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10918-C

November 13, 2000

Ref: 50885.00

David J. Brillhart, PE
Chief Project Manager
New Hampshire Department of Transportation
John O. Morton Building
1 Hazen Drive
PO Box 483
Concord, NH 03302-0483

Re: I-93 Salem - Manchester Corridor Improvements Study
Rail Alternatives Evaluation Report

Dear Jeff:

Enclosed are 30 copies of the Rail Alternatives Evaluation Report for the I-93 Salem – Manchester Corridor Improvements Study. This final report incorporates the comments received from the Department during the course of developing the document. The final chapter of the document includes a basic cost analysis that follows the Federal Transit Administration's (FTA) most recent guidance. This information provides an additional basis for comparison of the rail alternatives.

As the Department has acknowledged throughout the development of the Rail Alternatives Evaluation Report, this document offers an initial overview and evaluation of three possible rail service alternatives. The information in this document should provide a solid foundation for future studies of passenger rail alternatives in New Hampshire.

Thank you for the opportunity to work with you and the Department in the development of this report and the previously completed Rail Infrastructure Report. We are pleased that the Department asked VHB to undertake this important rail study as part of the I-93 corridor study. Please feel free to contact either Bruce Tasker or me if we can provide further assistance to you and the Department with the rail alternatives.

Very truly yours,

VANASSE HANGEN BRUSTLIN, INC.

David C Wilcock

David C. Wilcock, PE
Rail Alternatives Task Manager

DCW/dw

Enclosure

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INFO **ACTION**

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☐ SURVEY ☐
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☐ **RETURN TO:**

John JDB

For your info. Note estimates on the back - some info we can use for future estimates

Then file

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NH DEPT OF TRANSPORTATION

Rail Alternatives Evaluation Report

I-93 Salem-Manchester Corridor Improvements

Salem, Windham, Derry,
Londonderry, Manchester,
New Hampshire

Prepared for **New Hampshire Department of Transportation and**
Federal Highway Administration

Prepared by ***VHB*/Vanasse Hangen Brustlin, Inc.**
Bedford, NH

November 13, 2000

Rail Alternatives Evaluation Report

I-93 Salem-Manchester Corridor Improvements

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Prepared for **New Hampshire Department of Transportation and Federal Highway Administration**

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Bedford, NH

November 13, 2000

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Acronyms

Acronym	Description
ADA	Americans with Disabilities Act
AHCW	Automatic Highway Crossing Warning System
AREMA	American Railway Engineering and Maintenance-of-Way Association
B&M	Boston & Maine Railroad Corporation
CMAQ	Congestion Mitigation and Air Quality Improvement Program
CWR	Continuous Welded Rail
DEIS	Draft Environmental Impact Study
DMU	Diesel Multiple Unit
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GRS	Guilford Rail System
GTI	Guilford Transportation Industries
JTW	Journey to Work
M&L	Manchester and Lawrence Railroad
MAA	Manchester Airport Authority
MBTA	Massachusetts Bay Transportation Authority
MIS	Major Investment Study
MP	Milepost
NCHRP	The National Cooperative Highway Research Program
NH DOT	New Hampshire Department of Transportation
NHML	New Hampshire Main Line
NJT	New Jersey Transit
NNEPRA	Northern New England Passenger Rail Authority
NRPC	Nashua Regional Planning Commission
OTM	Other Track Material
SNHPC	Southern New Hampshire Planning Commission
SNJLRTS	Southern New Jersey Light Rail Transit System
STRY	Springfield Terminal Railway

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1

Introduction

1.1 Background

The New Hampshire Department of Transportation (NHDOT) is preparing a Draft Environmental Impact Statement (DEIS) to evaluate improvements for an 18 mile segment of I-93 extending from the junction of I-93, I-293, and NH 101 in Manchester, New Hampshire, to the Massachusetts/New Hampshire state line in Salem, New Hampshire. As part of the analysis, consideration needs be given to the possibility of passenger rail service between southern New Hampshire and the greater Boston area of Massachusetts.

The expansion of existing and development of new passenger rail services is a popular transportation topic in the New England and throughout the country. The Massachusetts Bay Transportation Authority (MBTA) has aggressively rebuilt and expanded the commuter rail system in eastern Massachusetts over the past 25 years. Amtrak is preparing to launch a new high speed rail service between Boston, New York, and Washington DC. Early next year, Amtrak and the Northern New England Passenger Rail Authority (NNEPRA) plan to institute intercity passenger rail service along the 114 mile rail corridor between Portland, Maine and Boston. This service includes nine stations located in: Portland, Old Orchard Beach (seasonal), Saco, and Wells, Maine; Dover, Durham (seasonal), and Exeter, New Hampshire; and Woburn and Boston, Massachusetts. NNEPRA plans to spend approximately $50 million to completely rebuild 78 miles of the rail corridor between Portland and the Massachusetts state line. The work program includes the complete reconstruction of the track structure, repairs and/or replacement of undergrade bridges, installation of a new signal system and grade crossing protection system, and drainage improvements.

With respect to the transportation needs in south central New Hampshire, the NHDOT proposes to construct improvements to I-93, but to do so with regard to long term infrastructure needs and the likely need to eventually revive passenger rail service in the region. In terms of existing infrastructure, two rail corridors could be used to provide such service. Both existing corridors originate in Manchester and run south to connect with existing passenger rail lines in Lowell and Lawrence, Massachusetts

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respectively, where service is currently provided to Boston. In addition, a rail option utilizing portions of the I-93 highway corridor is a third possibility worthy of consideration.

The purpose of this document is to analyze rail transit options for these three corridors. This report summarizes the infrastructure, equipment, and operational requirements associated with the implementation of passenger rail service on the two existing rail corridors as well as the introduction of rail service within the I-93 highway corridor. It also summarizes the issues and costs relative to the three corridors.

It should be noted that the rail service options included in this report are not intended to be the final word on which rail corridor might be carried forward to construction and implementation. This report provides a broad perspective based on conceptual data relative to rail service possibilities. All three rail corridors could potentially provide travel options to present and future users of the I-93 highway corridor. With that said, the implementation of commuter rail service on the West Rail Corridor between Lowell and Nashua is an active, ongoing initiative with the state. It is expected to be the first step towards re-establishing commuter rail service between southern New Hampshire and the greater Boston area. Whether passenger rail service should be implemented beyond Nashua along the West Rail Corridor, on the East Rail Corridor, and/or the I-93 Rail Corridor requires further study and development independent of the I-93 study. In particular, the additional study efforts should evaluate the environmental impacts, the needs of the affected communities, and issues relative to Massachusetts. This *Rail Alternatives Evaluation Report* provides a first step in considering the merits of passenger rail service beyond Nashua on the West Rail Corridor, along the East Rail Corridor, and along the I-93 Rail Corridor. It also provides a basis for designing the I-93 highway improvements in a manner that does not preclude an I-93 Rail Corridor service option in the future.

1.2 Study Methodology and Report Organization

This *Rail Alternatives Evaluation Report* focuses on defining possible rail transit service options. The two key components considered in this report are the operational requirements and infrastructure needs. The operations planning process focuses on the identification and development of rail transit operating assumptions and a preliminary operating plan for each of the proposed rail transit service options. An operating plan at this conceptual stage of project development is used to frame the parameters of the service. This process is interactive with the travel demand forecasting and infrastructure planning process. It includes equipment considerations and interface issues with other service modes.

The infrastructure planning process begins with an evaluation of existing conditions along the rail corridors including data relative to general corridor characteristics, track structure, undergrade bridge structures, grade crossings and signal and

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communications system. This step for the two existing rail corridors has been documented in the *I-93 Salem-Manchester Corridor Improvements; Rail Infrastructure Report* submitted in July 1999. The second step of the process is to define an operating plan that describes the route and its connection to the existing passenger rail system, station locations, and the service possibilities. This information will help to develop a schematic track layout. Necessary infrastructure improvements will be defined for each corridor. Future phases of work will further refine the schematic level of information of the alternative chosen for implementation.

The assumptions, costs, and findings provided for the West Rail Corridor in Chapters 2 and 3 are based on the information found in the *Draft Major Investment Study (MIS) for Nashua Passenger Rail Service* prepared by the *Nashua Regional Planning Commission (NRPC).* This study, known as the Lowell – Nashua – Manchester Commuter Rail Extension Project, examined the feasibility of extending existing commuter rail service on the MBTA's Lowell Line to the southern New Hampshire region. The NHDOT submitted the final version of the MIS document to the Federal Transit Administration (FTA) in the Fall of 1999. In November 1999, the NRPC was notified by New Hampshire's congressional delegation that the initial $1 million of a $16 million requested earmark was available to initiate the environmental review and preliminary design process. In addition, a $12 million request for the purchase of commuter rail coaches and locomotives was approved by the state's Congestion Mitigation and Air Quality Advisory Committee in March 2000.

The MIS documents an incremental approach to the restoration of service along a 31-mile section of the former Boston & Maine Railroad's New Hampshire Main Line (NHML) rail corridor from Lowell, Massachusetts through Nashua and Merrimack to Manchester, New Hampshire. The approach being examined by the NRPC considers a two-phase approach to the restoration of service. Phase 1 would include an extension of service from the existing MBTA terminus in Lowell to a new park and ride station located adjacent to F.E. Everett Turnpike at Exit 2 (Sagamore Bridge) in Nashua. The Phase 1 effort would extend service approximately 11 miles. For Phase 2, the NRPC is considering a further extension of the service from Nashua to Manchester a distance of 19 miles. Within this 19-mile segment, three potential station sites are being considered: Star Drive in Merrimack, the proposed Airport Connector Road in Bedford, and Commercial Street/Granite Street in Manchester. Each of these station sites could be considered as an interim terminus of service if additional incremental phases of work are necessary. The MIS also documents the potential current market for commuter rail service, estimates the capital cost requirements, provides an operational and economic analysis including a revenue-expenses analysis, analyzes alternatives like increased bus service, and identifies a preferred alternative.

The assumptions, costs, and findings developed for the East Rail Corridor in Chapters 4 and 5 and for the I-93 Rail Corridor in Chapters 6 and 7 are based on information developed specifically for the I-93 study. Information presented in the

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New Hampshire I-93 Alternatives Study Rail Infrastructure Analysis[1] was used as the starting point for this current assessment. A full field review of existing conditions was completed along the East Rail Corridor from Lawrence to Manchester as documented in the *I-93 Salem-Manchester Corridor Improvements: Rail Infrastructure Report*[2]. Unit cost data for infrastructure, equipment, and annual operating costs is based on the information developed for the West Rail Corridor. Data regarding the right-of-way issues at Manchester Airport was obtained through the NHDOT. The service plan for the East Rail Corridor and the I-93 Rail Corridor were developed to be consistent with the levels of service proposed for the West Rail Corridor.

Chapters 6 and 7 address the creation of a new rail corridor within or adjacent to the I-93 highway corridor between the Massachusetts state line and Exit 5 in Londonderry. South and north of these limits, the I-93 Rail Corridor could connect with the existing East Rail Corridor. The layout and costs are related to, and in varying degrees intertwined with, the improvements proposed for the highway. As such, the layouts for both the rail and highway alignments will be developed in an iterative manner in an effort to minimize costs and impacts.

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[1] Draft *New Hampshire Route I-93 Alternatives Study Rail infrastructure Analysis*, Parsons Brinkerhoff Quade & Douglas, December 1992.

[2] *I-93 Salem – Manchester Corridor Improvements: Rail Infrastructure Report*, Vanasse Hangen Brustlin, Inc., July 1999

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2

West Rail Corridor: Operations Plan

This chapter presents the preliminary operations plan for the extension of commuter rail service along the West Rail Corridor from Lowell to Manchester. It includes a description of the route characteristics including proposed station locations, the proposed service plan, a preliminary projection of ridership developed from the New Hampshire DOT statewide model and a mode choice model (NCHRP Report 187, "Quick-Response Urban Travel Estimation Techniques and Transferable Parameters"), an assessment of equipment needs, and an estimate of annual operating costs and revenue projections.

2.1 Route Description

The 31-mile West Rail Corridor runs between Lowell, MA, and Manchester, NH, via the towns of Chelmsford and Tyngsboro, MA, and Nashua, Merrimack and Bedford, NH. The rail corridor generally parallels the Merrimack River and US 3. Existing service on the Lowell Line extends from North Station in Boston, Massachusetts to downtown Lowell along the New Hampshire Main Line (NHML), for a distance of 25 miles. The station in Lowell is currently the northern terminus of commuter rail service on the MBTA's Lowell Line. The limits of this study's efforts are from Lowell Station northerly to Manchester along what is now Guilford Rail System's (GRS) Freight Main Line and Northern Main Line. Historically, the entire line from Boston to Manchester is referred to as the New Hampshire Main Line (NHML). To avoid confusion in this report, the line will be referred to as the NHML or the West Rail Corridor. The traditional NHML milepost (MP) designations will be used. This system starts with MP 0.0 in Boston at North Station. The existing Lowell station is located at MP 25.3 and the proposed Manchester station is located at MP 55.9.

2.1.1 Route Characteristics

As mentioned above, the proposed West Rail Corridor service will connect to the existing MBTA service in Lowell. The length of the service extension from Lowell, MA, to

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Manchester, NH is approximately 31 miles. With the current length of service between Lowell and Boston of 25 miles, this will result in a total service route from Boston to Manchester of approximately 56 miles. Figure 2-1 shows the proposed route location and station sites discussed in the following section.

The State of New Hampshire is currently in the process of developing commuter rail service from Lowell to Nashua. Although the rail corridor improvements are not completed and the rail service is not yet operating, it is projected to be by 2020, the forecast year of this report. Therefore, many aspects of the operation and infrastructure development plans in this report will refer to the extension of rail service from Nashua to Manchester, while other sections will refer to the entire service as planned from Boston to Manchester via Lowell and Nashua.

The MBTA owns the NHML right-of-way from North Station to the Massachusetts/New Hampshire state line. Once in New Hampshire, the Boston & Maine Corporation own the line. The line is double track from North Station to the Chelmsford Wye located approximately 3 miles north of the Lowell station. From the Chelmsford Wye to downtown Manchester, there is a single main line track. A two-mile long passing siding is located in Merrimack. Springfield Terminal Railway Company (STRY) operates freight service on the line. In New Hampshire, this service includes a coal train operating on an evening schedule and local freight service that is operated on an as-needed basis (approximately 3 days a week).

2.1.2 Stations and Facilities

Four potential commuter rail station sites are proposed along the corridor between Lowell and Manchester in Nashua, Merrimack, Bedford and Manchester. These locations are based on the Nashua Regional Planning Commission's (NRPC) *Draft MIS for Nashua Passenger Rail Service*. The following is a brief description of each station location and their proposed facilities. The milepost refers to the station site location on the NHML.

Nashua – US 3 (FE Everett Turnpike) @Exit 2 (MP 36.2)

The proposed station site is located south of downtown Nashua immediately north of the Sagamore Bridge and east of the FE Everett Turnpike Exit 2 interchange. Figure 2-2 shows the general locus of the proposed station site. This location would serve the greater Nashua area and areas east of the Merrimack River. Preliminary plans call for the construction of a 550-space park and ride facility. With the station's easy access from US 3 and its large number of parking spaces, it will potentially serve transit riders not only from the Nashua area, but also diverted Boston bound commuters from all along the US 3 corridor. Construction of the park and ride lot and station platform at this location has already been approved for funding through the Congestion Mitigation and Air Quality (CMAQ) program. Additional funding would be required if a station building or other passenger amenities were constructed or if additional parking spaces were required.

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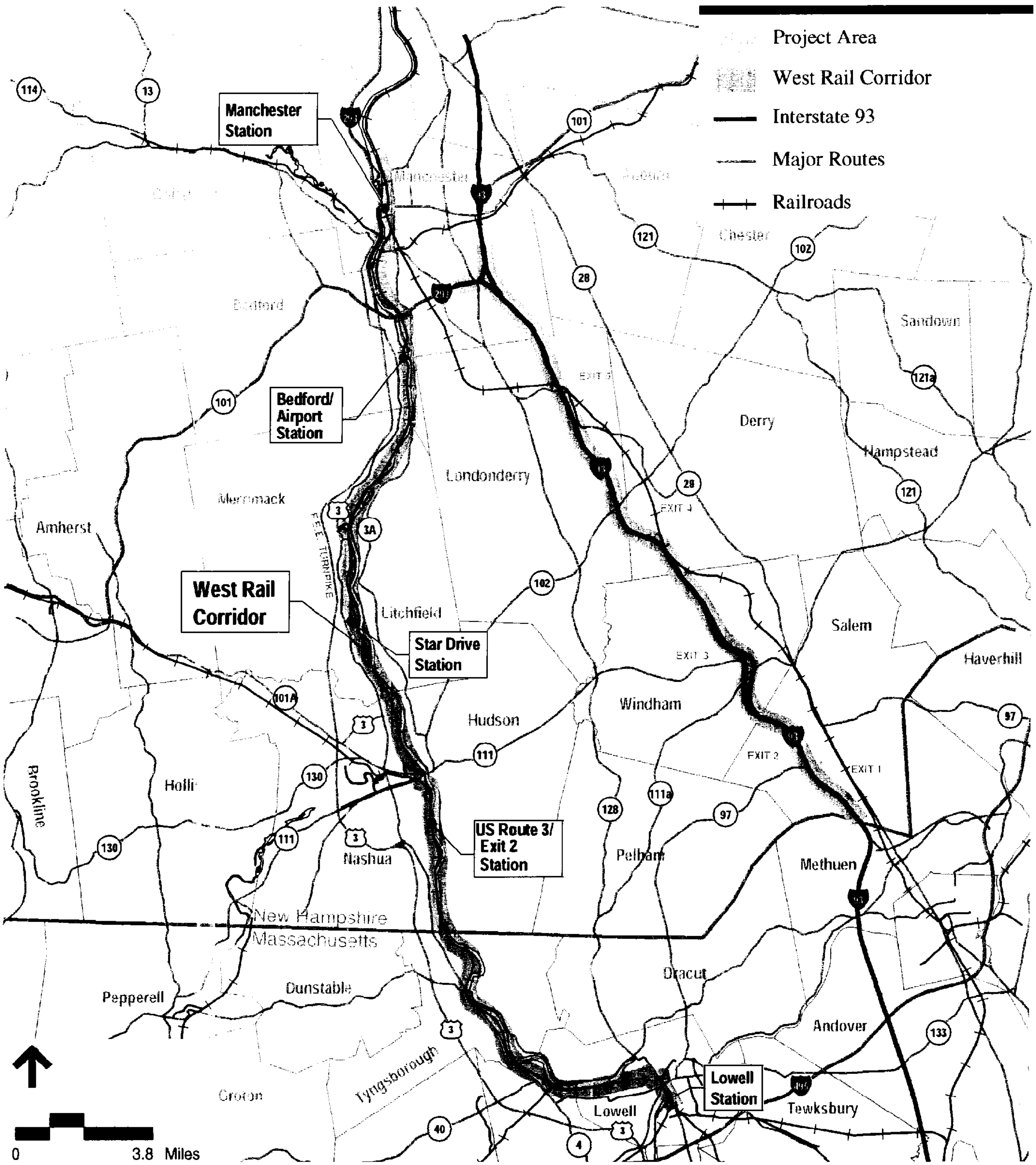

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West Rail Corridor
Route Layout

Figure 2-1

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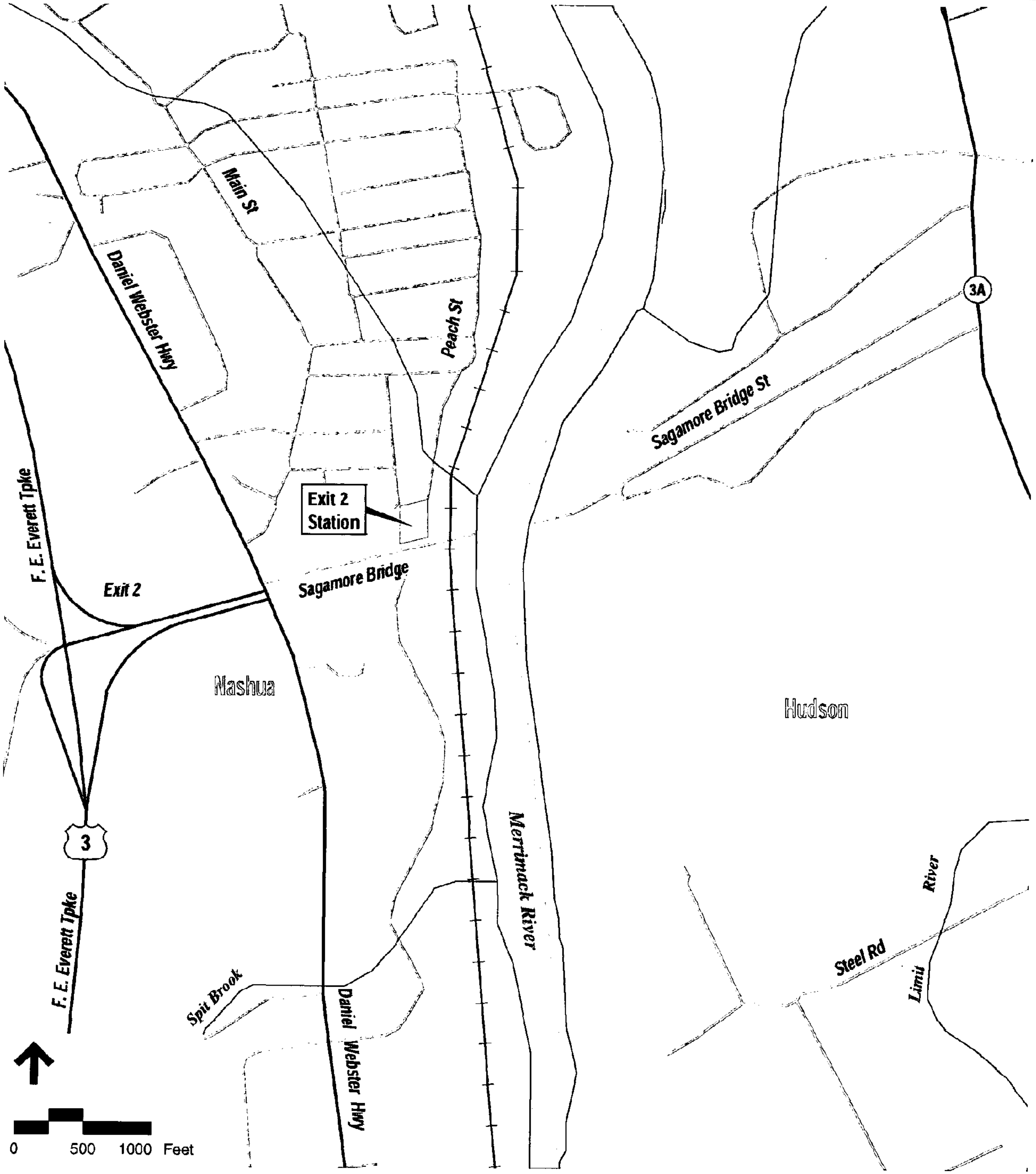

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West Rail Corridor
Nashua US Route 3 / Exit 2 Station
Site Location

Figure 2-2

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Merrimack – Star Drive (MP 44.3)

The proposed site for the Merrimack station is on Star Drive approximately 5 miles north of Nashua and 0.5 mile south of the Exit 1/F.E. Everett Turnpike interchange. The general locus of the proposed station site is shown in Figure 2-3. This station would serve residents of Merrimack and the north portion of Nashua. Plans call for the construction of a 250-space park and ride facility that, in addition to being utilized by local residents, could attract riders from the larger area. CMAQ funding has also been approved for the construction of a park and ride lot at this location. Additional funding would be required to construct a station including platforms and other passenger amenities or if more parking spaces were required.

Bedford – Airport Station (MP 51.5)

The proposed Manchester Airport station site is located in Bedford on the west side of the Merrimack River. Figure 2-4 shows the general locus of the proposed station site. It will have convenient access from both the F.E. Everett Turnpike and from the east side of the Merrimack River via the proposed airport access road and bridge that is currently being planned over the river. The station will serve both commuters and communities west of the river and could provide access to the airport, approximately 2 miles away, through a shuttle bus service from the planned 300-space parking lot.

Manchester – Downtown @ Commercial Street (MP 55.0)

The proposed Downtown Manchester station site is located at the south end of Commercial Street on the west side of the old Manchester freight yard. The five-acre site is bounded by Commercial Street to the north, the NHML to the east, the Goffstown Branch to the south, and the Merrimack River to the west. The general locus of the proposed station site is shown in Figure 2-5. Commercial Street connects to US 3 and I-293 within one mile of the site. Pedestrian access to area employment centers is also reasonably good from the site. This station will primarily serve the local Manchester market. It is assumed that 500 parking spaces will need to be provided.

The City of Manchester has examined this site as the potential location for a multimodal transportation center. Locating a facility on this site would allow intercity bus, local bus, and future rail service to converge at one convenient point in the city. The NHDOT recently applied for funding through the CMAQ Program to construct the park-and-ride lot. The application is pending.

Layover Facility – Manchester Freight Yard (MP 54.6)

There is no existing facility in Manchester to accommodate the overnight storage and servicing of the passenger trains. Provision of a layover and maintenance facility will help to provide flexibility for future passenger train operations. Without this layover facility, each of the last northbound trains in the afternoon/evening would have to return to Lowell or Boston for storage and servicing, resulting in higher operating costs and potential constraints on the early morning service schedule. It is assumed that this facility could be located in the Manchester Freight Yard as shown in Figure 2-5. All new infrastructure (track, buildings, utilities) will be required as discussed in Section 3.2.

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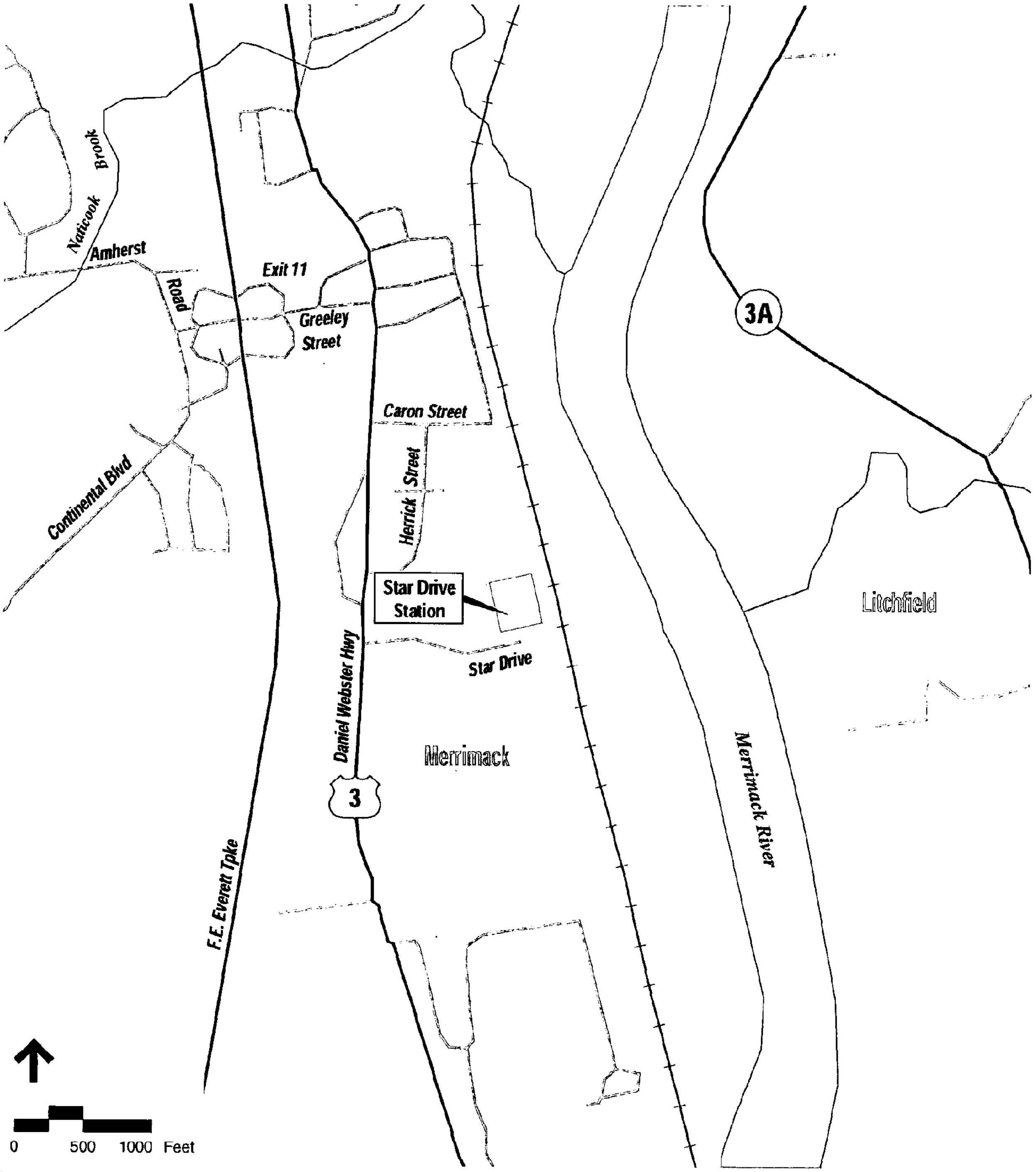

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West Rail Corridor
Merrimack Star Drive Station
Site Location

Figure 2-3

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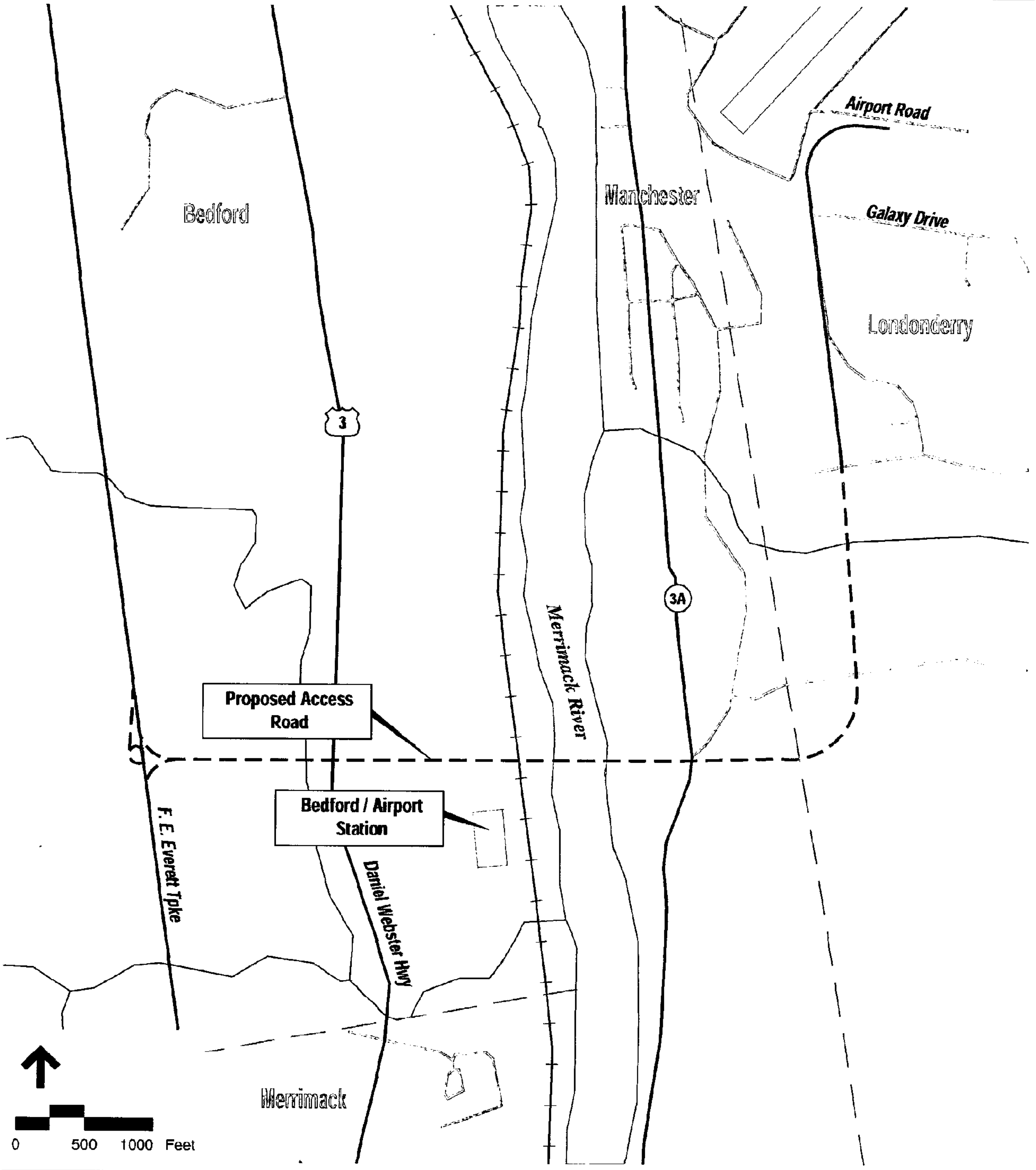

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West Rail Corridor
Bedford / Airport Station
Site Location

Figure 2-4

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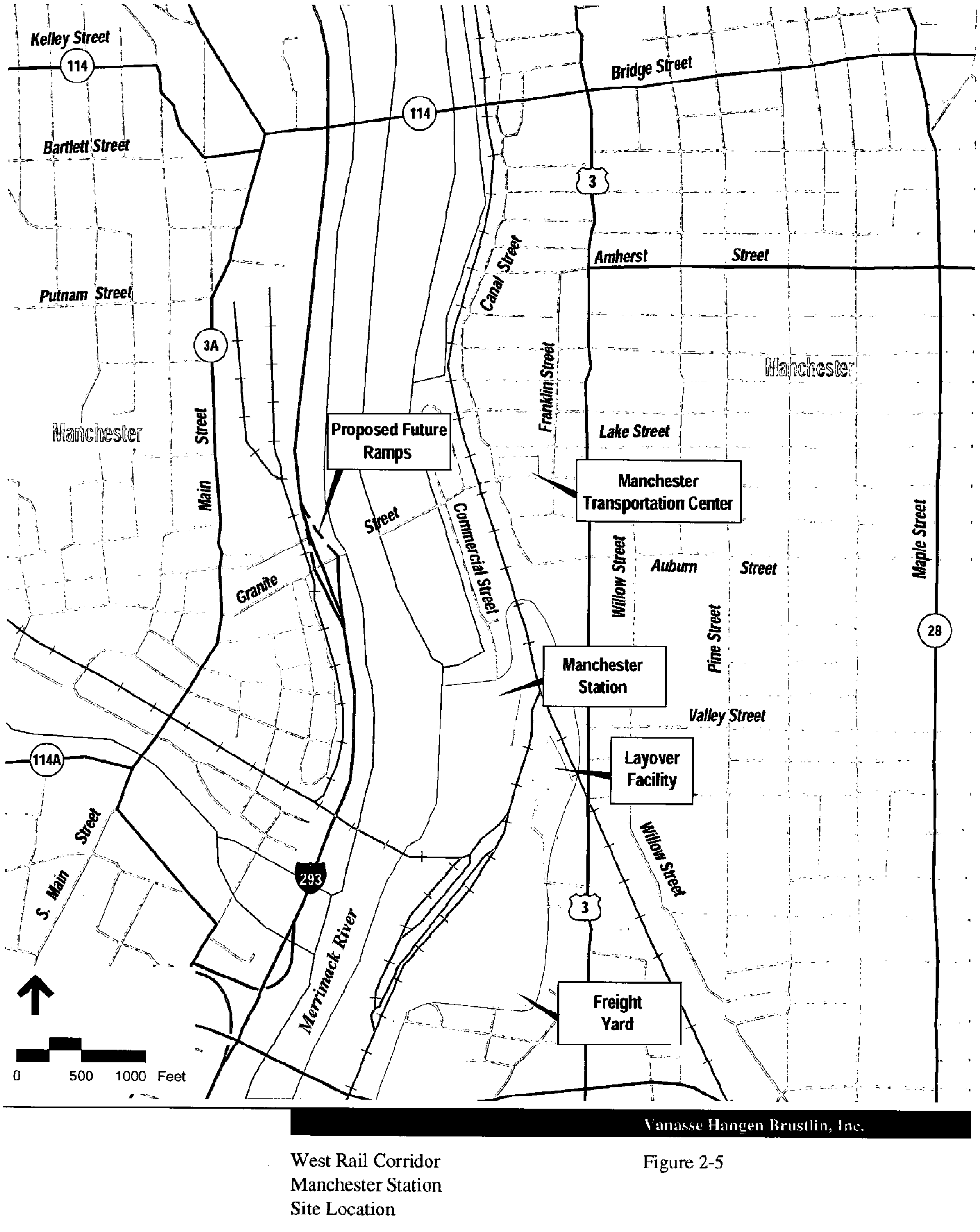

West Rail Corridor
Manchester Station
Site Location

Figure 2-5

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2.1.3 Speed and Travel Time

Infrastructure improvement plans for the corridor call for the replacement of all existing rail, and the upgrading of other track material to allow up to 60-mph passenger operating speed where conditions permit. Travel times were calculated based on the acceleration and deceleration characteristics of a traditional diesel-locomotive hauled passenger train. Geometric and civil speed restrictions were factored into the calculations as well as station stops and dwell times.

