Hampshire Capitol Corridor*. The report assessed the economic impacts of restoring intercity passenger rail service between Boston and Concord. The study supports the case that the implementation of passenger rail along this corridor is a net economic benefit for New Hampshire.
- In 2011, the University of New Hampshire Survey Center conducted a poll of New Hampshire residents' attitudes regarding the extension of commuter rail service on the Capital Corridor. It

suggested that a majority of residents strongly favored extending commuter service into New Hampshire and a plurality supported using federal funding to study the issue.

- In 2014, a second poll was conducted that found 68% of New Hampshire residents favor the Capitol Corridor project to extend passenger rail service up the Merrimack River valley into New Hampshire. Only 7% of the statewide sample opposed the service expansion, while twenty five percent were undecided or had no opinion.

1.2 Project Purpose

The purpose of the Capitol Corridor study was to:

- Identify a multimodal public transportation strategy (considering intercity rail, commuter rail, express bus) that will leverage the existing transportation infrastructure to improve connectivity to and from Boston, the region's largest economic hub;
- Diversify transportation options and reduce single-mode reliance on roadways for the movement of people and goods;
- Support mobility options that match emerging demographic trends and preferences in the corridor, and;
- Maintain the region's high quality of life through strategic infrastructure investments.

Project Need

The dynamics of the Capitol Corridor have contributed to the need for improved public transportation service, as described below.

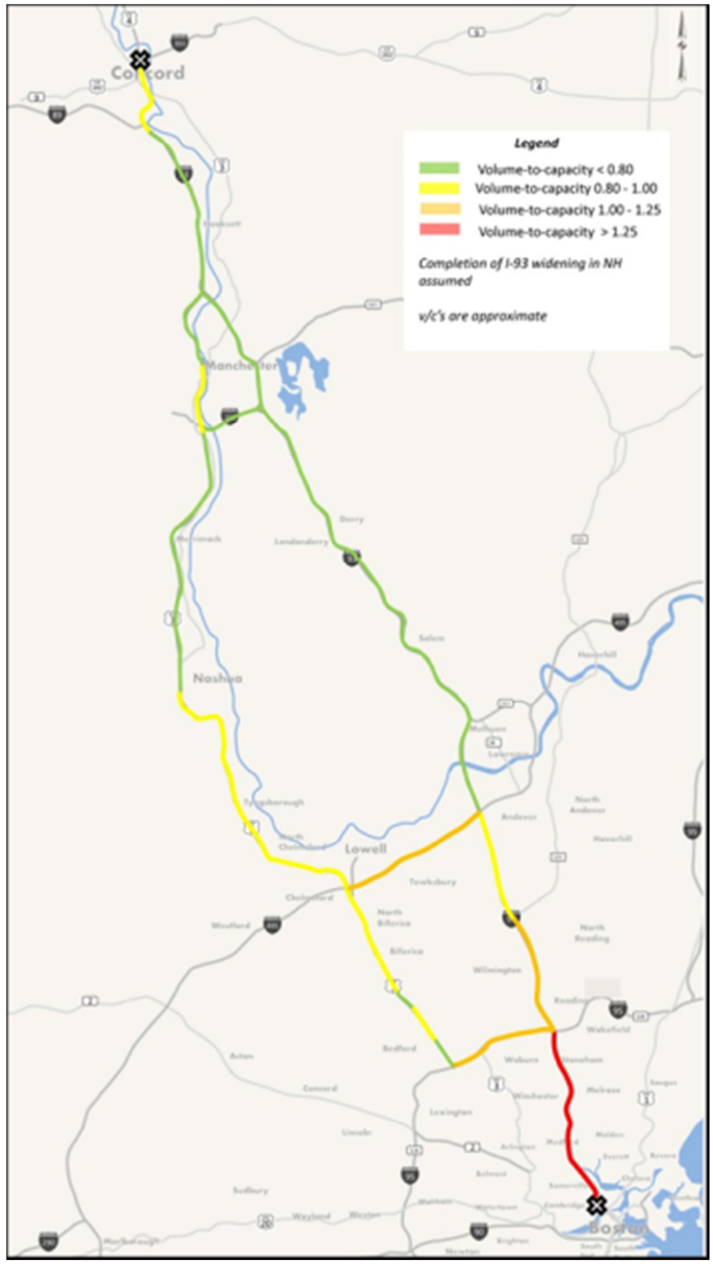
- **Projected population growth will result in increased roadway congestion.** As population density increases over the coming years, an increased number of multi-modal transportation options to Boston, the region's largest employment center, will be critical to mitigate corresponding increases in roadway congestion, particularly along I-93 and Route 3.
- **New Hampshire's existing transportation network does not effectively connect existing modes.** Increased levels of corridor transit investment will improve local and regional mobility by linking travelers to the network of existing transportation modes: roadway, buses, commuter rail, heavy rail, light rail, bicycles, and airplanes. These increased linkages will improve ridership and usage across all of the modes, while promoting sustainable mobility.
- **Regional economy suffers from singular dependency on roads for movement of goods and passengers**. Investing in transportation infrastructure that provides an alternative to roadway transport will provide new linkages for New Hampshire's businesses, industries and residents to the New England and national transport network.
- **New Hampshire is experiencing a young professional "brain drain."** While the region's overall population is projected to grow in the coming decades, young professionals are choosing to leave southern New Hampshire to be closer to the employment, cultural and social opportunities that

are associated with larger urban centers. Improved transit connectivity will support the attraction and retention of young professionals within the Capitol Corridor.

- **New Hampshire is getting older.** New Hampshire's senior population continues to grow. Improved transportation services that support "car-light" mobility will be required to accommodate these emerging demographic and lifestyle trends, and will continue to make New Hampshire attractive to residents from childhood through retirement.

- **Residential development patterns resulting from population growth may negatively impact the region's existing quality of life**. If population growth is not guided through strategic infrastructure investments that promote efficiency, the resulting uncoordinated sprawl-development patterns will diminish the region's high quality of life and negatively impact its unique character.

Figure 1-2: Current AM Peak Highway Volume-to-Capacity Ratios



- **Improved transportation options will attract employers to New Hampshire and improve employment options for New Hampshire residents.** A mismatch between locations of residence and employment forces many in New Hampshire to spend comparatively long periods of time commuting to work. Investing in more efficient transportation modes will improve connectivity between existing centers of residence and employment, and increased levels of multi-modal access may catalyze additional business investment within New Hampshire.

- The existing transportation network cannot accommodate increased levels of demand without negative environmental consequences. The expansion of existing roadways and construction of new roadways will not be sufficient to sustainably accommodate the projected growth in travel demand, causing negative environmental consequences associated with an increased number of vehicle miles traveled and corresponding congestion.

1.3 Population and Employment

Population

While both the New Hampshire and the Massachusetts portions of the corridor are projected to grow over the next two decades, the Massachusetts portion is projected to grow at a slightly faster pace. It can be anticipated that this population growth will increase demand on the transportation network, which may result in increased levels of congestion and travel times, particularly in the southern portion of the corridor which already experiences intense peak hour highway congestion.

Table 1-1: Historical, Existing and Forecast Population in the Capitol Corridor Study Area

Geography	1990	2000	2010	2020	2030	2035	Total Change 2010-2035	Percent Change 2010-2035
MA study area	3,474,873	3,666,175	3,782,361	3,942,000	4,093,000	4,182,000	399,639	10.6%
NH study area	647,011	733,134	775,520	801,029	832,598	840,034	64,514	8.3%
Total	**4,121,884**	**4,399,309**	**4,557,881**	**4,743,029**	**4,925,598**	**5,022,034**	**464,153**	**10.2%**

Source: MAPC, NMCOG, MVPC, NH OEP/CNHRPC

Note: areas include Boston Region MPO, NMCOG, MVPC, CNHRPC, SNHRPC, Nashua RPC, and Rockingham Planning Commission,

The nation's largest population cohort falls between the ages 35 and 64. The fraction of New Hampshire's total population that falls within that age cohort is higher than Massachusetts, New England or the nation. The growth of New Hampshire's population over age 65 increased at a significantly faster rate between 2000 and 2011 than in Massachusetts, New England or the nation as a whole.

The median age has increased within the study corridor, New Hampshire, Massachusetts, New England and the United States. The increase in median age has been greatest within the study corridor (four years), which is more than twice the nationwide increase in median age during the same time period (1.7 years).

Residents of New Hampshire and the study corridor are older and aging at a faster pace than the surrounding states and the nation. As New Hampshire's residents age, a robust multi-modal transportation network that reduces reliance on single-car ownership will be necessary to support the continued mobility and maintain the quality of life of these residents.

In addition to understanding existing and projected population growth, it is important to ensure that the specific needs of mobility-challenged populations are taken into consideration when developing and evaluating transport investment strategies. These households rely on public transportation for local and regional travel. Maximizing project benefits to these populations while minimizing adverse impacts is important to the success of expanded public transportation services (rail or bus) in the Capitol Corridor.

Table 1-2: Zero Car Households in the Study Corridor

Geography	Zero Car Households	Total Households	Percent of Households with Zero Cars
Boston Region MPO	193,254	126,402	15.3%
Merrimack Valley Planning Commission	13,644	143,769	9.5%
Northern Middlesex Council of Governments	9,099	129,979	7.0%
Massachusetts Total	**215,997**	**1,537,150**	**14.0%**
Central New Hampshire RPC	2,958	54,519	5.4%
Nashua RPC	3,533	87,570	4.0%
Rockingham Planning Commission	2,798	80,423	3.4%
Southern New Hampshire Planning Commission	5,937	124,784	4.8%
New Hampshire Total	**15,226**	**347,296**	**4.4%**
STUDY CORRIDOR TOTAL	**231,223**	**1,884,446**	**12.3%**

Source: American Community Survey 2010 Five-Year Data

Employment

Employment levels within the five study corridor counties are shown in Table 1-3. Employment has generally been growing at one to two percent per year over the last five years.

Table 1-3: Number of Jobs in the Five Counties that the Study Corridor Passes Through (2013 Q2)

Geography	2013 Q2	2012-2013 Change
New Hampshire	602,462	1.1%
Hillsborough County, NH	193,248	1.2%
Merrimack County, NH	75,768	1.0%
Rockingham County, NH	139,900	1.6%
Massachusetts	3,352,700	1.3%
Middlesex County, MA	847,700	1.9%
Suffolk County, MA	608,100	1.7%

New Hampshire Source: Longitudinal Employer-Household Dynamics; http://ledextract.ces.census.gov/
Massachusetts Source: Bureau of Labor Statistics, County Employment and Wages in Massachusetts – Second Quarter 2013; http://www.bls.gov/ro1/maqcew.htm

Massachusetts and New Hampshire each forecast industry growth (by the North American Industry Classification System) to 2020. Massachusetts organizes the projections by Workforce Investment Areas (WIAs), while New Hampshire uses the RPC jurisdictions. While the WIA boundaries do not exactly conform to the Capitol Corridor study area, the study area generally falls within four WIAs.
Table 1-4 highlights the fastest-growing industries through 2020. The fastest-growing industry in each geography is highlighted in bold font. The fastest growing industries in Massachusetts are – with the exception of construction – service-oriented industries: finance and insurance, professional, scientific and technical services, and other services. New Hampshire's fastest-growing industry – with the exception of professional, scientific and technical services in Nashua RPC – is health care and social assistance. These findings reflect New Hampshire's comparatively higher older population and the role of Boston as a regional finance, technology and business service hub.

Table 1-4: Projected Change in Industry Employment 2010 – 2020

	Massachusetts					New Hampshire			
NAICS Industry	**Boston WIA**	**Greater Lowell WIA**	**Lower Merrimack Valley WIA**	**Metro North WIA**	**North Shore WIA**	**Rockingham RPC**	**Central NH RPC**	**Southern NH RPC**	**Nashua RPC**
Construction		**50%**			**41%**				
Wholesale Trade		49%			33%				
Retail Trade									
Transportation and Warehousing		34%							
Finance and Insurance				**60%**					20%
Professional, Scientific and Technical Services	36%		**44%**	27%		22%	17%	23%	**26%**
Administrative / Support / Waste Mgmt. / Remediation				24%	26%	19%	20%	19%	
Health Care and Social Assistance						**24%**	**25%**	**25%**	24%
Arts, Entertainment and Recreation	33%		35%						
Other Services	**43%**		37%						

Source: Massachusetts Executive Office of Labor and Workforce Development, the Bureau of New Hampshire Employment Security

Households within the study corridor have a median income over $80,000 per year. This is greater than median incomes of New Hampshire, Massachusetts, New England and the nation. This may reflect the fact that the study corridor includes the most densely developed areas of Massachusetts and New Hampshire (where residents tend to have higher incomes) and excludes the majority of the lower density, rural areas (where residents tend to have lower incomes). Median household income within the study corridor has risen by two percent (in 2011 constant dollars) between 2000 and 2011, which outperformed New Hampshire, Massachusetts, New England, and the nation.

While the study corridor fraction of the population living below the poverty line is lower than for all of New Hampshire, all of Massachusetts or the entire nation, it has increased 18 percent increase between 2000 and 2011. As the population living in poverty grows, it will be increasingly important to provide these residents with lower-cost mobility options that reduce the need to own a car.

1.4 Existing and Future Land Use

A legacy of New Hampshire and Massachusetts' colonial and nineteenth century industrial past is the prevalence of the traditional town center pattern of development, which was designed to support pedestrian rather than vehicular traffic. This style of development has a comparatively high-density mix of uses in the "downtown" that is easily accessed on foot from the surrounding residential areas. While some infrastructure elements have been retrofitted to facilitate driving, the historic downtown development patterns of Boston, Lowell, Nashua, Manchester and Concord, and other smaller towns within the study corridor, reduce the prioritization of cars and elevate the role of pedestrian and non-motorized modes of transportation.

Another traditional land use pattern, particularly within the New Hampshire portion of the corridor, includes rural, farmland and open spaces. These land uses, and the environmental assets they preserve, are a critical element of New Hampshire's identity and a major factor in the continued high quality of life for New Hampshire residents.

As the population has grown over the decades and development has spread outside of these traditional town centers, auto-oriented, lower-density residential and commercial development patterns have emerged. These patterns, which can be found throughout the study corridor, are typically dominated by the segregation of land uses (as opposed to the mixed-use patterns that can be found in the town center style of development). These separated land uses are connected by comparatively few limited access roadways, which can result in increased levels of traffic congestion during peak travel times.

Both Massachusetts' and New Hampshire's population is projected to grow over the next two decades; according to recent research one-quarter of New Hampshire residents were born in Massachusetts and the population of Massachusetts-born residents is growing faster than the population born in the state[3]. Regardless of the source of the population growth, it will continue to exert increased development pressure on New Hampshire's communities. In the absence of a strategic land use framework, this pressure could result in increased levels of congestion, encroachment into open spaces, and a reduced quality of life.

Communities throughout New Hampshire and Massachusetts, including those within the study corridor, have recognized the potential costs associated with policy and regulatory inaction, and have undertaken numerous land use and development planning activities that are designed to encourage more sustainable land use patterns.

Travel Patterns and Market Analysis

Market analysis provides a critical first step to estimate travel demand in the Capitol Corridor. The market analysis provides the "big-picture" travel flows in the study area and identifies their relationship to the corridor by quantifying the total size of the travel market and key origin-destination travel patterns.

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[3] Kenneth M. Johnson; *Many New Voters Make the Granite State One to Watch in November*; Carsey Institute; http://cola.unh.edu/sites/cola.unh.edu/files/research_publications/IB-NHVoter08.pdf

The geographic area of the Capitol Corridor travel market is defined by the existing track alignment along the banks of the Merrimack River extending north from Lowell through the proposed station locations of Nashua, Manchester and ending in Concord. This corresponds roughly with the US Route 3 corridor in New Hampshire. The full length of the corridor varies by alternative, but at its maximum, generally runs from Concord's intercity bus terminal adjacent to the rail corridor in the north, to Boston North Station in the south. This section will focus on the New Hampshire market in the proposed study area.[4]

This analysis focuses on the three main work and business travel markets in the Capitol Corridor, these are:

- New Hampshire to Massachusetts,
- New Hampshire to New Hampshire, and
- Massachusetts to New Hampshire.

Mobility of individuals and their ability to reach places of employment, particularly to locations outside their areas of residence, is highly dependent on the availability of an automobile. Workers without an automobile, or access to one, are transit dependent if they live outside walking or biking distance of their jobs.

Corridor population[5] within the proposed service catchment area is an important indicator of the potential use of transportation infrastructure and services. The corridor connects the three largest cities in New Hampshire: Concord, Manchester and Nashua. These cities, as well as the other communities on the corridor, represent nearly 39 percent of the population and just over 41 percent of the employment in the entire State of New Hampshire. Concord, Manchester and Nashua by themselves account for 24 percent of the population and just over 27 percent of the employment in the state.

- **New Hampshire to Massachusetts Work Trip Market -** The New Hampshire communities within the corridor generate approximately 200,000 work trips, of which over 28,000 (14 percent) are destined for locations in eastern Massachusetts. Of these 28,000 trips, approximately 10,000 (35 percent) are destined to locations along the existing MBTA Lowell commuter rail line. These trips are the main component of the New Hampshire to Massachusetts market that would be served by the Capitol Corridor.
- The main destinations of the New Hampshire work trips are Lowell and Boston/Cambridge. Lowell attracts just over 2,000 work trips from the corridor communities and Boston/Cambridge attracts just over 4,000. The Boston/Cambridge trips face severe congestion during work commuting times and are considered a very strong market for the Capitol Corridor service.

[4] The New Hampshire market is considered to be communities along the corridor and consists of; Concord, Manchester, Nashua, as well as Bow, Pembroke, Hooksett, Goffstown, Bedford, Londonderry, Merrimack, Litchfield, and Hudson.
[5] Population, employment and commuting to work numbers are from the U.S. Census Bureau, 2006-2010 American Community Survey 5-year estimates.

- **New Hampshire to New Hampshire Work Trip Market -** Of the approximately 200,000 work trips generated by the New Hampshire corridor communities, just over 170,000 remain in New Hampshire and a large majority of these nearly 148,000 stay within the corridor itself. Not all of these trips are part of the market that the Capitol Corridor project would serve, but they do show the relatively large number of work trips within New Hampshire.
- The intra-New Hampshire market consists primarily of the work trips among the major cities of Concord, Manchester and Nashua. Excluding intra-city trips, the work trip market between these cities approaches 10,000 trips each weekday.
- **Massachusetts to New Hampshire Work Trip Market -** This market is the smallest of the three major work trip markets, with a total of 1,370 work trips from the Massachusetts communities in the corridor to the cities of Concord, Manchester or Nashua. The majority of these trips are from the cities of Lowell (773) and Boston (300). Similar to the trips from New Hampshire to Boston, the trips from Boston face the severe congestion during peak commuting hours.

1.5 Transportation Facilities and Services

The Capitol Corridor's robust transportation network includes roadways, highways, transit services, intercity passenger rail service, freight railroads, airport, and pedestrian and cyclist facilities. Despite the dense, multi-modal nature of this transportation network, peak highway demand outstrips available capacity and opportunities exist to improve connectivity between the current modes.

Highway Facilities

The limited access highways that connect New Hampshire's major population centers to metropolitan Boston are I-93, US Route 3/Everett Turnpike, I-95/Route 128, I-293, and, I-495. These limited access highways cover 134 miles of limited access freeway facilities and interchanges, shared between the States of New Hampshire and Massachusetts. The breakdown on the corridor mileage is as follows:

- I-93: 65 miles;
- US Route 3: 49 miles;
- I-95/Route 128: 11 miles;
- I-293: 11 miles, and;
- I-495: 9 miles.

The corridor has experienced rapid population growth, and many of the new residents commute to jobs in Greater Boston. New Hampshire and Massachusetts have expanded the highway system to accommodate increasing traffic, and the prospects for additional expansion are unlikely due to financial and environmental constraints. At a minimum, the advent of passenger rail service may delay the need for further highway widening. Traffic volume at the state line on US Route 3/Everett Turnpike in Nashua grew by nearly 26 percent from 2002 to 2009, to 88,200 (average daily traffic), and projections are for continued traffic growth in the corridor in both states. More detail on existing highway conditions is provided in *Chapter 2: Existing Conditions* of this Service Development Plan.

Public Transportation Services and Facilities

The Capitol Corridor has a variety of commuter and local bus operators, as well as MBTA commuter rail service and Amtrak intercity passenger rail service on the Downeaster line.

Amtrak Downeaster Service

Intercity passenger rail service between Boston and Portland was restored in 2001, after an absence of more than 35 years. The Downeaster service features five daily round trips between Portland and Boston North Station, with eight intermediate stops—Woburn, Haverhill, Exeter, Durham-UNH, Dover, Wells, Saco, and in season, Old Orchard Beach. On November 1, 2012, two daily Downeaster trains were extended to Freeport and Brunswick, ME. Ridership on the Downeaster service in Fiscal 2013 was nearly 560,000 passengers, up 3.4 percent from the year before. Most trains make the Boston-Portland trip in two hours, thirty minutes.[6] More detail on existing intercity passenger rail service is provided in *Chapter 2: Existing Conditions* of this Service Development Plan.

MBTA Commuter Rail Service

On a typical weekday in 2013, Lowell was served by 44 MBTA revenue trains to and from Boston's North Station. The 25-mile trip serving up to seven intermediate station stops takes 44 to 49 minutes. Six weekday non-revenue "dead head" trains run between Lowell and Boston to stage the service because there is no facility for the overnight storage or maintenance of the trains in Lowell. Typical weekday MBTA ridership on the entire line is 17,500 passenger trips, including both northbound and southbound travel. Lowell is the busiest station on the line with 4,280 weekday boardings and alightings. The running time between Lowell and Boston ranges between 45 and 49 minutes with a maximum allowable speed of 70 mph. The daily schedule includes approximately 150 daily deadhead train miles. More detail on existing commuter rail service is provided in *Chapter 2: Existing Conditions* of this Service Development Plan.

Regional and Local Bus Service

Seven regional and four local bus operators provide service within New Hampshire and intercity service to Boston and beyond. Boston Express provides the primary commuter service within the study area along the heavily congested Massachusetts segments of Interstate 93. Existing traffic congestion along I-93 and Route 3 significantly impact scheduled travel times for express and intercity bus services. For instance, Boston Express' 6:30am southbound departure from Londonderry (Exit 4) on the I-93 service is scheduled for a one hour trip to Boston South Station. Meanwhile, the 9:50am southbound departure is scheduled for a two hour and twenty minute trip, which is a built-in or induced delay of one hour and twenty minutes. More detail on existing bus services is provided in *Chapter 2: Existing Conditions* of this Service Development Plan.

Freight Railroad Service and Facilities

The New Hampshire Main Line (NHML) was, and remains, a principal artery of the Boston and Maine (B&M) Railroad's network and a key economic link between the Granite State and the national economy. Since the 1980s the B&M has belonged to a regional amalgam of railroads initially called the

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[6] Amtrak Fact Sheet, Fiscal Year 2013, State of New Hampshire

Guilford Rail System, later changing its name to Pan Am Railways (PAR). Headquartered in Billerica, MA, PAR owns and operates the former B&M and Maine Central Railroads as an integrated system, roughly running from Bangor to Albany with numerous branches in New Hampshire and other New England states. North of Chelmsford, Pan Am refers to the route as its "Northern Branch." More detail on existing rail freight rail service is provided in *Chapter 2: Existing Conditions* of this Service Development Plan.

Air Travel

Expanded public transportation in the corridor could create an additional connection between the Manchester-Boston Regional Airport and Boston. This would create a system in which the three principal Boston-area airports are connected by rail (with the MBTA Blue Line connection at Boston-Logan Airport and the MBTA commuter rail connection to Providence's TF Green Airport). Manchester-Boston Regional Airport is an important economic engine for New Hampshire and the region; creating jobs, facilitating commerce and providing access to the global marketplace. Manchester-Boston Regional Airport contributes over $1 billion annually to the region's economy and accounts for more than 3,500 jobs in the three-county region contiguous to the airport. A connection to the airport through an intermodal station adjacent to the airport access highway would create new rail-air connectivity.

Manchester-Boston Regional Airport strongly supports the development of passenger rail service in New Hampshire as part of a multi-modal solution to meet the growing and changing transportation needs of the region. The airport incorporated a review of passenger rail service (and an anticipated airport rail station) as a focus of its 2011 *Master Plan Update* and determined that there are important synergies between passenger rail and air passenger transportation systems. Manchester-Boston Regional Airport will benefit from both rail ridership by enplaning passengers (air travelers originating from the area and using passenger rail service to travel to the airport from their home or business) and deplaning passengers (air travelers accessing New England through Manchester-Boston Regional Airport and using passenger rail service to travel from the airport to their final destination).

1.6 Economic Development and Land Use

Access to Boston-based Employment

Public transportation investment along the Capitol Corridor will improve multimodal connectivity between New Hampshire's residents and Boston, the region's major employment center. Expanded access to Massachusetts' diversified employment base will benefit existing New Hampshire residents, and may encourage them to stay in their current communities rather than moving closer to Boston.

Business Attraction in New Hampshire

In addition to improved access to Boston's employment market, public transport investment in the corridor may be leveraged to lure businesses into New Hampshire. Millennials – the 18- to 34- year olds that will rival the Baby Boomers in size and cultural influence – have repeatedly stated a preference for built environments that support a car-light or car-free urban-style existence. These Millennials are the rising "creative class" – those workers whose career orientation is towards ideas and innovation rather than heavy manufacturing and assembly lines. As businesses – particularly tech-oriented businesses –

look for lower-cost alternatives to downtown Boston and more Millennial-friendly environments than the Route 128 corridor, the communities of the Capitol Corridor can increase their attractiveness by investing in non-automotive transport. Improved connectivity will not only improve access to Boston-based employment, but can draw these "creative class" workers (and the companies that want to hire them) into the New Hampshire portion of the Capitol Corridor.

More Strategic and Sustainable Land Use Patterns

Access to the Boston employment market and the attraction of businesses into New Hampshire both rely on the efficient flow of people between their homes and places of employment. Regardless of any transport investment, travel in the corridor is anticipated to increase. In the absence of transportation network investment, this growth in travel will lead to increased levels of congestion and decreased levels of mobility. Simply expanding the roadway network is not a solution to this problem as it would likely induce additional demand, that in turn would further exacerbate the congestion problem.

While mobility problems are most directly solved by transportation investment, land use patterns play a critical role in supporting the efficient movement of people and goods. In addition to using public transportation investment to expand transportation network capacity, strategic land use planning that focuses higher-density, mixed-use development near public transportation stations can reduce demand on the transportation network by supporting trip efficiencies. This land use pattern would reflect a return to the traditional New England "town center" style of development.

More efficient land use patterns can also encourage the expansion of employment opportunities closer to home, resulting in shorter travel distances. This would reduce demand on the transportation network, which would reduce overall travel times and congestion.

Sustainability and Quality of Life

A sustainable transportation system is one that meets and balances the existing environmental, social and economic needs of a community without compromising resources for future generations.

Environmental

A portion of the New Hampshire character is rooted in the natural beauty of the state, including its mountain ranges, chains of lakes, sea coast, and protected forest land. The environmental impacts of increased levels of development and corresponding growth in transportation network demand may negatively impact these environmental assets unless proactive investments in sustainable infrastructure are pursued.

New Hampshire's Energy, Environmental, and Economic Development Benchmark Report[7], released by the New Hampshire Energy and Climate Collaborative in 2012, reports that transportation accounts for 35 percent of the New Hampshire's energy use and 46 percent of the its greenhouse gas (GHG) emissions. Total transportation-related energy consumed and GHG emission rates have remained flat in recent years, even though VMT and per capita VMT have decreased approximately five percent between

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[7] http://www.unh.edu/news/releases/2012/jun/ds28climate.cfm

the peak in 2006 and the most recent data in 2009. At the same time, public transport use has increased 25 percent between 2000 and 2010.

Because the New Hampshire Capitol Corridor is home to the three largest cities in the state (Concord, Manchester and Nashua) as well as two major north-south arteries (Route 3 and I-93), transportation network investments that support mode shift away from automobiles are likely to support a decrease in per capita VMT and may support reductions in GHG emissions.

Economic

The New Hampshire Center for Public Policy Studies' From Tailwind to Headwind: New Hampshire's Shifting Economic Trends8, published in 2012, found that demographic trends in the state are related to economic trends. The state's economic advantage has traditionally been rooted in three areas: consistent population growth, increased productivity, and a more resilient economy than its competitors. However, data shows that population growth is slowing, labor force participation is declining (due to the aging of the population), and the rate of growth in educational attainment is slowing.

Like the Baby Boomer generation before them, the sheer size of the Millennial generation, those born between approximately 1982 and 2003, means their preferences will shape every aspect of the country's economy and culture in the coming decades. Communities that invest in infrastructure and that make policy decisions which are attractive to this generation will be successful in creating an economic framework for sustainable growth. This is particularly important for New Hampshire, which is aging at a higher-than average rate. A 2013 report by U.S. Public Interest Research Group, *A New Direction: Our Changing Relationship with Driving and the Implications for America's Future*[9], found that:

- Young people aged 16-to-34 drove 23 percent fewer miles on average in 2009 than they did in 2001—a greater decline in driving than any other age group. The severe economic recession was likely responsible for some of the decline, but not all.
- Millennials are more likely to want to live in urban and walkable neighborhoods and are more open to non-driving forms of transportation than older Americans.
- If the Millennial-led decline in per capita driving continues for another dozen years, even at half the annual rate of the 2001-2009 period total vehicle travel in the United States could remain well below its 2007 peak through at least 2040—despite a 21 percent increase in population.

The New Hampshire Capitol Corridor is home to one of the largest private employers in the state (BAE Systems), and the state's largest labor pool. Public transport investment within this corridor will provide a lower-cost commuting alternative that links New Hampshire residents with employment opportunities while increasing New Hampshire's attractiveness as a place to do business.

[8] http://www.nhpolicy.org/UploadedFiles/Reports/New_Hampshire_New_Reality_2012_final1.pdf
[9] http://www.uspirg.org/sites/pirg/files/reports/A%20New%20Direction%20vUS.pdf

Social

In his 2012 report *New Hampshire Demographic Trends in the Twenty-First Century*[10], Kenneth Johnson of the Carsey Institute at the University of New Hampshire documents several trends that can be extracted from the most recent census data:

- New Hampshire's population increase is slowing, New Hampshire's population is aging, the pace of demographic change is uneven in the state, and the state is becoming more diverse.
- Young adults are migrating to metropolitan cores, family age residents are migrating to suburbs, major metropolitan cores are losing older residents, and rural counties are losing young adults.
- Many towns in the New Hampshire Capitol Corridor, including Manchester and Nashua, have the largest concentrations for young persons (<18) in the state.

Quality of Life

Granite State Future is a statewide project coordinating the development of regional plans in each of the RPC's jurisdictions. It recognizes the interconnection between development patterns, availability of housing choices, and diversity of transportation choices as a means to preserve natural resources, community vitality and promote energy efficiency. Public transportation investment within the Capitol Corridor would be a powerful investment that can be leveraged to implement this regional, multi-discipline vision to maintain New Hampshire's high quality of life.

1.7 Goals and Objectives

A set of goals, objectives and evaluation measures were developed to determine how well a public transportation (intercity rail, commuter rail, or express bus) investment along the Capitol Corridor will address regional and corridor needs. These goals and objectives, summarized below, build on the stated objectives of current and recent planning in the corridor as described above. This body of work demonstrates the role that integrated transportation and land use planning can play in supporting an economically, environmentally, and socially sustainable community. A major public transportation investment would be a significant step in implementing this integrated planning approach within the Capitol Corridor.

[10] http://gencourt.state.nh.us/house/committees/committee_websites/waysmeans/DOI%202013/Report-Johnson-Demographic-Trends-NH-21st-Century.pdf

Table 1-5: Capitol Corridor Study Goals and Objectives

Goals	Objectives
Economic Development and Land Use Support the vision for growth laid out in local and regional development plans	• Improve access to higher-paying jobs in Greater Boston • Support development patterns and lifestyle choices that are attractive to younger, highly educated professionals • Leverage the younger, highly educated employee base to attract new businesses and grow existing ones • Promote concentrated development (TOD) to mitigate sprawl development patterns • Improve the potential for additional freight rail business through infrastructure upgrades
Transportation and Mobility Leverage the existing transportation network to improve access and mobility within the corridor and throughout the region	• Mitigate congestion within the study corridor, particularly towards the southern end of the corridor • Expand the capacity of the transit network • Increase transit ridership and mode share through expansion of the existing rider base and attraction of choice riders • Provide travel time savings • Improve the efficiency, convenience and reliability of transit service
System Integration Invest in transportation improvements that complement the existing multi-modal transportation network	• Increase corridor modal connectivity • Provide connections to other corridors within the region • Increase access to Manchester-Boston Regional Airport through additional transit service • Balance system capacity (Amtrak, MBTA, Boston Express, Concord Coach) • Ensure operating efficiency
Sustainability Support transportation investments that contribute to an environmentally, economically, and socially sustainable community	• Leverage existing transportation infrastructure to qualify for federal transportation investment dollars • Mitigate potential adverse environmental impacts resulting from anticipated development • Support growth patterns that attract and retain residents from childhood through retirement • Improve access to other tourism, recreation and cultural attractions in greater Boston and New Hampshire

2.0 EXISTING CONDITIONS

This chapter describes existing travel conditions, services and facilities along the Capitol Corridor. The review covers rail, bus and highway conditions, services and facilities.

2.1 Railway Facilities and Services

The first passenger train in New Hampshire arrived in Nashua from Lowell, Massachusetts in October 1838.[11] Passenger rail service along this alignment was soon extended to Manchester and Concord with further extensions into the White Mountains and westerly to Hanover and White River Junction. The New Hampshire Main Line (NHML) was, and remains, a principal artery of the Boston and Maine (B&M) Railroad's network. Consequently, the line functions as a key economic link between the Granite State and the national economy. NHML passenger service ran for almost 130 years until it was abandoned in 1967. Passenger service was briefly restored in 1980, but abandoned again when federal funding expired. Freight service has been operated continuously for 175 years.

Based on a review of Twentieth Century passenger timetables, the fastest trips between Boston and Concord were offered in the 1950s when the new light Budd RDC self-propelled diesel rail cars made the 73 mile trip in as little as 82 minutes. During the steam age, in the first half of the century, the shortest travel times were 120 minutes for the same destination pair.

In the first quarter of the Twentieth Century, there were 29 passenger stations between Boston and Concord (see **Error! Reference source not found.**). With the rise of the highway network, that number was gradually reduced to 16 in 1945.

Table 2-1: Passenger Service Summary 1910-1954

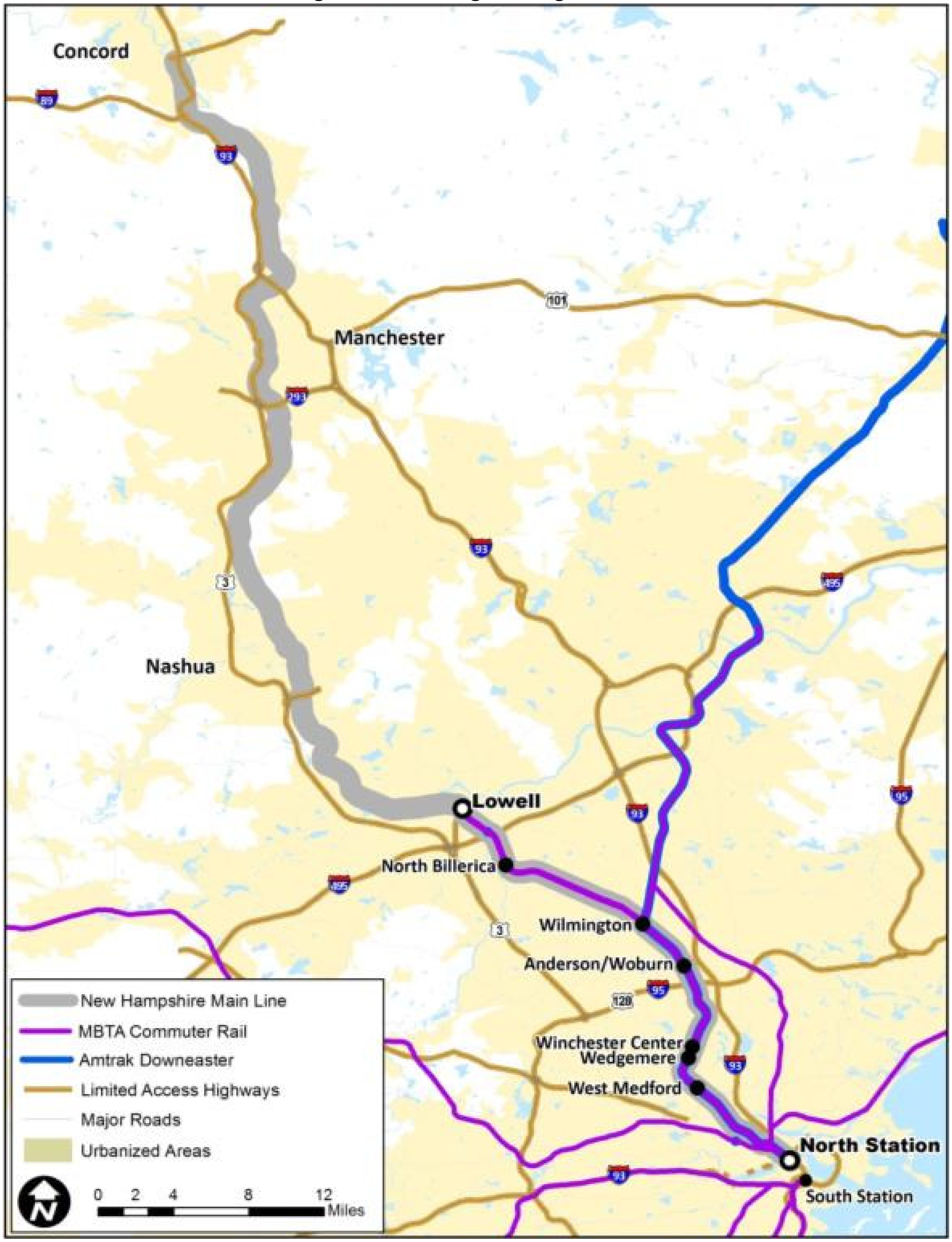
Year	Number of Stations	Nashua Trains	Manchester Trains	Concord Trains
1910	29	30	28	28
1926	29	26	24	24
1945	16	18	17	17
1954	16	19	22	21

Source: Jacobs analysis of historic public timetables

The numbers of weekday passenger trains serving the line also declined from a high of 30 in 1910 to a low of 18 in 1945. In 1954, with the introduction of new Budd RDC cars and post-war prosperity, the B&M slightly expanded the frequency of passenger trains along the line. However, by the late 1960s, the passenger service was no longer profitable and was discontinued due to the growth of the interstate highway system.

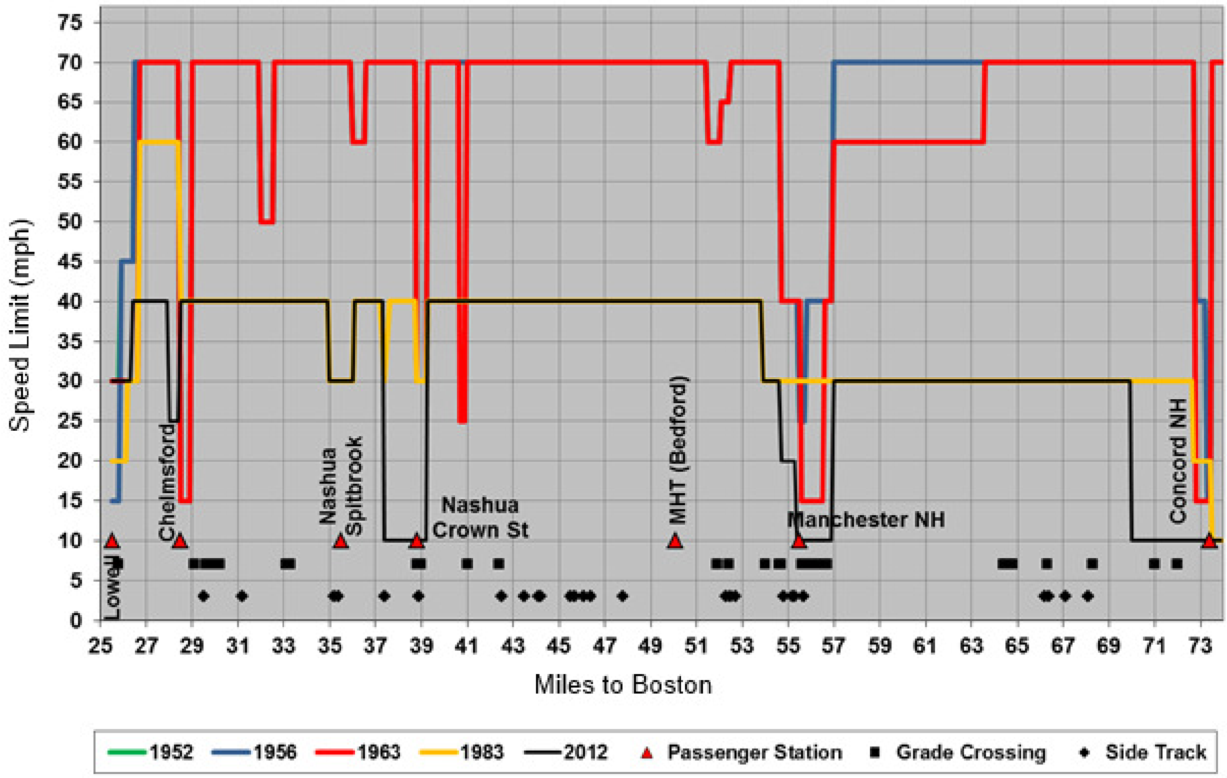
[11] New Hampshire Department of Transportation. *New Hampshire State Rail Plan 2012*. p. 21.

Figure 2-1: Existing Passenger Rail Services



A review of B&M employee timetables showing speed limits for the line during the 1950s and 1960s indicated that the maximum allowable speed along most of the line between Lowell and Concord was 70 mph with numerous speed restrictions for curves, densely settled urban areas with a high density of grade crossings and railway yards (see Figure 2-2).

Figure 2-2: Historic and Existing Speed Profiles for NHML from Lowell, MA to Concord, NH



When passenger service was abandoned due to declining ridership in the late 1960s, the B&M stopping maintaining the line for passenger speeds and lowered the maximum allowable speeds to 40 mph south of Manchester and 30 mph north to Concord. Currently, the short segment between Lowell and Chelmsford is part of the B&M's existing freight mainline and is still operated and maintained at a 60 mph freight standard. The maximum allowable passenger speeds between Lowell and Boston are between 60 and 70 mph.

Since the 1980s, the B&M has belonged to a regional amalgamation of railroads initially called the Guilford Rail System, later changing its name to Pan Am Railways. Today the Pan Am, headquartered in Billerica, Massachusetts, owns and operates the former B&M and Maine Central Railroads as an integrated system. This system generally runs from Bangor, Maine to Albany, New York with numerous branches in New Hampshire and other New England states. North of Chelmsford, Pan Am refers to the route as its "Northern Branch."

Track Configuration

Once a busy mainline railway, the NHML was double tracked to Concord and beyond. However, today the railway is largely single tracked north of Chelmsford with some passing sidings, yards in Nashua and Manchester, and numerous turnouts to customer sidings.[12] A track configuration chart for the segment north of Lowell can be found in Chapter 3: Service Alternatives. The 48-mile segment between Lowell and Concord has 26 switches off the mainline to yards, customers, sidings and branches. The most notable freight customers along the line are Public Service of New Hampshire (PSNH), Quebec Cement, Anheuser Busch and Nashua Corporation. The PSNH power plant in Bow regularly receives unit trains of coal (approximately 100 annually) and is by far the state's largest volume receiver of rail freight. This may change in the future as PSNH considers a potential future conversion to natural gas turbines.

The NHML has two active branches:

- The Hillsboro Branch leads west from Nashua approximately 30 miles to Bennington, NH. The eastern most 12 miles to Wilton are owned and operated by Pan Am Railways. The 18 miles between Wilton and Bennington, are owned by the State of New Hampshire and operated by the Milford-Bennington Railroad.
- New England Southern Railroad (NEGS) operates north from Concord using 18 miles of the state-owned line that runs north from Concord toward Lincoln.

Ownership

In Massachusetts, the southernmost 34.5 miles of the line were acquired by the Massachusetts Bay Transportation Authority (MBTA) in the 1960s. At that time the MBTA acquired most of the mainline assets of the B&M and the New Haven Railroads in eastern Massachusetts. Today, the southernmost 25.4 miles of the route between Boston and Lowell are busy with passenger traffic operated by the MBTA and Amtrak, and some local freight services operated by Pan Am.

In New Hampshire, the NHML is property of Pan Am Railways. In 2011, Pan Am conveyed trackage rights to the MBTA for the operation of passenger trains on the NHML northward into New Hampshire between the state line and Concord.

Railway Signal System and Traffic Regulation

The train control signal system for the route supports Northeast Operating Rules Advisory Committee (NORAC) Rule 261 between North Station and Manchester. Rule 261 allows for bi-directional operation with automatic wayside block signals on all mainline tracks. North of Manchester, there are no wayside signals and operations are governed by Data Communication System (DCS) rules, wherein a Form D train order issued over the radio by the railroad dispatcher in Billerica, Massachusetts is necessary to move a train.

[12] The line is double tracked for the 25 miles between Boston's North Station and the Gallagher Intermodal Terminal in Lowell.

Track Conditions and Potential for Upgrades

Inspection of MBTA and Pan Am timetables and track charts coupled with a hi-rail inspection trips in April and June 2014 between Lowell, Massachusetts and Concord, New Hampshire provided the following information concerning track conditions.

Railway track is the structure consisting of rails, fasteners, tie plates, ties and stone ballast that guides and supports the train as it moves down the railroad. More than 150 years of development has led to near universal standards for track design but marginal innovations are made every few years. The predominant track form worldwide consists of flat-bottom steel rails that support and guide the wheels of the rail vehicle. The rails are seated on steel plates that are fastened to and supported by timber ties. The ties are laid in a bed of crushed stone, also known as ballast.

For generations, the rails were laid in 39-foot sections that were tied together with joint bars and bolts. The joints in the rail are a weak point in the track structure, subject to substantial maintenance to provide a smooth route for the vehicle wheels. Loose and damaged joints diminish ride quality, tie life and maximum allowable speeds. Beginning in the 1950s US railroads started welding their rails into long continuous ribbons that significantly improved ride quality and eliminated most maintenance associated with joints. The conversion to welded rail has been a long process. Today, most heavily trafficked and higher speed railways use track constructed with continuously welded rails fastened to the ties with an array of resilient elastic steel fasteners that further reduce maintenance and improve ride quality. Routes with less traffic have generally not been updated with welded rail or the newer fastening devices.

In recent decades, the US rail industry has been using heavier rail for main line track construction. Heavier rail can support greater axle loads and higher train speeds with less stress, damage, and resulting maintenance compared to lighter rail. Rail weight is graded in pounds per yard. For most new construction, the MBTA and Amtrak use rail in the range of 132 to 136 lbs/yard, but substantial portions of both networks use rail in range of 112 to 115 lbs/yard. For instance, most of Amtrak's Downeaster route between Boston and Brunswick runs on 115 lbs rail. Pan Am Railway's main line is built with 100, 112 and 115 lbs rail.

The traditional rule of thumb for track life has been that timber ties should be replaced after 20 years and rail should be expected to last 50 years. The MBTA has had several bad experiences with concrete ties and is not installing them on their commuter rail road. With the materials technology and manufacturing advances of the second half of the 20th Century, both rail and ties are showing longer lifecycles but there is considerable variability in longevity. Depending on a variety circumstances, some timber ties last as long as 40 years while other ties fail in as little as four years after installation. Heavier traffic tends to reduce track life. Moisture from poor drainage and weak ballast support also tends to hasten the deterioration of wooden ties.

- **Inspections** - US railway track used for passenger operations is subject to two inspections per week that visually check for track defects and obstructions. The most common defects are loose or missing fasteners which are fixed by the inspection patrol, as discovered. In addition to frequent inspections, a program of renewal and replacement is required to keep the track up to the desired Federal Railroad Administration (FRA) standard.
- **Ballast** - Once installed, operating track is maintained by periodically renewing (supplementing) the ballast while refining any deviation in the grade and cross level of track.
- **Ties** - There are typically 24 ties per 39-foot section of rail. Only eight to ten of those ties need to be in good condition to support 60 mph passenger trains. The remainder can be allowed to deteriorate. In order to maintain a constant distribution of good ties in the track structure, the ties are periodically renewed to replace the worst with new ties.
- **Rail** - Rail is regularly ground to keep the surface smooth and in good condition. The rail is also subject to regular ultrasonic inspection to find hidden defects in the steel. Where the rail is jointed, defective rails are cutout and replaced. The mechanism for replacing a bad spot in a string of welded rail requires cutting to remove the bad spot and welding in a plug rail to replace it. Wholesale rail replacement programs are infrequent, unless anticipated changes to traffic on the line require greater strength or higher allowable speeds.

Track Class and Maximum Speeds

Standards for track maintenance and maximum speeds are set by the Federal Railroad Administration (FRA). Tracks maintained to a higher standard are allowed to operate at a higher speed. Passenger train speeds generally range between 60 mph for FRA Track Class 3 up to the Class 7 maximum speed of 125 mph (see Table 2-2). Currently, the Northeast Corridor between Boston and Washington is the only route in the United States that permits speeds in excess of 125 mph.[13][14] Most passenger routes and mainline freight routes are maintained to FRA Class 3 or 4. Branch lines and other lightly used routes are maintained to FRA Class 2 or 1.

Table 2-2: Federal Railroad Administration Track Class and Maximum Allowable Speeds (mph)

Track Class	Freight Trains	Passenger Trains
Excepted	10	N/A
1	10	15
2	25	30
3	40	60
4	60	80
5	80	90
6	110	
7	125	
8	160	
9	200	

49 CFR 213.9 - CLASSES OF TRACK: OPERATING SPEED LIMITS (Classes 1-5), and 49 CFR 213.307 - CLASS OF TRACK: OPERATING SPEED LIMITS (Classes 6-9)

[13] U.S. Department of Transportation (USDOT), Federal Railroad Administration (FRA), *Code of Federal Regulations (CFR), Title 49, Track Safety Standards Part 213, Subpart A to F, Class of Track 1-5*, July 11, 2013

[14] U.S. Department of Transportation (USDOT), Federal Railroad Administration (FRA), *Code of Federal Regulations (CFR), Title 49, Track Safety Standards Part 213, Subpart G, Class of Track 6 and Higher*, July 11, 2013

Current Track Class and Speeds

Within the southern 25 miles of the NHML between Boston and Lowell, the MBTA currently operates daily commuter rail service, independent of most freight operations, with some segments maintained to a 70 mph speed standard. Most of trackage is rated for 60 mph passenger operations. It is presumed that any future passenger rail trains operating within this section of commuter rail territory would use existing track and be restricted to the current time table speeds.

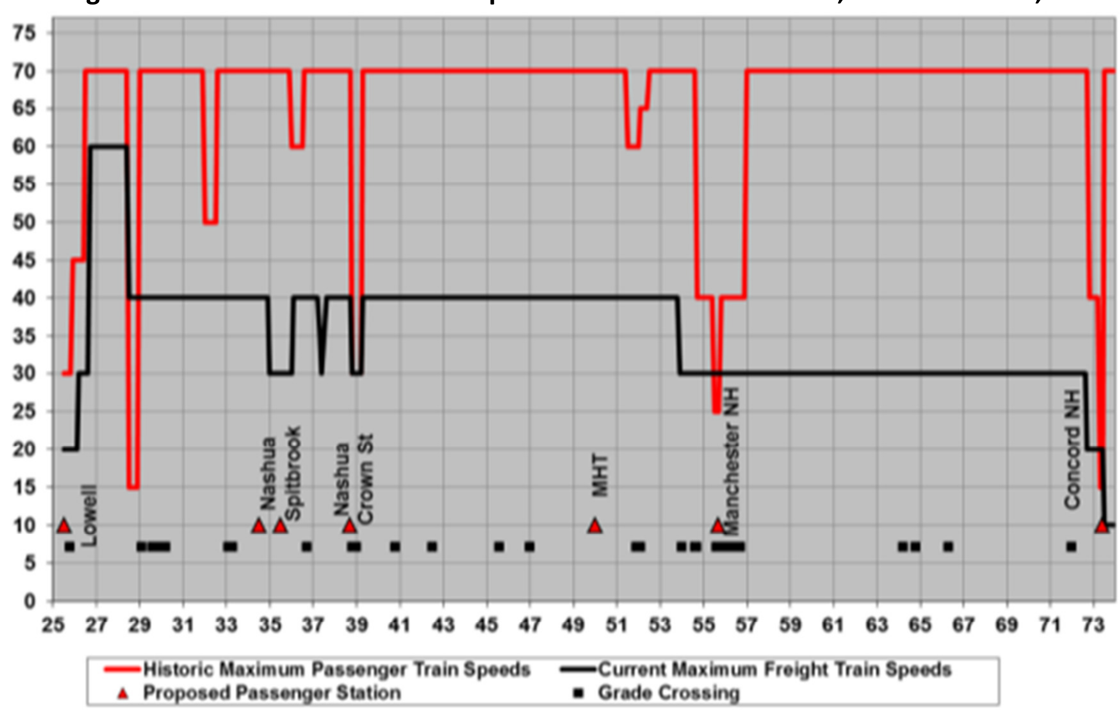
Existing rail traffic north of Lowell consists solely of freight movements with varying levels of train volume depending on the location. The greatest traffic is on the southern portion of the route between Lowell and North Chelmsford, MA. Traffic density between North Chelmsford and Concord, NH decreases as the route extends north of the New Hampshire state line into Nashua, Manchester, Bow and Concord with typically no more than two train movements per day north of Bow.

North from Lowell is a three-mile section of track to North Chelmsford that experiences heavy freight traffic. This segment of Pan Am Railway's east-west main line is maintained for a maximum freight speed of 40 mph (Class 3).

At North Chelmsford the line splits at a wye. The western leg is Pan Am's east-west main line and northern leg is the lesser-traveled NHML. The NHML line runs northerly another seven miles to the New Hampshire state line where right of way and track ownership changes from the MBTA to Pan Am Railways.

Pan Am's ownership continues thirty-nine miles to the north through the cities of Nashua, Manchester and Concord, NH with mostly 40 and 30 mph freight speeds on predominately Class 3 track north to Bow with Class 2 track north to Concord. Figure 2-3 shows the current freight train speeds between Lowell and Concord.

Figure 2-3: Current and Historical Speeds for NHML from Lowell, MA to Concord, NH



Track Conditions

The track conditions along the route are consistent with the assigned FRA Track Class and maximum speeds. Over the 25 miles where the MBTA operates its Lowell commuter rail service, all of the rail is welded with the latest major tie renewal completed in 1992. The oldest rail on this segment was manufactured in 1980. Much of the track uses 132 lbs rail but approximately 20 of the 51 track miles between Boston and Lowell uses 115 lbs rail.

The character of the Pan Am main line between milepost (MP) 25.5 and MP 28.5 varies radically from the MBTA service segment. The track is jointed here and the northbound track is primarily constructed with 100 lbs rail manufactured in 1927. The southbound track is mostly constructed with 112 lbs relay rail from 1965. Relay rail is rail that had been previously used at a different location where it was removed and reinstalled at its present location. Field inspection indicates that tie conditions along this segment are commensurate with the track class. (e.g., at least 10 out of every 24 ties are in good condition.)

The density and composition of traffic on the line change north of the wye at North Chelmsford. Fewer trains are operated but one of the regular trains is a long (approximately 90 car), heavy (over 10,000 tons) coal train bound for the power plant in Bow at MP 68, approximately 40 miles north of the wye. Similar to the Pan Am main line, the rail is almost all jointed. There are approximately two miles of welded rail just north of downtown Manchester. Nearly all of the rail is 112 lbs manufactured during the first half of the 1940s. Records supplied by Pan Am indicate that the last major tie renewals took place in the 1990s but field inspections indicate that the line seems to be in a near constant state of spot tie renewal to maintain sufficient track structure to safely support the coal train. North to Manchester the line is rated as FRA Class 3. North to Bow, the nominal track condition is FRA Class 2. Informal inspection of the line indicates that the coal train's requirements force Pan Am to keep approximately half the ties in good condition to support and guide the heavy train. Where the vertical profile of the railroad is not restricted by grade crossings, the bed of ballast supporting the coal train tends to be deep with full ballast shoulders.

Railway Bridges

A review of Pan Am track charts and inspection and rating reports indicate that there are 25 bridges along the NHML between Lowell's Gallagher Terminal and Concord. The FRA requires all rail carriers to implement bridge management programs that include annual inspections of railroad bridges and determination of the safe load capacity of the structure. Pan Am reports rate the 25 structures along the route subject to passenger rail restoration generally fair to good, with one bridge noted in poor condition.

The locomotive is the heaviest vehicle in a passenger train with a typical weight of 250,000 pounds. All of the rated bridges along the route are qualified to carry this load. Most of the bridges are rated to safely carry cars with a gross weight of 286,000 pounds or more. The bridge classified as being in the poorest condition is rated to carry a capacity of 263,000 pounds. *The two longest bridges crossing the Merrimack River are not rated and should be inspected before passenger service is restored.*

Highway Grade Crossings

There are 35 locations identified between Lowell's Gallagher Terminal and Stickney Avenue in Concord where roadways or pedestrian paths cross the railway at grade. Grade crossings are of particular concern as they present the greatest accident hazard on the railway due to the potential for vehicle/pedestrian conflicts with trains. Grade crossings will require sensitive treatment should substantially greater volumes of trains be reintroduced along the route. Federal safety regulations require trains to sound their horns at all grade crossings. A federally sanctioned "quiet zone" may be established cooperatively with the local community working with the railroad to make substantial investments that reduce the likelihood of accidents

The density of 35 crossings along the 48-mile route is relatively low for a suburban railway. The railway generally hugs the bank of the Merrimack River and only several of the streets are heavily travelled. Most of the grade crossings lead to relatively small riverfront residential enclaves or industrial sites. Of the 35 grade crossings, 21 are public roads, 13 are private driveways, and one is an informal community crossing.

Public grade crossings are roadways that are under the jurisdiction of and maintained by, a public authority. Private grade crossings are on privately-owned roadways, such as those leading into an apartment complex, housing estate or commercial / industrial development. A private crossing is not intended for public use and is not maintained by a public road authority. Nationwide there are approximately 148,000 public crossings and 95,000 private crossings.

- **Lowell**: There are **NO** grade crossings on the study corridor in the City of Lowell.
- **Chelmsford**: There are three private crossings in the Town of Chelmsford. One of these actually functions as a public crossing since it leads into a substantial new residential development on the riverfront.
- **Tyngsborough**: There are two private crossings in the Town of Tyngsborough. One leads to an older established residential enclave. The other leads to several commercial buildings and a boat launching ramp.
- **Nashua**: There are four public crossings in the City of Nashua, three of which are heavily travelled. There is also one private unprotected crossing and one informal crossing used by local residents to recreationally access undeveloped land along the riverfront.
- **Merrimack**: There are four private crossings in the Town of Merrimack, all of which are lightly travelled.
- **Bedford**: There are **NO** public or private grade crossings in the Town of Bedford.
- **Manchester**: There are 13 public and one private crossing in the City of Manchester. Seven of the crossings are located along a single mile of the route adjacent to Manchester's Mill District. Granite Street is undoubtedly the most heavily trafficked crossing along the study corridor.
- **Hooksett**: There are two public crossings in the Town of Hooksett. Neither grade crossing is heavily travelled.
- **Bow**: There are two public and two private grade crossings in the Town of Bow. Three lead into a single farm or industrial plant and one is a busy local street.
- **Concord**: There are **NO** roadway grade crossings along the study corridor in the City of Concord.

Current Rail Passenger Services

On a typical weekday in the spring of 2013, Lowell was served by 44 MBTA revenue trains to and from Boston's North Station. The 25-mile trip serves up to seven intermediate station stops. The running time between Lowell and Boston ranges between 45 and 49 minutes with a maximum allowable speed of 70 mph. Six weekday non-revenue "dead head" trains run between Lowell and Boston to stage the service because there is no facility for the overnight storage or maintenance of the trains in Lowell. Typical weekday MBTA ridership on the entire line is 17,500 passenger trips including both northbound and southbound travel. Lowell is the busiest passenger station on the line with 4,280 weekday boardings and alightings.

The current NHML MBTA service provides 64 weekday passenger trains to and from North Station (see Table 2-3). Of those trains, 44 are revenue trains running between Boston and Lowell and six are the aforementioned non-revenue deadhead trips. The remaining 14 trains are a mix of peak-period, short-turn trains between Woburn and Boston and a variety of express and reverse-peak trains running between Boston and Haverhill via the Wildcat Route. The line also serves 10 Amtrak Downeaster trains from Portland to Boston North Station via Woburn and the Wildcat Route.

The Lowell service requires four train sets in the morning and five train sets in the afternoon. As shown in

Table 2-4, the peak five trains are required to be six, five, six, seven and five cars long. The seven car train regularly carries 652 passengers. All but one car assigned to the Lowell service is a single-level coach. The maximum length of any train berthing at North Station is eight cars. As ridership on the NHML grows, the number of higher capacity bi-level coaches on the route will need to be increased.

Table 2-3: MBTA Service, Ridership and Revenue Statistics

			MBTA				
Station	**Mile Post**	**Amtrak Weekday Revenue Trains**	**Weekday Revenue Trains**	**Typical Weekday Southbound Boardings**	**Cash Fare**	**Average Revenue per Passenger Boarding**	**Typical Total Weekday Passenger Revenue**
Lowell	25.5		44	2,141	$6.75	$6.67	$28,566
North Billerica	21.8		44	1,427	$6.25	$6.38	$18,195
Wilmington	15.2		47	758	$5.25	$5.09	$7,711
Woburn	12.6	10	57	1,743	$4.75	$4.77	$16,640
Mishawum	11.9		6	50	$4.75	$4.95	$495
Winchester	7.8		49	1,002	$4.25	$4.34	$8,701
Wedgemere	7.3		48	740	$4.25	$4.36	$6,459
West Medford	5.5		49	884	$1.70	$1.83	$3,244
North Station	0	10	58	n/a	n/a	n/a	n/a
Totals		**10**	**58**	**8,745**		**$5.15**	**$90,011**

Source: MBTA Conductor's Audit Reports Thursday - February 9, 2012 and Jacobs Analysis

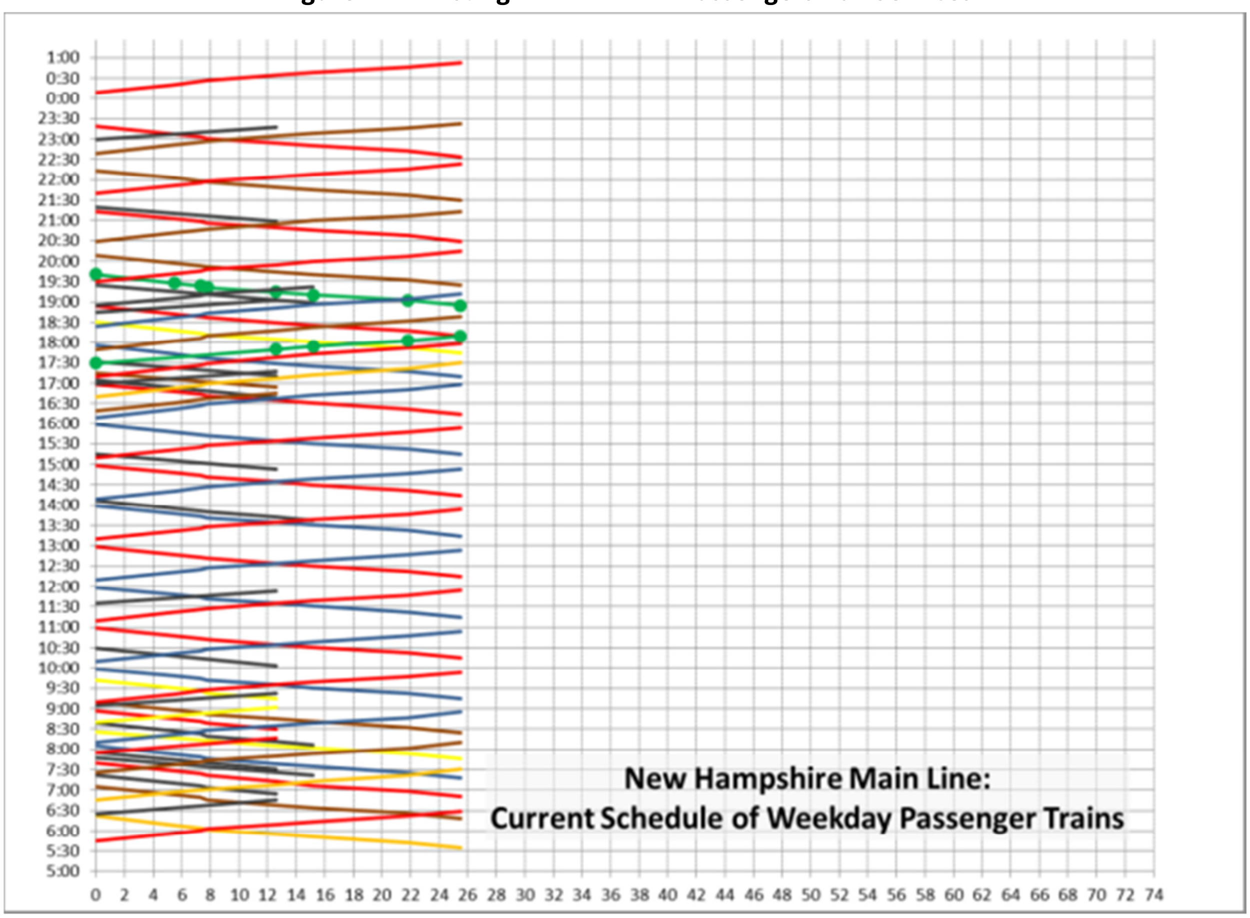
Table 2-4: MBTA NHML Peak Train Lineup

Set	Peak Train	Single Level Coaches	Bi Level Coaches	Seats	Peak Riders
N	310	6		684	579
O	304	4	1	636	493
P	306	6		684	600
Q	308	7		798	652
R	327	5		570	480

A stringline diagram, also referred to as a time-distance diagram, is helpful for planning the flow of traffic on a railroad. These diagrams are a graphical depiction of the timetable and provide a visual representation of trains scheduled to operate on a corridor. The diagrams show distance and station locations along the x-axis and time along the y-axis. The stringlines show the time and location of each scheduled trip. The slope of line indicates direction and relative speed with upward lines representing northbound trips and downward lines representing southbound trips. Intersecting lines show when and where trains will meet and identify where passing sidings or double tracking will be required.