Based on the three intermediate station stops and geometry constraints, travel time between Manchester and Lowell is estimated to be 35 minutes. This includes 30 seconds of dwell time at each of the proposed stations. Total travel time between Manchester and Boston's North Station is estimated to be between 80 and 85 minutes based on the existing travel time and service plan between Lowell and North Station. Table 2.1-1 summarizes the travel time estimate.

Table 2.1-1
West Rail Corridor: Estimated Travel Times

Segment	Travel Time [minutes]
Manchester to Manchester Airport	6
Manchester Airport to Merrimack	8
Merrimack to Nashua	9
Nashua to Lowell	12
Lowell to Boston (varies)	45 – 50
Total Travel Time	**80 – 85**

2.2 Proposed Service Description

The proposed service description includes a definition of the level of service, development of a preliminary operating plan, and consideration of the equipment requirements. The following paragraphs summarize these aspects of the proposed West Rail Corridor Service.

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2.2.1 Service Alternatives

In the *Draft MIS for Nashua Passenger Rail Service* prepared by the *Nashua Regional Planning Commission (NRPC)* three service alternatives were developed for the proposed service. These alternatives will help to determine the service that creates the best balance of ridership and operating costs. The alternatives considered include high, moderate and low levels of service as outlined below. All alternatives assume through service from Manchester to Boston and include all existing MBTA stops plus the four additional stations discussed above. Although there may be a possibility of altering MBTA service schedules in the future in order to provide a more integrated overall service, it was assumed that MBTA schedules would not be changed at the initiation of service.

Alternative 1 – High

This alternative provides a total of 12 weekday round trips to Boston, with 6 in the peak periods, and 6 during the midday/evening periods. Weekend service consists of 4 round trips on both Saturdays and Sundays.

Alternative 2 – Moderate

The moderate level of service scenario includes 8 weekday roundtrips to Boston, with 5 in the peak periods and 3 during the midday/evening periods. Weekend service consists of 3 round trips on both days.

Alternative 3 – Low

This alternative offers 6 weekday roundtrips to Boston, with 4 in the peak periods and 2 in the midday/evening periods. Weekend service includes 3 round trips on Saturday only.

2.2.2 Schedules

Conceptual service schedules for these three scenarios with departure times at each of the new stations are included in Appendix A. All schedules are designed as extensions of the existing MBTA's scheduled service to Lowell without requiring any schedule changes. The proposed schedules are focused on providing service to Boston in the morning and back to Manchester in the evening.

2.2.3 Equipment Requirements

The equipment requirements vary depending on the service scenario (low, moderate, or high) selected. The proposed schedules do not alter the current service plan on the MBTA Lowell Line, instead they are based on extending existing trains from Lowell or Nashua to Manchester adding on the projected running time to the equipment service schedule.

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The MBTA presently operates approximately 188 trains each weekday on the Northside commuter rail system (trains into and out of North Station). This weekday service is provided by 21 sets of equipment. A set of equipment includes a locomotive and up to nine passenger coaches. Equipment sets rotate between the five Northside commuter rail lines throughout the service day. For example, an inbound train from Lowell can be turned at North Station to become the next outbound train to Rockport. Mid-day servicing (cleaning, fueling, minor repairs) is also built into the operating plan.

On the Lowell Line, two sets of equipment are "deadheaded" to Lowell in the early morning to operate as the first two morning inbound trips (Train Nos. 302 and 304). The term "deadhead" refers to the non-revenue movement of equipment for the purpose of positioning. The third inbound train of the morning is operated using the first outbound revenue train to Lowell (Train No. 301). Altogether, approximately nine different sets of equipment are used to provide the 46 weekday daily trips operated on the Lowell Line. Two of these sets only provide for one trip on the Lowell Line. The other seven sets provide between three and eight trips.

For the service extension to Manchester, the requirements are difficult to assess. The 16 miles of track from Nashua to Manchester is owned by the Boston & Maine Corporation (B&M). Springfield Terminal Railway (STRY) currently operates freight service over the line. Both the B&M and STRY are part of the Guilford Rail System, an entity controlled by Guilford Transportation Industries (GTI). To operate service over this single track segment (there is a single passing siding located at Reeds Ferry in Merrimack), an access agreement is required between the State of New Hampshire, GTI and the MBTA. The terms of this access agreement will define how service is to be operated. Ultimately, this agreement, through the operating terms, will dictate the number of additional equipment sets necessary to operate the service. At this time, our best judgement indicates that from four to eight additional sets of equipment (compared to today's fleet) could be required to operate service to Manchester.

2.3 Ridership and Revenue Projections

Ridership projections were developed for the West Rail Corridor Alternative using a mode choice model (NCHRP Report 187, "Quick-Response Urban Travel Estimation Techniques and Transferable Parameters"). These estimates are generally based on the moderate level of service where sufficient peak period service is provided so that altering the timing of work trips is not required. Further details regarding the specific ridership forecasting methodology are provided in Appendix B. Based on the ridership estimates and the MBTA's commuter rail fare structure, farebox revenue projections have also been developed. The results of these two procedures are summarized in the following sections.

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2.3.1 Ridership

The 2020 estimated boardings for the West Rail Corridor Alternative by station is shown in Table 2.3-1. The station boardings are based on commuter work trips to Boston with standard commuter rail trip impedances detailed in the ridership projection methodology in Appendix B. The average travel time for the trip from Manchester to North Station in Boston along the West Rail Corridor is 83 minutes. The boardings shown in the following table represent approximately one-half of the average daily trips attributable to the commuter rail service extension, with the other half of the trips ending at the new stations. The projected total daily ridership for the West Rail Corridor Alternative attributable to the extension of service between Nashua and Manchester is 1,154 trips (577 trips inbound, 577 trips outbound).

Table 2.3-1
West Rail Corridor: 2020 Daily Station Boardings

Station	Boardings
Downtown Manchester	189
Bedford/Manchester Airport	228
Merrimack	160
Total Daily Boardings	**577**

2.3.2 Revenue Projections

For the purpose of this study, it has been assumed that the 1999 MBTA commuter rail zone fare system would be used for the rail service in New Hampshire. This system has established service zones based on the distance from Boston to the outlying station. The further the outlying station is located from Boston, the higher the fare.

The proposed Nashua Station is located approximately 36 miles from North Station in Boston. This distance places the proposed station in Zone 8 that presently includes the Ayer and Newburyport stations. The one-way fare for trips from Zone 8 is $4.00.

The proposed Star Drive Station in Merrimack is located approximately 44 miles from North Station in Boston. This distance places the proposed station in Fare Zone 9. The MBTA's Zone 9 currently includes the Leominster and Fitchburg stations that are located approximately 45 and 50 miles from North Station. The one-way fare for Zone 9 trips is $4.75.

Both the proposed Airport Station (52 miles) in Bedford and the Manchester Station (55 miles) are located over 50-miles from North Station. The MBTA presently does not have any stations beyond a 50-mile distance from Boston. In the past, there was a station located in Gardner that was approximately 60 miles from North Station. It was included in Zone 11 where a one-way fare was $6.00. The 1999 MBTA commuter rail fare structure

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is the same as when the Gardner Station was in service. Therefore, it will be assumed that the proposed Airport Station in Bedford and Manchester Station are located in Zone 11.

The MBTA offers a substantial discount to commuters purchasing monthly passes. For Zone 9 (Merrimack), the monthly pass to Boston costs $136 compared to $209 for an average of 22 round trips per month at full fare ($4.75 one-way, $9.50 round trip). The monthly savings to Zone 9 commuters is $73. Therefore, it is cost effective for the commuter to purchase a monthly pass for as few as 15 round trips per month.

Since this analysis is based primarily on work trips, it is assumed that 90% of the projected riders purchase monthly passes to Boston and 10% purchase passes for intermediate destinations. Using these assumptions, the annual revenue projection for the moderate service scenario is $0.93 million. Table 2.3-2 summarizes the revenue estimates. The revenue calculations are included in Appendix C.

Table 2.3-2
West Rail Corridor: Annual Ridership and Revenue Projections

Station	Total Annual Trips	Annual Revenue ($ million)
Downtown Manchester	96,390	$0.32
Bedford/Manchester Airport	116,280	$0.36
Merrimack	81,600	$0.25
Total	**294,270**	**$0.93**

2.4 Annual Operating Costs

Preliminary annual operating costs were calculated based on estimated train miles and the current MBTA commuter rail operating costs. The *Draft MIS for Nashua Passenger Rail Service* reports that the MBTA's budgeted cost is $45 per train mile for the 1999 fiscal year. This number was adjusted by a 3.5% inflation rate for year 2000 to $46.50 per train mile. This unit cost includes four general categories of costs:

- Transportation – The costs associated with the personnel directly involved in the movement of trains or buses. This includes the salaries of train engineers, conductors, trainmen, and supervisors.
- Administrative – The cost to administer the service and manage operating personnel.
- Mechanical (Vehicle Maintenance) – The costs to maintain and operate the equipment. This includes the daily cleaning and maintenance of the equipment, all major overhaul and repair work, and fuel costs.
- Engineering (Non-Vehicle Maintenance) – The right-of-way maintenance costs. This includes items such as rail replacement, pavement maintenance, grade crossings and the electrical system.

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Table 2.4-1 summarizes the estimated annual incremental operating costs for service from Manchester to Nashua for all three service scenarios.

Table 2.4-1
West Rail Corridor*: Annual Operating Costs (2000 Dollars)

Service Level	Annual Train Miles	Operating Costs
Low	65,426	$3.0 m
Moderate	96,924	$4.5 m
High	136,324	$6.3 m

* Manchester to Nashua Segment

As mentioned earlier, an access agreement will be required between the State of New Hampshire, GTI and the MBTA. There are three major components of the access agreement: train operations, infrastructure maintenance and liability assignment. Each of these components will require negotiations, which will impact operating costs. As discussed previously, equipment costs can vary with the outcome of the train operations component of the agreement. Typical maintenance costs have been included in the costs detailed above, however they also can vary depending on the terms of the access agreement. The greatest unknown in terms of operating costs are those associated with the assignment of liability. Although a starting point for negotiations with GTI will likely be similar to recent agreements for passenger rail service in Vermont and Maine, the terms and costs associated with assigning liability can vary widely. The magnitude will not be known until negotiations for the service are concluded.

2.5 Capital Equipment Costs

As discussed in section 2.2.3, the West Rail Corridor rail service alternatives will require the procurement of additional locomotives and coaches to provide the proposed service. The number of additional trains varies by the amount of service operated. A detailed fleet management plan for the MBTA's Northside commuter rail service will need to be developed to determine the actual number of additional trains required.

For the West Rail Corridor, the requirements for additional equipment are difficult to project. Assuming that up to 75 percent of the proposed service could require new equipment, the high service scenario which proposes 12 roundtrips to Manchester yields eight new trains. With the moderate service scenario of 8 roundtrips, six new sets of equipment could be required. To operate the low service scenario of 6 roundtrips, four additional sets of equipment could be required to operate service to Manchester.

The cost for a set of equipment varies depending on the type of passenger coach (single level or bi-level, control coach (operators controls for push-pull operation) or blind coach and the number of coaches in each set of equipment (the consist). A typical Lowell Line train equipment consist is generally six to seven single level coaches. All recent MBTA

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coach procurements however, have been for the higher capacity bi-level coaches. For planning purposes, the following equipment costs were used:

- Diesel locomotive - $2.5 million
- Control cab coach - $2.0 million
- Blind coach - $1.1 million

A single seven car train consist (one locomotive, six blind coaches, and one control cab coach) cost approximately $11.1 million. These unit costs represent averages. A contingency of 20 percent is recommended for planning purposes at the current stage of project development. Table 2.5-1 summarizes the capital equipment cost estimates for the three service scenarios.

Table 2.5-1
West Rail Corridor: Capital Equipment Costs (2000 Dollars)

	Cost ($M)		
Service Level	**Sub-Total**	**Contingency**	**Total**
Low	$44.4	$8.9	$53.3
Moderate	$66.6	$13.3	$79.9
High	$88.8	$17.8	$106.6

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3

West Rail Corridor: Infrastructure Improvements

This section of the report presents the recommended infrastructure improvements necessary to support commuter rail service between Lowell and Manchester. The entire West Rail Corridor is currently classified Class 3 based on the Federal Railroad Administration (FRA) track classification criteria. The following proposed improvements support the upgrade to FRA Class 4 track with the intention to maintain the tracks to Class 3 standards. This will allow the operation of passenger trains up to 60 mph except where restricted by geometric and civil constraints.

The recommended improvements are based upon the *Draft MIS for Nashua Passenger Rail Service* prepared by the *Nashua Regional Planning Commission (NRPC)*. As previously noted, the NHDOT is moving forward with implementation of commuter rail service between Lowell and Nashua. The recommended improvements for this 11-mile segment are included for completeness. As part of NHDOT's initiative to extend service to Nashua, the preliminary engineering plans are under development.

The recommendations presented in this I-93 corridor study consider the constraints of the existing infrastructure and the needs of the current and future users of the rail corridor. Prior study efforts have documented a set of infrastructure improvement recommendations and capital infrastructure cost estimates. A summary of these efforts can be found in the Appendix D.

3.1 Layout

The proposed service along the West Rail Corridor would run along the New Hampshire Main Line (NHML) from Lowell to Manchester, a distance of approximately 31 miles. Stations are proposed at the existing MBTA station in Lowell, south of Nashua at Exit 2 on US 3, in Merrimack at Star Drive, at the proposed Airport Access Road in Bedford, and in downtown Manchester. The *I-93 Salem-Manchester Corridor Improvements; Rail Infrastructure Report* concluded that the West Rail Corridor infrastructure between Lowell and Manchester is mostly in a fair to good condition. An upgrade rather than a complete replacement will be required to establish the desired service.

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3.2 Capital Infrastructure Program

A series of specific infrastructure improvements were developed based on the existing conditions and standard commuter rail infrastructure design criteria. These improvements are illustrated in Figure 3-1 and summarized below.

3.2.1 Alignment and ROW

The alignment will follow the existing right-of-way from milepost 25.3 in Lowell to milepost 55.9 in Manchester. The existing corridor utilizes two tracks from Lowell to the Chelmsford Wye and one track from Chelmsford Wye to Manchester. This existing infrastructure layout will be retained including the Merrimack Siding, a 2-mile long passing siding located between milepost 46 and 48 in Merrimack. One additional siding is proposed at the downtown Manchester station. A new siding is needed at this location to provide the commuter trains with a location off the main line to layover between runs. Other passing sidings could be required depending on the terms of the operating agreement between the State of New Hampshire, GTI, and the MBTA.

3.2.2 Track Structure

The track structure includes the rails, ties, ballast, roadbed, special trackwork (i.e. turnouts, etc.), and other track material.

Rail and Crossties

Based on existing (1999) track condition, it is recommended that the existing rail be replaced with 115 LB continuously welded rail (CWR) and 75 percent of the crossties be replaced. The track structure should be upgraded to Class 4 and maintained to Class 3, which allows operating speeds of up to 60 MPH for passenger trains. Between Lowell Station and Granite Street in Manchester, the existing Track 1 will be upgraded. Between Lowell and the Chelmsford Wye (MP 29), the existing second track will be reconstructed to support up to 40 mph freight operations. This second track will be extended, approximately a half mile past the Chelmsford Wye to reduce the potential for conflicts between passenger and freight trains at that location. A 33 percent tie replacement ratio and surfacing of the 3-mile segment of Track 2 is assumed.

The Merrimack Siding, MP 43.6 to MP 45.8, will be reconstructed to allow for 45-mph passenger train speeds. Additional track construction is needed within the Manchester Yard, where a layover facility is proposed that includes multiple tracks to support the overnight storage and servicing of passenger trains. The number of tracks is dependent on the level of service operated. For this study, six tracks have been assumed, as needed to support the moderate level of service.

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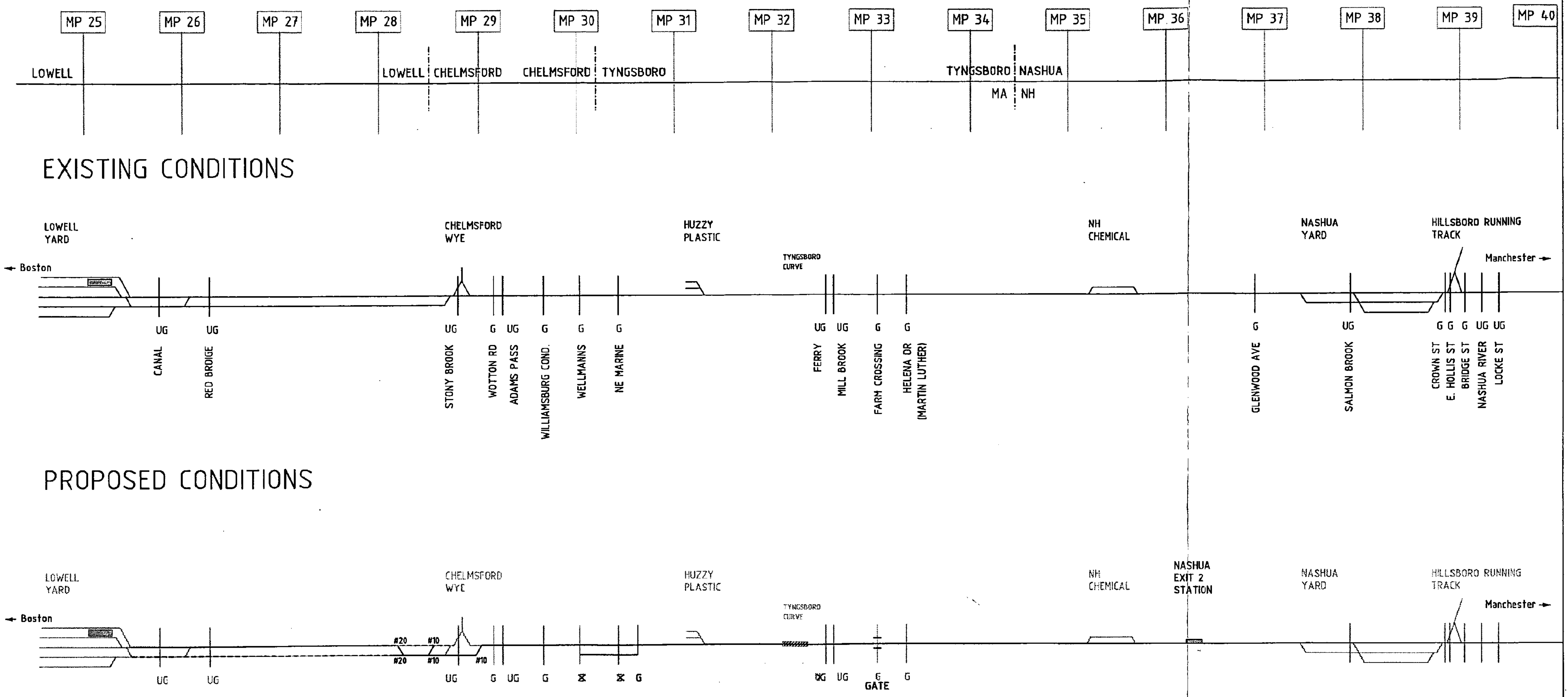

TRACK 1	INSTALL NEW RAIL AND TIES INSTALL NEW TRACK STRUCTURE AND TURNOUTS INSTALL NEW RAIL AND TIES
TRACK 2	UPGRADE EXISTING RAIL INSTALL NEW TRACK STRUCTURE AND TURNOUTS
GRADE X-INGS	CLOSURE AND RELOCATION
CIVIL	FENCING REMOVAL, NEW ROAD AND GRADE CROSSING FENCING
STATIONS	NEW STATION FACILITY
STRUCTURES	REHABILITATE ALL UNDERGRADE STRUCTURES REHABILITATE WALL REMOVE AND FILL-IN FERRY RD
SIGNAL SYSTEM	IMPROVE INTERLOCKING AND CONTROL CENTER RECONFIGURE WYE GRADE CROSSING PROTECTION AT ALL GRADE CROSSINGS GATED CROSSING

Legend

Existing Conditions
Existing ————
Abandoned - - - - - - -

Proposed Conditions
Existing ————
Proposed ————

G = At Grade Crossing
UG = Undergrade Bridge (Railroad over Road)

Vanasse Hangen Brustlin, Inc.

West Corridor
Proposed Infrastructure Improvements

Figure 3-1 (a)

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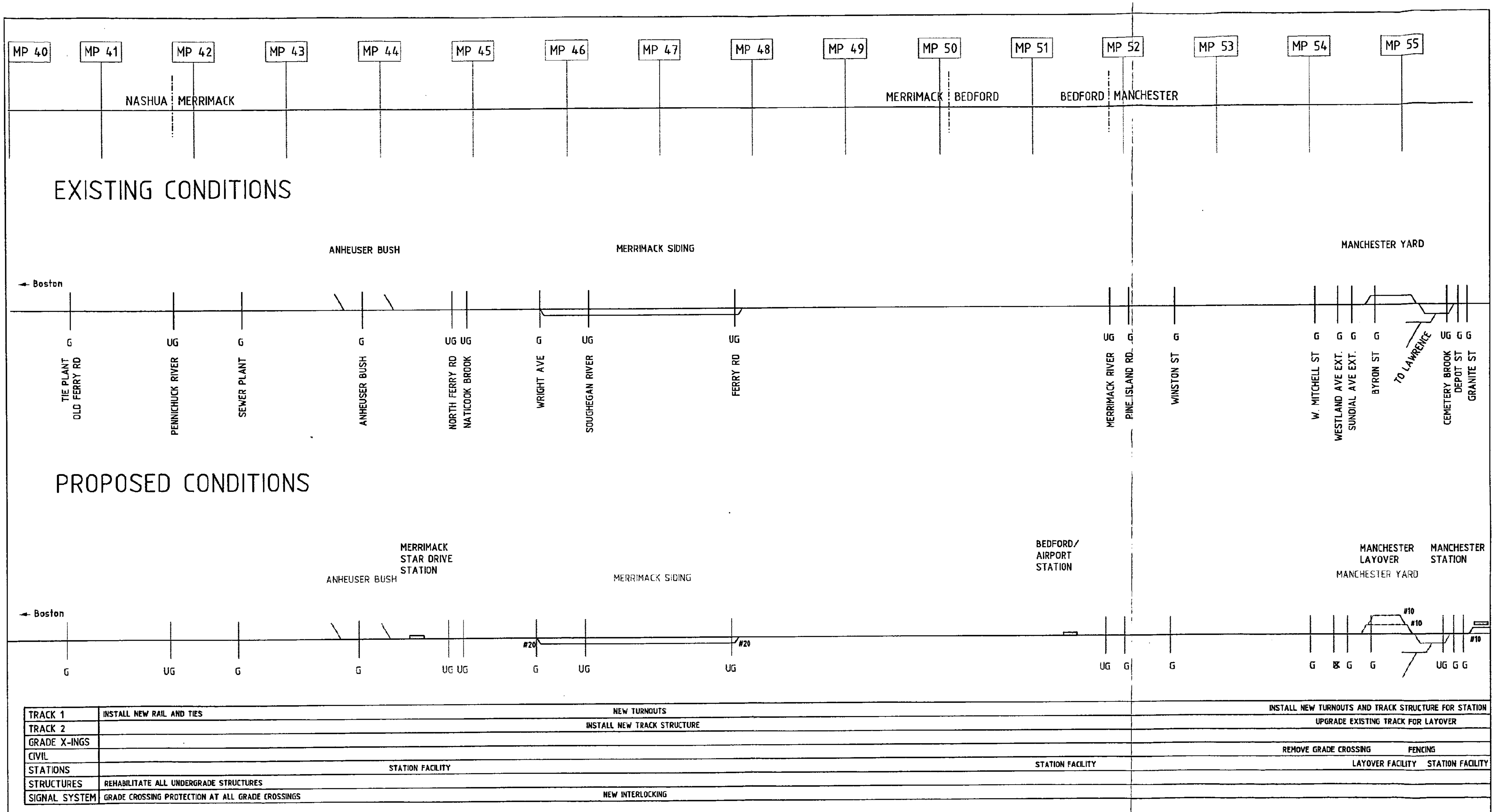

Legend

Existing Conditions
Existing ————
Abandoned ------------

Proposed Conditions
Existing ————
Proposed ————

G = At Grade Crossing
UG = Undergrade Bridge (Railroad over Road)

Vanasse Hangen Brustlin, Inc.

West Corridor
Proposed Infrastructure Improvements

Figure 3-1 (b)

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Other track material (OTM)

With the installation of CWR along the entire route, new, six-inch tie plates are required throughout. Anchors and spikes will also have to be replaced.

Ballast

The existing ballast and roadbed are in good condition. For the infrastructure improvement program, it has been assumed that the existing ballast does not need to be replaced and will be retained. During the preliminary design phase (should this alternative be advanced), a geotechnical program should be developed to fully assess the condition of the ballast and roadbed.

Special trackwork

Existing turnouts in Lowell, Nashua, and at the Manchester Yard will require replacement.

Drainage

Throughout the corridor the drainage system is mostly in a good condition. Ditches might have to be cleaned and rebuilt where necessary.

3.2.3 Grade Crossing Surfaces

There are 22 existing grade crossings along the West Rail Corridor, of which 12 are public crossings and 10 are private crossings. With the recommended consolidation of two private crossings and the closing of one pedestrian crossing, there will be 20 crossings located along the West Rail Corridor. This section addresses the grade crossing surface. Recommendations about improvement and installation of highway crossing warning systems (gates and/or lights) at the public crossings are presented in section 3.2.7.

The majority of the crossing surfaces are in poor to fair condition. It will be necessary to replace the existing crossing surfaces at all grade crossings. At the public crossings, the installation of a new rubber crossing surface material is recommended. The private crossings will need to be evaluated individually to assess the appropriate surface treatment.

In Chelmsford and Tyngsboro, it is recommended that two private crossings be consolidated (Wellman's crossing and NE Marine crossing) into a single relocated crossing north of the existing crossings. A new roadway is proposed to connect the existing driveways with the relocated crossing on the east side of the tracks. It is also proposed to gate and fence the private farm crossing at MP 28.10 in Tyngsboro and to close the pedestrian crossing at the Westland Avenue Extension in Manchester. The crossing in Manchester does not have an existing crossing surface and appears to be a makeshift crossing for pedestrians.

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3.2.4 Civil

Fencing

There is a limited amount of fencing located along the length of the corridor. Open access is available from nearly all adjacent properties. Typically, the MBTA erects fencing in urban areas where pedestrian traffic across the rail line could present a potential hazard. Based on this practice, fencing is recommended along the first mile in Lowell, through the downtown Nashua area for about 2 miles, and in the Manchester area for about 3 miles.

Earthwork

No major earthwork is expected along the corridor. The new service will require general clearing and grubbing though out the corridor, especially in the areas of siding track construction where the roadbed will need to be prepared for the new tracks.

3.2.5 Stations and Facilities

Stations

As described previously in section 2.1.2, stations are proposed for the following locations:

- Nashua at the Exit 2 interchange from US 3 (FE Everett Turnpike),
- Merrimack at Star Drive just east of US 3 and approximately one mile south of Exit 11 on the F.E. Everett Turnpike,
- Bedford at the proposed Airport Access Road, and
- Downtown Manchester south of Commercial Street adjacent to the Manchester freight yard.

The proposed locations of these station sites were previously shown in Figures 2-2 through 2-5.

The stations will consist of a platform with canopy, benches, lighting, signage, surface walkways and drainage. Parking facilities will be provided with their size depending on estimated ridership and the type of station. All four proposed stations will potentially draw commuters from the US 3 corridor.

The station platform will be high or low level depending on whether they have to accommodate freight service. Stations located on segments of the rail corridor with freight service require a low level platform due to the width of the freight cars. To provide access for handicapped passengers, the stations with low level platforms will include a mini-high platform.

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Layover Facility

As described in the Operations Plan, a layover facility is needed at the Manchester end of the route. This facility will accommodate the overnight storage of trains and allow for the routine daily cleaning and servicing of the equipment and any minor repairs. The Manchester Yard is the proposed location for this facility. New tracks will be constructed in the yard area to facilitate the layover of up to six trains. The facility would also include a small building for the service crew and supply storage.

3.2.6 Structures

Undergrade Bridges

There are 18 undergrade bridge structures (i.e. bridges that carry the railroad over a roadway, waterway, or other physical feature) located along the NHML between Lowell and Manchester. Minor maintenance and repairs will be required to rehabilitate the existing undergrade structures for commuter rail service. This will include replacement of up to 50 percent of the bridge timbers. The existing undergrade structure at Ferry Street in Tyngsboro will be removed and the abandoned street will be back filled.

Retaining Walls

Minor repairs are required to reinforce the existing retaining wall along the Tyngsboro Curve.

3.2.7 Signal System

The existing signal system is not satisfactory to provide safe and reliable commuter rail service. A complete new system is therefore necessary. The two elements of the new system include the automatic highway crossing warning (AHCW) system and the wayside signal system. The following paragraphs briefly summarize these two elements of the signal system.

Automatic Highway Crossing Warning (AHCW)

The AHCW will control all movements between highway and rail traffic along the corridor. The proposed AHCW system would provide motorists and pedestrians with warnings at each of the active intersections. Modern solid-state, constant warning grade crossing predictors are proposed for installation at all 12 public grade crossings and at several of the more active private crossings. This equipment is designed to provide a constant warning time to vehicular motorists regardless of the oncoming train speed. Use of auditory and visual signal systems provide warnings in compliance with FRA regulations. The final decision regarding the level of protection at each crossing will need to be made during the preliminary design stage of project development. A team of inspectors from the FRA and the NHDOT will need to evaluate each crossing in detail

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and make a final recommendation regarding the appropriate level of protection. For cost estimating purposes, it has been assumed that the highest level of protection (gates, warning lights, and bells) will be installed at all 20 grade crossing locations.

Wayside Signal System

The wayside signal system controls all train movements along the corridor. The existing wayside control system is at the end of its lifetime and needs to be replaced completely. The system's block spacing can not provide for intermixed freight and passenger operations due to the different operating speeds. The current system utilizes open pole lines and underground cables. Rehabilitation of the existing signal system for the proposed service is comparably expensive. It is therefore recommended to install electronic coded track circuits between control points. This equipment utilizes the rails for all train detection and wayside signal control, therefore poles and cables are no longer necessary. Wayside signal system improvements would include rationalizing the existing Lowell interlocking to permit more efficient passenger train operations north of the station, installing two new control points located at either end of the proposed station track in Manchester, and reconstructing the existing interlocking at the south end of the Nashua Yard to create a passing siding within the yard limits. The upgrade of the passing siding in Merrimack requires the reconstruction of the control points and either end of the siding. It will also be necessary to reconstruct the existing interlocking at the Manchester Yard.

3.3 Capital Infrastructure Cost Estimate

3.3.1 Methodology

Capital infrastructure costs include improvements to the existing infrastructure for the entire West Rail Corridor from Lowell to Manchester. Since initial review of the corridor and development of the cost estimate, the State of New Hampshire has progressed the project of establishing rail service from Lowell to Nashua. This initiative is expected to be completed prior to 2020, the forecast year of this report. Since the Lowell-Nashua segment of the West Rail Corridor is a committed state project, the cost of the infrastructure improvements estimated at $21.5 million[3] for that segment will be subtracted from the total capital cost estimate prior to completing the cost analysis for this study.

The capital cost estimate includes improvements to the existing infrastructure like rail and other track materials, grade crossings, signal and communications system, undergrade bridge structures, and construction of new facilities like stations. These infrastructure capital cost estimates do not include the cost of real estate or

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[3] *Draft Major Investment Study (MIS) for Nashua Passenger Rail Service*, Nashua Regional Planning Commission, June 1999

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environmental mitigation. The capital cost for equipment (locomotives and coaches) was previously discussed in section 2.5. The estimate accounts for the cost of construction contingencies, incidentals (unknowns), and design, survey, construction and administrative services. These items are added as a percentage of the total construction items.

3.3.2 Infrastructure Cost Estimate

Unit costs for the capital items were estimated using several sources. These sources include cost data from the MBTA and from other commuter rail properties. In developing the capital cost estimates, six general categories of costs were considered. They are:

- Track Structure: rails, ties, other track materials, special trackwork, ballast, and sub-ballast.
- Grade Crossings: crossing surface and roadway safety improvements.
- Civil: New street (roadway) construction, clearing and grubbing, excavation and fill, and fiber optic cable relocation.
- Structures: bridges, culverts, tunnels and retaining walls.
- Facilities: stations, platform and parking for stations, and utilities for the layover.
- Signal System: the wayside signal system, train control, and at-grade crossing protection.

The total cost for the recommended infrastructure improvements from Lowell to Manchester is $73.2 million as shown in Table 3.3-1. The section under analysis in this report from Nashua to Manchester totals $51.7 million, which is the $73.2 million total cost less the projected infrastructure costs for the Lowell-Nashua segment of $21.5 million. A more detailed cost estimates can be found in Appendix E. With a total length of approximately 19 miles for the extension from Nashua to Manchester, the cost per mile is about $2.75 million. This number lies within the range of the previous estimates, if escalated to current dollar value, summarized in Appendix D.

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Table 3.3-1
West Rail Corridor: Total Infrastructure Costs (2000 Dollars)

Infrastructure Item	Cost ($M)
Track Structure	$18.4
Grade Crossings	7.9
Civil	0.6
Structures	1.6
Facilities	8.0
Signal System	17.7
Sub-total	**$54.2**
Contingency (20%)	10.8
Survey/Design/Construction Services (15%)	8.1
LOWELL to MANCHESTER	**$73.2**
NASHUA to MANCHESTER ONLY	**$51.7**

It should be noted that the West Rail Corridor costs reported in this document are slightly higher than the costs reported in the NRPC's *Draft MIS for Nashua Passenger Rail Service*. The NRPC document did not include the cost of stations and facilities ($8 m plus $3.6 m in contingencies and service) which this report does include. In addition, several other minor adjustments were made to the track infrastructure, grade crossings, and signal system cost estimates.

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East Rail Corridor: Operations Plan

This chapter presents the preliminary operations plan for the extension of commuter rail service along the East Rail Corridor from Lawrence to Manchester. The chapter includes a description of the route characteristics including the proposed station locations, the proposed service plan, a preliminary projection of ridership developed from the NHDOT statewide model and a mode choice model (NCHRP Report 187, "Quick-Response Urban Travel Estimation Techniques and Transferable Parameters"), an assessment of equipment needs, and an estimate of annual operating costs and revenue projections.

The greatest challenge in developing an operations plan for the East Rail Corridor is the segment of the route adjacent to the Manchester Airport. The Manchester Airport Authority recently purchased a portion of the M&L right-of-way in Londonderry and Manchester from milepost 20.93 to 26.8. The purchase allows the airport authority to extend Runway 6-24 easterly across the railroad right-of-way between mileposts 23 and 24. This runway extension effectively severs the at-grade railroad alignment adjacent to the airport. To reconnect the corridor, either a tunnel will have to be built under the extended runway or a new rail alignment around the airport identified. The NHDOT has completed a preliminary review of a 4.2-mile alternative alignment located to the east of the airport and NH 28. The evaluation of the tunnel and relocation alignment is presented in Chapter 5, Infrastructure Layout – East Rail Corridor. For the purposes of developing a preliminary operating plan, it was assumed that the travel time over either the existing or relocated alignment is approximately the same.

4.1 Route Description

The proposed East Rail Corridor runs for 28 miles along the former Boston & Maine (B&M) Railroad's Manchester & Lawrence (M&L) Branch between Manchester, Salem, and Lawrence, MA. The rail corridor generally runs along the east side of I-93, and to the west of NH 28. The corridor connects with the Haverhill Line of the MBTA's commuter rail network just south of Lawrence Station.

The limits of this study's efforts start at the former B&M's West Route Main Line in Lawrence and extends northerly along the M&L Branch to the Manchester yard. Just south of downtown Manchester the line joins GRS' Northern Main Line (historically the New Hampshire Main Line) at the north end of the yard.

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4.1.1 Route Characteristics

The proposed line would service the municipalities of Lawrence, MA and Salem, Derry, Londonderry, and Manchester, NH. The line is approximately 28 miles long between Lawrence and Manchester, with a total length between Manchester and Boston (North Station) of approximately 54 miles. The only current operations along the line are limited freight service by STRY, between Lawrence and Salem. One customer remains in New Hampshire just over the state line. The records indicate that an approximate 7-mile stretch (between MP 0.0 and 7.6) is still in service. The remaining sections of the line are out of service.

Current ownership of the right-of-way along the corridor is primarily held by the MBTA, Boston & Maine Corporation, and by the State of New Hampshire. The MBTA owns the line from its connection to the Haverhill Line in Lawrence to the New Hampshire State line. From the state line to Broadway in Salem, the Boston & Maine Corporation is the owner. The remainder of the line is owned by the State of New Hampshire with several exceptions. In the Town of Derry, one segment was sold to a private owner and a second segment to the Town of Derry. The sale to the Town includes an agreement to protect the corridor for future reuse as a transportation corridor. The sale to the private owner, which includes approximately one mile of the corridor from High Street to NH 28, did not include any agreement protecting the corridor. In Londonderry, there are two segments near I-93/Exit 5 where a private interest has purchased either the middle portion or the outside portions of the ROW. Neither of these sales included an agreement regarding the future transportation use of the corridor. Recently, a 5.9-mile section of the right-of-way, from milepost 20.93 (just west of I-93 in Londonderry) to Elm Street in Manchester (MP 26.8), was purchased by the Manchester Airport Authority to allow for expansion of the airport. The segments of the corridor located north and south of the airport property that were not required as part of the expansion project have been purchased by the NHDOT (June 2000).

The proposed line would be single track except for one 1,500 to 2,000 foot segment between the I-93/Exit 1 and the I-93/Exit 5 stations where a passing siding would be located. This siding would allow trains traveling in opposite directions to pass maintaining the proposed schedule. The siding allows a higher level of service to be accommodated on the line, while providing maximum flexibility in the future. Without the siding, service would be limited to a single train operating over the line. This type of operation would provide a low level of service and poor connectivity to the MBTA's commuter rail service in Lawrence.

A more detailed description of the existing conditions of the line's infrastructure is available in the *I-93 Salem-Manchester Corridor Improvements; Rail Infrastructure Report* submitted in July 1999. Figure 4-1 shows the proposed route and station sites discussed in the following section. Figure 4-2 shows the proposed new railroad alignment developed by NHDOT at Manchester Airport.

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4.1.2 Stations and Facilities

New stations are proposed at three locations along the corridor in Salem, Londonderry and Manchester. These locations were chosen considering the following criteria:

- Location in areas with possible high ridership and city/town centers
- Proximity to I-93 and other major routes or destinations
- Location of historic stations
- Availability of ample sized lots for station facilities, parking and access

For the initial service planning, the number of stops was limited to reduce overall travel times and construction costs. Regional stations at I-93 Exit 1/Rockingham Park, Exit 5/Londonderry, and Manchester Airport were evaluated to maximize regional access to the service. Smaller neighborhood stations that could attract walk-up and drop-off activity could be considered in downtown Derry and Windham. At this time however, the station site analysis was limited to locations that could accommodate the large parking demands associated with the regional service.

Since this service is a branch off an existing MBTA line (unlike the West Rail Corridor, that is a direct continuation of service), Lawrence Station will be designated as milepost 0. The following is a brief description of each station and their planned facilities.

Salem – I-93/Exit 1 Rockingham Park (MP 6.2)

The proposed station site in Salem is in the vicinity of Rockingham Park west of NH 28 and just north of Rockingham Park Boulevard. The general locus of the station is shown in Figure 4-3. This site has easy access to both NH 28 and I-93 through the Rockingham Park Boulevard interchange (Exit 1). It would draw commuters from Derry, Windham, Salem and other surrounding towns. In the area identified for the station, approximately 400 parking spaces would be provided.

Londonderry - I-93/Exit 5 (MP 19.4)

Located in the northwest quadrant of the I-93/NH 28 interchange in Londonderry, this proposed station site would draw commuters from the entire region. As shown in Figure 4-4, this station would provide an excellent alternative for southbound commuters with its easy access from I-93 via Exit 5. A shuttle bus connection to Manchester Airport could also be provided to draw on the market created by the airport's recent expansion efforts. The required 500 parking spaces can be accommodated at this location.

Airport Station (MP 22.8)

As an alternative to the Londonderry I-93/Exit 5 site and the operation of a shuttle bus connection to the airport, it may be advantageous to locate a station adjacent to the airport. This facility could be constructed to provide an easy connection between the rail service and the airport to further draw on the market created by the airport's recent expansion efforts. A small parking facility could be provided however, the focus of this station would be the intermodal connection to take advantage of the proximity of the rail to the Airport Terminal. This station option is only feasible with the proposed tunnel alignment option. Figure 4-5 illustrates the general station locus and intermodal connectivity of the site.

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Manchester – Downtown @ Commercial Street (MP 27.8)

The proposed Downtown Manchester station site is located at the south end of Commercial Street on the west side of the old Manchester freight yard. The five-acre site is bounded by Commercial Street to the north, the NHML to the east, the Goffstown Branch to the south, and the Merrimack River to the west. The general locus of the proposed station site is shown in Figure 4-6. Commercial Street connects to US 3 and I-293 within one mile of the site. This station will primarily serve the local Manchester market. A 500-space parking lot will be required on the site.

The City of Manchester has examined this site as the potential location for a multimodal transportation center to allow intercity bus, local bus, and future rail service to converge at one convenient point in the city. The NHDOT recently applied for funding through the CMAQ Program to construct the park-and-ride lot. This application is based on the NHML (West Rail Corridor) being designated as the commuter rail service corridor. In order to make this site work for the East Rail Corridor, some modifications to the site layout will be required. Most notably, the platforms will need to be constructed adjacent to the M&L line with a pedestrian connection to the proposed park-and-ride lot. This connection will need to cross the NHML. It is likely that this crossing will need to be grade separated (pedestrian overpass).

Layover Facility – Manchester Freight Yard (MP 27.8)

There is no existing facility in Manchester to accommodate the overnight storage and servicing of the passenger trains. Provision of a layover and maintenance facility will help to provide flexibility for future passenger train operations. Without this layover facility, each of the last northbound trains in the afternoon/evening would have to deadhead back to Lowell or Boston for storage and servicing, resulting in higher operating costs and potential constraints on the early morning service schedule. It is assumed that this facility could be located in the Manchester Freight Yard as shown in Figure 4-6. All new infrastructure (track, buildings, utilities) will be required as discussed in section 5.2.

4.1.3 Speed and Travel Time

Infrastructure improvement plans for the corridor call for the replacement of all existing rail, and the upgrading of other track material to allow a 60-mph passenger train operating speeds where conditions permit. Travel times were calculated based on the acceleration and deceleration specifications for a traditional diesel-locomotive hauled locomotive passenger train. Based on station stops and geometry constraints travel time between Manchester and Lawrence is approximately 31-minutes. This includes 40 seconds of dwell time at each of the proposed three intermediate stations. Total travel time between Manchester and Boston's North Station is estimated to be between 84 and 105 minutes. Table 4.1-1 summarizes the travel time estimate.

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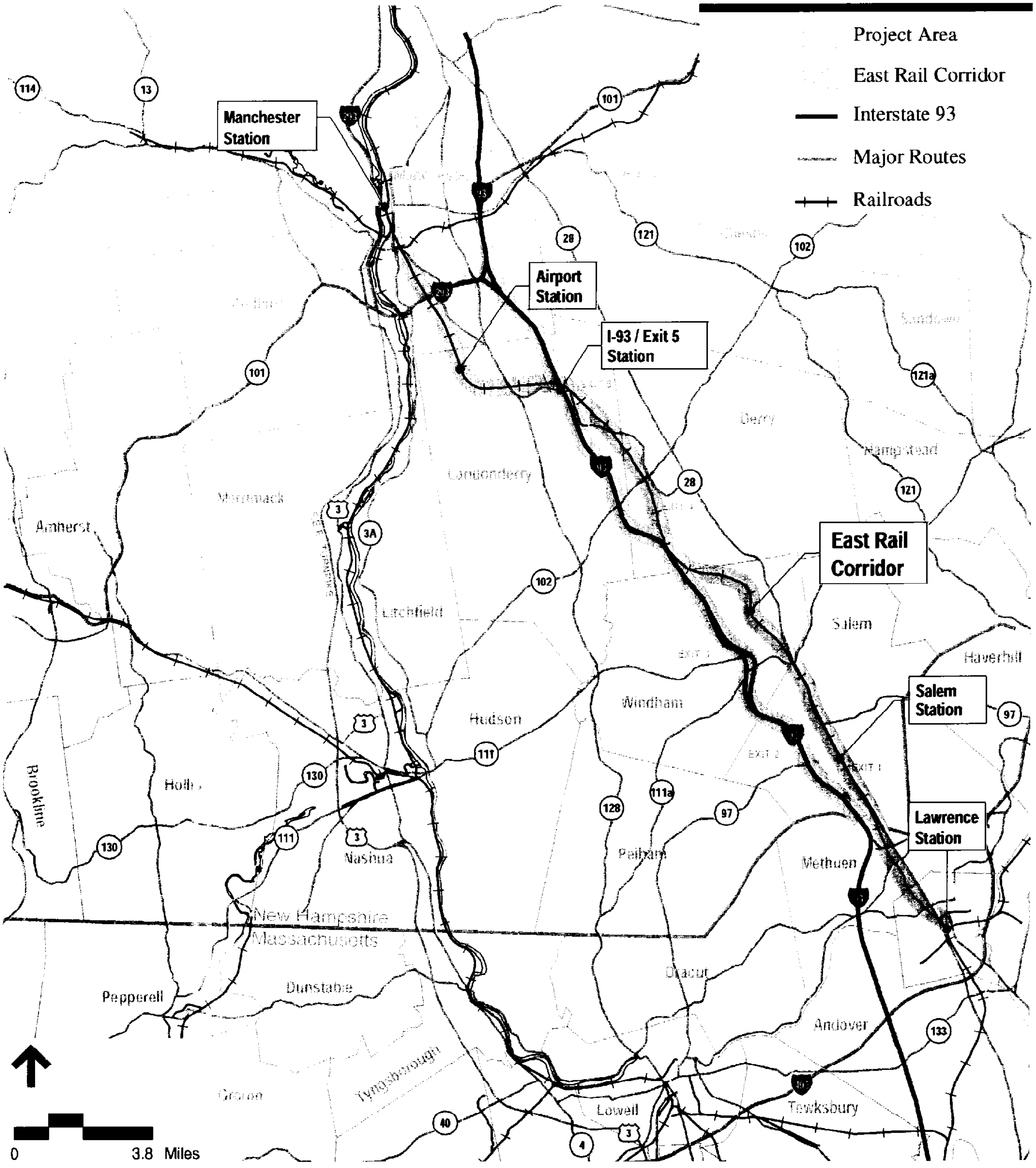

Vanasse Hangen Brustlin, Inc.

East Rail Corridor
Route Layout

Figure 4-1

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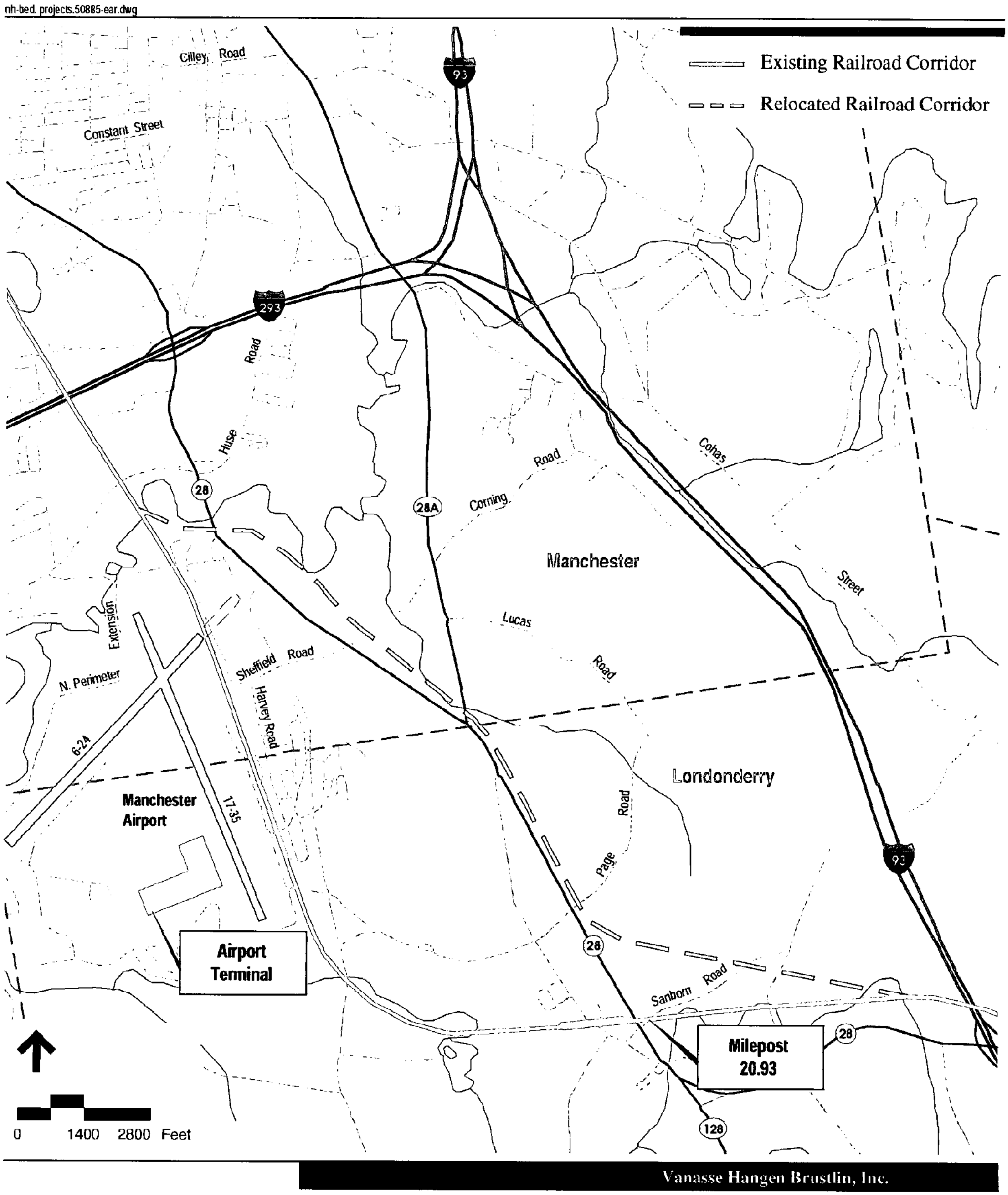

East Rail Corridor
Airport Right of Way Relocation

Figure 4-2

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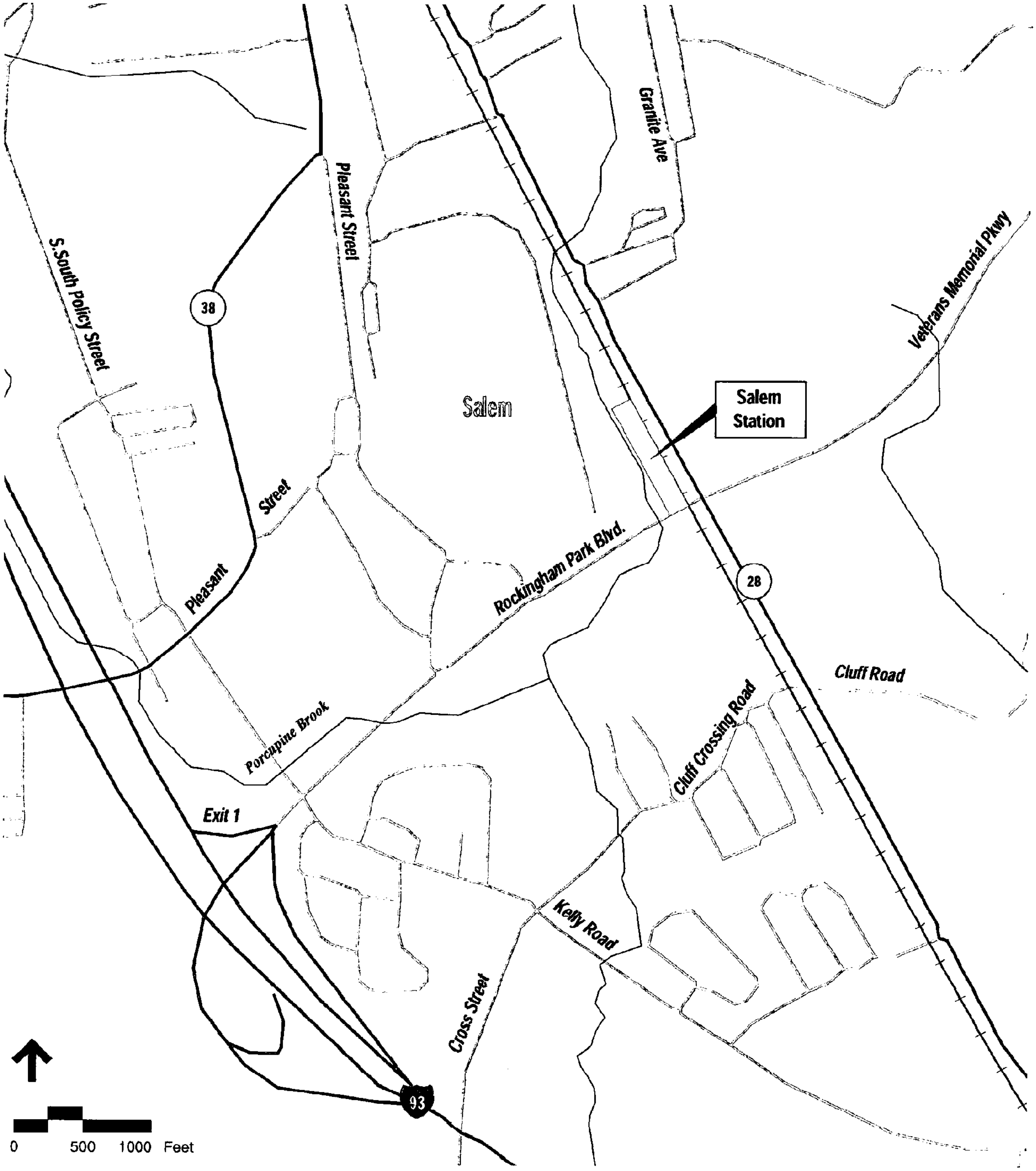

East Rail Corridor
Salem I-93/Exit 1 Station
Site Location

Figure 4-3

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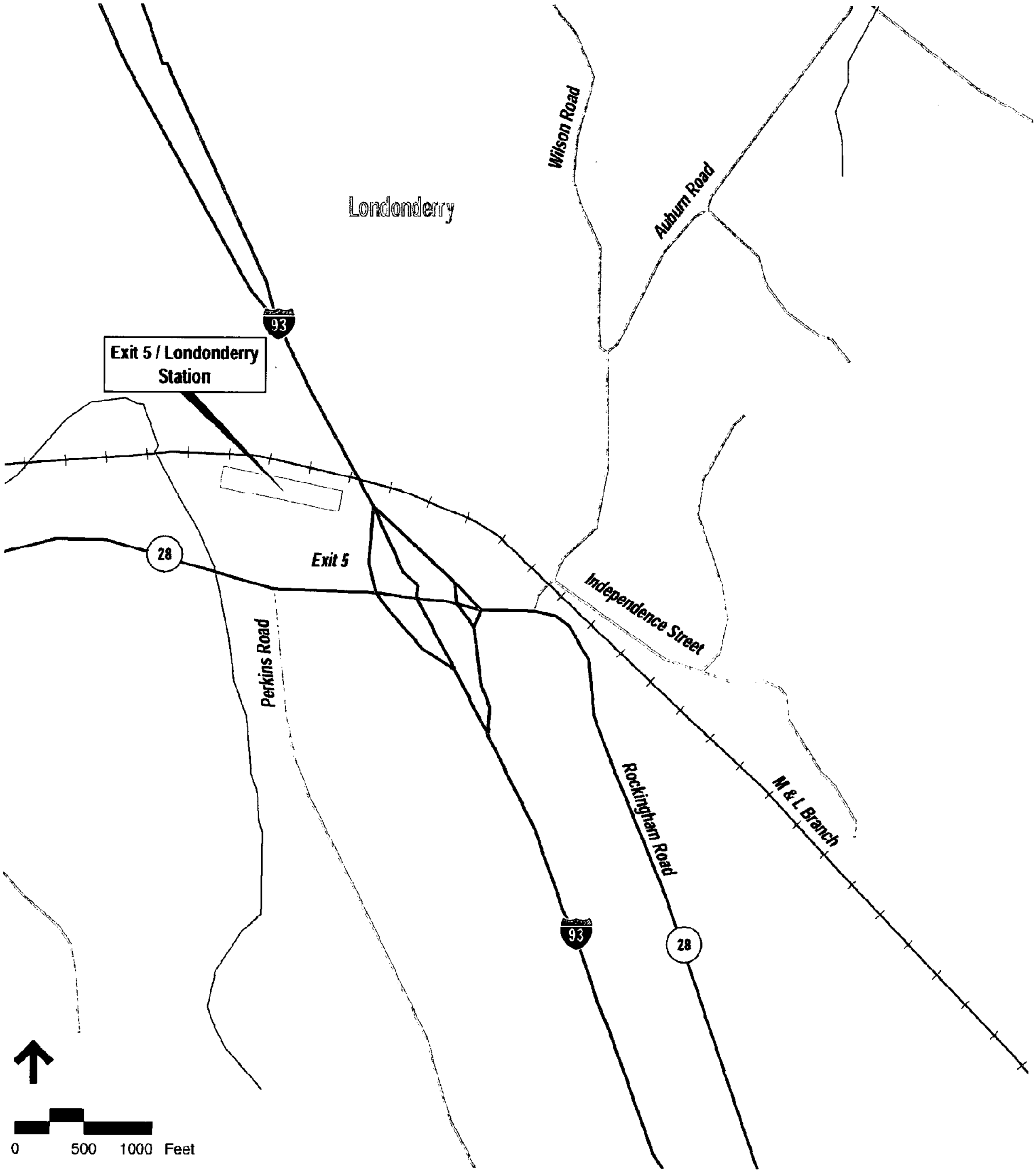

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East Rail Corridor
Exit 5 / Londonderry Station

Figure 4-4

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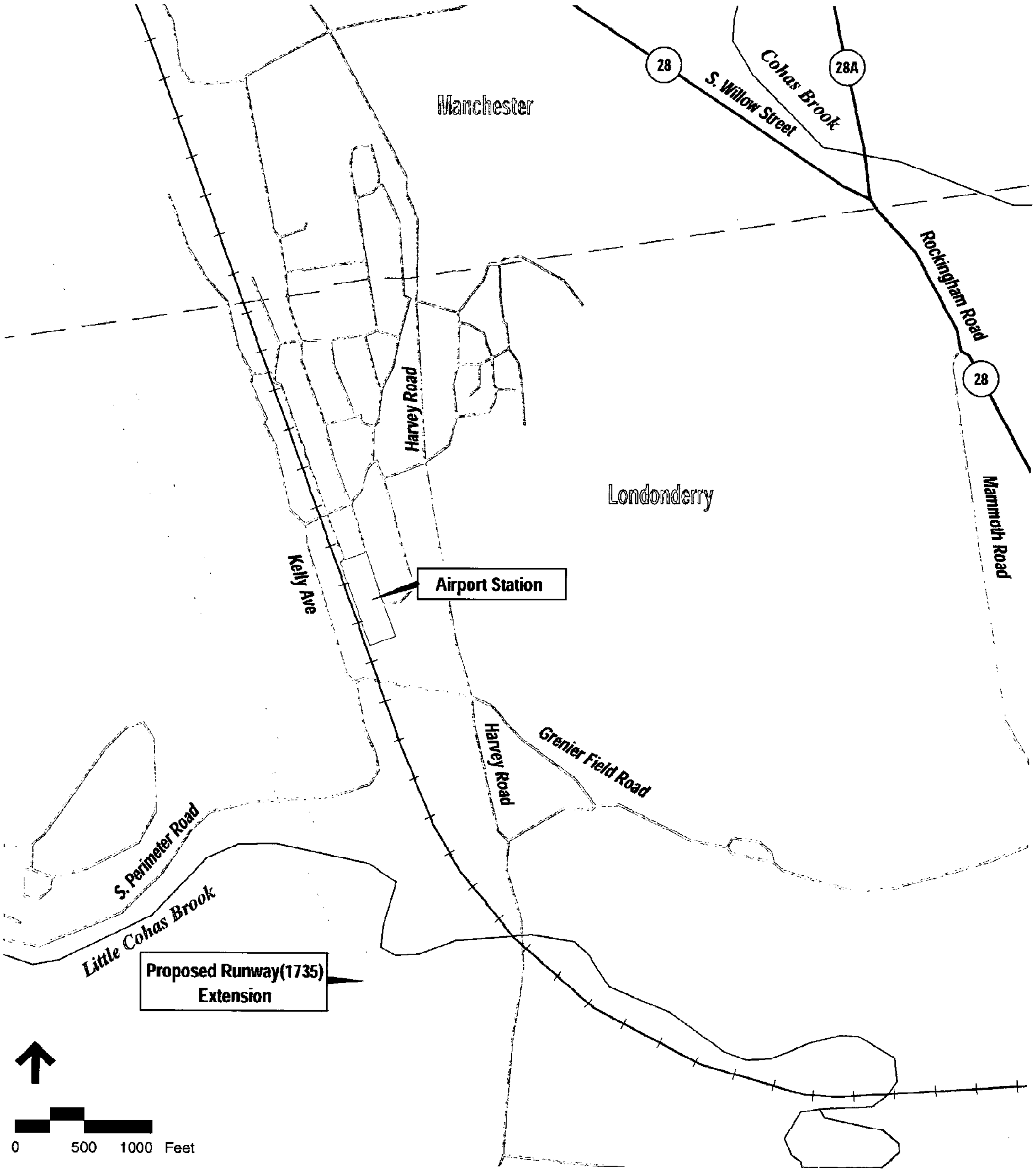

Vanasse Hangen Brustlin, Inc.

East Rail Corridor
Airport Station
Site Location

Figure 4-5

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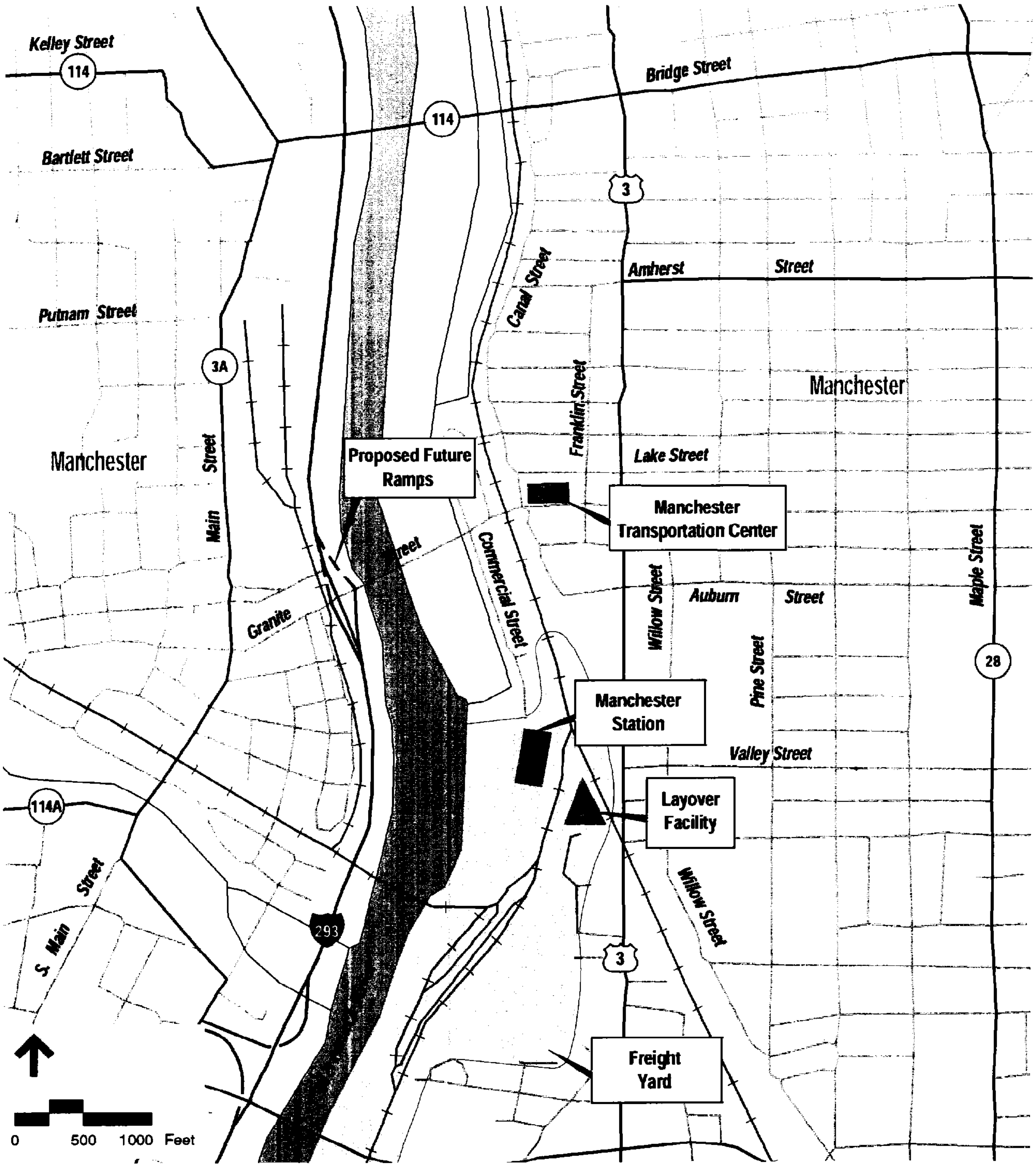

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East Rail Corridor
Manchester Station
Site Location

Figure 4-6

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Table 4.1-1
East Rail Corridor: Estimated Travel Times

Segment	Travel Time [min]
Manchester to I-93/NH 28/Airport	10
I-93/NH 28/Airport to Salem	14
Salem to Lawrence	7
Transfer Time*	5 – 15
Lawrence to Boston (varies)	48 - 59
Total Travel Time	**84 – 105**
Average Peak Direction Travel Time	**94**

* Scheduled transfer time of 5 minutes during peak period in predominant direction of travel. Off-peak and reverse peak transfer times vary up to 15 minutes in length.