A stringline diagram illustrating current weekday passenger operations on the line is shown in Figure 2-4 For reference, North Station is located at Milepost 0 and Lowell is at Milepost 25. Nashua, Manchester and Concord are located at Mileposts 39, 55 and 73, respectively. The timetable of services can be found in Chapter 3: Service Alternatives.

Figure 2-4: Existing NHML MBTA Passengers Rail Services



Stringline diagrams are used to identify potential schedule conflicts (meets/passes), potential open slots for new service and resource planning (crews, locomotives, etc.). The schedule is also impacted by certain track restrictions that determine line capacity such as physical track layout, number of tracks and the number and spacing of sidings. If a stringline becomes vertical, it means that the train must stop at that location for the duration of the vertical line. Required changes in scheduled departures and arrivals, station dwell times, and train meets can be identified and adjusted in the stringline diagram and then used to update the timetables.

Figure 2-5: Amtrak Downeaster Service Map

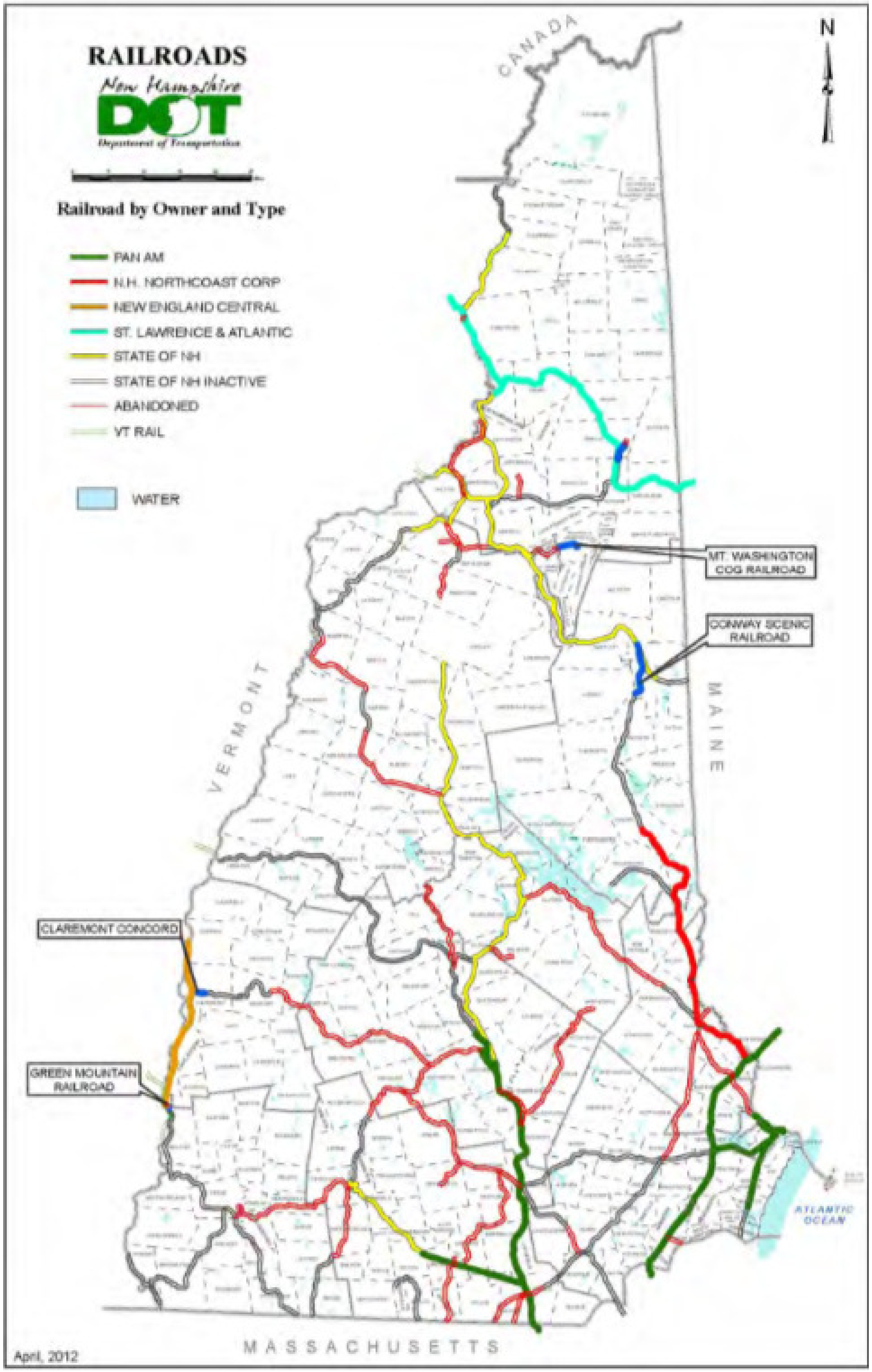
Amtrak Downeaster service between North Station and Brunswick, Maine also operates on the line as far north as Woburn. It then uses the "Wildcat Route" to travel northeasterly Haverhill, MA and on to Maine. Each Downeaster train serves passengers to and from the north at North Station and Woburn. No southbound Amtrak passengers are allowed to board at Woburn and no northbound tickets to Woburn are sold from North Station. The Downeaster averages 1,400 passengers per day at all stations. The typical daily passenger traffic at Woburn is 30 boardings and alightings.

Rail Freight Service

The New Hampshire rail system is composed of five primary owners of the railroad lines: Pan Am Railways, New Hampshire Northcoast Corporation, New England Central Railroad, St. Lawrence & Atlantic Railroad and the State of New Hampshire (see Figure 2-6). In addition to these five primary owners, four of which are also railroad operators, there are six additional freight railroads that either operate on small segments of track in New Hampshire or over track owned by others, such as state-owned lines. These include: Claremont-Concord Railroad, Green Mountain Railroad, Milford-Bennington Railroad, New Hampshire Central Railroad, New England Southern, and Twin State Railroad.

New Hampshire's population and industry are well served by three intermodal terminals located near the state's borders in Worcester, MA; Ayer, MA; and Auburn, ME. New Hampshire and the rest of New England is often referred to as a cul-de-sac in the national rail network, since the area is primarily a freight destination, and no major rail routes traverse the region. Rail volumes in New England tend to be

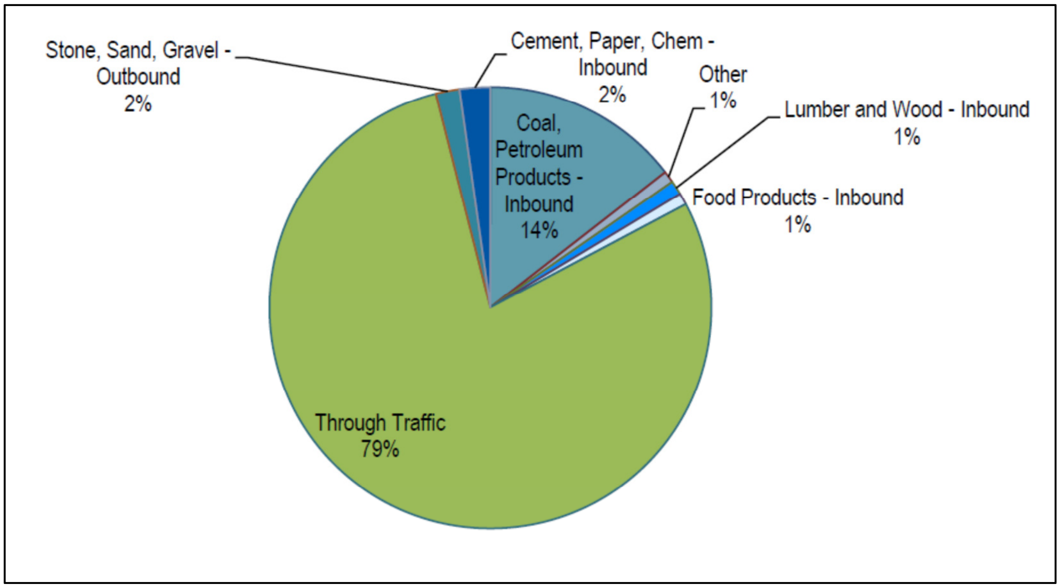
Figure 2-6: New Hampshire Railroads by Owner and Type



Source: New Hampshire State Rail Plan, 2012 considerably lower than other parts of the nation, with only a single Class I rail connection between Boston and Albany, NY.

Approximately 85 percent of national rail freight tonnage is bulk commodities, such as agriculture and energy products, automobiles and components, construction materials, chemicals, equipment, food, metals, minerals, and pulp and paper. Figure 2-7 illustrates that the commodities most commonly shipped to New Hampshire are coal and petroleum products bound for local consumption.

Figure 2-7: New Hampshire Freight Rail Traffic by Commodity/Direction (percent of carloads)



Source: New Hampshire State Rail Plan, 2012

The commodity most commonly shipped from New Hampshire is sand and gravel bound for cement and asphalt plants in Massachusetts. Almost 80 percent of the rail cars moving through the state are through movements between Maine, Eastern Canada and balance of the US.

The NHML connects to the national freight network only at Lowell, MA. This corridor currently receives three quarters of all rail freight tonnage shipped into New Hampshire. While the freight received is quite diverse, traffic flow is dominated by coal for electric generation shipped to Bow, NH. Clay, concrete, glass, and stone also comprise much of the remaining rail freight tonnage moving on the corridor. Other products shipped along the corridor include farm products, lumber and wood products, food, chemicals, and some nonmetallic minerals. Significantly more freight rail traffic is shipped into Southern New Hampshire than is shipped out. Shippers categorize the small amount of outbound freight rail traffic as miscellaneous freight.

Most rail traffic currently shipped to New Hampshire is for local consumption and the volume of outbound rail traffic other than building materials is quite minor. Unless there is major shift New Hampshire's economy to produce, process or consume large volumes of bulk commodities, it is unlikely that the total volume of rail traffic to or from the Granite State will grow at a rate that varies significantly from expected population growth. That is not to say that rail freight in the state would not benefit from improvements to a key rail line serving the state's major population centers, but the magnitude of benefit for long journeys on the national network will likely be relatively small.

2.2 Highway Facilities and Level of Service

This element of the existing conditions chapter summarizes the physical characteristics and usage patterns of the major limited access highways serving the Capitol Corridor. For more information on the NHCC Highway Facilities and Level of Service the reader is referred to the NHCC Project Task 2: Highway Existing Conditions Technical Memorandum. More detail concerning the highway network and its performance is found in NHCC Project Document Task 2: Highway Existing Conditions.

The Capital Corridor's limited access highways that connect New Hampshire's major population centers to metropolitan Boston are I-93, US Route 3 / Everett Turnpike, I-95 / Route 128, I-293, and, I-495. An overall corridor study map showing the subject corridors is shown in Figure 2-8.These highways cover 268 directional miles of limited access freeway facilities and interchanges, shared between the States of New Hampshire and Massachusetts. The breakdown on the corridor mileage is as follows:

- 130 directional miles on I-93;
- 98 directional miles on US Route 3;
- 22 directional miles on Route 128 / I-95; and,
- 18 directional miles on I-495.

Most analysis focuses on I-93 since it is the only direct link into Boston from the study corridor. US Route 3, I-95/Route 128 and I-495 all feed into I-93 for the purposes of travel along the Capitol Corridor to and from the regional core.

Highway Geometrics

I-93 southbound offers three lanes for travel between Hooksett and I-293 where it drops a lane until it reaches the State Line in Massachusetts. A fourth general purpose (GP) lane is added in the vicinity of Wilmington near the Route 125 interchange.

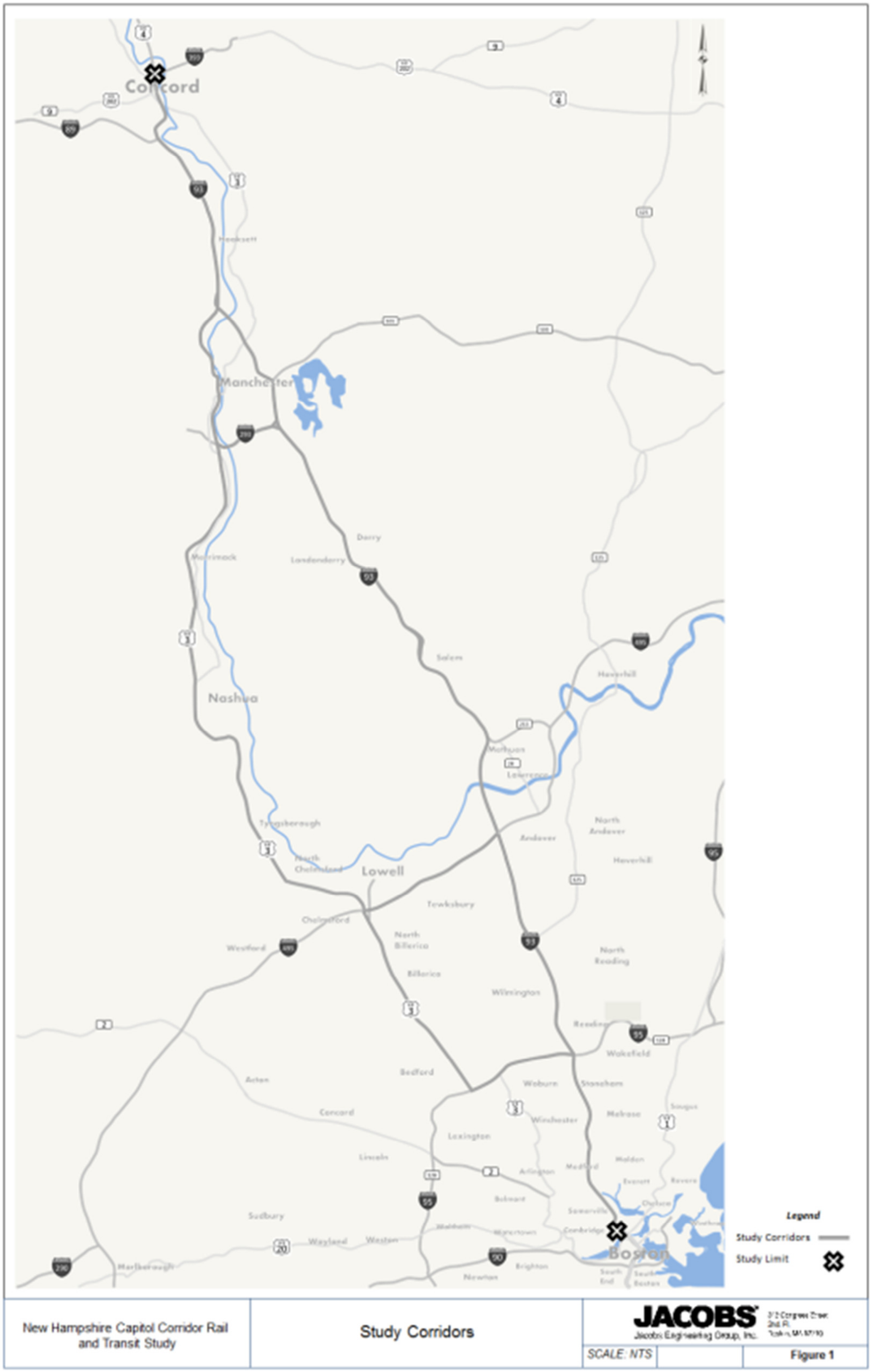
Near Medford and Somerville, MA, south of Exit 30, I-93 southbound splits into one high occupancy vehicle (HOV) lane and three GP lanes. After Exit 28, the three GP lanes on I-93 southbound drop to two GP lanes for approximately 1,360 feet before regaining the third GP lane at Exit 29.

I-93 is currently being widened to four GP travel lanes in each direction in New Hampshire between Exits 1 and 5 from the Massachusetts State Line to Manchester, NH for a distance of approximately 19.8 miles. The project is expected to be completed in 2018. For the purposes of this study the widening project is presumed to be complete.

US Route 3 / The Frederick Everett Turnpike southbound generally carries two GP travel lanes from Concord to I-89 where it adds a third lane. US Route 3 carries three GP lanes from I-89 to the I-93 split.

After the I-93 split, US Route 3 generally carries two GP lanes from Manchester, NH to NH Route 101, where US Route 3 widens and fluctuates between three and four lanes. It narrows and fluctuates between two and three GP lanes from Exit 13 in Merrimack, NH to Exit 8 in Nashua, NH. From Exit 8 and to the Massachusetts State Line, US Route 3 fluctuates between four and three GP lanes. In Massachusetts, US Route 3 generally carries three GP lanes from the State Line to Route I-95/128 in Burlington, MA.

Figure 2-8: Study Corridor Highways



I-95/Route 128 northbound generally carries four GP lanes between US Route 3 and I-93. It should be noted that north of I-93, I-95 has a lane drop from four to three GP travel lanes.

I-495 northbound generally carries three GP lanes between US Route 3 and I-93.

I-93 northbound generally carries four GP travel lanes from Exit 29 in Somerville, MA to Exit 41 in Wilmington, MA. After Exit 41, a lane is dropped and there are three GP lanes up to the State Line. In New Hampshire, I-93 northbound carries two GP lanes from the State Line to Exit 5 in Manchester, NH. After Exit 5, I-93 northbound fluctuates between two and four lanes up to Exit 7 where it generally settles to three GP lanes up until the US Route 3/Frederick Everett Turnpike merge. As noted above, I-93 is currently being widened to four GP travel lanes in each direction in New Hampshire from the State Line to Manchester, NH for a distance of approximately 19.8 miles.

US Route 3 northbound generally carries three GP travel lanes from Burlington, MA though the State Line to Merrimack, NH. Starting before Exit 10, US Route 3 northbound fluctuates between three and two lanes up to the I-93 merge. North of the I-93 merge, US Route 3 northbound fluctuates between three and four GP lanes. After the I-89 interchange, US Route 3 northbound carries two GP lanes up to Concord, NH.

I-95/Route 128 southbound carries three GP travel lanes into the I-93 interchange and adds a fourth lane south of the interchange which carries through to and beyond US Route 3.

I-495 southbound carries three GP travel between I-93 and US Route 3.

Breakdown Lanes & Managed Lanes

Peak period breakdown travel lanes on I-93 northbound and southbound between Exits 45 and 47 exist at this time, but will be permanently removed with the reconstruction of the Methuen interchange at Route 110/113 and I-93.

There is an existing managed lane on I-93 southbound that begins in Medford, MA. After Exit 30 and before Exit 28, I-93 southbound splits into one high occupancy vehicle (HOV) lane and three GP lanes. There is a 4-foot painted buffer separation between the HOV lane and the adjacent GP lanes. The HOV lane ends at the Leonard P. Zakim Bunker Hill Bridge at the I-93/Route 1 merge. There are no other entrances or exits for the southbound HOV lane between the Mystic Avenue on-ramp entrance and the Zakim Bridge. Buses, carpools (defined as two or more occupants), motorcycles, and vanpools using the HOV Lane can save up to ten minutes during morning peak period commute. The HOV restrictions apply between 6:00 AM and 10:00 AM, Monday through Friday.

Highway Level of Service

Level of Service (LOS) is commonly used to describe the operating conditions for ground transportation facilities. LOS for freeway facilities is calculated from vehicular speed, volume, and density. LOS ranges from LOS A to F, where LOS A describes free-flow operations, LOS E describes operations at capacity, and LOS F describes breakdown conditions and unstable traffic flow.

LOS analysis for freeway sections is based upon density of vehicles. Density is measured in passenger cars per mile per lane (pc/mi/ln). LOS is a term used to denote different operating conditions that occur at a given roadway segment under various traffic volume loads. It is a qualitative measure of the effect of a number of factors including roadway geometrics, speed, travel delay, freedom to maneuver, and safety.

The LOS for ramp merge and diverge points are based upon the density of vehicles upstream of the merge and downstream of the diverge points. Weave sections are defined as the segment of roadway bounded by an on-ramp followed with an off-ramp, creating a potential conflict for vehicles trying to enter the roadway and vehicles trying to exit the roadway within the same stretch of pavement.

Given the regional scale of this study, LOS and volume-to-capacity (v/c) were identified as appropriate performance measures to evaluate the limited access freeway conditions during the weekday peak hours. The LOS criteria for freeway sections, ramp junctions, and weaving segments are shown in Table 2-5.

Table 2-5: Highway LOS Thresholds

LOS	Freeway	Ramps	Weaving
	Density (cars/mile/lane)	Density (cars/mile/lane)	Density (cars/mile/lane)
A	0 – 11	0-10	0-10
B	> 11 – 18	> 10-20	>10-20
C	> 18 – 25	>20-28	>20-28
D	> 25 – 35	>28-35	>28-35
E	> 35 – 45	>35	>35-43
F	Overcapacity	Overcapacity	>43

Source: 2000 Highway Capacity Manual

Year 2013 existing weekday morning peak hour LOS and volume-to-capacity ratios for inbound traffic towards metropolitan Boston are shown in Figure 2-9. Under current conditions, there is severe traffic congestion inbound towards Boston during the weekday AM peak hour. The vehicular demand exceeds capacity with a v/c ratio greater than 1.25 from Exits 36 to 27. Various sections between Exits 36 and 27 have LOS E conditions. I-93 between I-95/Route 128 and I-495 is generally over-capacity with LOS E and F conditions. I-95/Route 128 between US Route 3 and I-93 is generally over-capacity with traffic congestion

The existing weekday evening peak hour LOS and volume-to-capacity ratios for outbound traffic from metropolitan Boston are shown in Figure 2-10. Under current conditions, there is severe traffic congestion outbound from Boston during the weekday PM peak hour. The vehicular demand exceeds capacity with a v/c ratio greater than 1.25 for various segments between Exits 27 to 39. Various sections between Exits 27 and 39 have LOS E and F conditions. North of Exit 39 and up to I-495, I-93 is generally at or over capacity. I-95/Route 128 between US Route 3 and I-93 is generally over-capacity with traffic congestion, and predominately at or near capacity closer to US Route 3.

Peak Travel Speeds

Travel speed and time data for the network was collected via real-time, GPS-equipped, anonymous cell phone technology - through two internet mapping sources (www.google.com/maps and www.bing.com/maps). The internet data established current travel speeds and hot spot locations for congestion between the major population centers in New Hampshire and Boston. The data collection was undertaken in June 2013 during the weekdays - excluding Mondays and Fridays.

Year 2013 existing weekday morning peak period travel speeds for inbound traffic towards Boston are shown in Figure 2-11. The existing weekday evening peak period travel speeds for outbound traffic from metropolitan Boston are in Figure 2-12.

Travel Time Contours

Year 2013 existing weekday morning peak hour travel time contours for inbound traffic towards Boston are shown in Figure 2-13. The existing weekday evening peak hour travel time contours for outbound traffic from Boston are shown in Figure 2-14

Travel times from Concord to Boston during the inbound AM commute are bottom-heavy due to the gradual increase in congestion approaching Boston. Nearing Boston, congestion is severe with speeds less than 30 mph. Travel times inbound currently take up to 20 minutes from Medford, Malden, and Everett - areas only 4 miles from Boston – with an average speed of 12 mph. Expanding radially by another 4 miles, the travel times into Boston double to 40 minutes – still with an average speed of 12 mph. Between I-95 and I-495, travel times into Boston can take up to 60 minutes by vehicle.

Travel times outbound from Boston during the PM commute are top-heavy due to the severe congestion experienced exiting Boston northbound – but not as severe as the morning peak hour. Travel times outbound currently take up to 20 minutes to Medford, Malden, and Winchester - areas only 7 miles from Boston – averaging just over 20 mph. Expanding radially by another 7 miles, the travel times exiting Boston double to 40 minutes – still averaging just over 20 mph. Travel times to Lawrence currently take less than 60 minutes, and commutes to beyond Salem, NH take less than 70 minutes. Travel times from Boston to Concord take less than 90 minutes in weekday PM peak hour traffic.

Figure 2-9: Year 2013 AM Peak Hour Highway Level of Service

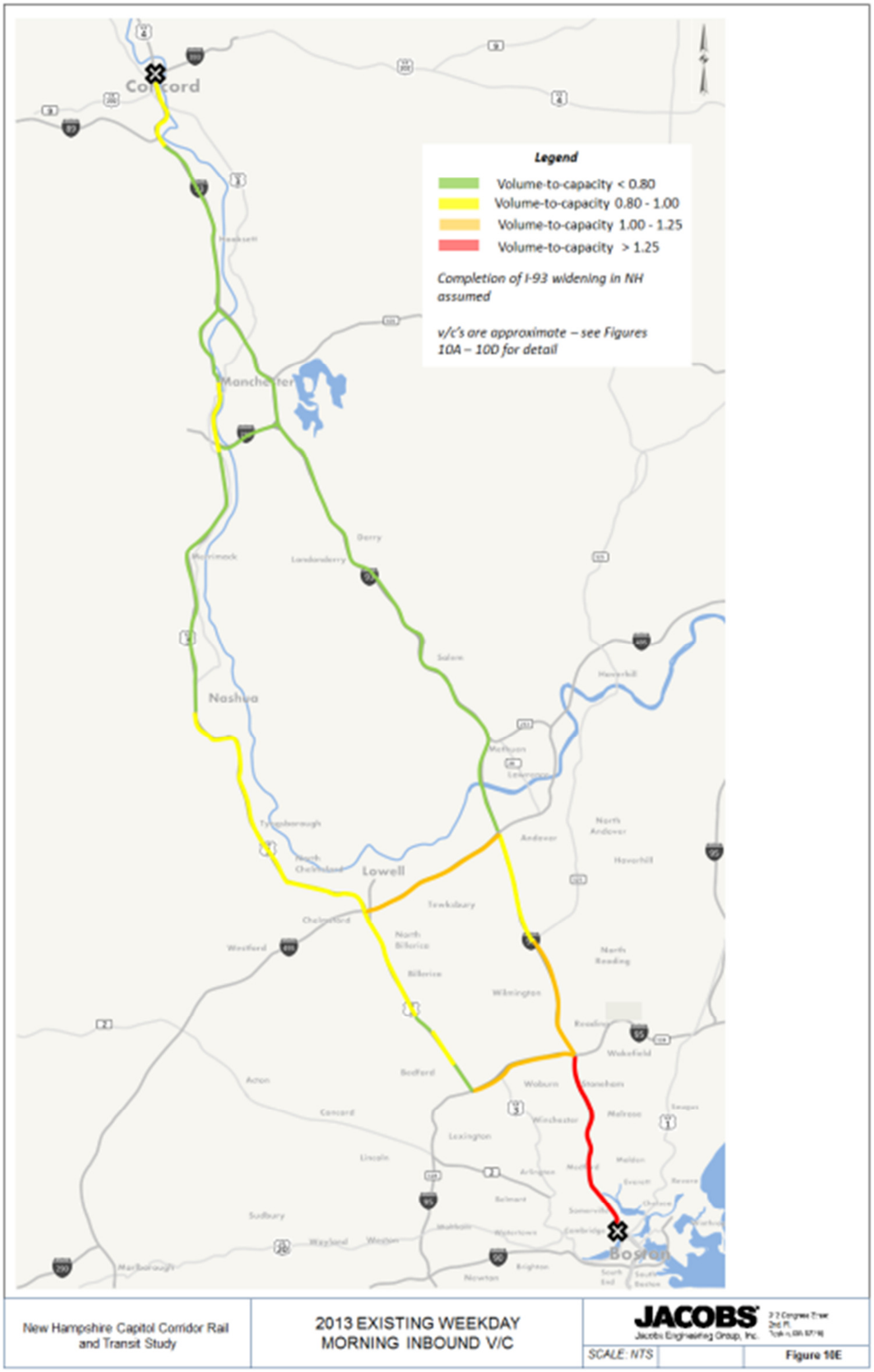


Figure 2-10: Year 2013 PM Peak Hour Highway Level of Service

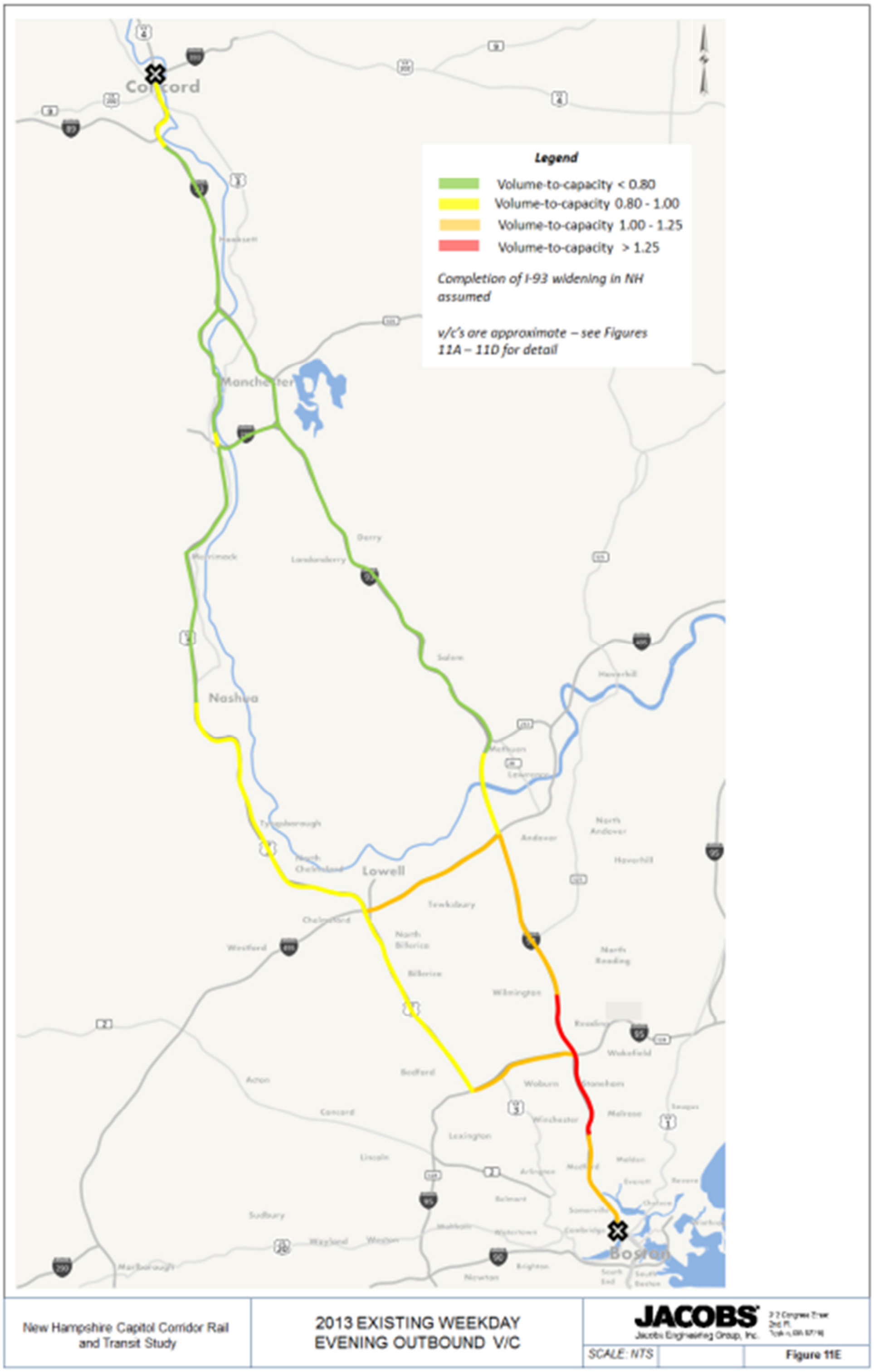


Figure 2-11: Year 2013 Weekday Morning Inbound Speeds

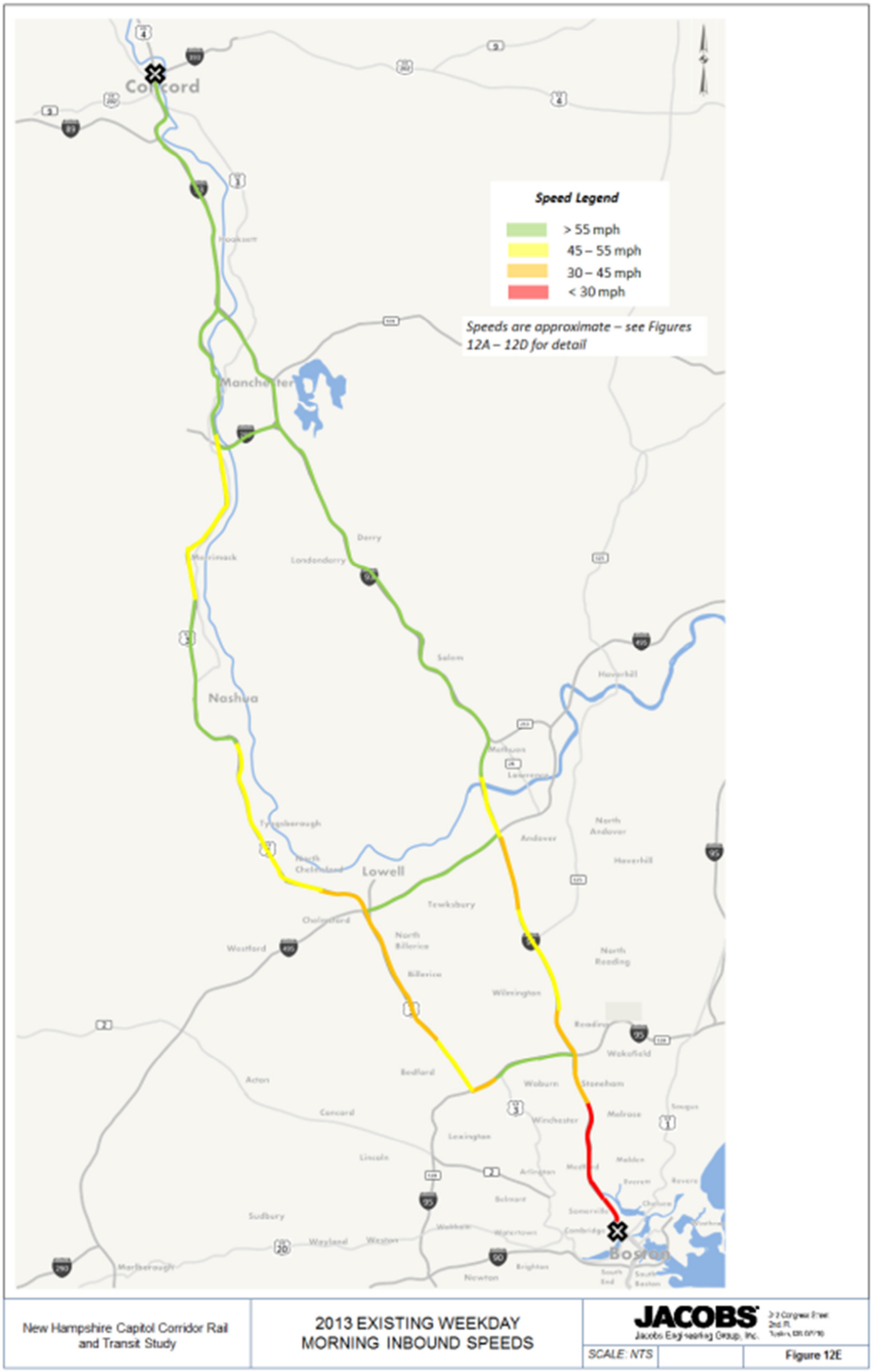


Figure 2-12: Year 2013 Weekday Evening Outbound Speeds

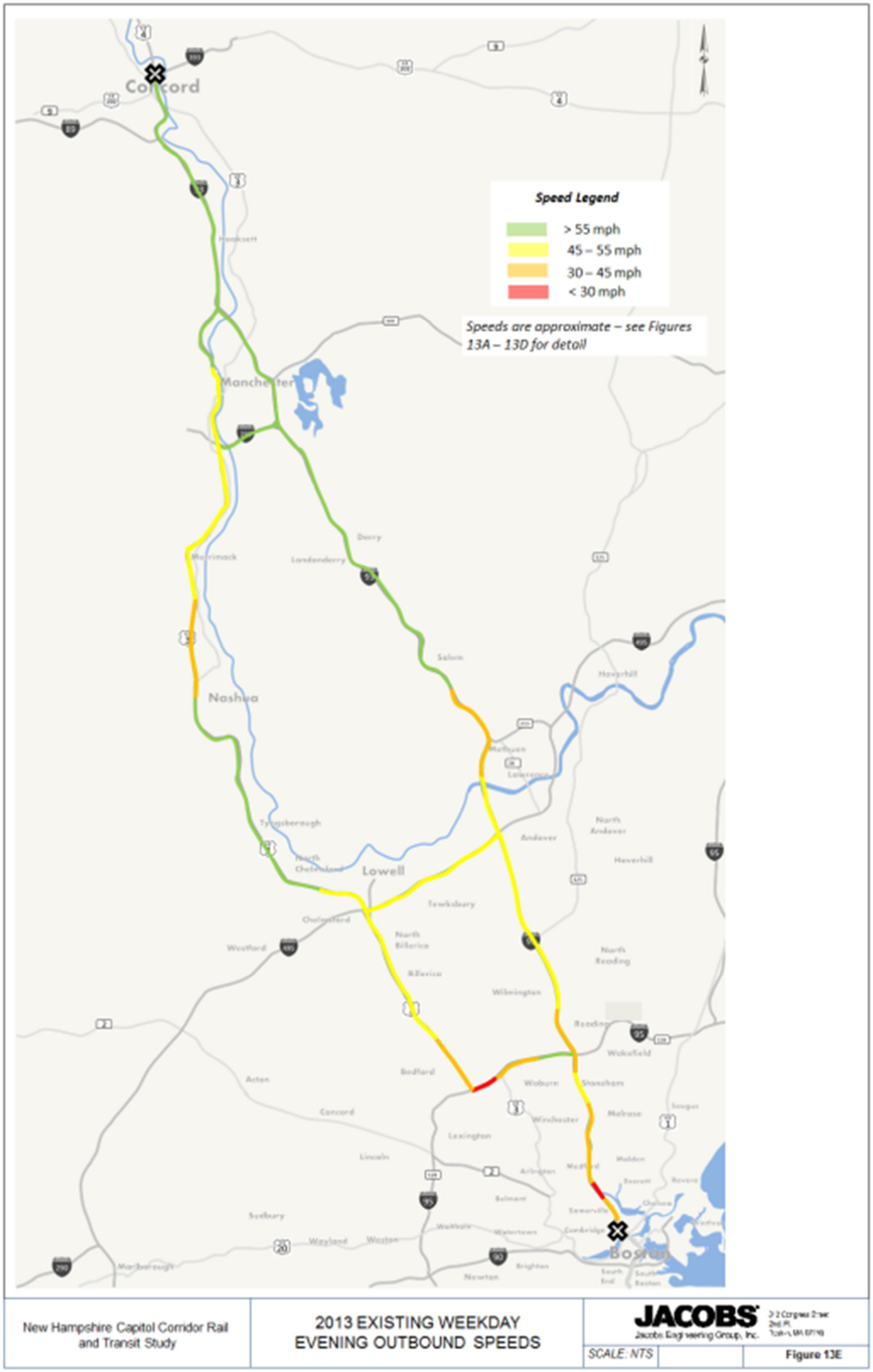


Figure 2-13: Year 2013 Evening Inbound AM Peak Period Travel Time Contours

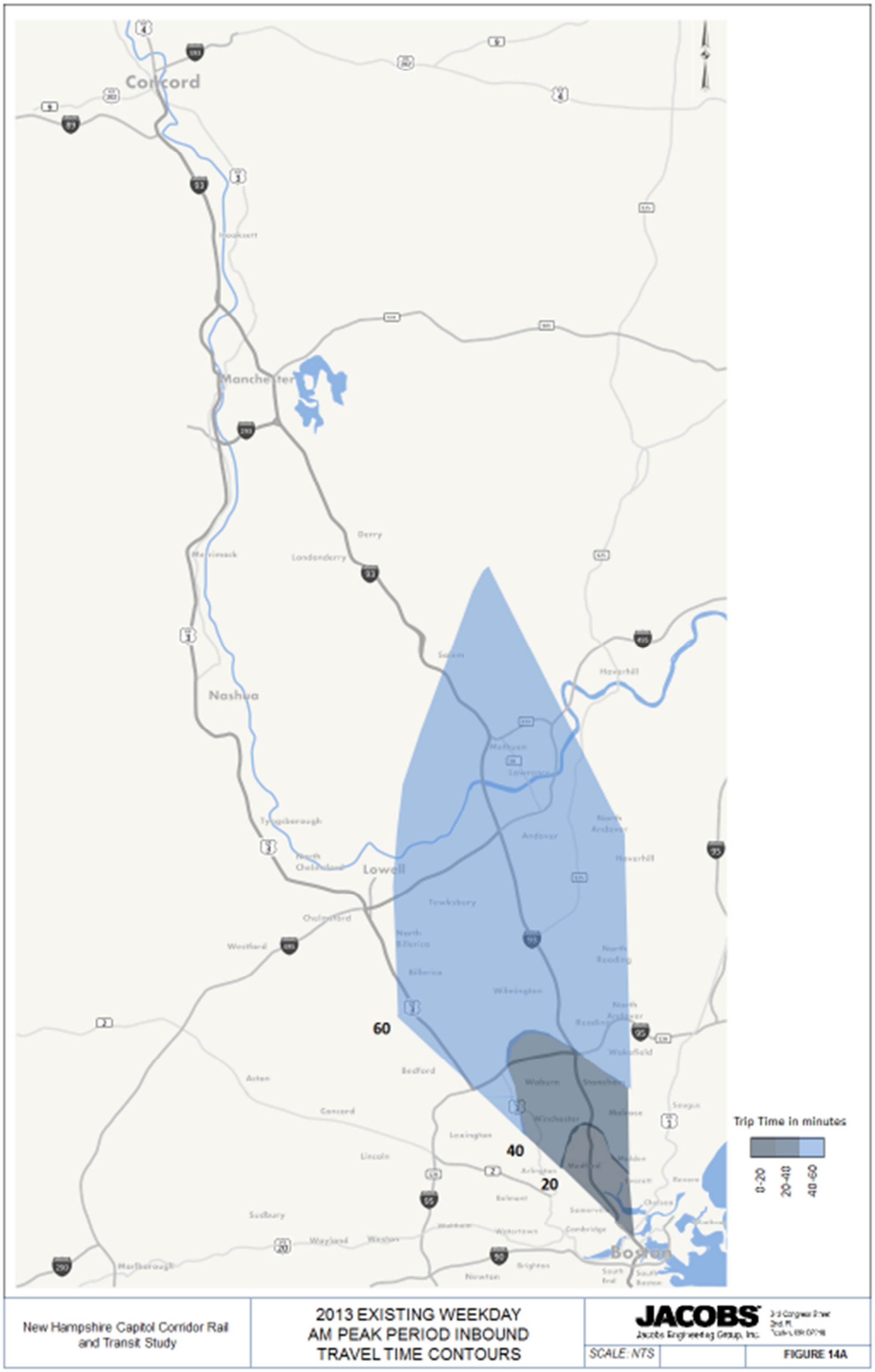
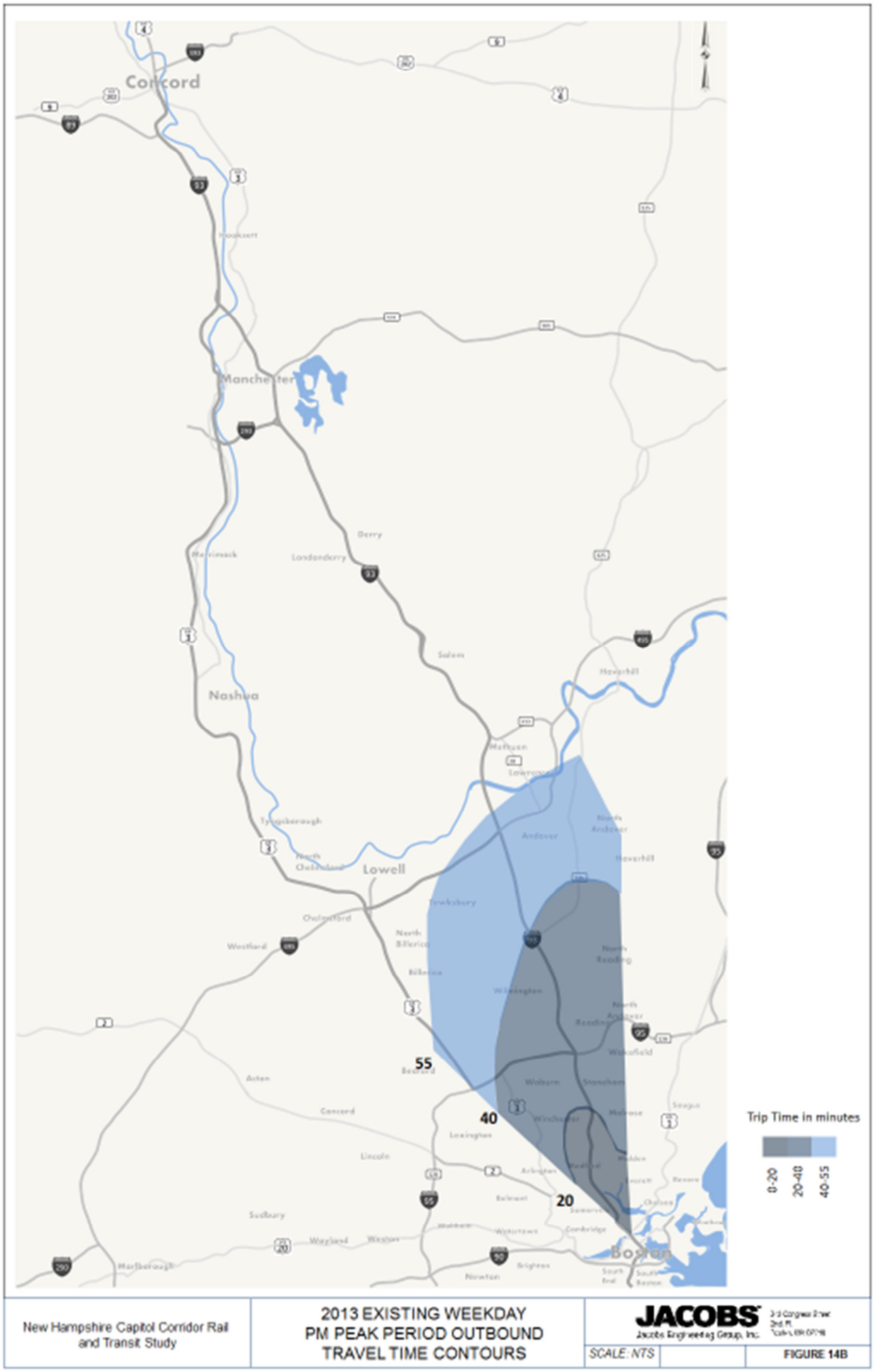


Figure 2-14: Year 2013 Evening Outbound PM Peak Period Travel Time Contours



Highway Conditions Summary

Severe traffic congestion is evident entering and exiting Boston via I-93 North during the weekday peak periods. When travel speeds drop below 30 mph, traffic volumes are generally understood to exceed road capacity by over 25%. Average peak period speeds on I-93 have been shown to drop to as low as 12 mph for the last eight miles inward to Boston-.

The current freeway infrastructure on I-93 North is a contributing factor to the severe traffic congestion experienced entering and departing Boston. After Exit 28 in Somerville, the three general purpose lanes on I-93 southbound drops to two general purpose lanes for over 1,000 feet before regaining the third lane at Exit 29. This lane drop less than four miles away from Boston is currently a choke point causing severe congestion on I-93 on typical weekday AM conditions.

In New Hampshire, I-93 North is currently being widened to four GP travel lanes in each direction between Exits 1 and 5 from the MA State Line to Manchester, NH for a distance of approximately 19.8 miles. This will add tremendous peak hour vehicular capacity and facilitate more efficient traffic operations in New Hampshire.

However, the future lane imbalance with the I-93 SB lane drop from four lanes to three lanes between the NH State Line and Exit 41 in Wilmington, MA for approximately 11.5 miles is expected to be a key choke point and source of congestion in the future AM peak period.

In the northbound direction during the PM peak period, after Exit 41 and the Route 125 interchange, I-93 northbound drops a lane and consist of three GP lanes to the NH State Line. In the future, this reduction from four to three lanes at Exit 41, and back to four lanes in NH is expected to be choke point and a source of peak hour congestion in the weekday PM.

Additionally, the peak period breakdown travel lanes on I-93 northbound and southbound between Exits 45 and 47 will permanently be eliminated with the reconstruction of the Methuen interchange at Route 110/113 and I-93.

With regards to managed lanes and the benefits of higher travel speeds and higher person throughputs, there is an existing managed lane on I-93 southbound that begins in Medford, MA. After Exit 30 and before Exit 28, I-93 southbound splits into one high occupancy vehicle (HOV) lane and three GP lanes. There is a 4-foot painted buffer between the HOV lane and the adjacent GP lanes. The HOV lane ends at the Bunker Hill Bridge at the I-93/Route 1 merge. There are no other entrances or exits for the southbound HOV lane between the Mystic Avenue on ramp entrance and the Zakim Bridge.

While there is a managed lane for I-93 southbound that spans approximately two miles, it does not span the nine mile breadth of inbound congestion during the AM peak period which begins just south of I-95/Route 128. There are no managed lanes northbound on I-93 to improve travel speeds or user throughput during the weekday PM peak period.

2.3 Corridor Bus Services[15]

In total, seven regional and four local bus transit operators provide service within New Hampshire and intercity service to Boston and beyond. All of these services are subject to the same highway congestion that affects automobile traffic on I-93 and other elements of the corridor highway network. Each of these services has access to the HOV lane on I-93 that travels 2.5 miles between the Shore Drive overpass in Somerville and the Bunker Hill Bridge,, potentially saving up to 10 minutes compared with morning peak travel in the general purpose lanes.

Boston Express provides the primary commuter service from the study area to Boston along the heavily congested Massachusetts segments of Interstate 93. The service was initially introduced by NHDOT as a mitigation measure during highway construction along I-93. Concord Coach also provides intercity service to Boston along the central spine of New Hampshire as far north as Berlin, NH. In Massachusetts, the MBTA and MVRTA also provide commuter service to Boston along I-93 from communities to the north of the city.

Additional New Hampshire regional bus service between communities outside of the study area and to Boston operates through the study area or along segments of the study corridor. Dartmouth Coach provides service from Dartmouth University in Hanover, NH and White River Junction, VT to Boston and travels non-stop through the study area along I-89 and I-93. Service to and from the New Hampshire Seacoast is operated by C&J from Dover, NH, Durham, NH, Portsmouth, NH and Newburyport, MA to Boston and New York City. Finally, Greyhound provides intercity service from Boston to Manchester, Concord and points north and west and from Boston to Nashua via Worcester, MA and Leominster, MA.

Local bus service within the New Hampshire portion of the study area is provided by Concord Area Transit, Manchester Transit Authority and Nashua Transit Service. Local bus service in Massachusetts is also provided within the study area by the Lowell Regional Transit Authority. Interconnections between these local providers are limited.

Boston Express

Boston Express is a privately operated network of commuter buses that were originally procured by the State of New Hampshire as a mitigation measure for the expansion project on Interstate 93. NHDOT allocated capital investment to acquire the buses and construct a number of park and ride facilities.

Two routes provide service to Boston South Station from the downtown Manchester bus terminal on Canal Street at Granite Street and via park and ride facilities on Route 3 or I-93. The Route 3 service makes stops at Exit 8 in Nashua and Exit 35 in Tyngsborough, MA, while the I-93 service makes stops at Exit 5 in North Londonderry, Exit 4 in Londonderry and Exit 2 in Salem.

The I-93 service operates 24 peak period trips per day at 15–30 minute headways and 31 off-peak trips 30-60 minute headways. The Route 3 service operates 14 peak period trips per day at 20-30 minute headways and 32 off-peak trips per day at 45-120 minutes headways.

[15] For more information on the Bus Services in the NHCC the reader is referred to the *NHCC Project TASK 2: EXISTING BUS SERVICES Technical Memorandum*.

Most Boston Express trips follow I-93 directly to Boston South Station, but many of the southbound peak period trips on the I-93 service travel through downtown Boston to serve commuters on the way to or from South Station. Northbound trips to New Hampshire do not circulate through downtown, but depart directly from South Station and travel north on I-93.

Existing traffic congestion along I-93 significantly impacts Boston Express' scheduled travel times. For instance, the 6:30am southbound departure from Londonderry (Exit 4) on the I-93 service is scheduled for a one hour trip to South Station. Meanwhile, the 9:50am southbound departure is scheduled for a two hour and twenty minute trip, which is a built-in or induced delay of one hour and twenty minutes.

Average daily ridership on the I-93 service is approximately 1,200 boardings and on the Route 3 service is approximately 600 daily boardings.

Figure 2-15: Boston Express and Concord Coach Bus Routes

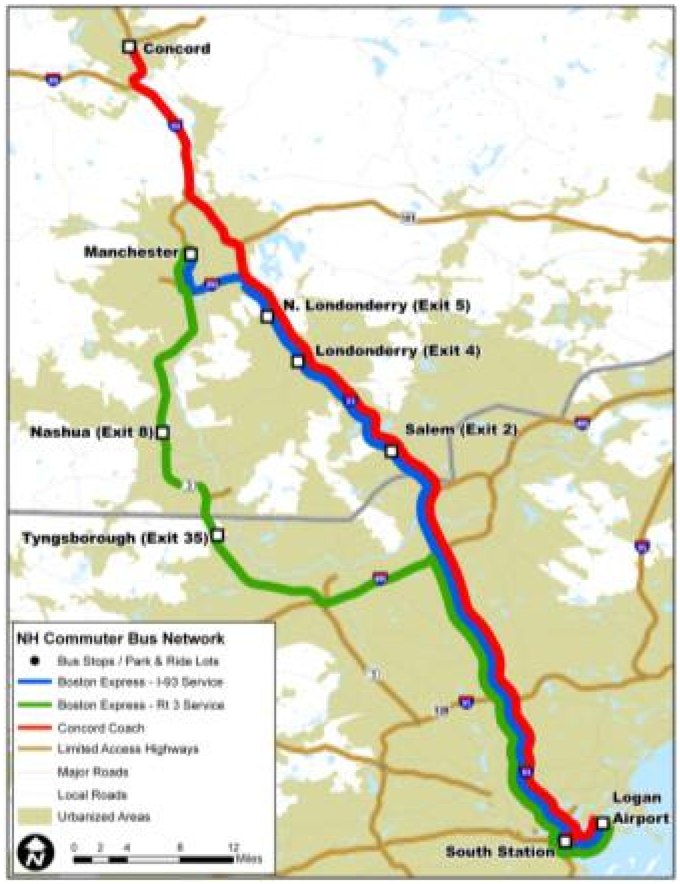


Table 2-6: Boston Express I-93 Service

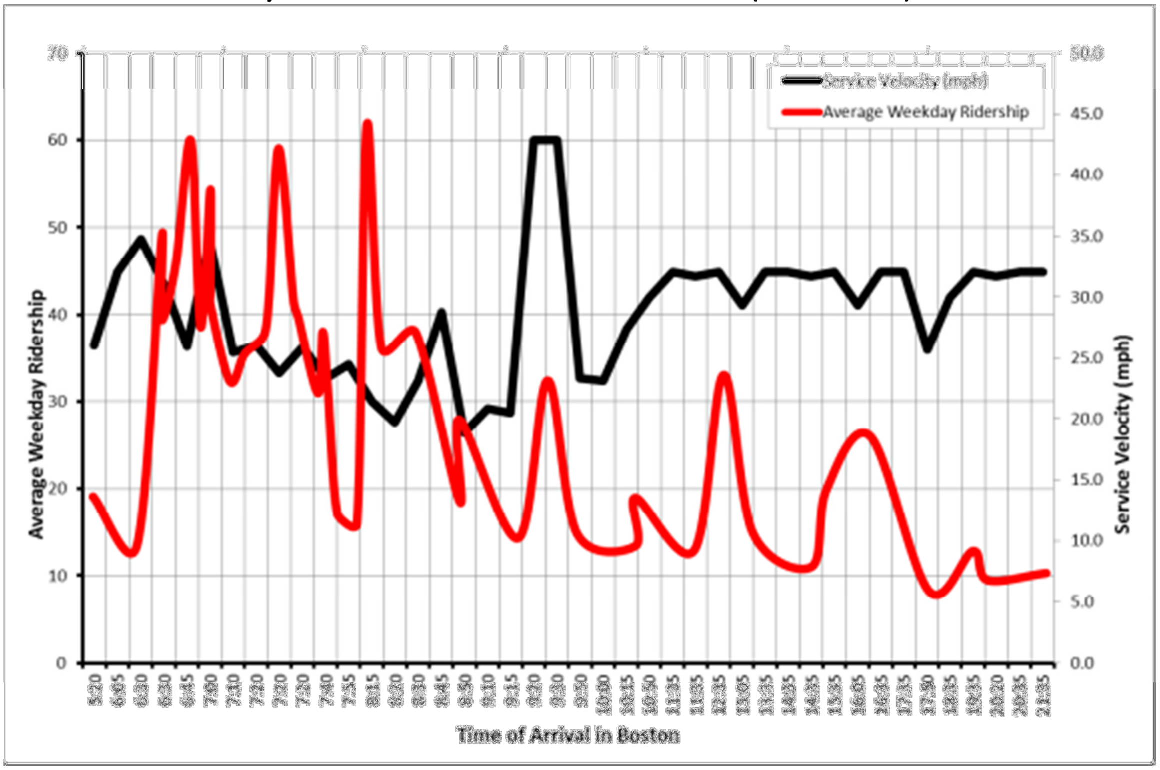
	I-93 Southbound Service	I-93 Northbound Service
Average Weekday Ridership (March 2013)	613	602
Peak Trips	12	12
Off-Peak Trips	17	14
Span of Service	4:00am – 9:50pm	7:15am – 11:55pm
Peak Headways	20-30 min	15 min
Off-Peak Headways	30-60 min	60 min

Table 2-7: Boston Express Route 3 Service

	Route 3 Southbound Service	Route 3 Northbound Service
Average Weekday Ridership (March 2013)	298	306
Peak Trips	7	7
Off-Peak Trips	16	16
Span of Service	5:30am – 8:35pm	7:15am-11:00pm
Peak Headways	30 min	20-30 min
Off-Peak Headways	90-120 min	45-90 min

Figure 2-16 shows the average weekday ridership and service velocity by the southbound time of arrival in Boston for March 2013. The black line shows scheduled service velocity in miles per hour by time of day. As would be expected service velocity is substantially higher for midday and evening trips. The red line shows average daily ridership for each scheduled trip. Boston Express suffers due to traffic congestion on I-93, because its service velocity is lowest when demand for its service is highest.

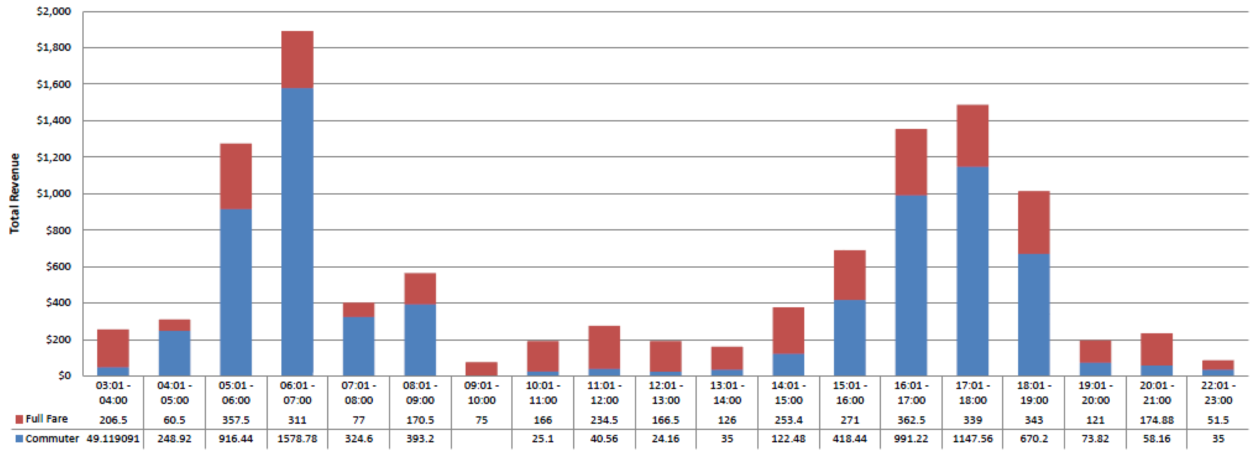
Figure 2-16: Average Weekday Ridership and Service Velocity by Southbound Time of Arrival in Boston (March 2013)



Most peak users of the Boston Express service are regular commuters as evidenced by their use of the discounted multi-ride commuter tickets. The off peak riders are much more likely to travel using a full fare one-way ticket. Figure 2-17 shows the number of passengers per hour who use a multi-ride commuter ticket (blue) and the number who purchase full fare, single ride tickets.

Boston Express operates commuter service on a franchise from the State of New Hampshire and receives an annual subsidy. The subsidy is assessed each year based on operating revenue shortfalls. Its sister operation Concord Coach, operates as an entirely private entity and does not receive operating support for its intercity service. Both services use buses purchased with financial assistance from the State of New Hampshire. All the park and ride lots in the corridor used by Boston Express and Concord Coach were constructed and are owned by state or local governments.

Figure 2-17: Boston Express Total Revenue Collected by Fare Type and Departure Time



Concord Coach

Formerly known as Concord Trailways, Concord Coach Lines, Inc. is an intercity bus company originally founded in 1967, and expanded in 1988 with the purchase of the Trailways franchise. Concord Coach Lines operates along the I-93 corridor with service from Berlin, NH and Littleton, NH through Concord to Boston South Station and Logan Airport. It also operates service in the I-95 corridor between Bangor, ME and Boston. New Hampshire DOT tracks Concord Coach boardings at the Concord NH bus station on Stickney Avenue. In 2012, ridership averaged approximately 150 passenger boardings per day.

Concord Coach operates a total of 13 northbound and 12 southbound trips per day between Concord, South Station and Logan Airport in Boston. Two roundtrips per day operate between Concord and Littleton. One roundtrip per day operates between Concord and Berlin and a truncated weekend-only service operates between Concord and as far north as North Conway. Boston Express tickets are cross-honored on all trips between Manchester, North Londonderry, Salem and Boston.

Table 2-8: Concord Coach I-93 Bus Service

	Southbound Service	Northbound Service
Ridership	n/a	n/a
Peak Trips	4	5
Off-Peak Trips	8	8
Span of Service	5:00am-8:50pm	7:15am-11:20pm
Peak Headways	60 min	60 min
Off-Peak Headways	60 – 120 min	60 – 120 min

Massachusetts Bay Transportation Authority (MBTA)

The MBTA operates four peak-period, weekday-only express bus services within the study corridor along I-93 from Woburn, Burlington and West Medford to Haymarket and State Street in downtown Boston. Together these four routes carry almost 2,000 weekday passenger trips. These routes are subject to the same peak period traffic congestion on I-93 that adversely impacts motorists and other express bus services.

Table 2-9: MBTA I-93 Bus Service

Route	Garage	Terminals	Weekday Boardings		
			Inbound	Outbound	Total
325	Charlestown	Elm St. - Haymarket Station	171	149	320
326	Charlestown	West Medford - Haymarket Station	227	207	434
352	Charlestown	Burlington - State Street	180	197	377
354	Fellsway	Woburn Line - State Street	365	427	792
		Total	**943**	**980**	**1,923**

Merrimack Valley Regional Transit Authority (MVRTA)

The MVRTA Boston Commuter Bus provides four inbound trips in the morning and four outbound trips in the evening via I-93. These buses, carry 257 passenger trips on a typical weekday and are subject to the same peak congestion that impacts other users of I-93.

Greyhound

Greyhound provides intercity service from Boston to Manchester, Concord and points north and west. Four daily Montreal-bound trips depart from Boston, three of which stop at Manchester Airport, two stop in Manchester and one stops in Concord. Of the four daily southbound trips from Montreal to Boston, one stops in Concord and Manchester, while all four stop at Manchester Airport. Greyhound also provides one trip per day between Boston, Nashua, Manchester and Concord via Worcester, MA and Leominster, MA.