4.2 Proposed Service Description

The proposed service description includes a definition of the level service, development of a preliminary operating plan, and consideration of the equipment requirements. The following paragraphs summarize these aspects of the proposed East Rail Corridor Service.

4.2.1 Service Alternatives

Lawrence Station is the third to last outbound stop on the MBTA's Haverhill Line. Existing service continues north of Lawrence to stations in Bradford and Haverhill where service terminates. The existing Haverhill service focuses on the weekday peak periods with the majority of service scheduled in the predominate direction of travel (to Boston in the morning, to Haverhill in the evening). There are few reverse peak period trains to Haverhill because of the significant amount of single-track located along the line. This operation presents a constraint for the provision of additional service between Lawrence and Boston.

Unlike Lowell Station that is at the end of an existing line where service terminates, Lawrence is a mid-point (or mid-line) station. Existing service cannot be routed to Manchester without reducing the frequency of service to Haverhill. With the current infrastructure constraints on the Haverhill Line, it does not appear possible to accommodate direct through service to Manchester. Therefore, the service proposed for the East Rail Corridor will operate as a shuttle service between Manchester and Lawrence. In Lawrence passengers will be required to transfer to existing MBTA trains to reach points south to Boston or north to Haverhill.

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As with the West Rail Corridor, three service alternatives are proposed for the Lawrence to Manchester service. The service alternatives vary in the number of trips offered and the frequency of weekend service.

Alternative 1 – High

This alternative includes 12 roundtrips (24 total trips) with six morning roundtrips and six afternoon/evening roundtrips. During the weekday morning peak period, the southbound trips from Manchester are able to meet four inbound Haverhill Line trains arriving in Boston before 9 AM. During the PM peak period, the northbound trips are able to meet four outbound Haverhill Line trains that depart Boston between 4:25 PM and 7:00 PM. Altogether, 10 of the 12 southbound trips and nine of the 12 northbound trips are able to connect with Haverhill Line trains. On weekends, 4 round trips are provided on both days.

Alternative 2 – Moderate

This alternative offers eight roundtrips (16 total trips) with four morning roundtrips and four afternoon/evening roundtrips. During the weekday morning peak period, the southbound trips are able to meet three Haverhill Line trains that arrive in Boston before 9 AM. During the PM peak period, northbound trips are able to meet three outbound Haverhill Line trains that depart Boston between 4:25 PM and 7:00 PM. Altogether, seven of the inbound trips and six of the outbound trips are able to meet Haverhill Line trains. On weekends, 3 round trips are provided on both days.

Alternative 3 – Low

This alternative offers six roundtrips (12 total trips) with three morning roundtrips and three afternoon/evening roundtrips. During the weekday morning peak period, the southbound trips from Manchester are able to meet two inbound Haverhill Line trains arriving in Boston before 9 AM. During the PM peak period, the northbound trips are able to meet two outbound Haverhill Line trains that depart Boston between 4:25 PM and 7:00 PM. Altogether, five of the six southbound trips and five of the six northbound trips are able to connect with Haverhill Line trains. Weekend service will include 3 round trips on Saturday only.

4.2.2 Schedules

Conceptual service schedules for these three scenarios, with departure times at each of the stations, can be viewed in Appendix F. The schedules are focused on providing service to Boston in the morning and back to Manchester in the evening. This service is provided through connections with the existing MBTA service at Lawrence Station. In the development of these schedules, it was assumed that current train schedules between Lawrence and Boston would remain unchanged in an effort to minimize the disruption of existing MBTA service.

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4.2.3 Equipment Requirements

The proposed service between Lawrence and Manchester is designed to maximize the use of operating personnel and equipment. The equipment requirements vary depending on the service scenario (low, moderate, or high) selected. These requirements are based on the proposed schedule of service. As noted in Section 4.2.1, the service between Manchester and Lawrence is limited to a shuttle train operation. For operations planning purposes, the shuttle train has been assumed to include of a single locomotive and three coaches with one of the three coaches being a cab control coach.

For the service extension from Lawrence to Manchester, the requirements are somewhat easier to assess than for the West Rail Corridor service. There are a variety of owners along the East Rail Corridor alignment: the MBTA, GTI, NHDOT, and potentially the Manchester Airport Authority if a tunnel is constructed beneath Runway 6-24. To operate service over this single track segment, an operating agreement is required between the state of New Hampshire, GTI, the MBTA, and possibly the MAA. The terms of this operating agreement will define how service is to be operated. Ultimately, this agreement, through the operating terms, will dictate the number of additional equipment sets necessary to operate the service. It is anticipated that one train set, consisting of a locomotive and three coaches, is required to operate the low service scenario and two sets are required to operate the moderate and high service scenarios. An additional spare train set would be required for each of the alternatives to provide backup for maintenance, overhaul, and potential breakdowns of trains.

4.3 Ridership and Revenue Projections

Ridership projections have been estimated for the East Rail Corridor Alternative. These estimates are generally based on the moderate level of service where sufficient peak period service is provided so that altering the timing of work trips is not required. Further details regarding the specific methodology of ridership estimation are provided in Appendix B. Based on the ridership estimates, farebox revenue projections have also been calculated for the East Rail Corridor Service.

4.3.1 Ridership

The projections of station boardings in 2020 are included in Table 4.3-1 for the East Rail Corridor. These projections are based on the operating plan described in this chapter summarized as a rail shuttle operation between Manchester and Lawrence and a transfer to the MBTA commuter rail system at the Lawrence Station. All ridership is projected from commuter work trips to Boston with the standard commuter rail trip impedances, as detailed in the ridership projection methodology in Appendix B, and the addition of a 5 minute transfer to MBTA commuter rail service in Lawrence. The boardings in Table 4.3-1 represent approximately one-half of the average daily trips attributable to the commuter rail shuttle service, with the other half of the trips ending at the new stations. The projected total daily ridership for the East Rail Corridor Alternative service between Lawrence and Manchester is 1,814 trips (907 inbound trips, 907 outbound trips).

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Table 4.3-1
East Rail Corridor: 2020 Daily Station Boardings

Station	Boardings
Downtown Manchester	179
Exit 5/Londonderry	393
Exit 1/Salem	335
Total Daily Boardings	907

4.3.2 Revenue Projections

As previously discussed in Section 2.3.2, it has been assumed that the MBTA commuter rail zone fare system would be applied for the purposes of this study. This system has established service zones based on the distance from Boston to the outlying station. The further the outlying station is located from Boston, the higher the fare. The revenue generated from passenger fares attributable to the service will be the incremental fare between the boarding station in New Hampshire and Lawrence the for Boston bound riders, or the interzonal fare between the boarding station and Lawrence for intermediate stop customers.

The proposed I-93/Exit 1 Station in Salem is located approximately 32 miles from North Station in Boston. This distance places the proposed station in Zone 7 that presently includes the Haverhill and Rowley stations. The one-way fare for trips from Zone 7 is $3.75.

The proposed I-93/Exit 5 Station and Airport Station in Londonderry are located approximately 44 miles and 49 miles respectively from North Station in Boston. This distance places the proposed stations in Fare Zone 9. The MBTA's Zone 9 currently includes the Leominster and Fitchburg stations that are located approximately 45 and 50 miles from North Station. The current one-way fare for Zone 9 trips is $4.75.

The proposed Manchester station is located approximately 54 miles from North Station. The MBTA presently does not have any stations beyond a 50-mile distance from Boston. In the past, there was a station located in Gardner that was approximately 60 miles from North Station. It was included in Zone 11 where a one-way fare was $6.00. The MBTA fare commuter rail fares have not changed since the Gardner Station was in service. Therefore, it will be assumed that the proposed Manchester Station is located in Zone 11.

The MBTA offers a substantial discount to commuters purchasing monthly passes. For Zone 9 (I-93 Exit 5 and Airport stations), the monthly pass to Boston costs $136 compared to $209 for an average of 22 round trips per month at full fare ($4.75 one-way, $9.50 round trip). The monthly savings to Zone 9 commuters is $73. Therefore, it is cost effective for the commuter to purchase a monthly pass for as few as 15 round trips per month.

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Since this analysis is based primarily on work trips, it has been assumed that 90% of the projected riders purchase monthly passes to Boston and 10% purchase passes for intermediate destinations. Using these assumptions, the annual revenue projection for the moderate service scenario is about $268,000. Table 4.3-2 summarizes the revenue estimates. The revenue calculations are included in Appendix C.

Table 4.3-2
East Rail Corridor: Annual Ridership and Revenue Projections

Station	Total Annual Trips	Annual Revenue ($ million)
Exit 1 /Salem	91,290	$0.05
Exit 5 /Londonderry	200,460	$0.13
Downtown Manchester	170,850	$0.09
Total	462,570	$0.27

4.4 Annual Operating Costs

Preliminary annual operating costs were calculated based on estimated train miles and the current MBTA commuter rail operating costs. The *Draft MIS for Nashua Passenger Rail Service* reports that the MBTA's budgeted cost is $45 per train mile for the 1999 fiscal year. This number was adjusted by a 3.5% inflation rate for year 2000 to $46.50 per train. This unit cost includes four general categories of costs:

- Transportation – The costs associated with the personnel directly involved in the movement of trains or buses. This includes the salaries of train engineers, conductors, trainmen, and supervisors.
- Administrative – The cost to administer the service and manage the operating personnel.
- Mechanical (Vehicle Maintenance) – The costs to maintain and operate the equipment. This includes the daily cleaning and maintenance of the equipment, all major overhaul and repair work, and fuel costs.
- Engineering (Non-Vehicle Maintenance) – The right-of-way maintenance costs. This includes items such as rail replacement, pavement maintenance, grade crossings and the electrical system.

The unit operating cost of $46.50 per train mile reflects a typical MBTA consist of one locomotive and seven to eight coaches. The MBTA staffs each peak period train with one engineer, one conductor, and two trainmen (or an assistant conductor and one trainmen). The proposed train consist for the planned service is one locomotive and three coaches. Assuming that you can operate the shuttle trains with one less crew member (using only an engineer, conductor, and one trainman) and that the locomotive maintenance

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represents a disproportionate share of the mechanical cost component, the average unit cost of $46.50 per train mile was reduced by 40 percent to $27.90 to reflect the operating cost of the shuttle train. These unit costs reflect the total cost to provide the desired service and include transportation, mechanical, engineering and administrative costs. Table 4.4-1 summarizes the operating costs for all three service scenarios.

Table 4.4-1
East Rail Corridor: Annual Operating Costs (2000 Dollars)

Service Level	Annual Train Miles	Operating Costs
Low	102,200	$2.9 m
Moderate	129,900	$3.6 m
High	191,700	$5.4 m

Since portions of the line are owned and operated by the State of New Hampshire, GTI and the MBTA an access agreement between the three parties will be necessary. There are three major components of the access agreement: train operations, infrastructure maintenance and liability assignment. Each of these components will require negotiations, which will impact operating costs. As discussed previously, equipment costs can vary with the outcome of the train operations component of the agreement. Typical maintenance costs have been included in the costs detailed above, however they also can vary depending on the terms of the access agreement. The greatest unknown in terms of operating costs are those associated with the assignment of liability. Although a starting point for negotiations with GTI will likely be similar to recent agreements for passenger rail service in Vermont and Maine, the terms and costs associated with assigning liability can vary widely as the magnitude will not be known until negotiations get underway.

4.5 Capital Equipment Costs

As discussed in section 4.2.3, the East Rail Corridor rail service alternatives will require the procurement of additional locomotives and coaches to provide the proposed service. The number of additional trains varies by the amount of service operated. A detailed fleet management plan for the MBTA's Northside commuter rail service will also be needed to determine the number of additional coaches required for the Haverhill Line to accommodate the additional ridership.

Since the proposed service for the East Rail Corridor is a shuttle between Manchester and Lawrence, the equipment requirements are fairly straightforward. A single shuttle train set consisting of a locomotive and three coaches is all that could be required for the Low service scenario. With the Moderate and High service scenarios, a second shuttle train consist is required. One spare set of equipment is required for each service scenario.

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The cost for a set of equipment varies depending on the type of passenger coach (single level or bi-level, control coach (operators controls for push-pull operation or blind coach) and the number of coaches in the consist. For planning purposes, the following equipment costs should be considered:

- Diesel locomotive - $2.5 million
- Control cab coach - $2.0 million
- Blind coach - $1.1 million

For the three coach shuttle consist, the cost is approximately $6.7 million. These unit costs represent averages. A contingency of 20 percent is recommended for planning purposes at the current stage of project development. Table 4.5-1 summarizes the capital equipment cost estimates for the three service scenarios.

Table 4.5-1
East Rail Corridor: Capital Equipment Costs (2000 Dollars)

	Cost ($M)		
Service Level	Sub-Total	Contingency	Total
Low	$13.4	2.7	$16.1
Moderate	$20.1	4.0	$24.1
High	$20.1	4.0	$24.1

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East Rail Corridor: Infrastructure Improvements

This section of the report presents the recommended infrastructure improvements necessary to support commuter rail service between Lawrence and Manchester. Part of the East Rail Corridor track structure is currently classified as FRA Class 1 which allows passenger train operating speeds up to 15 mph and 10 mph for freight trains. The remaining track structure has been removed and the right-of-way has been abandoned. The following proposed improvements are focussed on developing a Class 4 track structure. The track will then be maintained to Class 3 standards, which will allow the operation of passenger trains up to 60 mph except where restricted by geometric and civil constraints.

The recommended improvements are based upon a review of existing infrastructure conditions and the proposed Operations Plan described in Chapter 4. The recommendations consider the constraints of the existing infrastructure and the needs of the current and future users of the rail corridor. In addition, both the tunnel option and the relocation right-of-way option are considered at the airport.

5.1 Layout

The proposed service would utilize approximately 27 miles of the Manchester & Lawrence line (M&L). Stations are proposed in Lawrence at the existing MBTA station, in Salem at I-93/Exit 1 near Rockingham Park, at the I-93/Exit 5 (NH 28) interchange in Londonderry, at Manchester Airport, and in downtown Manchester. The existing conditions report identified some significant challenges to the construction of this line including issues resulting from the expansion and relocation of the airport as well as the need for new structures (bridges).

The East Rail Corridor track structure is either in poor condition or non-existent. A complete reconstruction would be necessary to provide safe and reliable commuter rail service. The right-of-way from milepost 20.93 in Londonderry to Elm Street in Manchester (MP 26.8) was purchased by the Manchester Airport Authority to allow for expansion of the Airport. The segments north and south of the Airport that are not required as part of the expansion were purchased by the NHDOT (June 200). The Airport runway 6-24 has been extended, discontinuing the corridor between MP 23 and 24, through the Airport. For planning and estimating purposes, both

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construction of a tunnel under the extended runway 6-24 (Option 1) and relocation of the alignment (Option 2) are considered. The proposed line would be single track except for a 2-mile segment in Derry where a passing siding will be located. This siding is necessary to accommodate the passing of trains.

5.2 Capital Infrastructure Program

A series of specific infrastructure improvements were developed based on the existing conditions and standard rail infrastructure design criteria. These improvements are illustrated in Figure 5-1 (a) and (b) for the existing M&L alignment. As noted previously, the existing M&L alignment has been severed between MP 23 and 24 at the airport. Figure 5-1 (c) illustrates the approximate location of the relocation alignment and notes the major features (grade crossings, structures). The general approach along the track segment at the airport is discussed in the following section.

5.2.1 Alignment and ROW

The proposed service will follow the existing alignment from Lawrence to milepost 20.93 in Londonderry. From MP 20.93 to downtown Manchester there are two options. The first option is to follow the existing M&L alignment. This option would require the construction of a tunnel beneath Runway 6-24 at the airport. The tunnel would descend just north of the Harvey Road crossing (MP 22.2) to the runway and ascend to meet existing grade between Gold Street (MP 24.9) and Spring Garden Street (MP 25.9). Existing streets crossing the railroad right-of-way (Perimeter Road, George Street, Bouchard Street and Perimeter Road) will require the construction of bridges to cross the below-grade rail line.

The second option is to follow a proposed new alignment developed by the NHDOT. This new alignment departs from the M&L alignment at approximately MP 20.5 just west of the I-93 southbound overhead structure. The alignment travels along the east side of NH 28 for approximately 4.2 miles. It rejoins the M&L alignment just north of Cohas Brook at Gold Street (MP 24.9). Figure 4-2, previously shown, illustrates the location of the new alignment. All street crossings are assumed to be at grade.

From MP 25 to 27.3, both alignment options will follow the existing M&L right-of-way to the NHML junction located in the Manchester Yard. Both alignments will be single track except for a 2-mile passing siding in Derry.

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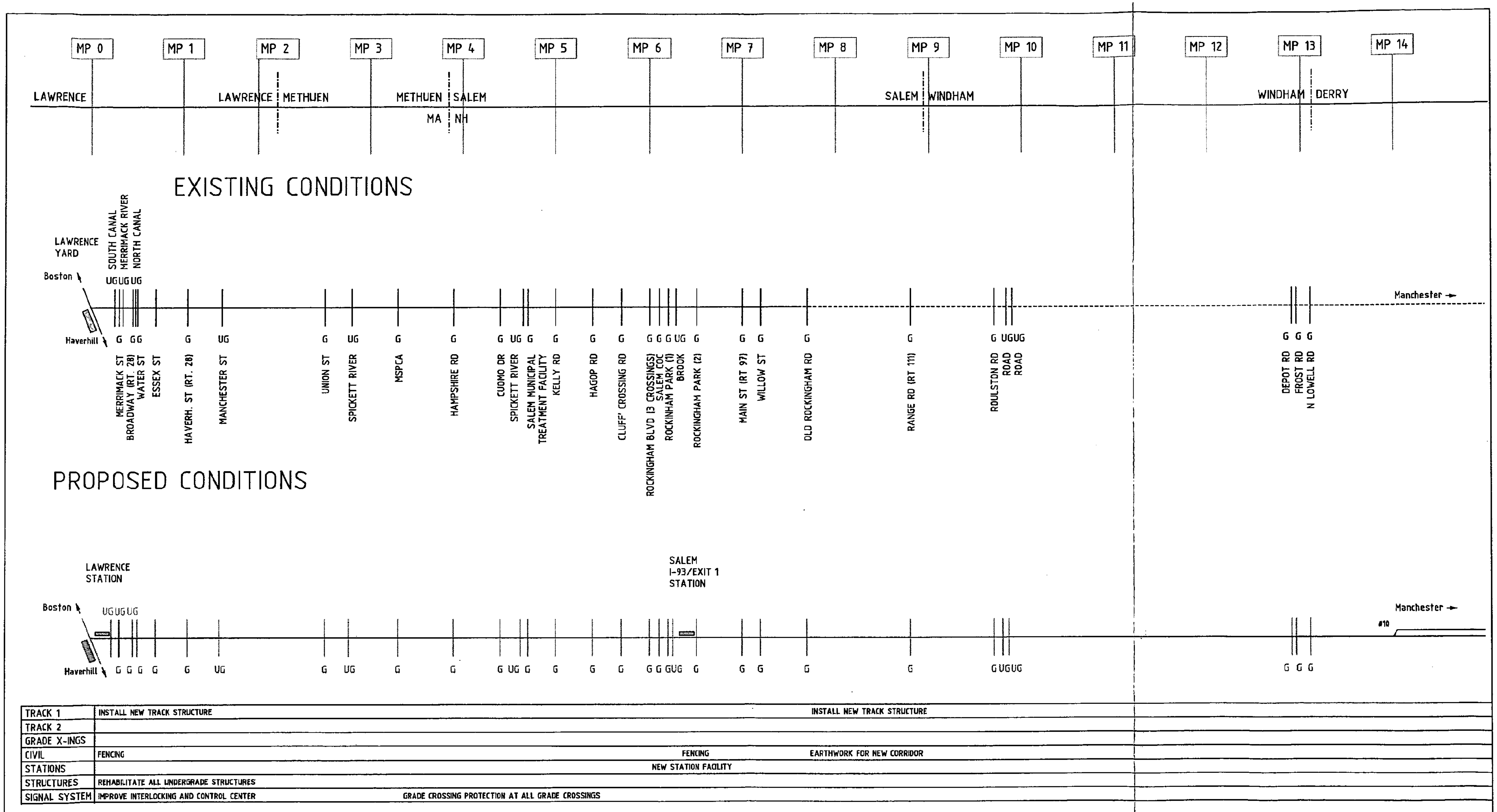

Legend

Existing Conditions	Proposed Conditions	
Existing ———	Existing ———	G = At Grade Crossing
Abandoned - - - - - -	Proposed ———	UG = Undergrade Bridge (Railroad over Road)

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East Corridor
Proposed Infrastructure Improvements

Figure 5-1 (a)

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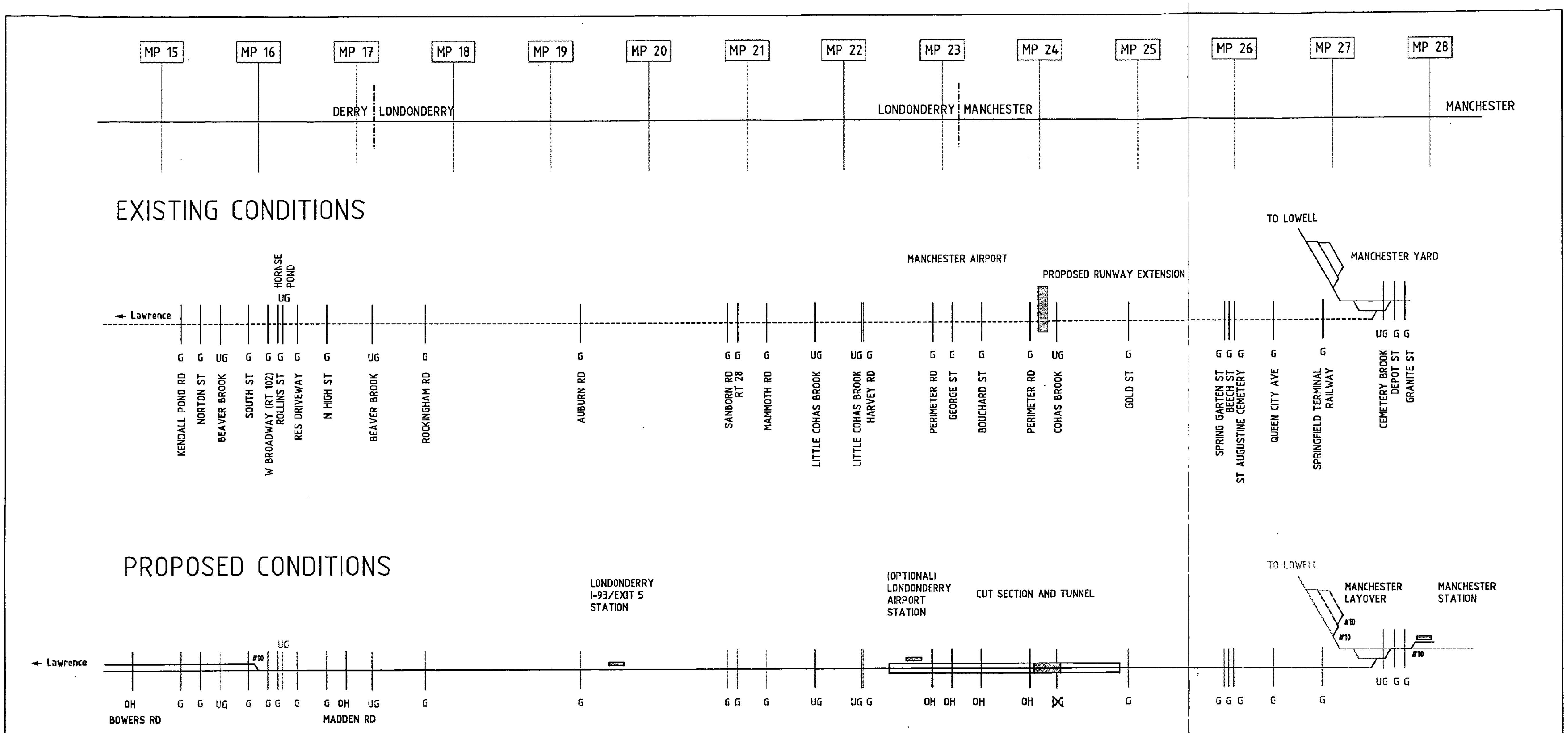

TRACK 1	INSTALL NEW TRACK STRUCTURE	NEW TURNOUTS, STATION AND LAYOVER TRACKS
TRACK 2	INSTALL NEW TURNOUTS AND TRACK STRUCTURE FOR PASSING SIDING	UPGRADE EXISTING TRACK FOR LAYOVER
GRADE X-INGS		
CIVIL	EARTHWORK FOR NEW CORRIDOR FENCING	FENCING
STATIONS	NEW STATION FACILITY NEW STATION FACILITY	LAYOVER FACILITY STATION FACILITY
STRUCTURES	NEW OVERHEAD STRUCTURE NEW OVERHEAD STRUCTURE REHABILITATE ALL UNDERGRADE STRUCTURES REPLACE EX. GC WITH OVERHEAD STRUCTURES & DEPRESS TRACKS INTO BOAT/ SECTION TUNNEL	
SIGNAL SYSTEM	GRADE CROSSING PROTECTION AT ALL GRADE CROSSINGS	

Legend

Existing Conditions

Existing ————

Abandoned ------------

Proposed Conditions

Existing ————

Proposed ————

G = At Grade Crossing

OH = Overhead Bridge (Road over Railroad)

UG = Undergrade Bridge (Railroad over Road)

Vanasse Hangen Brustlin, Inc.

East Corridor

Proposed Infrastructure Improvements

Option 1 :
Boat Section and Tunnel

Figure 5-1 (b)

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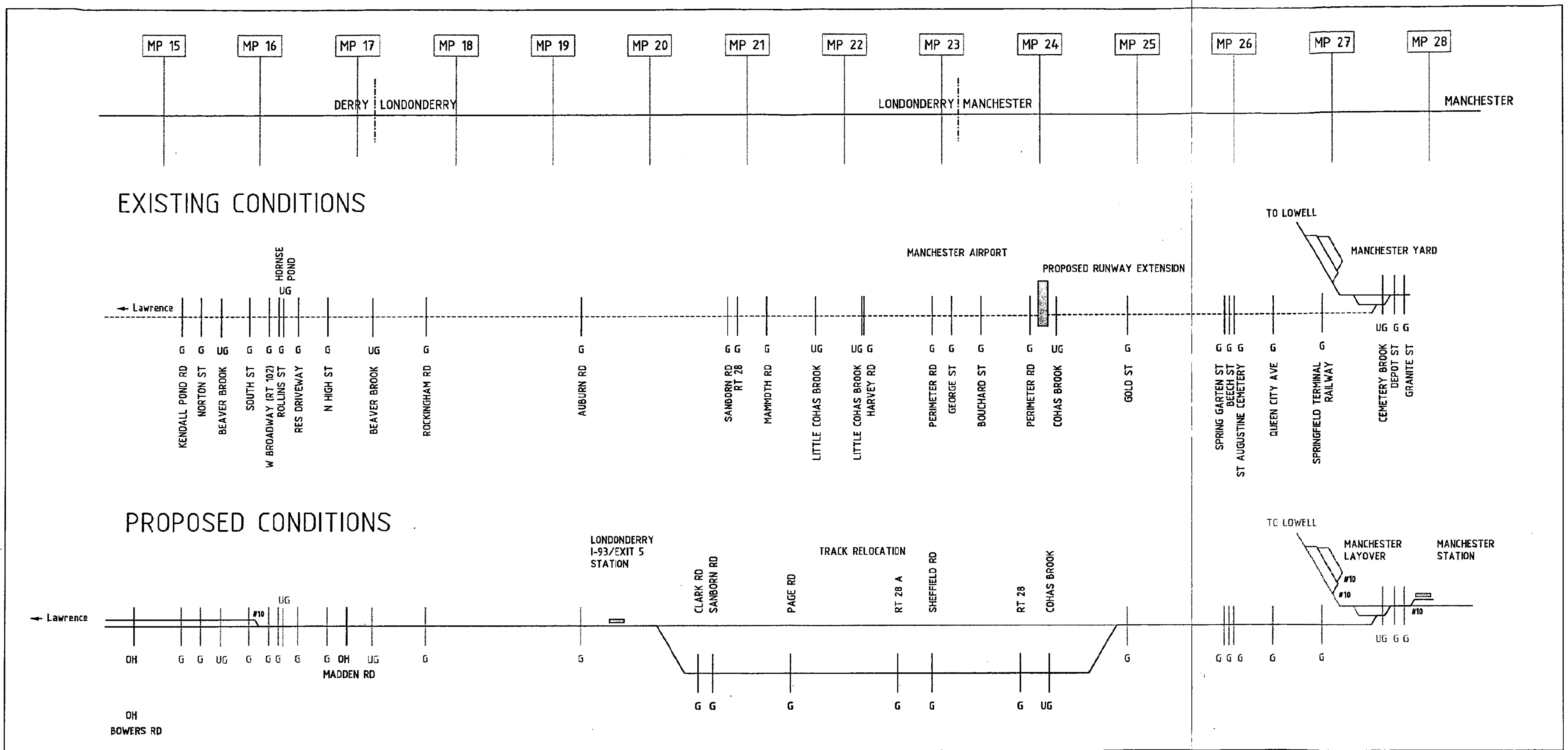

TRACK 1	INSTALL NEW TRACK STRUCTURE INSTALL NEW TRACK STRUCTURE FOR RELOCATION	NEW TURNOUTS, STATION AND LAYOVER TRACKS
TRACK 2	INSTALL NEW TURNOUTS AND TRACK STRUCTURE FOR PASSING SIDING	UPGRADE EXISTING TRACK FOR LAYOVER
GRADE X-INGS	INSTALL NEW GRADE CROSSINGS	
CIVIL	EARTHWORK FOR NEW CORRIDOR FENCING	FENCING
STATIONS	NEW STATION FACILITY	LAYOVER FACILITY STATION FACILITY
STRUCTURES	NEW OVERHEAD STRUCTURE NEW OVERHEAD STRUCTURE REHABILITATE/REPLACE ALL UNDERGRADE STRUCTURES INSTALL NEW CULVERT	
SIGNAL SYSTEM	GRADE CROSSING PROTECTION AT ALL GRADE CROSSINGS	

Legend

Existing Conditions	Proposed Conditions	G = At Grade Crossing
Existing ————	Existing ————	OH = Overhead Bridge (Road over Railroad)
Abandoned ------------	Proposed ————	UG = Undergrade Bridge (Railroad over Road)

Vanasse Hangen Brustlin, Inc.

East Corridor

Figure 5-1 (c)

Proposed Infrastructure Improvements

Option 2 :
Relocation

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5.2.2 Track Structure

The track structure includes the rail, ties, ballast, roadbed, special trackwork (i.e. turnouts, etc.), and other track material.

Rail

Since all remaining rail on the M&L line is in poor condition, new rail should be placed throughout the whole corridor. It is recommended that 115 pound continuous welded rail (CWR) be installed. Between Lawrence Station and the proposed Salem station, the existing rails will be replaced. In the abandoned section between the proposed Salem Station and the NHML, a complete new track structure including subballast, ballast, rails, and ties has to be installed.

Based on the Operations Plan, a passing siding is necessary between milepost 14 and 16 in Derry to allow for the scheduled meets between southbound and northbound trains. The siding should be approximately 2 miles in length to allow the meets to occur at speed rather than requiring one train to stop. At the Manchester Station a second track will be provided to serve the station platform.

Crossties

Existing ties only meet the minimum requirements for Class 1 operations. They should be completely replaced where they still exist and installed where the track is abandoned.

Other track material (OTM)

With the installation of CWR along the entire route, new, six-inch tie plates are required throughout. Anchors and spikes will also have to be replaced.

Ballast

The existing ballast and sub-ballast have to be replaced throughout the corridor, since the existing ballast is in poor condition and no ballast is present in the abandoned section.

Special trackwork

New turnouts are required at the two siding locations and at the Manchester Yard. Existing turnouts in Lawrence and at the Manchester Yard will have to be replaced.

Drainage

Throughout the corridor the drainage is mostly in fair to poor condition. Ditches will have to be cleaned and rebuilt in many locations.

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5.2.3 Grade Crossings

There are 50 existing grade crossings along the East Rail Corridor, of which 42 are public and 8 are private crossings. With the construction of the tunnel under Runway 6-24, a minimum of four grade crossings (Perimeter Road, George Street, Bouchard Street, and Perimeter Road) will be eliminated and replaced by overhead structures. This would reduce the number of at-grade crossings along the route to 46. If the alignment is relocated between MP 20.93 and MP 25, seven existing crossings (NH 28, Mammoth Road, Harvey Road, Perimeter Road, George Street, Bouchard Street, and Perimeter Road) will be eliminated but six new ones will be created (Clark Road, Sanborn Road, Page Road, NH 28A, Sheffield Road, and NH 28). The relocated rail alignment at the airport would result in a total of 49 at-grade crossings along the route.

At the public crossings, the installation of a new rubber crossing surface material is recommended. The private crossings will need to be evaluated individually to assess the appropriate surface treatment. Recommendations regarding highway crossing warning systems are presented in section 5.2.7.

5.2.4 Civil

Fencing

Few sections of fence exist along the route. Open access is available from nearly all adjacent properties. In urbanized areas, pedestrian traffic across the rail line would present a potential hazard. Therefore, fencing is recommended where the right-of-way passes through the cities of Lawrence, Derry, and Manchester. The specific locations are the first 1.25 miles north from Lawrence Station, in the town of Derry for a length of 1.5 miles, and within Manchester for about 3 miles.

Earthwork

General clearing and grubbing will be necessary along most of the existing corridor to prepare the roadbed for the new tracks. The existing subballast has to be replaced in most cases, therefore excavation is required in these locations. In several areas along the abandoned section, excavation and filling might be necessary to establish the new alignment. Based on the field review it is anticipated that about 50% of the abandoned section will require earthwork. The roadbed will have to be regraded and aligned to accommodate the replacement of the sub-ballast.

With the tunnel (Option 1) at the airport, significant earthwork will be required. To get the tunnel deep enough to pass safely below the runway pavement structure, it has been assumed that the tracks will begin descending just north of the Harvey Road crossing (MP 22.2). The tracks will start to ascend just north of the runway reaching the existing grade between Gold Street (MP 24.9) and Spring Garden Street (MP 25.9). The track structure will be constructed in an open cut section except for the tunnel beneath the runway and a short tunnel beneath Cohas Brook.

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The relocated right-of-way (Option 2) also will require significant earthwork. The entire 4.2-mile section will need to be cleared and grubbed. The route will need to be graded and an embankment constructed to support the track structure. Additional earthwork will be required at the six new grade crossings.

5.2.5 Stations and Facilities

Stations

In support of the proposed service, four station facilities and one layover facility are anticipated. These stations would be located in Lawrence, Salem at the I-93/Exit 1 interchange, Londonderry at the I-93/Exit 5 (NH 28) intersection, and in Manchester at the freight yard. A proposed station site adjacent to the Airport in Londonderry is an alternative to the I-93/Exit 5 station site if the tunnel concept is implemented. The proposed locations of these station sites were previously shown in Figures 4-3 through 4-6.

The station facilities will consist of a platform with canopy, benches, lighting, signage, surface walkways and drainage. Adequate parking facilities will be provided at each station based on projected ridership and parking needs. The station platforms will be high or low level depending on whether it has to accommodate freight service. Stations with freight service would require low level platform due to the width of the freight cars. To provide train access for the disabled, these stations will be equipped with a short, high-level access platform. Stations without freight service will have a full-length high-level platform that permits easy and quick train boarding. Although freight service currently only exists from Salem south, it is likely that freight rights will be retained along the length of the corridor.

The existing platform at the MBTA station in Lawrence is on the Haverhill Line just north of the junction with the M&L. Therefore, the proposed East Rail Corridor service could not use the existing platform without making a backup maneuver. There are two solutions to avoid this cumbersome, time-consuming operation. One is to relocate the entire Lawrence Station south of the junction. The other would be to create a second platform in the wye along the M&L Branch and to provide short and easy access between the two platforms allowing fast and convenient transfers. Since there may be freight traffic along the platform track, the platform would be a low-level platform with a mini-high-level platform and ramp for disabled passengers.

Layover Facility

As described in the Operations Plan, a layover facility is needed at the Manchester end of the route. This facility will accommodate the overnight storage of trains and allow for the routine daily cleaning and servicing of the equipment and any minor repairs. The location proposed for this facility is the Manchester Yard. New tracks would be constructed in the yard area to facilitate the layover of up to six trains. The facility would also include a small building for the service crew and supply storage.

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5.2.6 Structures

Undergrade Bridges

There are 16 undergrade bridge structures (i.e. bridges that carry the railroad over a roadway, waterway, or other physical feature) located along the M&L between Lawrence and Manchester. Based on the existing conditions report and the general lack of maintenance on the abandoned sections of the M&L ROW, it has been assumed that all open deck undergrade bridges will be replaced with ballast deck structures. The ballast deck structure helps to reduce future maintenance needs. This results in the replacement of ten bridges on the segment between Lawrence and the airport. Three existing arch bridges will be rehabilitated. From the airport to Manchester, two undergrade bridges may require replacement with the tunnel (Option 1) depending on the limits of the cut section. There appears to be only one undergrade bridge required (Cohas Brook) for the relocated alignment (Option 2).

Overhead Structures

Two new overhead structures will be required on the segment from Lawrence to the airport. At Bowers Street and Madden Road in Derry, the existing road overpass has been removed and the road profile lowered. Two new structures will be necessary to allow sufficient overhead clearance underneath the roads. From the airport to Manchester, four new overhead bridges (Perimeter Road, George Street, Bouchard Street, and Perimeter Road) will be required for Option 1. There do not appear to be any overhead bridge requirements on the relocated alignment (Option 2).

Cut/Tunnel Sections

Between MP 20.9 and MP 25, the tunnel option introduces two short tunnels: one about 1,500 feet long beneath the airport runway and another tunnel segment 200 feet or less under Cohas Brook. The top of rail in the tunnel is assumed to be approximately 54 feet below the existing runway surface. This elevation is based on an assumed runway pavement structure depth of 10 feet, a clearance of at least 16 feet between the base of the runway pavement structure and the roof of the rail tunnel, a roof slab thickness of 5 feet, and vertical clearance in the tunnel of 23 feet (AREMA) to allow for any future freight needs. The entire cut and tunnel section is approximately 15,000 feet in length (using a maximum grade of 1.5 percent). The cross-section for both the cut and tunnel segments is assumed to be wide enough for two tracks. Although the operations analysis indicates that at this point single track is sufficient in this area, a double-track cross section is preferred to accommodate the future needs of multiple users. Weighing the incremental cost of coming back later to construct a two track width versus providing the full two-track section in one step, it was assumed to be more cost-effective to build the wider section now. Therefore, the capital cost estimate reflects the two-track width throughout this 15,000-foot segment.

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5.2.7 Signal System

Currently there is no signal and communications infrastructure in place on the East Rail Corridor. A new system is necessary to provide safe and reliable operations. The two elements of the new system include the automatic highway crossing warning (AHCW) system and the wayside signal system. The following paragraphs briefly summarize these two elements of the signal system.

Automatic Highway Crossing Warning (AHCW)

The AHCW will control all movements between highway and rail traffic along the corridor. The proposed AHCW system would provide motorists and pedestrians with warnings at each of the active intersections. Modern solid-state, constant warning grade crossing predictors are proposed for installation at all public grade crossings and at several of the more active private crossings. This equipment is designed to provide a constant warning time to vehicular motorists regardless of the oncoming train speed. Use of auditory and visual signal systems provide warnings in compliance with FRA regulations. The final decision regarding the level of protection at each crossing will need to be made during the preliminary design stage of project development. A team of inspectors from the Federal Railroad Administration and the NHDOT will need to evaluate each crossing in detail and make a final recommendation regarding the appropriate level of protection. For cost estimating purposes, it has been assumed that the highest level of protection (gates, warning lights, and bells) will be installed at all grade crossing locations.

On the first seven miles of the corridor the signal system will also provide for the intermixed freight trains. The three grade crossings at Rockingham Boulevard in Salem will require coordination with the roadway intersection traffic signals because of the short distance between the crossings and the intersections.

Wayside Signal System

The wayside signal system controls all train movements along the corridor. There is no existing wayside control system in place. It is recommended that electronic coded track circuits be installed between control points. This equipment utilizes the rail for all train detection and wayside signal control.

A new wayside and AHCW system will need to be installed to permit efficient passenger train operations. It will be necessary to equip the passing siding track with two control points at the north and south ends. The existing Lawrence Station interlocking (the signals and turnouts that control and direct train movements through the station) and the MBTA Control Center will need to be rationalized (reconfigured). In addition, it will be necessary to reconstruct the existing interlocking at Manchester Yard.

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5.3 Capital Infrastructure Cost Estimate

5.3.1 Methodology

Capital infrastructure costs include improvements to the existing infrastructure like rail and other track materials, grade crossings, signal and communications system, undergrade bridge structures, and construction of new facilities like stations. These infrastructure capital cost estimates do not include the cost of real estate or environmental mitigation. The capital cost for equipment (locomotives and coaches) was previously discussed in section 4.5. The estimate accounts for the cost of construction contingencies, incidentals (unknowns) and design, survey, construction and administrative services. These items are added as a percentage of the total contract items.

5.3.2 Infrastructure Cost Estimate

Unit costs for the capital items were estimated using several sources. These sources include cost data from the MBTA and from other commuter rail properties. In developing the capital cost estimates, six general categories of costs were considered. They are:

- Track Structure (rails, ties, and other track materials), ballast, and sub-ballast.
- Grade Crossings: crossing surface and roadway safety improvements.
- Civil: New street (roadway) construction, clearing and grubbing, excavation and fill, and fiber optic cable relocation.
- Structures: bridges, culverts, tunnels and retaining walls.
- Facilities: stations, platform and parking for stations, and utilities for the layover.
- Signal System: the wayside signal system, train control, and at-grade crossing protection.

The total costs for the recommended infrastructure improvements are summarized in Table 5.3-1. More detailed cost estimates can be found in the Appendix G. With a total length of approximately 27 miles, the cost per mile for Option 1 (tunnel) is about $11.6 million per mile ($318.0 million) and about $3.6 million per mile ($97.1 million) for the Option 2 (relocation). The major difference between the two options is the cost of the cut (boat) and tunnel structures for the alignment through the airport. The other major infrastructure item costs are approximately the same except for the facilities cost. The Option 1 (tunnel) estimate includes an additional station at the airport.

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Table 5.3-1
East Rail Corridor: Total Infrastructure Costs (2000 Dollars)

Infrastructure Item	Option 1 (Tunnel) Cost ($M)	Option 2 (Relocation) Cost ($M)
Track Structure	23.4	23.4
Grade Crossings	15.4	17.4
Civil	2.8	3.3
Structures	173.4	12.2
Facilities	9.0	4.5
Signal System	11.7	11.7
Sub-total	**$235.5**	**$71.9**
Contingency (20%)	47.1	14.4
Survey/Design/Construction Services (15%)	35.3	10.8
TOTAL INFRASTRUCTURE COST *	**$317.9**	**$97.1**

* Real Estate costs have not been estimated for this study. While some additional real estate will need to be purchased as part of either of the alternatives, total real estate needs have not been assessed. The exception is the cost of property required for Option 2 of the East Rail Corridor Alternative to relocate the rail around the Manchester Airport. That cost was previously estimated by the NHDOT to be approximately $10 million.

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I-93 Rail Corridor: Operations Plan

This chapter presents the preliminary operations plan for the introduction of rail service along the I- 93 corridor from Exit 5 in Londonderry to Lawrence, Massachusetts. The chapter includes a description of the route characteristics including the proposed station locations, the proposed service plan, a preliminary projection of ridership developed from the New Hampshire DOT statewide model and the mode choice model (NCHRP Report 187, "Quick-Response Urban Travel Estimation Techniques and Transferable Parameters"), an assessment of equipment needs, and an estimate of annual operating costs.

This alternative differs from the West and East Rail Corridor Alternatives by both alignment and mode. While parts of the existing M&L Branch (East Rail Corridor) are utilized for the alignment, it principally follows the I-93 right-of-way, either in the median or immediately outside the travel ways. The alignment diverges from I-93 south of Exit 1 in Salem to connect with the M&L corridor and then follows this corridor into Lawrence where it meets the MBTA commuter rail service at Lawrence Station.

The second difference between the previously examined rail corridors and the I-93 Rail Corridor Alternative is mode. Both the East and West Rail Corridors would be operated using traditional commuter rail equipment. The I-93 Rail Corridor Alternative, however, would utilize light rail technology (either electric or diesel).

The introduction of rail transit within the I-93 corridor is not meant to replace auto travel, but rather provide travelers with mobility options between southern New Hampshire and Boston. Although this report focuses on a rail corridor between Exit 5 in Londonderry and Lawrence, MA, there are two extensions or enhancements that would further improve mobility options in southern New Hampshire by creating a larger, more regionally focused system.

As evidenced by the congestion along the I-93 corridor, there are a great number of people commuting between southern New Hampshire and the Merrimack Valley region of Massachusetts. I-93 carries a large percentage of these commuters to employment centers all along the I-93 corridor. With these travel patterns in mind, one potential extension of this rail alternative is to continue the alignment down the I-93 highway corridor from the New Hampshire border to the Woburn Transportation Center that is currently under construction in Massachusetts, a distance of 20 miles.

The extension to Woburn would provide riders two primary mobility improvements. It would provide a more direct route to the Boston transportation system, including

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express busses to Logan Airport. It would also provide direct transit service to many employment centers located along the I-93 corridor that are not currently served by commuter oriented transit from the southern New Hampshire region. This extension would provide a transit alternative to a number of I-93 commuters where there presently is none.

Although the Woburn extension is a logical addition to the I-93 Rail Corridor Alternative, this report does not provide a detailed evaluation of the extension, as all the work would be outside New Hampshire's jurisdiction. This concept is briefly discussed however, in order to demonstrate how the I-93 Rail Corridor Alternative could fit into the regional transportation network.

The other potential extension is to the north, providing service to Manchester Airport. Similar to the East Rail Corridor, the I-93 Rail Corridor continues along the M&L Branch north of the I-93 / M&L Branch intersection in the area of Exit 5 in Londonderry. Since the proposed location of a necessary layover/maintenance is near the Airport, the only additional improvements needed would be the construction of the station itself. Although a direct connection to the airport terminal is not likely to be a viable option, a shuttle bus service from the terminal could be provided with minimal additional costs. Similar to the Woburn extension, the airport extension has not been fully evaluated and information concerning the station is included only as a potential addition to the I-93 Rail Corridor Alternative and not a basic (assumed) component of it.

6.1 Route Description

The proposed I-93 Rail Corridor Alternative runs in a 23 mile alignment between Lawrence, MA and Londonderry, NH via the towns of Salem, Windham, and Derry, NH. From the MBTA's Lawrence Station, the proposed rail line runs along the former B&M Railroad's M&L Branch to just south of Salem, NH. At that point the rail line branches from the M&L to connect with the I-93 highway corridor. The alignment then remains within the I-93 highway corridor from south of Exit 1 to Exit 5 in Londonderry, NH. In the vicinity of I-93 Exit 5 the rail line then turns west out of the I-93 highway corridor and briefly follows the M&L Branch to the terminal station near Exit 5. A short segment of track is provided to the airport where the layover facility is proposed.

The study area for this alternative stretches from the former B&M's Line in Lawrence along the M&L corridor, and then along the I-93 corridor north of Methuen towards I-93 Exit 5. The Lawrence commuter rail station is designated as milepost 0.0 and mileposts increase northbound along the corridor. The New Hampshire/Massachusetts state line is at MP 3.9 and the final station in Londonderry at I-93/Exit 5 is at MP 20 with an additional 3 miles to a proposed layover/maintenance facility at the airport.

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6.1.1 Route Characteristics

The proposed I-93 Rail Corridor Alternative would serve the municipalities of Lawrence, MA and Salem, Windham, Derry, and Londonderry, NH. Stations would be located at I-93 interchanges, allowing the service to be easily accessed from the highway. The proposed alignment is 20 miles long between Lawrence and Londonderry, with a total length between Londonderry and Boston of approximately 46 miles.

The I-93 portion of the alignment extends a distance of 16.5 miles from the Massachusetts state line at Salem to the I-93/Route 28 Exit 5 interchange in Londonderry. The highway right-of-way is owned by the NHDOT. The I-93 facility is a limited (fully controlled) access highway originally constructed in the early 1960s. At present it consists of four travel lanes (two lanes northbound, two lanes southbound) and adjacent shoulders. The roadway right-of-way varies from about 150 to 500 feet in width. The median is typically 70 feet or more in width, although in some areas it is as narrow as 30 feet. Near the NH 111/Exit 3 interchange, the northbound and southbound lanes diverge more than 1,200 feet.

The 3.5 mile segment of the corridor that runs along the M&L Branch between Lawrence, MA and the New Hampshire state line is owned by the MBTA. Springfield Terminal Railway, owned by GTI, currently operates freight service along this stretch of track. Operation of the proposed service will therefore need to make allowances for continuation of this freight service and will likely require an agreement between NHDOT, the MBTA, and GTI.

The line as proposed will be single track except for two passing sidings. One siding is proposed at Exit 4 extending south for approximately ½ mile, the other approximately a ½ mile long just south of the Exit 2 station. These sidings will permit the smooth operation of the proposed services. The extension of sidings, additional sidings, or double tracking of the entire corridor would be required if the operating plan were changed to provide more frequent service. Although the corridor is being proposed initially as single track with the two passing sidings, it is being designed to accommodate double track along the entire line. The additional track would allow the most operating flexibility, permitting trains from both directions to pass. Figure 6-1 shows the proposed route and station sites discussed in the following section.

6.1.2 Stations and Facilities

New stations are proposed for four locations along the corridor: at Exit 2/Salem, Exit 3/Windham, Exit 4/Derry and Exit 5/Londonderry. All station locations were chosen considering the following criteria:

- ➢ Technical feasibility
- ➢ Availability of ample sized lots for station facilities, parking, and access
- ➢ Location in areas with possible high ridership
- ➢ Location of existing I-93 interchanges

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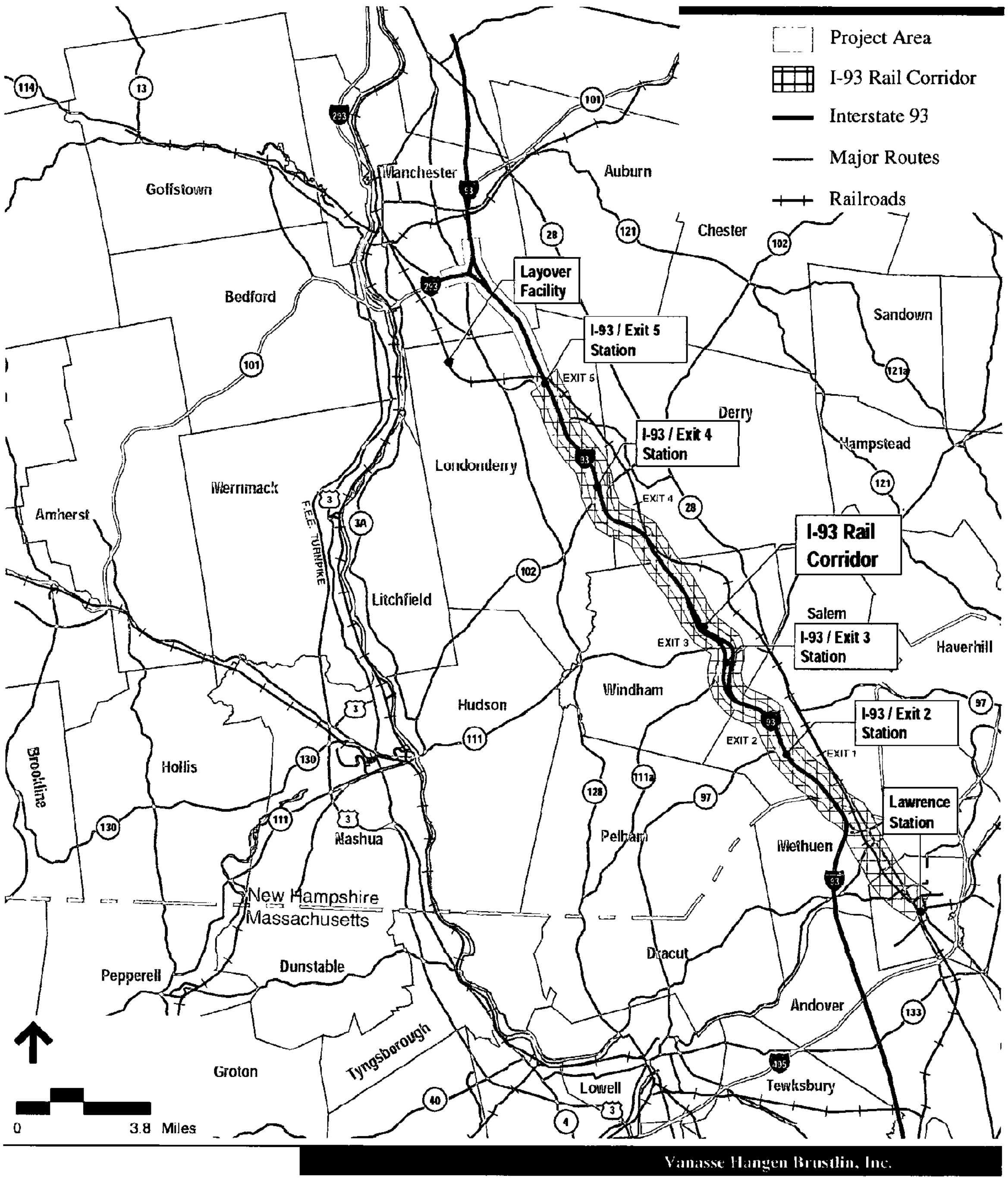

I-93 Rail Corridor
Route Layout

Figure 6-1

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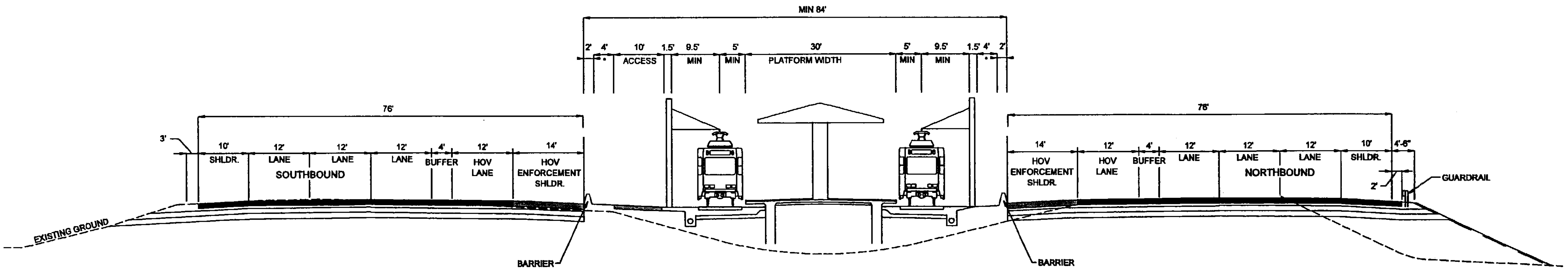

* Appurtenance

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Figure 6-2

Station in Median

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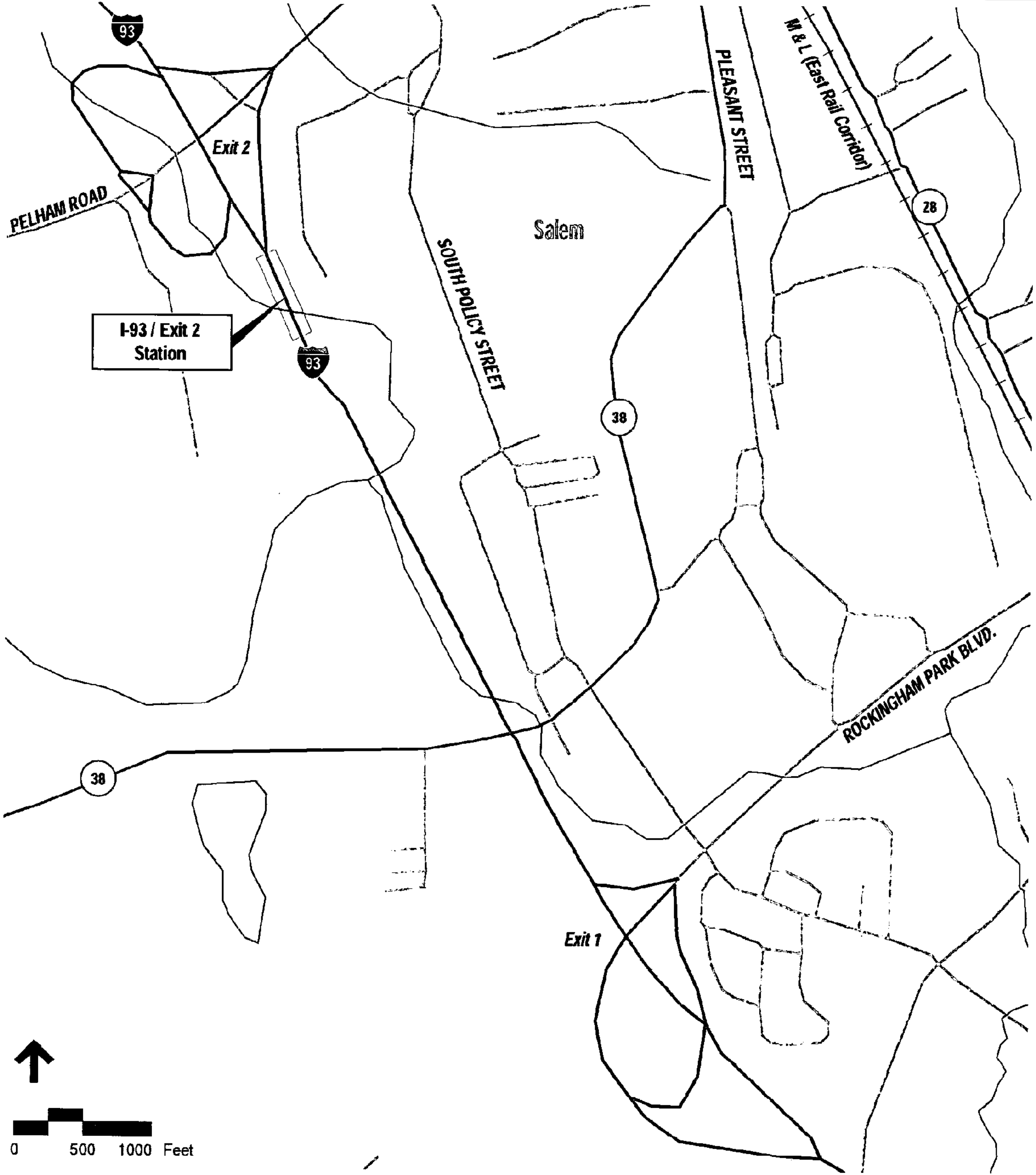

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I-93 Rail Corridor
Salem I-93 /Exit 2 Station
Site Location

Figure 6-3

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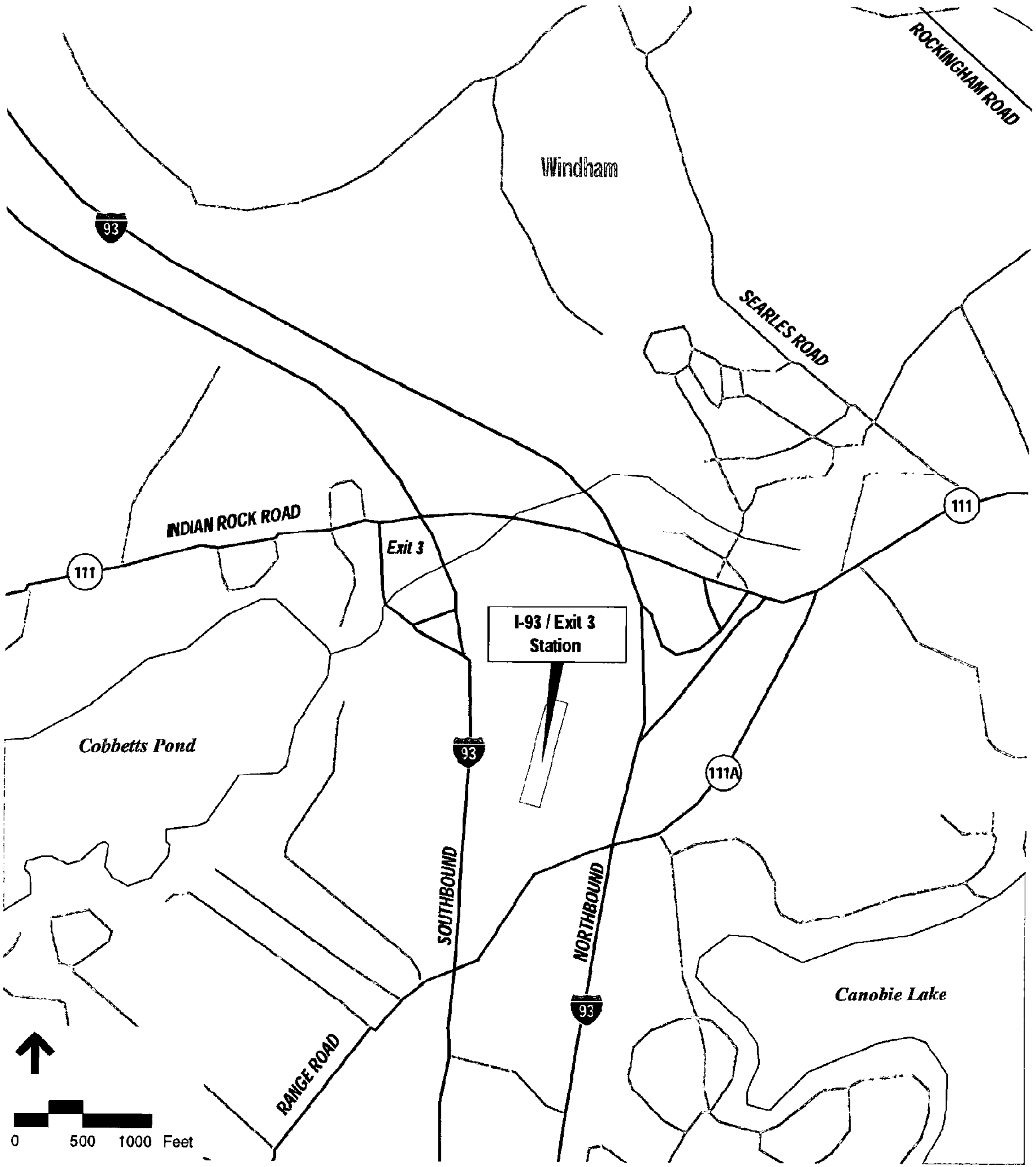

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I-93 Rail Corridor
Windham I-93 /Exit 3 Station
Site Location

Figure 6-4

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As part of the highway improvements, new park-and-ride/bus station facilities are proposed at Exits 2, 3, and 5. In lieu of the possibility of rail service in the I-93 highway corridor, the park-and-ride/bus station facilities have been sited to coincide with potential train station locations. Where appropriate, the planned park-and-ride/bus station facility lots could be expanded to accommodate carpoolers, bus passengers and rail passengers. Station platforms sited within the I-93 median would require elevated walkways to carry passengers from the parking lots over I-93 to the platform. All stations would have platform canopies, wind screens and other passenger amenities. Figure 6-2 displays a typical section of a station. The following is a brief description of each station location along the basic corridor and its planned facilities.

Lawrence (MP 0.0)

The proposed terminus for the I-93 Rail Corridor Alternative is the MBTA's commuter rail station in Lawrence. This facility will provide New Hampshire commuters with a direct connection to the MBTA's commuter rail service to North Station in Boston. The new service would not likely attract additional park-and-ride users at this location. Consequently, the Lawrence Station will not require an increase in the number of parking spaces. Changes to the platform facilities will be required in order to accommodate the transfer of passengers from the I-93 rail system to the MBTA's Haverhill Line.

I-93/Exit 2 - Salem (MP 7.1)

The general locus of the Exit 2/Salem station is shown in Figure 6-3. This site provides access to NH 28 and I-93 via NH 97 as well as access to Rockingham Park Boulevard and Exit 1. The proposed station layout includes the platform in the median with the parking lot on the east side of I-93. A pedestrian overpass would be required over the northbound lanes of I-93 to connect the planned 400-space parking lot to the station platform.

I-93/Exit 3 - Windham (MP 10)

Located at the I-93/NH 111 interchange in Windham, this proposed station site would draw commuters from communities both east and west of I-93, intercepting them prior to reaching the most congested parts of I-93. The proposed station site includes both the 250-space parking lot and the station platform in the I-93 median, south of NH 111. The general location of this station, is shown in Figure 6-4.

I-93/Exit 4 - Derry (MP 16.8)

The general locus of the proposed Derry rail station site is shown in Figure 6-5. The rail station site would be an extension to the north of the existing park-and-ride/bus facility, with an additional 200 parking spaces adjacent to the rail station to provide a majority of parking in close proximity to the station. A station at this location would require a platform in the median with a pedestrian overpass providing access.