Dartmouth Coach

Dartmouth Coach provides intercity service from New Hampshire's Upper Valley to Boston and New York City. It does not make any stops or provide any service to communities within the study area.

Manchester Transit Authority (MTA)

The MTA provides bus service throughout Manchester and operates express service to Nashua and Concord. Thirteen routes provide scheduled service to Manchester and surrounding destinations. Two express routes provide service from downtown Manchester to Concord and from downtown Manchester to the Nashua Mall. The Concord Express originally served the Manchester-Boston Regional Airport (MHT), but that service was eliminated to low ridership.

Nashua Transit System (NTS)

The NTS comprises nine local routes that begin and end their trips at the downtown Transit Center behind City Hall. Each route operates 12-13 roundtrips per day on hourly headways.

Concord Area Transit (CAT)

The CAT operates three weekday routes serving the City of Concord and surrounding communities. Each route operates 12-13 hours per day.

Lowell Regional Transit Authority (LRTA)

The LRTA operates 12 local routes and one downtown shuttle serving the City of Lowell and the towns of Billerica, Burlington, Dracut, Chelmsford, Tewksbury, Tyngsborough, Westford and Wilmington. All 12 routes now operate on hourly headways. The downtown shuttle operates on 30 minute headways from 7:30 AM - 7:00 PM.

3.0 SERVICE ALTERNATIVES

The study team held numerous meetings with a wide variety of stakeholders including public officials from New Hampshire and Massachusetts, all the regional public transportation providers, Amtrak, Pan Am Railways and the general public. The project rationale derived from the process of assembling and evaluating information concerning existing and likely future travel conditions in the corridor, . This research and consultation led the team to understand the opportunities and constraints it faced in frame alternatives for improved public transport service in the corridor. As the study was jointly funded by the Federal Railroad and Transit Administrations, the range of alternatives considered and developed covered both bus and rail service options. The bus service options included modifications to the frequency and operating conditions of the existing Boston Express commuter bus system. The rail service options included extensions of the MBTA's Lowell Line service and options for intercity rail services that would overlay on the existing mix of passenger and freight rail services that are currently operated along the corridor.

The most salient transport problem addressed in developing the alternatives was improving connections between Southern New Hampshire and the regional core in downtown Boston. The principal travel obstacle in the corridor is the extreme peak period highway congestion that slows Boston bound travel to a 12 mph crawl for the final eight miles of a typical morning peak trip into the city.

The study team consulted with the MBTA, Pan Am, NHDOT, MassDOT, Boston Express and others to develop a set of two base, nine rail and three bus service options for preliminary screening. Using preliminary estimates of cost, demand and revenue the study team consulted with project stakeholders and the general public to screen the 14 preliminary options down to seven final options (three rail, three bus) for refinement and more detailed analysis. This chapter introduces the 14 preliminary options then reviews the final options in more detail.

Table 3-1: **Preliminary Rail Service Options**

Options	Weekday Revenue Trains			Route Miles	Stations Served
	Nashua	Manchester	Concord		
Base Service	0	0	0	26	8
INTERCITY PASSENGER RAIL OPTIONS					
Intercity 8	8	8	8	73	6
Intercity 12	12	12	12	73	6
Intercity 16	18	18	18	73	6
COMMUTER AND REGIONAL RAIL OPTIONS					
1. Concord Regional	30	8	8	73	13
2. Concord Commuter	26	22	18	73	13
3. Manchester Regional	34	16	0	56	12
4. Manchester Commuter	30	20	0	56	12
5. Nashua Commuter	34	0	0	39	10
6. Nashua Minimum	16	0	0	35	9

Table 3-2: Conceptual Bus Service Options

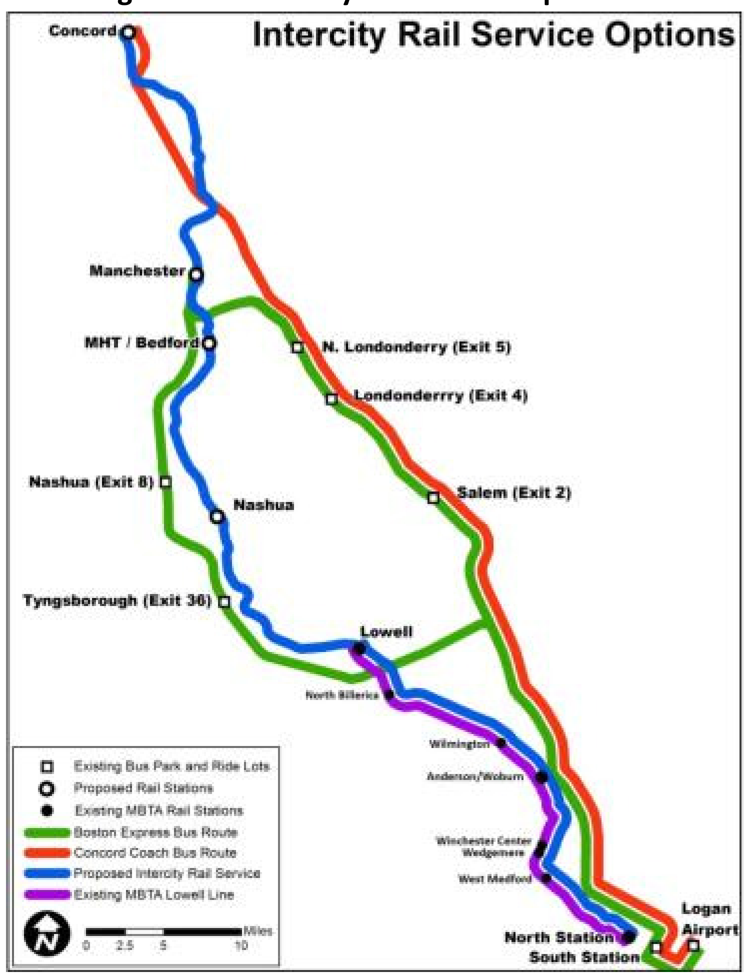
Options	Weekday Revenue Trips								Weekday Vehicle Miles	%& Increase in Weekday Vehicle Miles
	Manchester	N. Londonderry	Londonderry	Salem	Nashua	Tyngsboro	South Station	Logan Airport		
Base (Existing Service)	18	46	17	39	24	23	80	58	3,932	0%
Base+ (Base Expanded)	32	40	39	40	38	38	120	120	5,850	49%
BoS (Bus on Shoulder)	18	46	17	39	24	23	80	58	3,932	0%
BoS+ (Bus on Shoulder Expanded)	32	40	39	40	38	38	120	120	5,850	49%

3.1 Preliminary Intercity Passenger Rail Service Options

The study team devised a hierarchy of three conceptual options that could be operated as an independent "Granite State" intercity rail service that would extend 73 miles northward from North Station to Concord. These options are based on historic and current physical attributes of the NHML, the schedule of passenger services on the line and general service parameters for Amtrak services in corridors of less than 150 miles. Each service would:

- Operate independently of the MBTA and Amtrak Downeaster passenger services already serving the southernmost 25 miles of the route;
- Require no upgrades to infrastructure south of Lowell;
- Require upgrades to rail infrastructure north of Lowell including;
- Upgrade 48 miles of existing track to FRA Class 4 providing for maximum passenger train speeds of 70 mph, since no historic records show higher speeds along

Figure 3-1: Intercity Rail Service Options



the route since its opening in the 1800's;

- Establish Crown Street in Nashua as a passing point for northbound and southbound passenger trains (Intercity Options 12 and 18);
- Install one or more industrial sidings between Nashua and Concord allowing passenger trains to pass or meet freight trains;
- Install a passing siding on the PanAm mainline west of North Chelmsford to reduce the need for trains to stand east of North Chelmsford on the route between Lowell and Nashua;
- Install Northeast Operating Rules Advisory Committee (NORAC) Rule 261 signals between Manchester and Concord (approximately 18 miles), and;
- Install MBTA Positive Train Control protection.

The services would stop at six passenger stations north of Boston. Details concerning these stations are provided in the NHCC Profit Stations and Layovers Technical Memorandum. The distance and travel time to Boston for each of these stations are listed in Table 3-3.

Table 3-3: Initial Conceptual Design Miles and Travel Time to Boston

Station	Miles to Boston	Time to Boston
Concord	73.4	1:36
Manchester	55.5	1:22
MHT / Bedford	50.1	1:09
Nashua	38.8	0:56
Lowell	25.5	0:38
Woburn	12.6	0:23

The projected travel times compare favorably with historic minimum travel times between Concord and Boston (see Table 3-4).

Table 3-4: Historic Minimum Concord-Boston Travel Times

	1910	1926	1945	1954
Travel Time	2:00	2:05	1:35	1:22
Average Speed (mph)	37	35	46	54

Source: Jacobs analysis of archived public timetables

Intercity 8

The eight-train per day Intercity 8 Rail Option would provide four daily round trips over the 73 mile route stopping at five intermediate stations including the Manchester Airport (see Table XX). The end-to- end trip time would be approximately 96 minutes. The service would entail 586 daily train miles. Presuming an average cost of $36 per train mile, Intercity 8 would cost approximately $8 million per year to operate.

Table 3-5: Intercity 8 Preliminary Timetable

380	382	384	386		Station	MP		381	383	385	387
6:38	10:38	14:53	19:53	Read Down	**Concord NH**	73.3		10:07	14:22	18:57	23:37
6:52	10:52	15:07	20:07		**Manchester NH**	55.7		9:41	13:56	18:31	23:11
7:05	11:05	15:20	20:20		**MHT (Bedford)**	50.1		9:33	13:48	18:23	23:03
7:18	11:18	15:33	20:33		**Nashua**	39.0		9:20	13:35	18:10	22:50
7:36	11:36	15:51	20:51		**Lowell**	25.5		9:02	13:17	17:52	22:32
7:52	11:52	16:07	21:07		**Anderson/ Woburn**	12.6		8:46	13:01	17:36	22:16
8:15	12:15	16:30	21:30		**North Station**	0.0	Read Up	8:30	12:45	17:20	22:00

The service could be extended with possible connections to private bus services for North Country destinations. No substantial changes in express bus service for commuting to Boston via US Route3/Everett Turnpike or I-93 would be expected. Local bus service to the intercity rail stations could be offered but would not be integral to the service design. The service would use a single four-car train set stored in Concord. A spare locomotive and a spare coach would also be required.

Intercity 12

The twelve-train per day Intercity 12 Rail Option would operate six daily round trips. The service would provide travelers in both New Hampshire and Massachusetts with more convenient morning northbound trips and evening southbound trips that would not be available with Intercity 8. The service would entail 880 daily train miles. Presuming an average cost of $36 per train mile, Intercity 12 would cost approximately $12 million per year to operate.

Table 3-6: Intercity 12 Preliminary Timetable

Southbound						
Train	**380**	**382**	**384**	**386**	**388**	**390**
Concord NH	6:33	8:33	10:33	16:33	18:33	22:33
Manchester	6:47	8:47	10:47	16:47	18:47	22:47
MHT (Bedford)	7:00	9:00	11:00	17:00	19:00	23:00
Nashua	7:13	9:13	11:13	17:13	19:13	23:13
Lowell	7:31	9:31	11:31	17:31	19:31	23:31
Woburn	7:47	9:47	11:47	17:47	19:47	23:47
North Station	8:10	10:10	12:10	18:10	20:10	0:10
Northbound						
Train	**381**	**383**	**385**	**387**	**389**	**391**
North Station	6:20	8:23	10:23	16:23	18:23	22:23
Woburn	6:36	8:39	10:39	16:39	18:39	22:39
Lowell	6:52	8:55	10:55	16:55	18:55	22:55
Nashua	7:13	9:13	11:13	17:13	19:13	23:13
MHT (Bedford)	7:26	9:26	11:26	17:26	19:26	23:26
Manchester	7:34	9:34	11:34	17:34	19:34	23:34
Concord NH	8:00	10:00	12:00	18:00	20:00	0:00

As with Intercity 8, the service could be extended with possible connections to private bus services for North Country destinations. No substantial changes in express bus service for commuting to Boston via US Route 3/Everett Turnpike or I-93 would be expected. Local bus service to the rail stations could be offered but would not be integral to the service design. The service would use two four-car train sets. One would be stored in Concord and the other in Boston. A spare locomotive and one spare coach would also be required.

Intercity 18

The eighteen-train per day Intercity 18 Rail Option would provide nine daily round trips. This would constitute bi-hourly, bi-directional service 18 hours per day between Concord and Boston. It represents an upper limit on the density of intercity service that could be considered between Central New Hampshire and Downtown Boston. The service would entail 1,319 daily train miles. Presuming an average cost of $36 per train mile, Intercity 18 would cost approximately $17 million per year to operate. As with the other options, Intercity 18 could be extended with possible connections to private bus services for North Country destinations. No substantial changes in express bus service for commuting to Boston via US Route3/Everett Turnpike or I-93 would be expected. Local bus service to the intercity rail stations could be offered but would not be integral to the service design. Like Intercity 12, the service would use two four-car train sets. One would be stored in Concord and the other in Boston. A spare locomotive and one spare coach would also be required.

Table 3-7: Intercity 18 Preliminary Timetable

Southbound									
Train	**380**	**382**	**384**	**386**	**388**	**390**	**392**	**394**	**396**
Concord NH	6:33	8:33	10:33	12:33	14:33	16:33	18:33	20:33	22:33
Manchester	6:47	8:47	10:47	12:47	14:47	16:47	18:47	20:47	22:47
MHT (Bedford)	7:00	9:00	11:00	13:00	15:00	17:00	19:00	21:00	23:00
Nashua	7:13	9:13	11:13	13:13	15:13	17:13	19:13	21:13	23:13
Lowell	7:31	9:31	11:31	13:31	15:31	17:31	19:31	21:31	23:31
Woburn	7:47	9:47	11:47	13:47	15:47	17:47	19:47	21:47	23:47
North Station	8:10	10:10	12:10	14:10	16:10	18:10	20:10	22:10	0:10
Northbound									
Train	**381**	**383**	**385**	**387**	**389**	**391**	**393**	**395**	**397**
North Station	6:20	8:23	10:23	12:23	14:23	16:23	18:23	20:23	22:23
Woburn	6:36	8:39	10:39	12:39	14:39	16:39	18:39	20:39	22:39
Lowell	6:52	8:55	10:55	12:55	14:55	16:55	18:55	20:55	22:55
Nashua	7:13	9:13	11:13	13:13	15:13	17:13	19:13	21:13	23:13
MHT (Bedford)	7:26	9:26	11:26	13:26	15:26	17:26	19:26	21:26	23:26
Manchester	7:34	9:34	11:34	13:34	15:34	17:34	19:34	21:34	23:34
Concord NH	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	0:00

3.2 Preliminary Commuter Rail Options[16]

Meetings with MassDOT and the MBTA in the Spring of 2012 indicated a willingness to work with NHDOT on the provision of passenger service along the New Hampshire Main Line (NHML) from New Hampshire to North Station. This cooperation could come in the form of MBTA operation of trains into New Hampshire or the operation of intercity trains along the same route. It was stated that with the imminent relocation of the Spaulding Hospital immediately west of North Station that two new station tracks at the terminal would be opened providing capacity for one additional peak Amtrak train in each direction. MBTA would also be willing to extend its service into New Hampshire provided that the service extension was essentially transparent to existing MBTA passengers using the services offered between Lowell and Boston and that the net cost of the service extension to Massachusetts taxpayers would be zero.

The "net cost of zero" would be achieved via a "Pilgrim Partnership" arrangement with NHDOT that would mimic the successful rail service funding and operational arrangements between Rhode Island and Massachusetts that allow the MBTA to offer passenger rail service into Rhode Island. The broad outline of the "Pilgrim Partnership" calls for the host state to provide the MBTA with an ongoing flow of capital funds. The funds, much of which would be federal formula grants, would be spent at the MBTA's prerogative on rolling stock and facilities necessary for its overall commuter rail operation. Some of the funded assets may be used for the interstate service but none of the assets are dedicated or obligated to that service. With that capital funding in place, the MBTA would agree to operate trains into the neighboring state in exchange for the passenger revenue collected from out of state passengers. The funding host state would be responsible for upkeep of the fixed infrastructure in its state and any fees charged by the host railway. The MBTA would then pay for management, train crews, fuel, and maintenance of rolling stock.

The study team devised a hierarchy of six conceptual rail services that could be operated as an extension of MBTA Lowell service northward into New Hampshire. These options were based on historic and current physical attributes of the NHML, the schedule of passenger services on the line and parameters of the MBTA's offer to operate the service as integral portion of its other services to and from North Station. Each service would:

- extend existing MBTA service into New Hampshire;
- be generally transparent to existing MBTA customers;
- have no impacts on existing Amtrak service between North Station and Maine;
- require no upgrades to infrastructure south of Lowell, and;
- require upgrades to rail infrastructure north of Lowell including:
  - Upgrades to existing track (up to 48 miles) to FRA Class 3 providing for maximum passenger train speeds of 60 mph[17];
  - Installation of second mainline track between North Chelmsford and downtown Nashua;

[16] For more information on the NHCC Preliminary Rail Alternatives the reader is referred to the *NHCC Project TASK 4: PRELIMINARY RAIL SERVICE OPTIONS Technical Memorandum*.

- Installation of at least one siding between Nashua and Bow allowing passenger trains to pass or meet freight trains serving this segment;
- Installation of NORAC Rule 261 signals between Manchester and Concord. (approximately 18 miles), and;
- Installation of MBTA Positive Train Control protection.

Class 3 track was selected for the preliminary options to reduce costs. An upgrade to Class 4 would cost more for track upgrades and maintenance. The estimated difference in running times between Nashua and Lowell with an upgrade to Class 4 would be one minute. Class 4 track would cut approximately six minutes on the running time between Concord and Lowell. For one commuter rail option (2) the team used Class 4 speeds (up to 70 mph) in order to establish an economic harmony between the existing MBTA schedules and rolling stock and crew requirements.

The six conceptual commuter rail services are described below. The services would stop at up to six passenger stations north of Lowell. Table 3-8 lists the five stations with their distance to Boston and projected maximum and minimum travel times. Details concerning these stations are provided in the NHCC Project Stations and Layover Facilities Technical Memorandum. For more detailed information concerning the preliminary rail options the reader is referred to the NHCC Project Definition of Final Alternatives Technical Memorandum.

Table 3-8: Initial Conceptual Designs: Miles and Minutes to Boston

Station	Miles to Boston	Maximum Travel Time to Boston	Minimum Travel Time to Boston
Concord	73.4	1:54	1:46
Manchester	55.5	1:32	1:25
MHT / Bedford	50.1	1:24	1:17
Downtown Nashua	38.8	1:14	1:02
Nashua South	35.5	1:08	0:54

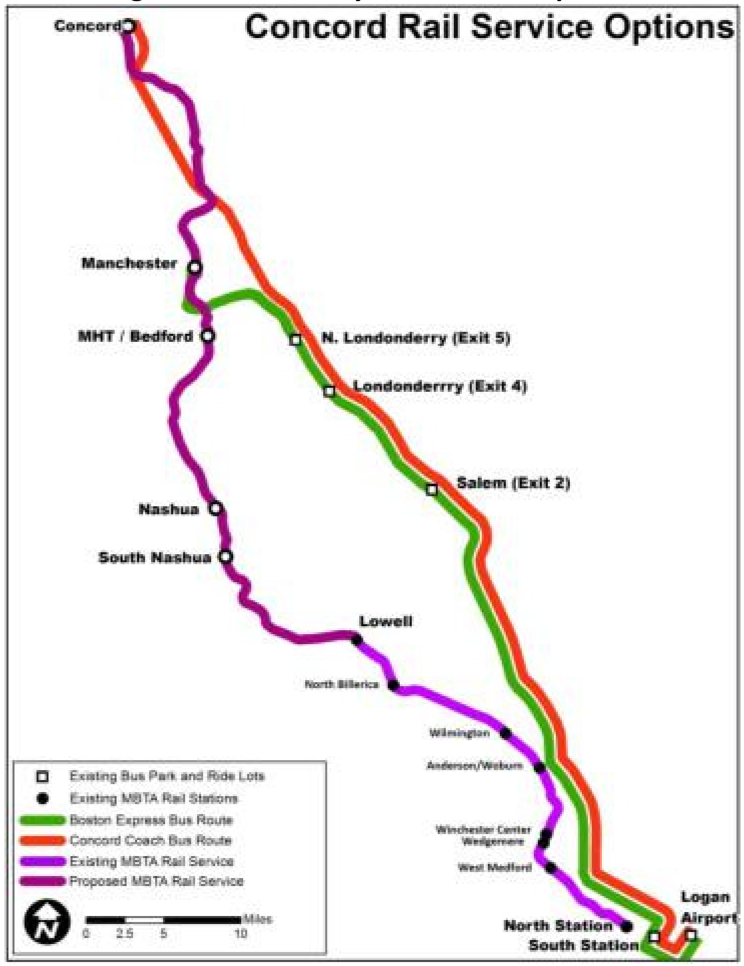
Option 1: Concord Regional Rail Service

Option 1 provides a mix of commuter train service for Nashua with a lower frequency regional service provided for Manchester and Concord. The service adds six new stations to the line with eight weekday trains for Concord and Manchester and 30 weekday trains for Nashua. All MBTA deadhead trains are eliminated. A layover facility for one train set would be required in Concord and for three trains in the vicinity of Nashua. The service would require an additional train set conservatively estimated at seven coaches. Additional coaches on the other five train sets assigned to the service would be required to carry the new passengers on to the NHML services. Up to twelve coaches and one locomotive would be added to the MBTA's weekday line up of equipment for one new seven car train and five additional coaches on existing consists assigned to the service.

Option 2: Concord Commuter Rail Service

Compared with Option 1, Option 2 provides a more ambitious level of service for Concord (and Manchester). It is the only commuter rail option that would require Class 4 track and would necessitate extensive track upgrades, with maximum speeds between Lowell and Concord restored to their historic maximum of 70 mph where possible. Like Option 1 it adds six new stations to the line but provides 18 trains to Concord, 22 to Manchester and MHT/Bedford, with 26 trains to Nashua. Four MBTA train sets assigned to the line are stored overnight in the vicinity Concord.

Figure 3-2: Intercity Rail Service Options



Owing to the higher maximum speeds, the travel times from Concord, Manchester and Nashua would be somewhat shorter, approximately 105 minutes, 90 minutes and 66 minutes respectively. The largest time saving resulting from the higher speeds is for the 73 mile trip to Concord. Like Option 1, the service would require an additional train set of conservatively estimated at seven coaches. Up to 12 coaches and one locomotive would be added to the MBTA's weekday line up as in Option 1.

Option 3: Manchester Regional Rail Service

Option 3 provides a mix of commuter train service for Nashua with a lower frequency regional service provided north to Manchester. MBTA service would be extended 30 miles to downtown Manchester. The service adds five new stations to the line with 16 weekday trains for Manchester and 34 for Nashua. As with Options 1 and 2, all MBTA deadhead trains are eliminated. A layover facility for four train sets would be constructed in the vicinity of Manchester. Up to 12 coaches and one locomotive would be added to the MBTA's weekday line up of equipment.

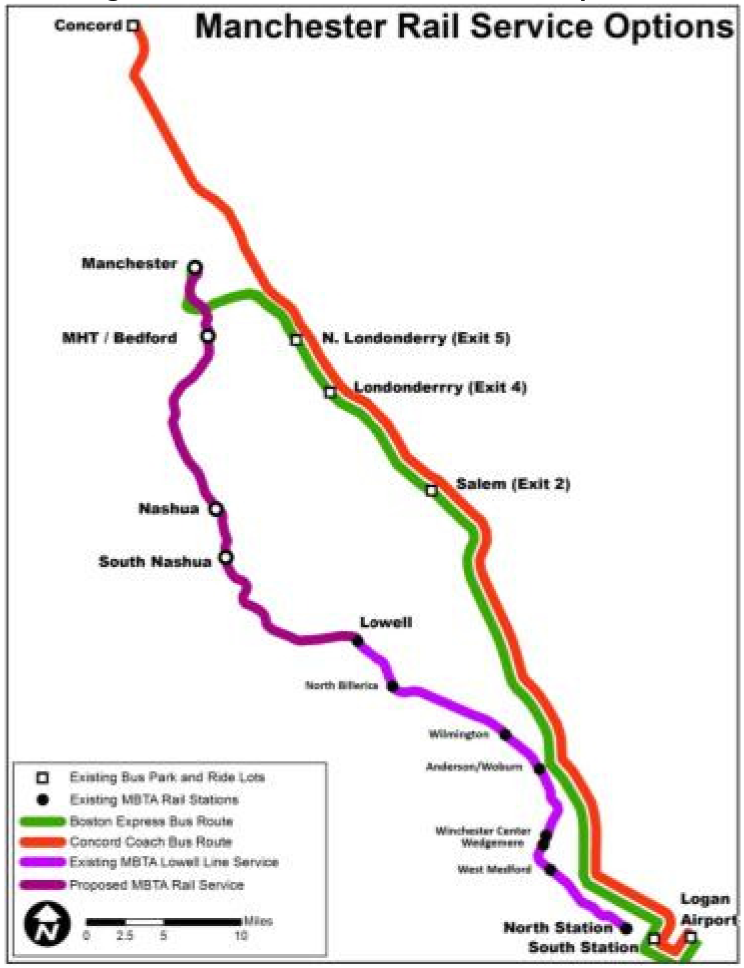
Option 4: Manchester Commuter Rail Service

Option 4 provides more extensive service for Manchester compared with the Options 1 through 3. As with Option 3, MBTA service would be extended 30 miles to downtown Manchester. The service adds five new stations to the line with 20 weekday trains for Manchester and 30 for Nashua. As with the previous options, all MBTA deadhead trains are eliminated. As with Option 3, a layover facility for four train sets would be constructed in the vicinity of Manchester. Also as with the previous options, up to 12 coaches and one locomotive would be added to the MBTA's weekday line up.

Option 5: Nashua Commuter Rail Service

Option 5 provides commuter train service to and from Downtown Nashua with no rail service beyond to Manchester or Concord. It could be developed and operated as an interim service coordinated with bus service for Manchester and Concord until service is implemented further north. MBTA service would be extended 13 miles from Lowell to Downtown Nashua. The service adds two new stations to the line with 34 weekday trains for Nashua. A layover facility for four train sets would be constructed in the vicinity of Nashua. As with the other options, up to 12 coaches and one locomotive would be added to the MBTA's weekday line up.

Figure 3-3: Manchester Rail Service Options



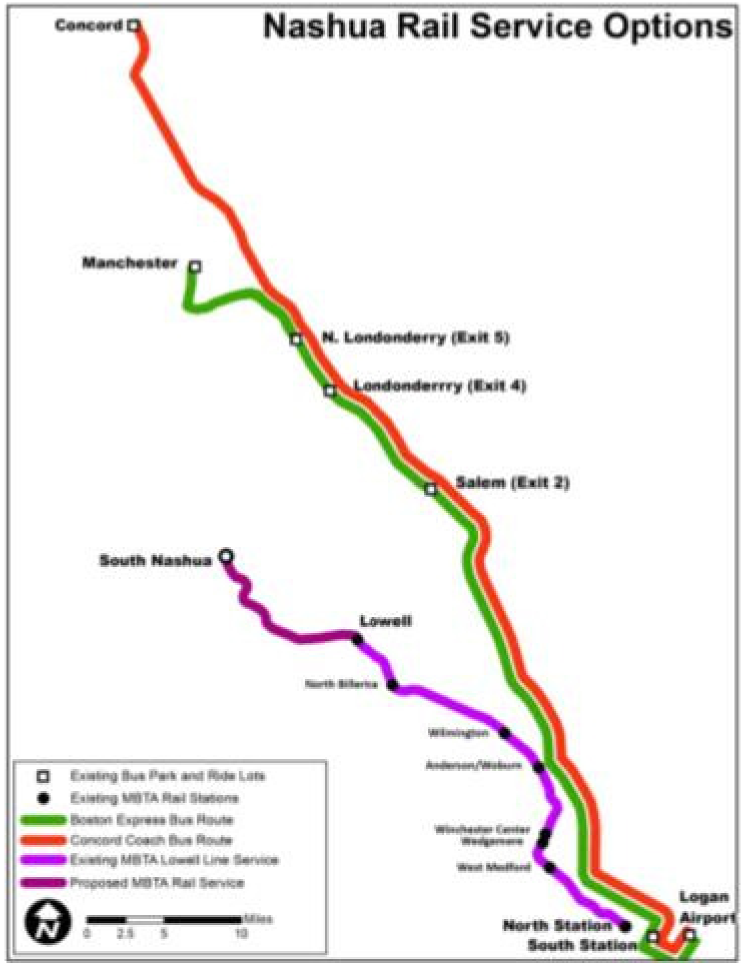
Option 6: Nashua Minimum Rail Service

Option 6 provides a minimal peak only commuter rail service to and from South Nashua with no rail service beyond Nashua to Manchester or Concord. It is specifically designed to minimize the MBTA operating cost of extending service to Nashua. Like Option 5, it could be developed and operated as an interim service coordinated with bus service while markets and finances for more New Hampshire were given time to develop.

MBTA service would be extended 9.7 miles to the South Nashua station located at or immediately across the New Hampshire State Line. The service adds one new station to the line with 16 weekday trains for Nashua. As with Option 5, a layover facility for four train sets would be constructed in the vicinity of South Nashua. Similar to the previous options, up to 13 coaches and one locomotive would be added to the MBTA's weekday line up of equipment. The South Nashua station would be located approximately at Milepost 35.2 in the vicinity of Pheasant Lane Mall or Spit Brook Road.

Rail Option 6 is proposed to provide service from Boston North Station to South Nashua during peak periods only and would travel only as far north as Lowell, MA during off-peak periods. The rail service could potentially be supplemented by a schedule of feeder buses that would extend the reach of off-peak trains north to South Nashua to ensure that adequate mid-day mobility and travel options are available to daily commuters. Six inbound and six outbound buses could be provided throughout the day and could be operated with a single vehicle.

Figure 3-4: Nashua Rail Service Options



To schedule the feeder service with a single bus, the study team decided to prioritize travel time for southbound passengers. The proposed timetables found in the NHCC Project Definition of Final Alternatives Technical Memorandum show that southbound trips are scheduled to provide five minutes for the transfer from bus to rail. This will require that the bus portion of the trip is operated reliably to ensure that the connection to the train is made on time. The northbound trips will depart using the same bus and passengers will therefore wait approximately fifteen minutes for the transfer from rail to bus. This is due to the time required for crews to turn the train in Lowell. This longer transfer time built in to the schedules will allow for any delays on outbound rail trips from Boston and ensure that transferring passengers are not left at the station in Lowell.

3.3 Preliminary Bus Service Options[18]

Recognizing that any rail service would require a substantial investment in upgrading track and constructing support facilities, the study team also developed options that could improve the frequency and or travel time of express and intercity bus service offered in the corridor. Recognizing that peak period bus service from New Hampshire to Boston is mired in the same crawling automobile traffic that slows travel for motorists, the study team spent considerable time researching the potential benefits of offering Bus-on-Shoulder (BoS) service along I-93 in Massachusetts. The team also developed options that would expand the frequency and directness of bus service between downtown Boston and southern New Hampshire. The mix of more and frequent service resulted in three bus service options for consideration plus the base (existing) service option as summarized in Table 3-9.

Table 3-9: Preliminary Bus Service Options

Options	Weekday Revenue Trips								Weekday Vehicle Miles	%& Increase in Weekday Vehicle Miles
	Manchester	N. Londonderry	Londonderry	Salem	Nashua	Tyngsboro	South Station	Logan Airport		
Base (Existing Service)	18	40	19	32	37	21	80	58	3,932	0%
Base+ (Base Expanded)	32	39	38	39	37	37	120	120	5,850	49%
BoS (Bus on Shoulder)	18	40	19	32	37	21	80	58	3,932	0%
BoS+ (Bus on Shoulder Expanded)	38	39	38	39	37	37	120	120	5,850	49%

This portion of the Service Development Plan describes how Bus-on-Shoulder could be developed to offer some peak travel time savings. It then goes on to summarize the three bus service investment options. Additional details on the preliminary bus option can be found in the NHCC Project Definition of Final Alternatives Technical Memorandum.

Base Service (Existing)

The Base Service currently offered in the corridor is used as a baseline to compare the performance of any proposed transit service expansion to existing conditions. It is assumed to include any planned improvements to the highway network that would be in place by 2030, such as the NHDOT I-93 improvement project and various interchange and lane improvements within Massachusetts. This option also includes the existing park and ride lots throughout the corridor. It maintains the current express and intercity bus service between New Hampshire, South Station and Logan Airport along I-93. It does not incorporate any expansion of rail service on the Capitol Corridor, but includes the proposed commuter rail extension to Plaistow, NH. Table 3-10and Table 3-11 list the number of weekday trips

[18] For more information on the NHCC Preliminary Bus Alternatives the reader is referred to the *NHCC Project TASK 4: PRELIMINARY BUS SERVICE OPTIONS Technical Memorandum*.

and scheduled travel times between the park and ride lots and the South Station bus terminal and the preliminary timetable can be found in the NHCC Project Definition of Final Alternatives Technical Memorandum.

Table 3-10: Base Service Bus Trips

	Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsboro (Exit 35)	South Station	Logan Airport
SB Trips	8	21	7	20	12	11	42	31
NB Trips	10	25	10	19	12	12	38	27
Total	18	46	17	39	24	23	80	58

Table 3-11: Base Service Travel Times to/from South Station

		Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsboro (Exit 35)
Max	Off-peak	2:15	1:40	1:50	1:20	1:45	1:30
	Peak	2:20	1:30	1:45	1:25	1:50	1:35
Min	Off-peak	1:05	1:05	1:15	0:45	1:04	0:50
	Peak	1:40	1:05	1:00	0:45	1:00	1:05

Base+ (Base Expanded)

The Base+ Option increases the frequency of bus service along the study corridor by providing additional peak period, point-to-point, non-stop trips from each of the New Hampshire park and ride lots to Boston South Station. The service would add approximately 40 trips to the daily schedule, and would provide more frequent service to and from each of the existing park and ride lots. The additional service would require approximately ten additional vehicles and drivers. There are no transit priority measures proposed in this option that would aim to increase service velocities or decrease travel times.

Peak period point-to-point service would be provided between each park and ride lot and Boston South Station at 30 minute headways, except for Manchester service which would be operated at 60 minute headways throughout the day. Hourly off-peak service would provide service to each park-and-ride lot within the I-93 or Route 3 corridors. Table 3-12 and Table 3-13 list the number of weekday trips and scheduled travel times between the park and ride lots and the South Station bus terminal and the preliminary timetable can be found in the NHCC Project Definition of Final Alternatives Technical Memorandum.

Table 3-12: Base+ Trips

	Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsboro (Exit 35)	South Station
SB Trips	16	20	19	20	18	18	60
NB Trips	16	20	20	20	20	20	60
Total	32	40	39	40	38	38	120

Table 3-13: Base+ Travel Times

		Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsboro (Exit 35)
Max	Off	2:15	1:40	1:50	1:20	1:45	1:30
	Peak	2:20	1:30	1:45	1:25	1:50	1:35
Min	Off	1:05	1:05	1:15	0:45	1:04	0:50
	Peak	1:40	1:05	1:00	0:45	1:00	1:05

BoS (Bus on Shoulder)

The Bus on Shoulder option aims to provide faster peak period service by utilizing Bus on Shoulder (BoS) operations. The option would not add any additional trips, but would provide faster, more reliable travel times between New Hampshire and Boston South Station. The proposed timetables maintain the existing arrival and departure times at South Station and modify the departure and arrival times at New Hampshire park and ride lots based on the estimated travel time savings that would be possible from BoS operation. The service would not require any additional vehicles to operate the proposed schedule. It could potentially reduce vehicle requirements by allowing vehicles to operate more reliably so that they could provide multiple peak period roundtrips. Table 3-14 and Table 3-15 list the number of weekday trips and scheduled travel times between the park and ride lots and the South Station bus terminal and the preliminary timetable can be found in the NHCC Project Definition of Final Alternatives Technical Memorandum.

This option could potentially be combined with a viable passenger rail option or advanced as a Transportation Systems Management (TSM) approach or be implemented as a companion to a potential rail service improvement. A TSM is a Federal Transit Administration designation for an option that would contain a collection of low cost transportation improvements that seek to mitigate congestion or enhance the operational capacity of the existing transportation network.

Table 3-14: BoS Trips

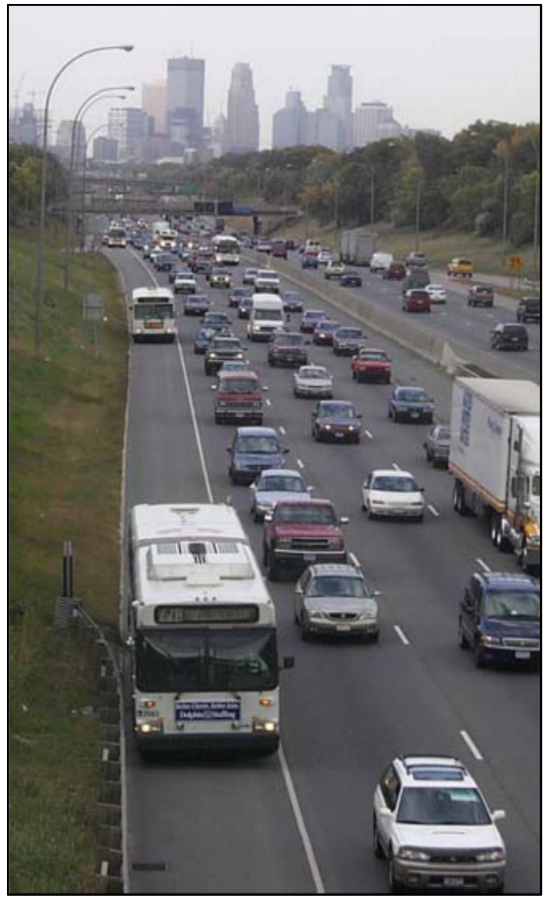
	Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsboro (Exit 35)	South Station
SB Trips	8	21	7	20	12	11	42
NB Trips	10	25	10	19	12	12	38
Total	18	46	17	39	24	23	80

Table 3-15: BoS Travel Times

		Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsboro (Exit 35)
Max	Off	1:35	1:20	0:00	1:00	1:20	1:05
	Peak	2:10	1:27	1:37	1:15	1:40	1:25
Min	Off	1:25	1:05	0:00	0:45	1:04	0:50
	Peak	0:53	0:52	0:57	0:37	0:51	0:51

Bus on Shoulder (BoS) Service

Figure 3-5: Bus on Shoulder in Minneapolis



Bus use of highway shoulders has been an operational practice in North America for over 20 years. This growing practice allows professional bus drivers the discretionary authority to drive within highway shoulders to reduce travel times and increase the reliability of transit service. The longstanding history of bus-on-shoulder (BoS) operations and the increasing number of communities pursuing such projects point to the success of this practice in terms of both passenger and institutional benefits, and automobile driver acceptance. Many agencies have demonstrated that BoS can safely and cost-effectively improve transit service on congested roadways.

Highway shoulders, generally used as an emergency breakdown lane and for emergency response vehicles can be easily adapted for bus use. The key design requirements are a minimum lane width of 10 feet (12 feet preferred), adequate shoulder pavement strength, drainage inlets level with roadway, and signage. Conflicts with pavement edge rumble strips and lateral obstructions adjacent to shoulders sometimes need to be addressed. The costs for these upgrades vary widely, but are modest compared with most highway widening and interchange reconstruction costs.[19]

Two of the earliest and most extensive BoS networks are operated in Minneapolis and Ottawa. Both systems have been in safe operation for more than 20 years. In Ottawa, buses can use the shoulders of limited access highways at any time with maximum allowable speeds of 62 mph (100 kmh). The more conservative, Minneapolis system allows buses to use the shoulder of the highway when the speed of general traffic drops below 35 mph. Buses on the shoulder may operate at speeds 15 mph faster than travel in other lanes up to a maximum speed of 35 mph. The more liberal Ottawa approach is consistent with current general purpose vehicle use of highway shoulders on I-93 and I-95 in Greater Boston where automobiles are allowed to travel at 65 mph in the shoulder during peak periods.

With over 300 miles of bus-on-shoulder operations, the Twin Cities and Ottawa examples are the most extensive North American BoS networks. Many other communities have found this practice to be advantageous. As of 2012, transit buses were also operating on shoulders in Virginia, Maryland, Illinois,

[19] Martin, Peter C. (2006). *TCRP Synthesis 64*: *Bus Use of Shoulders, A Synthesis of Transit Practice*, Transportation Research Board, National Research Council, Washington D.C. 2006, 100 pp.

Washington, New Jersey, Georgia, Delaware, California, Florida, Kansas, North Carolina, Ohio and Ontario.

Locally, the Merrimack Valley Planning Commission and Massachusetts DOT are evaluating BoS operations for I-93 in Massachusetts. That study assumes that BoS service along I-93 would follow the Minnesota operating model of 35 mph maximum speeds between I-495 and the Leonard P. Zakim – Bunker Hill Bridge in Boston.

Benefits of BoS

The direct benefits of BoS include reduced travel times and increased service reliability. BoS allows bus operators to maintain travel speeds, even in the case of unexpected traffic conditions, in turn increasing the reliability of the transit service. Not only are actual travel times reduced once buses are allowed to bypass congestion, but customers perceive even greater reductions in travel time. Since perceptions are a key determinant in travel mode decisions, perceived travel time savings are a real catalyst for increased transit market share.

Safety

Despite the long history of BoS, communities considering new BoS systems are often concerned with potential safety impacts. These concerns often focus on the ability of buses to merge in and out of general purpose lanes around highway entrances and exits or vehicles stopped on the shoulder (disabled vehicles, tow trucks, emergency responders, etc). BoS networks in operation, however, have proven that thoughtfully designed BoS operations are inherently safe.

In the Twin Cities area approximately half of all bus routes operated by the region's two largest transit providers operate on corridors that have the option to use BoS at some point along the route. The number of accidents involving these buses is low considering the scope of BoS operations. During the initial ten years, between 1991 and 2001, there were 200 BoS accidents. Since the Twin Cities BoS system averaged 90 miles over this period, the number of accidents can be expressed as 0.2 accidents per mile per year. Most accidents were minor scrapes or mirror clips. No injuries were reported. Since 2001, there has been one injury.[20] An automobile struck a BoS bus from the rear killing the automobile driver. After 15 years of operations, Minneapolis Metro Transit reserves only $7,000 per year for damages resulting from BoS-related accidents. In other words, Metro Transit currently budgets approximately $26 per mile, annually, for BoS-related damages and contingencies.

Travel on the shoulder is advantageous only under congested conditions when buses have an opportunity to bypass slow moving traffic. Because buses only operate on shoulders when traffic in general purpose lanes is slow, the potential for accidents, especially those causing injury, are low. Whether operating a bus or private auto, drivers' ability to react to changing conditions is much greater at low speeds. For example, merging around obstructions is relatively easy for both buses and slow moving traffic on congested roadways.

[20] State and Local Policy Program, Hubert H. Humphrey Institute of Public Affairs, University of Minnesota (June 2007). Bus-only Shoulders in the Twin Cities. Prepared for the FTA. Retrieved from http://www.hhh.umn.edu/img/assets/11475/Bus/Only/Shoulders/Report/FINAL.pdf

Existing Conditions

I-93 in New Hampshire is currently undergoing reconstruction to add two general purpose lanes in each direction as a congestion mitigation measure. Travel is not currently permitted on the shoulders. I-93 in Massachusetts is three lanes in either direction between the State Line and Exit 41 (Route 125) in Andover. South of Exit 41, an additional general travel lane is added in each direction.

Peak vehicles in Massachusetts have been allowed to travel at speeds for up to 65 mph along the shoulders of I-93 north of Exit 41 since 1999[21]. Traffic flow in the peak periods is facilitated by the use of the shoulder in the peak direction between 6:00am and 10:00am in the morning, and between 3:00pm and 7:00pm in the afternoon. Shoulder use is not currently permitted for use by transit vehicles or commercial buses. Permission to use the breakdown lane for full speed general purpose traffic operations was extended by the Federal Highway Administration as an interim measure until a fourth lane is added north of Exit 41.

Table 3-16: Estimated BoS Bus Travel Time Savings by Time of Day and Direction

	Arrival Time at Boston South Station	Morning Peak Southbound							
		6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00
Typical Day	From NH State Line	0:07	0:08	0:08	0:09	0:08	0:08	0:12	0:13
	From I-495	0:07	0:08	0:08	0:09	0:08	0:08	0:12	0:13
	From I-95	0:07	0:08	0:08	0:09	0:08	0:07	0:08	0:08
Bad Traffic Day	From NH State Line	0:12	0:23	0:26	0:37	0:24	0:27	0:02	0:00
	From I-495	0:12	0:23	0:26	0:33	0:23	0:27	0:02	0:00
	From I-95	0:10	0:21	0:13	0:16	0:15	0:27	0:02	0:00
	Departure Time from Boston South Station	**Afternoon Peak Northbound**							
		4:00	**4:30**	**5:00**	**5:30**	**6:00**	**6:30**	**7:00**	
Typical Day	To I-95	0:00	0:01	0:02	0:02	0:02	0:00	0:00	
	To I-495	0:00	0:01	0:02	0:02	0:02	0:00	0:00	
	To NH State Line	0:00	0:01	0:02	0:05	0:03	0:00	0:00	
Bad Traffic Day	To I-95	0:06	0:07	0:09	0:12	0:08	0:07	0:01	
	To I-495	0:09	0:12	0:13	0:15	0:16	0:11	0:09	
	To NH State Line	0:10	0:19	0:18	0:29	0:25	0:20	0:13	

BoS operations would preclude shoulder use for private automobiles so that some mitigating measure may be necessary if BoS were implemented on this portion of I-93 before it is widened in

[21] Use of the breakdown lane for travel in the peak periods was instituted in 1999 after Andover State Representative Barry Finegold brought legislators and officials from Massachusetts and New Hampshire together to discuss options to reduce congestion on I-93.

Massachusetts' Essex County. There are currently no funded Massachusetts plans to widen I-93 between the State Line and Exit 41.

MassDOT is planning to reconstruct Exit 46 in Methuen. When complete a short portion of the highway between the state line and Exit 41 will not have breakdown lane creating a potential choke point for any BoS implementation north of the Merrimack River. Typical peak traffic operates at free flow conditions along this segment so the impact on BoS benefits at this location would be minimal.

As noted in Chapter 2 of the SDP, Boston Express scheduled morning peak travel times are as much as 45 minutes longer than off peak travel times due to congestion along their route (see Table 3-16). BoS operations could reduce some, but not all of this congestion related delay from the bus schedules. Using a methodology detailed in the NHCC Project Definition of Final Alternatives Technical Memorandum, the study team estimated that travel time savings from a MN-Style BoS operation would save as much as 12 minutes on typical day. On days where the impacts of traffic congestion are compounded by accidents or incidents the savings would escalate to as much as 37 minutes based on estimates derived from the study sample data.

Bos+ (Expanded Bus on Shoulder)

The BoS+ service option provides faster and more frequent service by combining the increased service of Base+ with BoS operations to improve reliability and service velocity. Like the Base+ option, the service would add approximately 40 trips to the schedule, but would provide more frequent service to and from each of the existing park and ride lots than the Bus on Shoulder Option. The additional service would require approximately ten additional vehicles and drivers.

Peak period point-to-point service would be provided between each park and ride lot and Boston South Station at 30 minute headways, except for Manchester service which would be operated at 60 minute headways throughout the day. Hourly off-peak service would provide service to each park-and-ride lot within the I-93 or Route 3 corridors. Table 3-17 and Table 3-18 list the number of weekday trips and scheduled travel times between the park and ride lots and the South Station bus terminal and the preliminary timetable can be found in the NHCC Project Definition of Final Alternatives Technical Memorandum.

Table 3-17: BoS+ Trips

	Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsboro (Exit 35)	South Station
SB Trips	16	20	19	20	18	18	60
NB Trips	16	20	20	20	20	20	60
Total	32	40	39	40	38	38	120

Table 3-18: BoS+ Travel Times

		Manchester	N. Londonderry (Exit 5)	Londonderry (Exit 4)	Salem (Exit 2)	Nashua (Exit 8)	Tyngsboro (Exit 35)
Max	Off	1:35	1:20	0:00	1:00	1:20	1:05
	Peak	2:10	1:27	1:37	1:15	1:40	1:25
Min	Off	1:25	1:05	0:00	0:45	1:04	0:50
	Peak	0:53	0:52	0:57	0:37	0:51	0:51

3.4 Multimodal Options

Throughout the study process, representatives of New Hampshire's intercity bus operators (Boston Express, Concord Coach, C&J and Dartmouth Coach) have indicated a willingness to work with NHDOT on the continued provision of commuter bus service along the I-93 corridor from New Hampshire to South Station. The continuation or expansion of the existing Boston Express bus service does not preclude the opportunity for a combined bus and rail option in a later phase of the study. Some multi-modal alternatives suggested by stakeholders included:

- Rail in the Route 3 corridor with Bus on Shoulder in the I-93 corridor;
- Rail serving the North Station market with bus serving the South Station market, and;
- Rail service during peak commute hours and bus service during off-peak hours.

The intercity bus operators are very supportive of implementing a Bus on Shoulder strategy on I-93, and the co-location or sharing of station and park and ride facilities between the various modes.

3.5 Screening Preliminary Alternatives[22]

The study team developed preliminary estimates of ridership, operating costs, capital costs along with land use, economic development and environmental impacts of the nine rail and three bus alternatives to screen the alternatives down to a more manageable number for final evaluation. The team's recommendations were reviewed with all stakeholders including the Federal Railroad Administration and Federal Railroad Administration as well as the general public before being finalized. Table 3-19 shows the basic performance metrics calculated for each alternative.

Table 3-19: Preliminary Estimates of Basic Economic Performance Metrics for Preliminary Alternatives

	Typical Weekday NH Passengers	Required Capital Expenditure (Millions)	Annual Operating Cost (Millions)	Annual Incremental Passenger Revenue (Millions)	Net Operating Cost (Millions)
Intercity 8	1,460	$162	$7.7	$3.5	$4.2
Intercity 12	1,720	$174	$11.6	$4.1	$7.45
Intercity 16	2,040	$174	$17.3	$4.9	$12.4
1. Concord Regional	2,700	$226	$11.1	$6.1	$5.0
2. Concord Commuter	3,020	$206	$13.3	$7.1	$6.1
3. Manchester Regional	3,120	$164	$9.7	$7.2	$2.5
4. Manchester Commuter	3,060	$164	$9.9	$7.1	$2.8
5. Nashua Commuter	2,040	$124	$6.8	$4.2	$2.6
6. Nashua Minimum	1,480	$124	$5.2	$2.7	$2.4
Base+	346	$6	$3.0	$0.8	$2.2
BoS	692	$7	$0.0	$1.7	$0.0
BoS+	1,038	$14	$3.0	$2.5	$0.5

[22] For more information on the NHCC Preliminary Screening the reader is referred to the *NHCC Project Task 5: Preliminary Screening of Alternatives Technical Memorandum*.

Figure 3-6 summarizes the overall economic, land use/economic development and environmental estimates. After extensive consultation primarily focusing on the fiscal constraints faced by the State of New Hampshire, three rail and three bus alternatives were selected for more detailed evaluation (see Table 3-20). The two commuter rail options with the lowest potential net operating cost, the one intercity rail option with the lowest preliminary net operating cost and the three low cost bus alternatives were recommended for refinement and detailed evaluation

The Intercity 8 alternative was selected from the three Intercity Rail Service Options, because of its low net operating cost and reasonable mobility benefit perspectives. As shown in Table 3-21, the numbers of additional riders attracted by more frequent service with Options 12 and 18 did not keep pace with the forecast cost of the additional service.

Figure 3-6: Preliminary Screening of Conceptual Alternatives

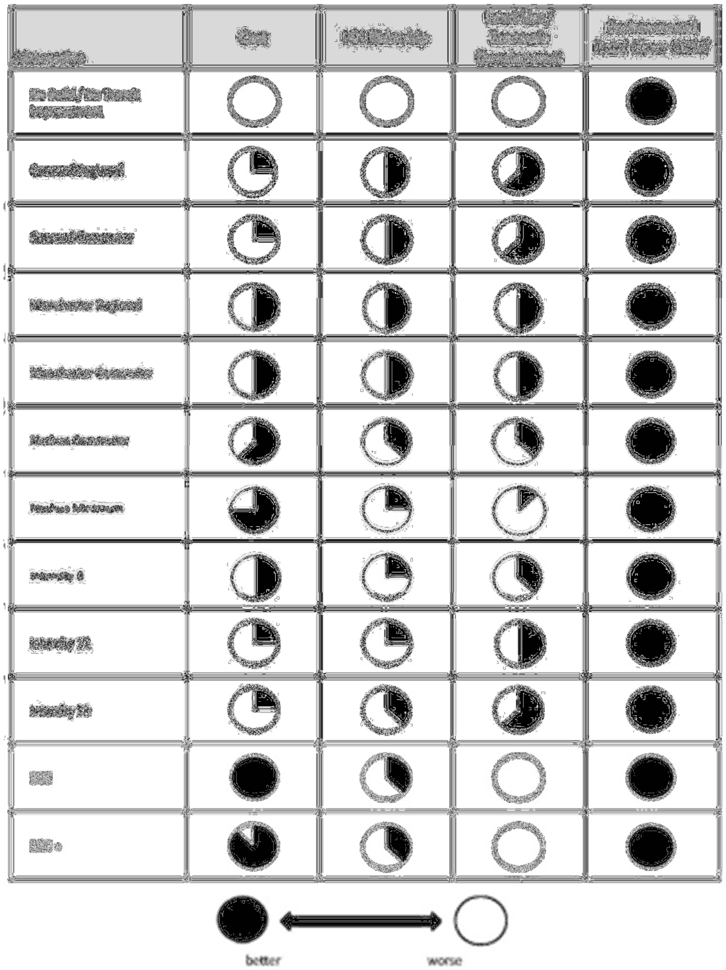


Table 3-20: Service Options Selected for Detailed Evaluation

Service Option	Required Capital Expenditure (Millions)	Net Operating Cost (Millions
Intercity 8	$162	$3.6
Manchester Regional	$164	$2.5
Nashua Minimum	$124	$2.4
Base+	$6	$2.2
BoS	$7	$0.0
BoS+	$14	$0.5

Table 3-21: Comparison of Intercity Rail Alternatives on Ridership and Net Operating Costs

	Typical Weekday NH Passengers	Net Operating Cost (Millions)
Intercity 8	1,460	$3.6
Intercity 12	1,720	$6.9
Intercity 16	2,040	$11.8

3.6 Final Alternatives[23]

The balance of this chapter describes the refinements to the six final alternatives with special emphasis on the preferred intercity and commuter rail alternatives. Among the most salient of the refinements was resolution concerning the disposition of express bus services should any of the rail service options be implemented. The final alternatives included;

Table 3-22: Final Service Alternatives

Concord Intercity Rail (IR8)	• Four daily intercity passenger rail round trips between Concord, NH and Boston, MA making intermediate stops at Manchester, Bedford/MHT Airport, Nashua Crown Street, Lowell, MA and Woburn, MA. • Base BX service is retained.
Manchester Regional Rail (CR 3)	• Extends MBTA commuter rail service north from Lowell, MA to Manchester, NH with intermediate stops at South Nashua, NH/Tyngsborough, MA, Nashua Crown Street and Bedford/MHT Airport. • BX I-93 service to Manchester, North Londonderry, Londonderry and Salem is retained. • BX Route 3 service to Manchester, Nashua and Tyngsboro is eliminated.
Nashua Commuter Rail (CR 6)	• Extends MBTA commuter service north from Lowell, MA to Manchester, NH with an intermediate stop at South Nashua, NH/Tyngsborough, MA. • BX I-93 service to Manchester, North Londonderry, Londonderry and Salem is retained. • BX Route 3 service to Manchester, Nashua and Tyngsboro is eliminated.
Base+	• New Hampshire's Boston Express (BX) bus service is increased from current 80 buses per day to 120 buses per day. • All peak buses run direct and non-stop between each New Hampshire park and ride lot and Boston South Station with service every 30 minutes. • Each park and ride lot sees hourly off-peak (but not direct) service. • No changes to existing passenger rail services.
BoS	• Existing Boston Express (BX) bus service of 80 daily trips is permitted to operate within the I-93 shoulder south of I-495 to bypass congestion in general travel lanes. • Savings of 8 to 12 minutes predicted during the AM peak period. • No significant travel time savings predicted during in the PM peak period.
BoS+	• The Base+ service of 120 daily trips is permitted to operate within the I-93 shoulder south of I-495 to bypass congestion in general travel lanes. • Savings of 8 to 12 minutes predicted during the AM peak period. • No significant travel time savings predicted during in the PM peak period.

[23] For more information on the NHCC Final Rail and Bus Alternatives the reader is referred to the *NHCC Project DEFINITION OF FINAL ALTERNATIVES Technical Memorandum*.

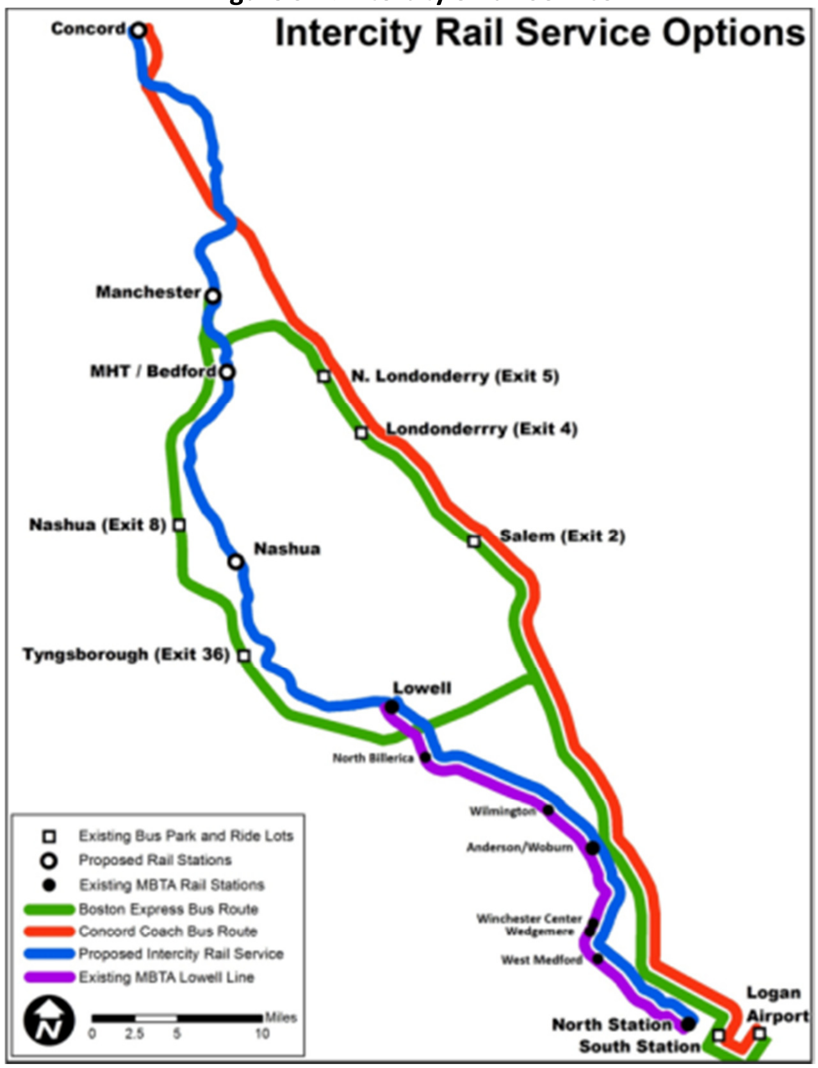
Concord Intercity Rail (IR8)

- Four daily intercity passenger rail round trips between Concord, NH and Boston, MA making intermediate stops at Manchester, Bedford/MHT Airport, Nashua Crown Street, Lowell, MA and Woburn, MA.
- Base BX service is retained.

The eight-train per day Intercity 8 Rail Option would provide four daily round trips over the 73 mile route stopping at five intermediate stations (see Figure 3-7. The end to end trip time would be approximately 96 minutes and the service would operate 586 daily train miles.

A proposed timetable is shown in Table 3-23. Presuming an average cost of $36 per train mile, the Intercity 8 Option would cost approximately $8 million per year to operate.

Figure 3-7: Intercity 8 Rail Service



The service could be extended with possible connections to private bus services for North Country destinations. No changes are proposed to express bus service for commuting to Boston via I-93 or Route 3. Local bus service to the intercity rail stations could be offered but would not be integral to the service design. A Boston Express / Concord Coach / rail fare integration scheme similar to that employed by the Downeaster at Portland, ME could be employed at the Concord and Manchester stations that would be shared by both intercity rail and coach bus services.

Anticipated ridership responses to the service initiative would include new riders attracted to the intercity rail service. It is anticipated that few current MBTA passengers living in New Hampshire would shift from using MBTA Lowell and North Billerica Stations to the new intercity rail service. Some BX and Concord Coach customers might shift to intercity rail service from Nashua, Manchester and Concord. The overall increase in the quality and frequency of transit options to Manchester and Concord may stimulate bus ridership as has seemed to be the case at the shared terminal in Portland, ME.

Table 3-23: Proposed Intercity 8 Timetable

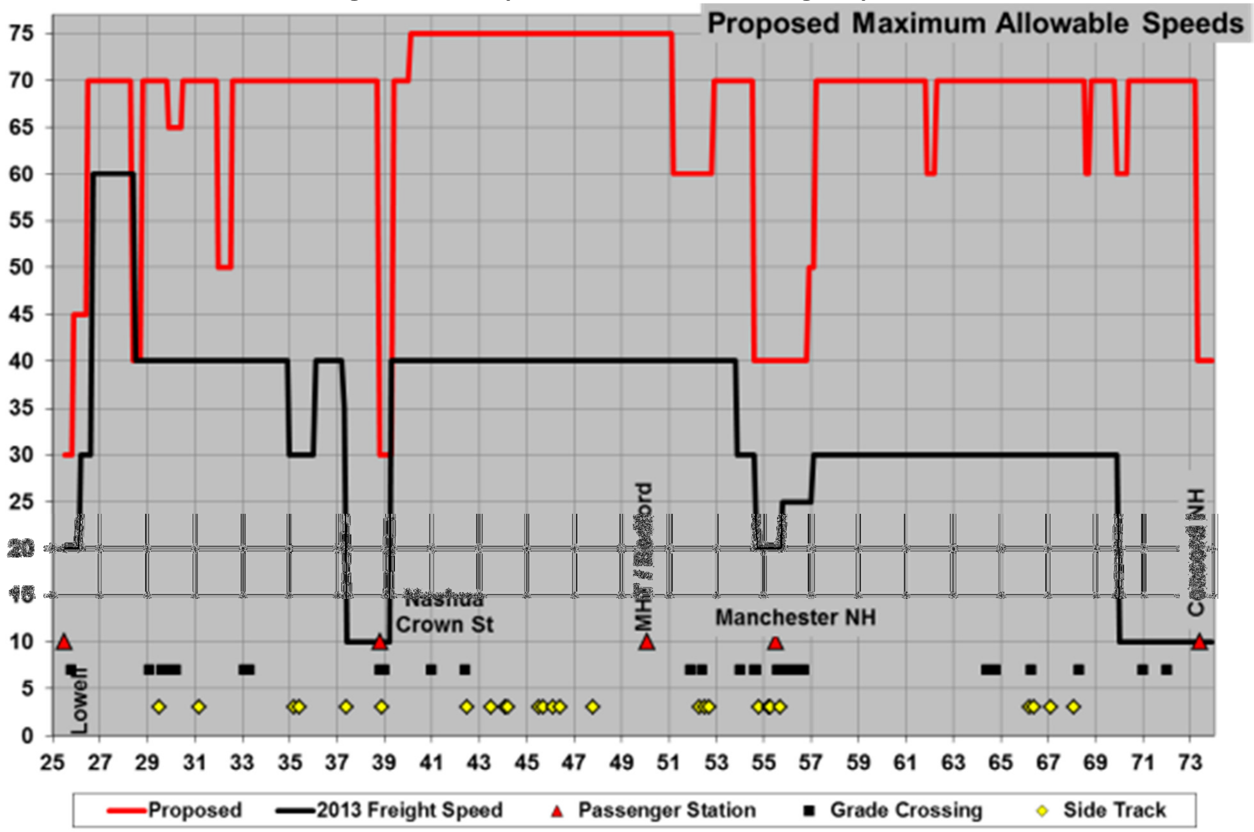
380	382	384	386		Station	MP		381	383	385	387
6:41	10:41	14:56	19:56	Read Down	**Concord NH**	73.3	Read Up	10:05	14:20	18:55	23:35
6:54	10:54	15:09	20:09		**Manchester NH**	55.7		9:39	13:54	18:29	23:09
7:07	11:07	15:22	20:22		**MHT (Bedford)**	50.1		9:31	13:46	18:21	23:01
7:20	11:20	15:35	20:35		**Nashua**	39.0		9:18	13:33	18:08	22:48
7:36	11:36	15:51	20:51		**Lowell**	25.5		9:02	13:17	17:52	22:32
7:52	11:52	16:07	21:07		**Anderson/ Woburn**	12.6		8:46	13:01	17:36	22:16
8:15	12:15	16:30	21:30		**North Station**	0.0		8:30	12:45	17:20	22:00

No improvements south of MBTA's Lowell Gallagher Terminal would be required. North of Lowell the railroad would be upgraded to permit safe, reliable operation of eight daily passenger trains at speeds of up to 75 mph. Recommended upgrades to track, bridges, crossings, and signals are summarized below.