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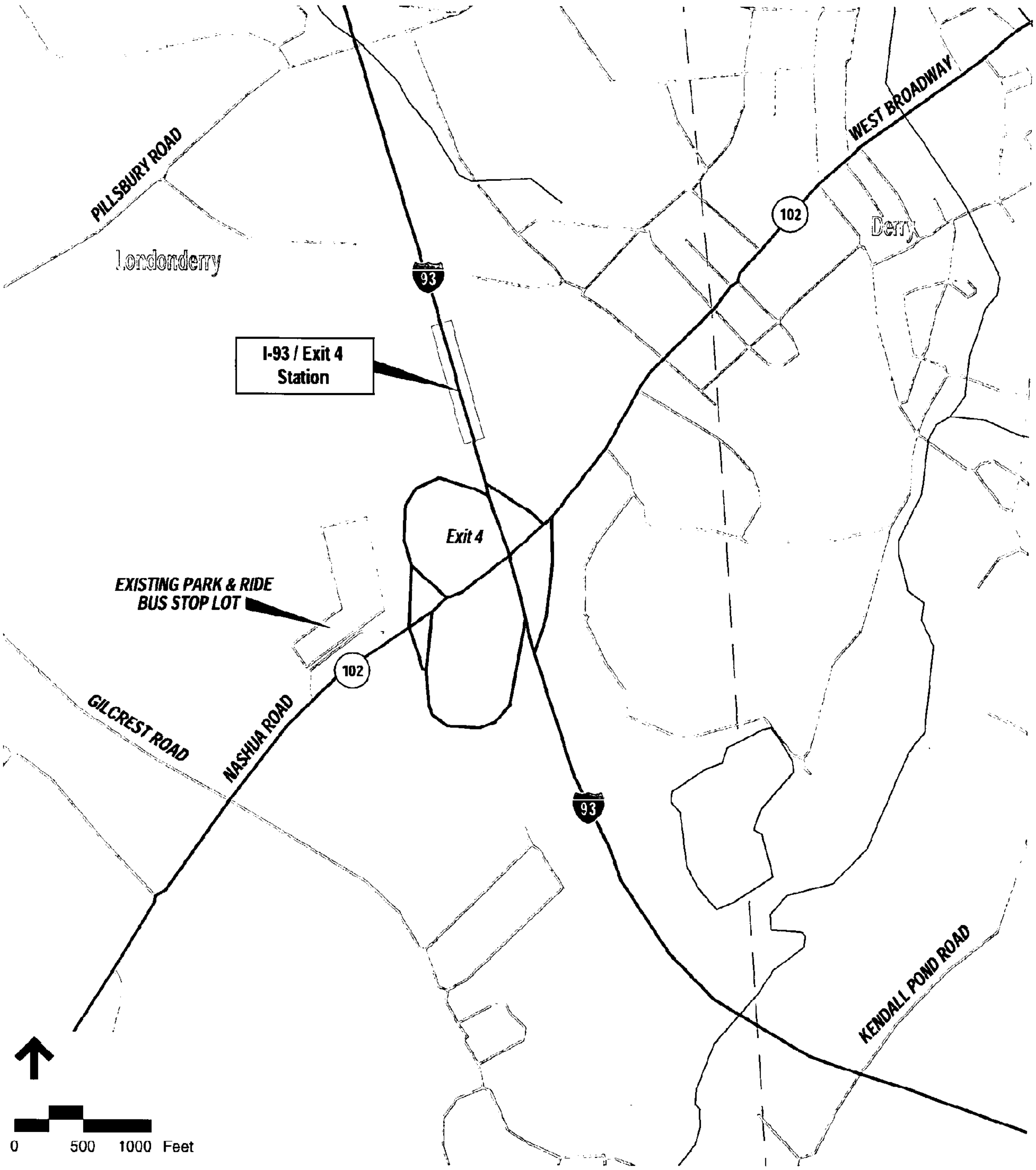

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I-93 Rail Corridor
Derry I-93 /Exit 4 Station
Site Location

Figure 6-5

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I-93/Exit 5 - Londonderry (MP 20)

Two possible sites are under consideration in the area of Exit 5. The general loci of the proposed Londonderry station sites are shown in Figure 6-6. The station site would include a platform and a 500-space parking lot. The northerly station site is located along the M&L Branch to the west of I-93. The station platform would be accessed directly from the station. The southerly station site is located south of Exit 5 on the west side of I-93. This site would require the platform to be accessed via a pedestrian bridge over the I-93 highway travel lanes. Either location would serve commuters from Derry and Londonderry via NH 28 as well as commuters from the southern tier of Manchester via I-93.

Layover/Maintenance Facility – Manchester Airport (MP 22.5)

A layover and maintenance facility would be required at some point along the corridor to accommodate the overnight storage and servicing of the light rail trains. The location of the proposed facility is near the airport. This site provides the best location to keep down operating costs by minimizing deadhead miles and to fit in with existing industrial land use. Along with the rehabilitation of tracks along a portion of the M&L Branch, the required maintenance facility would include the installation of storage tracks, a maintenance building and all utilities required for the operation of such a facility.

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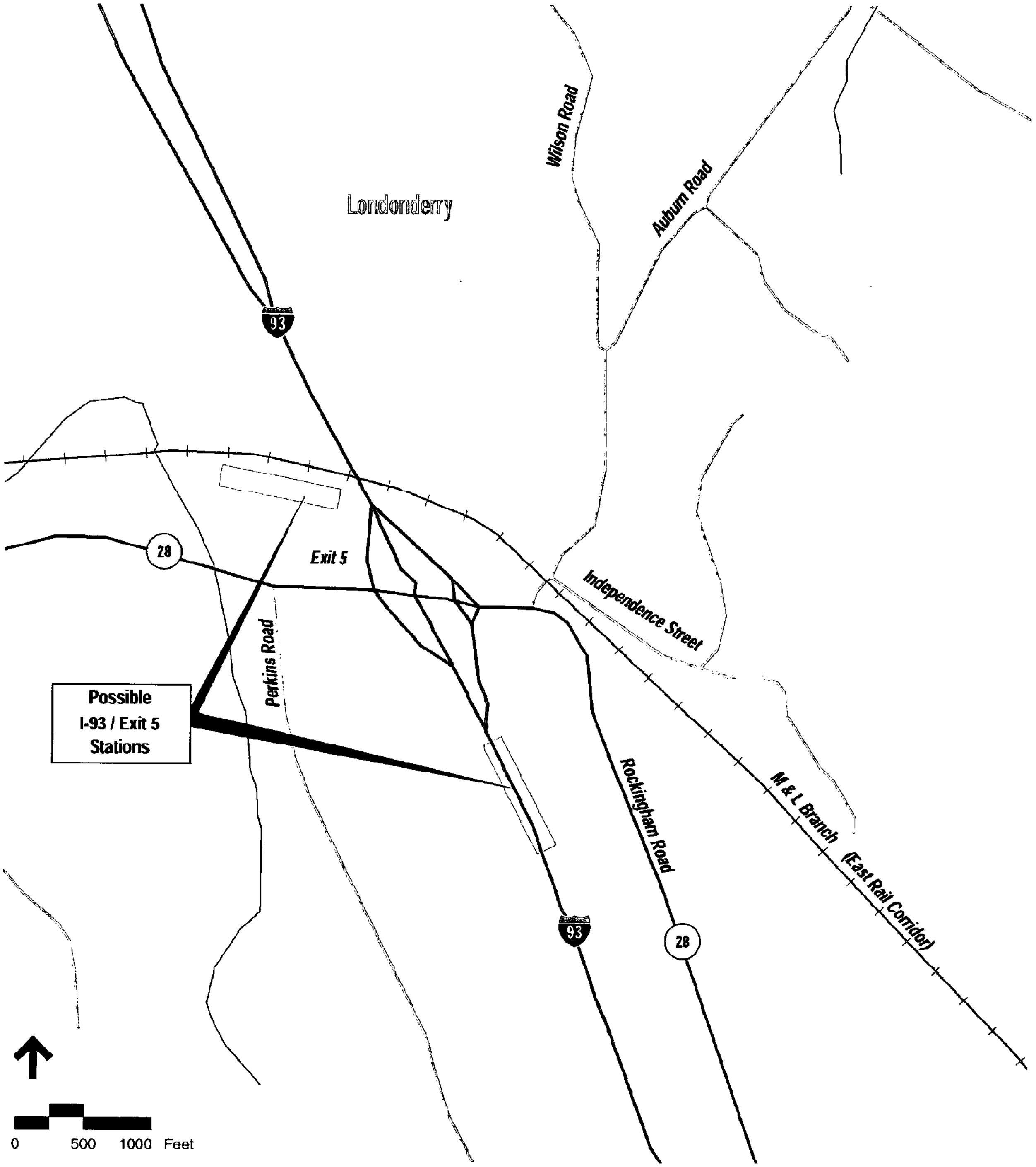

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I-93 Rail Corridor
Londonderry I-93 / Exit 5 Station
Site Location

Figure 6-6

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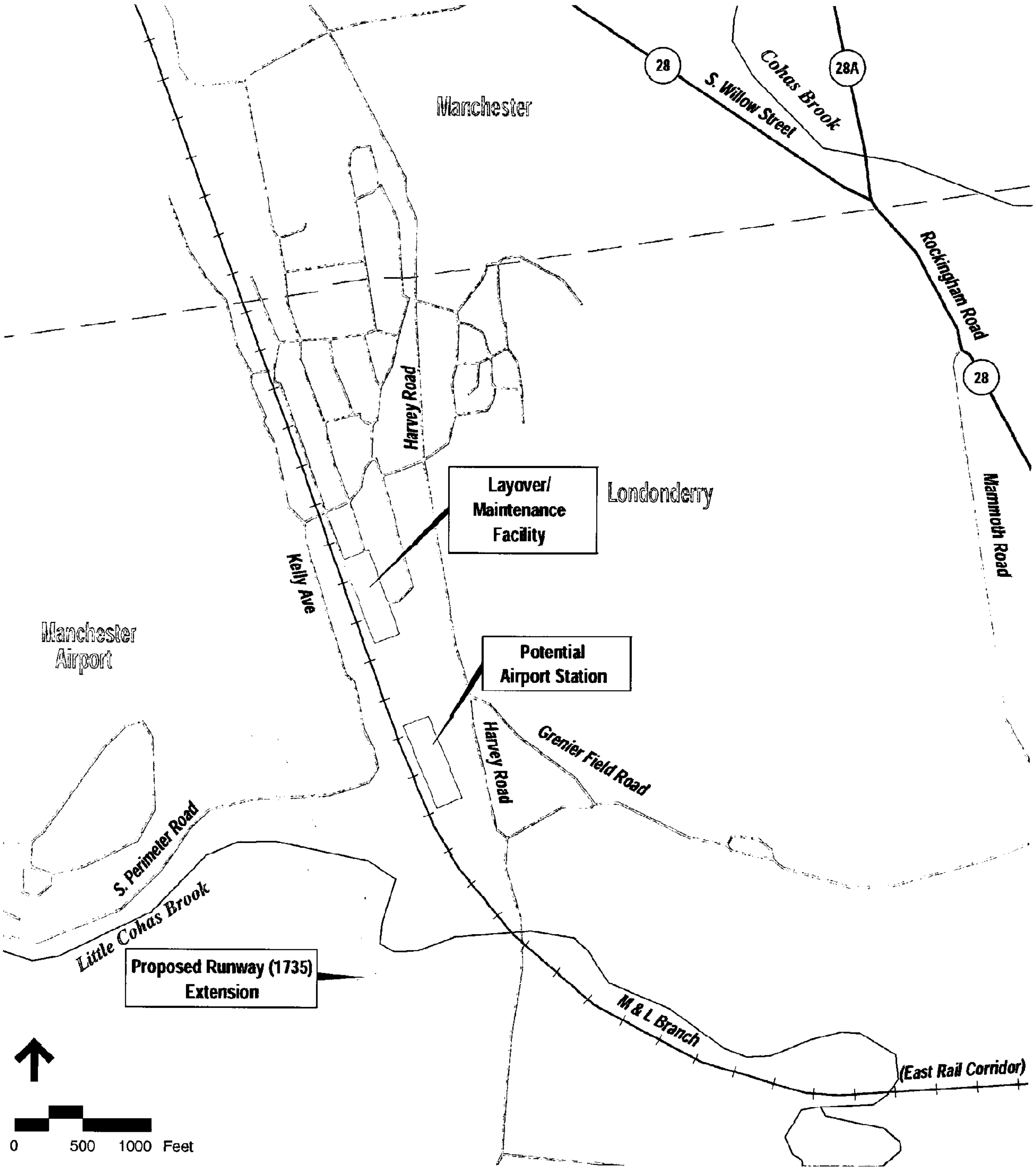

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I-93 Rail Corridor
Layover / Maintenance Facility
Site Location

Figure 6-7

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6.1.3 Speed and Travel Time

The proposed service would run with a maximum operating speed of 60 mph. Travel times were calculated based on the acceleration and deceleration characteristics of diesel light rail vehicles, which have higher acceleration and deceleration rates than traditional commuter rail trainsets. Travel time between Lawrence and Exit 5/Londonderry is approximately 26 minutes based on the location of the proposed stations and known geometry constraints. The calculated travel time includes 30 seconds of dwell time at each proposed station. A 5 minute delay has also been included for passenger transfer between the I-93 rail service and the MBTA commuter rail at Lawrence station. Total travel time between Exit 5/Londonderry and Boston's North Station, during peak periods, is estimated to be approximately 83 minutes. Table 6.1-1 summarizes the travel time estimates.

Table 6.1-1 I-93 Rail Corridor: Estimated Travel Times

Segment	Travel Time [min]
Exit 5/Londonderry to Exit 4/Derry	5
Exit 4/Derry to Exit 3/Windham	8
Exit 3/Windham to Exit 2/Salem	4
Exit 2/Salem to Lawrence	9
Transfer Time	5
Lawrence to Boston	48-59
Total Travel Time	**78-89**
Average Peak Direction Travel Time	**83**

6.2 Proposed Service Description

The proposed service description includes a definition of the level of service, development of a preliminary operating plan, and consideration of the equipment requirements. The following paragraphs summarize these aspects of the proposed I-93 Rail Corridor Service.

6.2.1 Service Alternatives

Lawrence station is the third to last stop on the MBTA's Haverhill Line. Existing service continues north of Lawrence to stations in Bradford and Haverhill where service

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terminates. The existing Haverhill service focuses on the weekday peak periods with the majority of service scheduled in the predominate direction of travel (to Boston in the morning, to Haverhill in the evening). There are few reverse peak period trains to Haverhill because of the limited amount of double-track located along the line. This presents a constraint for the provision of additional service between Lawrence and Boston.

Due to regulatory issues that prohibit light rail operation on corridors with heavy rail traffic unless there is temporal (time of day) or physical (separate track) separation, the proposed service will not run past Lawrence Station. The service will provide a shuttle operation between Exit 5/Londonderry (or Manchester Airport) and Lawrence with a transfer connection to the MBTA Haverhill Line. More detailed information on regulatory issues can be found in Section 6.2.4.

As with each commuter rail corridor, three service alternatives are proposed for the I-93 light rail weekday service. The alternatives vary in the number of trips offered and the frequency of weekend service. Each schedule includes the potential service to Manchester Airport for illustration purposes. The addition of this station adds 5 minutes to the run time and does not affect service levels or coordination of service with MBTA commuter rail.

Alternative 1 – High

This alternative includes 12 roundtrips (24 total trips) with six morning roundtrips and six afternoon/evening roundtrips. During the weekday morning peak period, the southbound trips are able to meet four inbound Haverhill Line trains arriving in Boston before 9 AM. During the PM peak period, the northbound trips are able to meet four outbound Haverhill Line trains that depart Boston between 4:25 PM and 7:00 PM. Altogether, 10 of the 12 southbound trips and nine of the 12 northbound trips are able to connect with Haverhill Line trains. On weekends, 4 round trips are provided on both days.

Alternative 2 – Moderate

This alternative offers eight roundtrips (16 total trips) with four morning roundtrips and four afternoon/evening roundtrips. During the weekday morning peak period, the southbound trips are able to meet three Haverhill Line trains that arrive in Boston before 9 AM. During the PM peak period, northbound trips are able to meet three outbound Haverhill Line trains that depart Boston between 4:25 PM and 7:00 PM. Altogether, seven of the inbound trips and six of the outbound trips are able to meet Haverhill Line trains. On weekends, 3 round trips are provided on both days.

Alternative 3 – Low

This alternative offers six roundtrips (12 total trips) with three morning roundtrips and three afternoon/evening roundtrips. During the weekday morning peak period, the southbound trips are able to meet two inbound Haverhill Line trains arriving in Boston before 9 AM. During the PM peak period, the northbound trips are able to meet two

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outbound Haverhill Line trains that depart Boston between 4:25 PM and 7:00 PM. Altogether, five of the six southbound trips and five of the six northbound trips are able to connect with Haverhill Line trains. Weekend service will include 3 round trips on Saturday only.

6.2.2 Schedules

Conceptual schedules for these three scenarios, with departure times at each of the stations, can be viewed in Appendix H. The schedules are focused on providing service to Boston in the morning and back to the southern New Hampshire region in the evening. The proposed service would require transfers to the MBTA's existing commuter service at the Lawrence Station. In the development of these schedules, it was assumed that current train schedules between Lawrence and Boston would remain unchanged in an effort to minimize the disruption of existing MBTA service.

6.2.3 Equipment Requirements

The proposed service between Lawrence and Exit 5/Londonderry is designed to maximize the use of operating personnel and equipment. The equipment requirements vary depending on the service scenario (low, moderate, or high) selected and the proposed schedule of service. As noted in Section 6.2.1, the service between Exit 5 /Londonderry and Lawrence will require transfers to the existing MBTA Commuter Rail system. It has been assumed that trains would likely be diesel light rail vehicles although, if desired, an electric light rail system would be possible. It is anticipated that one train set, consisting of three train cars, is required to operate the low service scenario and two sets are required to operate the moderate and high service scenarios. An additional spare train set would be required for each of the alternatives to provide backup for maintenance, overhaul, and potential breakdowns of trains.

6.2.4 Regulatory Issues

Two agencies at the United States Department of Transportation are involved in the governance of passenger rail systems. The Federal Railroad Administration (FRA) has jurisdiction over matters of railroad safety and research on the *general* railroad system in the United States. The general railroad system is defined as the network of rail lines operated by Class 1, regional, short line, and terminal railroad companies. On all tracks where a freight train, intercity passenger train, or commuter rail train is operated, the FRA has jurisdiction. The FRA is responsible for rules and regulations governing the safe operation of train traffic over the general railroad system. The second Federal agency involved in the governance of passenger rail operations is the Federal Transit Administration (FTA). The FTA is responsible for the traditional urban transit systems: subways, light rail (trolley) services, buses, ferryboats, and people movers.

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An important focus of both agencies is public safety. The regulations of the FRA address the protection of the general populace, avoidance of equipment failure, avoidance of employee failure, and sufficient crashworthiness of the equipment. To accomplish these protections, FRA has implemented a number of different regulations over the years. The two primary areas of regulation are the physical design of equipment and infrastructure and inspection and maintenance of the equipment and infrastructure. An important FRA consideration is the crashworthiness of the vehicle. If a vehicle does not meet FRA's crashworthiness standards, it cannot operate on the general railroad system in mixed traffic. Simply put, light rail vehicles and all current foreign models of diesel multiple units in service do not meet FRA's standards.

The FRA and FTA recently issued a joint statement of policy concerning Shared Use of the Tracks of the General Railroad System by Conventional Railroads and Light Rail Systems. This policy statement was noticed in the July 10, 2000 edition of the Federal Register. The FRA noticed a separate document in the Federal Register pertaining to railroad safety on November 1, 1999. The policy stated the FRA can continue to grant waivers, when appropriate, allowing a non-compliant vehicle to operate on the general railroad system when its operation is completely separate from other railroad traffic. Although in the past this has taken the form of separate operating windows where each type of traffic operates during distinct time-periods, other methods of separation will be considered.

For the evaluation of the I-93 Rail Corridor Alternative it is assumed that non-FRA compliant diesel light rail vehicles will be used. Since the MBTA system uses standard commuter rail locomotives and coaches and needs to operate during the same peak periods, the light rail equipment will not be able to operate over the MBTA.

The operating plans and service scenarios developed for the I-93 Rail Corridor Alternative utilize a portion of the M&L corridor to provide connecting service at the Lawrence Station to Boston bound commuter rail service. As previously noted there is currently freight traffic operating on this section of track. In order for non-FRA-compliant light rail vehicles to operate on the line, an access agreement would be necessary with the operating railroad, STRY, and the owner of the track, the MBTA, to time separate the freight traffic, leaving only night time or mid-day windows for the freight to operate. This would allow the FRA to grant a waiver permitting both the light rail vehicles and freight service to operate over the line.

6.3 Ridership and Revenue Projections

Ridership projections were estimated for the I-93 Rail Corridor Alternative using the mode choice model. These estimates are generally based on the moderate level of service where sufficient peak period service is provided so that altering the timing of work trips is not required. Further details regarding the specific methodology of ridership estimation are provided in Appendix B. The projections are based solely, on peak direction work trips to Boston, utilizing the rail service between Exit 5/Londonderry and Lawrence and with a transfer there to the MBTA commuter rail system in Lawrence.

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Revenue projections have also been calculated based on the ridership projections developed for the I-93 Rail Corridor Alternative.

6.3.1 Ridership

The projections of station boardings in 2020 are included in Table 6.3-1 for the I-93 Rail Corridor. These projections are based on the operating plan described in this chapter summarized as a rail operation between I-93 Exit 5/Londonderry and Lawrence with a transfer to the MBTA commuter rail system at Lawrence Station. All ridership is projected from commuter work trips to Boston with the standard transit trip impedances, in addition to a 5 minute transfer to commuter rail in Lawrence, as detailed in the ridership projection methodology in Appendix B. These boardings represent approximately one-half of the average daily trips attributable to the rail service, with the other half of the trips boarding in Lawrence, MA and ending at the new I-93 stations. The total daily ridership is projected to be 1,778 trips (889 inbound trips, 889 outbound trips).

Table 6.3-1
I-93 Rail Corridor: 2020 Daily Station Boardings

Station	Boardings
Exit 5 /Londonderry	389
Exit 4 /Derry	209
Exit 3 /Windham	95
Exit 2 /Salem	196
Total Daily Boardings	**889**

6.3.2 Revenue Projections

Although the vehicles are different, the I-93 Rail Corridor Alternative service characteristics are similar to commuter rail services. Therefore, this study assumes a fare structure similar to that used by the MBTA for their commuter rail service. The MBTA has established service zones based on the distance from Boston to the outlying station. The further the outlying station is located from Boston, the higher the fare. The system also allows for travel between fare zones and has established fare levels for this type of travel.

Each of the proposed stations is categorized according to the MBTA's current commuter rail zone criteria. It is assumed that the proposed service will meet the MBTA's commuter rail service at the Lawrence station, which is located in Zone 6. The fares for travel on the proposed service are based on the number of zones traveled and the corresponding fares established by the MBTA. The MBTA offers both one-way fares and monthly passes, which provide a substantial discount for commuters. It is assumed that the proposed service would offer a similar pass program.

The proposed I-93/Exit 2 Station in Salem is located approximately 34 miles from North Station in Boston. This distance places the proposed station in Zone 7, which presently includes the Haverhill and Rowley stations. Consequently, travel between the Salem station and Lawrence spans 2 zones, resulting in a one-way fare of $1.75 and a monthly pass price of $55.

The proposed I-93/Exit 3 Station in Windham is located approximately 37 miles from North Station in Boston. This distance places the proposed station in Zone 8, which presently includes the Ayer and Newburyport stations. Consequently, travel between the Windham station and Lawrence spans 3 zones, resulting in a one-way fare of $2 and a monthly pass price of $62.

The proposed stations at Exit 4 near Derry, and Exit 5 in Londonderry are located approximately 44 miles s and 47 miles from North Station respectively. These distances place the stations in Fare Zone 9. The MBTA's Zone 9 currently includes the Leominster and Fitchburg stations, which are located 45.3 and 49.5 miles from North Station. Consequently, travel between these stations and Lawrence span 4 zones, resulting in a one-way fare of $2.25 and a monthly pass price of $69.

A passenger traveling between stations on the proposed service would pay a fare consistent with the number of zones traveled, as specified above. However, none of the proposed stations on the I-93 service have significant trip attractors within a reasonable walking distance of the station. Therefore, for the purpose of this analysis it is assumed that all riders are destined for Lawrence. Since the analysis is based primarily on work trips, it has been assumed that 70% of the projected riders purchase monthly passes to Boston and 30% purchase one-way tickets. Using these assumptions, the annual revenue projection for service from Lawrence to Exit 5 /Londonderry is $0.6 million. Table 6.3-2 summarizes the revenue estimates.

Table 6.3-2
I-93 Rail Corridor: Annual Ridership and Revenue Projections

To/From Station	Total Annual Trips	Annual Revenue ($ million)
Exit 2 /Salem	198,390	$0.09
Exit 3 /Derry	106,590	$0.06
Exit 4 /Windham	48,450	$0.16
Exit 5 /Londonderry	99,960	$0.30
Total	453,390	$0.61

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6.4 Operating Costs

Preliminary annual operating costs were calculated based on the proposed service schedule. For the purpose of these cost estimates, the current MBTA commuter rail operating costs are used as a measure of potential costs for light rail service in the I-93 median. The *Draft MIS for Nashua Passenger Rail Service* reports that the MBTA's budgeted cost is $45 per train mile for the 1999 fiscal year. This number was adjusted by a 3.5% inflation rate for year 2000 to $46.50 per train mile. This unit cost includes four general categories of costs:

- Transportation – The costs associated with the personnel directly involved in the movement of trains. This includes the salaries of train engineers and conductors and supervisors.
- Administrative – The cost to administer the service and manage the operating personnel.
- Mechanical (Vehicle Maintenance) – The costs to maintain and operate the equipment. This includes the daily cleaning and maintenance of the equipment, all major overhaul and repair work, and fuel costs.
- Engineering (Non-Vehicle Maintenance) – The right-of-way maintenance costs. This includes items such as rail replacement, pavement maintenance, grade crossings and the electrical system.

The average cost of $46.50 per train mile reflects a typical consist of one locomotive and seven coaches. The proposed light rail consist includes three self-propelled coaches. Assuming that you can operate the light rail shuttles with one less crew member (using only an engineer, conductor, and one trainman) and that the locomotive maintenance represents a disproportionate share of the mechanical cost component, the average unit cost of $46.50 per train mile was reduced by 40 percent to $27.90 to reflect the operating cost of the light rail shuttle. These unit costs reflect the total cost to provide the desired service and include transportation, mechanical, engineering and administrative costs. Table 6.4-1 summarizes the operating costs for all three service scenarios operating between the Exit 5/Londonderry station and Lawrence.

Table 6.4-1
I-93 Rail Corridor: Annual Operating Costs (2000 Dollars)

Service Level	Annual Train Miles	Operating Costs
Low	69,600	$1.9 m
Moderate	98,300	$2.7 m
High	143,800	$4.0 m

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6.5 Capital Equipment

Due to the geometry of the I-93 corridor (i.e. the grades and curves) standard commuter rail equipment is not a viable option. Light rail vehicles can easily operate at grades up to 4 percent and curves with as tight as an 82-foot radius, which are the type of curves and grades required to operate within the I-93 highway corridor. Typical commuter rail equipment is not capable of operating in such an environment. Therefore, this alternative assumes the implementation of light rail technology. Two types of light rail technology could be considered for this corridor:

- Traditional Light Rail
- Diesel Light Rail

6.5.1 Traditional Light Rail

The technology of trolleys has been around for over 100 years. The "traditional" trolley or light rail service is characterized by lightweight vehicles operating singly or in short (usually two or three-car) trains on fixed rails in rights-of-way within urban areas. The light rail line right-of-way can be completely separate from automobile traffic or can operate in a mixed traffic (automobile/trolley) setting. Light rail vehicles are driven electrically with power being drawn from an overhead electric line, called a catenary, via a trolley pole or a pantograph. The vehicles have lower top speeds (40-60 mph) than diesel powered vehicles, but higher acceleration/braking rates to accommodate lines with short distances between stops. They can also negotiate sharper curves and steeper grades than traditional commuter rail equipment. Modern light rail vehicles can be designed to serve both low and high level platforms.

The light rail vehicle is not compliant with FRA crashworthiness standards. It cannot be operated on the general railroad system in mixed traffic. There are, however, several systems (San Diego and Baltimore) that have been granted waivers by the FRA to operate light rail vehicles on the general railroad system by separating traffic by time of day. The operating plan used by both systems (freight and light rail) defines specific time blocks when light rail service is operated. Freight trains operate during different time windows when there is no light rail vehicles on the system.

Light rail system infrastructure costs are similar to those associated with "traditional" commuter rail. However, there is an added cost for the power system that includes the overhead catenary system and electrical sub-stations. A typical unit cost for the overhead catenary system is approximately $400,000 per single track mile. Sub-stations can cost up to $2 million each. Typically, a sub-station is required every mile or two depending on the system power requirements. These infrastructure costs generally lend themselves to urban areas where ridership is heavy along short distances, therefore minimizing infrastructure costs. On average, a modern light rail vehicle costs approximately $2.5 to $3.5 million.

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6.5.2 Diesel Light Rail

Over the past 10 years, a new light rail technology has emerged in North America. This new technology is a cross between "traditional" light rail and Diesel Multiple Units (DMU). The diesel light rail system is essentially the same as traditional light rail system except that the vehicles are powered by diesel engines, not electric, eliminating the need for the overhead catenary system. Each light rail vehicle has a diesel engine on board, similar to a DMU, which provides flexibility in the makeup of each trainset. The diesel light rail vehicle is not compliant with FRA crashworthiness standards. It cannot be operated on the general railroad system without a waiver granted from FRA. Diesel light rail system infrastructure costs are similar to those associated with the "traditional" commuter rail. The primary advantage of diesel light rail over traditional light rail is reduced infrastructure costs since an overhead power system is not required.

The first US application of diesel light rail technology is proposed for the Southern New Jersey Light Rail Transit System (SNJLRTS). The project, being developed by New Jersey Transit (NJT), will use an existing 34-mile single track freight corridor between Trenton and Camden. NJT is requesting a waiver from FRA to permit the use of the non-compliant European technology on the general railroad system. The proposed operating plan will separate light rail and freight activity by time of day. Light rail service will generally operate between 5:30 AM and 10:00 PM. Freight trains will operate between 10:00 PM and 5:00 AM. The total design/build bid price to reconstruct the 34-mile corridor and provide 20 diesel light rail vehicles was $452 million. The infrastructure program includes the complete rehabilitation of the single track line to FRA Class 3 standards (permitting up to a maximum operating speed of 60 MPH for passenger and 40 MPH for freight trains), adding a second track in many locations, and installation of a signal and communications system with automatic protection for the 52 grade crossings.

The reduced capital costs for the new diesel light rail systems make them a more attractive system. These reduced costs in addition to the type of vehicle performance desired in a non-urban environment, such as the I-93 corridor, where increased maximum speeds are more crucial than reduced acceleration/braking distances, results in the diesel light rail being a more attractive option for service along this corridor. All estimates were developed with the assumption that diesel light rail technology would be employed, however the design does not preclude the use of traditional light rail if that is the preferred technology.

6.5.3 Capital Equipment Cost Estimate

Regardless of the type of rail technology used along this corridor, the fleet size and vehicle costs are generally the same. As discussed earlier in this chapter, the I-93 Rail Corridor service alternatives will require the procurement of two or three train sets (one or two to operate and one spare train set) to provide the proposed service. The number of light rail vehicles varies by the amount of service operated.

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Since the proposed service for the I-93 Corridor service is a shuttle between Exit 5/ Londonderry and Lawrence, the equipment requirements are fairly straightforward. A single shuttle train set is all that would be required for the low service scenario. A spare set would be required to provide backup for maintenance and repair of the vehicles. With the moderate and high service scenarios, a second shuttle train consist is required for operations with a third, or spare, set needed for substitute service when equipment is being repaired or maintained.

For the three car shuttle consist, the estimated cost is approximately $10.2 million ($3.4 million per car) based on the latest procurement in the United States of diesel light rail vehicles (SNJLRTS). A contingency of 20 percent is recommended for planning purposes at the current stage of project development. Table 6.5-1 summarizes the capital equipment cost estimates for the I-93 rail corridor option.

Table 6.5-1 I-93 Rail Corridor: Capital Equipment Costs (2000 Dollars)

	Capital Equipment Cost ($M)		
Service Level	**Sub-Total**	**Contingency**	**Total**
Low	$20.4	$4.1	$24.5
Moderate	$30.6	$6.1	$36.7
High	$30.6	$6.1	$36.7

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I-93 Rail Corridor: Infrastructure Layout

This section of the report presents the recommended infrastructure improvements necessary to support light rail commuter service between Lawrence, MA and Londonderry, NH via the I-93 corridor. The following proposed improvements are focused on developing a FRA Class 4 track structure. The track would then be maintained to Class 3 standards, which will allow the operation of passenger trains at 60 mph where not constrained by geometric and civil restrictions.

The recommended improvements are based upon the review of existing infrastructure conditions and the proposed Operations Plan described in Chapter 6. The recommendations consider the constraints of the existing infrastructure and the needs of the current and future users of the rail corridor.

7.1 Layout

Similar to the East Corridor Alternative, the proposed service would utilize portions of the M&L Branch, however, the major portion of the corridor is within the I-93 highway corridor. Stations for the basic system are proposed in Lawrence at the existing MBTA station, in Salem at I-93/Exit 2, at I-93/Exit 3 in Windham, at I-93/Exit 4 serving Derry, and at the I-93/Exit 5 (NH 28) interchange in Londonderry. The conceptual design of the alignment, which provides for the future needs and growth of the service, includes provisions for double tracking the entire section within the I-93 right-of-way. Also included in the conceptual design are provisions for electrification and an access roadway for maintenance. Typical sections are included in Appendix I.

Although the conceptual design has been developed to accommodate double track and electrification, the cost estimate includes only the necessary infrastructure for the currently proposed services. The infrastructure for electrification has not been included in the estimate since the assumption is that diesel light rail vehicles would initially be used. Additionally the cost estimate includes a single track along the corridor except for two 2,500 to 3,000 foot double track segments. These double track segments, or sidings, would allow trains to pass each other along the corridor as needed based on the proposed schedules.