The intercity 8 service option would require more extensive infrastructure upgrades than the commuter rail options as it is approximately 18 miles longer than the Option 3 Manchester Regional service. The service would also operate at higher maximum speeds; up to 75 mph between MHT and Nashua and 70 mph at many other locations (see Figure 3-8).

Unlike Options 3 and 6, no double track would be required between North Chelmsford (MP 28.5) and the southern end of the Tyngsboro Curve (MP 32). Industrial sidings would be created at three key areas of freight activity in Nashua and Merrimack to eliminate conflicts between local freight deliveries and through passenger trains. At these locations the existing mainline track would be retained as an industrial siding with an entirely new parallel mainline track constructed in the same alignment for use by through trains. Adding a second track would be straightforward as the railway was once entirely double tracked with the double track bed still largely intact.

Figure 3-8: Proposed Maximum Passenger Speeds



Four new passenger stations would be constructed (see Table 3-24). They would be a mix of high level platforms and low level platforms with MBTA "mini-high" platforms for handicapped accessibility. High level platforms would be preferred at all locations. A low-level with mini-high platform approach would be employed where no path was available for Pan Am freight trains to avoid using the platform track to ensure a clear route for wide freight loads. The platforms at Nashua and Manchester would be less complex than for the commuter rail options because no intercity trains would turn from northbound to southbound at these stations.

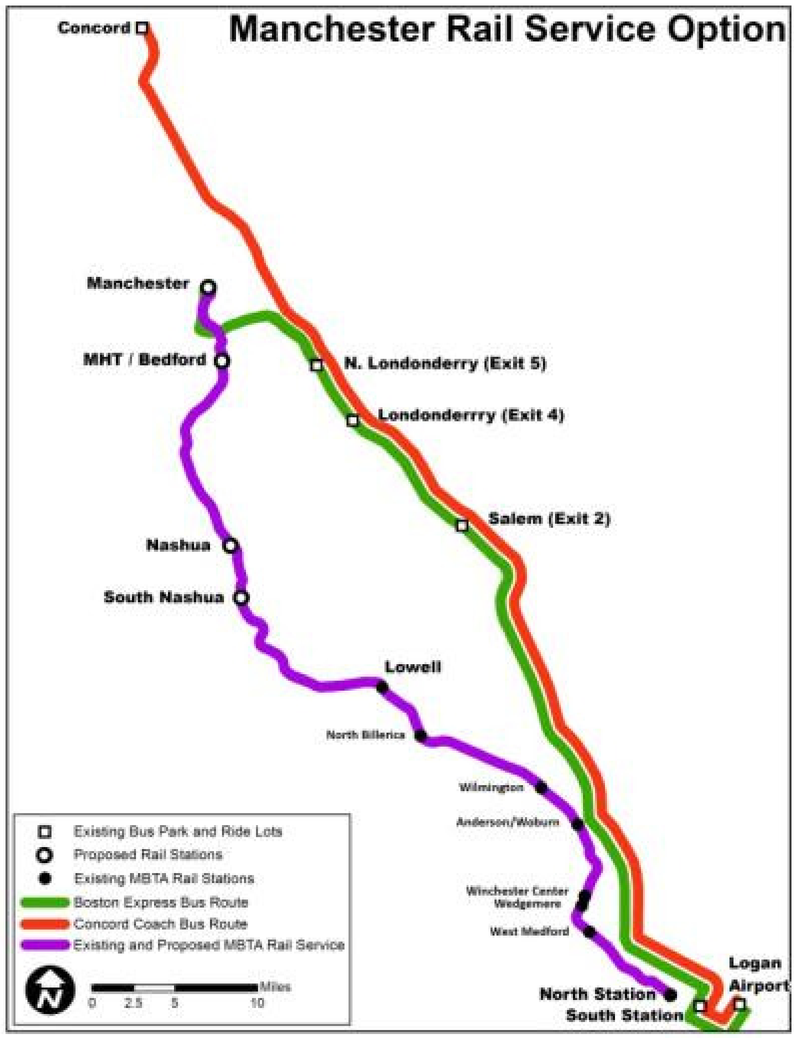
Table 3-24: Intercity 8 Passenger Station Development Plan

Station	MP	Type	Comments
Concord	73	HL	Single High Level platforms located on the stub end terminal track to the east of the main line
Manchester	55	LL	Single Low Level platform with mini-high to the east of the single mainline track
MHT/Bedford	52	LL	Single Low Level platform with mini-high to the west of the single mainline track
Nashua	39	LL	Single Low Level platform with mini-high to the west of the single mainline track

Manchester Regional Rail (CR 3)

- Extends MBTA commuter rail service north from Lowell, MA to Manchester, NH with intermediate stops at South Nashua, NH/Tyngsborough, MA, Nashua Crown Street and Bedford/MHT Airport.
- BX I-93 service to Manchester, North Londonderry, Londonderry and Salem is retained.
- BX Route 3 service to Manchester, Nashua and Tyngsboro is eliminated.

Figure 3-9: Proposed Manchester Commuter Rail and Bus Service Configuration



The Manchester Regional Rail Option would extend MBTA service 30 miles north from Lowell to downtown Manchester. The service initiative would provide all day commuter rail service between Boston and Nashua with a lower frequency regional service provided north to Manchester (see Figure 3-9). The service adds four new stations to the line with 16 weekday trains for Manchester and 34 weekday trains for Nashua. Eight optional connecting bus trips could be added between Nashua and Manchester to supplement the schedule of rail services with additional midday and evening mobility options. All existing MBTA deadhead trains on the Lowell Line would be eliminated.

A layover facility for four train sets would be constructed in the vicinity of Manchester. The number of weekday MBTA train miles operated on the line would increase 42% to 2,068. Six MBTA trains would be marginally adjusted with most changes required on light ridership reverse peak trains. Up to 12 coaches and one locomotive would be added to the MBTA's weekday equipment line up.

Ridership response to this service initiative is anticipated to include new riders attracted to rail service provided to the proposed New Hampshire stations. It is assumed that some current MBTA rail passengers living in New Hampshire would shift to these new stations from the existing MBTA Lowell and North Billerica Stations. It is also anticipated that many or most passengers from the discontinued BX Route 3 service would shift to the commuter railroad. Ridership impacts on the BX I-93 mainline services to Londonderry and North Londonderry and Salem would be likely negligible.

Five new passenger stations would be constructed for Option 3 (see Table 3-25). They would be a mix of high level platforms and low level platforms with MBTA "mini-high" platforms for handicapped accessibility. High level platforms would be preferred at all locations. A low-level with mini-high platform approach would be employed where no path was available for Pan Am freight trains to avoid using the platform track to ensure a clear route for wide freight loads.

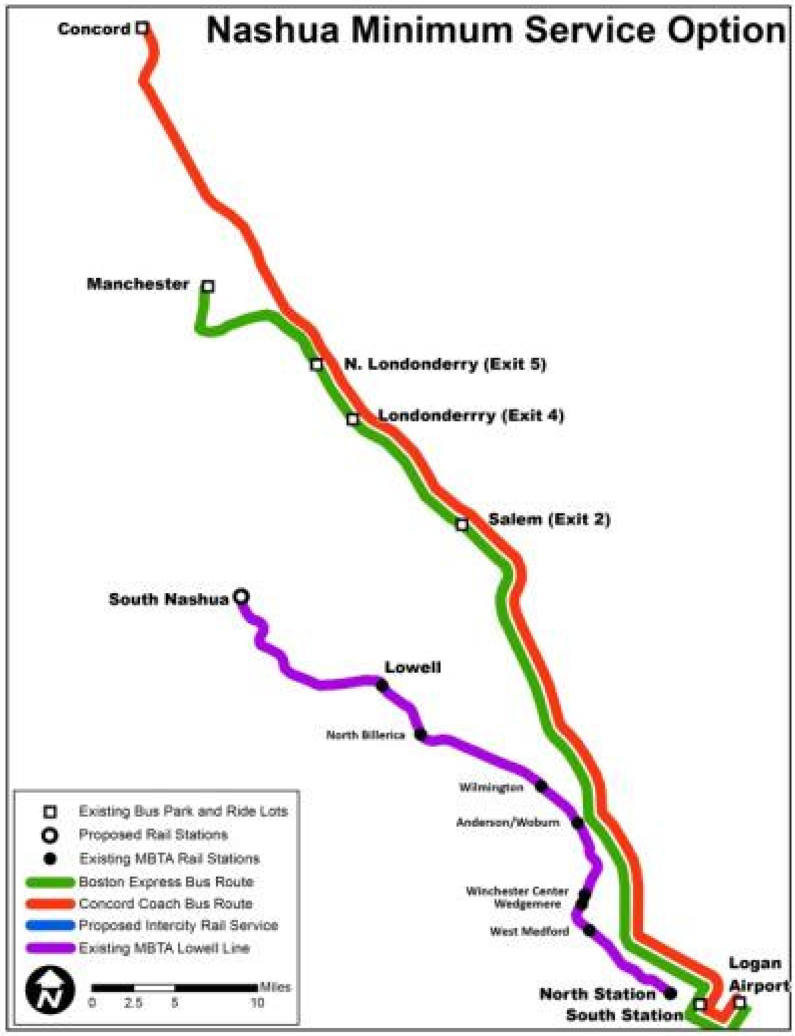
Table 3-25: Option 3 Passenger Station Development Plan

Station	MP	Type	Comments
Manchester	55	HL	Single High Level platform to the east of the eastern mainline track.
MHT/Bedford	52	LL	Single Low Level platform with mini-high to the west of the single mainline track
Nashua	39	HL	Single island High Level platform between two mainline tracks. Oversize freight would run around platform using yard tracks.
Tyngsboro / South Nashua	35	LL	Single Low Level platform with mini-high to the west of the single mainline track

Nashua Commuter Rail (CR 6)

- Extends MBTA commuter service north from Lowell, MA to at South Nashua, NH/Tyngsborough, MA.
- BX I-93 service to Manchester, North Londonderry, Londonderry and Salem is retained.
- BX Route 3 service to Manchester, Nashua and Tyngsboro is eliminated.

Figure 3-10: Proposed Nashua Commuter Rail and Bus Service Configuration



The South Nashua Minimum service option provides a minimal peak-period only commuter rail service to and from South Nashua with no rail service further north to Manchester or Concord. It is specifically designed to minimize the MBTA operating cost of extending service to Nashua. It could be developed and operated as an interim service coordinated with bus service while markets and finances for more New Hampshire were given time to develop.

MBTA service would be extended 13.5 miles north from Lowell to the South Nashua Station located near the Massachusetts – New Hampshire State Line (see Figure 3-10). The service adds one new station to the line with 20 weekday trains for South Nashua. A layover facility for four train sets would be constructed in the vicinity of South Nashua. Up to 6 coaches and one locomotive would be added to the MBTA's weekday line up of equipment.

The number of weekday MBTA train miles operated on the line would increase only 3% to 1,496. Schedules for several MBTA trains would be marginally adjusted with most changes required on light ridership reverse peak trains.

Optional midday and early evening feeder bus service between Lowell and South Nashua could provide connecting service to fill out a complete schedule of services. Four midday and two early evening bus round trips linking South Nashua with the Lowell MBTA train station could supplement the peak only rail service. Boston Express I-93 service to Manchester, North Londonderry, Londonderry and Salem would be retained, while Route 3 service to Nashua and Tyngsboro would be eliminated.

Ridership response to this service initiative is anticipated to include new riders attracted to rail service provided to the proposed new station. It is assumed that some current MBTA rail passengers living in New Hampshire would shift to this new station from the existing MBTA Lowell and North Billerica Stations. It is also anticipated that many or most passengers from the discontinued BX Route 3 service would shift to the commuter railroad. Ridership impacts on the BX I-93 mainline services to Londonderry and North Londonderry and Salem would be likely negligible.

One new passenger stations would be constructed for Option 6 (see Table 3-26). They would be a mix of high level platforms and low level platforms with MBTA "mini-high" platforms for handicapped accessibility. High level platforms would be preferred at all locations. A low-level with mini-high platform approach would be employed where no path was available for Pan Am freight trains to avoid using the platform track to ensure a clear route for wide freight loads.

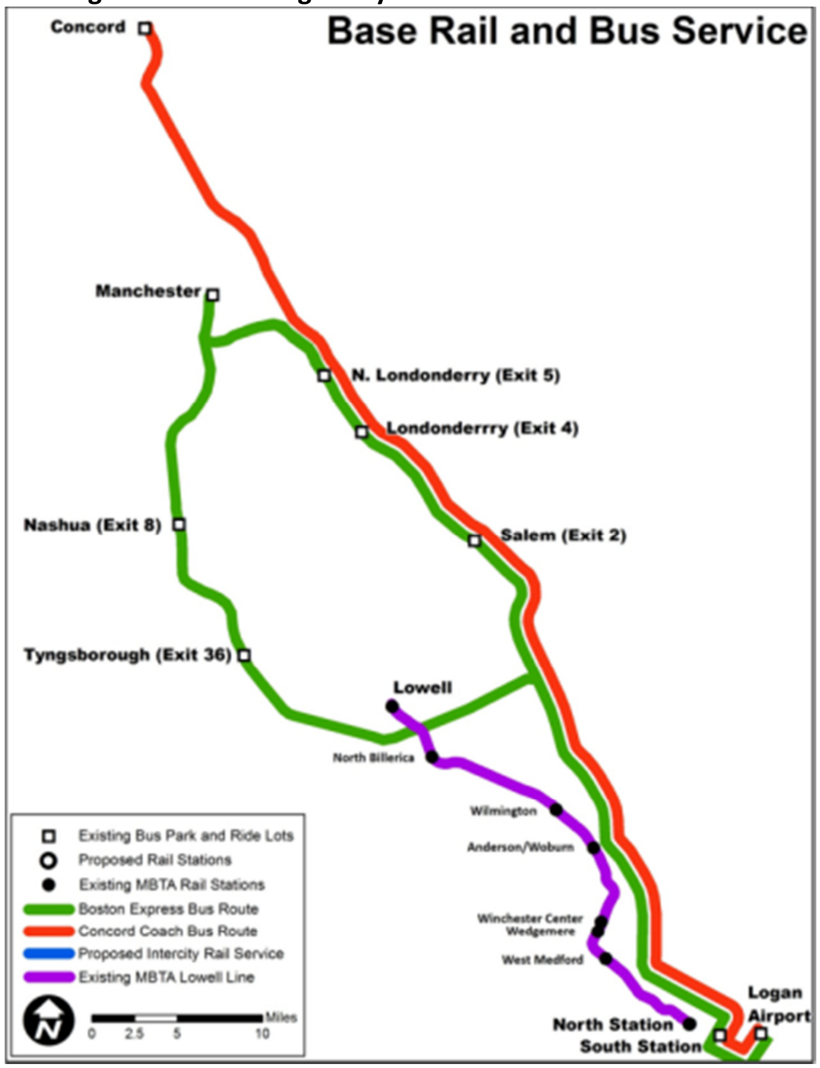
Table 3-26: Option 6 Passenger Station Development Plan

Station	MP	Type	Comments
South Nashua / Tyngsboro	35	LL	Single Low Level platform with mini-high platform to the west of the single mainline track.

Base+ (Base Expanded)

- New Hampshire's Boston Express (BX) bus service is increased from current 80 buses per day to 120 buses per day.
- All peak buses run direct and non-stop between each New Hampshire park and ride lot and Boston South Station with service every 30 minutes.
- Each park and ride lot sees hourly off-peak (but not direct) service.
- No changes to existing passenger rail services.

Figure 3-11: Existing Study Corridor Bus and Rail Services



The Base+ Option increases transit service frequency and directness within the study corridor by providing peak period point-to-point, non-stop trips from each of the New Hampshire park and ride lots to points within downtown Boston (southbound trips only), South Station and Logan Airport. The service would add approximately 40 trips to the schedule and would require approximately ten additional vehicles. There are no transit priority measures proposed in this option that would result in increased service velocities or decreased travel times.

Peak period point-to-point service would be provided at 30 minute headways, except for Manchester service which would be operated at 60 minute headways throughout the day. Hourly off-peak service would provide non-point-to-point service between each park and ride lot within the I-93 or Route 3 corridors and Boston South Station and Logan Airport without circulating through downtown Boston. A timetable for the proposed service is included in NHCC Project Definition of Final Alternatives Technical Memorandum.

Anticipated ridership response to this service initiative would include increased ridership at all BX park and ride lots and some possible reduction of ridership on MBTA commuter rail service from Lowell and perhaps North Billerica, MA.

BoS (Bus on Shoulder)

- Existing Boston Express (BX) bus service of 80 daily trips is permitted to operate within the I-93 shoulder south of I-495 to bypass congestion in general travel lanes.
- Savings of 8 to 12 minutes predicted during the AM peak period.
- No significant travel time savings predicted during in the PM peak period.

The Bus on Shoulder (BoS) Option aims to provide faster peak period service by permitting buses to operate within the I-93 shoulder south of I-495 to bypass peak congestion in Massachusetts. Typical Southbound AM peak period savings would be 8 to 12 minutes depending upon arrival time. Typical Northbound PM peak period savings would be approximately 5 minutes. The option would not add any additional trips or operate in a point-to-point manner, but would provide faster, more reliable peak travel times. The proposed schedules maintain the existing arrival and departure times at South Station and modify the departure and arrival times at New Hampshire park and ride lots based on the estimated travel time savings resulting from bus on shoulder operation. The service would not require any additional vehicles to operate the proposed schedule. A timetable for the proposed service that reflects time savings estimated using a variety of sources is included in NHCC Project Definition of Final Alternatives Technical Memorandum.

Ridership response to the service initiative is anticipated to include increased ridership at all BX park and ride lots and some possible reduction of ridership on MBTA commuter rail service from Lowell and perhaps North Billerica.

BoS+ (Expanded Bus on Shoulder)

- The Base+ service of 120 daily trips is permitted to operate within the I-93 shoulder south of I-495 to bypass congestion in general travel lanes.
- Savings of 8 to 12 minutes predicted during the AM peak period.
- No significant travel time savings predicted during in the PM peak period.

The BoS+ option merges the increased frequency and directness of the Base+ Option with the peak period congestion bypass feature of the BoS Option. It would offer faster and more direct peak service with more frequent off-peak service to all New Hampshire park and ride lots. The timetable prepared for this analysis merges the BoS and Base+ service concepts and can be found in NHCC Project Definition of Final Alternatives Technical Memorandum. Ridership response to this service initiative is anticipated to include increased ridership at all park and ride lots and some possible reduction of ridership on MBTA commuter rail service from Lowell and perhaps North Billerica.

3.7 Screening Final Alternatives[24]

In refining and then screening the various service options, the study team coordinated extensively with the FRA, FTA, MBTA, MVRTA, Pan Am Railways and Boston Express regarding the design of the alternatives and the necessary infrastructure and rolling stock investments. Schedules, stringline diagrams and corresponding track configuration diagrams were prepared for each of the rail options. Schedules and equipment rosters were prepared for the bus options. From this information the team was able to make more detailed and accurate estimates of costs for each rail and bus service option. Another round of ridership forecasts was prepared using more sophisticated forecasting techniques. Separate models were used for the intercity rail, commuter rail and express bus options. Amtrak's ridership forecasting team prepared the patronage forecasts for the Intercity 8 Option. Each of the key economic performance metrics and their assumptions are described in Table 3-27 and the final estimates of cost and demand are summarized in Table 3-28.

Table 3-27: Key Economic Performance Metrics and Assumptions

Economic Performance Metric	Evaluation Assumptions
New NH Transit Passenger Trips	Includes all new transit trips originating in New Hampshire including rail trips diverted from Lowell to Nashua. It also includes any changes in Boston Express (BX) ridership.
New Corridor Transit Passenger Miles	Includes all transit trip miles made by passenger rail and BX. It reflects downward adjustments in BX passenger miles for options where BX service is reduced or eliminated.
Total Project Value (Millions)	Includes the cost of all necessary infrastructure investment, including railroad improvements, stations, rail yards and bus shoulder lanes. It also includes the value of any rolling stock (buses or trains) necessary for the option. Finally it also includes the prorated value of the MBTA's 37-mile Nashua to Concord trackage rights based on the length of the option in New Hampshire. The Intercity 8 option would use Amtrak's statutory trackage right, not the rights acquired by the MBTA.
NH Costs after Federal Grants and MA Contributions (Conservative Case)	Assumes that MBTA contributes rolling stock and trackage rights to the project, but does not contribute to the cost of infrastructure improvements north of Lowell. It also assumes that the FTA does not consider the MBTA contribution of rolling stock or trackage rights as contributing to eligible project value. Consequently, the 50% FTA grant would cover half of the infrastructure investment. This also assumes that FRA would fund half of the overall project value for the intercity rail project and that no federal capital funding would be available for the bus options.

[24] For more information on the NHCC Final Screening and Selection of the Local Preferred Alternatives the reader is referred to the *NHCC Project Task 5: Final Screening of Alternatives Technical Memorandum*.

Economic Performance Metric	Evaluation Assumptions
Annual Operating Cost (Millions)	Updated preliminary cost estimates for commuter rail options. Final estimates for intercity and bus options. Assumes weekday only operation for commuter rail and bus services. Intercity service would operate 365days per year.
Net Operating Cost (Millions)	Annual operating costs minus forecast passenger revenue and federal formula funds. FTA fixed guideway formula funding is distributed for commuter rail service but not for bus or intercity rail programs.
Annual NH Debt Service	Assumes that NH share of project cost would be retired with 20 year bonds at 5% annual interest.
NH Annual Total Cost	Sum of Net Operating Cost and Annual Debt service
NH Annual Cost Per New Passenger Mile	This efficiency metric shows NH Annual cost divided by new annual transit passenger miles.
NH Annual Cost per New NH Rider	This efficiency metric shows NH Annual cost divided by new annual NH transit passengers.

Table 3-28: Forecasts for Passenger Demand, Capital Cost, Operating Cost and Economic Metrics

	Concord Intercity	Manchester Regional	Nashua Minimum	Expanded Bus	Bus on Shoulder	Bus on Shoulder+
New NH Transit Passenger Trips	946	2,568	670	338	48	374
New Corridor Transit Passenger Miles	48,853	90,506	5,542	15,905	2,112	17,495
Forecast Capital Cost (Millions)	$256	$246	$119	$10	$7	$17
NH Costs after Federal Grants and MA Contributions (Pessimistic Case)	$128	$97	$49	$10	$1	$17
Annual Operating Cost (Millions)	$8	$11	$4	$3	$0	$3
Net Operating Cost (Millions)	$5	$2	$2	$2	$0	$2
Annual NH Debt Service (Millions)	$10	$8	$4	$1	$1	$1
NH Annual Total Cost (Debt Service and Operating Deficit) (Millions)	$15	$9	$6	$3	$1	$4
NH Annual Cost Per New Passenger Mile	$1.19	$0.41	$3.89	$0.75	$1.11	$0.80
NH Annual Cost per New NH Rider	$61	$14	$32	$35	$49	$37

Review of the forecast performance indicates that the Manchester Regional Rail service, while expensive from a capital and operating cost perspective, would generate the greatest mobility benefits and the lowest unit costs per passenger mile and per passenger.   The bus options would be relatively inexpensive but would generate limited mobility benefits with resulting high unit costs per passenger and per passenger mile. The Intercity 8 Rail option would be slight more expensive to construct than the Manchester Regional Rail service. It would also attract fewer passengers and fewer passenger miles, resulting in a reduced operating efficiency. The Nashua Minimum rail service option would be half as expensive as the other rail options but would attract many fewer passengers, resulting in relatively unattractive measures of efficiency.

The balance of this Service Development Plan focuses on the most attractive Intercity Rail Service with some discussion of the Manchester Regional Rail service that could be implemented as a precursor or complement to intercity service for Concord.

4.0 MARKET ANALYSIS

This chapter describes the methods and findings of the project's market analyses and patronage forecasts for the intercity rail options. Two sets of forecasts were prepared. The first set, prepared in 2013 supported preliminary analyses and screening. A second, more detailed, set of forecasts was prepared for each of the final options including the preferred eight-train per day Concord-Boston intercity rail option.

4.1 Ridership Forecasting[25]

Preliminary forecasts for the Capitol Corridor rail service options were prepared using the Federal Transit Administration's (FTA) Aggregate Rail Ridership Forecasting Model 2.0 (ARRF2). Since the proposed service was only 73 miles long (shorter than some commuter rail lines in New York, Florida, and California) it was decided that the ARRF2 model would provide reasonable first estimates of potential ridership for both the commuter and intercity rail options under consideration in the corridor. These first forecasts were for initial screening purposes. After initial screening, more robust forecasts were developed in consultation with the FRA and FTA.

Limitations of the ARRF2 Model

The ARRF2 model is intended to develop order-of-magnitude estimates of rail ridership. The results presented in the preliminary estimates are considered to have "sketch planning" levels of accuracy sufficient for preliminary screening purposes.

- The ARRF2 model produces daily ridership estimates for new proposed rail services.
- As an "order of magnitude model," the total ridership forecast provides a rough estimate of ridership.
- The model does not produce boarding or alighting data by station. Tthis chapter outlines how boardings by station data were estimated from the ARRF2 results.
- The boardings per station include riders that may have previously boarded at the Lowell station or any other station, but now choose to board at a new station. The CTPS on-board survey completed in 2008-2009 indicates that for the existing Lowell line, Boston's North Station accounts for 85 percent of all inbound alightings. It is reasonable to expect local or regional passenger service on this line would have a similarly high percentage of inbound alightings at North Station.

[25] For more detail on the preliminary forecasts for all the rail options the interested reader is referred to NHCC Project Memorandum: Preliminary Ridership Forecast Based on the Aggregate Rail Ridership Forecasting Model 2.0 Prepared by Cambridge Systematics, August 23, 2013

Aggregate Rail Ridership Forecasting Model 2.0 (ARRF2) Overview

The model as described in the ARRF2 Model Application Guide is as follows:

> *This model estimates total unlinked rail transit trips for light rail and commuter rail systems by applying a series of expected rail shares to the amount of total (all mode) travel to work occurring within the rail corridor as recorded in the Year 2000 Census Transportation Planning Package (CTPP). Ridership is adjusted up or down to account for the level-of-service (speed and frequency) of the modeled rail line as compared to the baseline values for the rail lines used to calibrate the model. This model is intended to develop order-of-magnitude estimates of ridership for new rail lines in metropolitan areas.*

The model uses the Census Transportation Planning Package (CTPP) worker flows, station locations, and service operational characteristics to estimate ridership. The service operational characteristics are based on the proposed service, the rail station locations with distance-buffers using Geographic Information System (GIS) software and the CTPP data to estimate the worker flows within the service area. Figure 4-1 shows the input data setup required to run the ARRF2 model.

Figure 4-1: ARRF2 Inputs

Input Data

1. System Operational Characteristics
   - 1a. Directional Route Miles
   - 1b. Weekday Train Revenue Miles
   - 1c. Weekday Train Revenue Hours
   - 1d. Average Speed in MPH (if blank, computed from 1b and 1c)
   - 1e. Trains per day per direction (if blank computed from 1a and 1b)

2. CTPP Flows
   - 2a. Home within 2 miles of any station and Work within 1 mile of any station
     - 2.a.i Employment <50,000 / square mile
     - 2.a.ii Employment >50,000 / square mile
   - 2b. Home within 6 miles of a PNR station and Work within 1 mile of any station
     - 2.b.i Employment <50,000 / square mile
     - 2.b.Ii Employment >50,000 / square mile

3. Suburban-CBD Service flag
   - 3a. Code 1 if service is designed for connecting suburban areas to CBD otherwise, code 0

Project Use of ARRF2

For the Capitol Corridor preliminary forecast, ARRF2 was applied to the existing MBTA Lowell Commuter Rail line to determine a baseline value. Each alternative was analyzed as in incremental addition to the service corridor.

ARRF2 Base Case Lowell Line Forecast

The ARRF2 model was used to produce daily ridership forecasts for the commuter and intercity rail service options. Prior to analyzing the alternatives, the existing MBTA Lowell commuter rail line was tested using the ARRF2 model. The purpose of this was to establish a benchmark for the ARRF2 model to use as an adjustment to the alternative forecasts.

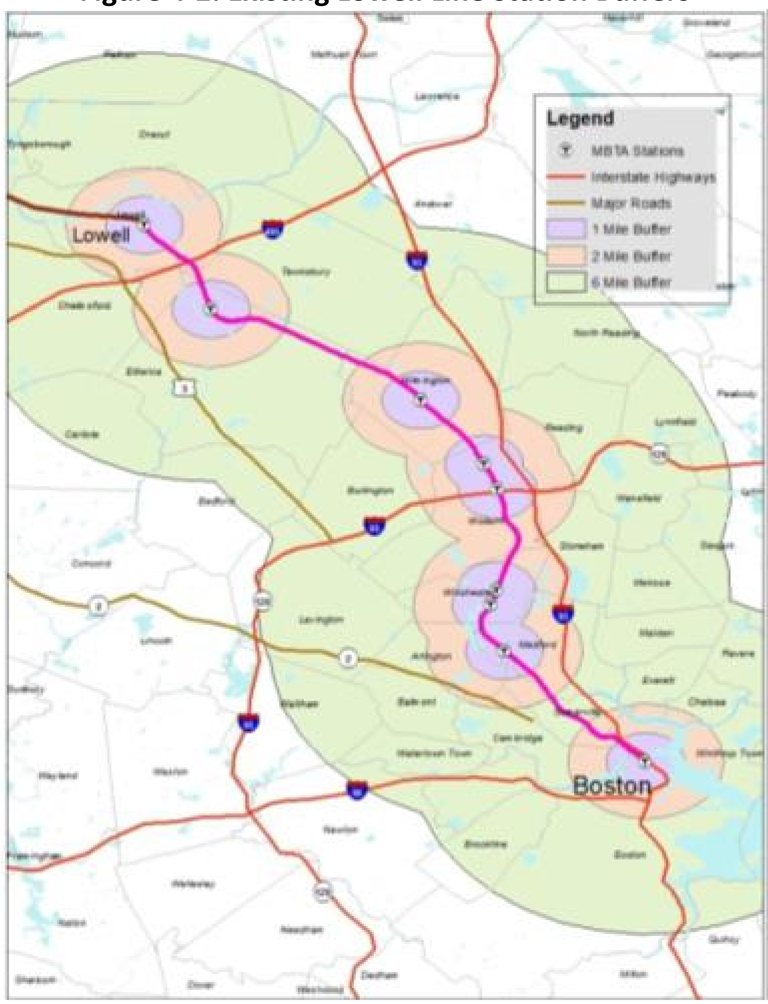
The ARRF2 model uses buffers around the rail stations to determine the catchment area for work flows. Figure 4-2 shows the one-, two-, and six-mile buffers around the existing MBTA Lowell commuter line.

The ARRF2 model produced a forecast of 9,096 riders using the Lowell line's operational characteristics and the CTPP worker flows.

System Operational Characteristics

ARRF2 uses several system characteristics that describe the rail service's operational parameters as inputs to the forecasts. Specific characteristics used by the model include directional route miles, average train speed, and the number of trains per day. The directional route miles are used to provide the model with information regarding the extent of the system. The figures for average train speed and number of trains inform the model concerning the quality of service being provided. The weekday train revenue miles and weekday revenue hours are used to calculate the average train speed. The weekday revenue miles and the directional route miles are used to calculate the number of trains per day.

Figure 4-2: Existing Lowell Line Station Buffers



CTPP Flows

CTPP data was used to approximate the market of trips that travel within the corridor. These worker flows were split into various submarkets which were used to estimate the magnitude of "walk-to" and "drive-to" markets for each train station. The "walk- to" flows are estimated using the number of households which are within a two-mile radius of any train station on the line. These flows are further segmented by the number of households which have travel flows to areas within a one-mile radius of any station, by employment densities less than 50,000 employees per square mile and by work flows to areas with more than 50,000 employees per square mile.

The park-and-ride flows are estimated using the number of households that are within a six-mile radius of any train station on the line. These flows are further segmented by the number of households which have workflows to areas within a one-mile radius of any station, by areas with employment densities less than 50,000 employees per square mile and those with work flows to areas with greater than 50,000 employees per square mile.

ARRF2 Lowell Line Forecast: System Operational Characteristics

The Lowell station is 25.5 rail miles from North Station in Boston which gives the base service a total of 51 direction route miles of service. Based on the current train schedules, the service offers 1,299 weekday train revenue miles and 38.52 weekday train revenue hours.

Base CTPP Travel Flows

Using the two-mile station buffering procedure for the existing Lowell line, the total number of households within two miles of a station that had employment within one mile of a station was 16,111 households (see Table 4-1). Of these households, 8,231 are employed in areas with less than 50,000 employees per square mile and 7,880 are in areas with more than 50,000 employees per square mile.

The six-mile buffer for park and ride trip estimation, results in 49,909 households within six miles of a station and also are employed within one mile of a station. A total of 22,770 and 27,139 households are employed in areas with less than, and greater than 50,000 employees per square mile, respectively.

Table 4-1: **Lowell Line Base CTPP Flows**

CTPP Flows	Base
Home within two miles of any station and Work within one mile of any station	
Employment <50,000/square mile	8,231
Employment >50,000/square mile	7,880
Home within six miles of a PNR station and Work within one mile of any station	
Employment <50,000/square mile	22,770
Employment >50,000/square mile	27,139

4.2 Preliminary Intercity Rail Forecasts

The operational characteristics of the proposed intercity regional services are based on the number of daily trains and the average speed. These values are shown in Table 4-2.

Table 4-2: Intercity Service Statistics

	Intercity 8	Intercity 12	Intercity 18
Directional Route Miles	146.8	146.8	146.8
Weekday Train Revenue Miles	46	46	46
Weekday Train Revenue Hours	8	12	18

The buffers used for the alternative analysis are presented in Figure 4-3. Depending on the stations included in each intercity and commuter rail alternative, some or all of these buffers were used.

Figure 4-3: NHML Proposed Station Buffers

New Hampshire CTPP Worker Flows

The worker flows can be broken down into three groupings for the alternatives including the existing Lowell line worker flows plus each incremental extension. These groupings are the Nashua flows, the Nashua/Manchester flows, and the Nashua/Manchester/Concord flows.

ARRF2 evaluated the incremental differences in service to analyze the alternatives. The CTPP flows shown in Table 4-3 are for the entire corridor and include those for the existing Lowell line. It shows that the incremental difference in flows for each of the alternative is simply the difference between the alternative flow and the base flows for the MBTA Lowell line.

Table 4-3: Lowell Line Base and Intercity CTPP Flows

CTPP Flows	Base (A)	Intercity Rail Markets (Concord, Manchester, Nashua) (B)	Incremental Intercity Flows (B-A)
Home within two miles of any station and Work within one mile of any station			
Employment <50,000/square mile	8,231	11,046	2,815
Employment >50,000/square mile	7,880	8,147	267
Home within six miles of a PNR station and Work within one mile of any station			
Employment <50,000/square mile	22,770	30,951	8,181
Employment >50,000/square mile	27,139	27,818	679

Comparison of Observed and Forecasted Ridership

The MBTA Lowell line sees approximately 8,745 daily boardings, whereas the base forecast was for 9,096 boardings. Using this actual and alternative forecast ridership and a boarding factor of 1.9, a combined scaling and rider-to-board conversion factor was developed to adjust the alternative forecasts. The scaling factor corrects for error in the base condition (existing) forecast, and the boarding factor converts boardings to riders. Table 4-4 lists the unadjusted and adjusted forecast for each alternative.

Table 4-4: Adjusted and Unadjusted Alternative New Riders Forecasts

Alternative	Unadjusted Forecast	Adjusted Forecast
Base	9,096	8,745
Intercity 8	659	633
Intercity 12	769	740
Intercity 18	913	878

City Boarding Distribution

The gross forecasts of ridership were allocated to three origin regions as a first step toward deriving station level forecasts. The CTPP flow data and service information for each city were combined to allocate boardings at the city level. Since these market shares were based on the magnitude of worker flows within the corridor, it is understandable that Nashua was shown to have the largest market share (see Table 4-5). This means that while Manchester is the larger city, more Nashua residents work in the Boston area than residents of Manchester. These market shares were then weighted by the number of trains that would stop in each city for the various alternatives.

Table 4-5: City Market/Level of Service Weighted Distribution Factors

Alternative	Market Distribution		
	Nashua	Manchester	Concord
Intercity 8	0.51	0.39	0.10
Intercity 12	0.51	0.39	0.10
Intercity 18	0.51	0.39	0.10

Station Boarding Distribution

The second step in deriving station level forecasts was to distribute the city level forecasts to the proposed stations. To allocate the boardings in cities with two or more stations, the team used the population within the six-mile catchment area and an accessibility factor. For the intercity services, the only necessary station allocation involved MHT/Bedford and the downtown Manchester Station which were allocated at 53 percent to Downtown Manchester and 47 percent for Bedford/MHT.

Preliminary Ridership and Boarding Estimates

Table 4-6 presents the preliminary total ridership and southbound boarding estimates for the three intercity rail service options as determined using the ARRF2 forecasting model.

Table 4-6: Preliminary Total Ridership and Southbound Boarding Forecasts

	Total Ridership	Southbound Boardings
Intercity 8	1,260	630
Intercity 12	1,480	740
Intercity 18	1,760	880

Station Southbound Boarding Distribution

Preliminary station level southbound boarding and total ridership estimates are presented in Table 4-7.

Table 4-7: Rounded Total Ridership and Station Level Boarding Estimates

		Northbound Boardings	Southbound Passenger Boardings			
Alternative	Total Ridership	Boston	Nashua	Bedford /MHT	Manchester	Concord
Intercity 8	1,260	600	320	120	130	60
Intercity 12	1,480	700	370	140	160	70
Intercity 16	1,760	840	440	160	190	90

Preliminary Estimates of Passenger Miles

Estimates of the passenger miles that would be expected from each service option were developed for the purposes of comparing alternatives on their mobility benefits and to facilitate derivation of revenue forecasts (see Table 4-8). Weekday passenger mile estimates were derived by multiplying the forecast southbound boardings at each station multiplied by the distance from each station to Boston North Station. This product was then doubled to reflect the mileage resulting from returning northbound trips.

Table 4-8: Forecast Southbound Boardings and Weekday Passenger Miles

		Forecast SB Boardings			Weekday Passenger Miles		
Intercity Rail Station	Miles to Boston	Intercity 8	Intercity 12	Intercity 18	Intercity 8	Intercity 12	Intercity 18
Concord	73.3	60	70	90	8,796	10,262	13,194
Manchester	55.7	130	160	190	14,482	17,824	21,166
MHT/ Bedford	50.1	120	140	160	12,024	14,028	16,032
Nashua	39	320	370	440	24,960	28,860	34,320
	Totals	630	740	880	60,262	70,974	84,712

Final Intercity Rail Forecasts

A separate more refined forecast for the selected Intercity 8 Rail service option was prepared in collaboration with Amtrak and its ridership forecasting consultant; which has been supporting Amtrak's Market Research & Analysis Department with ridership and ticket revenue forecasts for all of Amtrak's services across the United States[26]. For the purposes of this study, Amtrak estimated ridership on the 73 mile, eight-train-per-day Concord service by analogy to the nearby 114 mile 10-train-per-day Downeaster service. Each station on the proposed intercity rail service was associated with a Downeaster "surrogate" station with similar travel time, station demographics, and train service characteristics. The model was then factored for differences between the surrogate Downeaster station and the proposed Capitol Corridor station. The Capitol Corridor stations and their Downeaster surrogate stations are shown in

Table 4-9.

Table 4-9: Intercity Rail Station Associations (June 26, 2014)

NHML Existing and Proposed Stations			Surrogate Downeaster Stations		
Station Name	**Miles to Boston**	**Population**	**Station Name**	**Miles to Boston**	**Population**
Boston North Station	0.0	2,667,000	Boston North Station	0.0	2,667,000
Woburn, MA	12.6	1,087,000	Woburn, MA	12.6	1,087,000
Lowell, MA	25.2	746,000	Haverhill, MA	32.1	662,000
Nashua, NH	39.0	340,000	Exeter, NH	51	187,000
Bedford, NH	50.1	120,000	Durham, NH	62	83,000
Manchester, NH	55.7	266,000	Exeter, NH	51	187,000
Concord, NH	73.3	166,000	Dover, NH	68	162,000
Station Name	**Employment**	**Income**	**Station Name**	**Employment**	**Income**
Boston North Station	1,705,000	146,275,000	Boston North Station	1,705,000	146,275,000
Woburn, MA	574,000	60,660,000	Woburn, MA	574,000	60,660,000
Lowell, MA	370,000	40,388,000	Haverhill, MA	287,000	32,237,000
Nashua, NH	169,000	16,025,000	Exeter, NH	90,000	9,128,000
Bedford, NH	59,000	5,332,000	Durham, NH	36,000	3,297,000
Manchester, NH	134,000	12,112,000	Exeter, NH	90,000	9,128,000
Concord, NH	88,000	6,740,000	Dover, NH	64,000	5,921,000

Notes: 1) Based on county-level demographic data from Moody's Economy.com
2) Demographics calculated as follows: Determine the population, employment, and income within a 10, 15, 20, and 25-mile radius around the stations (as the crow flies), then multiply by factors of 1.4, 0.9, 0.5, and 0.2 respectively. The sum of these four numbers is the assumed station catchment area.
3) Demographic differences between the primary and surrogate stations are adjusted for in the model.

[26] For more detail on the final forecasts for all the final options the interested reader is referred to NHCC Project Report: Final Ridership Prepared by Cambridge Systematics, September 2014.

The model used Fiscal Year 2013 Amtrak Downeaster ridership/revenue data. In the Amtrak model for the Downeaster, Boston-Woburn (13 miles) has a higher observed yield than Boston-Haverhill (34 miles) in FY13. This Boston-Woburn/Boston-Lowell assumption has been maintained for the Capitol Corridor ridership estimates. The fares used in the ridership estimates are listed in Table 4-10.

Table 4-10: Intercity Rail Station Fares

Capitol Corridor Station	Surrogate Station	Weekday Fares	Weekend Fares
Boston North Station	Boston North Station	-	-
Woburn	Woburn	$12	$12
Lowell	Lowell	$6	$9
Nashua	Haverhill, MA	$7	$11
Bedford/MHT	Durham, NH	$10	$14
Manchester	Exeter, NH	$9	$14
Concord	Dover, NH	$13	$15

This intercity rail forecasting model, like most intercity rail forecasting models, predicts annual riders for station pairs along the line. The projected ridership by station pair is listed in Table 4-11. Total ridership along the line is projected to be 354,100 passengers per year.

Table 4-11: Annual Inter-City Rail Ridership Estimates

	Concord	Manchester	Bedford/MHT	Nashua	Lowell
Concord					
Manchester	900				
Bedford/MHT	200	1,000			
Nashua	600	1,400	1,600		
Lowell	1,300	900	4,200	700	
Woburn	900	500	5,700	800	100
Boston	52,800	130,900	43,600	91,600	14,400

The station pair ridership data is condensed to the New Hampshire station level annual ridership by summing the station trip origins and destinations at each station. The station level ridership forecast are converted to annual boardings by dividing the ridership by two, and annual boardings are converted to daily boardings by dividing by 365 days. These data are shown in Table 4-12.

Table 4-12: Inter-City Rail Boarding Estimates

	Annual		Daily
Station	Ridership	Boardings	Boardings
Concord, NH	56,700	28,350	78
Manchester, NH	135,600	67,800	186
Bedford / MHT, NH	56,300	28,150	77
Nashua, NH	96,700	48,350	132
Total	345,300	172,650	473

4.3 Final Estimates of Passenger Miles

An estimate of the passenger miles that would be expected from the final intercity rail service option was developed to facilitate derivation of revenue forecasts and for the purposes of comparing with other non-intercity rail alternatives on their mobility impacts. Weekday passenger mile estimates were derived by multiplying the annual station pair forecasts by the station pair distance and dividing by 365.

Table 4-13: Passenger Miles

<table>
<tr><th rowspan="2">Station</th><th colspan="3">Passenger Miles</th></tr>
<tr><th>Annual</th><th colspan="2">Daily</th></tr>
<tr><td>Concord</td><td>2,014,305</td><td>5,519</td><td rowspan="4">24,762</td></tr>
<tr><td>Manchester</td><td>3,725,930</td><td>10,208</td></tr>
<tr><td>Bedford/MHT</td><td>1,408,625</td><td>3,859</td></tr>
<tr><td>Nashua</td><td>1,889,190</td><td>5,176</td></tr>
<tr><td>Lowell</td><td>353,965</td><td>970</td><td rowspan="3">25,314</td></tr>
<tr><td>Woburn</td><td>242,810</td><td>665</td></tr>
<tr><td>Boston</td><td>8,642,665</td><td>23,679</td></tr>
<tr><td>Total</td><td>18,277,490</td><td>50,075</td><td>50,075</td></tr>
</table>

Forecast Reductions in Automobile Vehicle Miles Traveled (VMT)

The preferred intercity rail option would provide new service in the corridor, but unlike the existing commuter bus and proposed commuter rail services, it was not designed for the work-trip market in the corridor. It is assumed that the intercity rail riders will all be new transit riders that have diverted trips from automobiles. To convert passenger miles to vehicle miles, an average vehicle occupancy of 1.67 [27]persons per vehicle was used. The VMT shown in Table 4-14reduction from the inter city rail service is not concentrated in the morning and afternoon peak periods as it is with the commuter bus and commuter rail options.

Table 4-14: Inter-City Rail Change in Vehicle Miles Traveled

<table>
<tr><th>Station</th><th colspan="2">VMT Reduction</th></tr>
<tr><td>Concord</td><td>3,305</td><td rowspan="4">14,827</td></tr>
<tr><td>Manchester</td><td>6,113</td></tr>
<tr><td>Bedford/MHT</td><td>2,311</td></tr>
<tr><td>Nashua</td><td>3,099</td></tr>
<tr><td>Lowell</td><td>581</td><td rowspan="3">15,158</td></tr>
<tr><td>Woburn</td><td>398</td></tr>
<tr><td>Boston</td><td>14,179</td></tr>
<tr><td>Total</td><td>29,985</td><td>29,985</td></tr>
</table>

[27] 2009 National Household Survey Data, http://nhts.ornl.gov/tables09/fatcat/2009/avo_TRPTRANS_WHYTRP1S.html

5.0 RAIL SERVICE DESIGN AND OPERATIONS

This chapter describes the service design and provides an operations overview for the preferred Intercity Passenger Rail Service. The Intercity 8 Rail Service alternative was selected from the three Intercity Rail Service Options, because of its low net operating costs and reasonable level of mobility benefit. The number of additional riders attracted by more the frequent service that would be offered by Options 12 and 18 did not keep pace with the forecast cost of the additional service. In preliminary estimates, the Intercity 8 option was projected to carry 946 daily passengers at a net operating cost of $3.6 million. By comparison, the Intercity 12 and 18 options would carry 1,104 and 1,308 daily passengers respectively at net operating costs of $6.9 and $11.8 respectively.

Design Objectives

In designing the Intercity 8 Service Option, the study team worked to maximize the service frequency that could be effectively offered with a single set of equipment and limited crews serving the five major population centers along the corridor: Concord, Manchester and Nashua in New Hampshire and Lowell and Boston in Massachusetts. The design also provides service to the suburban Massachusetts intermodal hub in Woburn that is served by intercity passenger rail service between Portland, Maine and Boston (Amtrak Downeaster). The operating characteristics of the successful Downeaster service were influential to the design of the Intercity 8 option. Both services (the *Downeaster* and the potential "*Granite State"*) would offer arrivals and departures at North Station at similar times of day.

Design Constraints, Assumptions and Paradigms

In designing the service, the study team was guided by the following constraints, assumptions and paradigms:

- The new service must overlay onto the existing schedule and mix of passenger trains currently using North Station including all of the MBTA's north side commuter rail service and Amtrak's Downeaster service. The design needed to be particularly cognizant of the 68 weekday MBTA and Amtrak passenger trains that use portions of the route between Lowell and Boston.
- In order to gain acceptance from the host railway, the service needs to be completely transparent to existing MBTA customers.
- In order to minimize required capital investment and maximize the benefits from a limited capital budget, it was assumed that there would be no upgrades to infrastructure south of Lowell where successful passenger services are already offered. Instead, investments would be focused along the portions of the route that are currently "freight-only".
- Also to minimize required capital investment, the service was designed to respect limited capacity at North Station. The MBTA has allowed that one new peak period arrival/departure by an intercity train could be accommodated at North Station once the currently inoperable Tracks 11 and 12 are put into service.
- Also to minimize capital expenditure, any track improvements would need to stay within the existing rail right of way. The line follows the banks of the Merrimack River for most of its route between Lowell and Concord. Since the frequency of curves and degree of curvature associated

with the line is quite high due to its riverine routing, this constraint had a significant impact on maximum allowable speeds north of Lowell.

- To provide for harmonious operations with Pan Am Railways (PAR) (the freight carrier and owner of the route in New Hampshire), the study team focused on providing industrial siding tracks at key locations along the line to avoid conflicts between intercity passenger trains and local freight train pick-ups and deliveries at customer locations.

Intercity Passenger Rail Service Design Overview

Meetings with Amtrak, MassDOT and the MBTA in the spring of 2013 indicated a willingness to work with NHDOT on the provision of passenger service along the New Hampshire Main Line (NHML) from New Hampshire to North Station. This cooperation would take the form of Amtrak operation of intercity trains into New Hampshire or MBTA operation of commuter trains along the same route. The MBTA felt that two new station tracks would be opened at North Station with the imminent relocation of the Spaulding Hospital immediately to the west, providing capacity for one additional peak Amtrak train in each direction. MBTA would also be willing to extend its service into New Hampshire provided that the service extension was essentially transparent to existing MBTA passengers using the services offered between Lowell and Boston.

The study team devised a hierarchy of three conceptual services that could be operated as an independent Amtrak "Granite State" service 73 miles northward from North Station to Concord, NH. The options were based on historic and current physical attributes of the NHML, the schedule of passenger services on the line and general service parameters for Amtrak services in corridors of less than 150 miles. Each service would:

- Operate independently of the MBTA and Amtrak Downeaster passenger services already serving the southernmost 25 miles of the route;
- require no upgrades to infrastructure south of Lowell;
- require upgrades to rail infrastructure north of Lowell including:
  - Upgrades to 48 miles of existing track to FRA Class 4 providing for maximum passenger train speeds of at least 70 mph[28];
  - Establishing Downtown Nashua as a passing point for northbound and southbound passenger trains (Intercity Options 12 and 18);
  - Installation of two or more industrial sidings between Nashua and Concord allowing passenger trains to pass or meet freight trains serving these segments;
  - Installation of a passing siding on the PAR freight mainline west of North Chelmsford to reduce the need for trains to stand east of North Chelmsford on the route between Lowell and Nashua. MassDOT and MBTA have since committed to providing this passing siding independent of this planning initiative to solve capacity problems on the adjacent Fitchburg route also shared by MBTA and PAR trains;

[28] Seventy mph was initially selected as no historic records showed higher speeds along the route since its opening in the 1800's. Further later analysis indicated that 75 mph Maximum Allowable Speeds could be supported for a relatively short segment between Nashua and Manchester.

- Installation of Northeast Operating Rules Advisory Committee (NORAC) Rule 261 signals between Manchester and Concord (approximately 18 miles), and;
- Installation of Positive Train Control protection.

The proposed services would call at six passenger stations north of Boston (see Table 5-1).

Table 5-1: Proposed Stations with Distance and Travel Time to Boston

Station	Miles to Boston	Approximate Travel Time to Boston
Concord	73.4	1:29
Manchester	55.5	1:09
MHT / Bedford	50.1	1:01
Nashua	38.8	0:48
Lowell	25.5	0:32
Woburn	12.6	0:16

The projected travel times compare favorably with historic minimum travel times between Concord and Boston (see Table 5-2). The presumed maximum allowable speeds between Lowell and Concord are shown in Figure 5-1: Proposed NHML Maximum Allowable SpeedsFigure 5-1.

Table 5-2: Historic Minimum Concord-Boston Travel Times

	1910	1926	1945	1954
Travel Time	2:00	2:05	1:35	1:22
Commercial Velocity (mph)	37	35	46	54

Source: Jacobs analysis of archived public timetables

Figure 5-1: Proposed NHML Maximum Allowable Speeds

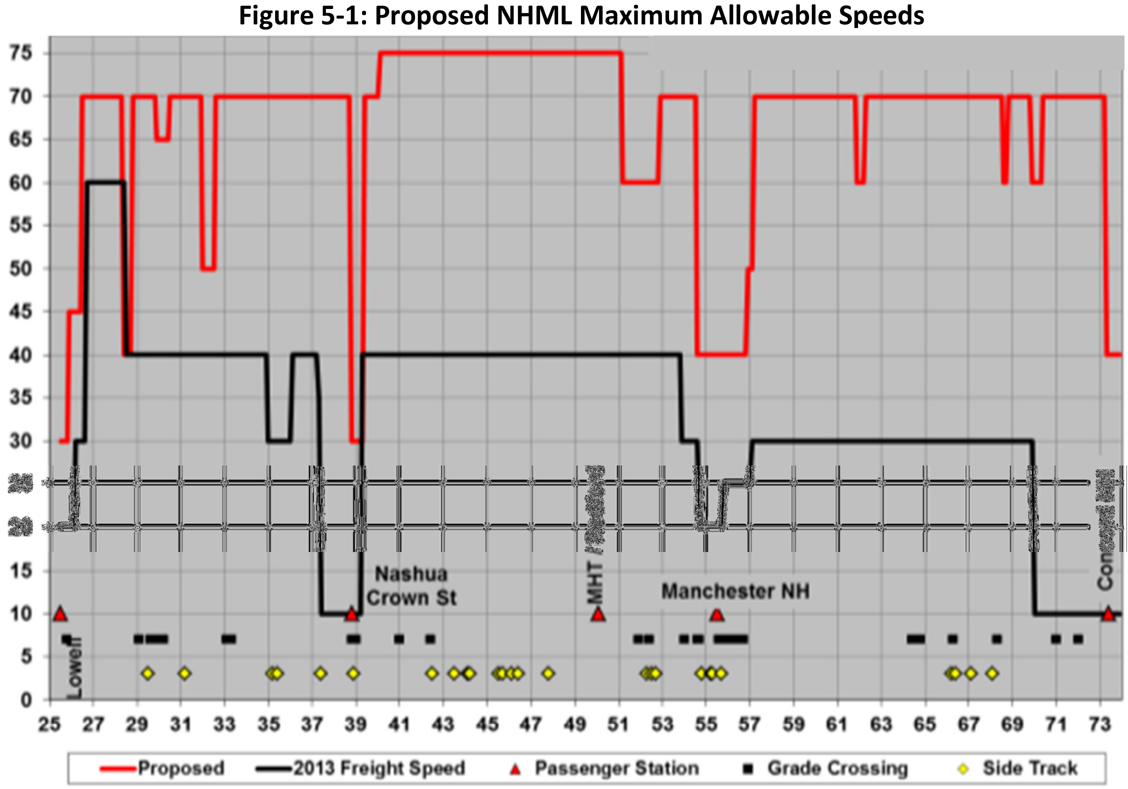


Table 5-3 summarizes the three conceptual Amtrak services that were considered for the restoration of passenger service on the line. The Intercity 12 and Intercity 18 options were ultimately screened out from further consideration.

Table 5-3: Operating Characteristics of Proposed Intercity Rail Service Options

Options	Weekday Revenue Trains			Route Miles	Stations	Weekday Train Miles
	Nashua	Manchester	Concord			
Intercity 8	8	8	8	73	6	586
Intercity 12	12	12	12	73	6	880
Intercity 18	18	18	18	73	6	1,319

Each intercity rail and commuter rail service was designed using custom train scheduling and stringline diagraming tools that are used for many rail scheduling and planning assignments at the MBTA and other passenger railroads. Given the relatively low density of freight traffic on the NHML, it was decided in consultation with the FRA that full RTC simulation models of the route would not be necessary for this particular study.

Intercity 8 Rail Service

- Four daily intercity passenger rail round trips between Concord, NH and Boston, MA making intermediate stops at Manchester, Bedford/MHT Airport, Nashua Crown Street, Lowell, MA and Woburn, MA.
- Base Boston Express bus service is retained.

The eight-train per day Intercity 8 Rail Option would provide four daily round trips over the 73 mile route stopping at five intermediate stations (see Figure 5-2). The end to end trip time would be approximately 96 minutes and the service would operate 586 daily train miles.

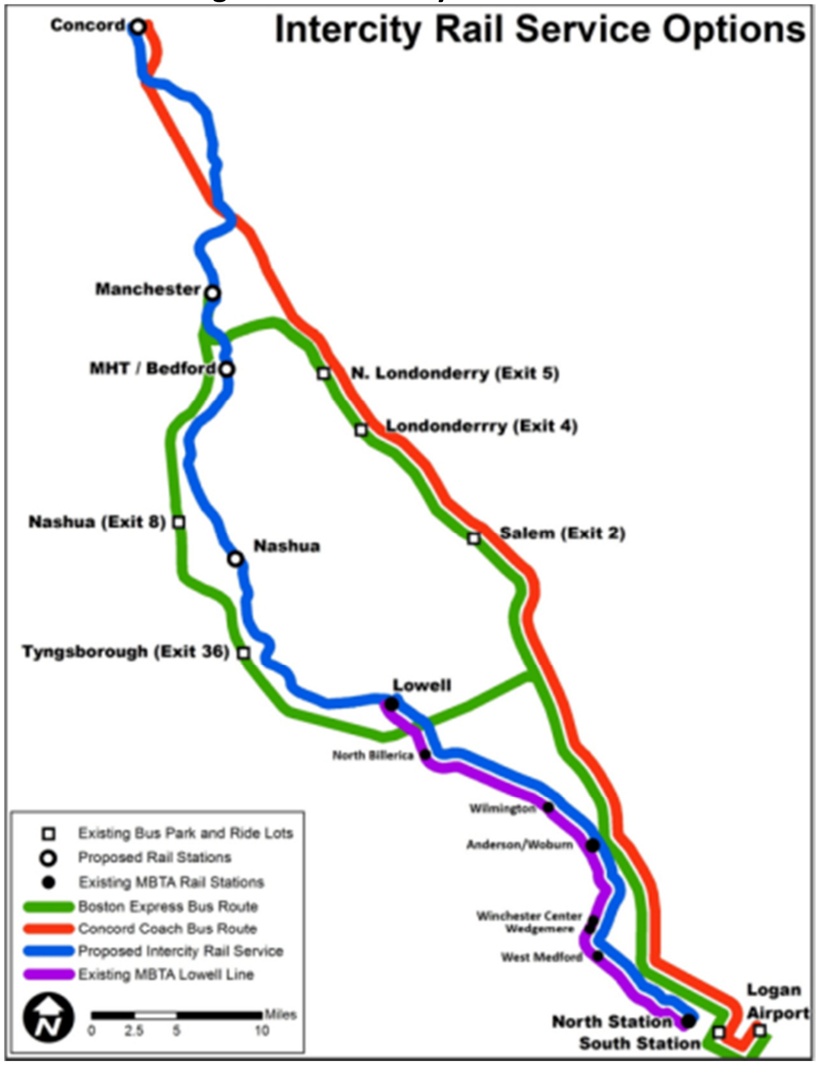
A proposed timetable for the service is shown in Table 5-4. A full NHML schedule is found in Figure A-1 in the Appendix and a stringline time distance diagram showing the proposed service integrated with the existing MBTA service on the line are found in Figure 5-3.

Presuming an average cost of $36 per train mile based on recent experience of the nearby Amtrak Downeaster service, the Intercity 8 Option would cost approximately $7.7 million per year to operate.

The service could be extended with possible connections to private bus services for North Country destinations. No changes are proposed to express bus service for commuting to Boston via I-93 or Route 3. Local bus service to the intercity rail stations could be offered but would not be integral to the service design. A Boston Express / Concord Coach / rail fare integration scheme similar to that employed by the Downeaster at Portland, Maine could be employed at the Concord and Manchester stations that would be shared by both intercity rail and coach bus services.

It is presumed that service would be offered with a single push-pull locomotive hauled train set with four coaches. The rolling stock would be similar in configuration and performance to the equipment used for the Downeaster and MBTA commuter rail service. The train set would be stored and serviced overnight at the Concord Station where a plug-in and basic cleaning and servicing facilities would be provided. It is assumed that the intercity service would be operated from the same pool of equipment used to provide Downeaster service with an extra locomotive and control coach added to that pool to offset the additional burden this service would create. Amtrak would provide heavy maintenance at its facilities in Boston's Southampton Street Yard or further south on the Northeast Corridor as is the practice with the Downeaster equipment.

Figure 5-2: Intercity 8 Rail Service



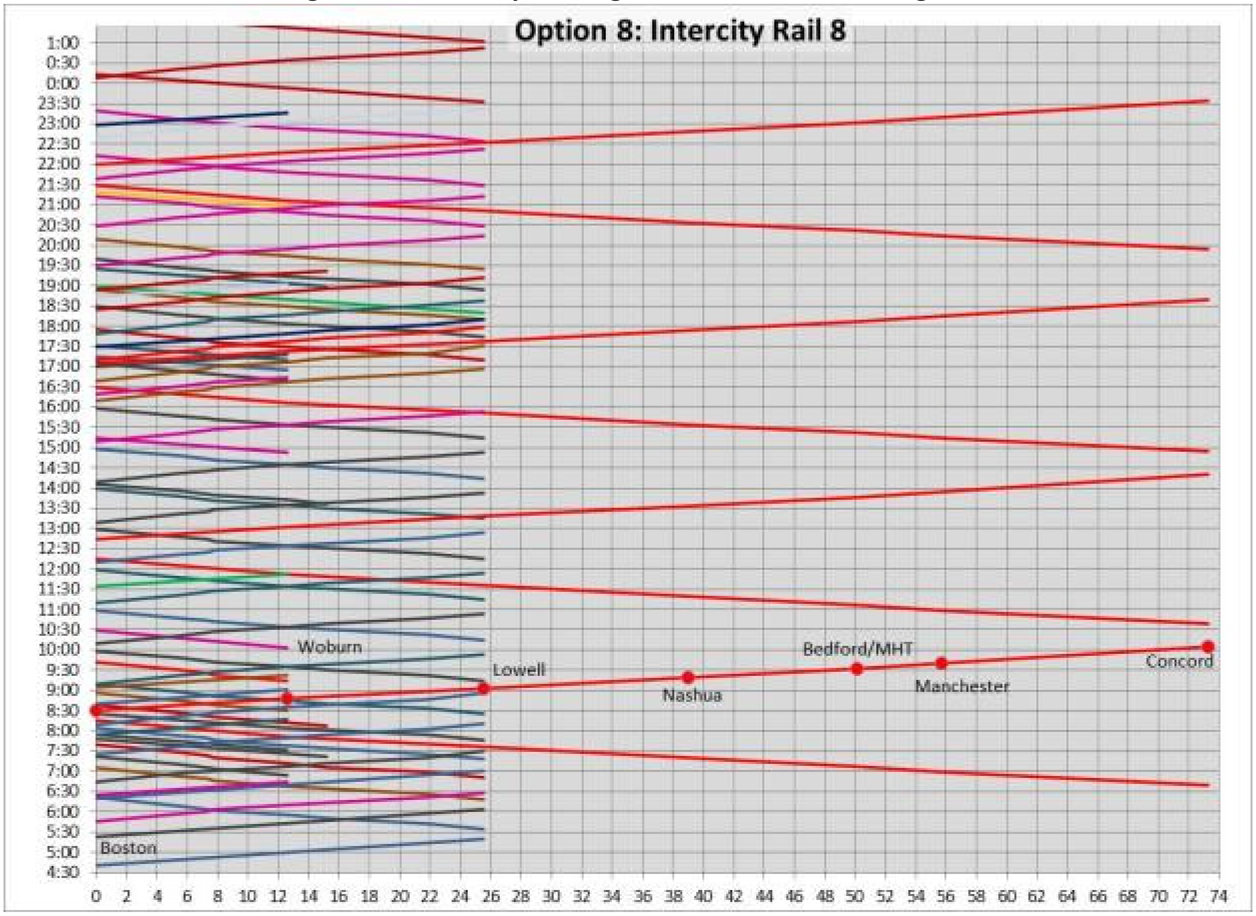
Two crews would be required to provide service each day. One crew would handle Trains 380 to 383; while the other crew would handle Trains 384 to 387. A full roster of three crews plus a spare would be necessary to handle routine service requirements. The minimum required crew would be an engineer and conductor although it is likely that Amtrak would operate the service with a third crew member to assist with operation of doors and management of passengers.

Table 5-4: Proposed Intercity 8 Timetable

380	382	384	386		Station	MP		381	383	385	387
6:39	10:39	14:54	19:54	Read Down	**Concord NH**	73.3	Read Up	9:59	14:14	18:49	23:39
6:58	10:58	15:13	20:13		**Manchester NH**	55.7		9:38	13:53	18:28	23:08
7:07	11:07	15:22	20:22		**MHT (Bedford)**	50.1		9:30	13:45	18:20	23:00
7:20	11:20	15:35	20:35		**Nashua**	39.0		9:17	13:32	18:07	22:47
7:36	11:36	15:51	20:51		**Lowell**	25.5		9:02	13:17	17:52	22:32
7:52	11:52	16:07	21:07		**Anderson/ Woburn**	12.6		8:46	13:01	17:36	22:16
8:15	12:15	16:30	21:30		**North Station**	0.0		8:30	12:45	17:20	22:00

For the purposes of this study, it was presumed that the service would be operated by Amtrak. Certain economies in crewing, equipment maintenance and administrative overhead might be available if the service were operated by the MBTA and its passenger rail contractor in a manner similar to the operation of their new 78-mile Cape Flyer service. The Cape Flyer was started in the summer of 2013 as a seasonal weekend only experiment. After two seasons of operation it appears that it may become permanent and a model for the operation of other short distance intercity rail services into Boston.

Figure 5-3: Intercity 8 Stringline / Time-Distance Diagram



6.0 STATIONS AND LAYOVER FACILITIES

This chapter describes the design requirements and evaluation criteria used to identify and assess potential sites for the passenger rail stations and layover facilities proposed to support the NHCC Intercity Rail service options. It then describes the recommended sites, evaluates their performance and provides preliminary designs, where appropriate. A total of eight intercity passenger rail stations and three layover site options were identified through a combination of stakeholder meetings and public outreach, review of existing and historical conditions, previous studies and field inspections. Four stations and one layover facility were recommended for the intercity passenger rail service.

Design Requirements

Each of the rail stations would require ADA compliant platforms for passengers to board and alight the trains, provide a canopy for shelter, have provisions for buses and automobiles to pickup and drop-off passengers, and provide direct access to and from major highways and nearby land uses. All, but one, of the stations would require parking designated for rail passengers. The sites located in downtown Manchester are too constrained to provide dedicated commuter parking, but ample public parking capacity is located within short walking distance of the identified sites.

Where possible, the study team strove to design platforms that were “high-level” for their full length. High-level platforms ease boarding for all passengers by eliminating the need for stairways to climb into and out of the passenger coaches. High-level platforms may conflict with freight train movements; therefore, a short 85-foot long section of high-level platform, commonly referred to as a “mini-high” might be substituted for a full length high platform at some stations. Platform specifications[29] are listed below;

- Low-level platforms must be eight inches above the top of rail;
- High-level platforms must be 48 inches above top of rail;
- The preferred side platform width is 12 feet; 10 feet is acceptable and eight feet is the absolute minimum width;
- Long side-platforms may taper to a minimum width of eight feet at the ends;
- The preferred center-island platform width is 22 feet for a minimum of half the platform length;
- Long center-island platforms may taper to a minimum width of 12 feet at the ends;
- Outbound platforms should be 765 feet long (shorter platform lengths could be accommodated for the initial service but longer platforms would provide more room for growth and flexibility in service design and operations), and;
- Inbound platforms of a minimum 710 feet would be permissible.

[29] See pp. 2-6 to 2-8.

Table 6-1 identifies the eight potential intercity rail station site locations and the preliminary requirements for the site.

Table 6-1: Potential Station Sites

Station	Requirements	Potential Sites
Nashua	• Downtown Station to anchor future Nashua TOD • Park and Ride Availability • Integrate with local NTS bus service	• Crown Street • Beazer East
Bedford / MHT Airport	• Park and Ride Station for Commuter Rail and Intercity Rail Options • Shuttle Bus to MHT airport • Direct Access to Route 3 and I-293	• NHDOT parcel below the Ray Wieczorek Drive / Pearl Harbor Memorial Bridge
Manchester	• Downtown anchor to support existing development and Manchester TOD • Integrate with local MTA bus service and Downtown Intercity Bus Terminal	• Queen City Avenue • Granite Street • Spring Street / Bridge Street
Concord	• Downtown Station to anchor Concord TOD • Integrate with existing Intercity Bus Terminal and local CATS bus service • Park and Ride availability	• Depot Street • Stickney Avenue

Table 6-2 lists the number of station tracks required for the intercity rail service option. This was determined by evaluating the need for trains to turn or meet in stations, as indicated by the preliminary service schedules.

Table 6-2: Number of Required Intercity Rail Station Tracks

Station	Tracks
Nashua	1
Bedford / MHT Airport	1
Manchester	1
Concord	1

The number of parking spaces proposed for each station was based on two factors: (1) forecast ridership and (2) functional station type (see Table 6-3). Downtown stations would provide parking only where available at the rate of one parking space for every two forecast riders. The regional park and ride station at Bedford/MHT would provide one space for each forecast rider. The Nashua Crown Street station site is currently owned by the City of Nashua and has been proposed to accommodate up to 255 parking spaces. Only accessible parking spaces are proposed for downtown Manchester, since there are many pay-for-parking lots within close proximity of each of the proposed station sites. Finally, there is an existing, heavily-utilized park and ride lot at Stickney Avenue in Concord. Due to the nature of intercity travel, at least 100 additional spaces are proposed at this location even though this would exceed the one-space per forecasted rider standard.

Table 6-3: Preliminary Ridership Forecasts and Parking Space Requirements

	Total	Nashua	Bedford/MHT	Manchester	Concord
Ridership Forecasts	730	200	210	240	80
Parking Space Requirements	545	255	210	0-	100

Site Evaluation Criteria

The following list of evaluation criteria was developed to guide the station site selection process. The evaluation criteria measures were given a rating of one for poorly performing sites to five for highly performing sites. The environmental criteria was designated as Yes or No, while the Ownership criteria was designated G for government-owned or P for privately-owned.

1. **Market**
    - Does the site adequately serve the travel market of Boston-bound travel for residents of Nashua, Manchester, Concord and surrounding towns?
2. **Access**
    - Is the site adequately served by major roads with connections to the regional highway network?
    - Is there existing parking available at the site?
3. **Track Operational Characteristics**
    - Is the track straight and free of existing sidings?
    - Are there any grade crossings adjacent to the site?
    - What are train deadhead cost savings and travel time efficiencies?
    - Requirement for new traffic/train signals?
    - Are bridge structures required for roadway access or yard leads?
    - Maintain freight rail movements/clearances
4. **Parcel Size/Configuration/Ownership**
    - Is there adequate land available for station platforms and facilities?
    - Is there sufficient land for parking lots sized to meet ridership forecasts?
    - What is the assessed value per acre?
    - Would displacement of residents/businesses be required?
5. **Land Use**
    - What are the predominant surrounding land uses?
    - What are municipal and community aspirations/priorities?
    - Consideration of environmental justice including accessibility by minority populations and low-income households

6. **Sensitive Receptors**
   - Are there any residential buildings or educational, medical or religious facilities near the site that would have a heightened sensitivity to noise or vibration impacts?
7. **Environmental**
   - Is the site adjacent to a river or within a flood zone?
   - Is the site in or adjacent to jurisdictional wetlands?
   - Does the site have a history of contamination?
   - Has the site been designated as threatened or endangered species habitat?
   - Does the site have nearby sensitive receptors for noise/air quality impacts?
8. **Ownership**
   - Is the property owned by state or local government or is it privately held?
   - Is property for sale or held by single or multiple owners?

Preliminary Station Sites

Multiple locations were identified for each of the five proposed stations based on field inspections, interviews with local officials, and a review of previous studies. Each of the evaluated sites and their milepost (MP) distance from Boston are listed in Table 6-4 and discussed in detail below. Several sites were eliminated during the preliminary assessment, while eight locations were advanced for further evaluation.

Table 6-4: Preliminary Intercity Station Sites

Station	Sites Evaluated	Milepost
Nashua	25 Crown Street	38.8
	Beazer East	41.0
Bedford / MHT Airport	NHDOT parcel below Ray Wieczorek Drive	50.1
Manchester	Queen City Avenue / Jac-Pac	54.9
	Granite Street	55.7
	Spring Street / Bridge Street	56.4
Concord	Depot Street	72.6
	Stickney Avenue	73.4

Once the station sites were identified, schematic designs were overlaid on annotated aerial imagery prepared by Jacobs Engineering in September 2013. These schematic designs included tracks, switches, platforms, roadways, pathways, parking, circulation, buildings, and other related features. Parcel mapping information provided by the municipalities and NHDOT was also incorporated as part of the schematic designs. It will be necessary for the schematic designs to be reviewed by Amtrak, MBTA, Pan Am, NHDOT and other stakeholders prior to being finalized. The following sections describe and document each station site with findings from the initial site review. Parcel mapping, site photos, previous station site plans, preliminary schematics, and the proposed conceptual station plan are presented for preliminary environmental and financial review.

6.1 Nashua Station Options

Figure 6-1 illustrates the location of the two potential station locations that could be developed as a Nashua Station. They are Crown Street, and the Beazer-East site.

Figure 6-1: Potential Nashua Station Locations

Nashua: Crown Street

This site is located south of Crown Street site and north and west of the Pan Am rail yard. It is the approximate location of Nashua's historic main line train station. Another station was located on the Hillsboro Branch at Railroad Square on Main Street.

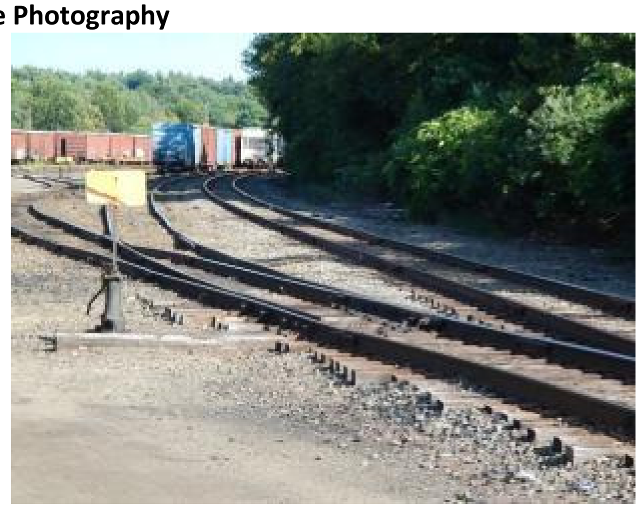
Potential station locations were also evaluated at Bridge Street and East Hollis Street with regard to how a full-length (765 foot) passenger rail station platform could be configured on the site. The Bridge Street site was eliminated because only 520 feet would be available for a platform between the Nashua River railroad bridge on the north and the Bridge Street crossing on the south. The East Hollis Street site located between Bridge Street and East Hollis Street was also eliminated as the platform length would be limited to approximately 400 feet. Site features and challenges include:

City-owned and locally preferred location for a downtown Nashua station

- The station platform would be located adjacent to the Triangle Pacific building, which could potentially be redeveloped
- It is the only viable site near downtown that can accommodate platform requirements
- City plans call for 255 parking spaces and reuse of existing industrial buildings
- Additional parking supply would be constrained by the size of the parcel

Figure 6-2: Site Photography

Facing southeast towards the Pan Am Rail Yard



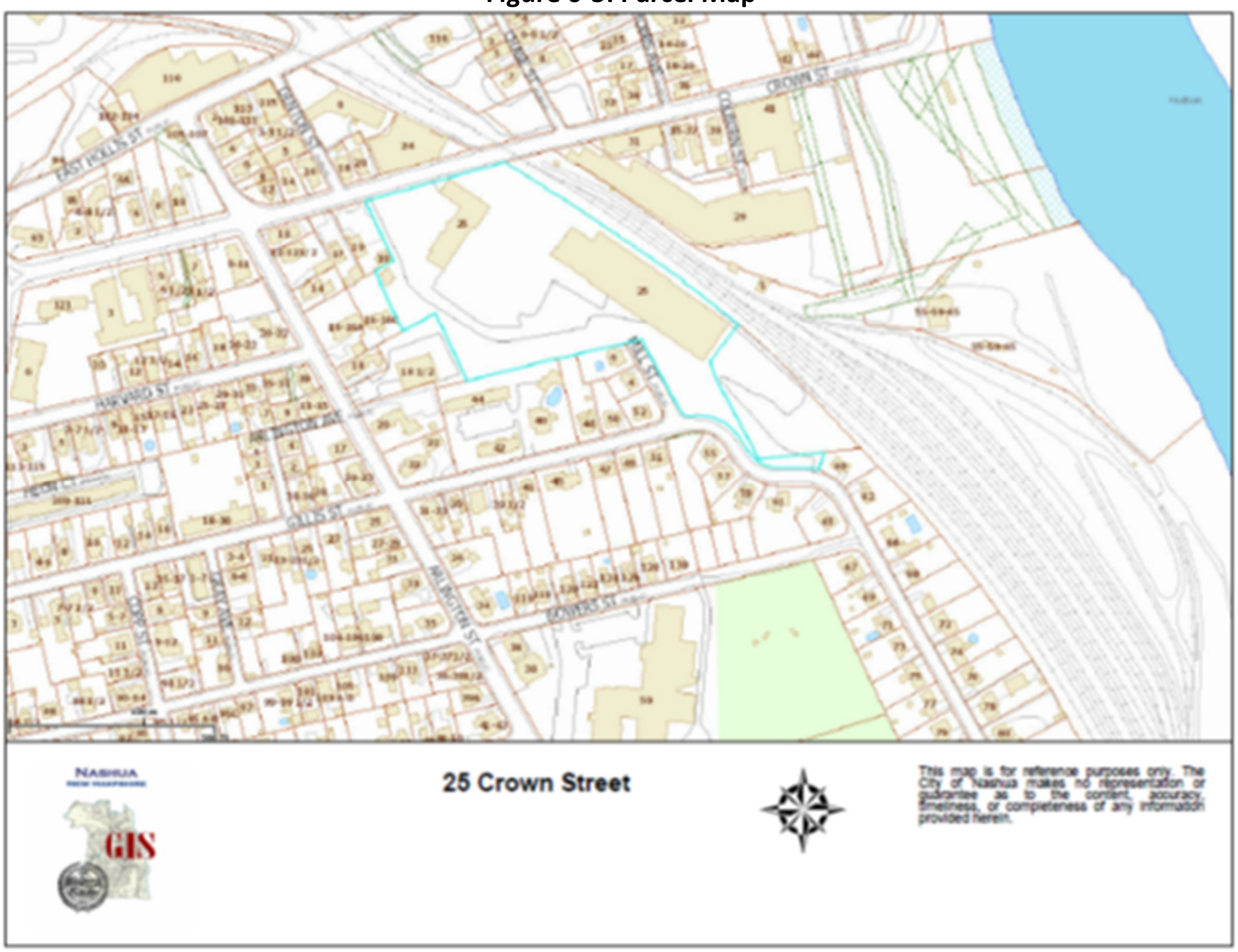
Facing south towards the vegetated area west of the Pan Am Rail Yard where the proposed platforms would be located

Figure 6-2: Site Photography

Facing northwest as the NHML continues north, the Hillsboro Branch turns off towards the west

Facing west towards downtown Nashua

Figure 6-3: Parcel Map



Evaluation

Category	Rating	Notes
Market	4	Close (0.8 miles) to Main Street in downtown Nashua
Access	4	Multiple local road access points
Track	5	Only viable stretch of track in the downtown area
Land use	4	Future park and ride site for the city, mixed industrial/residential
Parcel	5	Seven acre site owned by the city, designated for transit
Environmental	Y	Potential soil remediation, unknown; most likely urban fill. Possible complications from site demolition
Owner	G	Government owned (City of Nashua)
Noise	Y	Mixed residential neighborhoods near site
Miscellaneous	Y	City would like to utilize this site as a park and ride location

Assessment: Advanced

This site is recommended as a downtown station for the City of Nashua. Local officials have been contemplating a station at Crown Street for several years with well-developed plans shown in Figure 6-4. The City and State recently cooperated to acquire the site with the intention of developing a park and ride lot independent of the proposed rail service, as shown in Figure 6-5 and Figure 6-6.

Since this location would rely on pedestrian and bicycle accessibility, a new sidewalk would be necessary on the south side of Crown Street and east of Arlington Street to ensure safe access to the site. A pedestrian/bicycle connection off Harvard Street would provide improved accessibility from the surrounding neighborhoods.

Figure 6-4: City of Nashua Excerpt from East Hollis Street Master Plan

Figure 6-5: City of Nashua Park and Ride Site Plan

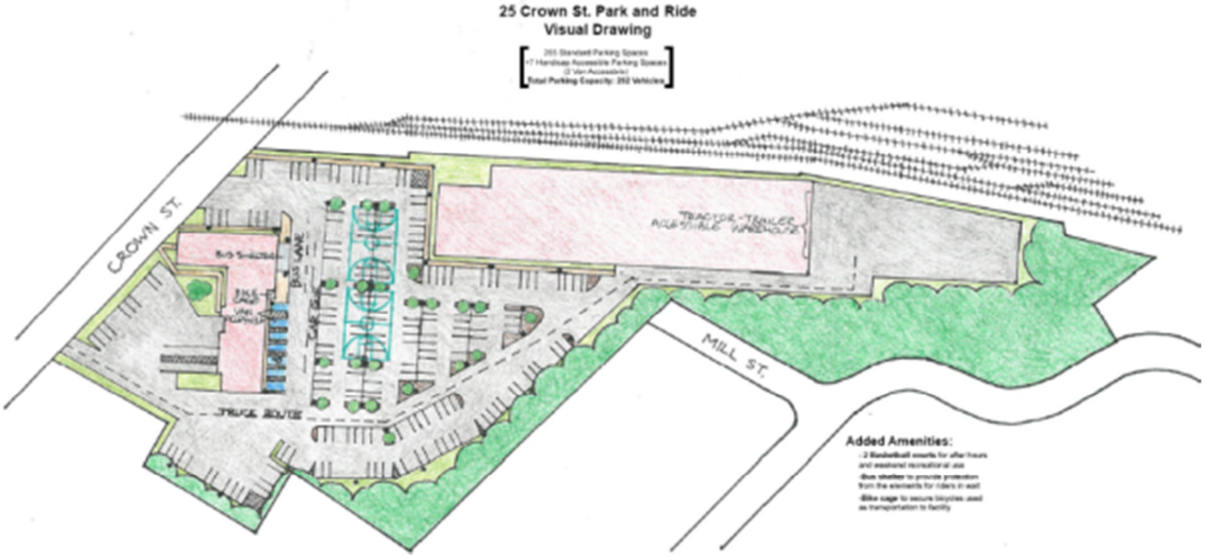


Figure 6-6: City of Nashua Park and Ride Site Plan

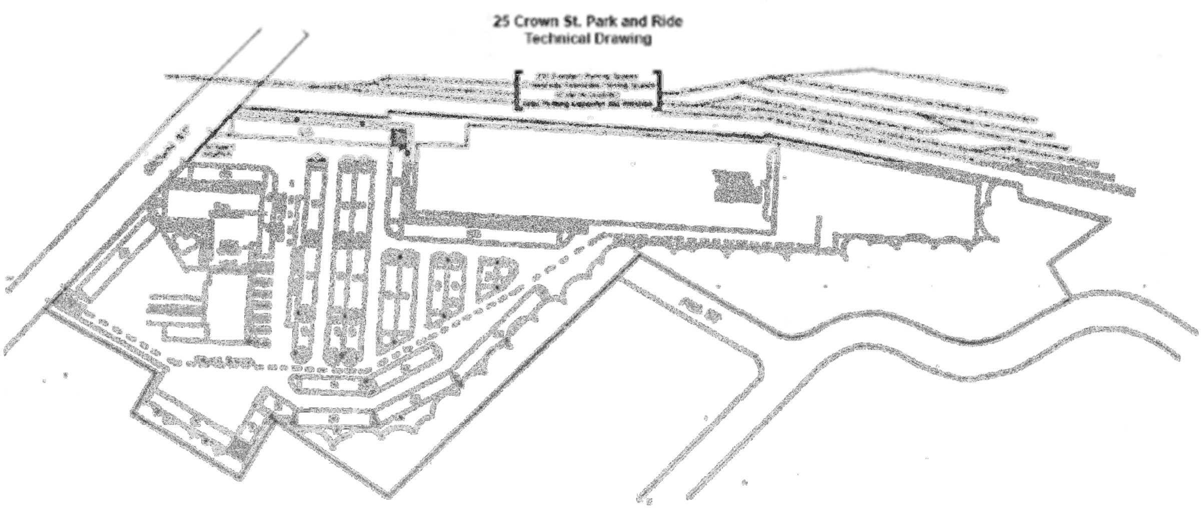
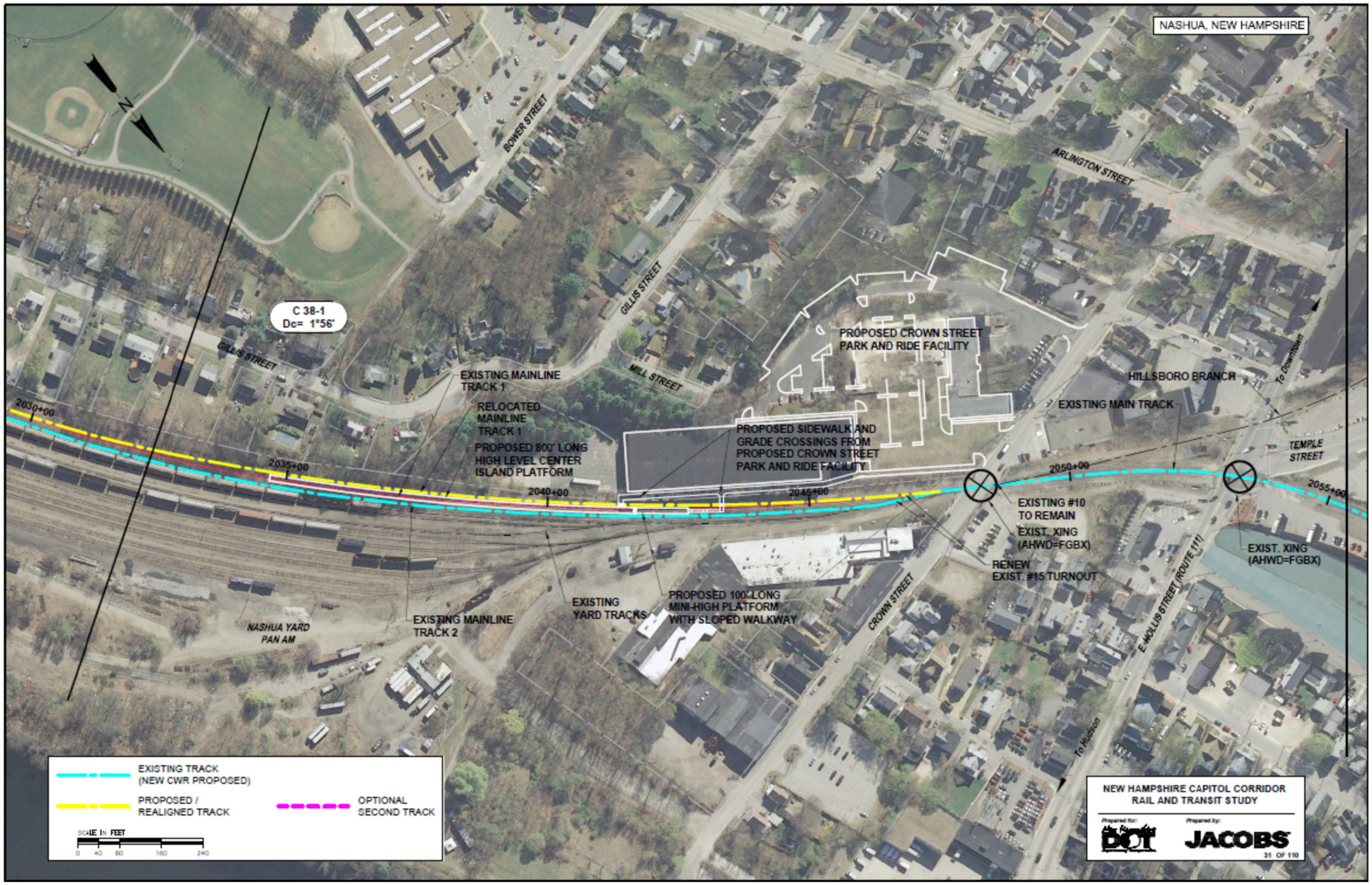


Figure 6-7: Preliminary Station Design



North Nashua: Beazer-East

The Nashua Beazer-East site is located in the southwest corner of a large industrial parcel owned by Beazer-East, Inc. The site was formerly owned by Koppers Company, a manufacturer of railroad ties. Their manufacturing operations included treating ties with creosote. The site was found to be contaminated with creosote and is currently in the process of being cleaned up. It is contemplated that the site will be developed once the remediation effort is completed. Land is principally residential immediately west of the site. Greeley Park is located to the south is owned by the City of Nashua, and is primarily used as a site for launching boats on the Merrimack River. Hills Ferry Road is currently the only access roadway across the railroad tracks into the site. The existing 36.5 kw power line right-of-way proposed to allow the extension of Henry Burke Highway into site with an overpass over the tracks, although this option was eliminated from further consideration in 2011. Two small industrial buildings are the only buildings currently on the parcel. The brownfield site is north of downtown Nashua and does not relate well to current or future rail service or City of Nashua redevelopment plans. However, it does present a large undeveloped parcel along the railway. Site features and challenges include:

- The site has 96 acres available, providing multiple options
- Access issues include the need to navigate through a residential neighborhood
- It may be possible to extend Hills Ferry Road into Greeley Park
- Further north, Pennichuk Street is another potential access path with local access options from Route 3 via Daniel Webster Highway and Concord Street
- Planned development at the site is mixed use retail and residential
- The site is free of wetlands but adjacent to Merrimack River
- Site is contaminated with creosote and is currently undergoing remediation

Figure 6-8: Site Photography

Monitoring wells

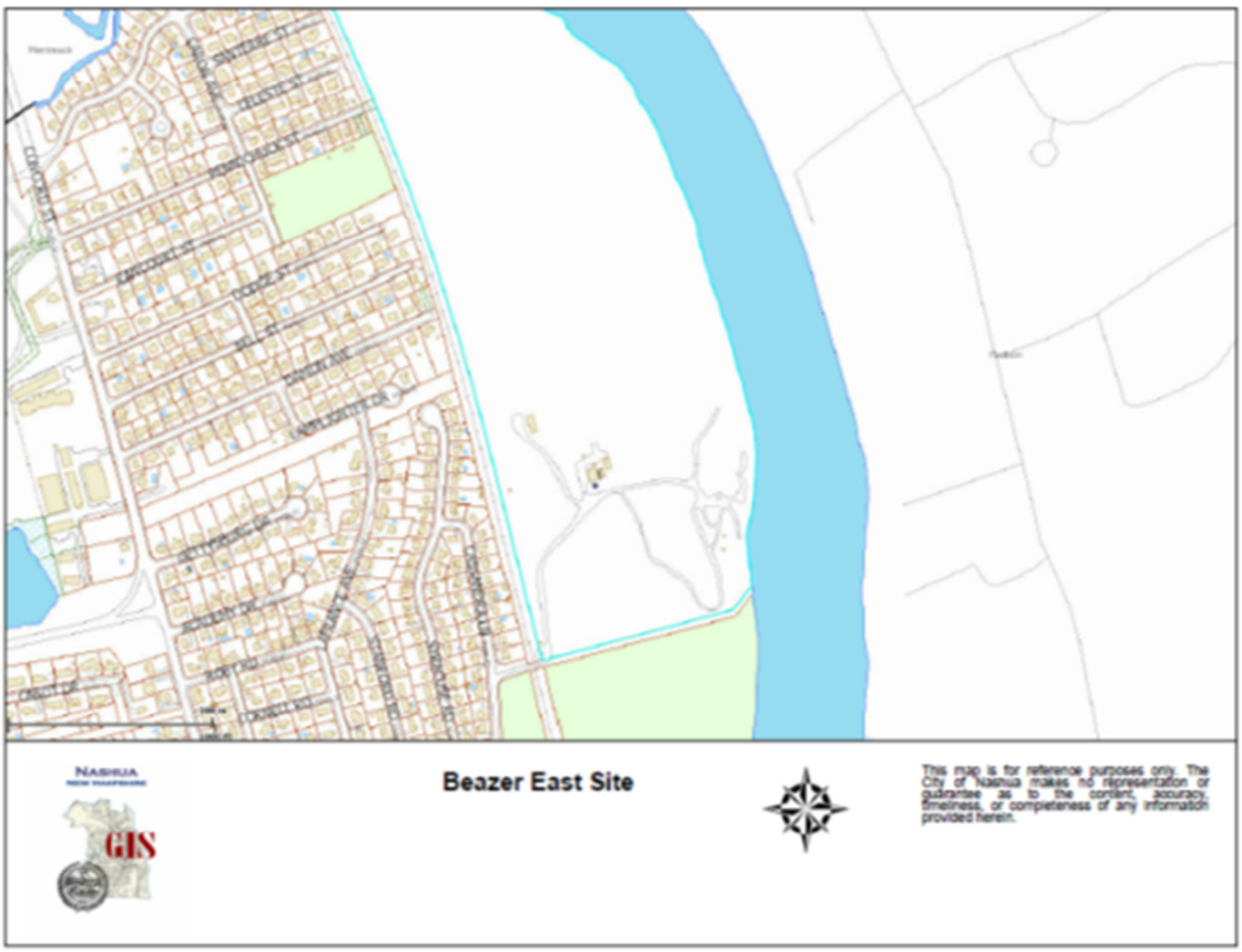
Remediation building

Figure 6-8: Site Photography

Hills Ferry Road at-grade crossing

Existing signal

Figure 6-9: Parcel Map



Evaluation

Category	Rating	Notes
Market	2	The North Nashua site is closer to Merrimack and City of Nashua residents would need to drive north to go south
Access	2	Indirect from Route 3, with access through a residential neighborhood
Track	5	Straight track, no issue
Land use	3	Vacant parcel, but adjacent to existing neighborhood
Parcel	5	Large vacant parcel, plenty of land
Environmental	Y	Site has existing soil contamination; would not interfere with proposed use
Owner	P	Privately owned, available for development; a station here could help spur redevelopment
Noise	Y	Vacant lot with adjacent neighborhood
Miscellaneous	Y	Need to create new access

Assessment: Eliminated

This site was eliminated from further consideration due to the nature of its poor relation to potential rail service, site access constraints, and existing soil contamination.

Bedford / Manchester Airport (MHT)

The proposed Manchester Airport (MHT) station in Bedford would provide a location for air-rail passenger interchange and also serve as a regional park and ride for northern Hillsborough and southern Merrimack counties. The site is located under the Ray Wieczorek Drive / Pearl Harbor Memorial Bridge that provides a direct connection between Route 3 and Manchester-Boston Regional Airport (MHT). This site has also been proposed as a development node within the Town of Bedford (Figure 6-12). A proposed shuttle bus would meet all trains and provide connecting service along the 2.8 mile (6 minute) route between the MHT Airport passenger terminal and the proposed station. Similar air-rail shuttle connections are used with great success at airports in Baltimore, Boston, and Milwaukee. The station parking lot would be managed to avoid use by air passengers and keep spaces available for rail passengers. The mode of operation at the Amtrak MKE station in Milwaukee or at the Amtrak BWI station in Baltimore would be considered for parking management. The Town of Bedford supports this station location and has developed plans for mixed use redevelopment in the vicinity of the station. Site features and challenges include:

- NHDOT owns the property on the south side of the bridge, some of which was set aside as mitigation as part of the bridge construction
- Property on the north side of bridge is privately held by WB Merrimack River Realty
- Sebbens Brook is a valuable environmental resource located on the south side of the bridge
- Access is difficult to the south of the bridge, although there may be the potential to develop site access through the existing parcel south of the brook
- A small brook and wetland areas also exist on the north side of the bridge
- A propane gas service yard on the north side of the bridge may need to be relocated
- A power line bisects the site north of the bridge

Figure 6-10: Site Photography

Railroad right-of-way facing south

Overhead power lines

Figure 6-10: Site Photography

Railroad right-of-way facing north

Wetlands adjacent to the proposed station

Figure 6-11: Parcel Map

Evaluation

Category	Rating	Notes
Market	5	Only direct access point to the airport
Access	5	Direct access to the site from Ray Wieczorek Drive
Track	5	Straight unencumbered track
Parcel	4	Potential need to utilize multiple parcels
Land use	5	Mostly vacant, surrounding transportation uses
Sensitive Receptors	5	No sensitive receptors
Environmental	Y	Wetlands – Values need to be assessed
Ownership	G/P	State owns some of the parcels, some are privately held

Assessment: Advanced

The proposed MHT station has been previously identified as a potential passenger rail station by state and local officials. Local plans, published in 2010, embrace the concept of a rail station along the river near the bridge linking Route 3 with the Manchester/Boston Regional Airport. The station would be a focal point for regional travel and local development as well as for air-rail intermodal passenger transfers. An 800-foot long platform is proposed to be located on the west side of the tracks. The site also has ample room to accommodate the necessary parking without the need for additional land acquisition.

Figure 6-12: Town of Bedford Concept Plans for Station Area (2010)

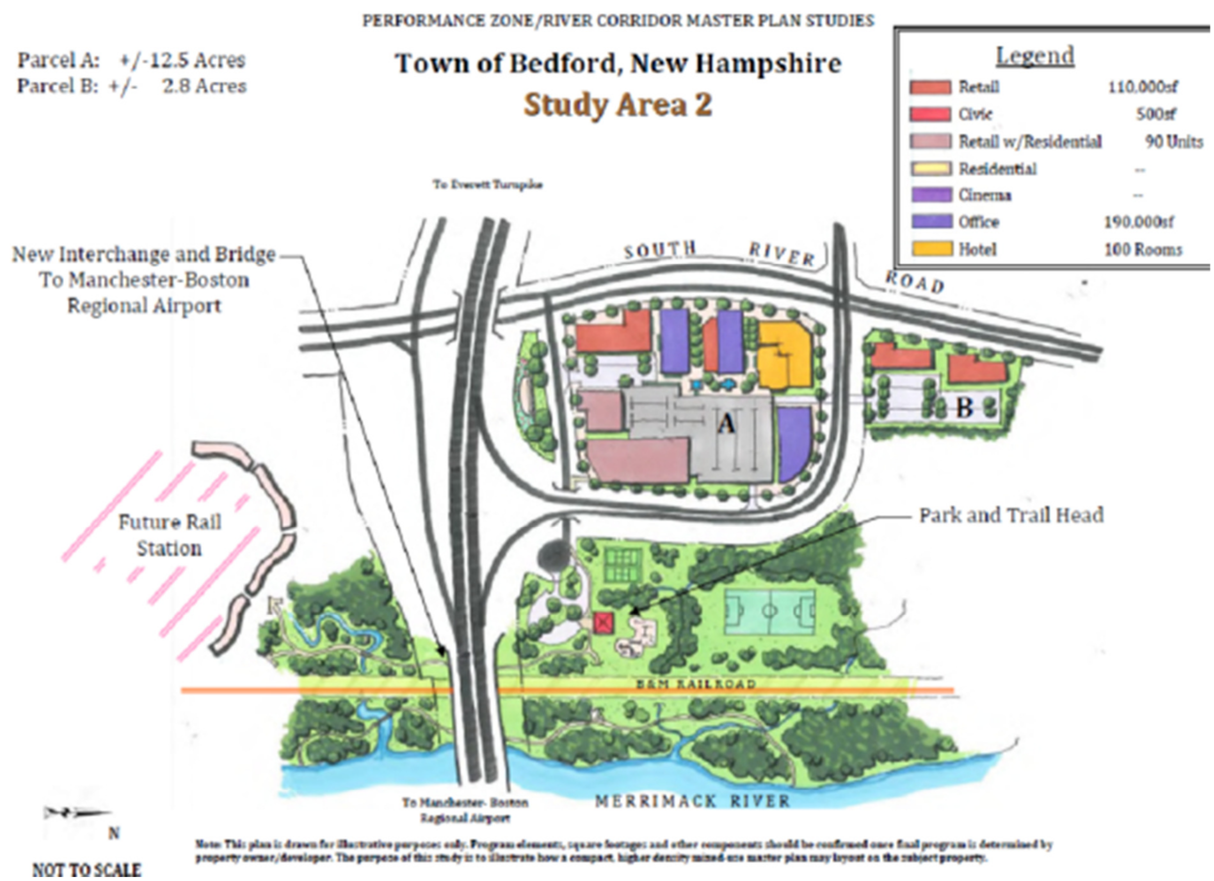
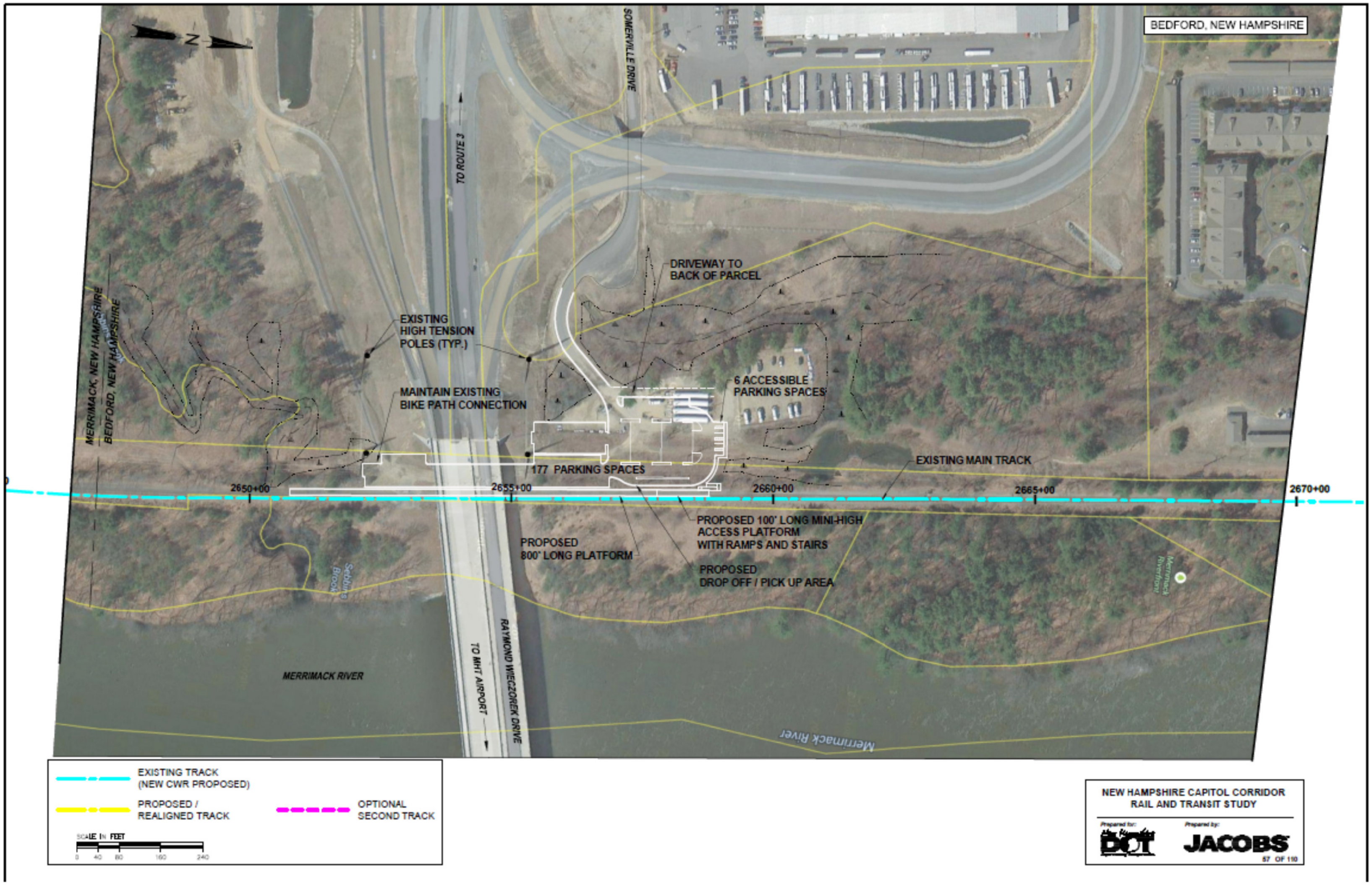


Figure 6-13: Preliminary Station Design



6.2 Manchester Station Options

Three station sites for downtown Manchester were identified and evaluated. Key roles to be fulfilled by the downtown Manchester station include serving as a downtown anchor to support existing development; to support future Manchester "Transit Oriented Development" (TOD); to integrate the passenger rail service with the local MTA bus hub, and; to provide multimodal connections with Manchester's downtown intercity bus terminal.

Manchester: Queen City Avenue

The station proposed at the former "Jac-Pac" site is located under the Queen City Avenue bridge, where it crosses the railway. This location is situated approximately 7,500 feet (30-minute walk) from the downtown bus terminal and the southern end of Manchester's most intense urban development.

Assessment: Eliminated

The Queen City Avenue site was suggested by local officials but eliminated early in the site selection process due to its weak relationship to the existing downtown and distance from other transit services.

Manchester: Granite Street

Manchester's main passenger rail station stood for many decades on the south side of Granite Street before the building was demolished and the site redeveloped. The site is proximate to the center of Manchester's densest urban development, across the street from the intercity bus terminal and a short walk to the Manchester Transit Authority's downtown hub at Veteran's Park. Site features and challenges include:

Figure 6-14: Historic Manchester Rail Station

- Close to downtown, ample private pay-parking available in nearby garages and surface lots
- Across Granite Street from the existing Intercity Bus Terminal
- City of Manchester owns parcel 930-6 which is presently used for public parking
- 1,500 feet (5-minute walk) to MTA's local bus hub at Veteran's Park
- Direct access to I-293 (Exit 5)
- Existing development adjacent to the site and along the rail right-of-way

Figure 6-15: Site Photography

Facing south towards the location of proposed station platforms from the Granite Street at-grade crossing

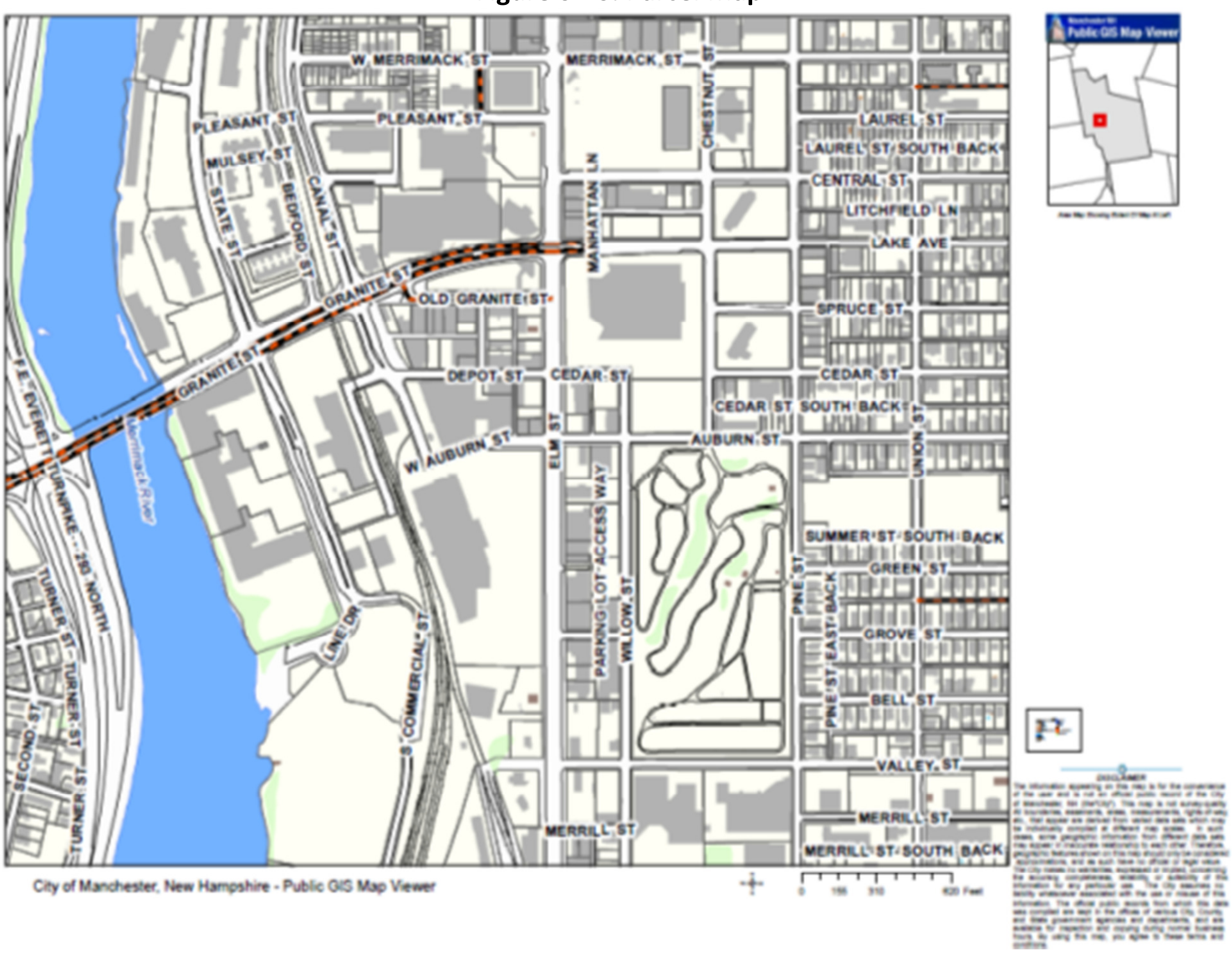
Facing north towards the Millyard from the Granite Street at-grade crossing

Figure 6-15: Site Photography

Facing northeast towards the intercity bus terminal from the Granite Street at-grade crossing

Facing west towards I-293

Figure 6-16: Parcel Map



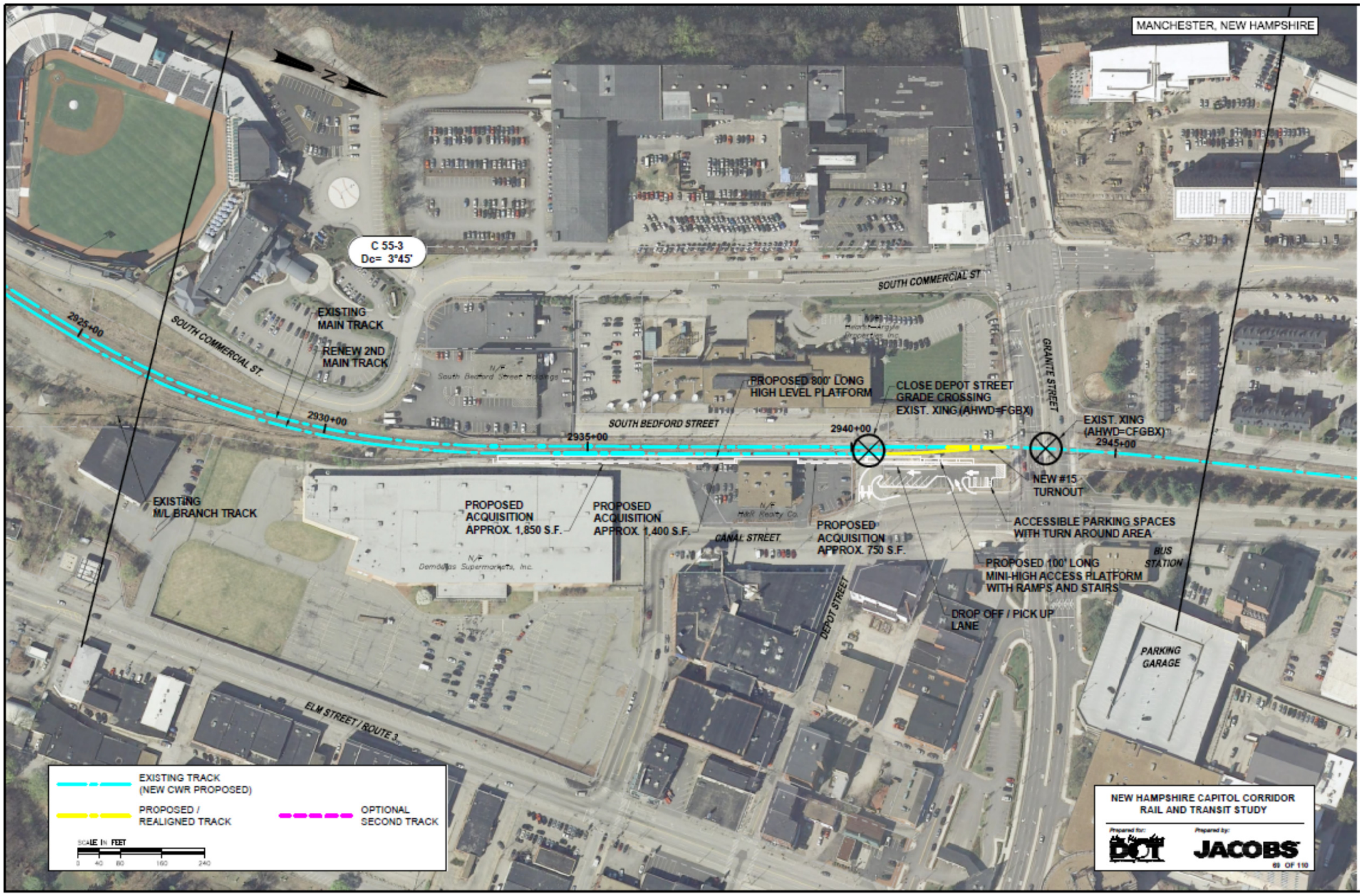
Evaluation

Category	Rating	Notes
Market	5	Located within downtown Manchester
Access	5	Direct access from I-293 with public parking lots and garages nearby
Track	5	Straight track, with no issues
Parcel	5	Tight space, may need surrounding properties for station facilities and parking would need to be located off-site
Land use	4	Existing commercial uses
Sensitive Receptors	4	Surrounding commercial buildings
Environmental	N	Nothing obvious
Ownership	P	Privately owned parcels

Assessment: Advanced

This site is recommended as the downtown station for the City of Manchester. The recommended station design would close the Depot Street crossing and develop the city-owned parcel on the corner of Granite and Canal Streets that is presently used for public parking. A two track station option has been developed with a high level platform serving the east track. This would enable the efficient operation of a terminal station and allow for unimpeded freight traffic to and from the north.

Figure 6-17: Preliminary Station Design

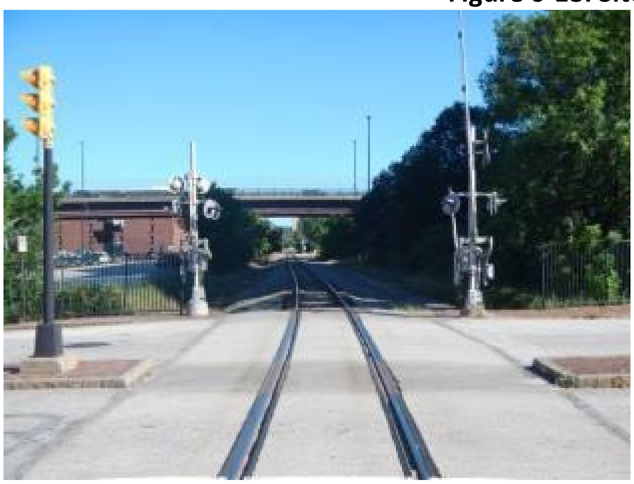


Manchester: Spring Street / Bridge Street

The Manchester Spring Street / Bridge Street site is located on the north end of the Millyard District near the Spring Street grade crossing and under the Bridge Street overpass. The property is owned by the City of Manchester. There are a large number of jobs and existing surface and structured parking lots proximate to the site. Site features and challenges include:

- City of Manchester-owned parcel
- Indirect access to I-293 (Exit 6)
- Ample private parking available in adjacent surface and structured parking lots
- 2,500 feet (10 minute walk) from Intercity Bus Terminal at corner of Canal and Granite
- 2,900 feet (12 minute walk) to MTA local bus hub at Veteran's Park

Figure 6-18: Site Photography



Facing north the location of proposed station platforms from the Spring Street at-grade crossing

Facing south from the Spring Street at-grade crossing

Facing southeast towards existing parking structure from the Spring Street at-grade crossing

Facing west towards the Millyard from the Spring Street at-grade crossing

Figure 6-19: Parcel Map

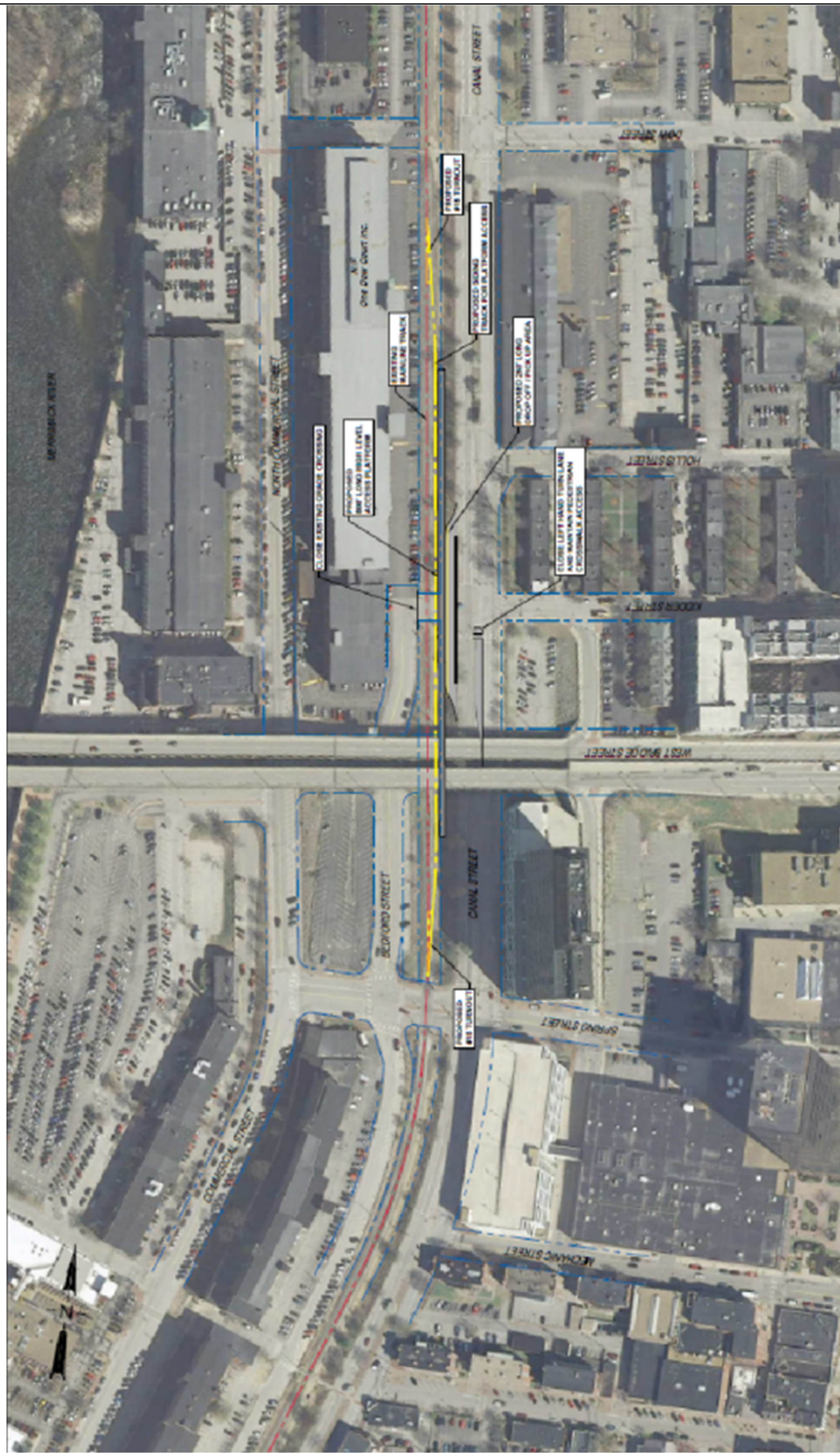
Evaluation

Category	Rating	Notes
Market	5	Located within downtown Manchester
Access	4	Indirect access from I-293, public parking garage nearby
Track	3	Curve in track, may require eliminating one or more grade crossings
Parcel	4	Tight space, may need surrounding properties for station
Land use	5	Existing commercial uses
Sensitive Receptors	4	Surrounding commercial buildings
Environmental	N	Nothing obvious
Ownership	P	Privately owned parcels

Assessment: Advanced

This site has the potential to operate as the downtown station for the City of Manchester. The recommended station design would construct an 800-foot long station platform on the east side of the tracks (see Figure 6-20).

Figure 6-20: Preliminary Station Design



6.3 Concord Station Options

Figure 6-21 illustrates the location of the two potential station locations that could be implemented to serve the Concord Intercity 8 Rail Service Option. They are Depot Street and Stickney Avenue.

Figure 6-21: Potential Concord Station Locations

Concord: Depot Street

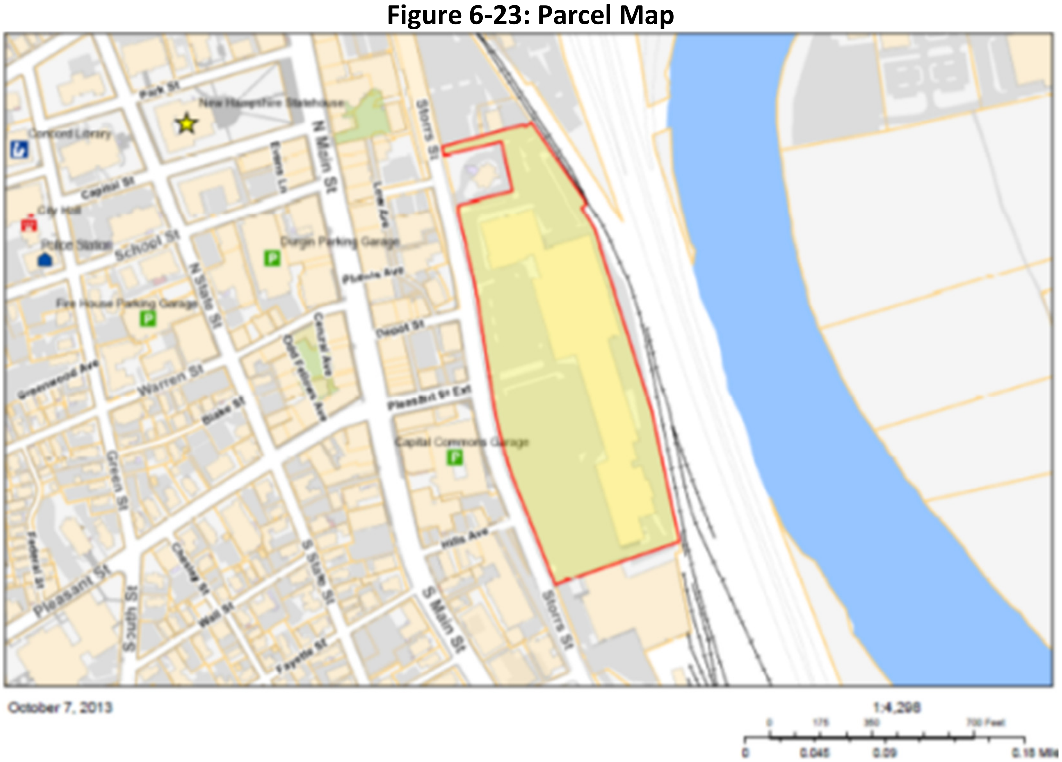
The Depot Street location is the site of Concord's historic passenger rail depot that was demolished in 1960. The site is a block from Main Street and a short walk to the State Capital. The former railway yard at this location however, has been redeveloped as a strip mall with a large parking lot.

Site features and challenges include:

- Privately-owned site with active retail uses and proposed for redevelopment
- City of Concord officials are less interested in this site as a railway depot
- Nearby Liquor Commission Warehouse is being sold
- Land adjacent to I-93 has been identified by NHDOT for proposed highway widening and realignment

Figure 6-22: Historic Concord Rail Station

Figure 6-23: Parcel Map



Evaluation

Category	Rating	Notes
Market	5	Close to downtown Concord
Access	5	Access from Main Street; Could have access from I-93
Track	4	Slight curve in the track at this location, but enough straight tracks for platform
Parcel	5	Large enough to be suitable for redevelopment
Land use	4	Existing commercial development
Noise	5	Located between I-93 and commercial development
Environmental	N	Nothing obvious
Ownership	P	Privately owned

Assessment: Eliminated

Local officials are more supportive of the nearby Stickney Avenue site where the railway station could be built on public land and would be much closer to the existing intercity bus terminal. Consequently, preliminary plans for the Depot Street site were not prepared.

Concord: Stickney Avenue

Stickney Avenue extends approximately 2,000 feet between I-393 and Loudon Road and runs parallel to I-93 and the Pan Am Railways New Hampshire Main Line (NHML). The railroad forks at this location several blocks north of the Depot Street site. The NHML heads northwest toward Lebanon, White River Junction, Montpelier and Montreal. The New Hampshire Southern Railroad (NEGS) branch diverges northerly towards the Lakes Region and the White Mountains. The NHML line is the former Boston and Maine line, now owned by the State of New Hampshire, and is the anticipated route of a restored passenger rail service between Boston and Montreal. The design of the station at this site should not preclude any future extension of passenger rail service along either branch.

Concord's state-owned intercity bus terminal is also located on Stickney Avenue. The City of Concord is interested in developing its passenger rail terminal on state-owned land immediately west of the bus terminal. The City is also planning to extend Storrs Street northward on the west side of the site to connect with South Commercial Street and encourage redevelopment of the site (Figure 6-26 and Figure 6-27). Plans for the terminal area need to reserve space to restore a run around track used by the NEGS that was removed but not replaced in the course of an abandoned project to build a hotel on the site.

Site features and challenges include:

- NHDOT planning to demolish former highway garage buildings on the east side of the site
- Existing track spur creates constraints
- There is ample vacant land for parking
- Direct access to I-93 (Exit 4)
- Intercity bus terminal is located at the furthest point from existing rail line and it would be difficult to combine the two facilities
- Large U-Haul rental and self-storage facility located adjacent to the site and across from existing intercity bus terminal
- The Friendly Kitchen soup kitchen devoted to feeding the hungry opened in a new purpose-built structure on the north end of the site in late 2012
- Existing neighborhood:
    - Five houses located on Herbert Street
    - One duplex at 6 Higgins Street
    - Homeless encampments and squatting in vacant buildings

Figure 6-24: Parcel Map

Figure 6-25: Site Photography

Tracks behind abandoned NHDOT buildings

Railroad right-of-way under I-393 overpass

Figure 6-25: Site Photography

Houses on Herbert Street

U-Haul rental and self-storage facility

Friendly Kitchen

Railroad right-of-way behind Friendly Kitchen

Evaluation

Category	Rating	Notes
Market	5	Close to existing intercity bus terminal and park and ride lot
Access	4	Close to I-393, but needs a more direct access point from I-393 and I-93; This would be solved with proposed reconstruction of I-93 and extension of Storrs Street
Track	3	Track realignment necessary due to proposed Storrs St Extension and to maintain freight access north of Concord
Parcel	5	Large site with flexibility and potential for redevelopment
Land use	5	Former NHDOT buildings
Sensitive Receptors	4	Adjacent to I-93 but proximate to commercial and residential uses
Environmental	Y	Potential remediation
Ownership	G	Government ownership

Assessment: Advanced

This site is highly rated as it could hold both a station and layover yard. The station would have one platform serving one or two tracks and the joint station/layover facility. Current requirements call for only one track, but with future expansion of intercity service, two storage tracks may eventually be required. A layover yard would be required at or near the terminus of the proposed Intercity 8 rail service option. The preliminary station design shows that there is ample land within the larger site for the construction of a railway station with parking, train layover on the station tracks or on an adjacent track and NEGS run around track while still allowing for the City of Concord's redevelopment plans to proceed.