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The proposed sidings are necessary for the high and moderate service level operating plans, which require trains to meet and pass at speed as a regularly scheduled occurrence. The sidings are proposed to be approximately 1/2 mile in length to minimize the infrastructure costs. If the high level of service is selected as the preferred operating plan, the sidings could be lengthened to permit more flexibility in the operating schedule, which would allow trains to pass without slowing or stopping to take the siding. The conceptual design of the corridor has been developed with space for double track in case it becomes necessary to schedule trains closer then every 20 minutes. With such frequent service, the entire corridor would need to be double tracked.

The northern section of the I-93 Rail Corridor utilizes a portion of the M&L Branch where the track structure is either in poor condition or non-existent. A complete reconstruction of this track structure is necessary to provide a safe and reliable rail service.

The southern section of the I-93 Rail Corridor, which is also along the M&L Branch, contains FRA Class 1 track structure. FRA Class 1 track only allows passenger trains to operate at speeds of up to 15 mph and up to 10 mph for freight trains. This section will require track rehabilitation to meet FRA Class 4 standards. The remainder of the line would require the construction of an entirely new track structure to be built within the I-93 highway corridor.

7.2 Capital Infrastructure Program

A series of specific infrastructure improvements have been developed based on the existing condition of the I-93 corridor and standard rail infrastructure design criteria. These improvements are illustrated in Figure 7-1 and summarized below.

7.2.1 Alignment and ROW

The proposed alignment for the I-93 Rail Corridor Alternative would begin at the Lawrence Station, designated as milepost 0.0. From the station, the corridor would follow the existing M&L rail right-of-way to milepost 3.2. At this point, the alignment will diverge from the M&L Branch to swing over to the west side of I-93. At milepost 6.3 the alignment will be carried into the I-93 median until milepost 19.9. At this point, the alignment would be carried out of the I-93 median to rejoin the M&L Branch at milepost 20. Trains will continue north along the M&L Branch to the site of the layover facility, near the airport, at approximate milepost 22.9.

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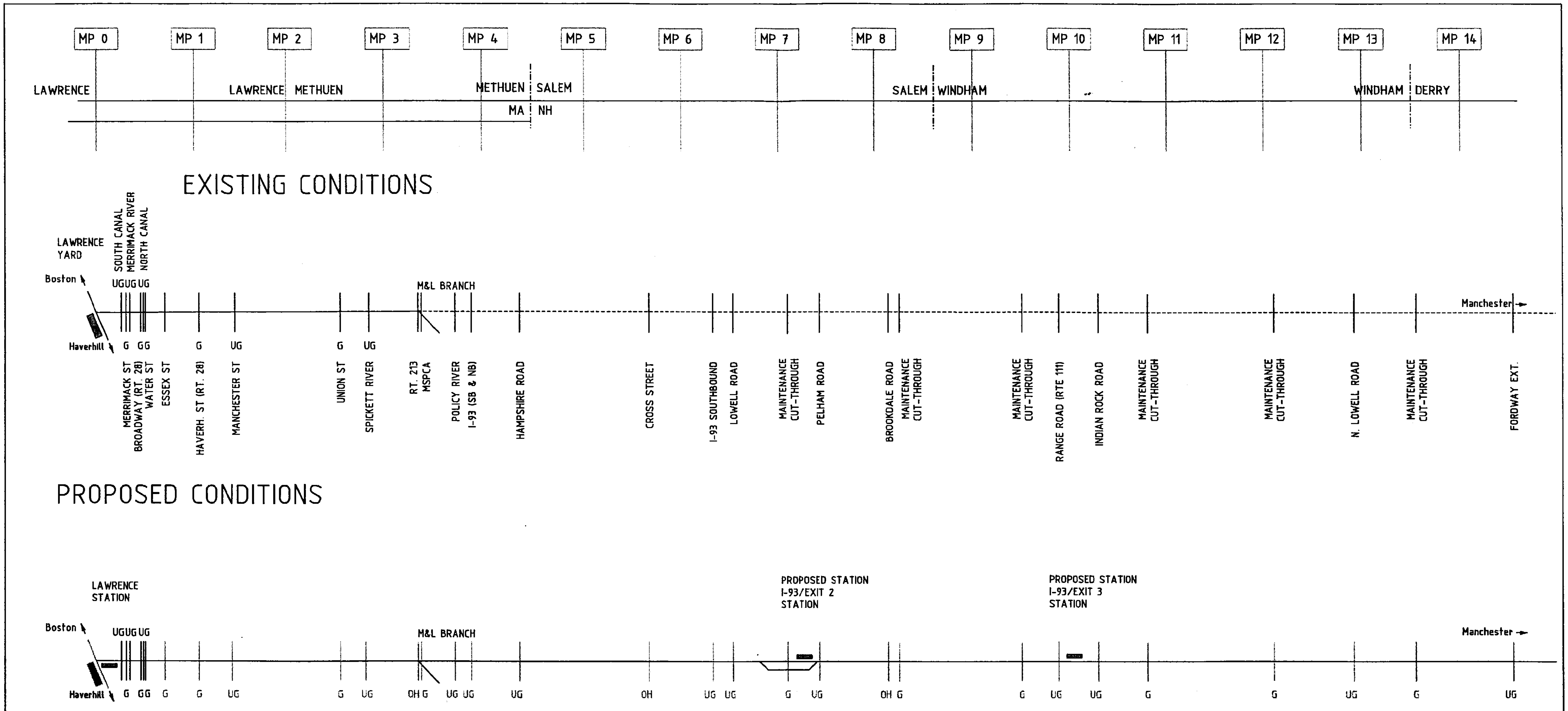


TRACK 1	INSTALL NEW TRACK STRUCTURE	INSTALL NEW TRACK STRUCTURE
TRACK 2		INSTALL NEW TURNOUTS AND TRACK STRUCTURE FOR PASSING SIDING
GRADE X-INGS	INSTALL NEW GRADE CROSSINGS	INSTALL NEW GRADE CROSSINGS
CIVIL	FENCING	EARTHWORK FOR NEW CORRIDOR
STATIONS	NEW STATION FACILITY	NEW STATION FACILITY
STRUCTURES	REHABILITATE ALL UNDERGRADE STRUCTURES	NEW UNDERGRADE STRUCTURES
SIGNAL SYSTEM	IMPROVE INTERLOCKING AND CONTROL CENTER	GRADE CROSSING PROTECTION AT ALL GRADE CROSSINGS

Legend

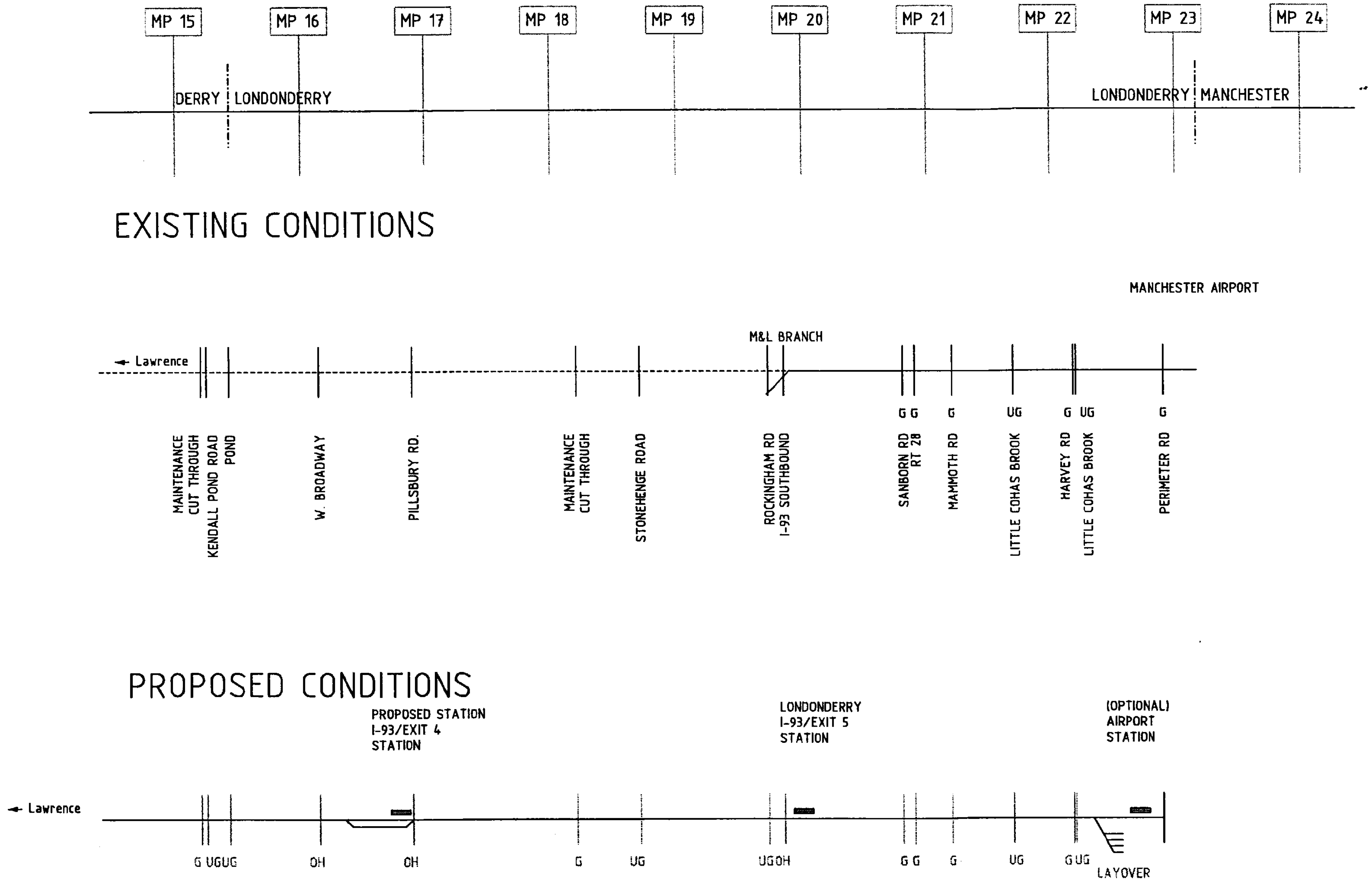
Existing Conditions
Existing ————
Abandoned - - - - - - - -

Proposed Conditions
Existing ············
Proposed ————

G = At Grade Crossing
UG = Undergrade Bridge (Railroad over Road)

Vanasse Hangen Brustlin, Inc.

I-93 LRT CORRIDOR
Figure 7-1 (a)
Proposed Infrastructure Improvements



TRACK 1	INSTALL NEW TRACK STRUCTURE
TRACK 2	INSTALL NEW TURNOUTS AND TRACK STRUCTURE FOR PASSING SIDING
GRADE X-INGS	INSTALL NEW GRADE CROSSINGS
CIVIL	EARTHWORK FOR NEW CORRIDOR
STATIONS	NEW STATION FACILITY NEW STATION FACILITY NEW STATION FACILITY (OPTIONAL)
STRUCTURES	NEW OVERHEAD STRUCTURES REHABILITATE ALL UNDERGRADE STRUCTURES
SIGNAL SYSTEM	GRADE CROSSING PROTECTION AT ALL GRADE CROSSINGS

Legend

Existing Conditions	Proposed Conditions	G = At Grade Crossing
Existing ———	Existing ———	OH = Overhead Bridge (Road over Railroad)
Abandoned -------	Proposed ———	UG = Undergrade Bridge (Railroad over Road)

Vanasse Hangen Brustlin, Inc.

I-93 LRT CORRIDOR

Figure 7-1 (b)

Proposed Infrastructure Improvements

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7.2.2 Track Structure

Construction of a light rail line along the I-93 highway corridor would include a complete overhaul of the existing track structure on the portion of the M&L Branch to be used and new track construction for other portions of the alignment. The track structure includes the rail, ties, ballast, roadbed, special trackwork (i.e. turnouts or sidings, etc.), and other track material.

Rail

New 115 pound continuous weld rail (CWR) is proposed throughout the corridor.

Crossties

The majority of the I-93 Rail Corridor will be a new track structure constructed in an area where there previously was none. This area will require all new crossties. The crossties on the southern portion of the corridor that follows the M&L Branch only meet the minimum requirements for FRA Class 1 operations. This section will require total tie replacement. The northern section of the corridor that follows the M&L Branch between Exit 5 and the Layover facility is an abandoned rail corridor that will also require all new crossties.

Other Track Material (OTM)

There will be total replacement of rail and crossties for both the new track structure and the rehabilitated M&L corridor. This will result not only in the replacement of rail and ties but also in the replacement of all other track material, including rail anchors, tie plates and all rail fasteners.

Ballast

The existing ballast and sub-ballast will need to be replaced or installed throughout the entire corridor. This full replacement includes the sections of active and inactive rail lines since any existing ballast is in such poor condition it will require full replacement.

Special trackwork

A new turnout would be needed where the corridor diverges from the M&L Branch in Massachusetts. Additional turnouts will be required at each end of the two passing sidings and within the layover facility to access the storage tracks.

Drainage

Throughout the existing portions of the corridor the drainage is mostly in fair to poor condition. Most of the ditches will have to be cleaned and rebuilt where necessary. In the areas of entirely new track structure, drainage facilities will be incorporated into the design.

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7.2.3 Grade Crossings

There are 11 existing at-grade highway rail crossings along the M&L Branch sections of the I-93 Rail Corridor, all of which are to remain at-grade. Within the I-93 highway corridor section of the line there would be 17 grade-separated crossings and eight at-grade crossings. The at-grade crossings are all cut-through access roadways, located in the highway median for highway maintenance operations and emergency vehicle access. It would be preferable to either grade separate these crossings or reduce the number of crossings. The issues involved with these at-grade crossing locations would need to be resolved as part of the preliminary design and layout of the rail line. Of the 11 existing at-grade crossings, 10 are public with only one known private crossing. All at-grade crossings would be constructed with new full depth rubber crossing surface material. Recommendations regarding highway crossing warning systems are presented in Section 7.2.7.

7.2.4 Civil

Fencing

In urbanized areas, pedestrian traffic across the rail line could present a potential hazard. Therefore, fencing is recommended where the right-of-way passes through the City of Lawrence for the first 1.25 miles. Other areas that may require fencing will be evaluated on a case by case basis during the preliminary design of the rail layout. The installation of fencing in Lawrence, or other areas, will prevent pedestrians from crossing the tracks at locations without pedestrian crossing protection. Much of the rail line located in the I-93 highway corridor, which is already fenced and protects pedestrian traffic.

Earthwork

General clearing and grubbing will be necessary along most of the corridor to prepare the roadbed for the new tracks. In portions of the alignment where track was previously in place, the existing sub-ballast has to be replaced. In most cases, this will require excavation. Additional earthwork may be necessary in several areas along the abandoned rail right-of-way as well as along portions of new sections of rail alignment. The roadbed will need to be graded and an embankment constructed to support the new track structure. Grading the roadbed will facilitate the replacement of the sub-ballast as well as provide the optimal operating environment and geometrics for light rail operations.

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7.2.5 Stations and Facilities

Stations

In support of the proposed service, four new stations and one layover facility are anticipated along with some modifications to the MBTA's Lawrence Station. The new stations would be located near I-93 interchanges at I-93/Exit 2 in Salem, at I-93/Exit 3 in Windham, at I-93/Exit 4 in Derry, and at I-93/Exit 5 (NH 28) in Londonderry. The proposed locations of these station sites were previously shown in Figures 6-3 through 6-7. The Lawrence Station would require modifications to facilitate the transfer of passengers from the light rail shuttle to the MBTA commuter rail service.

The station facilities will consist of a platform with canopy and benches, lighting, signage, surface walkways and drainage. Pedestrian bridges will be required at the Exit 2/Salem, Exit 4/Derry and possibly Exit 5/Londonderry stations to provide access from the parking facilities, over the highway lanes, to the station platform in the highway median. All the I-93 stations are located adjacent to park-and-ride facilities that will be constructed prior to the implementation of rail service. These park-and-ride lots will be adequate to address projected rail rider demand, with the exception of the Exit 4 station that will require the construction of additional parking spaces in close proximity to the station platform. The existing Exit 4 park-and-ride lot is not close enough to the rail corridor to be effectively used.

High level platforms have been planned at each new station since no freight service is expected along the segments of the line that include the stations. High level platforms improve passenger flow and provide access to disabled passengers. There is a possibility of having low-floor vehicles, thus eliminating the need and cost of high-level platforms. Some of the diesel light rail vehicles have low floors making them potentially compliant with the Americans with Disabilities Act (ADA) requirements. However, standard high-level vehicles have been assumed since diesel light rail vehicles are new to the U.S. market and it is unknown whether they will fully comply with ADA requirements.

The existing MBTA station in Lawrence (MP 0.0) currently has a platform that serves the Haverhill line. South of the existing platform the M&L Line branches north to Manchester, while the Haverhill Line branches east to Haverhill. The proposed I-93 Rail Corridor service could therefore not be served by the existing platform. The planned station modifications for the I-93 service would include the construction of a second platform near the station on a siding off the wye. A short and easy access would be provided between the two platforms to allow for convenient and fast transfers.

Layover Facility

As described in the Operations Plan, a layover facility is needed at the Manchester end of the line. This facility will accommodate the overnight storage of trains and allow for the routine daily cleaning and servicing of the equipment and any minor

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repairs. The location proposed for this facility is just south of Manchester Airport. The storage tracks would be able to facilitate the layover of up to three trains sets. The facility would also include a small building for the service crew and supply storage.

7.2.6 Structures

Undergrade Bridges

There are 21 undergrade bridge structures (i.e. bridges that carry the railroad over a roadway, waterway, or other physical feature) located along the alignment of the proposed I-93 Rail Corridor Alternative. Based on the existing conditions report and the general lack of maintenance on the abandoned sections of the M&L ROW, it has been assumed that all existing open deck undergrade bridges will be replaced with ballast deck structures. The ballast deck structure helps to reduce future maintenance needs. Any new bridges constructed for the I-93 Rail Corridor Alternative would also be ballast deck structures. This results in the replacement of seven bridges along the corridor and the construction of fourteen new bridges.

Overhead Structures

There do not appear to be any overhead bridge changes required along the corridor. Of the five overhead bridges, there is sufficient vertical clearance at existing structures or sufficient clearance with planned highway bridge replacements so that no changes will be required due to the I-93 rail service.

7.2.7 Signal System

Currently there is no signal and communications infrastructure in place on the proposed I-93 Rail Corridor. A new system is necessary to provide safe and reliable operations. The two elements of the new system include the automatic highway crossing warning system (AHCW) and the wayside signal system. The following paragraphs briefly summarize these two elements of the signal system.

Automatic Highway Crossing Warning (AHCW)

The AHCW will control all movements between highway and rail traffic along the corridor. The proposed AHCW system would provide motorists and pedestrians with warnings at each of the active intersections. Modern solid-state, constant warning grade crossing predictors are proposed for installation at all the public grade crossings. This equipment is designed to provide a constant warning time to vehicular motorists regardless of the oncoming train speed. Use of auditory and visual signal systems provide warnings in compliance with FRA regulations. The final decision regarding the level of protection at each crossing will need to be made

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during the preliminary design stage of project development. A team of inspectors from the FRA and the NHDOT will need to evaluate each crossing in detail and make a final recommendation regarding the appropriate level of protection. For cost estimating purposes, it has been assumed that the highest level of protection (gates, warning lights, and bells) will be installed at all grade crossing locations.

Wayside Signal System

The wayside signal system controls all train movements along the corridor. There is no existing wayside control system in place. It is recommended that electronic coded track circuits be installed between control points. This equipment utilizes the rail for all train detection and wayside signal control.

A new wayside and AHCW system will need to be installed to permit efficient passenger train operations. It will be necessary to equip the passing siding tracks with two control points at the north and south ends. The existing Lawrence Station interlocking and the MBTA Control Center will need to be rationalized to permit light rail passenger service operation in the Lawrence Station area.

7.3 Capital Infrastructure Cost Estimate

7.3.1 Methodology

Capital infrastructure costs include improvements to the existing infrastructure like rail and other track materials, grade crossings, signal and communications system, undergrade bridge structures, and construction of new facilities like stations. These infrastructure capital cost estimates do not include the cost of real estate. The capital cost for equipment has been previously discussed in Section 6.5. The estimate accounts for the cost of construction contingencies, incidentals, and design, survey, construction and administrative services. These items are calculated as a percentage of the total contract items.

7.3.2 Infrastructure Cost Estimate

Unit costs for the capital items were estimated using several sources. These sources include cost data from the MBTA and from other transit properties. In developing the capital cost estimates, six general categories of costs were considered. They are:

- Track Structure (rails, ties, and other track materials), ballast, and sub-ballast.
- Grade Crossings: crossing surface improvements and safety
- Civil: New street (roadway) construction, clearing and grubbing, excavation and fill, and fiber optic cable relocation.

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- Structures: bridges, culverts, tunnels and retaining walls
- Facilities: stations, platform and parking for stations, parking for utilities, layover
- Signal System: the wayside signal system, train control, and at-grade crossing protection

The total costs for the recommended infrastructure improvements are summarized in Table 7.3-1. More detailed cost estimates can be found in Appendix J. With a length of approximately 23 miles, the total cost for the I-93 Rail Corridor Alternative is about $177 million ($7.7 million/mile). This includes the construction of the layover/ maintenance facility near the airport and the 2.9 miles of track to access the site.

Table 7.3-1 Total Infrastructure Costs – I-93 Corridor (2000 Dollars)

Infrastructure Item	Cost ($M)
Track Structure	$19.0
Grade Crossings	5.5
Civil	2.7
Structures	69.9
Stations & Facilities	8.1
Signal System	25.7
Sub-total	**$131.7**
Contingency (20%)	26.1
Survey/Design/Construction Services (15%)	19.6
TOTAL INFRASTRUCTURE	**$176.6**

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8

Summary of Rail Alternatives

This final chapter of the report presents a preliminary summary of the services, impacts, and estimated costs associated with providing passenger rail service to southern New Hampshire along each of the three rail corridors examined. The study has looked at three rail corridors that could influence travel demands along the I-93 corridor and provide travel options to the residents of southern New Hampshire. The rail alternatives reviewed in this study are not envisioned to replace I-93 or eliminate the need to upgrade the highway. By the same token, improvements to I-93 should, to the extent practical, be designed to not preclude future possibilities of passenger rail service either in the I-93 Corridor or along the East Rail Corridor. Ultimately which, if any, of these rail corridors should be carried forward to provide passenger rail service is an issue that will require further, more detailed study, independent of improving I-93.

8.1 Service

The implementation of commuter rail service from southern New Hampshire to Boston would provide commuters with new mass transportation options. In other geographic regions, the implementation of passenger rail service has helped to reduce pollution, improve air quality, and reduce highway congestion by removing automobiles from the region's road network. The following sections summarize the potential services and the ridership that would be generated by the implementation of the rail services, representing the possible reduction of drivers from area roadways.

8.1.1 Service Characteristics

West Rail Corridor passenger service would be provided utilizing a direct extension of the MBTA's Lowell Line. Travel time from Manchester to Boston is projected to be between 80 and 85 minutes. Service would range from a low alternative of six weekday and three Saturday roundtrips to a high alternative of 12 weekday and four weekend roundtrips. All trips will be extensions of existing MBTA service to Lowell.

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East Rail Corridor passenger service would be provided utilizing a rail shuttle service. Trains would operate along the corridor to the MBTA's Lawrence Station. Passengers from the trains would transfer to MBTA Haverhill Line trains in Lawrence. Travel time is projected to be between 84 and 105 minutes, with an average peak-direction travel time of 94 minutes. With the proposed shuttle operation, transfer times at Lawrence add between five and fifteen minutes to the total commute time. The service frequency ranges from six weekday and three Saturday roundtrip trains for the low frequency service scenario to 12 weekday and four weekend roundtrip shuttles for the high frequency service scenario.

I-93 Rail Corridor passenger service would be provided utilizing a light rail shuttle operation. These light rail trains would operate along the I-93 corridor, from Exit 5 in Londonderry, meeting with the MBTA commuter rail system in Lawrence. At Lawrence station passengers would be required to transfer from the light rail train to an MBTA commuter rail trains. Travel time is projected to average 83 minutes from Londonderry to Boston.

8.1.2 Ridership

Projected ridership for each rail corridor alternative is provided in Table 8.1-1. The total daily trips represent the sum of the boardings and alightings for each proposed station along the rail corridor. The net-new daily transit trips represent the total daily train trips minus those trips diverted from other transit services to identify the new transit trips generated by the alternative.

Table 8.1-1
Ridership Projection Summary

	Ridership	
Service*	**Total Daily Train Trips**	**Net-New Daily Transit Trips**
West Rail Corridor (Nashua to Manchester)	1,154	606
East Rail Corridor (Lawrence to Manchester)	1,814	886
I-93 Rail Corridor (Lawrence to Londonderry)	1,778	926

* Ridership projections represent moderate service scenario

8.2 Construction and Operational Impacts

The rail service options have impacts that need to be quantified. These impacts range from the type, amount, and cost of construction to MBTA service and operational impacts. The following paragraphs summarize these potential impacts.

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It should be noted that environmental impacts (i.e. natural, cultural, socio-economic impacts) are not addressed in this report. These impacts would need to be addressed in a subsequent study, independent of the I-93 improvement study, as is necessary to determine if the benefits out weigh the total impacts of initiating rail service on any of the rail corridors.

8.2.1 Construction

The West Rail Corridor is currently maintained for freight operations. The infrastructure improvements required to support commuter rail service include replacement of rail, ties, ballast, grade crossing protection systems, and the signal system. In addition, some level of repair/upgrading is anticipated for the undergrade structures. Additionally some impacts would be expected with the construction of the rail stations. These improvements will need to be completed while maintaining existing rail traffic along the corridor. Impacts associated with rail station facilities are anticipated.

On the East Rail Corridor, a new track structure and earthwork along the abandoned sections are required as well as the development of rail stations. Conflicts with existing rail service are not an issue except possibly between Lawrence, MA and Salem, NH where there is some minimal freight service. The tunnel or relocation of the alignment required at the airport results in substantial impacts. The East Rail Corridor would have extensive environmental impacts as a result of relocating the rail line around or under the extended runway at the airport. In addition, there would likely be socio-economic impacts associated with addressing conflicts in densely developed areas, conflicts at the large number of grade crossings, and station development in downtown areas.

On the I-93 Rail Corridor, an entirely new track structure is required for the alignment within the I-93 highway corridor. This would include earthwork, retaining walls, bridges and stations along the alignment. Impacts would be minimal along this section since most track work would be within the I-93 median and stations would be adjacent to park-and-ride lots proposed as part of the highway improvements. The sections of the corridor that are along the M&L Branch will also require the rehabilitation of the track structure. Although there is the potential for some impacts during construction to existing rail service between Lawrence, MA and Salem, NH it should be minimal as freight service is not frequent.

8.2.2 MBTA Operations

Service on the West Rail Corridor would be an extension of existing MBTA trains from Lowell to Manchester. This extension will have an impact on the existing service between Lowell and Boston and, to some extent, on the entire Northside commuter rail service. The larger systemwide impact is a result of the changes that will be required in the fleet management plan. With the longer runs to Manchester,

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the MBTA will likely have to reconsider the deployment of the Northside commuter rail fleet and integrate the new set(s) of equipment.

The East Rail Corridor service will have less of an impact on MBTA operations than the West Rail Corridor Alternative. With the existing constraints on the Haverhill Line, it was assumed that all service between Lawrence and Manchester would be provided via a shuttle train. This service plan only impacts the overall MBTA Northside service to the extent required to integrate the servicing of the shuttle equipment and providing additional coaches for the Haverhill Line trains to accommodate the shuttle train passengers. To provide direct/through service to Boston, the existing single track segments of the Haverhill Line would need to be double tracked.

The I-93 Rail Corridor service would have even less impact on MBTA operations. Since all light rail vehicles would shuttle only between Lawrence and Londonderry and would be serviced at the maintenance facility near the airport, there would be no daily operations impact to the MBTA system. Additional coaches may be required for the Haverhill Line trains to accommodate the passengers transferring at the Lawrence Station. In addition, it would be desirable to coordinate the operating plans of the Haverhill Line service with the I-93 Rail Corridor service in order to offer seamless service to passengers. Operating plan manipulations would likely only occur where the impacts to both services are beneficial.

8.2.3 Freight Operations

The proposed commuter rail services outlined will need to be integrated with existing freight services along the West Rail Corridor and the East Rail Corridor. As documented in the Existing Conditions report prepared for this study[4], STRY handles daily freight service along the West Rail Corridor between Lowell and Manchester. Service from Lowell to Nashua Yard consists of main line and local freight trains and the unit coal train to Bow. North of Nashua, service consists primarily of the unit coal train and local freight service. The main line service generally operates in the late evening or early morning hours while the local freight service operates during the day. On the East Rail Corridor, there is little freight activity. STRY operates a local freight train as far north as Salem on an "as needed" basis. Due to the limited freight service on both corridors, the two proposed commuter rail services should not present any major scheduling issues or conflicts.

With the I-93 Rail Corridor Alternative the scheduling of freight service becomes more of an issue. As detailed previously, there are regulatory concerns regarding the operation of light rail vehicles and freight rail vehicles on the same track. Since the diesel light rail vehicles to be used for this service will not be compliant with FRA crash worthiness standards, some form of separation from the freight service will be required. Separation could be either specific time windows of operation or separate

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[4] *I-93 Salem – Manchester Corridor Improvements: Rail Infrastructure Report*, Vanasse Hangen Brustlin, Inc. July 1999

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tracks within the same right-of-way. Due to the limited nature of freight service on the corridor, it is assumed that time separation would be most cost-effective. Although approval would be required from FRA and an access agreement would be required with GTI, freight service could be restricted to night time or midday hours.

8.3 Safety Considerations

Introduction of commuter rail service will change the operating characteristics of both the West and East Rail Corridors. Presently, the West Rail Corridor is an active rail line but with a relatively low volume of train traffic. The low service scenario would introduce six weekday daily roundtrips (12 trains) and three weekend roundtrips (six trains) to the corridor. The high service scenario would introduce 12 weekday daily roundtrips (24 trains) and four weekend roundtrips (eight trains) to the corridor. These levels of service represent a substantial increase in train traffic along the line.

Rail service on a majority of the East Rail Corridor and I-93 Corridor is either minimal or non-existent. An occasional freight train services the remaining customers along the initial six-mile segment between Lawrence and Salem. Introduction of commuter rail service will represent an even greater increase in rail traffic along the East Rail Corridor than the West Rail Corridor. Rail service introduced along the I-93 Rail Corridor would result in trains operating in locations where none have operated before.

Along all corridors, introduction of rail service means more trains passing by adjacent residential neighborhoods and across at-grade crossings. It will present a different set of circumstances to people living along the corridors and driving across the corridors. The following two sections summarize the potential neighborhood and crossing impacts that the service proposals could present in each corridor.

8.3.1 Grade Crossings and Bridges

At-grade crossings between railroads and streets are a major safety concern of the Federal Highway Administration (FHWA) and the FRA. Both agencies are focused on enhancing the safe use of at-grade crossings by motorists and trains. Recent research efforts have focused on developing new technologies that physically prevent motorists from entering the path of an on-coming train. There has also been funding made available to close at-grade crossings by grade separating when appropriate.

With the recommended consolidation of two existing crossings, there will be 20 at-grade crossings along the 31-mile West Rail Corridor. This represents a density of 0.65 crossings per mile (or a crossing every 1.5 miles). Of the 20 crossings, 12 are public and eight are private. These crossings are generally located in less developed areas given the route's close proximity to the Merrimack River. The crossings

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currently experience at least one or two trains a day. There are approximately four crossings that experience a moderate to high level of automobile traffic. They include: Crown Street, East Hollis Street, and Bridge Street in Nashua; and Granite Street in Manchester.

Along the East Rail Corridor, there will be either 46 or 49 at-grade crossings located along the 27-mile route depending on the alignment option selected at the airport. This represents a density of 1.7 to 1.8 crossings per mile (or a crossing every 0.55 to 0.59 miles). Of the 46 to 49 crossings, 38 to 43 are public and eight are private. Approximately half (46%) of the crossings are presently inactive. Many of the inactive crossings are located in developed areas. There are at least 10 crossings that handle a moderate to high level of automobile traffic located along the corridor. These crossings include: Broadway (NH 28) in Lawrence; Rockingham Park Boulevard (3 separate crossings), Main Street (NH 97), and Range Road (NH 111) in Salem; West Broadway (NH 102) in Derry; Rockingham Road (NH 28) and Perimeter Road in Londonderry; and Granite Street in Manchester.

Along the I-93 Rail Corridor, there would be 18 at-grade crossings located along the 23-mile route. This represents a density of 0.8 crossings per mile (or a crossing every 1.3 miles). Of the 18 crossings, all but one is public. Only 33 percent of the crossings are currently active while four are inactive and eight would be new crossings. Only the Broadway (Rt. 28) crossing in Lawrence would handle a moderate to high level of automobile traffic.

Undergrade bridges (bridges that carry the railroad over a physical feature such as a stream or road) are also a safety consideration. The undergrade bridges represent a potential area where trespassers could become trapped on the right-of-way. As with at-grade crossings, the increased frequency of train traffic presents a greater safety consideration to people working or living adjacent to the corridor.

There are 18 undergrade bridges located along the West Rail Corridor. This represents a density of 0.6 undergrade bridges per mile (or a bridge every 1.67 miles). Of the 18, 11 are located over a waterway (river or stream), four are located over streets, and three are located over pedestrian paths. Along the East Rail Corridor, there are 15 undergrade structures. This represents a density of 0.54 undergrade bridges per mile (or a bridge every 1.8 miles). Of the 15, 12 are located over a waterway (river or stream), two are located over abandoned streets, and one is located over an active street. Along the I-93 Rail Corridor there would be 22 undergrade structures. This represents a density of 0.92 undergrade bridges per mile (or a bridge every 1.1 miles). Of the 22, nine are located over a waterway (river or stream), while the remaining 13 are located over an active street. Figures 8-1 through 8-4 illustrate the location and density of the crossings along the two corridors.