Figure 6-26: City of Concord Storrs Street Extension Plans

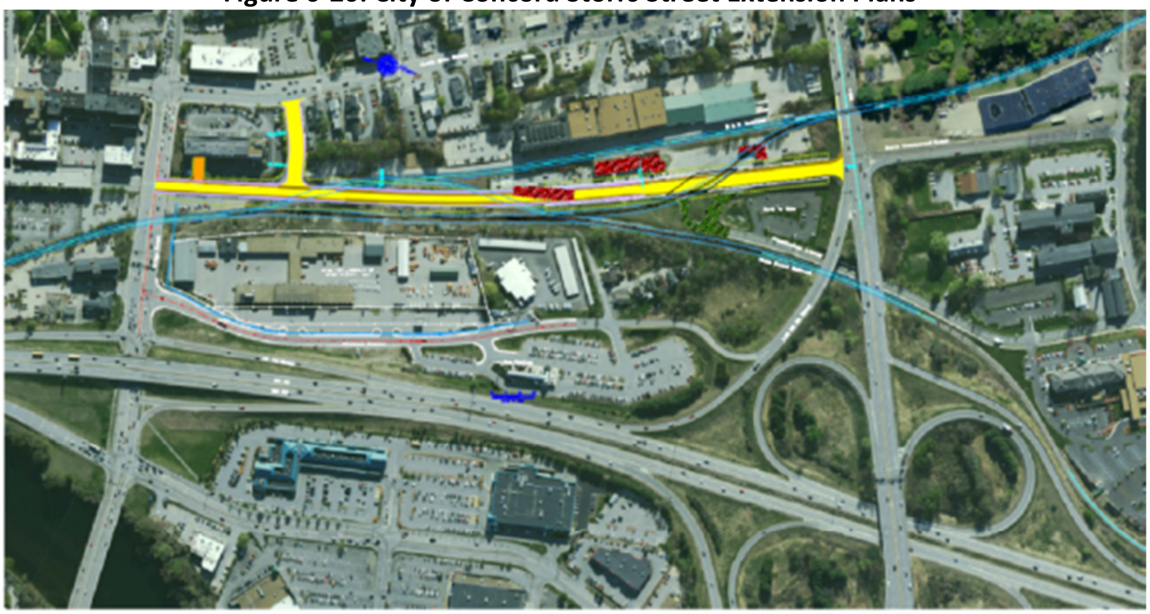
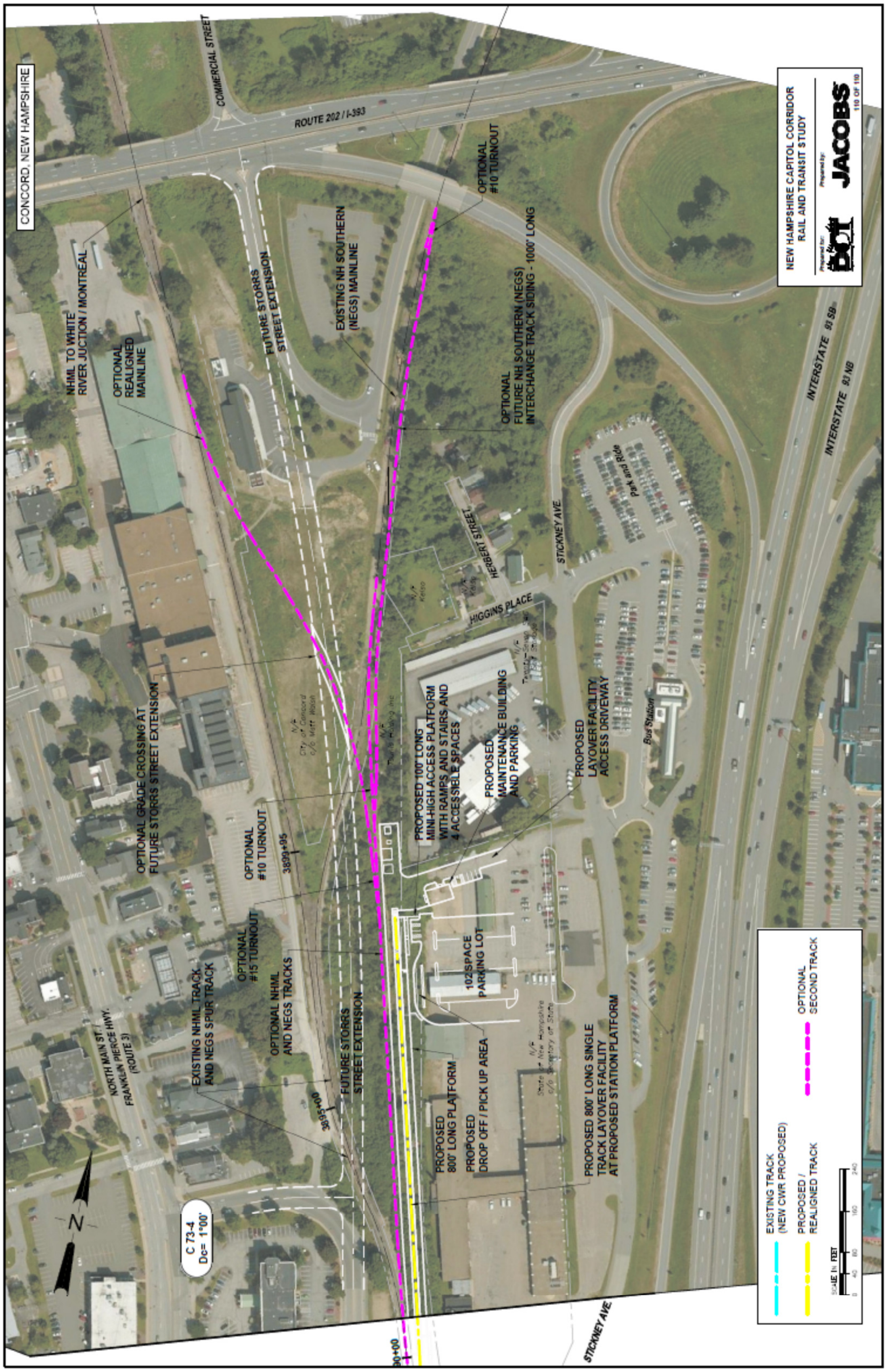


Figure 6-27: Alternative City Plan for Storrs Street Extension

Figure 6-28: Preliminary Station and Layover Design



6.4 Evaluation of Station Sites

Table 6-5 summarizes the evaluation criteria described earlier in this report that were used to guide the layover site selection process. Criteria were given a rating of one for poorly performing sites to five for highly performing sites. The Owner criteria was designated was designated G for government-owned or P for privately-owned, while the Environmental criteria was designated as Yes or No.

The Beazer East site in Nashua was eliminated from further consideration due to the nature of its poor relation to potential rail service, site access constraints, and existing soil contamination. The Queen City Avenue site was eliminated early in the site selection process due to its weak relationship to the existing downtown and distance from other transit services. Finally, the Depot Street site in Concord was eliminated because local officials are more supportive of the nearby Stickney Avenue site where the railway station could be built on public land and would be much closer to the existing intercity bus terminal.

Table 6-5: Site Evaluation Summary

	Market	Access	Track	Parcel	Land Use	Noise	Environmental	Ownership	Assessment
Nashua									
Crown Street	4	4	5	4	5	3	Y	G	***Advanced***
Beazer East	2	2	5	3	5	3	Y	P	Eliminated
Bedford / MHT									
Ray Wieczorek Dr	5	5	5	4	5	5	Y	G/P	***Advanced***
Manchester									
Queen City Ave	-	-	-	-	-	-	-	-	Eliminated
Granite Street	5	5	5	5	4	4	N	P	***Advanced***
Bridge Street	5	4	3	4	5	4	N	P	***Advanced***
Concord									
Depot Street	5	5	4	5	4	5	N	P	Eliminated
Stickney Avenue	5	4	3	5	5	4	Y	G	***Advanced***

6.5 Cost Estimates

Capital cost estimates were developed for each of the advanced station sites using unit costs that were generated for a directly applicable peer site. The MBTA Fitchburg Commuter Rail - Wachusett Extension Project is currently underway and moving in to construction. The detailed capital costs were prepared by Jacobs Engineering and partner Keville Enterprises, Inc. in January, 2013. The estimated construction cost with escalations and contingencies came to $13,303,000 for a single track siding station with one 800-foot high-level side platform and 360 parking spaces.

These detailed costs were used to inform cost estimates for each of the proposed station sites through the use of allocation factors. These allocation factors included variables such as the number of parking spaces, number of platforms, number of side tracks, square feet of existing wetlands and whether there was the possibility of contaminated soils (see Table B-1 in the Appendix). This allowed for the application of the Wachusett station unit costs even where the characteristics of the sites were different. The costs for Pheasant Lane Mall include a parking garage that was estimated at ten times the cost per space of a surface space. This figure is consistent with Jacobs estimates for other parking garages. The summary of unit costs is shown in Table 6-6, and a detailed accounting of the capital cost calculation is contained in Table B-2 in the Appendix.

Table 6-6: Estimated Station Construction Costs for Intercity Passenger Rail Development30

	Nashua		Manchester		Concord
	Crown Street	Bedford / MHT	Granite Street	Spring Street	Stickney Avenue
Milepost	38.8	50.1	55.7	56.4	73.4
Parking	255	190	0	0	100
Platforms	1	1	1	1	1
Contaminated Soils	0.5	0	0.5	0	0
Square Feet of Wetlands	0	0	0	0	0
Side Tracks	0	0	0	0	0
Total direct cost	$4,212,500	$3,594,256	$2,761,239	$2,512,925	$3,082,046
Estimated contractor cost	$5,200,037	$4,436,858	$3,408,557	$3,102,030	$3,804,571
Estimated contractor allowances	$987,537	$842,602	$647,318	$589,105	$722,525
Escalation to Oct 2013 (3.8% / year)	$226,747	$193,346	$152,938	$138,351	$167,296
Escalated estimated construction cost	$5,730,308	$4,886,203	$3,865,020	$3,496,381	$4,227,866
Construction contingency	$573,030	$488,620	$386,501	$349,638	$422,786
Estimated construction cost	**$6,303,339**	**$5,374,824**	**$4,251,522**	**$3,846,019**	**$4,650,653**

Unit cost resources: MBTA Fitchburg Commuter Rail - Wachusett Extension Project: PS&E Construction Estimate; Jacobs / Keville Enterprises, Inc.; January, 2013

[30] For more detail on station cost estimates the reader is referred to NHCC Technical Memorandum: *TASK 4: SITE EVALUATION AND PRELIMINARY DESIGNS - PASSENGER STATIONS* July 2014

Beyond the railroad right of way that will be shared with Pan Am Railway freight trains, land will be required for stations facilities and parking. The cost for this land was estimated by consulting local public assessor records in Tyngsboro, Nashua, Bedford, Manchester and Concord to determine the current assessed value of each parcel that had been identified as necessary for a station (see Table B-3 in the Appendix). Where only a portion of the parcel would be required for the rail facility, GIS tools were used to determine what fraction of the overall parcel would be necessary and to prorate the cost accordingly.

Acquisition of private land for transportation improvements can be a litigious process.   The summary of estimate land costs in Table 6-7 includes an allowance of 220 percent to account for negotiations, takings, eminent domain and legal costs. The 220 percent was derived from the study team's experience working on similar projects in other jurisdictions, but it is possible that New Hampshire's experience may be different.

Table 6-7: Assessed Land Value and Estimated Cost for Selected Station and Layover Sites

	Parcel Size (Acres)	Required Portion	Assessed Value per Acre	Estimated Value	Estimated Cost with 220% Assemblage Factor
Crown Street	6.826	1	$ 45,224	$308,700	$987,840
Bedford / MHT	6.000	0.33	$ 29,416.67	$444,400	$1,422,080
Granite Street	0.5544	1	$ 279,132.58	$148,800	$476,160
Stickney Avenue	6.08	1	$ 237,990	$1,447,000	$4,630,400

6.6 Station Recommendations

Stations at ***Crown Street*** in Nashua and the ***Bedford / MHT Airport*** site below Ray Wieczorek Drive are recommended for the Intercity 8 Rail service option. The station site at ***Granite Street*** in Manchester is favored over the Spring Street / Bridge Street site as it provides better access to Route 3 and the existing Intercity Bus Terminal. Finally, a station at ***Stickney Avenue*** in Concord is recommended for the intercity rail service.

6.7 Layover Facilities

This section of the chapter describes the identification of potential sites for overnight storage and servicing of the intercity rolling stock in the vicinity of the proposed northern terminus in Concord.

Layover Design Requirements

Wherever the eventual layover facility is located, the project would need to provide a small railroad yard, capable of storing 1,000-foot long train sets (one locomotive and up to nine coaches allowing for service expansion). Only one track would be required for the Intercity Rail service options as the second consist used for the Intercity 12 and 18 options would be stored overnight in Boston, but room to expand each facility to accommodate at least one additional train would be desirable. Three potential locations in Concord were identified for a layover facility for overnight storage and light servicing for one train set with expansion space for at least one additional train set:

- Langdon Avenue Industrial Area
- Depot Street
- Stickney Avenue

A crew building would be required at each site and include a materials and equipment storage locker for mechanical personnel to store cleaning and maintenance materials onsite and perform running repairs to equipment. The facility's entrance would be paved, and have parking for a minimum of six cars. There would be 20-foot wide service lanes located on at least one side of each track with 4-foot wide walkways built between the tracks. High mast lighting with walkway lights would be located in the service walkways. The entire layover facility should be fenced in, and if necessary, noise walls could be constructed at additional expense beyond preliminary cost estimates.

Spill pans would be required under the locomotive (northern) end of each track, complemented by oil/water separators. Near the locomotive end of the track, air compressor and electric power hookups would be required so that locomotives could be shut down while still allowing for lights and HVAC in the coaches. These power and air connections would eliminate the need for locomotives to do a cold startup each morning. Two separate small buildings housing the power and air compressor would be required. Potable water along the tracks and sanitary service equipment would also be provided onsite. An inspection pit located under the yard lead, prior to the ladder leading towards the tracks would also be desirable.

Site Evaluation Criteria

In addition to ensuring that a site is of sufficient size and of a suitable configuration to support storage and maintenance, overnight noise is the overwhelming consideration in the siting of commuter rail layover facilities. Engines in the yard will need to be started at least 30 minutes before the first southbound train and the last train engine to pull into the layover yard would be shut down approximately 30 minutes after arrival of the last train of the night (see Table 6-8). At Concord, locomotives would power up before 6:30 am and be powered down after midnight.

Table 6-8: First and Last Trains of the Day at Concord for the Intercity Service

Time of First AM Train	Time of Last PM Train
6:38 am	11:37 pm

A diesel locomotive can often be as loud as a jackhammer when pulling or pushing a string of cars and approximately as loud as a lawnmower while idling. Nighttime noise is the number one source of complaints relative to layover facilities. Given these characteristics, an acceptable site must be distant from homes, hospitals and other sensitive receptors. Sites with the lowest levels of complaints tend to be at locations where there is already a high level of ambient noise such as on the skirt of a busy highway.

The following list of evaluation criteria was developed to guide the layover site selection process. The evaluation criteria measures were given a rating of one for poorly performing sites to five for highly performing sites. The Environmental criteria were designated as Yes or No, while the Ownership criteria was designated G for government-owned or P for privately-owned.

1. **Terminus**
   - Does the site adequately serve the proposed rail service options with northern terminals in Concord?
   - What are deadhead cost savings and travel time efficiencies?
2. **Track Operational Characteristics**
   - Is the track straight and free of existing sidings?
   - Are there any grade crossings adjacent to the site?
   - Requirement for new traffic/train signals?
   - Any bridge structures required for roadway access or yard leads?
   - Are freight train movements/clearances maintained?
3. **Access**
   - Would new roads be required for access for staff and deliveries?
   - Are local roadways compatible with the site to allow yard movements efficiently in a manner that would not extensively conflict with local roadways?

4. **Parcel Size/Configuration**
    - Is there adequate land available for layover tracks and maintenance facilities?
    - Would displacement of residents/businesses be required?
5. **Land Use**
    - Is the site currently zoned for industrial or compatible land uses?
    - What are the predominant surrounding land uses?
    - What are municipality and community aspirations/priorities?
    - Are there any environmental justice issues including possible impacts on minority populations and low-income households?
6. **Sensitive Receptors**
    - Are there any residential buildings or educational, medical or religious facilities near the site that would have a heightened sensitivity to noise or vibration impacts?
7. **Environmental**
    - Is the site adjacent to a river or within a flood zone?
    - Is the site in or adjacent to jurisdictional wetlands?
    - Does the site have a history of contamination?
    - Has the site been designated as threatened or endangered species habitat?
8. **Ownership**
    - Is the property owned by State or local government or is it privately held?
    - Is property for sale, single owner versus multiple, publicly owned land?
    - What are potential land acquisition costs based on assessed value per acre
    - Would there be relocation costs resulting from displacement of residents/businesses?

Preliminary Layover Facility Sites

Based on field inspections, interviews with local officials and review of earlier studies, three potential were identified for the Concord layover facility. The evaluated sites are listed in Table 6-9 and discussed in detail on the following pages. Several tentative sites were eliminated very early during the preliminary assessment, while three were advanced for formal preliminary evaluation.

Table 6-9: Potential Concord Layover Facilities

Sites Evaluated	Milepost
Langdon Avenue Industrial Area	72.0
Depot Street	72.6
Stickney Avenue	73.4

Once the layover facility sites were identified, schematic designs were overlaid on annotated aerial imagery prepared by Jacobs Engineering in September 2013. These schematic designs include tracks, switches, platforms, roadways, pathways, parking, circulation, buildings, and other related features. Parcel mapping information provided by the municipalities and NHDOT was also included in the schematic designs. It will be necessary for the designs to be reviewed by Amtrak, MBTA, PanAm, NHDOT and other stakeholders before being finalized.

The following sections describe and document each layover facility site with findings from the initial site review. Parcel mapping, site photos, earlier plans where appropriate and preliminary schematic designs are included for environmental and financial review.

6.8 Concord Layover Facility Options

Figure 6-29 illustrates the location of the three potential layover yards that could be implemented to serve the Concord Intercity 8 Rail Service Option. They are the Langdon Avenue Industrial Area, Depot Street, and Stickney Avenue.

Figure 6-29: Potential Concord Layover Yard Locations

Concord: Langdon Avenue Industrial Area

The industrial area located near Langdon Avenue in Concord is 1.3 miles south of the proposed Stickney Avenue terminal station could be developed as a layover yard.

Evaluation

Category	Rating	Notes
Terminus	4	Over one mile south of the proposed Concord terminal station at Stickney Avenue
Track	5	Long straight track section
Access	4	Access to South Main Street via Lehoux Ave
Parcel	4	Adequate space for storage tracks and facilities
Land Use	5	Vacant / existing industrial uses
Sensitive Receptors	2	Nearby residential neighborhood
Environmental	N	Nothing obvious
Ownership	P	Privately owned

Assessment: Eliminated

The site lies within 1,000 feet of residential neighborhoods west of Main Street and development of the site would require the taking of privately owned land. The availability of land to develop a combined station and layover yard at Stickney Avenue eliminated this site from further consideration.

Concord: Depot Street

This state-owned parcel near Depot Street and adjacent to I-93 would make an ideal site for a layover yard since the busy highway would help attenuate the sound of the trains overnight.

Evaluation

Category	Rating	Notes
Terminus	5	One-half mile south of the proposed Concord terminal station at Stickney Avenue
Track	4	Straight track section, former rail yard
Access	4	Access to Storrs St via mall parking lot access roads
Parcel	4	Adequate space for storage tracks and facilities, located between existing strip mall and I-93
Land Use	5	Vacant / transportation / existing commercial uses
Sensitive Receptors	5	Adjacent to I-93 and removed from downtown Concord
Environmental	N	Nothing obvious
Ownership	ROW	

Assessment: Eliminated

The City and State have other development plans for this site which is located one-half mile south of the proposed Stickney Avenue terminal station, so it was eliminated from further consideration.

Concord: Stickney Avenue

This option would co-locate the layover facility with the proposed station on a state-owned parcel near the existing intercity bus terminal. As noted earlier in this chapter, Stickney Avenue extends approximately 2,000 feet between I-393 and Loudon Road and runs parallel to I-93 and Pan Am Railway's New Hampshire Main Line (NHML). The railroad forks at this location which is several blocks north of the Depot Street site. The NHML heads northwest toward Lebanon, White River Junction, Montpelier and is the anticipated route of a restored passenger rail service between Boston and Montreal. The New Hampshire Southern Railroad (NEGS) branch diverges northerly towards the Lakes Region and the White Mountains. The design of the layover facility at this site should not preclude any future extension of passenger rail service along either branch.

The study team determined that the intercity passenger rail service options would require overnight storage for only one train set and that the train could be stored and serviced at the Concord terminal station. This would be consistent with current practice for the *Downeaster* operations in Portland and other minor intercity rail services such as Oklahoma City's *Heartland Flyer*. This site and the proposed station were discussed extensively earlier in this chapter.

Evaluation

Category	Rating	Notes
Terminus	5	Co-located with proposed Concord terminal station at Stickney Ave
Track	3	Track realignment necessary due to proposed Storrs St Extension and to maintain freight access north of Concord
Access	5	Access via Stickney Avenue
Parcel	5	Adequate space for storage tracks and facilities
Land Use	5	Former NHDOT buildings
Sensitive Receptors	4	Adjacent to I-93 but proximate to commercial and residential uses
Environmental	Y	Potential remediation
Ownership	G	Government ownership

Assessment: Advanced

This site is highly rated as it could accommodate both a station and layover yard. Current requirements call for only one track, but two storage tracks may eventually be required with the future expansion of intercity service. The station would have one platform serving one or both tracks and at the joint station/layover facility. The preliminary design shows that there is ample land within the larger site for the construction of a railway station with parking, train layover on the station tracks or on an adjacent track, a NEGS run around track and still allow for the City of Concord's redevelopment plans to proceed.

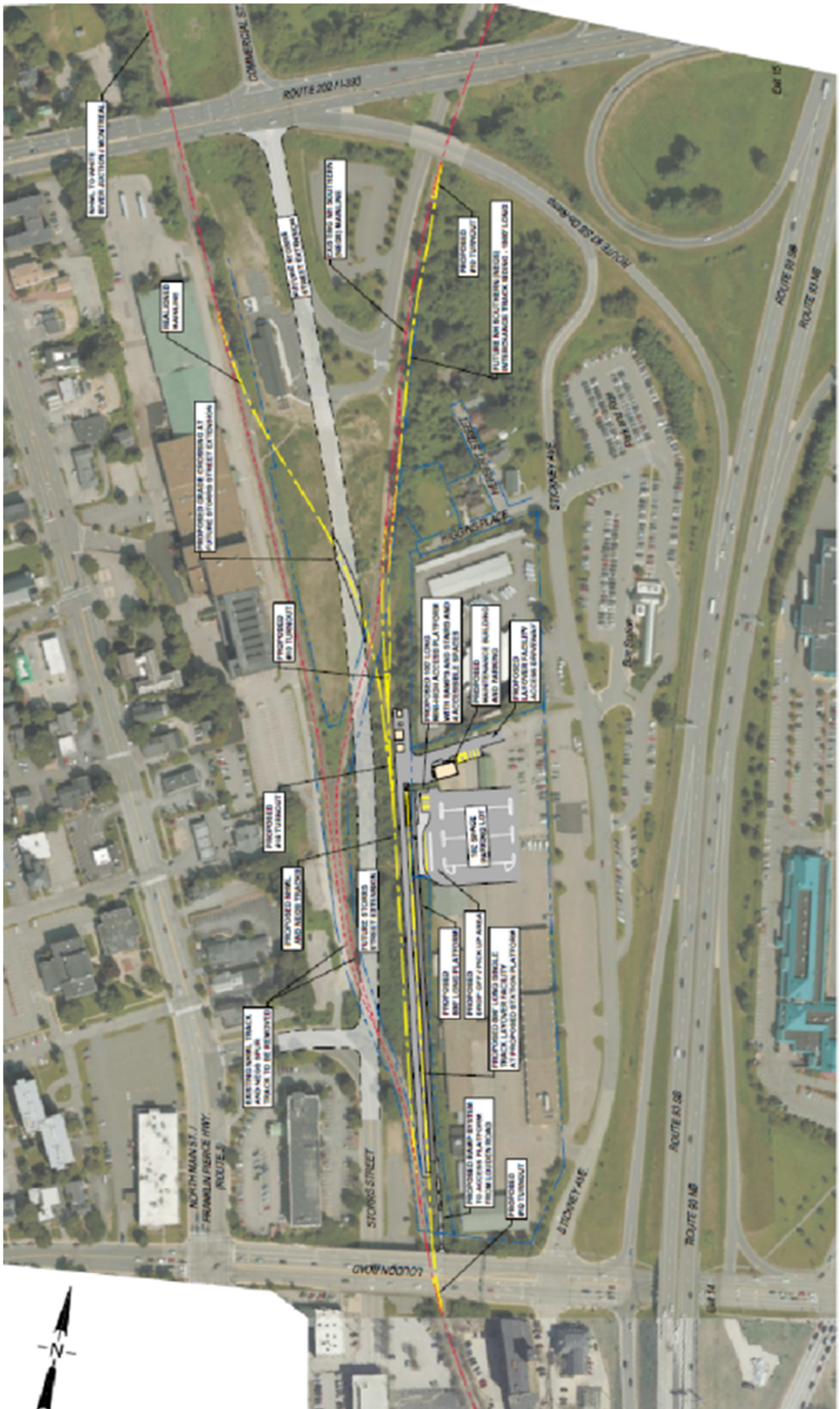


Figure 6-30: Preliminary Station and Layover Design

6.9 Evaluation of Layover Facility Sites

Table 6-10 summarizes the evaluation criteria that were used to guide the layover site selection process. Criteria were given a rating of one for poorly performing sites to five for highly performing sites. The Owner criteria was designated was designated G for government-owned or P for privately-owned, while the Environmental criteria was designated as Yes or No.

The Langdon Avenue site and the Depot Street site in Concord were eliminated because local officials are more supportive of the nearby Stickney Avenue site where the railway station could be built on public land and would be much closer to the existing intercity bus terminal.

Table 6-10: Concord Site Evaluation Summary

	Terminus	Track	Access	Parcel	Land Use	Sensitive Receptors	Environmental	Ownership	Assessment
Langdon Avenue Industrial Area	4	5	4	4	5	2	N	P	Eliminated
Depot Street South	5	4	4	4	5	5	N	ROW	Eliminated
Stickney Avenue	5	3	5	5	5	4	Y	G	***Advanced***

6.10 Cost Estimates

Costs to develop layover yards for overnight storage and light maintenance of the service rolling stock were estimated for the one site that advanced through preliminary evaluation. Estimates relied on unit costs recently generated by Jacobs Engineering for a directly applicable peer site. The MBTA Fitchburg Commuter Rail - Wachusett Extension Project is currently underway and moving in to construction. The estimated Wachusett layover construction cost with escalations and contingencies came to $13,303,000 for a layover facility with six tracks including 9,655 track-feet available for the storage of trains.

These detailed costs were used to inform cost estimates for each of the proposed layover facility sites through the use of allocation factors. These allocation factors included variables such as the number of storage positions, total track length (feet) and whether there was the possibility of contaminated soil disposal. This allowed for the application of the Wachusett layover facility unit costs even where the characteristics of the sites were different. The summary of unit costs is shown in Table C-1 in the Appendix. Detailed capital cost calculations are documented in Table C-2 in the Appendix.

Table 6-11: Estimated Layover Facility Capital Costs

Milepost	73.4
Number of storage positions	1
Total track length (feet)	800
Possibility of contaminated soils	1
Total direct cost	$3,100,795
Estimated contractor cost	$3,827,716
Estimated contractor allowances	$737,600
Escalation to Oct 2013 (3.8% / year)	$188,091
Escalated construction cost	$4,753,407
Construction contingency	$475,340
Estimated cost with contingency	**$5,228,747**

Source: MBTA Fitchburg Commuter Rail - Wachusett Extension Project: PS&E Construction Estimate; Jacobs / Keville Enterprises, Inc.; January, 2013

Beyond the railroad right of way that will be shared with Pan Am Railway freight trains, additional land will be required for layover yards. The cost for this land was estimated by consulting local public assessor records in Concord to determine the current assessed value of each parcel that had been identified as necessary for a layover yard (see Table C-3 in the Appendix). Where only a portion of the parcel would be required for the rail facility, GIS tools were used to determine what fraction of the overall parcel would be necessary and to prorate the cost accordingly.

Acquisition of private land for transportation improvements can be a litigious process. The summary of estimate land costs in Table 6-12 includes an allowance of 220 percent to account for negotiations, takings, eminent domain and legal costs. The 220 percent was derived from the study team's experience working on similar projects in other jurisdictions, but it is possible that New Hampshire's experience may be different.

Table 6-12: Assessed Land Value and Estimated Cost for Concord Layover and Station Site

Site	Parcel Size (Acres)	Assessed Value per Acre	Estimated Value	Estimated Cost with 220% Assemblage Factor
Stickney Avenue	6.08	$ 237,990	$1,447,000	$4,630,400

7.0 REQUIRED CAPITAL IMPROVEMENTS AND CAPITAL COSTS

This chapter describes the nature and cost of infrastructure improvements and other investments that would be necessary to operate the proposed intercity rail service. General information on stations is presented in this chapter, while more detailed information on station siting and design is presented in Chapter 6: Stations and Layover Facilities.

7.1 General Infrastructure Requirements

The study team consulted with MassDOT, MBTA, and Pan Am Railways and determined that no improvements would be required south of MBTA's Lowell Gallagher Terminal. North of Lowell the railroad would be upgraded to permit safe, reliable operation of eight daily passenger trains at speeds of up to 75 mph. Recommended upgrades to track, bridges, crossings, and signals are summarized below.

The Intercity 8 service option would require more extensive infrastructure upgrades than the proposed commuter rail options as it is approximately 18 miles longer than the Manchester Regional service. The service would also operate at higher maximum speeds; up to 75 mph between Nashua and Bedford/MHT and 70 mph north of Manchester.

Track

Study team engineers had originally recommended that this option be supported by replacing all of the over 70 year old 112 lb mainline rail between Lowell and Concord with new continuous welded rail (CWR) of a similar weight. The infrastructure requirements for each of the three remaining rail options were revisited in meetings with Pan Am Railways (PAR), MassDOT, the MBTA and NHDOT as the study progressed. The study team was able to refine the preliminary infrastructure requirements based on their feedback and with the aid of two hi-rail trips along the corridor with railroad officials. The principal adjustments in the track upgrades necessary for the intercity passenger rail service include:

- Reconsidered needs and limits of industrial freight sidings designed to avoid conflicts with passenger trains. Required sidings include:
  - Nashua Corporation (B41.8 to B42.5);
  - Anheuser-Busch (B43.8 to B44.8);
  - Merrimack Running Track/Jones Chemical (B45.6 to B47.9), and;
  - Public Service of New Hampshire Receiving Track (B66.4 to B 68.5).
- Reappraisal of existing track conditions to reduce required track upgrades:
  - Replace only one-third of all ties due to better than anticipated tie conditions. One-half of all ties had initially been slated from replacement at the outset of the study.
  - Retaining or relaying existing rail on tangent track and industrial sidings instead of replacing all rails to utilize all life left in existing rail and minimize initial required capital outlays. Relay and retained rail would need to be replaced in a multiyear program that would begin approximately ten years after start of service.

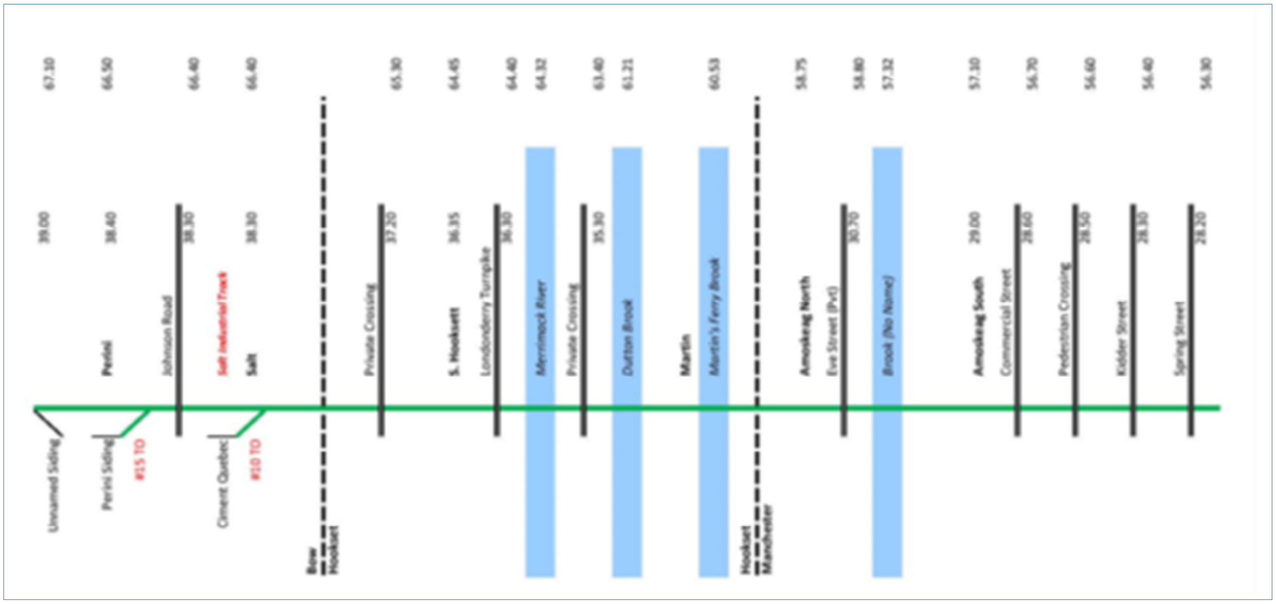
Pan Am Railways supplied more detailed data on bridge conditions, track conditions, crossings and other infrastructure in March of 2014. Using this information together with field inspections of track, crossings and selected bridges, the study team engineers were able to assemble more detailed evaluations of the conditions of existing assets and revise their estimates of cost accordingly.

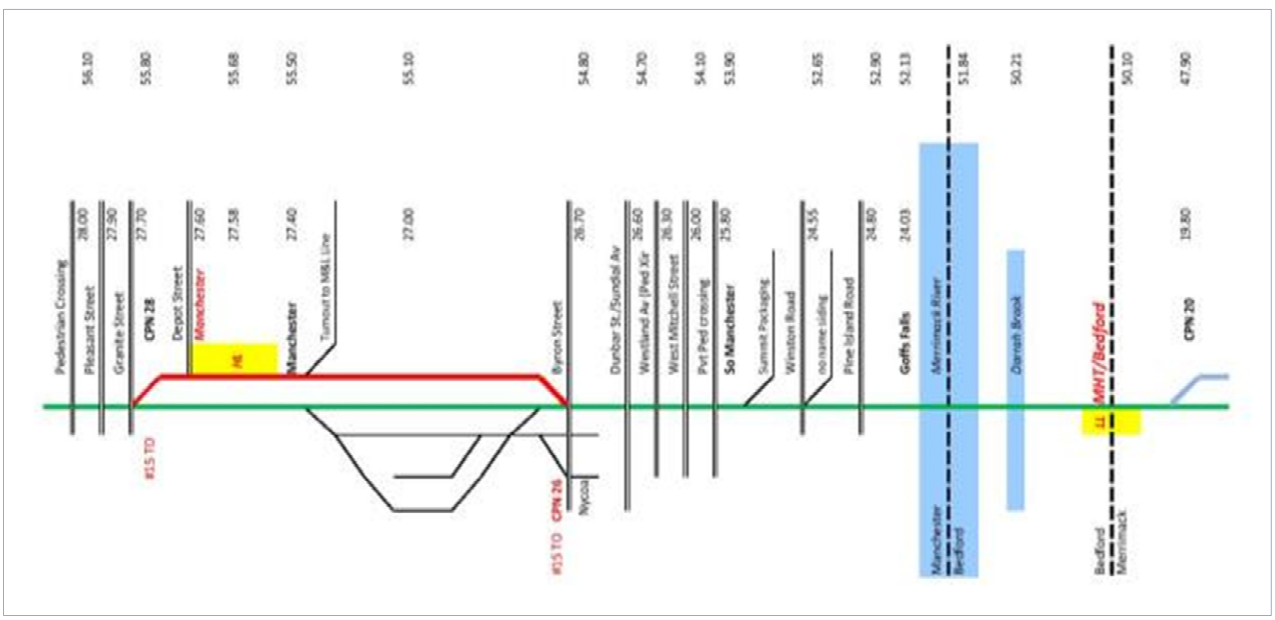
The track configuration necessary to support the service was identified by inspection of the time distance stringline diagrams with consideration of the timing and nature of freight uses on the line.

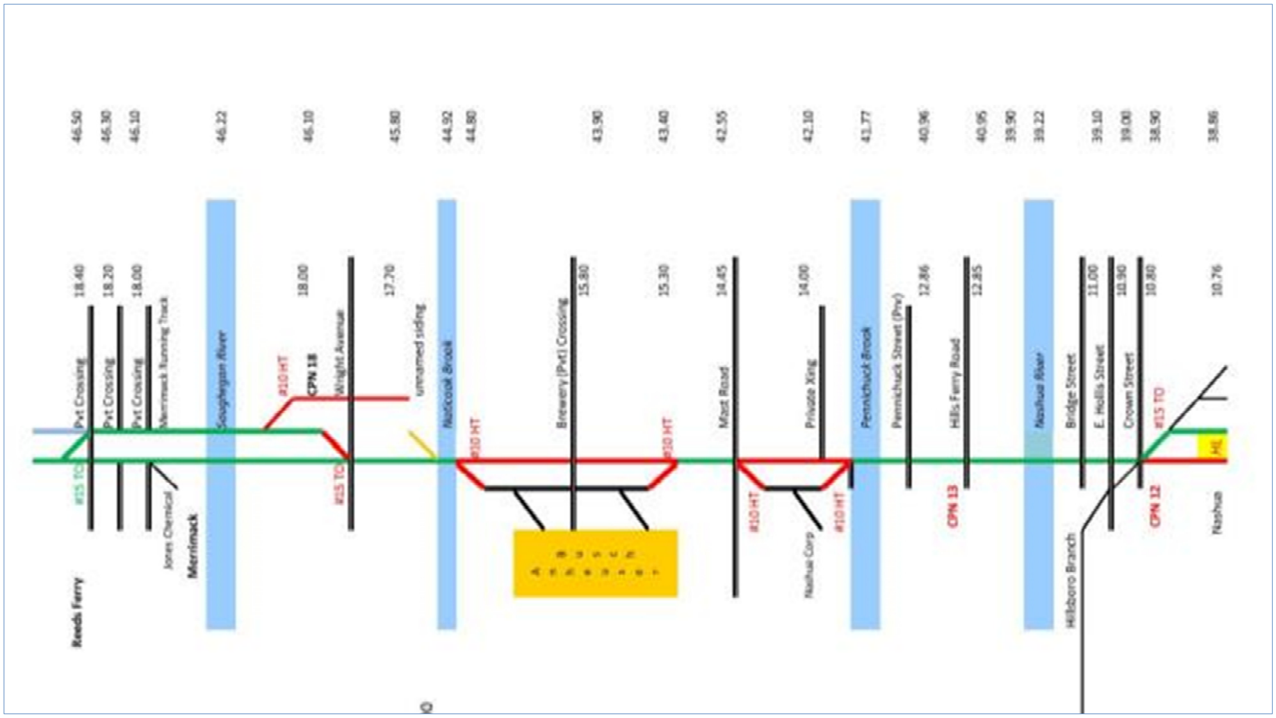
- Between Boston and Lowell, the line is busy with passenger service but has only limited unscheduled local freight service. No upgrades to the well maintained double track rail network would be required along this segment.
- Between Lowell and North Chelmsford the line is a segment of PAR's east-west mainline. This three-mile segment of double tracked railway carries up to eight through and several local freight trains each day. Threading eight non-stop intercity trains through this short double track segment should not prove challenging.
- From North Chelmsford to Concord, the line is 45 miles of mostly single track. Segments of second mainline track are recommended through the yards in Nashua and Manchester. Industrial sidings are recommended at locations were local trains stop to serve local customers. The industrial sidings will keep local freight trains from blocking the main while they serve customers.

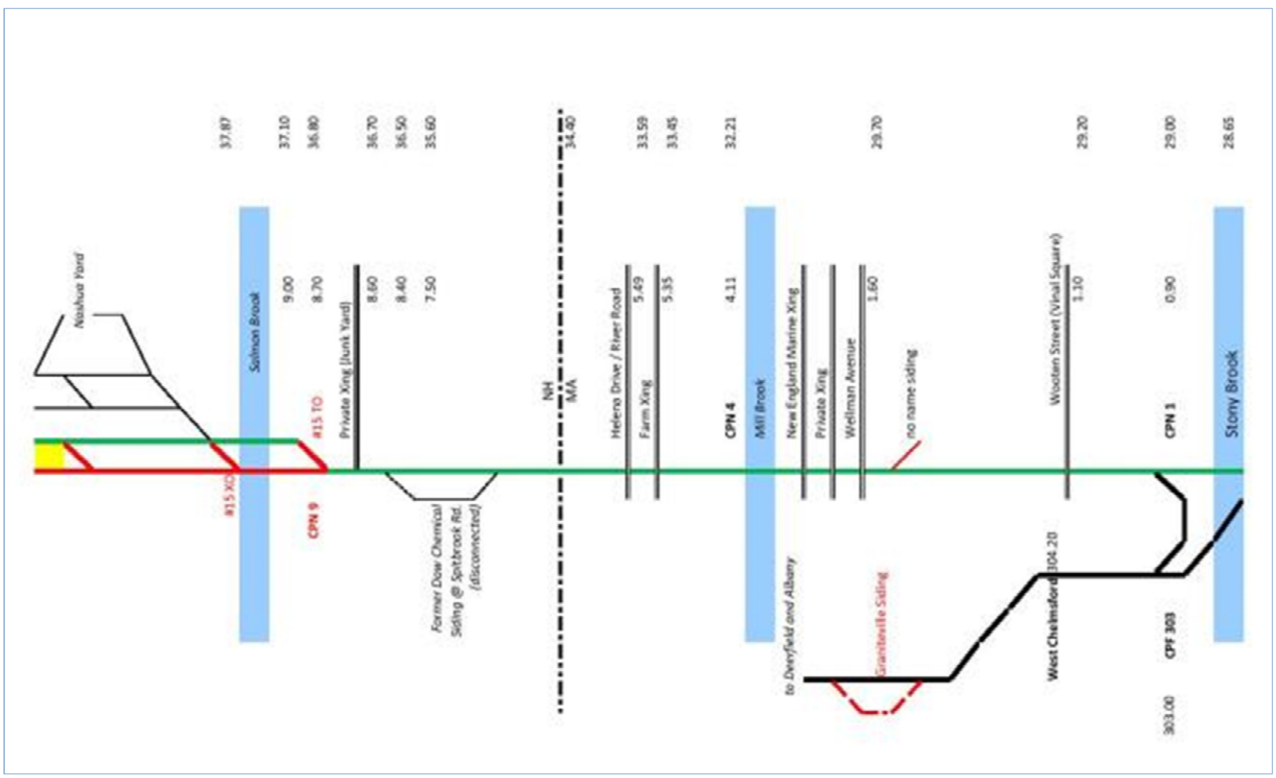
The proposed track configuration is found in Figure 7-1. No improvements are recommended for the tracks shown as black. Rail and ties will be replaced or renewed on existing tracks shown in green. Red tracks and switches represent new construction.

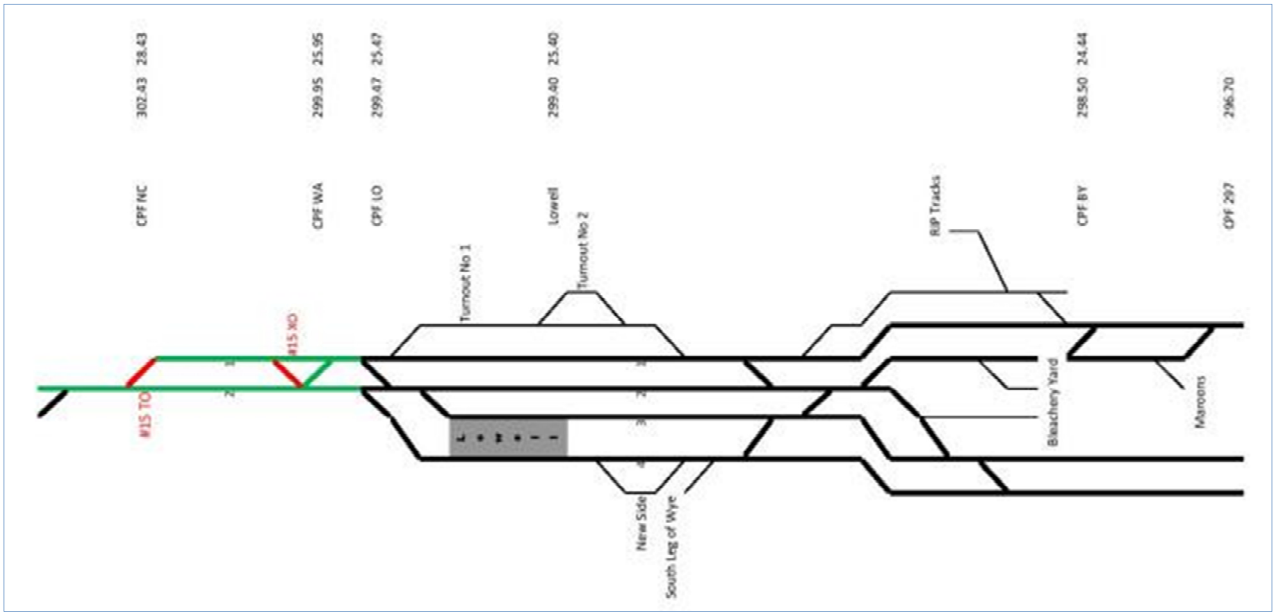
Figure 7-1: Intercity Rail Service Option Proposed Track Configuration






Reeds Ferry
Pvt Crossing
Pvt Crossing
Pvt Crossing
Merrimack Running Track
Jones Chemical
Merrimack
Souhegan River
#10 HT
CPN 18
Wright Avenue
unnamed siding
Naticook Brook
Brewery (Pvt) Crossing
Mast Road
Private Xing
Nashua Corp
Pennichuck Brook
Pennichuck Street (Pvt)
Hills Ferry Road
CPN 13
Nashua River
Hillsboro Branch
Bridge Street
E. Hollis Street
Crown Street
#15 TO
CPN 12
Nashua
HL


Nashua Yard
Salmon Brook
#15 XO
#15 TO
CPN 9
Private Xing (Junk Yard)
Former Dow Chemical Siding @ Spitbrook Rd. (disconnected)
NH
MA
Helena Drive / River Road
Farm Xing
CPN 4
Mill Brook
New England Marine Xing
Private Xing
Wellman Avenue
no name siding
Graniteville Siding
Wooten Street (Vinal Square)
West Chelmsford
CPN 1
CPF 303
Stony Brook



Unlike the higher frequency commuter rail options, no double track would be required between North Chelmsford (MP 28.5) and the southern end of the Tyngsboro Curve (MP 32). As noted above, industrial sidings would be created at three key areas of freight activity in Nashua and Merrimack to eliminate conflicts between local freight deliveries and through passenger trains. At these locations the existing mainline track would be retained as an industrial siding with an entirely new parallel mainline track constructed in the same alignment for use by through trains. Adding a second track would be straightforward as the railway was once entirely double tracked with the double track bed still largely intact.

NHML Track Profile, Alignment and Maximum Allowable Speeds

The NHML north of Lowell to Concord runs along the banks of the Merrimack River. This alignment has mostly gentle grades, with none steeper than 0.35 percent. The horizontal alignment curves to follow the river with few tangent (straight) segments more than one mile long. Between Lowell and Concord, 29.6 of the 48.5 track miles are curved. This constitutes 61 percent of the route. Many of the curves are sufficiently tight to impact maximum train speeds. The engineering required to achieve trains speeds of 80 mph or higher is substantially more challenging when the radius of the railway curve is less than 3,820 feet (1.5 degrees of curvature). Between Lowell and Concord there are 19.6 miles of such restrictive curves which constitute 40 percent of the route miles.

As noted earlier, the maximum historic passenger speed along the NHML was 70 mph. This reflects what clearly had been a long and careful analysis balancing the desire for passenger speed with maintenance costs, safety and freight economy. The calculation of maximum speeds through tight curves on tracks shared with freight trains involves a number of factors. Freight trains place operational and physical limits on maximum passenger train speeds through curves on tracks shared by freight and passenger trains. In order to ensure passenger comfort and safety through curves at higher speeds, tracks can be banked or *superevelated*. The extent of the bank is measured in inches reflecting the difference in elevation between the outside rail and its corresponding inside rail along the curve. With increased train speeds and sharper curves, more superelevation is required. However, when heavy freight trains move slowly (or stop) along a curve with high superelevation, the weight of the train can put unacceptable stresses on the lower inside rail of the curve. Consequently the maximum speed for a passenger train through a curve that is shared with freight trains is limited by the physical and operational demands of the freight service.

Passenger trains often run through curves at speeds that generate centrifugal forces somewhat greater than that compensated by the superelevation. In these circumstances, known as *underbalance*, the train and passengers tend to sway toward the outside of the curve. Using underbalance elevation in the geometric design of curves allows both a nominal amount of sway, considered safe and acceptable practice, and it alleviates some of the undue weight that heavy freight trains place on the low rail through the curves. A few specifics concerning the process of mathematically balancing freight and passenger train requirements are provided in the following paragraphs.

Concerning Railway Curve Design

Finding the right mix of superelevation and underbalance on curves is referred to as Equilibrium Elevation or Ee and is calculated by factoring the square of the speed, the degree of the curve and a derived constant value of 0.0007, shown in written form as: $Ee = 0.0007 \times Dc \times V^2$. Once Ee is found, its value is split between the sum of Ea (actual super-elevation) and Eu (underbalance or unbalance elevation), shown in written form as: $Ee = Ea + Eu$. The amount of actual elevation sets the maximum amount of cross level that is tolerated as a train stands on the curve. Unbalance elevation sets the amount of residual centrifugal force or sway that is tolerated as the passenger train traverses the curve at maximum speed.

Maximum values for Eu and Ea are guided by the American Railway Engineering and Maintenance Association (AREMA) but the controlling railway authority generally dictates its own standards within the AREMA guidelines.

- Underbalance (Eu) - Maximum values for Eu are typically three inches for passenger trains traveling on shared track.[31] The MBTA tries to use a more conservative value for the amount of unbalanced (deficiency) elevation allowed, using 1.5 inches as the preferred limit and allowing up to 2.75 inches as a maximum. This provides improved passenger comfort, better compatibility with freight operations and a margin below the FRA mandated three inch maximum.[32] A three inch maximum is used in this analysis.
- Actual Elevation (Ea) - The MBTA limits Ea to a maximum of six inches but recommends that Ea be limited to four inches on shared use track.[33] "Maximum Ea shall be six inches except it is desirable to limit Ea to four inches on routes where through freights operate and where trains are likely to stop or operate below the design speed on a regular basis. Amtrak track design

[31] *American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual for Railway Engineerin*g, Volume 1 - Track, Chapter 5, Part 3, 2012

[32] Massachusetts Bay Transportation Authority (MBTA) Railroad Operations, *Commuter Rail Design Standards Manual, Volume 1, Section I – Track and Roadway, Chapter 3 – Geometric Design Criteria, Revision No. 1, April 19, 1996.*, Page 3.7.

[33] Massachusetts Bay Transportation Authority (MBTA) Railroad Operations, *Commuter Rail Design Standards Manual, Volume 1, Section I – Track and Roadway, Chapter 3 – Geometric Design Criteria, Revision No. 1, April 19, 1996.*

standards allow an Ea maximum of six inches for passenger only track but face similar constraints as the MBTA when sharing track with heavy freight trains.[34]

Using the strictest design guidelines of Max Ea=4 and Max Eu=2.75, Figure 7-1 shows how the maximum allowable passenger speed decreases as a function of increasing curvature. Also note that passenger trains speeds of 80 mph cannot be sustained on shared track on curves greater than 1.5 degrees. However, as is often the case, design standards and other criteria used to determine geometric railroad alignments can be relaxed or otherwise modified, depending on numerous factors including operational and maintenance input from the predominate users. Other wayside factors like crossings, adjacent curves, station platforms, average train speeds vs. posted zone speed, yard limits, train make-up and equipment types, bridge/culvert conditions and other physical constraints also need to be considered in setting superelevation and train speeds during final track design.

Table 7-1: Maximum Passenger Train Speeds Through Curves on Shared Track

Degree of Curvature	Radius of Curve (feet)	Maximum Passenger Train Velocity (mph)
1.0	5,730	98
1.5	3,820	80
1.6	3,581	78
2.0	2,865	69
2.5	2,292	62
3.0	1,910	57
3.5	1,637	52
4.0	1,433	49
4.5	1,274	46
5.0	1,146	44
5.5	1,042	42
6.0	955	40
6.5	882	39
7.0	819	37
Maximum Cant (inches)		4
Max Cant Deficiency(inches)		2.75

Setting New Passenger Speeds on the NHML

An inventory and geometric analysis of the existing mainline horizontal curvature was prepared to evaluate the restoration of passenger rail service on the NHML north of Lowell to Concord, NH with Class 4 speeds. The following three vectors were computed for the 48.5 miles of new passenger railroad using the formulae described above.

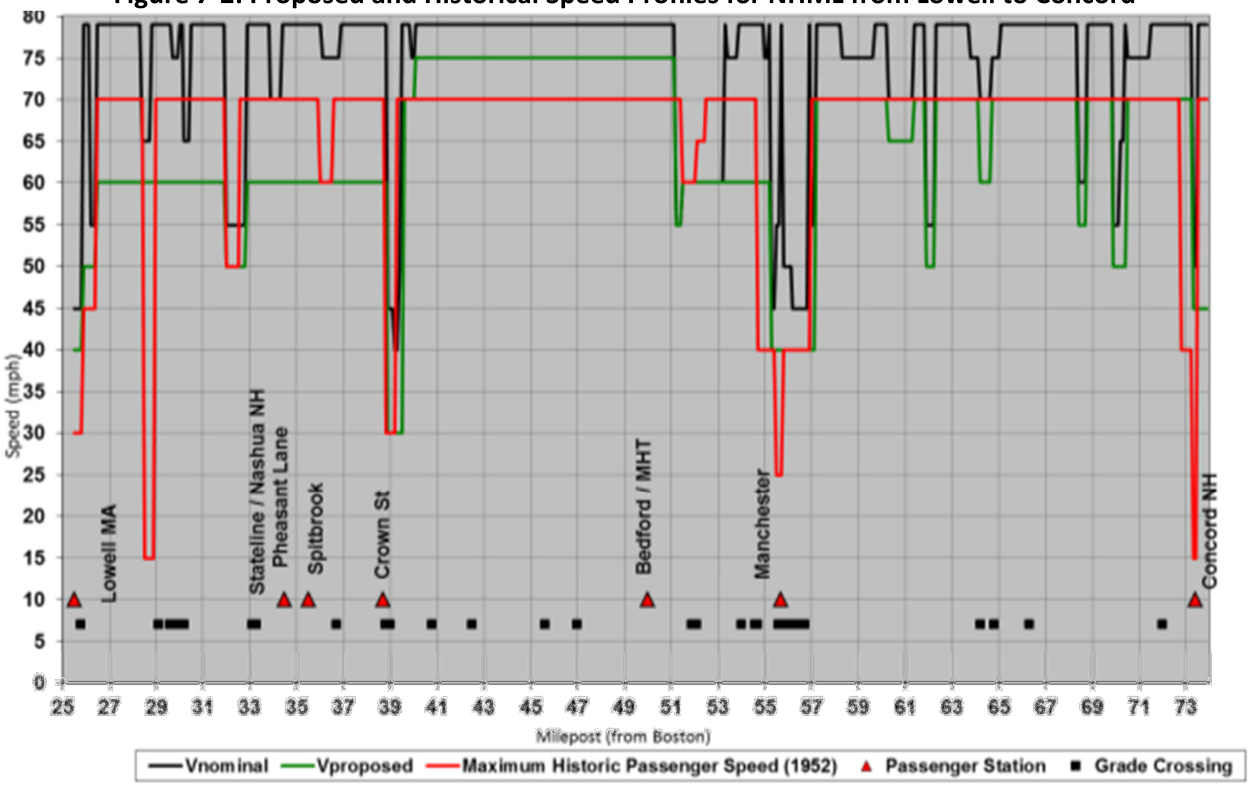
- Vnominal - Shows the maximum allowable Class 4 passenger speed at all points along the line assuming the least restrictive criterion of Max Ee = 9 is applied (Ea=6, Eu=3)

[34] Amtrak Engineering, *Track Design Specification, Spec No. 63*, Revised August 1, 2013.

- Vproposed – Is manually derived from Vnominal to smooth out speed limits and keep the value of Ea under five inches
- Ea based on Vproposed – is the calculated superelevation (Ea) at each point along the railway necessary to support Vproposed.

Figure 7-2 compares the values of Vnominal and Vproposed with the historic maximum speeds along the NHML before the Federal Railroad Administration established maximum values for Ea and Eu.

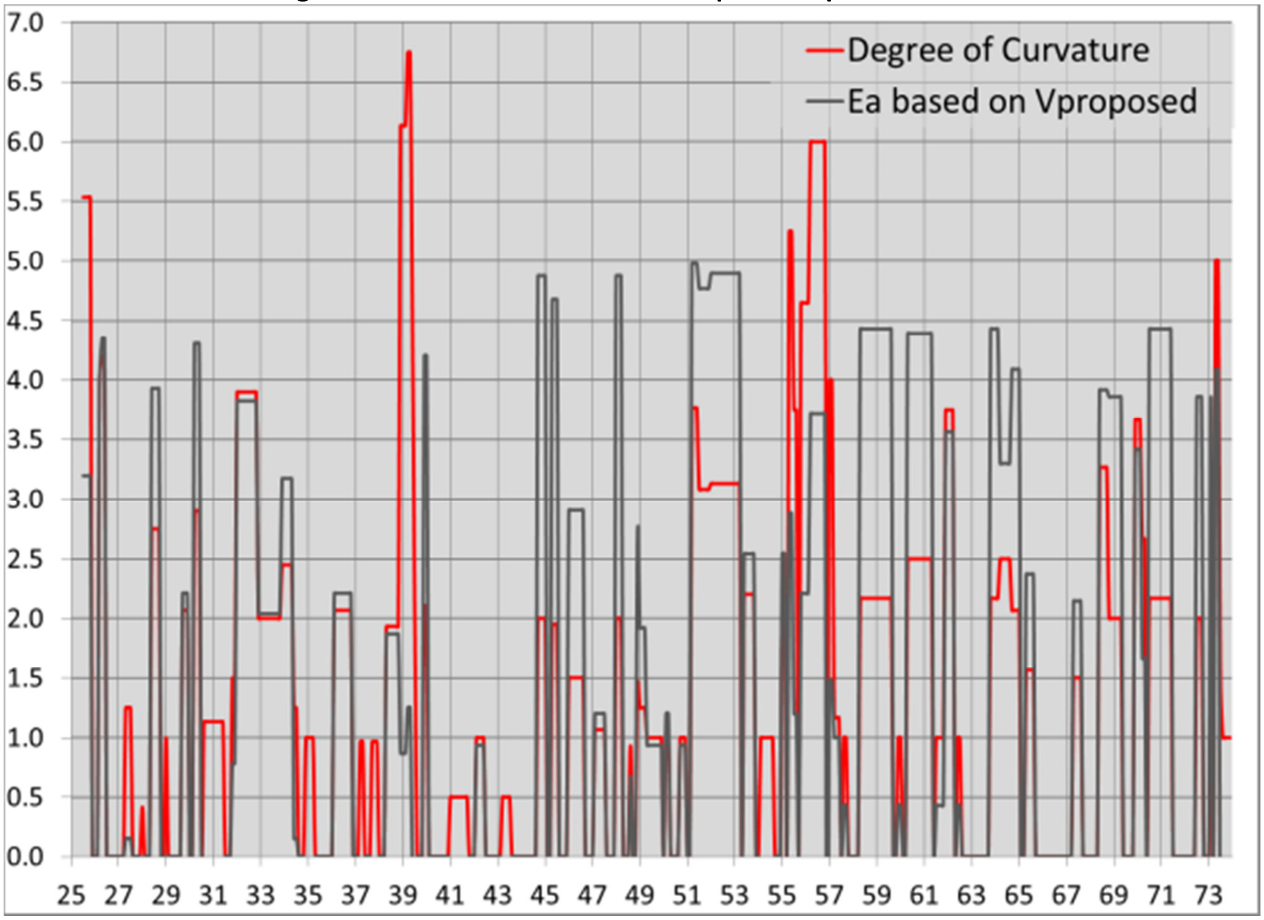
Figure 7-2: Proposed and Historical Speed Profiles for NHML from Lowell to Concord



The proposed maximum speed profile for passenger trains would generally provide for maximum speeds of 60 mph northward to Nashua, then 75 mph to Bedford/MHT and 60 mph to Manchester. North of Manchester the maximum passenger speed would be 70 mph with five areas of speed restrictions as low as 50 mph. The proposed speeds (Vproposed) are in some cases less than the historic maximum speeds which required superelevation and underbalance standards in several areas that are not possible in the 21st Century. The proposed speeds are also generally below the maximum allowable passenger speed in order to keep the required superelevation below 5 inches.

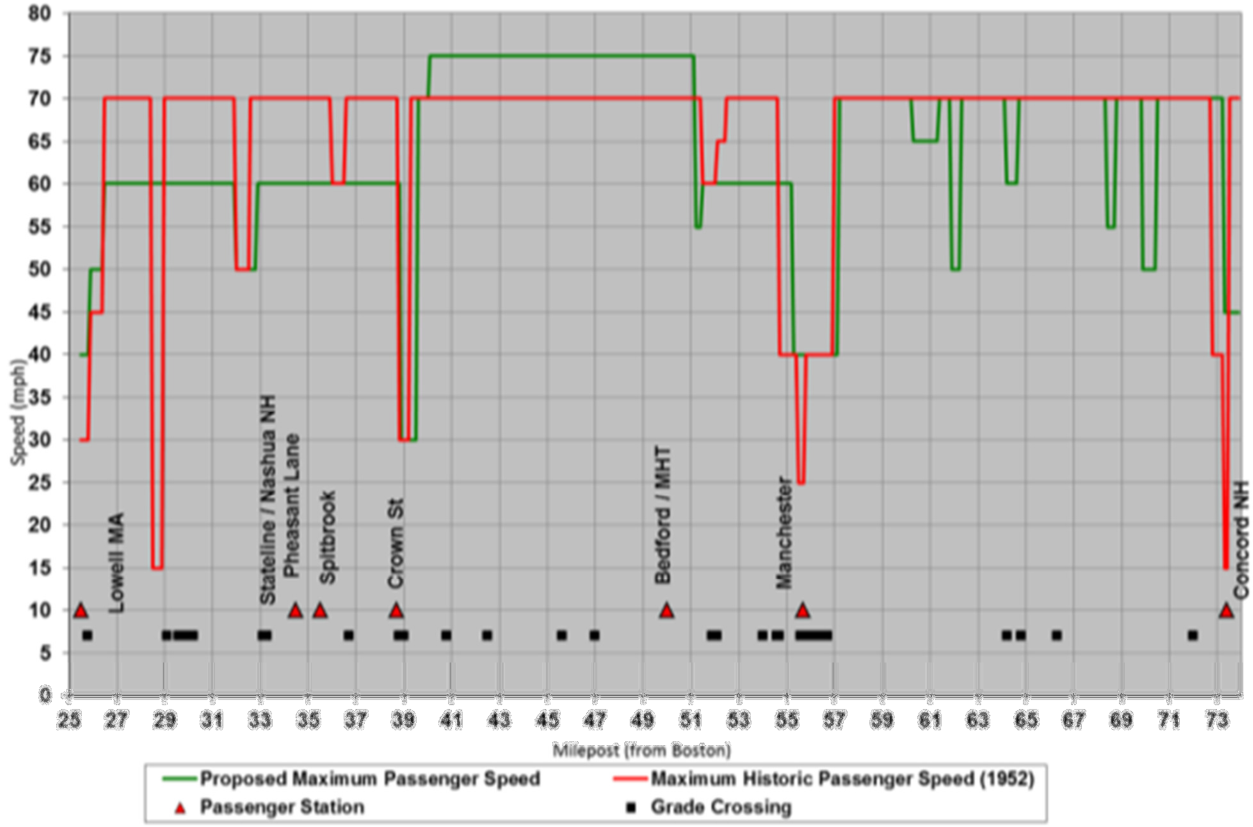
Figure 7-3 shows the degree of curvature and the inches of superelevation at each point along the rail corridor that would be necessary to support the speed profile described by Vproposed. In no case is the proposed superelevation in excess of five inches. A total 6.5 miles of track with superelevation greater than four inches but less than five inches is necessary to support Vproposed speeds. This track with high superelevation would constitute 13 percent of the route between Lowell and Concord.

Figure 7-3: NHML Curvature and Proposed Superelevation



In summary, the study team's evaluation of tradeoffs between speed and maintenance expense suggest that the railway can be economically restored to a 60 mph (FRA Class 3) passenger speed standard for most of its length with only a few geometrically imposed speed restrictions. FRA Class 4 operations allowing a 75 mph maximum speed may be economically achievable between the Nashua River and the point where the railway crosses the Merrimack River into Manchester. North of Manchester some substantial segments of 70 mph may be achievable for a modest increase in capital cost and maintenance expense (see Figure 7-4).

Figure 7-4: Proposed and Historical Speed Profiles for NHML from Lowell, MA to Concord, NH



With these track improvements in place, the study team's analysis indicates that travel times of 89 minutes for the 73 miles between Concord and Boston would be achievable making intermediate stops at Manchester, Bedford/MHT, Nashua, Lowell and Woburn.

Estimated Costs for Track Upgrades

Study team engineers developed cost estimates of the various necessary upgrades using information from current and recent passenger rail development projects elsewhere in New England together with inventory prices from the MBTA's commuter rail department.

New and Rebuilt Track

Costs for labor and materials for new and rebuilt track were developed using track construction metrics, costs experienced on the MBTA's recent and current work improving its line to Fitchburg and using current prices for materials in the MBTA/MBCR inventory system. The length in miles of new and rebuilt track required for each service option is summarized in Table 7-2. Retaining or relaying ('Relay') existing rail from another location on tangent track sections and industrial sidings instead of replacing all rails can maximize the lifespan left in existing rail and minimize initial required capital outlays. Relay and retained rail would need to be replaced in a multiyear program that would begin approximately ten years after start of service. Details showing where track would be replaced, rebuilt and renewed are found in the NHCC Study Conceptual Track Plans for Intercity 8 Rail Service. Cost parameters for new and rebuilt track are summarized in

Table **7-3**.

Table 7-2: Estimated Miles of New and Rebuilt Track by Type of Rail for Intercity 8 Rail Service

Replace Rail with CWR	Replace Rail with Relay Rail	New Track with CWR	New Track with Relay Rail
26.1	27.0	4.6	6.8

Table 7-3: Cost Parameters and Unit Costs for New Track

Cost Element	Quantity	Unit Cost	Subtotal	Source
Cost of New Track (New 115# CWR)			**$1,155,088/mile**	*$218.77/foot*
Materials			**$616,894**	
Wood ties	3,249	$47.21	$153,396	MBCR Inventory Value
Ballast (tons)	1,500	$33.64	$50,460	Fitchburg ML Improvement Project
Subballast (tons)	1,000	$36.13	$36,130	Fitchburg ML Improvement Project
Plates	6,498	$15.00	$97,477	MBCR Inventory Value
Spikes	19,495	$0.50	$9,748	MBCR Inventory Value
Anchors	6,498	$1.50	$9,748	MBCR Inventory Value
Thermite welds	6.6	$512.23	$3,381	Fitchburg ML Improvement Project
CWR rail (LF)	10,560	$24.30	$256,555	Fitchburg ML Improvement Project
Labor	5,280	$101.93	**$538,193**	Fitchburg ML Improvement Project
New Track (Jointed Relay Rail)			**$970,381/mile**	*$183.78/foot*
Materials			**$432,188**	
Wood ties	3,249	$47.21	$153,396	MBCR Inventory Value
Ballast (tons)	1,500	$33.64	$50,460	Fitchburg ML Improvement Project
Subballast (tons)	1,000	$36.13	$36,130	Fitchburg ML Improvement Project
Plates	6,498	$15.00	$97,477	MBCR Inventory Value
Spikes	19,495	$0.50	$9,748	MBCR Inventory Value
Anchors	6,498	$1.50	$9,748	MBCR Inventory Value
Joint bars (pr)	271	$65.00	$17,600	Fitchburg ML Improvement Project
Bolts	1,625	$2.50	$4,062	Fitchburg ML Improvement Project
Bond wires	135	$5.67	$768	MBCR Inventory Value
Relay rail (LF)	10,560	$5.00	$52,800	Jacobs Engineering Estimate
Labor	5,280	$101.93	**$538,193**	Fitchburg ML Improvement Project
Cost of New 115# CWR Replacement Rail			**$662,678/mile**	*$125.51/foot*
Materials			**$353,914**	
CWR rail (LF)	10,560	$24.30	$256,555	Fitchburg ML Improvement Project
Ties (33% of ties)	1,083	$47.21	$51,132	MBCR Inventory Value

Cost Element	Quantity	Unit Cost	Subtotal	Source
Anchors	6,498	$1.50	$9,748	MBCR Inventory Value
Plates (10%)	650	$15.00	$9,748	MBCR Inventory Value
Thermite welds	6.6	$512.23	$3,381	Fitchburg ML Improvement Project
Spikes (67%)	13,062	$0.50	$6,531	MBCR Inventory Value
Ballast (tons)	500	$33.64	$16,820	Fitchburg ML Improvement Project
Labor	3,029	$101.93	**$308,763**	Adjusted down for reduced material
Cost of Used (Relay) Replacement Rail			**$477,971/mile**	*$90.52/foot*
Materials			**$169,208**	
Relay rail (LF)	10,560	$5.00	$52,800	Jacobs Engineering Estimate
Ties (33% of ties)	1,083	$47.21	$51,132	MBCR Inventory Value
Anchors	6,498	$1.50	$9,748	MBCR Inventory Value
Plates (10%)	650	$15.00	$9,748	MBCR Inventory Value
Joint bars	271	$65.00	$17,600	Fitchburg ML Improvement Project
Bolts	1,625	$2.50	$4,062	Fitchburg ML Improvement Project
Bond wires	135	$5.67	$768	MBCR Inventory Value
Spikes (67%)	13,062	$0.50	$6,531	MBCR Inventory Value
Ballast (tons)	500	$33.64	$16,820	Fitchburg ML Improvement Project
Labor	3,029	$101.93	**$308,763**	Adjusted down for reduced material

Track Switches

The need for new and renewed switches in the track structure was identified as the track configuration was finalized for each option. Costs for new switches were derived using reported costs for installed switches on the MBTA's ongoing Fitchburg Line Improvement Project. Switch renewals were estimated at two-thirds of the installed cost for an entirely new switch. New and renewed switches for the Concord Intercity 8 Rail Option is listed in Table 7-4.

Table 7-4: New and Renewed Switches for Concord Intercity 8 Passenger Rail Option

Switch Location and Type	Installed Cost	Quantity
New #15 Crossover (B25.8)	$632,475	1
Renew #15 Crossover (B25.9)	$421,650	1
New #15 Turnout (CPF-NC)	$316,238	1
Renew #15 Turnout (CPF-NC)	$210,825	1
New #15 Crossover (B29)	$632,475	1
New #10 Turnout (B29.7) Courier Corp	$184,000	1
New #20 Turnout (B32.1) Tyngsboro Curve	$434,526	1
New #15 Turnout (B34.2) to Layover Facility	$316,238	
Renew #15 Turnout (CPN9)	$210,825	1
Renew #15 Crossover (B37.9) Robies	$421,650	1
Renew #15 Turnouts Nashua Yard/Station (B38.7)	$210,825	1
New #10 Hand Throw (B42.3) Nashua Corp Siding	$184,000	2

Switch Location and Type	Installed Cost	Quantity
Renew #10 Turnout to Nashua Corp	$122,667	2
New #10 Hand Throw (B43.5) Anheuser Busch	$184,000	2
Renew #10 Turnout (B43.6) Anheuser Busch	$122,667	1
New #15 Turnout (B45.4) Merrimack Running Track	$316,238	1
New #10 Hand Throw (B45.6) to NE Pole Siding	$184,000	1
Renew #10 Hand Throw (B46.1) Jones Chemical	$122,667	1
Renew #15 Turnout (B47.8) CPN 20	$210,825	1
Renew #10 Turnouts to Manchester Customers	$122,667	1
Renew #15 Turnout (B55.3) Manchester Yard	$210,825	1
New #15 Turnout (B55.6) to Layover Facility	$316,238	1
New #15 Turnout (B55.7) CPN 28 to Concord	$210,825	1
Renew #10 Hand Throw (B66.1) Cement Quebec	$122,667	1
Renew #15 Turnout (B66.4) Perini Siding	$210,825	1
Renew #10 Hand Throw (B67) Coastal Wood	$122,667	1
New #10 Hand Throw (B68) PSNH Siding	$122,667	1
Renew #15 Turnout (B72.7) Concord Yard	$210,825	1
Renew #10 Hand Throw (B73) Scrap Yard	$122,667	1
New #15 Turnout (B73.6) Loudon Rd/Concord Station	$316,238	1

Interlockings and Block Signals

The New Hampshire Main Line has a fully functioning Centralized Traffic Control (CTC) signal system in place between Lowell and CPN28 in Manchester that would be renewed and upgraded for the new passenger service. Existing block signals were identified by reference to PAR documentation. New and renewed interlockings were identified in the track configuration planning process (see Table 7-5). Estimated signal costs for new interlockings were based on the average value for six new interlockings constructed on the nearby MBTA Fitchburg Main Line. Estimated costs to renew block signals were derived from the same source. Costs for interlocking renewal were estimated at two-thirds the cost of a new interlocking.

Table 7-5: New and Renewed Interlockings and Block Signals for Concord Intercity 8 Passenger Rail

Interlocking Location and Treatment	Installed Cost	Quantity
Renew CPF-LO	$683,295	1
Renew Western Avenue	$683,295	1
New CPF-NC	$1,024,942	1
New CPN2 Crossover (B29)	$1,024,942	1
New CPN4	$1,024,942	1
Renew CPN6 So Nashua Station	$1,024,942	1
Renew CPN9	$683,295	1
Renew Nashua	$683,295	1
Renew CPN13 (12.86) Hills Ferry	$683,295	1
New CPN 18	$1,024,942	1
Renew CPN20	$683,295	1

Interlocking Location and Treatment	Installed Cost	Quantity
New Manchester	$1,024,942	1
Renew CPN28 (Granite Street)	$1,024,942	1
New Concord	$1,024,942	1
Block Signals		
Renew 27/27.1	$147,872	1
Renew 30.6/30.7	$147,872	1
Renew 352/353 (So Nashua) MP7	$147,872	1
Renew 14.4/14.5 Mast Road	$147,872	1
Renew 16.0/16.1 Anheuser Busch	$147,872	1
Renew 500/499 (MP22)	$147,872	1
Renew 540/539 (West Mitchell Street)	$147,872	1
Renew 28.6 (Commercial Street)	$147,872	1

Automatic Highway Crossing Warning (AHCW) Systems

The rail line has 35 highway and pedestrian crossings between Lowell and Concord. The study team inspected each crossing with an accompanying PAR signalman to determine its condition and identify necessary signal and warning system upgrades for each crossing. The site survey ran south to north to view the conditions at each of the 35 crossings from Wotton Street in Chelmsford, MA to Hall Street in Bow, NH. The specific cities and towns visited and the number of active crossings includes Chelmsford (3), Tyngsboro (2), Nashua (6), Merrimack (4), Manchester (14), Hooksett (2), and Bow (4).

The study team's estimate includes all material and labor to purchase and install new equipment and remove and dispose of old equipment including a 5 percent design contingency. The estimate includes costs for crossing houses complete with racks, crossing controllers, relays and wiring necessary for the control of the wayside equipment. Constant warning time control equipment has been included in the estimate due to the variation in speeds between passenger trains and freight trains which will both coexist on the line. Wayside equipment has been determined for each location to be either a two or four quadrant gate system or flasher-only system with foundations, cable, lights, and bells. A cost for a power service up-grade at each location has been included. All estimated backup details are based on current-year 2014 dollars. This estimate does not include any costs for the operating contractor (force account), future escalation, contractor's general conditions, overhead, profit, bond or any other allowances. Other general information and assumptions used in developing this cost estimate include:

1. Review of information contained in the US DOT Crossing Inventory.
2. Material and labor costs for contractor work are based on various sources including estimating publications, historical contractor rates from similar project bids, and experience of the estimators. A material list estimate from Safetran Systems dated 2004 was also used as reference. Material costs from that estimate where used have been escalated to be consistent with recent cost information.
3. The cost estimate includes assumption of manpower and assumes all work will be done on straight time.

4. The overall cost does not include any credit for salvageable equipment.
5. The cost estimate does not include any cost for upgrades to the wayside signal system.
6. Costs are included for interface at locations where electric switch locks may be required.
7. Cost was added at Crown Street and E. Hollis Street in Nashua between the main line and the Hillsboro Branch line specifically for a crossing control interface between the two locations.
8. From the site survey it was observed that the Manchester traffic signals along Canal Street provide signage and a steady flashing yellow light in advance of the crossing for warning motorists. Cost for an upgrade to this traffic system is not included.
9. From the site survey it was observed that several locations have traffic signals within 200 feet of the Highway Rail Grade Crossing Warning System and will need to be interconnected to pre-empt the traffic signals in accordance with the Manual on Uniform Traffic Control Devices (MUTCD).

The resulting signal cost estimates for each crossing are enumerated in Table 7-6.

Table 7-6: Estimated Signal Costs for AHCW System Upgrades

City	State	Grade Crossing	MP	Cost
Chelmsford	MA	Wotton Street	29.1	$241,750
Chelmsford	MA	Wellman Road	29.6	$260,650
Chelmsford	MA	Cross Street	30.0	$298,576
Tyngsboro	MA	New England Marine	30.5	$298,576
Tyngsboro	MA	Helena Dr/River Rd	33.5	$258,203
		Segment Total		$1,357,755
Nashua	NH	East Glenwood	36.9	$258,203
Nashua	NH	Crown Street	38.8	$324,364
Nashua	NH	East Hollis Street	38.9	$297,767
Nashua	NH	Bridge Street	39.0	$266,267
Nashua	NH	Hills Ferry Road	40.8	$258,203
Merrimack	NH	Mast Road	42.4	$258,203
Merrimack	NH	Anheuser Busch	43.7	$258,203
Merrimack	NH	Star Drive	44.1	$258,203
Merrimack	NH	New England Pole	45.7	$258,203
Manchester	NH	Pine Island Road	52.1	$220,403
Manchester	NH	Winston Road	52.6	$225,653
Manchester	NH	West Mitchell Street	54.0	$291,635
Manchester	NH	Sundial Avenue (Dunbar St)	54.6	$225,653
Manchester	NH	Bryon Street	54.7	$238,757
Manchester	NH	Depot Street	55.6	$13,304
		Segment Total		$3,653,026
Manchester	NH	Granite Street	55.7	$26,174
Manchester	NH	Pleasant Street	55.9	$288,485
Manchester	NH	Pedestrian Crossing #1	56.0	$132,190
Manchester	NH	Spring Street	56.2	$288,485
Manchester	NH	Kidder Street	56.3	$288,485
Manchester	NH	Pedestrian Crossing #2	56.5	$132,190
Manchester	NH	Commercial Street	56.6	$288,485

City	State	Grade Crossing	MP	Cost
Manchester	NH	Eve Street (Chauncey Ave)	58.7	$263,453
Hooksett	NH	Old Londonderry Turnpike	64.3	$263,453
Hooksett	NH	Edgewater Drive	64.8	$263,453
Bow	NH	Johnson Road	66.3	$263,453
Bow	NH	Robinson Ferry	68.3	$263,453
Bow	NH	Gavins Falls Road	69.8	$263,453
Bow	NH	Hall Street	71.0	$284,453
		Segment Total		$3,309,669

Grade Crossing Track Renewals

Each of the highway grade crossings would also be renewed with new track, and paving material. The estimated cost for upgrading each of highway grade crossings was based on the average value to upgrade the track and crossing material for six substantial crossings on the MBTA's ongoing Fitchburg Line Improvement Project at $165,950 per crossing.

Bridges

There are 25 railroad bridges along the route between Lowell and Concord spanning an aggregate 2,100 feet over waterways and roadways. The study team obtained inspection reports, plans and documentation for each bridge from PAR and the MBTA. The study team combined this information with selected field inspections to estimate costs to rehabilitate each of the railroad bridges along the route. The assessment of the bridge structures was limited to review and evaluation of this available information only. The scope of this study does not include bridge inspection and/or development of an independent load capacity rating for any of the bridges. Available information utilized in the assessment and evaluation of the 25 bridges within the study limits includes the following:

1. Bridge Inspection Reports obtained from MBCR
2. Bridge Inspection Reports obtained from Pan Am
3. Bridge Rating Reports obtained from Pan Am
4. Bridge Plans obtained from Pan Am
5. Video and photos from a Hi-Rail trip along the rail corridor
6. Photographs of some bridges where access was possible
7. GIS mapping and online aerial photos of the bridges

A Bridge Summary Sheet was developed for each bridge to summarize the basic information and condition of each bridge as identified in available bridge inspection reports. Based on condition ratings, inspector notes and available photographs, a recommended scope of repairs is presented, with concept level cost item quantities identified. The recommended repairs are also given a weighted rating of "Minor", "Moderate" or "Extensive" based on a subjective evaluation of the available information. Unit costs for various repair/rehabilitation work items are utilized for each of the three weighted ratings, and the appropriate unit cost is then applied to the specific cost item quantity for the given bridge.

The condition of each bridge is summarized in Table 7-7. Bridge repair cost information was developed for the purpose of establishing order-of-magnitude capital investment levels, and considered as representative of preliminary conceptual repair/rehabilitation requirements. As project design advances, development of more accurate needs and associated costs at each bridge based on further engineering assessment will be required, including hands-on inspections and load capacity ratings for two bridges that have not recently been rated.

Table 7-7: Estimated Bridge Rehabilitation Costs

City/Town	Bridge No.	Length (Feet)	Bridge Structure	Deck Type	Spans	Rehabilitation Costs
Lowell, MA	25.62	30' +/-	Deck Plate Girder	Open	1	$41,000
	25.69	154'-6"	Deck Plate Girder	Open	4	$99,000
	26.20	163'-0"	Thru Truss	Open	1	$183,000
Chelmsford, MA	28.65	43'-8"	Stone Arch	Ballast	2	$29,000
	29.10	13'-0"	I-Beam	Open	1	$58,000
Tyngsboro, MA	32.46	45'-9"	Frame Trestle	Open	6	$1,647,000
	32.56	12'-3"	Reinforced Concrete	Ballast	1	$50,000
Nashua, NH	37.87	17'-3"	Stone Arch	Ballast	1	$5,000
	39.22	113'-2"	Thru Truss	Open	1	$72,000
	39.39	35'-0"	Reinforced Concrete	Ballast	2	$75,000
	41.77	47'6"	Deck Plate Girder	Ballast	1	$422,000
Merrimack, NH	44.76	16'-0"	Reinforced Concrete	RCS	1	$95,000
	44.92	108'-8"	Deck Plate Girder	Ballast	3	$1,011,000
	46.22	111'-6"	Deck Plate Girder	Ballast	2	$980,000
	47.80	10'-0"	Reinforced Concrete	RCS	1	$8,000
Bedford, NH	51.84	655'-3"	Thru Truss	Ballast	4	$5,956,000
Hooksett, NH	60.53	12'-0"	Reinforced Concrete	RCS	1	$50,000
	61.21	15'-0"	Reinforced Concrete	RCS	1	$21,000
	64.32	487'-6"	Thru Truss	Ballast	3	$4,478,000
Bow, NH	67.63	15'-0"	Reinforced Concrete	RCS	1	$21,000
	70.82	17'-0"	Reinforced Concrete	RCS	1	$21,000
	71.12	11'-0"	Reinforced Concrete	RCS	1	$21,000
Concord, NH	71.47	16'-0"	Reinforced Concrete	RCS	1	$23,000
	71.54	10'-0"	Reinforced Concrete	RCS	1	$21,000
	73.33	Unknown	I-Beam	Timber	1	$16,000

Stations

Costs for station development were estimated for a number of alternative sites, as described in the Task 4 - Definition of Alternatives: Site Evaluation and Preliminary Designs - Passenger Stations. Estimates relied on unit costs recently generated for the MBTA's on-going improvements to the Fitchburg line. Those detailed capital costs were prepared by Jacobs Engineering and Keville Enterprises, Inc. in January, 2013 and are included in an Appendix to the above referenced Task 4 project document. The estimated Wachusett station construction cost with escalations and contingencies came to $13,303,000 for a station facility with a single track siding station with one 800-foot high-level side platform and 360 parking spaces.

Detailed costs for Wachusett were used to inform cost estimates for each of the proposed station sites through the use of allocation factors. These include variables such as the number of parking spaces, number of platforms, number of side tracks, square feet of existing wetlands and whether there was the possibility of contaminated soil disposal. This allowed for the application of the Wachusett station unit costs even where the characteristics of the sites were different. The costs for a station at the Pheasant Lane Mall site include a parking garage that was estimated at ten times the cost per space of a surface parking space. This figure is consistent with Jacobs estimates for other parking garages. Detailed capital cost calculations are documented in an Appendix to the above referenced Task 4 project document.

Layover Facilities

Costs to develop layover yards for overnight storage and light maintenance of the service rolling stock were estimated for a number of alternative sites, as described in the Task 4 - Definition of Alternatives: Site Evaluation and Preliminary Designs – Layover Facilities. Estimates relied on unit costs recently generated for the MBTA's on-going improvements to the Fitchburg line. The estimated Wachusett layover construction cost with escalations and contingencies came to $13,303,000 for a layover facility with six tracks including 9,655 track-feet available for the storage of trains.

These detailed costs were used to develop cost estimates for each of the proposed layover facilities through the use of allocation factors. These allocation factors included variables such as the number of storage positions, total track length (feet) and whether there was the possibility of contaminated soil disposal. This allowed for the application of the Wachusett layover facility unit costs even where the characteristics of the sites were different. Detailed capital cost calculations are documented in an Appendix to the above referenced Task 4 Project Document.

Right of Way Improvements

Restoration of passenger service on the New Hampshire Main Line will require some right of way improvements including relocation of fiber optic lines where new tracks are being restored to the right of way, vegetation removal, reestablishing ditches and cleaning shoulder ballast. The right of way hosts three separate private fiber optic installations north from Lowell to Nashua, two between Nashua and Manchester and one from Manchester north to Concord. Based on the experience of Jacobs telecommunications engineers, an allowance of $290,400 per route mile was used to estimate the costs of installing replacement fiber optic lines where new tracks were being laid. Allowances for other improvements were derived from earlier studies of the same right of way with costs escalated to current-year 2014 and are listed in Table 7-8.

Table 7-8: Allowances for Right of Way Improvements

Right of Way Improvement	Unit	Unit Cost
Relocate Fiber Optic Lines	Route Mile	$ 290,400
Vegetation Management	Route Mile	$ 20,925
Reestablish ditches	Route Mile	$ 39,600
Shoulder ballast cleaning	Track Mile	$ 39,930

Positive Train Control

The Rail Safety Improvement Act of 2008 (RSIA) created a new infrastructure requirement for all US passenger railroads. This new requirement should reduce the likelihood of:

- Train to train collisions;
- Injuries to rail roadway workers;
- Over-speed derailments, and;
- Accidents due to misaligned switches to sidings.

Under the RSIA, all conventional passenger railroads must operate with Positive Train Control (PTC) as soon as possible after December 2015. The MBTA installation of PTC is lagging the 2015 deadline like most of its peers and its ultimate costs are unknown. The study team employed a 2009 economic analysis prepared by the Federal Railroad Administration[35] to account for the cost of PTC, and then escalated the estimates to the current year at 4% per annum.

At the most basic level, all PTC systems require three equipment elements:

- Wayside Devices – Equipment to detect, monitor and communicate the status of track and switches installed in the field.
- Locomotive/Cab Car Devices – Equipment to monitor and control train status relative to information on field conditions communicated from central control and wayside equipment.
- Central Office Equipment – To integrate and communicate information concerning the status of trains, track maintenance crews, switches, signals and tracks.

The relevant work to install onboard locomotive and cab car devices should be completed for the MBTA, PAR and Amtrak fleets well before the proposed passenger rail service north of Lowell could be implemented. Similarly the PAR and MBTA dispatching offices should have the relevant Central Office Equipment by that time. Any new passenger railway mileage will require the installation of wayside devices.

Using information from the above referenced FRA study, the study team conservatively estimated that the more expensive Advanced Civil Speed Enforcement System (ACSES) wayside equipment would be deployed on the route with an average cost of $147,215 per track mile. If Enhanced Traffic Management System (ETMS) is installed, the PTC costs may be lower than estimated here.

[35] Roskind, Frank D, Senior Industry Economist, Federal Railroad Administration, Office of Safety Analysis POSITIVE TRAIN CONTROL SYSTEMS: ECONOMIC ANALYSIS. DEPARTMENT OF TRANSPORTATION, FEDERAL RAILROAD ADMINISTRATION, 49 CFR PARTS 229, 234, 235, AND 236 [DOCKET NO. FRA-2006-0132, NOTICE NO. 1] RIN 2130-AC03 July 10, 2009 202 302 9704 pp 112-119 (Retrieved from http://www.fra.dot.gov/downloads/PTC_/RIA_/Final.pdf on July 21, 2009)

Railroad Appliances

Various appliances such as train defect detectors, rail lubricators and electric locks for hand thrown turnouts would be required on the refurbished line. Installed unit costs for these appliances and estimated quantities required are listed in

Table 7-9.

Table 7-9: Unit Costs and Quantities of Railroad Appliances for Concord Intercity 8 Passenger Rail

Railroad Appliance	Installed Cost	Quantity
Train Defect Detector	$45,000	1
Rail Lubricator Unit	$8,000	6
Electric Locks for Industrial Sidings	$75,000	5
Electric Locks for Customer Turnouts	$75,000	12

7.2 Non-Infrastructure Costs

Multipliers for Allowances

As per typical practice, costs for various professional services and incidental non-itemized expenditures are estimated on the basis of total costs for all rail infrastructure improvements. These multipliers for professional services and incidental work are listed in Table 7-10.

Table 7-10: Professional Services and Incidental Items

Culverts and retaining walls	3% of infrastructure cost
Environmental (soil disposal, noise abatement, LEED)	3% of infrastructure cost
Final Engineering Design	8% of infrastructure cost
Construction phase engineering services	4% of infrastructure cost

Railroad Services

Mechanisms for estimating the costs for railroad project management, inspections and protective flagging are reviewed in Table 7-11.

Table 7-11: Railroad Services and Estimated Days of Inspections and Flagging for Concord Intercity 8 Passenger Rail Option

	Unit Cost	Quantity
Railroad Project Management	3% of Infrastructure cost	N/A
Maintenance & Protection of Railroad (Inspections)	$2.000 / day	270
Flagging	$2.000 / day	540

Land

Beyond the railroad right of way that will be shared with PAR freight trains, land will be required for stations, parking and overnight train storage yards. The cost for this land was estimated by consulting local public assessor records in Tyngsboro, Nashua, Bedford, Manchester and Concord to determine the current assessed value of each parcel that had been identified for a potential station or layover yard.

Where only a portion of the parcel would be required for the rail facility, GIS tools were used to determine what fraction of the overall parcel would be necessary and to prorate the cost accordingly.

Acquisition of private land for transportation improvements can be a litigious process. An allowance of 220 percent was added to all raw land costs to allow for negotiations, takings, eminent domain and legal costs. The 220 percent was derived from the study team's experience working on similar projects in other jurisdictions. New Hampshire's experience may be different.

Table 7-12: Assessed Land Value and Estimated Cost for Selected Station and Layover Sites for Concord Intercity 8 Passenger Rail Option

Facility Type	Parcel Size (Acres)	Required Portion	Assessed Value per Acre	Estimated Value	Estimated Cost with 220% Assemblage Factor
Stations					
Nashua - Crown Street	6.826	1	$ 45,224	$308,700	$987,840
Bedford / MHT	6.000	0.33	$ 29,416.67	$444,400	$1,422,080
Manchester - Granite Street	0.5544	1	$ 279,132.58	$148,800	$476,160
Concord - Stickney Avenue	6.08	1	$ 237,990	$1,447,000	$4,630,400
Layover Yards					
Concord - Stickney Avenue	6.08	1	$ 237,990	$1,447,000	$4,630,400

Infrastructure Contingency

In accordance with federal recommendations, a thirty-five percent contingency was applied to the sum of all infrastructure, engineering and land costs described above to allow for unforeseen and unusual circumstances that might have been unaccounted for in this conceptual engineering cost estimate.

Rolling Stock

For the Concord Intercity 8 Rail service, the Amtrak Downeaster's standard consist of four coaches with a locomotive was used as a model (see Table 7-13). It was further assumed that the Intercity 8 service would operate in the same equipment pool with the Downeaster's five train sets adding one more four-car train set, one spare coach and one spare locomotive to Amtrak's North Station complement.

Table 7-13: Unit Costs and Quantities of Railroad Rolling Stock for Concord Intercity 8 Passenger Rail Option

Rolling Stock	Purchase Price	Quantity
Coaches	$2,530,000	5
Locomotives	$5,320,000	2

Trackage Rights

The proposed rail services would be operated on a mix of tracks owned by the MBTA in Massachusetts and by the successors to the Boston and Maine Railroad in New Hampshire. The MBTA recently transferred $35 million dollars to PAR in exchange for the right to offer commuter rail service on

B&M/PAR tracks approximately 37 miles north from Tyngsboro, MA to Concord, NH. The value of these rights to the MBTA and PAR is approximately $946,000 per route mile. Without this transaction, the MBTA and NHDOT would need to purchase trackage rights from PAR to operate into New Hampshire. Consequently one of the cost elements for the commuter rail options is the $946,000 per route mile one-time trackage fee for every route mile operated into New Hampshire.

Intercity routes operated by Amtrak, in contrast to the MBTA, have statutory rights to operate over every railroad in the nation without paying trackage fees. Consequently the trackage rights and resulting fees would not be a concern or a cost for the Concord Intercity 8 Rail service option.

7.3 Total Estimated Costs

The ***Concord Intercity 8 Rail Service Option*** is projected to cost $172 million for infrastructure and land plus a $60 million contingency allowance. The cost also includes $23 million for the purchase of rolling stock that would the responsibility of NHDOT.

Table 7 14: Summary of Projected Capital Costs for Concord Intercity 8 Passenger Rail Option

Main Line Tracks	$42.1
Track Switches	$7.8
Interlockings	$12.0
Block Signals	$1.2
Grade Crossing Signals	$8.3
Grade Crossing Track Renewals	$5.6
Bridges	$15.4
Stations	$18.7
Layovers	$4.8
Right of Way Improvements	$8.8
Positive Train Control	$9.5
Railroad Appliances	$1.0
Direct Construction Expense Subtotal	**$135.2**
Multipliers for Allowances	$24.3
Railroad Services	$5.7
Land for Stations	$2.0
Land for Layovers	$1.4
Assemblage Allowance (220%)	$4.3
Subtotal Land	**$6.3**
Contingency	$60.0
Grand Total (INFRASTRUCTURE)	**$231.5**
Coaches	$12.7
Locomotives	$10.6
Grand Total (ROLLING STOCK)	**$23.3**
Trackage Rights	**$0.0**
Total Project Value	**$254.8**

8.0 FORECAST OPERATING COSTS AND REVENUES

This chapter describes the preliminary and final estimates of operating costs and passenger revenues anticipated for the preferred intercity rail service option.

8.1 Operating and Maintenance Costs

Operating and maintenance (O&M) costs comprise those expenses necessary for operation of the railway service. It is generally comprised of four principal elements:

- **Transportation**: Train crews, fuel, dispatching, train supplies, revenue collection, station staffing (if any) and transport supervision.
- **Maintenance of Equipment (MoE):** Sometimes referred to as "Mechanical", includes the maintenance and cleaning of locomotives and coaches.
- **Maintenance of Way (MoE):** Sometimes called "Engineering", includes maintenance of track, signals, communications, right of way, bridges, stations, and other facilities.
- **Administration**: includes general management, marketing, human resources, accounting, material management and other similar support functions.

Two stages of O&M cost estimates were prepared for the study:

1. A set of preliminary estimates were prepared for each of the three intercity rail (as well as the six commuter rail and three bus options).
2. Refined final estimates were prepared for the final intercity rail service design (as well as the two final commuter rail and three final bus options.)

This document describes the assumptions and methods that were applied to derive the preliminary and final O&M cost estimates.

Preliminary Estimates of O&M Cost

The study team's approach for estimating O&M costs were different for the intercity rail, commuter rail, commuter bus and feeder bus service components. The intercity rail estimates are described below. For information concerning the other service options the reader is referred to the NHCC Project *Operations & Maintenance Cost Methodology Report: Draft* September 2014

Service and operations planning for each intercity rail option was developed to include estimates of daily train miles, rolling stock requirements, track miles required, number and location of stations, and schedules of service. The three preliminary options were reviewed with Amtrak staff assigned to advise the study team and revised to reflect their feedback. The study team also consulted with Amtrak for guidance on preparing preliminary estimates of operating costs for the Service Development Plan. The team was referred to documentation from several recent service development plans:

- Feasibility Report on Proposed Amtrak Service: Chicago-Rockford-Galena-Dubuque; Prepared by M.W. Franke, Sr. Director - Corridor Planning and R.P. Hoffman Principal Officer - Midwest Corridors, Amtrak, Chicago, Illinois, Revised June 22, 2007
- Feasibility Report on Proposed Amtrak Service: Quad Cities-Chicago; Prepared by M.W. Franke Assistant Vice President – State and Commuter Partnerships (Central), R. P. Hoffman Principal Officer – Midwest Corridors and B. E. Hillblom Senior Director - State Partnerships; Amtrak Chicago, Illinois January 7, 2008
- Feasibility Report of Proposed Amtrak Service: Chicago – Peoria; Prepared by Policy and Development Department (Central) Amtrak, Chicago, Illinois September 26, 2011.
- New York – Vermont Bi-State Intercity Passenger Rail Study: Identification and Evaluation of Alternatives; March 9, 2012.

Review of these documents revealed that the preliminary (and final) operating cost estimates for Service Development Plans are typically derived in two ways. A measure of annual train miles is often the only cost factor used to derive a very simple and transparent operating cost estimate while other studies rely on Amtrak staff to develop estimates. The study team elected to use the annual train mile approach as documentation concerning Amtrak's methodology is not publicly available. The cost per train mile figures from the referenced reports ranged from $29.78 to $33.08 in the Amtrak Chicago-Quad Cities Report (Table 8-1) to $66.01 in the Amtrak Ethan Allen Report (Table 8-2).

Amtrak reviewed these findings and agreed that the average costs per train mile published for the Amtrak *Downeaster* service would be used to estimate operating costs for Capitol Corridor intercity rail options. The use of the *Downeaster* service between Portland, ME and Boston, MA is especially appropriate since this service also operates on tracks owned by MBTA and PanAm and runs into Boston's North Station. Table 8-3summarizes the cost factors that contribute to that service's $36.02 cost per train mile figure. This metric is roughly equivalent to the costs applied for Midwestern and New York/Vermont services reviewed in the studies recommended by Amtrak.   Using the simple cost of $36 per train mile, the preliminary estimates of operating cost in Table 8-4 were derived for the three intercity service options.

Table 8-1: Amtrak Chicago-Quad Cities Operating Cost Calculations

	Route A UP Belvidere	Route B ICE Airport	Route C CN Direct	Route D ICE-CN Hybrid
Length of Route (miles)	184.0	188.6	182.2	181.0
No. of Rail Carriers	4	5	2	4
Proposed Scheduled Running Time (hours:minutes)	5:25	5:42	5:10	5:22
"Order of Magnitude" Capital Cost ($ millions)	$43.8	$48.9-$55.4	$32.3	$34.5
Estimated Annual Ridership	53, 600	44, 300	74, 500	58, 400
Estimated Annual Revenue ($ millions)	$1.1	$1.0	$1.5	$1.2
Estimated Annual Operation Expense ($millions)	$4.1	$4.1	$4.4	$4.2
Estimated Annual Operation Contract ($millions)	$3.0	$3.1	$2.9	$3.0
Train Hours	5.4	5.7	5.2	5.4
Annual Ridership				
Annual Train Miles	134,320	137,678	133,006	132,130
Annual Train Hours	3,954	4,161	3,772	3,918
Cost per Train Mile	$30.52	$29.78	$33.08	$31.79
Cost per Train Hour	$1,036.88	$985.34	$1,166.59	$1,072.07

Source: Feasibility Report on Proposed Amtrak Service: Chicago-Rockford-Galena-Dubuque; M.W. Franke, Amtrak Sr. Director - Corridor Planning and R.P. Hoffman, Amtrak Principal Officer - Midwest Corridors; Revised June 22, 2007

Table 8-2: Amtrak Ethan Allen Operating Cost Calculation

"Fully Allocated Unit Operating Cost" per Train Mile	$ 66.01

Source: New York – Vermont Bi-State Intercity Passenger Rail Study Identification and Evaluation of Alternatives – Phase One; 3/9/2012

Table 8-3: Preliminary Downeaster Operating Cost Calculation

Annual Budget	$15,000,000
One Way Trip Length	114
Trips per Day	10
Trips per Year	3,652.5
Annual Train Miles	416,385
Cost per Train Mile	$36.02

Source: Northern New England Passenger Rail Authority (NNEPRA) 2013

Table 8-4: Derivation of Preliminary Estimates of Intercity Rail Operating Costs

Intercity Service Option	Trips per Day	Train Miles per Day	Train Miles per Year	Annual Operating Cost (@ $36/train mile)	Preliminary Estimate of Annual Operating Cost (millions)
Intercity 8	8	586	214,036	$7,705,296	**$8**
Intercity 12	12	880	321,054	$11,557,944	**$12**
Intercity 18	18	1,319	481,581	$17,336,916	**$17**

Final Estimates of O&M Costs

The Operations and Maintenance costs evolved over the preliminary stages of the study then were updated at the project close to reflect newer, but not substantial different information concerning operating costs for the Downeaster service used as a cost model for this service. An updated O&M cost estimate is discussed below.

The intercity rail service option that advanced through preliminary screening was developed to a higher level of detail, including estimates of daily train miles, rolling stock requirements, track miles required, number and location of stations, and schedules of service.

Revenue forecasts were then prepared so that the required operating support could be identified. Table 8-5 contains the final estimates of boardings and passenger miles for the preferred intercity passenger rail service option and identifies new transit trips that would be attracted to the service.

Table 8-5: Final Estimates of Demand and Passenger Miles for Preferred Intercity Rail Service

	Boardings	Miles to Boston	Passenger Miles
Concord	78	73.70	11,497
Manchester	186	55.80	20,758
MHT / Bedford	77	50.10	7,715
Nashua	132	38.70	10,217
New NH Boardings	473		
Annual Boardings (Millions)	2.78		
Annual NH Project Boardings (Millions)	0.24		
Incremental Daily Passenger Miles			48,853
Annual Passenger Miles (Millions)			17.8

8.2 Estimated Passenger Revenues

Two rounds of revenue forecasts were prepared for the study. The preliminary forecasts were used to screen the options down to the final set of multimodal transportation investment options, including the preferred Intercity Rail service option. The final revenue forecast was based on the final ridership forecast for the eight-train-per-day Concord service design.

Preliminary Estimates of Passenger Revenue

The preliminary estimates of passenger revenue were based on the ridership forecasts described in Chapter 4: Market Analysis. For screening purposes the service was assumed to use a fare structure similar to the MBTA's commuter rail fares and that daily ridership would be converted to an annual estimate using a factor of 284.4 based on MBTA experience. The use of a commuter rail annualization factor was considered prudent since the forecast model used for preliminary estimates was a commuter rail model. The resulting preliminary forecasts of annual revenue are shown in the Table 8-6.

Table 8-6: Preliminary Forecasts of Intercity Ridership and Revenue

Intercity Rail Station	One Way Fare	Average Revenue per Passenger	Forecast SB Boardings			Annual Revenue (millions)		
			Intercity 8	Intercity 12	Intercity 18	Intercity 8	Intercity 12	Intercity 18
Concord	$12.00	$11.26	60	70	90	$0.4	$0.4	$0.6
Manchester	$11.00	$10.01	130	160	190	$0.7	$0.9	$1.1
Bedford/MHT	$11.00	$10.01	120	140	160	$0.7	$0.8	$0.9
Nashua	$10.00	$9.41	320	370	440	$1.7	$2.0	$2.4
Totals			630	740	880	$3.5	$4.1	$4.9
					Revenue per Passenger Mile	$0.21	$0.20	$0.20

Final Estimates of Passenger Revenue

The final estimate of passenger revenue for the preferred intercity passenger rail service option was based on the Downeaster ridership model forecasts prepared by Amtrak and the Downeaster's average revenue per passenger mile of $0.173. Since the Amtrak model generated annual ridership estimates, it was unnecessary to apply an annualization factor.

Table 8-7: Final Forecasts of Intercity Ridership and Revenue for Eight-Train-per-Day Service

	Miles to Boston	Typical Daily Boardings	Annual Boardings	Annual Passenger Miles	Annual Revenue (millions)
Concord	73.3	78	28,350	4,156,110	$0.7
Manchester	55.7	186	67,800	7,552,920	$1.3
Bedford/MHT	50.1	77	28,150	2,820,630	$0.5
Nashua	39	132	48,350	3,771,300	$0.7
	Totals	473	172,650	18,300,960	$3.2

8.3 Estimated Operating Cost Performance

Table 8-8 lists the performance metrics for the preferred intercity passenger rail service option that can be used to compare its productivity and required operating support against the other study options. The intercity service is forecast to require $4.5 million of annual operating support beyond proceeds from passenger revenues.

Table 8-8: Final Intercity 8 Rail Service Option Performance Metrics

Performance Metric	Cost
Operating Cost per New Transit Passenger Trip	$31.91
Operating Cost per New Transit Passenger Mile	$0.43
Revenue per New Transit Passenger Mile	$0.173
Operating Deficit (millions)	$4.53
Operating Deficit per New Transit Passenger Trip	$18.78
Operating Deficit per New Transit Passenger Mile	$0.25
Required Operating Support (millions)	$4.5

9.0 PUBLIC BENEFITS

This chapter reviews the quantifiable public benefits that would be derived from the construction and operation of intercity passenger rail service in Concord-Boston NHML rail corridor. These benefits include:

- Reduced Vehicle Miles Traveled (VMT) on parallel highways leading to reduced congestion and improved air quality;
- Station area benefits stimulating and supporting sustainable land use patterns;
- Economic development benefits resulting from construction and operation of the rail service;
- Positive equity impacts on low income and minority populations in New Hampshire, and;
- Freight service benefits.

Vehicle Miles Traveled

Public transportation investments generally have some impact in reducing automobile traffic in the corridors where they operate. Reduced automobile traffic in turn tends to have a positive impact on air quality and roadway congestion. As estimated in Chapter 4: Market Analysis, the preferred intercity rail service option would reduce daily vehicle miles on the corridor's limited access highways by 44,794.

Station Area Benefits and Recommendations

Restoration of intercity passenger rail service between Concord and Boston along the NHML is expected to result in positive benefits that will stimulate and support new development. Ideally this would lead to sustainable development in the dense downtown cores of Concord, Manchester and Nashua and help to encourage sustainable development in the vicinity of the proposed airport station.

The study carefully considered existing development and zoning in each of the proposed station areas to reach the findings and recommendations summarized below[36].

All three cities within the NH study area have – to varying degrees - existing transit-supportive zoning and land use plans and policies. Some of the potential station locations would be better suited for transit-oriented development and supporting growth in transit use than others. The station locations in the urban centers of Concord, Manchester and Nashua are all primed for future transit growth and transit-oriented development.

Recommendations to build on existing transit-supportive zoning and land use plans and policies include;

Concord

- Continue to implement the Opportunity Corridor Master Plan. This plan has many of the elements necessary to promote a transit-supportive environment.
- Create policies to limit parking and consider charging a higher rate. Consider updating the zoning code to allow for parking maximum requirements instead of parking minimums for new

[36] For more information on station area development and land use the interested reader is referred to NHCC Project Report: Land Use and Economic Development Analysis, January 2014

development. Parking supply can require less land if managed in parking structures, as opposed to surface lots.
- Allow for greater residential and commercial densities and zoning incentives for increased development in station area.
- Define maximum setbacks to encourage higher density development. Consider removing minimum setbacks.
- 150-foot minimum lot frontages are too large to allow for the diverse mix of uses that the OCP district permits. A smaller frontage, such as the 22-foot minimum allowed in the CBP district, would create a more walkable and pedestrian friendly environment.
- Update the floor area ratio to at least one, to promote more density in the OCP district.

Manchester

- Implement recommendations in the Master Plan to update the zoning ordinance to allow for mixed use and high density residential.
- Allow multi-family and elderly housing as a permitted use instead of as a conditional use.
- Define specific parking maximums to allow for consistent development and to ensure parking supply does not exceed demand. Consider charging a higher rate for parking.
- Allow for residential and commercial densities, zoning incentives for increased development in station area.
- Dimensional regulations are not defined for the CBD, the zoning immediately around the station, other than a floor area ratio of five.
- The city should further define the maximum setbacks and other dimensional regulations to ensure that the urban design of new development enhances the walkability of the area.

Bedford/MHT

- The proposed station area lacks strong existing mixed-use or Transit Oriented Development (TOD) zoning.
- The Town of Bedford has prepared plans and policies that support the development of a mixed-use transit hub at the proposed station location, but no progress has been made towards achieving this vision.
- The potential station would primarily be used by residents who live in south suburban Manchester and for passengers traveling to and from the airport.
- This station would likely function as a park and ride location, with less of a focus on transit-oriented development.
- The area could potentially benefit from more commercial development, serving the needs of passengers traveling to and from the airport.

Nashua

The area surrounding the proposed station is currently zoned General Industrial. The potential station could benefit from a zoning change to allow for more development, such as commercial and/or mixed-use. Former industrial spaces could also be redeveloped into commercial properties. Commercial uses could lead to more jobs near the transit station, making this a strong location in terms of the FTA criteria. Mixing-uses would add residential development opportunities, thereby increasing the population that lives within a half-mile of the proposed Crown Street station.

- The allowed uses by zoning are not optimal for encouraging transit-oriented development and a more walkable and urban environment.
- Specific urban design principles should be created, such as small or no minimum setbacks and narrow lot frontages to encourage higher density development.
- The existing City of Nashua TOD land use code would be appropriate to apply to this location.
- Recommend policies to limit parking and potentially charge for parking.
- Consider updating the zoning code to allow for parking maximum requirements instead of parking minimums for new development.
- Consider working with residential developers to unbundle parking from the residential unit.

Economic Benefits

Building upon the land use and economic development analyses, the study team prepared an economic development assessment aimed at capturing the potential economic benefits of the corridor alternatives. The study team's analysis focused on the final alternatives, including intercity passenger rail to Concord and commuter rail to Nashua or Manchester. It also considered improvements to the existing commuter bus network. The Service Development Plan only reports the findings for the preferred intercity rail option compared to the No Build or No Action alternative[37].

Economic Benefits of Transportation Investments

The study team examined the literature and findings from recent studies of similar regional public transportation enhancement projects. Numerous studies have identified a net positive benefit of transport investment to the regional economy, resulting in travel time savings and congestion reduction, expanded access to jobs and workforce, and new development attracted to station areas. Studies have also found a positive impact on property values within station areas. While only a few studies have specifically examined intercity passenger rail, evidence from other rail system expansions in the greater Boston region similarly suggests that transit investment will have a positive effect on the communities it serves.

Station Area Economic Development Benefits

The study team conducted interviews with local stakeholders to gather information on the impact that the various proposed services could have in encouraging new development over the next 20 years. There was general consensus that passenger rail service (intercity or commuter) to Boston is important for the future development of southern New Hampshire. While some high tech, residential and institutional development is currently occurring near several of the proposed station locations, respondents felt that this would be difficult to maintain or boost (particularly in the case of high tech) without expanded passenger rail service. It was widely expressed that these sorts of transportation

[37] For more information on economic development impacts the interested reader is referred to NHCC Project Report: Economic Development Assessment, September 2014

enhancements can help to attract the type of workers necessary to facilitate growth, namely a younger demographic looking for urban to semi-urban living with walkable amenities.

The study team also assembled data on land use and zoning to evaluate the potential impact of the various project alternatives on development and redevelopment. The study team estimates were measured in terms of commercial square footage (office and retail) and housing units. Table 9-1 shows that the eight trains per day serving Nashua, Manchester, and Concord in the Intercity 8 Rail Service could potentially encourage the development of approximately 2,200 new residential units and 1.3 million square feet of commercial space supporting 3,700 new jobs by the year 2030.

Table 9-1: Total Development Potential for Preferred Intercity Rail Service

Commercial (Square Feet)	**Residential** (Units)	**Jobs**
1,284,000	2,200	3,700

Regional Economic Benefits

The economic modeling tool IMPLAN was used to estimate the economic benefits to the southern New Hampshire region of each intercity and commuter rail alternative. The following economic benefits were evaluated:

- Short-term benefits as a result of spending on construction of rail improvements in New Hampshire; and
- Long-term benefits as a result of the attraction of more residents and jobs to southern New Hampshire. These include benefits from construction of new real estate, as well as ongoing benefits from new worker earnings reinvested in the local economy.

Benefits of time savings to travelers cannot be directly monetized in this type of economic analysis. However, they are capitalized into land values, and therefore are indirectly considered through the real estate effects. Benefits of the bus alternatives were not estimated, as they would involve minimal capital investment, and stakeholder interviews suggested that associated development impacts would also be minimal.

The economic modeling found that the preferred Intercity 8 Rail Service would generate the greatest construction impacts of all the final alternatives (intercity rail, commuter rail, bus) under consideration (see Table 9-2). It would, however, have less development-related benefits when compared to the Manchester Regional commuter rail option due its lower service frequency. Overall, the Intercity 8 Rail Service has the potential to generate 350 new jobs over the construction period (2019-2022), 2,460 jobs related to new real estate development between 2021 and 2030; and 1,140 new jobs annually in 2030 and beyond (with benefits beginning to accrue after 2021) due to reinvested worker earnings. Table 9-3 shows that this new real estate development is projected to add $750 million to the state’s output between 2021 and 2030, with reinvested earnings adding $140 million per year beyond 2030.

Table 9-2: Employment Impacts of Preferred Intercity Rail Service (Number of Jobs)

Project Construction (2019-2022)	**Real Estate Development** (2021-2030)	**Reinvested New Resident Earnings** (Annual, 2030+)
350	2,460	1,140

Table 9-3: Forecast Gross Regional Product Impact of Intercity Rail Service (millions of 2014 dollars)

Project Construction (2019-2022)	**Real Estate Development** (2021-2030)	**Reinvested New Resident Earnings** (Annual, 2030+)
$100	$750	$140

Equity Impacts[38]

Equitable access to transportation services – and the mobility benefits that these services confer on riders – is an important consideration when assessing the alternatives developed in the study. Any major new public transportation (intercity rail, commuter rail or express bus) service would support broad improvements in mobility. They are also a particularly critical tool in increasing the mobility of transit-reliant or -dependent populations, generally including households below the poverty line, minorities, and households in affordable housing units. U.S. Census data was used to calculate statistics related to income, race and housing for households and individuals in Census tracts within a half-mile of the various Capitol Corridor alternatives. This includes the;

- Pan Am rail right-of-way between the state lines of New Hampshire and Massachusetts and the proposed rail station locations enroute to Concord, NH;
- Boston Express bus route between the state lines of New Hampshire and Massachusetts and the existing Manchester, NH Boston Express station, and;
- Concord Coach bus route between the state lines of New Hampshire and Massachusetts and the existing Concord, NH Concord Coach station.

These data were also collected for the states of New Hampshire and Massachusetts, and the United States as a whole. Comparison between the alternatives within the larger geographic context supported the analysis of which alternatives minimize potential adverse impacts on concentrations of households below the poverty line, minority populations and households in affordable housing unit, while supporting equitable transit access by these populations.

It is notable that no cuts to intercity or express bus services are contemplated should the Intercity 8 Rail service be implemented. The overall scope of transport services would actually be increased under this scenario. It is likely that the collocation of the bus and rail terminals in Concord and Manchester would

[38]For more information on economic development impacts the interested reader is referred to NHCC Project Report: TASK 7: CORRIDOR, REGIONAL EQUITY ANALYSIS, July 2014

strengthen both the bus and rail services as it has at the Downeaster's joint bus/rail terminal in Portland, Maine.

Table 9-4 summarizes the findings of the equity analysis for the Intercity 8 Rail Service compared with the status quo of continued express and intercity bus services. It finds that the Intercity 8 Rail Service would offer service to concentrations of:

- households below the poverty line;
- minority populations, and;
- households living in affordable housing units.

It would also expand access to new transportation alternatives in downtown Nashua, Manchester and Concord which have among the state's largest concentrations of transit-reliant or -dependent persons and households.

Table 9-4: Equity Comparison of Intercity Rail and Existing Bus Service

Station	Rail	Express Bus	Average Median Income	Pop Below Poverty Line	Minority Pop	Affordable Housing Units	Existing Bus Services	Intercity 8 Rail
Concord, NH	X	X	$39,000	18.0%	9.7%	398	X	X
Manchester, NH	X	X	$30,300	29.5%	26.1%	675	X	X
Bedford / MHT	X		$65,500	4.5%	5.2%	0		X
N. Londonderry, NH		X	$82,900	1.7%	4.7%	minimal	X	
Londonderry, NH		X	$84,700	3.9%	5.2%	minimal	X	
Nashua, NH		X	$80,500	4.4%	12.9%	minimal	X	
Nashua, NH: Crown St	X		$52,500	14.9%	12.2%	28		X
Salem, NH		X	$75,300	3.7%	5.9%	minimal	X	

Sources: U.S. Census, American Community Survey 2008-2012; various local New Hampshire Housing Authorities.

The three populations considered as part of this equity analysis – population below the poverty line, minority populations, and households living in affordable housing units - tend to be concentrated in the central areas of Concord, Manchester and Nashua. When compared against the existing commuter bus services, the Intercity 8 Rail Service would offer comparatively higher levels of service and transit access to these populations with minimal adverse impacts anticipated. The equity of and access to the rail alternatives would improve as transit service extends north to Concord. The Intercity 8 Rail Service would reach more individuals and households living below the poverty line, minority households, and households living in affordable housing units. The existing commuter bus service (or improved bus services) would also not adversely impact these populations, but it would not offer expanded access to these populations through new station locations.

Freight Service Benefits

As noted in the discussion of existing services in Chapter 2, the NHML carries most of the state's inbound rail freight, receiving three quarters of all rail freight tonnage shipped into New Hampshire. While the freight received is quite diverse, traffic flow is dominated by coal for electric generation shipped to Bow, NH. Clay, concrete, glass, and stone also comprise much of the remaining rail freight tonnage moving on the corridor. Other freight shipped along the corridor includes farm products, lumber and wood products, food, chemicals, and some nonmetallic minerals. Significantly more freight rail traffic is shipped into southern New Hampshire than is shipped out. Shippers categorize the small amount of outbound freight rail traffic as miscellaneous freight.

Most rail traffic currently shipped to New Hampshire is for local consumption and the volume of outbound rail traffic other than building materials (predominately sand and gravel) is quite minor. Unless there is major shift New Hampshire's economy to produce, process or consume large volumes of bulk commodities, it is unlikely that the total volume of rail traffic to or from the Granite State will grow at a rate that varies significantly from expected population growth. That is not to say that rail freight in the state would not benefit from improvements to a key rail line serving the state's major population centers. This portion of the Service Development Plan briefly discusses how investment in intercity passenger rail service might benefit freight services and commodity shippers along the NHML.

The largest rail shipper on the NHML (and the largest in the state) is Public Service of New Hampshire's (PSNH) Merrimack Generating Station. Merrimack Station is PSNH's largest power plant constituting approximately 10% of the state's power generation capacity. At 496 megawatts it produces enough energy to supply 190,000 New Hampshire households, and employs about 100 people. Its two coal-fired units were built in the 1960s and were once the cheapest source of electricity for the state.

But in recent years, New England has been become increasingly tied to natural gas. In 2013, natural gas powered plants produced 46 percent of the region's power, up from 15 percent in 2000. At this time, natural gas is cheaper than all other forms of energy. Further growth in the use of natural gas however is limited by pipeline capacity to supply the region. Until deficiencies in the capacity of the regional gas supply network are addressed it is likely that Merrimack Station will continue to receive eight to ten unit trains of coal each month using the NHML. However in the long run, it seems likely that the gas network bottleneck will be addressed. At that time, the economic attractiveness of Merrimack Station might be reduced and eventually close. When and if, it does close the economic sustainability of this 45-mile branch will be jeopardized.

PSNH is not the only rail shipper on the NHML. The Nashua Corporation in Nashua, Anheuser-Busch and Jones Chemical in Merrimack, and Nylon Corporation of America in Manchester are among the more prominent of perhaps a score of firms that ship or receive rail freight via the NHML. Should PSNH close its operations, the economic attractiveness of rail shipping for these smaller firms could be substantially degraded as the fixed cost of maintaining the line is spread over fewer tons of freight. These enterprises and their contribution to the regional economy could be imperiled.

The operation of intercity passenger (or commuter) rail on the line would provide one more user for the line that would defray some of the shared costs for its upkeep and operation. With a passenger rail service on the line, the cost of providing existing freight service would be somewhat reduced, potentially improving conditions for PSNH to keep operating its plant at Bow. No tangible estimate of this impact has been produced, but the positive influence of the passenger rail service on the economic operation of the 45-mile freight branch seems clear.

To facilitate shared operation of the line by freight and passenger services, the infrastructure improvements were designed to minimize the potential for conflicts between passenger and freight trains. The track configuration would offer two mainlines through Nashua and Manchester Yards. Industrial sidings would be established to allow local trains to service Nashua Corporation and the Anheuser -Busch brewery without blocking the main line. The Merrimack Running Track would restored to provide similar capacity for joint use by freight and passenger trains in this section and a new receiving track would be built at the PSNH facility to keep coal trains from standing on the main line.

The locations of the sidings are at locations where local land use plans encourage industrial growth and development. Therefore, the investment in passenger rail service that encourages "transit-oriented-development" may also encourage rail freight use by enhancing the capacity for freight operations in areas designated for heavy industry and facilitating the creation of "freight villages[39]"

Conclusion

The proposed intercity rail service would have demonstrable positive impacts in several areas. The following public benefits would be expected with the implementation of improved intercity or commuter rail service in the corridor:

- Reduced Vehicle Miles Traveled on parallel highways, leading to reduced congestion and improved air quality;
- Support for sustainable development patterns and uses within station areas;
- Economic development in the form of jobs, commercial development and home construction;
- Positive mobility impacts on low income and minority populations in New Hampshire, and;
- Sustaining current industrial development in southern New Hampshire and supporting possible future growth in heavy industry.

[39] For more information on land use plans and local zoning in the vicinity of new industrial tracks and running tracks the interested reader is referred to NHCC Project Memorandum: New Hampshire Capitol Corridor Layover and Siding Facilities: Land Use and Zoning (May 2014)

10.0 IMPLEMENTATION AND FINANCE

10.1 Implementation

The New Hampshire Capitol Corridor project was initiated to inform New Hampshire officials and interested stakeholders of the costs, benefits, requirements and obligations associated with substantially expanding non-automotive passenger transportation services in the Route 3 corridor encompassing Nashua, Manchester and Concord and linking them with Boston. The range of alternatives considered in the overall joint FRA/FTA project included: Intercity passenger rail service, extensions of existing MBTA commuter rail service and enhancements to the existing express bus network that serves south central New Hampshire.

As the study is complete, New Hampshire officials have made no decisions regarding which public transportation enhancement, if any, they are prepared to support and pursue at this time.

Should the New Hampshire decide that they are interested in developing an intercity rail service, the study and this document provides a “blueprint” for service design, infrastructure investment, likely ridership, revenues and costs. The study also provides full documentation relating to the National Environmental Protection Act (NEPA). This collection of analyses together with the NEPA documentation poises the intercity rail service project for implementation, provided that New Hampshire officials and the FRA identify a mutually attractive mechanism for financing the project.

Should New Hampshire elect to develop an eight-train-per-day intercity passenger rail service, they would need to notify Amtrak, Pan Am Railway (PAR) and the Massachusetts Bay Transportation Authority (MBTA) of their intention to develop and operate the service. It has been presumed that Amtrak would be the operator, but under some of the most recent federal passenger rail legislation it is possible that MBTA, PAR or a third party could operate the service. Depending upon the selected operator, details concerning how PAR would be engaged in service operation would need to be identified and resolved. Under Amtrak operation, the model for PAR/Amtrak cooperation is found in the parallel Downeaster Corridor. Should MBTA be asked to operate the service, it already owns passenger rail trackage rights to Concord. The model for MBTA operation would include elements of its Pilgrim Partnership Agreement with Rhode Island and elements of its new seasonal CapeFlyer intercity service between Boston and Hyannis. It is also possible that PAR might elect to operate the service for NHDOT. These political and institutional considerations have not been fully explored in this technical study.

It is likely that service implementation would involve the New Hampshire Rail Transit Authority (NHRTA). The NHRTA was legislatively created in 2007 as a mechanism to implement passenger rail service in the state, especially between Boston and Manchester and to stand as a liability buffer between the service and the state. It acts under a Memorandum of Understanding with NHDOT to promote passenger rail. The Authority was given bonding authority, but has no independent source of revenue that would allow it to issue (or retire) bonds that it might issue. The twenty-eight member Board of Directors represents potential host communities and state government; new members are to be added if service expands to areas not already represented. It is notable that many, if not most, state supported passenger rail services are operated through an independent authority rather than directly by the state DOT. Such authorities, among other considerations, provide a liability buffer between the railway operation and the state. The study team has conferred with NHDOT and the NHRTA concerning their potential roles in operating passenger rail service, but until funding is identified, no commitments have been made concerning the mechanism for management and oversight of the railway service. NHDOT and MassDOT have conferred extensively concerning their possible operation of passenger rail service in the state. Most of those discussions have focused on extensions of MBTA commuter rail service north into Manchester, but Massachusetts expressed willingness to cooperate with an intercity passenger rail service operated by others. Massachusetts in general is quite supportive of any new Boston-based rail services including those that cross interstate borders.

Pan Am (PAR) entered into an engineering agreement with NHDOT to help manage the study and is working with MassDOT and Amtrak on the provision of new intercity passenger rail services elsewhere in New England. They have been generally supportive of the project and accommodating to the study team.

10.1 Finance[40]

Implementation of intercity passenger rail service in the Capitol Corridor will require decisions about how to pay for the service. There are two types of costs that must be considered:

- First are costs of implementing the new service. These costs, which range from buying more rail cars to operate longer trains to the construction of new rail infrastructure. Referred to as capital costs., these are incurred upfront, before revenue service can begin.
- Second are the costs to operate and maintain the service, referred to as operating and maintenance (O&M) costs. These costs occur annually once service is begun.

This portion of the Service Development Plan identifies the different sources of funds that can be used to fund these two types of costs. All funding options focus on ways to leverage available federal funds. The federal funds of most interest are those considered "discretionary" in nature; in other words, they would not otherwise be available to New Hampshire for other purposes. The majority of discretionary federal funds are available to cover capital costs. To a far lesser extent, other types of federal dollars – so called formula funds – are available to pay for operations and maintenance. Receipt of federal funds is subject to a variety of eligibility rules, and most federal funds must be "matched" by state and/or local funds. A typical minimum non-federal match requirement is 20 percent, but many programs in practice require a 50% match for discretionary funds. (20% is more typical of formula funding schemes.)

Given the local match requirement, this assessment also identifies potential state and local sources of funds that could provide this match.

No recommendation on preferred sources of funds is made as part of this assessment. Each of the options that were identified and evaluated will be subject to more discussion and decision making once

[40] For more information on project finance the interested reader is referred to NHCC Project Report: Financial Assessment, October 2014

an alternative is identified as the preferred project for detailed development and ultimate implementation.

10.2 Passenger Rail and Public Transportation Funding in the U.S.

To provide context for understanding how public surface transport projects are funded across the United States, this section describes how other agencies have paid for new public transportation projects. A very broad range of funding sources is used to pay for the capital and O&M costs of projects across the country. As noted above, federal funds typically contribute a fairly large share of transit project capital costs; this section focuses on the non-federal (state/local) sources of funding typically used to match federal dollars.

Common Sources of State Funding

Most funding provided by states comes from General Fund appropriations, or through traditional taxes and fees, such as motor fuel taxes, sales taxes, and vehicle fees. State funding for public transportation (including intercity passenger rail, commuter rail, rail transit and bus) is generally used for both operating assistance and capital funds. Only a few states provide dedicated funding either for capital expenses (Arkansas, Idaho, Kentucky and Nevada) or operating expenses (Maine, South Dakota and Wisconsin).

Common Sources of Local Funding

Transit funding at the local level is primarily provided through General Fund allocations and dedicated local option taxes and fees. Value capture mechanisms can also provide funding for transport investments. The application of dedicated local taxes and value capture mechanisms (defined below) for transport will be dictated by enabling legislation that allows or restricts the use of these funding sources for transit. Table 2-1 contains a list and description of common local funding options.

Table 2-1: Common Sources of Local Funding

Revenue Source	Popularity[41]	Comments
Sales tax	High	Dedicated sales tax rates typically range from 0.25 to 1.0 percent.
Property tax	Medium	Some states provide enabling legislation that allows property tax revenues to be dedicated to public transport.
Motor fuel tax	Low	Some local governments apply a tax on fuel to transportation.
Vehicle fee	Medium-Low	Registration fees, driver license fees, car rental taxes and tolls.
Employer/payroll tax	Low	Taxes imposed directly on employers for the amount of gross payroll paid are not commonly applied at the local level.
Utility tax/fee	Low	Mainly used for local roads and streets.
Room/occupancy tax	Low	Typically dedicated to tourism or tourism-related facilities. Can be tied to transportation investments needed to enhance the visitor experience, mobility and accessibility.

[41] "Popularity" indicates how commonly used to finance major public transport investments like new passenger rail services.

Revenue Source	Popularity[41]	Comments
General revenue	High	Funding provided by local governments for public transport services, whether it is through a jurisdiction's annual budget or an appropriations process.
Value capture mechanism	Medium-Low	Special types of "property taxes" targeted to capture the benefits of services that improve property development. Typically low (less than five percent) yield relative to project cost.
Impact fees	High	One-time charges to developers on new development. Commonly used for roads, seldom for public transport.
Tax Increment Financing	Medium-Low	Specific, common value capture mechanism. Additional levies are typically pledged to bonds issued to finance new transport services.
Special assessment districts	Medium-Low	Another value capture mechanism. Additional property taxes dedicated to new services for the district.
Joint development	Medium-Low	Partnership between the rail agency and a private developer, commonly applied to transit-oriented development (TOD) on land at or adjacent to train stations.

Recent History in Passenger Rail Funding

To provide context for understanding how a passenger rail investment in the Capitol Corridor might be funded, information was assembled on eight new commuter or intercity rail systems that have opened in the U.S. over the past 15 years, as shown in Table 2-2.

Table 2-2: New Commuter Rail Systems in the U.S. and Primary Capital Funding Sources

System	Location	Year Opened	Length (mi)	Federal	State	Local General	Sales Tax	Other Local
Sounder Commuter Rail	Puget Sound, WA	2000	33	●			●	●
Rail Runner Express	Albuquerque, NM	2006	97		●			
Music City Star	Nashville, TN	2006	32	●	●	●		
FrontRunner	Salt Lake City, UT	2008	44				●	
Northstar Line	Minneapolis, MN	2009	40	●	●	●		●
Capital MetroRail	Austin, TX	2010	32				●	
Westside Express Service	Portland, OR	2009	15	●		●		
A-Train	Denton County, TX	2011	21				●	●

Capital funding for these projects has come from a variety of sources. The most common source, used in half of the projects, is FTA Section 5309 New Starts funding, which accounted for an average of 43 percent of these projects' capital costs. One project, the Rail Runner Express extending between Albuquerque and Santa Fe, was funded entirely through state bonds backed by state road and highway revenues, including gasoline and diesel fuel taxes and federal highway aid. Local funding was more diverse: three systems used General Funds, mostly from local counties. Four projects used bonds backed by local sales taxes. Other local funding sources include a motor vehicle excise tax by Sounder

Commuter Rail, and road tolls, which paid for 80 percent of the A-Train capital costs. The Northstar Line in Minneapolis received a contribution from the Minnesota Twins major league baseball team, helping to fund the terminal station next to the Target Field ballpark.

For operating costs, local sales taxes are the most common primary source, used by six of the eight new rail systems: Sounder Commuter Rail (Puget Sound), Rail Runner Express (Albuquerque), FrontRunner (Salt Lake City), Northstar Line (Minneapolis), Capital MetroRail (Austin), and A-Train (Denton County, TX). The Westside Express Service in Portland, OR is primarily funded through a payroll tax. Operating costs for the Music City Star in Nashville are primarily funded through federal grants and contributions from Metro Nashville.

It is also useful to consider how other passenger rail projects in the Northeast have been funded, particularly projects that represent extensions of the MBTA's system. For projects wholly located within the Commonwealth of Massachusetts, funding for extensions has been provided by a mix of state and federal sources, including the following:

- Extension of peak period commuter rail service from Framingham to Worcester was completed in 1994 and paid for with MBTA funds. Off-peak service was added in 1996, and a number of infill stations were added in 2000 and 2002 with no federal contribution.
- The 27.6-mile Greenbush Line to Scituate was a state air quality commitment project which opened for service in 2007. The $534 million project was also paid for with MBTA funds and no federal contribution
- Half of the capital costs of improvements to the Fitchburg commuter rail line were paid for with an FTA Section 5309 Small Starts grant. The other half was paid for by state transportation bond proceeds. A 4.5 mile extension to a new Wachusett station was paid for by a TIGER grant (see page 189). Construction is underway with completion expected in 2015.

Intercity passenger rail service between Portland, ME and Boston was restored in 2001. The construction cost of approximately $66 million was paid for by Congressional appropriations matched by state and local sources. Today, operation of the service is paid for through fares, which account for just under 50 percent of operating costs, federal funds (CMAQ, see page 188) allocated to operations, an annual subsidy from Maine of approximately $8 million, and an in-kind contribution from Massachusetts consisting of trackage rights. New Hampshire, which has three Downeaster stations in Exeter, Durham at the University of New Hampshire, and Dover, does not contribute financially.

Extensions of MBTA service south into Rhode Island have been implemented in accordance with the "Pilgrim Partnership," a 1989 cooperative agreement between the MBTA and Rhode Island DOT. These have included extension of MBTA commuter rail service to Providence, which was funded by RIDOT in part with "earmarks" in transportation appropriation bills (transportation earmarks have subsequently been prohibited by federal law) and state funds. In exchange for operation of the service by the MBTA, RIDOT conveys its portion of federal formula funds to the MBTA. Extension further south to Wickford Junction was paid for by an FTA Section 5309 Small Starts grant (50 percent of capital costs) and the remainder with a mixture of federal formula funds and state bonds.

In all cases, both nationally and in the Northeast, state sources of funding have been an integral part of each project's financial plan, including both construction and ongoing operations.

10.3 Annual Funding Needs

This section reviews the capital and O&M costs needed to construct and operate the proposed intercity passenger rail service. Capital and O&M costs were estimated in current (2014) dollars[42].

A four year construction period is assumed, beginning in 2019. The annual O&M costs for each alternative were also estimated based on costs for similar services provided elsewhere in New England.[43]

- Intercity Rail Service Capital Costs (Current Year): $256.5 million
- Intercity Rail Service Capital Costs (Year of Expenditure): $316.9 million
- Intercity Rail Service Annual O&M Costs: $7.7 million

10.4 Federal Funding Sources

This section describes the sources of federal funding that might be used to help pay for intercity passenger rail service in the Capitol Corridor. A key objective of any NHCC project financial plan will be to leverage federal sources to the greatest extent possible. Potential non-federal sources (state/local/other) are discussed in later sections.

Federal Funding Sources and Financing Tools

Within the U.S. Department of Transportation, the Federal Railroad Administration (FRA) administers the Railroad Rehabilitation & Improvement Financing (RRIF) program, which can be used for passenger rail projects, and in the past it has provided capital funding through the High-Speed Intercity Passenger Rail program (HSIPR). The Federal Transit Administration (FTA) administers the primary funding programs available for public transportation investment. It has funded intercity passenger rail programs, most notably the 114-mile Downeaster service running between North Station in Boston and Portland Maine. The Federal Highway Administration (FHWA) administers some federal-aid highway programs with flexible provisions that allow the transfer of funds for public transportation investments.

In addition, federal finance tools are available that can be used to advance project implementation by leveraging future revenue streams of dedicated funding.

This section summarizes potential federal funding and financing tools and their eligibility to fund the intercity passenger rail service to Concord on the NHML. Examples of other projects that have used these sources as part of their funding plan are identified. Table 4-1 provides a high level summary of the possible federal funding sources and tools discussed in this section.

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[42] See *Chapter 7: Required Infrastructure Improvements and Capital Costs* of this Service Development Plan for more details. Or see Cost and Revenue Estimates Report, Capitol Corridor Rail & Transit Alternatives Analysis (Parts A&B), Jacobs Engineering, September 2014.

[43] See *Chapter 8: Forecast Operating Costs and Revenues* of this Service Development Plan for more details.

Table 4-1: Federal Funding Sources and Tools

Funding Source	Capital, Operations, Both	Eligible Modes	Comments
FHWA Congestion Mitigation and Air Quality Improvement Program (CMAQ)	Both	Commuter Rail Intercity Rail Intercity Bus	Flex
FRA High-Speed Intercity Passenger Rail Program (HSIPR)	Capital	Intercity Rail	No funding currently available
U.S. DOT Transportation Investment Generating Economic Recovery (TIGER)	Capital	Commuter Rail Intercity Rail	No funding currently available
U.S. DOT Transportation Infrastructure Finance and Innovation Act (TIFIA)	Capital	Intercity Rail Commuter Rail Intercity Bus	Loan Program
FRA Railroad Rehabilitation & Improvement Financing (RRIF)	Capital	Intercity Rail Commuter Rail	Loan Program

FHWA Congestion Mitigation and Air Quality Improvement Program

The FHWA Congestion Mitigation and Air Quality Improvement (CMAQ) program funds transportation system capital expansion and improvements that are projected to increase rail or bus ridership. It may also be used to fund travel demand management strategies, shared ride services, and pedestrian and bicycle facilities. Projects must have a transportation focus, reduce air emissions, and be located in or benefit an air quality nonattainment or maintenance area. Funding is distributed based on a formula that considers the severity of air quality problems. The Federal share is 80 percent for most CMAQ projects.

In FY 2013, New Hampshire received $10.3 million in CMAQ funds. Using these funds for a project in the Capitol Corridor would require reallocation of some portion of the total NH apportionment. Under current rules, CMAQ funds can be used for the project's capital expenses as well as operating costs for a limited period of time. Operating assistance is limited to certain activities, including new transit, commuter and intercity passenger rail services. Under the federal transportation funding bill MAP-21, the operating funding period was extended from three to five years.

FRA Discretionary Programs

FRA occasionally makes funding available through discretionary programs that provide grants to eligible projects through a competitive application process. For example, the High Speed Intercity Passenger Rail Program (HSIPR) was created to make investments in a network of passenger rail corridors across the country. The program's objectives are to build new high-speed rail corridors, upgrade existing intercity passenger rail corridors, and lay the groundwork for future high-speed rail services through planning efforts. More than $10 billion in grant funding was provided after the enactment of program through the Passenger Rail Investment and Improvement Act (PRIIA) of 2008, including a FY2010 grant of $2 million to the New Hampshire Capitol Corridor for engineering and environmental analysis in the corridor. The program was highly competitive, with over $75 billion in total funding requests from 39 states, DC and Amtrak. While the program is not currently funded and no new funding appears to be likely in the near term (thus no applications are being accepted), the intercity rail alternative could be eligible for future grant solicitations should additional funding be allocated under this program.

Transportation Investment Generating Economic Recovery

Another discretionary funding source is the U.S. DOT's Transportation Investment Generating Economic Recovery (TIGER) program. Competitive grant applications are solicited on a periodic basis; there have been six rounds of funding since 2009, providing $4.1 billion to eligible road, rail, transit, and port projects. Rail and transit projects awarded TIGER funding have accounted for over 40 percent of total awards to date. The average award for transit projects was $17.6 million. The last round of awards was announced in September 2014. Should another round of funding be made available, the intercity passenger rail service (or some supporting infrastructure for its implementation) could be eligible projects for consideration.

U.S. DOT TIFIA Credit Assistance

The Transportation Infrastructure Finance and Innovation Act (TIFIA) program is a credit assistance program administered by the U.S. DOT that provides direct loans, loan guarantees, and standby lines of credit. Surface transportation projects that cost $50 million or more are eligible, including those for state and local governments, transit agencies, railroad companies, special authorities, special districts, and private entities. Rail projects involving the design and construction of intercity passenger rail facilities or the procurement of intercity passenger rail vehicles are also eligible. The TIFIA loan or loan guarantee amount should not exceed 49 percent of eligible costs; for standby lines of credit, the limit is 33 percent of the project costs. Dedicated revenues for repayment are required. Tax revenues, including sales taxes, are a common revenue pledge for TIFIA. A total of $1.0 billion has been authorized for this program in 2014.

FRA Railroad Rehabilitation and Improvement Financing Program

The Railroad Rehabilitation and Improvement Financing Program (RRIF) is an FRA loan program enacted under TEA-21 that provides direct federal loans and loan guarantees to finance the development of railroad infrastructure. Eligible applicants are railroads, state and local governments, government-sponsored authorities and corporations, joint ventures that include at least one railroad, and limited option freight shippers who intend to construct a new rail connection. Loans can cover up to 100 percent of project costs with interest rates equal to U.S. Treasury rates. SAFETEA-LU made amendments to the program but no changes were included in MAP-21. There have been few RRIF loans: out of a total of $35 billion in authorized funds, only $1.7 billion in loans have been awarded through FY2012. Reasons for the program's underutilization may be a result of the lack of federal subsidy as there is for TIFIA. Therefore, the costs associated with FRA's review of the RRIF loan application are covered by the applicants. In addition to this investigative fee, the applicant also pays a credit risk premium unless collateral is provided. Other issues include long loan processing times, and the perception that applicants bear the full risk of default.

Eligible projects include acquisition, improvement, or rehabilitation of intermodal or rail equipment or facilities; refinancing existing debt incurred for the purposes above; or developing or establishing new intermodal or railroad facilities. The Northern New England Passenger Rail Authority (NNEPRA), which operates the Downeaster passenger rail service between Portland and Boston, was approved for a RRIF loan in 2009, but this was relinquished in favor of the HSIPR grant awarded to the project.

10.5 Non-Federal Match Options for New Hampshire Services

This section reviews possible options for providing non-federal match for a transportation service investment along the NHML. These options were narrowed down from the longer list above, since some of the most commonly used sources of local funding are not available in New Hampshire. These include dedicated sales tax revenues, which is the most common source of local match in the United States, payroll taxes, and fuel taxes.

New Hampshire does not impose any sales or payroll taxes, and it assumed that they would not be implemented solely for a project on the NHML. Fuel taxes are constitutionally restricted in New Hampshire for use on construction, reconstruction and maintenance of public highways.[44] Because of this, a rail project on the NHML would be ineligible for this source of funds, and a change to the constitution is not perceived to be possible.

On the shorter list of legislatively possible New Hampshire revenue sources, a definition is first provided, followed by a judgment concerning feasibility and potential revenue estimate for each source. Ratings for feasibility reflect an assessment of 1) whether the source currently exists in New Hampshire; 2) whether public transport is an eligible expenditure for the funding source; 3) the extent of likely support for the source; and 4) actions (e.g., legislative) that would be required for use of the source as part of the project's financial plan.

The amount of revenue that might be generated from each source also is estimated. Each of the estimated yields is subject to change with alternative input assumptions and charge rates. The range of annual yield rating estimates are: greater than $5 million = High; $1-$5 million = Medium; less than $1 million = Low. Table 5-1summarizes the funding options. In general, each of the feasible sources identified below will require significant effort and commitment to implement. As potential sources are evaluated, it will be important to consider the level of required effort in the context of likely yield. While revenue estimates are provided for all options, sources with low feasibility are unlikely to be available given significant implementation challenges, and are not considered as part of potential funding approaches.

Table 5-1: Summary of Funding Options for NHCC Alternatives

Funding Source	Feasibility	Yield	Annual Estimate	Comments
NH State Capital Program	High	High	$10.0 million	7.6% of 2014 debt payment (principal + interest)
NH Parking Fees	High	Low	$0.5 million	Based on $3 per day parking fee
Toll Revenue	Medium	High	$12.3 million	$0.25 increase at Hooksett and Bedford toll facilities
Vehicle Registration Fees	Medium	High	$5.9 million	$5 fee on passenger vehicles and trucks statewide
Municipal Contribution	Medium	Medium	$1.0-3.0 million	$1 million/city with new stations; city discretion regarding source
RGGI	Medium	Low	$0.5 million	Based on historical awards
Property Tax	Low	High	$15.7 million	0.1 mill applied statewide

[44] Part II, Article 6-a of the New Hampshire Constitution

Funding Source	Feasibility	Yield	Annual Estimate	Comments
Lottery Revenues	Low	Medium	$3.7 million	5% of net proceeds.
Passenger Facility Charges	Low	Medium	$1.0 million	½ of $1.50 PFC increase beginning 2016.
Value Capture	Low	Low	--	Need more study to estimate

New Hampshire State Capital Program

The state of New Hampshire (Legislature/Governor) approves a capital budget every two years. The last approved budget, for years 2014-2015, was for $219.4 million (all projects, including highways, which are paid for with restricted revenues, i.e., fuel tax and highway user fees). The next cycle to approve the budget is initiated in the fall (projects are submitted by November 15). The budget is approved on February 15th of odd numbered years (i.e., the next budget will be approved in February 2015). The most recent budget included bond authority for the entire cost of the capital program ($219.4 million). Of this, $128.7 million are for projects funded with bonds that are repaid with unrestricted General Fund revenues.

For NHDOT, bonds for highway projects are repaid with highway revenues (restricted). The capital budget included $2.2 million in General Fund bonds for the Aeronautics, Rail and Transit Division of the NHDOT. The proceeds provide matching funds to FAA and FTA grants.

As of June 2013, the state had $963.2 million in outstanding general obligation debt, including bonds for Highways and the University of New Hampshire.

Feasibility of this source is assessed as follows:

- Existing source of funding for state capital investments through bonds repaid with unrestricted General Funds.
- Currently providing matching funds to Federal grants for the Aeronautics, Rail and Transit Division of NHDOT.
- Governor/Legislature support required.
- Only for capital expenses.

Yield is assessed as follows:

- Would need to assess feasibility of fully or partially providing NHCC project capital funding needs through the State Capital Program, while maintaining reasonable debt to state revenue ratios.
- The largest single funding allocation from bond proceeds in recent years was for $38 million, which is less than 15 percent of total funding needed for most costly of the NHCC alternatives.
- Assumes an annual allocation of $10 million in unrestricted General Funds to repay bonds issued through the capital budget to pay for construction of the NHCC. At the current debt service level (FY2014 = $132.2 million), $10 million represents about 7.6 percent of unrestricted General Fund revenues required to repay bonds.

Parking Fees

Parking facilities associated with the intercity passenger rail service could generate funding to support operations and maintenance expenditures. Revenue would vary with parking occupancy and the number of vehicles that use the parking facility in an average day. If most travel is work-related, chances are that most parking spaces are occupied by a single vehicle any given day, and the parking turnover rate would be low.

Feasibility:

- Parking at rail stations will be provided as part of the NHCC project, so would be considered a future available source for funding.

Yield:

- An estimated 470 parking spaces would available at planned rail stations. If fully occupied 240 days per year, and a per-day parking fee of $3.00, parking revenues would equal $0.3 million. For comparison, parking in Portland for the Downeaster is $4.00 per day. Most MBTA commuter rail park-and-ride facilities charge $4.00 per day; in Lowell, garage parking is priced at $5.00 per day.

This fee could be extended to other park and ride facilities, specifically those used by riders of intercity bus service between New Hampshire and Boston.

Toll Revenue

Transactions on the NH Turnpike facilities were $108.7 million in 2012, generating $116.8 million, of which $43.5 million was generated in the Central NH facility. Operating expenses were $40.7 million and debt service was $33.3 million. Toll revenues and bond proceeds are used to fund the agency's capital program.

According to NHDOT's 10-year plan, the bonding capacity of the NH Turnpike is capped at $766 million, of which $575 million has already been issued.

Feasibility:

- The use of turnpike toll revenue is restricted by state law to be used on the turnpike system.[45] Changes to this law would require legislative action.
- In addition to changes need to expand the use of toll revenue, any toll increase will require Governor and Council approval.

Yield:

- Based on the August 2012 Traffic & Revenue Study,[46] transactions on the Central Turnpike are estimated at $51.0 million for FY2013. A 25-cent toll rate increase applied to transactions at the Hookset and Bedford toll facilities could generate $12.3 million, before accounting for potential diversion due to a toll rate increase.

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[45] http://www.gencourt.state.nh.us/rsa/html/XX/237/237-9.htm
[46] New Hampshire Turnpike System Traffic and Revenue Study, New Hampshire Department of Transportation, August 12, 2012.

Vehicle Registration Fees

New Hampshire currently collects vehicle registration fees at the state and local level that vary by type, size, value, and age of the vehicle. State fees are restricted to use on highways, but municipalities have more latitude on the use of at least a portion of their revenue.

Feasibility:

- Changes to registration fees would require legislative action to modify Section 261:141 (Registration Fees) [47] and/or Section 261:153 (Municipal Permits for Registration)[48] of Title XXI (Motor Vehicles) in the state statutes.
- State-level registration fees are constitutionally restricted to be used for construction and maintenance of public highways, while local-level fees have a broader range of uses.[49]
- Fees are assumed to be applied statewide.

Yield:

- In 2011, nearly 840,000 passenger vehicle registrations and 334,000 truck registrations were processed in NH.[50] Assuming a $5 fee statewide, this translates to approximately $5.9 million annually.

This yield assumes a small statewide increase. Other assumptions could be made, including fee rates and geographies covered – i.e., only the municipalities served by a project in the Capitol Corridor.

Municipal Contributions

Cities often help pay for implementation and/or ongoing operation and maintenance of passenger rail projects. This has particularly applied to cities that receive a substantial new station that generates accessibility benefits as well as increases in development opportunities and property values. For this assessment, it is assumed that only the cities that will have rail stations – Nashua, Manchester, Concord, depending on the alternative – would make an annual contribution.

Feasibility:

- Cities would have the flexibility to identify their own sources of revenue, whether an existing source or a new source associated more directly with the project, such as a tax increment financing district, or some other value capture mechanism.

Yield:

- For purposes of this assessment, it is assumed that Nashua, Manchester, and Concord would contribute depending on the alternative selected. For example, each municipality might contribute as much as $1.0 million to the project on an annual basis.

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[47] http://www.gencourt.state.nh.us/rsa/html/XXI/261/261-141.htm
[48] http://www.gencourt.state.nh.us/rsa/html/XXI/261/261-153.htm
[49] Part II, Article 6-a of the New Hampshire Constitution
[50] https://www.nh.gov/safety/documents/2011-annual-report.pdf

Regional Greenhouse Gas Initiative

Proceeds from the auction of Regional Greenhouse Gas Initiative (RGGI) emissions allowances in New Hampshire go to the Greenhouse Gas Emissions Reduction (GHGER) Fund. Ten percent of funds are set aside for a low-income residential energy reduction program. The remainder is awarded in grants through an RFP process, which is focused on electric and fossil fuel energy efficiency programs. There is a list of eligible programs that does not include transportation-related projects, although the list indicates eligibility is not limited to that list.[51]

As of 2013, New Hampshire had received over $57 million in allowance auction revenues over five years.[52] Grant awards have ranged from as little as $8,000 to as much as $5 million.

No New Hampshire transportation project has yet been awarded grants from the GHGER Fund. In the ten states that participate in RGGI, one percent of CO2 allowance proceeds have been used "for a wide variety of greenhouse gas reduction programs, including programs to promote the development of carbon emission abatement technologies, efforts to reduce vehicle miles traveled, and programs to increase carbon sequestration." Therefore, there is some precedent in at least one of these states to use these funds for a transportation project.

Feasibility:

- Use of RGGI proceeds for passenger rail transit improvements in the NHCC would need to be confirmed.

Yield:

- For the purposes of this assessment, it is assumed that a project in the Capitol Corridor could receive annual grants of the same order of magnitude of historical grant awards through this program, or approximately $0.5 million per year.

Property Tax

Four types of property taxes are assessed in NH: town tax, local education tax, state education tax, and county tax. Property taxes are a common source of funding for rail transit projects in the U.S.

Feasibility:

- Major existing local source of revenue.
- Currently, all state-levied property taxes are dedicated to education. Using this revenue source for the Capitol Corridor would require legislative action.

Yield:

- In 2012, total assessed property value in New Hampshire was $156.6 billion.[53] The weighted statewide average of property tax rates was 20.71 mill.

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[51] https://www.puc.nh.gov/Sustainable%20Energy/GHGERF.htm

[52] http://www.rggi.org/docs/Investment_of_RGGI_Allowance_Proceeds.pdf

[53] NH Department of Revenue Administration

- Applying a tax rate of 0.1 mill (10 cents per $1,000 in assessed value) would generate approximately $15.7 million per year.

Lottery Revenues

New Hampshire has the oldest legal lottery in the United States. The state participates in or hosts a variety of lottery games, including scratch tickets and draw games.

Feasibility:

- Currently, all net lottery revenues in NH are dedicated to the state education fund.
- A new lottery game dedicated to intercity passenger rail or more broadly for transportation use would likely be needed, rather than diverting revenues from existing games. In either case, legislative action would be required.

Yield:

- Lottery revenues in NH, net of prizes and administrative expenses, totaled $74.3 million in 2013.
- If 5 percent could be applied to a transportation improvement project in the corridor, it would result in $3.7 million per year for the project.

Passenger Facility Charges

Manchester Airport currently collects the maximum $4.50 per enplanement passenger facility charge (PFC). Eligible projects include those improvements related to enhancing airport safety, capacity, security, and environmental concerns. Under its current approvals, the airport is authorized to collect PFC through November 2022.

In the near term, the PFC revenues at the $4.50 level are fully committed, including payments to debt service on outstanding bonds, approved pay-as-you-go projects for which the airport has not yet reimbursed itself, and additional projects identified in the capital improvement program.

Feasibility:

- In the current FAA reauthorization proposals, the cap on PFC levels may be raised beyond the $4.50 level to provide additional funding available outside of FAA's Airport Improvement Program (AIP). Beginning in FY 2016, the airport is assumed to increase its PFC level to $6.00. These additional collections are assumed to be used on a pay-as-you-go basis for future projects.[54]
- It appears that it is possible, but difficult, for a transit project to use this funding source given restrictions on project eligibility and the existing cap on PFC levels. If an eligible project could be developed, negotiations would be needed with the airport and FAA to include it in the airport's future capital plan.

Yield:

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[54] http://www.flymanchester.com/sites/default/files/public-documents/Manchester%20Airport%20Master%20Plan%20Update.pdf

- Enplanements at the airport have fallen since their 2.2 million peak in 2006, and totaled 1.36 million in 2011.[55] An additional $1.50 PFC would create an estimated $2 million annually. Assuming half of this increment could be directed towards a project in the corridor, this could provide $1 million annually to the project pending eligibility considerations.

Value Capture

Value capture includes revenue mechanisms such as impact fees, tax increment financing and special assessment districts. Without specifics on future development and potential development to result from implementation of new transit service in the corridor, it is difficult to generate estimates for impact fees or tax increment financing. An option is to estimate how much revenue could be generated through a special assessment district. Data needs/basic assumptions (for special assessment district example) are:

- Taxable property values in the cities/towns served by each corridor alternative (NH Department of Revenue), or within some agreed upon distance from the corridor and/or station locations.
- Historical trends on property value growth.
- Property tax rate.
- Alternatively, calculate tax rate, based on capital and O&M needs.

It should be noted that changes in development patterns and property values take time - and often considerable time – to be realized based in large part on market conditions and demand. Therefore, value capture would not be a near-term source of revenue for an intercity passenger project.

MassDOT/MBTA Contributions

An additional source of funding for the two commuter rail alternatives could be the Massachusetts Department of Transportation (MassDOT) and the Massachusetts Bay Transportation Authority (MBTA). NHDOT has had discussions with officials from these organizations about cost sharing arrangements for the commuter rail alternatives that would extend the MBTA's existing Lowell Line into New Hampshire. Intercity passenger rail was also discussed. Based on these discussions, the following contributions might be considered to support a New Hampshire intercity passenger rail service.

- First, the MBTA contributes track usage along its tracks (between Haverhill and Boston) and terminal space at North Station to Amtrak and the Downeaster at no charge. MassDOT has implied that it would offer a similar courtesy to a Granite State passenger rail service. It also explicitly offered that it could accommodate one additional peak intercity train (over and above the Downeaster) each morning and afternoon at North Station.
- Second, the MBTA owns the corridor rail line to the New Hampshire/Massachusetts border. North of the border, the line is owned and operated by Pan Am Railways (PAR). The MBTA recently acquired trackage rights for commuter rail service on the PAR line north to Concord in exchange for other considerations worth approximately $35 million. These trackage rights would not be necessary if Amtrak operated the service as assumed by this exploratory report. They

[55] http://www.flymanchester.com/sites/default/files/statistics/MHT%20Enplanements%202000-2012.pdf

could be employed for the project, however, if Massachusetts and New Hampshire were to collaborate to operate a new intercity passenger rail service without Amtrak's involvement.

Fares

The operating and maintenance costs of each alternative will be offset by the fares collected from riders. The study team estimates that the proposed intercity passenger service would cover approximately 40 percent of its operating costs from fare revenues.

Table 5-2: Annual Fare Revenue and Farebox Recovery Ratio

Annual O&M Cost (A)	$7.7 million
Fare Revenue (B)	$3.2 million
Required Operating Support (A-B)	$4.5 million
Farebox Recovery Ratio (A-B)/A	41 percent

Source: Jacobs Engineering, September 2014.

10.6 Summary

While final decisions on any major public transportation investment on the NHML will necessarily incorporate a broad range of considerations including benefits and impacts, the ability to identify stable and reliable sources of revenue will be critical to the advancement of passenger rail service in the Capitol Corridor. Leveraging available discretionary federal funds will be a key objective of any future funding plan.

This section summarized key findings regarding the potential to leverage federal funds by alternative. Suggestions were also provided on other sources of potential revenue to provide match for federal funds. Any new source of revenue to help pay for a new intercity passenger rail service will be subject to considerable review and input by New Hampshire officials and corridor stakeholders.

An intercity passenger rail service between Boston and Concord would rely on federal programs, namely FRA's High Speed Intercity and Passenger Rail Program. However, the HSIPR currently has no funding available. For purposes of this assessment, it is assumed that half the capital costs of the project might be paid for by a future HSIPR appropriation. With the Concord Intercity 8 Rail Service being the most costly project considered and with the considerable uncertainty regarding available federal funding, this alternative likely would place a high burden on other state sources. Local sources of funding could include CMAQ, parking revenue, and contributions for the three municipalities with stations, Nashua, Manchester, and Concord.

To help understand what this might mean in terms of an annual "bill" to New Hampshire for each alternative, debt service is calculated for the NH share of capital costs as well as construction payments made in advance of receipt of FTA funds. This annual debt service, which lasts only for the period of the bonds issued, is then added to the annual operating cost for each alternative, net of fares. The annual debt service must be viewed as a best case, since agreements with Massachusetts on cost sharing arrangements are subject to additional discussion and negotiation.

All numbers are subject to change as additional work and coordination with potential funding partners is advanced. Table 6-1 presents a summary of the Intercity Passenger Rail Financial Assessment.

Table 6-1: Intercity Passenger Rail Financial Assessment Summary (current year dollars in millions)

Infrastructure Cost	$233.2
Rolling Stock Cost	$23.3
Total Project Value	**$256.5**
Potential Federal Grant	$128.2*
New Hampshire Share (After federal contributions)	**$128.2**
Annual Payment to Retire NH Share[56]	$10.3
Annual Operating Cost	$7.7
Annual Passenger Revenue	$3.2
Required Operating Support	$4.5
Annual NH Cost for Intercity Passenger Rail Service	**$14.8**

* Assumes that 50% of capital funds are provided under FRA's HSIPR program

[56] 20 year bonds at five percent to retire the state/local match. Short term financing to cover lags in the federal reimbursement process during the construction process is not included in this estimate. The interest on the short term debt at three percent per annum to cover a $128.2 million grant would average approximately $1.9 million per year over a four year construction period.

Appendix A: Intercity 8 Rail Service Option Schedule

Figure A-1: Intercity 8 Rail Service Option Schedule

New Hampshire Main Line: Proposed ***Intercity 8*** *Service Schedule Class IV*

READ DOWN		302	304	352	306	208	680	308	380	310	212	356	312	358	314	682	316	318	382	320	322	222	324	684	326	384	686	360	232	330	334	336	DH333	236	338	340	342	#REF!	386	344	346	DH345	DH347
Concord NH	73.3								6:39										10:39							10:39													10:39				
Manchester NH	55.7								6:58										10:58							10:58													10:58				
MHT (Bedford)	50.1								7:07										11:07							11:07													11:07				
Nashua Downtown	39.0								7:20										11:20							11:20													11:20				
Nashua Tyngsboro	35.2								#N/A										#N/A							#N/A													#N/A				
Lowell	25.5	5:35	6:18		6:51			7:18	7:36	7:46			8:25		9:15		10:15	11:15	11:36	12:15	13:15		14:15		15:15	11:36				17:10	17:45	18:20	18:10		18:55	19:25	20:30		11:36	21:30	22:35	23:34	1:04
North Billerica	21.8	5:43	6:26		6:59			7:26	#N/A	7:54			8:33		9:23		10:23	11:23	#N/A	12:23	13:23		14:23		15:23	#N/A				17:18	17:53	#N/A	18:18		19:03	19:33	20:38		#N/A	21:38	22:43	#N/A	#N/A
Wilmington	15.2	5:51	6:34		7:06	7:22		#N/A	#N/A	#N/A	8:07		8:41		9:31		10:31	11:31	#N/A	12:31	13:31	13:37	14:31		15:31	#N/A				17:26	18:01	#N/A	18:26	19:00	19:11	19:41	20:46		#N/A	21:46	22:51	#N/A	#N/A
Anderson/ Woburn	12.6	5:55	6:38	6:55	7:13	#N/A	7:31	7:38	7:52	8:05	8:12	8:30	8:45	9:15	9:35	10:04	10:35	11:35	11:52	12:35	13:35	13:43	14:35	14:54	15:35	11:52	16:39	16:55	17:11	17:30	18:05	#N/A	18:30	19:04	19:15	19:45	20:50	20:59	11:52	21:50	22:55	#N/A	#N/A
Winchester Center	7.8	6:02	6:46	7:04	7:21	#N/A	#N/A	7:46	#N/A	#N/A	8:20	8:39	8:52	9:23	9:42	#N/A	10:42	11:42	#N/A	12:42	13:42	13:50	14:42	#N/A	15:42	#N/A	#N/A	#N/A	#N/A	17:37	18:12	#N/A	18:37	#N/A	19:22	19:52	20:57	#N/A	#N/A	21:57	23:02	#N/A	#N/A
Wedgemere	7.3	6:04	6:49	7:06	7:24	#N/A	#N/A	7:49	#N/A	#N/A	8:23	8:41	8:54	9:26	9:44	#N/A	10:44	11:44	#N/A	12:44	13:44	13:52	14:44	#N/A	15:44	#N/A	#N/A	#N/A	#N/A	17:39	18:14	#N/A	18:39	#N/A	19:24	19:54	20:59	#N/A	#N/A	21:59	23:04	#N/A	#N/A
West Medford	5.5	6:08	6:53	7:10	7:28	#N/A	#N/A	7:53	#N/A	#N/A	8:27	8:45	8:58	9:30	9:48	#N/A	10:48	11:48	#N/A	12:48	13:48	13:56	14:48	#N/A	15:48	#N/A	#N/A	#N/A	#N/A	17:43	18:18	#N/A	18:43	#N/A	19:28	19:58	21:03	#N/A	#N/A	22:03	23:08	#N/A	#N/A
North Station	0.0	6:22	7:05	7:22	7:40	7:48	7:55	8:05	8:15	8:26	8:39	8:57	9:10	9:42	9:59	10:30	10:59	11:59	12:15	12:59	13:59	14:07	14:59	15:15	15:59	12:15	17:05	17:15	17:32	17:56	18:31	19:00	18:54	19:25	19:41	20:09	21:14	21:20	12:15	22:14	23:20	0:14	1:44
							0:24		1:35																																		

READ UP		3801	3803	301	3805	351	305	307	355	309	381	357	681	311	315	317	683	383	319	321	323	325	327	359	359	685	331	385	333	335	337	687	237	339	341	343	387	345	689	347
Concord NH	73.3										9:59							14:14										18:49									23:29			
Manchester NH	55.7										9:38							13:53										18:28									23:08			
MHT Airport (Goff's Falls)	52.0										9:30							13:45										18:20									23:00			
Nashua Downtown	39.0										9:17							13:32										18:07									22:47			
Nashua Tyngsboro	35.2										#N/A							#N/A										#N/A									#N/A			
Lowell	25.5	5:20	6:03	6:29	7:00		7:30	8:11		8:56	9:02			9:54	10:54	11:54		13:17	12:54	13:54	14:54	15:54	16:58		17:31		17:59	17:52	18:10	18:39	19:12			20:15	21:14	22:24	22:32	23:24		0:54
North Billerica	21.8	#N/A	#N/A	6:22	#N/A		7:21	8:02		8:47	#N/A			9:47	10:47	11:47		#N/A	12:47	13:47	14:47	15:47	16:51		17:21		17:52	#N/A	18:03	18:32	19:05			20:08	21:07	22:17	#N/A	23:17		0:47
Wilmington	15.2	#N/A	#N/A	6:14	#N/A		7:13	7:54		8:39	#N/A			9:39	10:39	11:39		#N/A	12:39	13:39	14:39	15:39	16:43		17:13		17:43	#N/A	17:55	18:23	18:57		19:23	20:00	21:00	22:09	#N/A	23:09		0:39
Anderson/ Woburn	12.6	#N/A	#N/A	6:10	#N/A	6:45	7:08	7:50	8:17	8:35	8:46	9:02	9:23	9:35	10:35	11:35	11:53	13:01	12:35	13:35	14:35	15:35	16:38	16:45	17:08	17:18	17:38	17:36	17:50	18:18	18:52	19:03	19:19	19:55	20:55	22:05	22:16	23:05	23:18	0:35
Winchester Center	7.8	#N/A	#N/A	6:03	#N/A	#N/A	7:01	7:43	#N/A	8:28	#N/A	#N/A	#N/A	9:28	10:28	11:28	#N/A	#N/A	12:28	13:28	14:28	15:28	16:30	16:38	17:00	#N/A	17:30	#N/A	#N/A	18:10	18:44	#N/A	19:12	19:48	20:48	21:58	#N/A	22:58	#N/A	0:28
Wedgemere	7.3	#N/A	#N/A	6:01	#N/A	#N/A	#N/A	7:41	#N/A	8:26	#N/A	#N/A	#N/A	9:26	10:26	11:26	#N/A	#N/A	12:26	13:26	14:26	15:26	16:27	16:36	16:57	#N/A	17:27	#N/A	#N/A	18:07	18:41	#N/A	19:10	19:46	20:46	21:56	#N/A	22:56	#N/A	0:26
West Medford	5.5	#N/A	#N/A	5:57	#N/A	#N/A	6:57	7:37	#N/A	8:22	#N/A	#N/A	#N/A	9:22	10:22	11:22	#N/A	#N/A	12:22	13:22	14:22	15:22	16:23	16:32	16:53	#N/A	17:23	#N/A	#N/A	18:03	18:37	#N/A	19:06	19:42	20:42	21:52	#N/A	22:52	#N/A	0:22
North Station	0.0	4:40	5:23	5:45	6:20	6:25	6:45	7:25	7:55	8:10	8:30	8:40	9:05	9:10	10:10	11:10	11:35	12:45	12:10	13:10	14:10	15:10	16:10	16:20	16:40	17:00	17:10	17:20	17:30	17:50	18:25	18:45	18:55	19:30	20:30	21:40	22:00	22:40	23:00	0:10

Appendix B: Detailed Cost Estimates of Stations

Table B-1: Cost Factors Used to Calculate Proposed Station Capital Costs

Description	Materials			Material Cost Total	Labor		Total Direct Cost	Allocation Factor	Calculated Unit Cost
	Quantity	Units	Unit Costs		Man-hrs	Cost ($)			
SITE WORK									
Remove & dispose existing pavement	1,988	SY		-	95	$33,987	$33,987	Zero	$0
Remove and stock curbing	160	LF		-	85	$2,040	$2,040	Zero	$0
Clearing and grubbing	3.17	Acre		-	85	$4,311	$4,311	Half fixed half variable based on parking spaces	$2,156 + $6 per space
Cut, cap and abandon monitoring well	2	EA		-	85	$340	$340	1 if contaminated zero if not	$340
Site preparation - remove & dispose of boulders	4	EA	$50.00	$200.00	110	$880	$1,080	Zero	$0
Cleaning & sweeping roadway	109	HR		-	120	$13,080	$13,080	Unit	$13,080
Water for dust control	44,500	GL	$0.04	$1,780.00	85	-	$1,780	Unit	$1,780
Erosion control system (straw bale & silt fence)	4,677	LF	$1.00	$4,677.00	72	$15,153	$19,830	Unit	$19,830
Silt sack	23	EA	$100.00	$2,300.00	72	$1,656	$3,956	Unit	$3,956
Mobilization and demobilization for bulk excavation	1	LS	$6,000.00	$6,000.00	110	-	$6,000	Unit	$6,000
Unclassified excavation	18,768	CY		-	110	$92,902	$92,902	Unit	$92,902
Unclassified excavation - handling & off-site disposal	22,800	TN	$18.00	$410,400.00	110	-	$410,400	1 if contaminated zero if not	$410,400
Dispose of contaminated soil at in-state lined landfill	630	TN	$35.00	$22,050.00	110	$3,119	$25,169	1 if contaminated zero if not	$25,169
Dispose of contaminated soil at in-state recycling facility	630	TN	$75.00	$47,250.00	110	$3,119	$50,369	1 if contaminated zero if not	$50,369
Rock excavation	1,632	CY		-	110	$31,416	$31,416	Unit	$31,416
Rock excavation - haul & disposal	2,203	TN	$15.00	$33,048.00	110	-	$33,048	Half fixed half variable based on parking spaces	$16,524 + $46 per space
Soils testing services (LSP)	364	HR		-	110	$40,040	$40,040	Half fixed half variable based on parking spaces	$20,020 + $56 per space
Soil sampling and testing (assume 50-ft grid)	146	EA	$180.00	$26,280.00	150	-	$26,280	Half fixed half variable based on parking spaces	$13,140 + $37 per space
Grading	364,800	SF		-	85	$124,032	$124,032	Half fixed half variable based on parking spaces	$62,016 + $172 per space
Ordinary fill (processed gravel)	14,540	CY	$0.80	$11,632.00	110	$151,943	$163,575	Half fixed half variable based on parking spaces	$81,788 + $227 per space
Crushed stone - platform	50	CY	$30.00	$1,500.00	110	$880	$2,380	Half fixed half variable based on parking spaces	$1,190 + $3 per space
Wetland replication area	3,000	SF	$6.00	$18,945.00	85	$11,820	$30,765	Square feet of wetlands	$10.26
Subtotal				$586,062.00	5,325	$530,718	$1,116,780		
Subtotal retaining walls				$943,440.00		$1,265,872	$2,209,316	Based on site	$220,932
Subtotal drainage				$204,092.00	2,301	$198,634	$402,726	Half fixed half variable based on parking spaces	$201,363 + $559 per space
Subtotal site work - parking lot and drop-off area				$862,032.00	4,123	$375,564	$1,237,598	Parking Spaces (*10 for garage)	$3,438
Subtotal landscaping				$183,659.00	3,459	$250,968	$434,626	Quarter fixed/3/4parking spaces	$108,657 + $905 per space
STATION ELEMENTS									
Subtotal Rail road Components (Lead Track at Station)				$233,283.00	1,163	$145,611	$378,894	Side tracks	$378,894
Subtotal Platforms				$584,900.00	2,037	$275,225	$860,125	Half platforms	$430,063
Subtotal Electrical				$289,435.00	4,650	$391,260	$680,696	Platforms	$680,696
Subtotal Variable Message Signs				$61,194.00	264	$22,903	$84,097	Platforms	$84,097
Subtotal Division 10 - Specialties				$25,792.00	104	$8,867	$34,659	Unit	$34,659
Subtotal Division 2 - Site Improvements				$38,250.00	85	$6,120	$44,370	Parking Spaces	$123
Subtotal Division 5 - Metals				$271,227.00	2,230	$217,289	$488,516	Platforms	$244,258
Subtotal Water Supply System				$46,463.00	473	$43,424	$89,887	Unit	$89,887
DIRECT COST SUBTOTAL							**$8,062,290**		

Description	Materials			Material Cost Total	Labor		Total Direct Cost	Allocation Factor	Calculated Unit Cost
	Quantity	Units	Unit Costs		Man-hrs	Cost ($)			
CONSTRUCTION									
Subtotal General Requirements				-	224	$33,600	$33,600	Direct Costs	$33,600
Subtotal Construction Staging Provisions				$13,200.00	32	$2,304	$15,504	Direct Costs	$15,504
Subtotal Safety and Protection				$58,900.00	884	$63,619	$122,519	Direct Costs	$122,519
TOTAL DIRECT COST				$4,402,000	39,878	$3,832,000	**$8,234,000**		
General Conditions @		13%				$1,070,420	$1,070,420		
General Contractor Overhead @		4%				$372,176	$372,176		
General Contractor Profit @		4%				$387,064	$387,064		
General Contractor Bond @		1%				$100,637	$100,637		
ESTIMATED CONTRACTOR COST							**$10,164,000**		
Traffic officers services	1	AN				$54,000	$54,000	Unit	$54,000
Rodent control	1	AN	$64,000	$64,000			$64,000	Unit	$64,000
Site utilities (existing - National Grid Verizon poles)	1	AN	$24,000	$24,000			$24,000	Unit	$24,000
Electric company	1	AN	$105,000	$105,000			$105,000	Unit	$105,000
Install water system	1	AN	$9,000	$9,000			$9,000	Unit	$9,000
Risk allowance	1	AN	$1,100,000	$1,100,000			$1,100,000	Zero	$1,100,000
Dispose contaminated material (MCP compliance) at in-state facility	630	TN	$30	$18,900			$18,900	1 if contaminated zero if not	$18,900
Dispose contaminated material at non-RCRA out-of-state facility	630	TN	$65	$40,950			$40,950	1 if contaminated zero if not	$40,950
Hazardous / Special Waste Handling	1	LS	$10,000	$10,000			$10,000	1 if contaminated zero if not	$10,000
LSP Services for Contaminated Soils Disposal	1,260	TN	$20	$25,200			$25,200	1 if contaminated zero if not	$25,200
ALLOWANCES				$1,397,050		$54,000	$1,451,050		
SUBTOTAL							**$11,615,000**		
Escalation to Oct 2013 (based on 3.8% per year) @		4.12%					$478,899		
ESCALATED ESTIMATED CONSTRUCTION COST							**$12,094,000**		
Construction Contingency		10%					$1,209,400		
ESTIMATED CONSTRUCTION COST WITH CONSTRUCTION CONTINGENCY							**$13,303,000**		

Source: MBTA Fitchburg Commuter Rail - Wachusett Extension Project: PS&E Construction Estimate; Jacobs / Keville Enterprises, Inc.; January, 2013

Table B-2: Estimated Concord Station Capital Costs

	Nashua		Manchester		Concord
	Crown Street	Bedford / MHT	Granite Street	Spring Street	Stickney Avenue
Milepost	**38.8**	**50.1**	**55.7**	**56.4**	**73.4**
Parking	**255**	**190**	**0**	**0**	**100**
Platforms	**1**	**1**	**1**	**1**	**1**
Contaminated Soils	**0.5**	**0**	**0.5**	**0**	**0**
Square Feet of Wetlands	**0**	**0**	**0**	**0**	**0**
Side Tracks	**0**	**0**	**0**	**0**	**0**
SITE WORK					
Remove & dispose existing pavement	$0	$0	$0	$0	$0
Remove and stock curbing	$0	$0	$0	$0	$0
Clearing and grubbing	$3,682	$3,293	$2,156	$2,156	$2,754
Cut, cap and abandon monitoring well	$170	$0	$170	$0	$0
Site preparation - remove & dispose of boulders	$0	$0	$0	$0	$0
Cleaning & sweeping roadway	$13,080	$13,080	$13,080	$13,080	$13,080
Water for dust control	$1,780	$1,780	$1,780	$1,780	$1,780
Erosion control system (straw bale & silt fence)	$19,830	$19,830	$19,830	$19,830	$19,830
Silt sack	$3,956	$3,956	$3,956	$3,956	$3,956
Mobilization and demobilization for bulk excavation	$6,000	$6,000	$6,000	$6,000	$6,000
Unclassified excavation	$92,902	$92,902	$92,902	$92,902	$92,902
Unclassified excavation - handling & off-site disposal	$205,200	$0	$205,200	$0	$0
Dispose of contaminated soil at in-state lined landfill	$12,585	$0	$12,585	$0	$0
Dispose of contaminated soil at in-state recycling facility	$25,185	$0	$25,185	$0	$0
Rock excavation	$31,416	$31,416	$31,416	$31,416	$31,416
Rock excavation - haul & disposal	$28,229	$25,245	$16,524	$16,524	$21,114
Soils testing services (LSP)	$34,201	$30,586	$20,020	$20,020	$25,581
Soil sampling and testing (assume 50-ft grid)	$22,448	$20,075	$13,140	$13,140	$16,790
Grading	$105,944	$94,747	$62,016	$62,016	$79,243
Ordinary fill (processed gravel)	$139,720	$124,953	$81,788	$81,788	$104,506
Crushed stone - platform	$2,033	$1,818	$1,190	$1,190	$1,521
Wetland replication area	$0	$0	$0	$0	$0
Subtotal site preparation & earthwork	$748,498	$469,820	$609,075	$365,936	$420,612
Subtotal retaining walls	$220,932	$220,932	$220,932	$220,932	$220,932
Subtotal drainage	$343,995	$307,638	$201,363	$201,363	$257,297
Subtotal site work - parking lot and drop-off area	$876,632	$653,177	$0	$0	$343,777
Subtotal landscaping	$339,552	$280,696	$108,657	$108,657	$199,204
STATION ELEMENTS					
Subtotal Rail road Components (Lead Track at Station)	$0	$0	$0	$0	$0
Subtotal Platforms	$430,063	$430,063	$430,063	$430,063	$430,063
Subtotal Electrical	$680,696	$680,696	$680,696	$680,696	$680,696
Subtotal Variable Message Signs	$84,097	$84,097	$84,097	$84,097	$84,097
Subtotal Division 10 - Specialties	$34,659	$34,659	$34,659	$34,659	$34,659
Subtotal Division 2 - Site Improvements	$31,429	$23,418	$0	$0	$12,325
Subtotal Division 5 - Metals	$244,258	$244,258	$244,258	$244,258	$244,258
Subtotal Water Supply System	$89,887	$89,887	$89,887	$89,887	$89,887
DIRECT COST SUBTOTAL	**$4,124,697**	**$3,519,339**	**$2,703,686**	**$2,460,547**	**$3,017,806**
CONSTRUCTION					
Subtotal General Requirements	$17,190	$14,667	$11,268	$10,254	$12,577
Subtotal Construction Staging Provisions	$7,932	$6,768	$5,199	$4,732	$5,803
Subtotal Safety and Protection	$62,681	$53,482	$41,087	$37,392	$45,860
TOTAL DIRECT COST	$4,212,500	$3,594,256	$2,761,239	$2,512,925	$3,082,046
General Conditions @	$547,624.98	$467,253.28	$358,961.12	$326,680.21	$400,666.04
Subtotal	$4,760,125	$4,061,509	$3,120,201	$2,839,605	$3,482,712
General Contractor Overhead @	$190,405	$162,460	$124,808	$113,584	$139,308
Subtotal	$4,950,530	$4,223,970	$3,245,009	$2,953,189	$3,622,021
General Contractor Profit @	$198,021	$168,959	$129,800	$118,128	$144,881
Subtotal	$5,148,551	$4,392,928	$3,374,809	$3,071,317	$3,766,902
General Contractor Bond @	$51,486	$43,929	$33,748	$30,713	$37,669
ESTIMATED CONTRACTOR COST	$5,200,037	$4,436,858	$3,408,557	$3,102,030	$3,804,571
Traffic officers services	$54,000	$54,000	$54,000	$54,000	$54,000
Rodent control	$64,000	$64,000	$64,000	$64,000	$64,000
Site utilities (existing - National Grid Verizon poles)	$24,000	$24,000	$24,000	$24,000	$24,000
Electric company	$105,000	$105,000	$105,000	$105,000	$105,000
Install water system	$9,000	$9,000	$9,000	$9,000	$9,000
Dispose contaminated material (MCP compliance) at in-state facility	$9,450	$0	$9,450	$0	$0
Dispose contaminated material at non-RCRA out-of-state facility	$20,475	$0	$20,475	$0	$0
Hazardous / Special Waste Handling	$5,000	$0	$5,000	$0	$0
LSP Services for Contaminated Soils Disposal	$12,600	$0	$12,600	$0	$0
ALLOWANCES	$303,525	$256,000	$303,525	$256,000	$256,000
SUBTOTAL	**$5,503,562**	**$4,692,858**	**$3,712,082**	**$3,358,030**	**$4,060,571**
Escalation to Oct 2013 (based on 3.8% per year) @	$226,747	$193,346	$152,938	$138,351	$167,296
ESCALATED ESTIMATED CONSTRUCTION COST	$5,730,308	$4,886,203	$3,865,020	$3,496,381	$4,227,866
Construction Contingency	$573,030.83	$488,620.35	$386,501.98	$349,638.06	$422,786.63
ESTIMATED CONSTRUCTION COST WITH CONSTRUCTION CONTINGENCY	**$6,303,339**	**$5,374,824**	**$4,251,522**	**$3,846,019**	**$4,650,653**

Source: MBTA Fitchburg Commuter Rail - Wachusett Extension Project: PS&E Construction Estimate; Jacobs / Keville Enterprises, Inc.; January, 2013

Table B-3: Land Value of Proposed Intercity Passenger Rail Stations

Location	Address	Owner	Assessed Value	Land Use	Size (acres)	Improvements	Land	Total	$/Acre	Portion	Land Cost
CONCORD SITES											
Stickney Ave	11 STICKNEY AV	NEW HAMPSHIRE STATE OF	$ 4,068,400	STATE-NH MDL	6.08	$ 2,621,400	$ 1,447,000	$ 4,068,400	$ 237,990	1	$ 1,447,000
MANCHESTER SITES											
Bridge / Spring	CANAL ST	BOSTON AND MAINE CORP	$ 64,300	NOTAX C VA	0.1695	$ -	$ 64,300	$ 64,300	$ 379,351.03	1	$ 64,300
Bridge / Spring	CANAL ST	BOSTON AND MAINE CORP	$ 73,700	NOTAX C VA	0.5357	$ -	$ 73,700	$ 73,700	$ 137,577.00	1	$ 73,700
Granite St	100 GRANITE ST	BOSTON AND MAINE CORP	$ 78,700	NOTAX C VA	0.2300	$ -	$ 78,700	$ 78,700	$ 342,173.91	1	$ 78,700
Granite St	CANAL ST	CITY OF MANCHESTER	$ 70,100	NOTAX C VA	0.3244	$ -	$ 70,100	$ 70,100	$ 216,091.25	1	$ 70,100
BEDFORD SITE											
Bedford / MHT	SOMERVILLE DR	NEW HAMPSHIRE STATE OF	$ 444,400	STATE NH MDL	6.000	$ 134,000	$ 176,500	$ 310,500	$ 29,416.67	0.33	$ 58,245
NASHUA SITE											
Crown St	25 CROWN ST	NASHUA, CITY OF	$ 1,274,200		6.826	$ 941,100	$ 308,700	$ 1,274,200	$ 45,224	1	$ 308,700

Appendix C: Detailed Cost Estimates of Layover Facilities

Table C-1: Cost Factors Used to Calculate Proposed Layover Facility Capital Costs

Description	Materials				Labor				Total Direct Cost	Allocation Factor	Calculated Unit Cost
					Man-hrs		Cost ($)				
	Quantity	Units	Unit Costs	Total	Unit	Total	Unit	Total			
SITE WORK											
Miscellaneous site cleaning & clearing	1	LS	$2,000.00	$2,000				-	$2,000	Track Feet	$0.21
Erosion and sedimentation control (hay bale & silt fence)	8,180	LF	$1	$8,180	0.045	368	72	$26,503	$34,683	Track Feet	$3.59
Silt sack	15	EA	$100	$1,500	1	15	72	$1,080	$2,580	Track Feet	$0.27
Temporary construction access road	56	ton	$68	$3,808	0.09	5	85	$428	$4,236	Track Feet	$0.44
Clearing and grubbing	4	Acre	-	-	16	57	85	$4,811	$4,811	Track Feet	$0.50
Stripping and stockpiling of topsoil	745	CY	-	-	0.039	29	110	$3,155	$3,155	Track Feet	$0.33
Ordinary excavation	52,812	CY	-	-	0.039	2,033	110	$223,659	$223,659	Track Feet	$23.17
Unclassified excavation - handling & off-site disposal	64,170	TN	$18	$1,155,060			110	-	$1,155,060	Track Feet	$119.63
Dispose of contaminated soil at in-state lined landfill	1,780	TN	$35	$62,300				-	$62,300	Track Feet if contaminated, otherwise zero	$6.45
Dispose of contaminated soil at in-state recycling facility	1,780	TN	$75	$133,500				-	$133,500	Track Feet if contaminated, otherwise zero	$13.83
Rock excavation	1,000	CY		-	0.175	175	110	$19,250	$19,250	Zero	$0
Rock excavation - haul & disposal	1,350	TN	$18	$24,300			110	-	$24,300	Zero	$0
Soils testing services (LSP)	896	HR		-	1	896	110	$98,560	$98,560	Track Feet if contaminated, otherwise zero	$10.21
Soil sampling and testing (assume 50-ft grid)	194	EA	$180	$34,920				-	$34,920	Track Feet if contaminated, otherwise zero	$3.62
Tree removal - includes stumps	10	EA	$1,200.00	$12,000			85	-	$12,000	Zero	$0
Processed gravel ordinary fill	21,100	CY	$0.8	$16,880	0.095	2,005	85	$170,383	$187,263	Track Feet	$19.40
Gravel borrow sub-base (processed gravel)	28	CY	$0.8	$22	0.095	3	85	$224	$247	Track Feet	$0.03
Grading & finishing	483,958	SF		-	0.004	1,936	85	$164,546	$164,546	Track Feet	$17.04
DIRECT COST SUBTOTAL				$1,454,470		7,521		$712,599	$2,167,070	Total	
Subtotal Roadways & Walkways Pavements				$708,237		2,710		$220,993	$929,230	Storage Positions	$154,872
Subtotal Landscaping				$305,980		2,615		$188,294	$494,274	Number of track feet	$51.19
Subtotal Site Work - Drainage				$35,943		538		$46,357	$82,299	Number of track feet	$8.52
TRACK WORK											
Surface and Align Track	9,655	TF		-	0.1	966	145	$139,998	$139,998	Track Feet	$14.50
Tie with Assemblies	5,945	EA	$100	$594,500	0.18	1,070	145	$155,165	$749,665	Track Feet	$77.65
Ballast	7,575	TN	$15	$113,625	0.13	985	110	$108,323	$221,948	Track Feet	$22.99
Subballast	7,132	TN	$17	$121,240	0.13	927	110	$101,984	$223,224	Track Feet	$23.12
No. 10 turnouts	6	EA	$48,000	$288,000	220	1,320	145	$191,400	$479,400	Storage Positions	$79,900
Bituminous Pavement under switches	460	TN	$68	$31,280	0.25	115	85	$9,775	$41,055	Storage Positions	$6,843
Switch Stands	6	EA	$7,600.00	$45,600	20	120	145	$17,400	$63,000	Storage Positions	$10,500
Bump Post	6	EA	$3,250.00	$19,500	2	12	85	$1,020	$20,520	Storage Positions	$3,420
Rubber Seal	2,470	LF	$42.25	$104,358	0.05	124	85	$10,498	$114,855	Storage Positions	$19,143
Cable Trough at Feeder Receptacle	4	EA	$2,500.00	$10,000	16	64	85	$5,440	$15,440	Storage Positions	$2,573
Snowmelters	6	EA	$9,000.00	$54,000	56	336	85	$28,560	$82,560	Storage Positions	$13,760
12'x60' Oil Pan	6	EA	$2,800.00	$16,800	16	96	85	$8,160	$24,960	Storage Positions	$4,160
DIRECT COST SUBTOTAL				1,398,902		6,134		777,721	2,176,625		
Subtotal Switch Heaters				$120,185		1,580		$132,740	$252,923	Storage Positions	$42,154
LAYOVER FACILITY ELEMENTS											
Subtotal Site Structural				$843,150		3,564		$315,656	$1,158,806	Unit	$1,158,806
Subtotal Division 3 - Concrete Work				$21,865		217		$18,965	$40,831	Unit	$40,831

Description	Materials				Labor				Total Direct Cost		Allocation Factor	Calculated Unit Cost
					Man-hrs		Cost ($)					
	Quantity	Units	Unit Costs	Total	Unit	Total	Unit	Total				
Subtotal Division 4 - Masonry				$12,454		554		$81,539	$93,993		Unit	$93,993
Subtotal Division 5 - Metals				$101,991		245		$21,897	$123,889		Unit	$123,889
Subtotal Division 6 - Wood and Plastics				$2,749		10		$805	$3,555		Unit	$3,555
Subtotal Division 7 - Thermal and Moisture Protection				$43,601		197		$16,749	$60,352		Unit	$60,352
Subtotal Division 8 - Doors and Windows				$33,754		124		$10,521	$44,277		Unit	$44,277
Subtotal Division 9 - Finishes				$20,393		410		$29,529	$49,923		Unit	$49,923
Subtotal Division 13 - Special Construction				$56,160				-	$56,160		Unit	$56,160
Subtotal Division 10 - Specialties				$45,252		197		$14,756	$60,008		Unit	$60,008
Subtotal Division 12 - Furnishings						1		$36	$236		Unit	$236
Subtotal Division 33 - Site Utilities				$170,320		2,792		$240,716	$411,036		Unit	$411,036
Subtotal Mechanical Work				$47,131		359		$29,467	$76,599		Unit	$76,599
Subtotal Fire Protection System				$9,701		102		$8,710	$18,412		Unit	$18,412
Subtotal Plumbing Systems						362		$30,774	$62,239		Unit	$62,239
Subtotal Electrical				$1,361,985		6,386		-	$1,897,024		Number of storage positions	$316,171 per storage position
Subtotal Communication Systems						1,214		$100,370	$290,393		Unit	$290,393
DIRECT COST SUBTOTAL									**$15,156,327**			
CONSTRUCTION												
Subtotal General Requirements				$71,095		622		$64,410	$135,505		Half fixed half variable based on number of storage positions	$67,753 + $271,010 per storage position
TOTAL DIRECT COST				$7,087,000		38453		$3,599,000	**$10,686,000**			
General Conditions @							13%	$534,300	$534,300			
General Contractor Overhead @							4%	$448,800	$448,800			
General Contractor Profit @							4%	$466,760	$466,760			
General Contractor Bond @							1%	$121,358	$121,358			
ESTIMATED CONTRACTOR COST									**$12,257,000**			
Traffic officers services	1	AN						$54,000	$54,000		Unit	$54,000
Rodent control	1	AN	$64,000	$64,000				-	$64,000		Unit	$64,000
Site utilities (existing)	1	AN	$48,300	$48,300				-	$48,300		Unit	$48,300
Electric company	1	AN	$315,000	$315,000				-	$315,000		Unit	$315,000
Install water system	1	AN	$6,000	$6,000				-	$6,000		Unit	$6,000
Risk allowance	1	AN	$1,300,000	$1,300,000				-	$1,300,000		Zero	$0
Total Excavation	53800	**CY**										
Dispose Contaminated Material (MCP Compliance) at In-State Facility	1,780	TN	$30	$53,400				-	$53,400		1 if contaminated zero if not	$53,400
Dispose Contaminated Material at NON-RCRA Out-of-State Facility	1,780	TN	$65	$115,700				-	$115,700		1 if contaminated zero if not	$115,700
Hazardous / Special Waste Handling	1	LS	$10,000	$10,000				-	$10,000		1 if contaminated zero if not	$10,000
LSP Services for Contaminated Soils Disposal	3,560	TN	$20	$71,200				-	71,200		1 if contaminated zero if not	71,200
ALLOWANCES				$1,983,600				$54,000	$2,037,600			
SUBTOTAL									**$11,615,000**			
Escalation to Oct 2013 (based on 3.8% per year) @				4.12%					$478,899			
ESCALATED ESTIMATED CONSTRUCTION COST									$12,094,000			
Construction Contingency				10%					$1,209,400			
ESTIMATED CONSTRUCTION COST WITH CONTINGENCY									**$13,303,000**			

Source: MBTA Fitchburg Commuter Rail - Wachusett Extension Project: PS&E Construction Estimate; Jacobs / Keville Enterprises, Inc.; January, 2013

Table C-2: Estimated Concord Layover Facility Capital Costs

Category of Expense	Cost
SITE WORK (over and above station cost)	
Miscellaneous site cleaning & clearing	$0
Erosion and sedimentation control (hay bale & silt fence)	$0
Silt sack	$0
Temporary construction access road	$0
Clearing and grubbing	$0
Stripping and stockpiling of topsoil	$0
Ordinary excavation	$0
Unclassified excavation - handling & off-site disposal	$0
Dispose of contaminated soil at in-state lined landfill	$0
Dispose of contaminated soil at in-state recycling facility	$0
Rock excavation	$0
Rock excavation - haul & disposal	$0
Soils testing services (LSP)	$0
Soil sampling and testing (assume 50-ft grid)	$0
Tree removal - includes stumps	$0
Processed gravel ordinary fill	$0
Gravel borrow sub-base (processed gravel)	$0
Grading & finishing	$0
Subtotal Division 2 - Site Preparation & Earthwork	$0
Subtotal Roadways & Walkways Pavements	$154,872
Subtotal Landscaping	$0
Subtotal Site Work - Drainage	$0
TRACK WORK (over and above station cost)	
Surface and Align Track	$0
Tie with Assemblies	$0
Ballast	$0
Subballast	$0
No. 10 turnouts	$0
Bituminous Pavement under switches	$0
Switch Stands	$0
Bump Post	$0
Rubber Seal	$0
Cable Trough at Feeder Receptacle	$0
Snowmelters	$0
12'x60' Oil Pan	$0
Subtotal Track & Rail Work	$0
Subtotal Switch Heaters	$0
LAYOVER FACILITY ELEMENTS	
Subtotal Site Structural	$1,158,806.00
Subtotal Division 3 - Concrete Work	$40,831.00
Subtotal Division 4 - Masonry	$93,993.00
Subtotal Division 5 - Metals	$123,889.00
Subtotal Division 6 - Wood and Plastics	$3,555.00
Subtotal Division 7 - Thermal and Moisture Protection	$60,352.00
Subtotal Division 8 - Doors and Windows	$44,277.00

Category of Expense	Cost
Subtotal Division 9 - Finishes	$49,923.00
Subtotal Division 13 - Special Construction	$56,160.00
Subtotal Division 10 - Specialties	$60,008.00
Subtotal Division 12 - Furnishings	$236.00
Subtotal Division 33 - Site Utilities	$411,036.00
Subtotal Mechanical Work	$76,599.00
Subtotal Fire Protection System	$18,412.00
Subtotal Plumbing Systems	$62,239.00
Subtotal Electrical	$316,170.67
Subtotal Communication Systems	$290,393.00
DIRECT COST SUBTOTAL	$3,021,751
CONSTRUCTION	
Subtotal General Requirements	$79,044.58
TOTAL DIRECT COST	$3,100,795.92
General Conditions @	$403,103.47
Subtotal	$3,503,899
General Contractor Overhead @	$140,155.98
Subtotal	$3,644,055
General Contractor Profit @	$145,762
Subtotal	$3,789,818
General Contractor Bond @	$37,898.18
ESTIMATED CONTRACTOR COST	**$3,827,716**
Subtotal ALLOWANCES- Section 01020	**$737,600**
Traffic officers services	$54,000
Rodent control	$64,000
Site utilities (existing)	$48,300
Electric company	$315,000
Install water system	$6,000
Risk allowance	$0
Dispose Contaminated Material (MCP Compliance) at In-State Facility	$53,400
Dispose Contaminated Material at NON-RCRA Out-of-State Facility	$115,700
Hazardous / Special Waste Handling	$10,000
LSP Services for Contaminated Soils Disposal	$71,200
SUBTOTAL	$4,565,316
Escalation to Oct 2013 (based on 3.8% per year) @	$188,091.01
ESCALATED ESTIMATED CONSTRUCTION COST	$4,753,407
Construction Contingency	$475,340.68
ESTIMATED CONSTRUCTION COST WITH CONTINGENCY	**$5,228,747**

Source: MBTA Fitchburg Commuter Rail - Wachusett Extension Project: PS&E Construction Estimate; Jacobs / Keville Enterprises, Inc.; January, 2013