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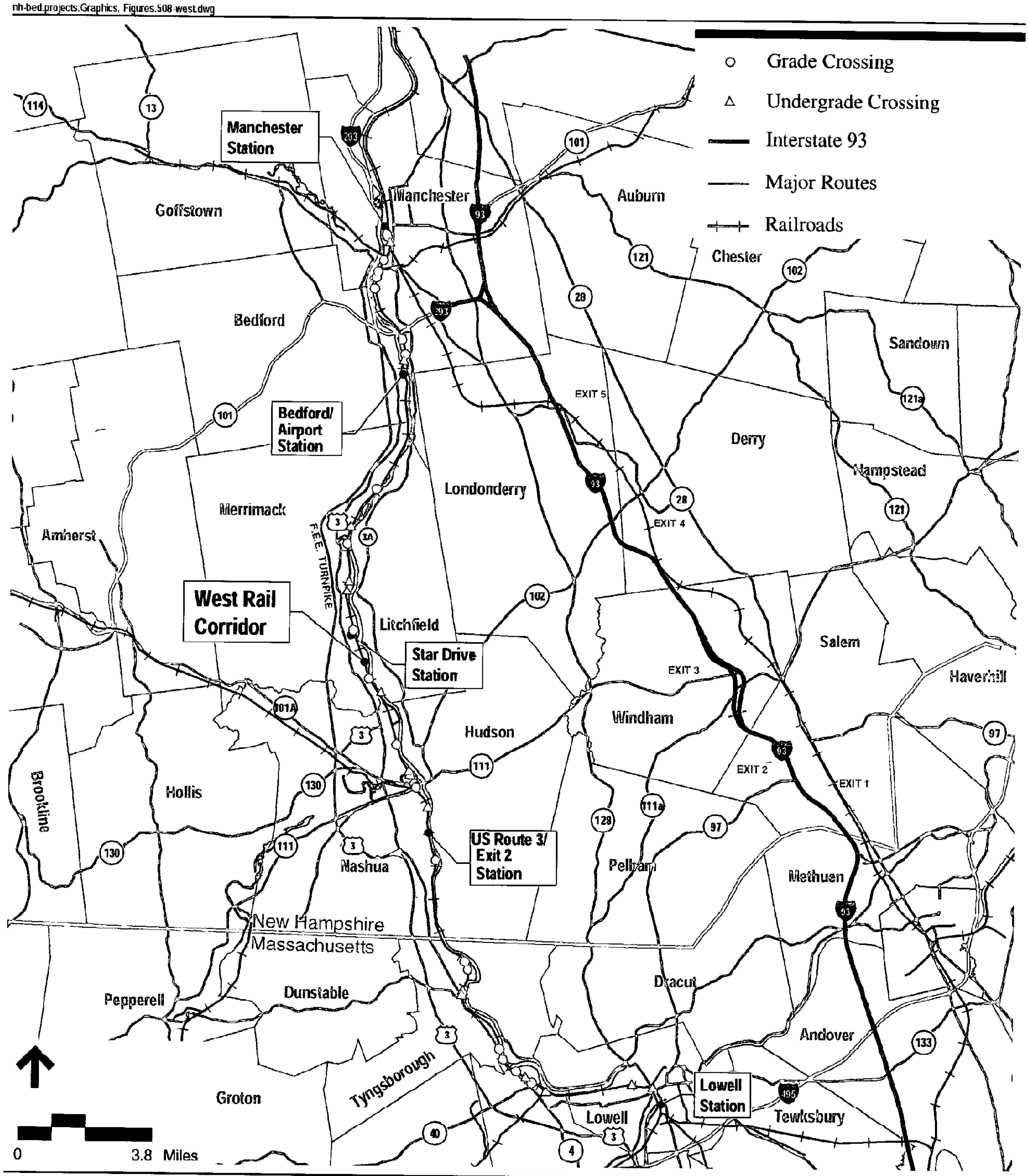

Vanasse Hangen Brustlin, Inc.

West Rail Corridor
Crossing Locations

Figure 8-1

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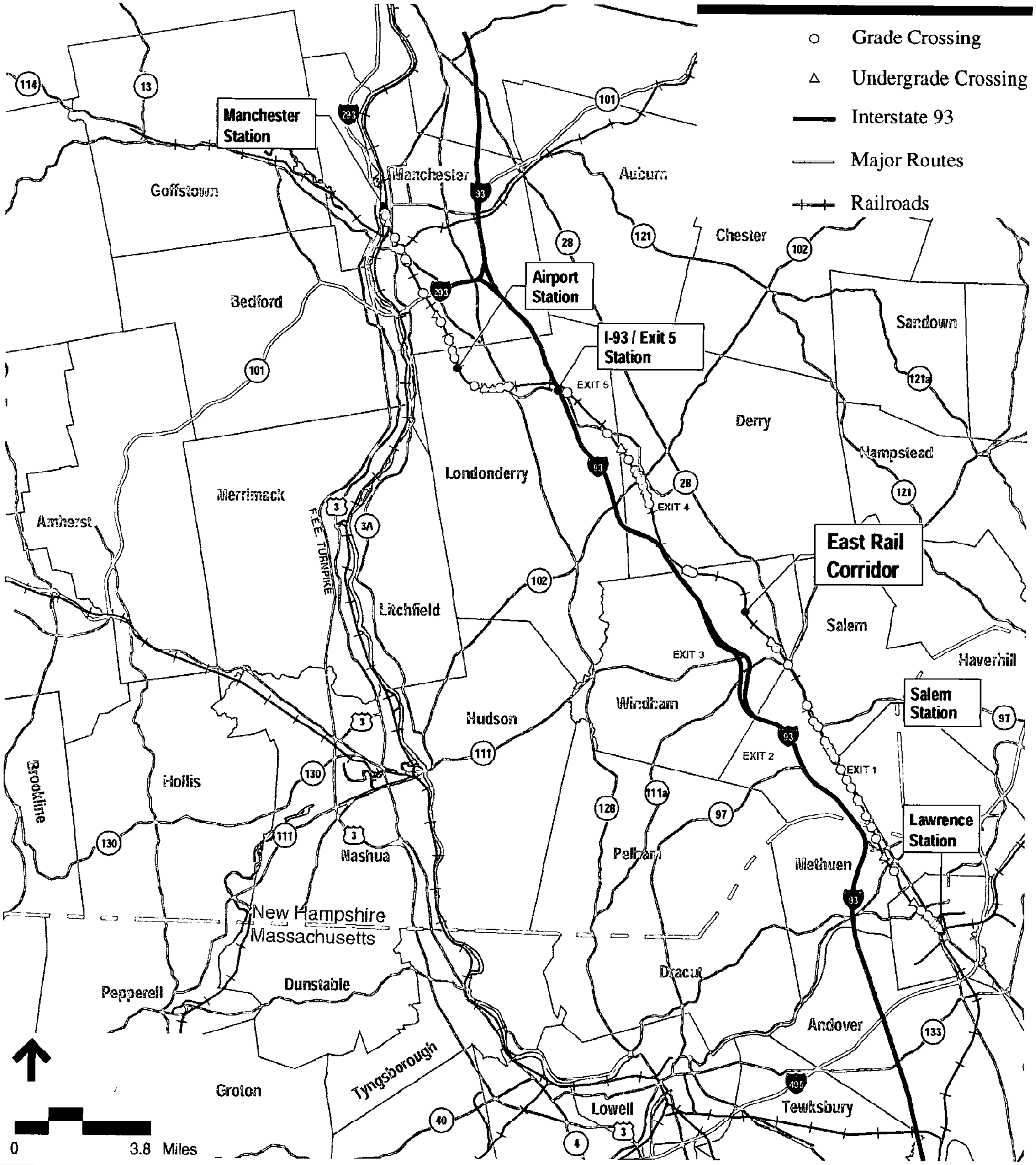

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East Rail Corridor Option 1
Crossing Locations

Figure 8-2

(Note: Option 1 assumes the East Rail Corridor passes through the Manchester Airport Facility via a tunnel under the runways.)

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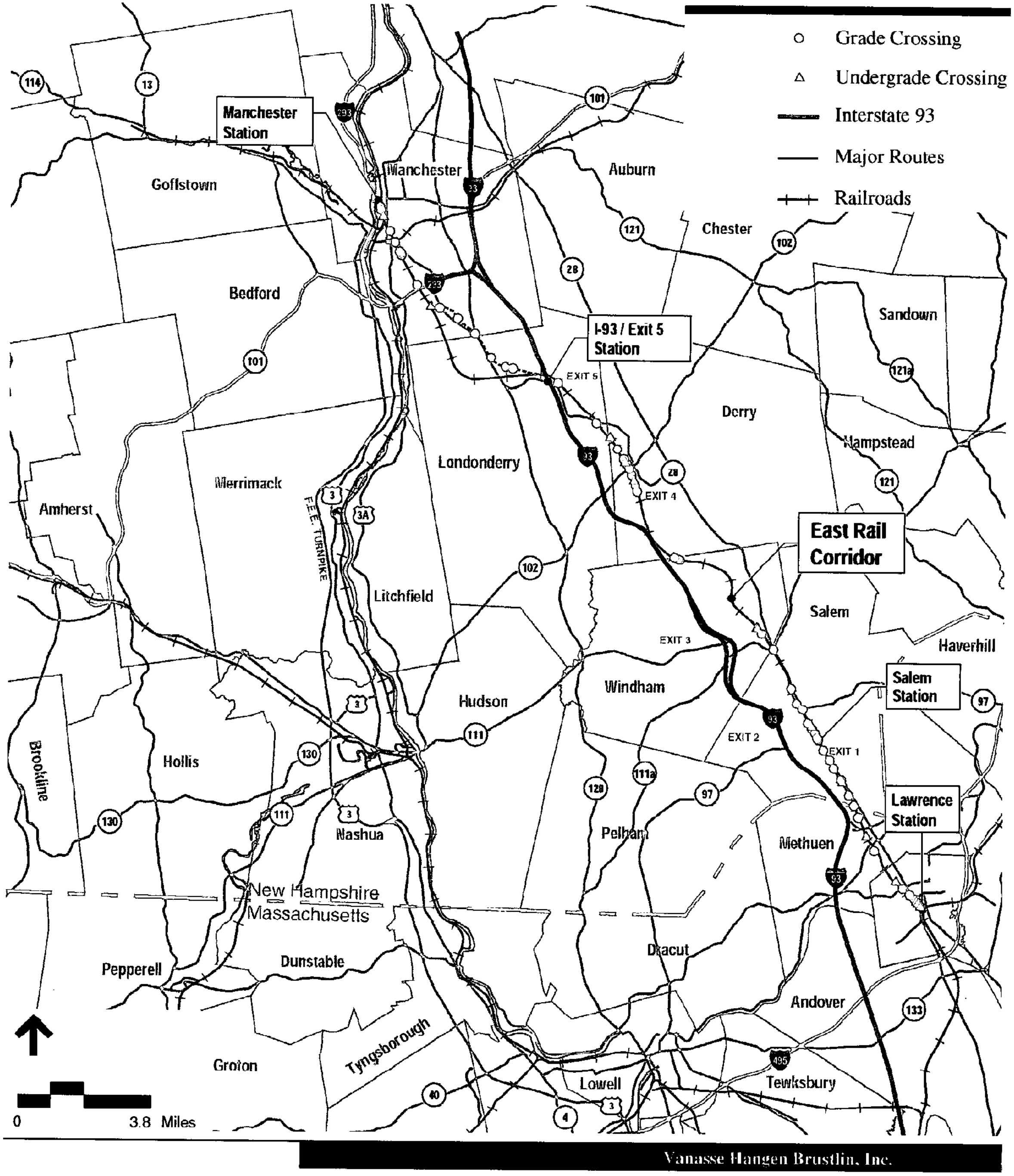

East Rail Corridor Option 2 Figure 8-3
Crossing Locations

(Note: Option 2 assumes the East Rail Corridor is relocated around the Manchester Airport Facility.)

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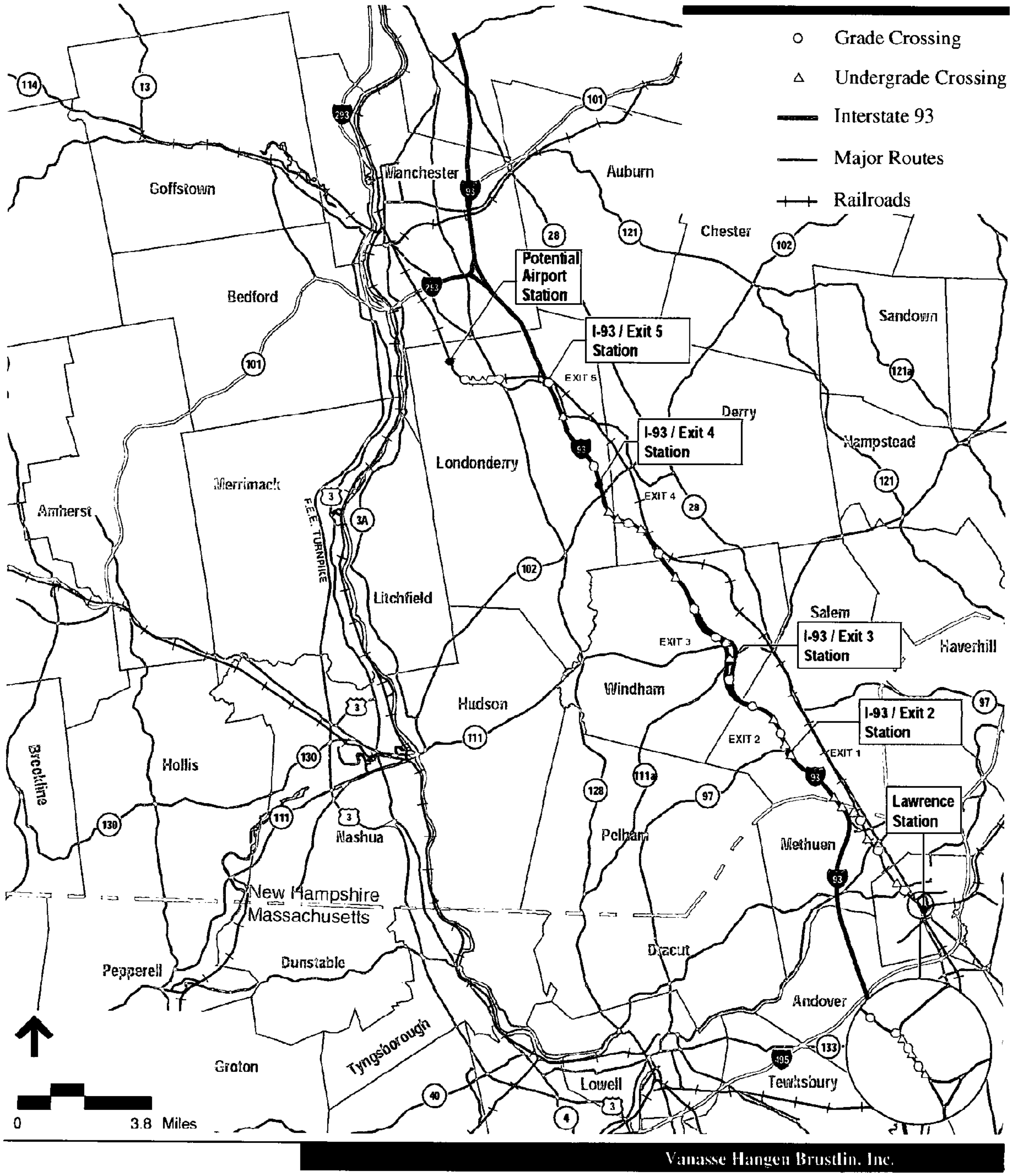

I-93 Rail Corridor
Crossing Locations

Figure 8-4

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8.3.2 Potential Neighborhood Impacts

All three corridors pass by or through residential neighborhoods. These areas, particularly those located along the East Rail Corridor, experience relatively little impact from existing rail activities. With the introduction of commuter rail service however, the potential for impacts would increase substantially.

Due to its location in the Merrimack River valley, the West Rail Corridor generally passes to one side of developed areas rather than through the areas. The location of the rail line in relation to neighborhoods will minimize the impact to neighboring residential areas.

The East Rail Corridor, which generally parallels I-93 and NH 28 in New Hampshire, passes directly through developed residential areas. Most of these communities have not experienced rail service along the line in over two decades. In addition, much of this corridor is presently used as a recreational trail. For these reasons, the restoration of rail service will be perceived as generating greater impacts.

The Massachusetts portion of the I-93 Rail Corridor passes through developed residential areas, however upon reaching New Hampshire avoids residential areas due to its location within the I-93 right-of-way. As a result, the impacts are expected to be less that either of the other two rail alternatives. Figure 8-5 illustrates the location of the rail corridors in reference to developed areas.

8.4 Cost Estimates

Two types of costs have been identified for the services outlined: annual operating and capital (equipment and infrastructure) cost. These results are summarized in the following sections.

8.4.1 Annual Operating Costs

The estimated annual operating costs for the different service levels for the West, East and I-93 Rail Corridor Alternatives are summarized in Table 8.4-1. The West Rail Corridor estimate reflects the extension of planned service between Boston and Nashua to Merrimack, Bedford and Manchester. The East Rail Corridor estimate reflects the operation of a shuttle train between Lawrence and Manchester. The I-93 Rail Corridor estimate reflects the operation of a light rail shuttle service between Lawrence and I-93/Exit 5 in Londonderry. The major cost differences between the corridors are the assumptions used for equipment and corridor length. With the East Rail Corridor it is the assumed that the service will only require a single locomotive and three coaches. The I-93 Rail Corridor operations plan similarly includes three passenger vehicles (light rail vehicles) in each consist. The West Rail corridor service, although shorter in distance assumes the use of seven coaches in each consist, thereby increasing the operating costs.

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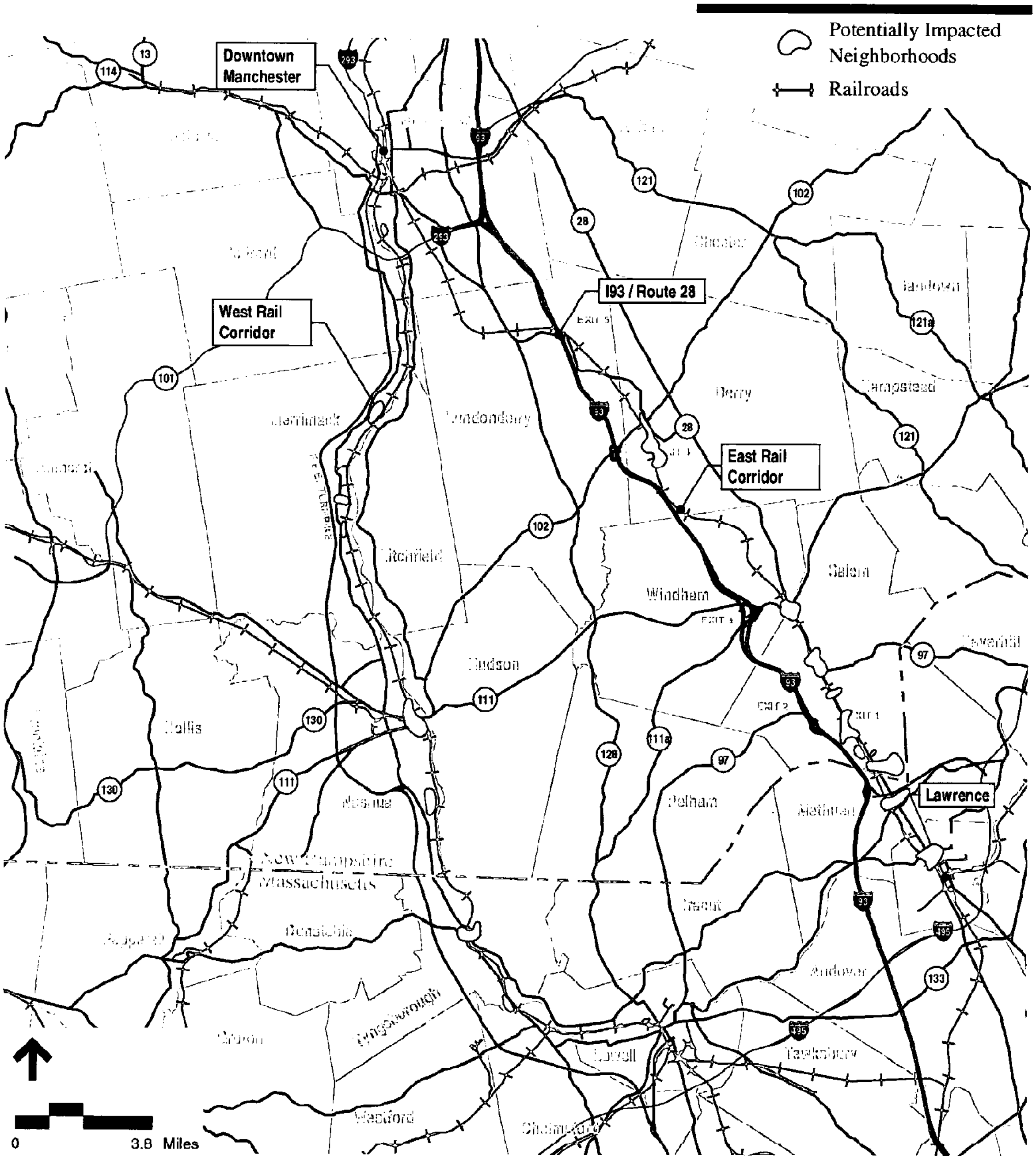

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Potential Neighborhood Impact Locations Figure 8-5

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Table 8.4-1
Operating Cost Summary (2000 Dollars)

	($ Millions)		
Service Level	West Rail Corridor	East Rail Corridor	I-93 Rail Corridor
Low	$3.0	$2.9	$1.9
Moderate	$4.5	$3.6	$2.7
High	$6.3	$5.4	$4.0

8.4.2 Capital Infrastructure Costs

The estimated construction costs for each rail corridor alternative is summarized in Table 8.4-2. As shown in the table, the West Rail Corridor Alternative from Nashua to Manchester would be the least expensive alternative from the capital infrastructure investment perspective at approximately $51.7 million. This lower cost reflects the fact that the line is shorter and is still in operation for freight service. While a substantial level of infrastructure investment is required to bring the West Rail Corridor up to a condition that provides for the reliable operation of passenger trains, the level is still substantially less than the East Rail Corridor options.

The East Rail Corridor options include construction of a tunnel to pass beneath the extended runway at Manchester Airport or relocation of the rail line along an approximately 4-mile long route. Either option substantially increases the cost of the infrastructure. In addition, much of the East Rail Corridor route is presently out of service. Track and bridges have been removed and the roadbed has deteriorated. These conditions contribute towards an overall cost estimate of $317.9 million for the tunnel (Option 1) and $97.1 million for the relocated alignment (Option 2).

The I-93 Rail Corridor principally runs along a new alignment and track structure within the I-93 right-of-way. The construction of this new alignment results in many new structures to separate highway-rail crossings. The required structures contribute substantially to the overall infrastructure cost of the corridor, which is estimated at $176.6 million.

On cost per mile basis, the infrastructure costs for the West Rail Corridor are approximately $2.75 million per mile, the East Rail Corridor costs range from $3.6 to $11.4 million per mile, while the I-93 Rail Corridor is approximately $7.7 million. The East Rail Corridor and I-93 Rail Corridor estimates are substantially higher than the cost for the West Rail Corridor because a complete new track structure is necessary. None of the existing infrastructure on the East Rail Corridor can be rehabilitated or re-used, and both options addressing the airport runway issue are expensive in comparison to the West Rail Corridor. In particular, the cost of the cut

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and tunnel structures for the alignment through the airport is estimated at approximately $165 million alone.

The capital infrastructure cost estimates do not include real estate acquisition costs for any of the alternatives. At this time, it is known that both East Rail Corridor options will require the acquisition of property in Derry and Londonderry where portions of the right-of-way have been sold. Additionally, the East Rail Corridor Option 2 (relocation) requires acquisition of approximately 30 acres (a four-mile corridor, 60 feet in width) with an estimated cost of $10 million. None of these real estate costs are included in the capital infrastructure cost estimate at this stage.

Table 8.4-2
Capital Infrastructure Cost Summary (2000 Dollars ($Millions))

Item	West Rail Corridor – Lowell to Manchester	East Rail Corridor – Tunnel Option	East Rail Corridor – Relocation Option	I-93 Rail Corridor
Track Structure	$18.4	$23.6	$23.4	$19.0
Grade Crossings	7.9	15.4	17.4	5.5
Civil	0.6	2.8	3.3	2.7
Structures	1.6	173.4	12.2	69.9
Facilities	8.0	9.0	4.0	8.1
Signal System	17.7	11.7	11.7	25.7
Sub-total	54.2	235.5	71.9	130.8
Contingency (20%)	10.8	47.1	14.4	26.2
Survey/Design/Construction Services (15%)	8.1	35.3	10.8	19.6
TOTAL INFRASTRUCTURE COST*	**$73.2****	**$317.9**	**$97.1**	**$176.6**

*Real Estate costs have not been estimated for this study. While some additional real estate will need to be purchased as part of any of the alternatives, the relative difference in cost for the three alternatives would not appear to be significant. The exception is the cost of property required for Option 2 of the East Rail Corridor Alternative to relocate the rail line around the Manchester Airport. That cost was previously estimated by the NHDOT to be approximately $10 million.

**The Infrastructure costs for the extension of rail service between Nashua and Manchester is estimated at $51.7 million. The State of New Hampshire committed to initiating rail service between Lowell and Nashua ($21.5 million estimated infrastructure costs) during development of this evaluation report.

8.4.3 Capital Equipment Costs

Both the East Rail Corridor and West Rail Corridor rail service alternatives will require the procurement of additional commuter rail equipment to provide the proposed service. The amount of additional equipment (coaches and locomotives) varies by the amount of service operated. A detailed fleet management plan for the

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MBTA's Northside commuter rail service will need to be developed to determine the actual number of additional trains required. The I-93 Rail Corridor will require new diesel light rail vehicles to be procured. The number of cars required also depends on the level of service operated.

The East Rail and I-93 Rail Corridor service alternatives require only a single train set (plus a spare set) for the low service scenarios. A train set would consist of a locomotive and three coaches for the East Rail Corridor service or three light rail vehicles for the I-93 Rail Corridor service. The moderate and high service scenarios for both corridors would require a third train set. Due to the uniqueness of both consist configurations, a spare train set would be required to provide back up for maintenance and breakdowns.

For the West Rail Corridor, the requirements for additional equipment are much more difficult to project. The requirements are based on the assumption that up to 75 percent of the proposed service could require new equipment. For the High Service scenario that includes 12 roundtrips to Manchester, this assumption yields eight new trains. With the moderate service scenario of eight roundtrips, six new sets of equipment could be required. To operate the low service scenario of six roundtrips, four additional sets of equipment could be required to operate service to Manchester.

A single seven-coach train (one locomotive, six blind coaches, and one control cab coach) costs approximately $11.1 million. For the three-coach commuter rail shuttle equipment consist, the cost is approximately $6.7 million. A diesel light rail three-car consist costs approximately $10.2 million. These unit costs represent averages. A contingency of 20 percent is recommended for planning purposes at the current stage of project development. Table 8.4-3 summarizes the capital equipment cost estimates for the two corridors.

Table 8.4-3
Capital Equipment Cost Summary (2000 Dollars)

	($Million)		
Alternative	**Sub-Total**	**Contingency**	**Total**
West Rail Corridor			
Low Service Scenario	$44.4	$8.9	**$53.3**
Moderate Service Scenario	66.6	13.3	**79.9**
High Service Scenario	88.8	17.8	**106.6**
East Rail Corridor			
Low Service Scenario	13.4	2.7	**16.1**
Moderate Service Scenario	20.1	4.0	**24.1**
High Service Scenario	20.1	4.0	**24.1**
I-93 Rail Corridor			
Low Service Scenario	20.4	4.1	**24.5**
Moderate Service Scenario	30.6	6.1	**36.7**
High Service Scenario	30.6	6.1	**36.7**

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8.5 Incremental Cost Analysis

Once the total capital and annual operating costs are developed, a basis for comparison needs to be provided. The financial evaluation process typically includes a step to develop the incremental annual cash flow requirements for each alternative. This step is accomplished by first converting the capital cost estimates to an annualized basis for comparison. A total annual cost (annualized capital and operating) is then presented for all of the alternatives. An annual revenue projection is also developed and applied against the total annual cost to determine the net annual cost (cash flow requirement). The following sections present the development of the total annual cost or incremental cost requirement for each alternative. The detailed cost calculations can be found in Appendix K.

8.5.1 Annualized Capital Costs

The capital cost estimates for the Rail Alternatives were described in Chapters 3, 5 and 7 of this document. These estimates included the fixed guideway, earthworks, signal and communications system, structures, facilities, highway items, and equipment costs necessary to provide the intended transportation services or improvements. The infrastructure capital cost estimates prepared for this study do not include the cost of real estate for the rail corridor or train stations.

The first step in annualizing capital costs is to estimate the useful life of each capital component. A component's useful life is defined as its reasonable life expectancy with normal maintenance and a mid-life rehabilitation. Table 8.5-1 summarizes the useful life spans utilized for this analysis.

Table 8.5-1
Useful Life Spans of Capital Assets

Category	Component	Useful Life (years)
Transit Infrastructure	Trackwork	30
	Earthwork	30
	Structures (new)	40
	Structures (minor repair)	5
	Signal and Communications System	30
	Power	30
	Stations	20
Transit Equipment	Locomotives/coaches	25

Annualized capital costs were developed based on the projected life cycle (life expectancy) for each major cost area or category (trackwork, structures, earthwork, vehicles, etc.). Capital equipment costs are also presented as an annual incremental

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cost based on the life of the equipment as defined by FTA. Annualized costs were calculated using the estimated useful life for each capital asset as noted above and a discount rate that reflects the time-value of money. This amortization was performed using a discount rate of 7 percent, in accordance with the latest federal guidance. Table 8.5-2 summarizes the annualization of capital costs for each alternative. The various components of each alternative were previously defined in Chapters 3, 5 and 7. The detailed calculations are provided in Appendix K.

As shown in the table, the total annual capital cost estimates range from $9.0 million for the West Rail Corridor to $44.9 million for the East Rail Corridor Tunnel Option. The differences in annualized capital costs between corridor service scenarios are due to the different equipment needs. Although the necessary infrastructure for the West Rail Corridor is minimal the equipment costs are not. This results in the total annual capital costs for the West Rail Corridor ($9.0 to $13.5 million) being similar to the East Rail Corridor-Relocated Alignment ($8.5 to $9.2 million) which requires more infrastructure yet less equipment. The I-93 Rail Corridor Alternative has annualized capital costs ranging from $15.8 million to $16.9 million.

Table 8.5-2
Annualized Capital Costs (2000 Dollars)

	($Million)		
Alternative	**Infrastructure**	**Equipment**	**Total**
West Rail Corridor			
Low Service Scenario	$4.4	$4.6	**$9.0**
Moderate Service Scenario	4.4	6.9	**11.3**
High Service Scenario	4.4	9.1	**13.5**
East Rail Corridor – Tunnel Option			
Low Service Scenario	42.9	1.4	**44.3**
Moderate Service Scenario	42.9	2.0	**44.9**
High Service Scenario	42.9	2.0	**44.9**
East Rail Corridor – Relocation Option			
Low Service Scenario	7.8	1.4	**9.2**
Moderate Service Scenario	7.8	2.0	**9.8**
High Service Scenario	7.8	2.0	**9.8**
I-93 Rail Corridor			
Low Service Scenario	13.7	2.1	**15.8**
Moderate Service Scenario	13.7	3.2	**16.9**
High Service Scenario	13.7	3.2	**16.9**

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8.5.2 Total Annual Costs

A total annual cost for each Rail Alternative was estimated by adding annual operating costs to the annualized capital costs developed above. Table 8.5-3 summarizes the total annual cost for each alternative.

As shown in the table, the total annual costs range from $12.0 million for the West Rail Corridor with the low service scenario to $50.3 million for the East Rail Corridor Tunnel Option with the high service scenario. The projected total annual cost of the West Rail Corridor and East Rail Corridor Relocation Option and the I-93 Rail Corridor are all fairly close. The East Rail Corridor Relocation Option ranges from $12.1 million to $15.2 million annually, the West Rail Corridor ranges from $12.0 million to $19.8 million annually, while the I-93 Rail Corridor ranges from $17.7 million to $20.9 million annually. Total annual costs vary most dramatically with the service scenarios for the West Rail Corridor due to the higher per mile operating costs of the longer train consists.

Table 8.5-3
Total Annual Costs (2000 Dollars)

Alternative	($Million) Capital Costs	Operating Costs	Total Costs
West Rail Corridor			
Low Service Scenario	$9.0	$3.0	**$12.0**
Moderate Service Scenario	11.3	4.5	**15.8**
High Service Scenario	13.5	6.3	**19.8**
East Rail Corridor – Tunnel Option			
Low Service Scenario	44.3	2.9	**47.2**
Moderate Service Scenario	44.9	3.6	**48.5**
High Service Scenario	44.9	5.4	**50.3**
East Rail Corridor – Relocation Option			
Low Service Scenario	9.2	2.9	**12.1**
Moderate Service Scenario	9.8	3.6	**13.4**
High Service Scenario	9.8	5.4	**15.2**
I-93 Rail Corridor			
Low Service Scenario	15.8	1.9	**17.7**
Moderate Service Scenario	16.9	2.7	**19.6**
High Service Scenario	16.9	4.0	**20.9**

8.5.3 Net Annual Costs

To identify the net annual cost for each Rail Alternative, the total annual operating costs are offset (reduced) by the amount of revenue (fares) collected from the patrons, based on the projected ridership for each rail alternative. Since ridership was developed for the moderate service scenario, the annual operating costs for that scenario was used to complete the incremental cost analysis. The net annual cost for each alternative reflects the total annual capital cost for the moderate service scenario minus the annual revenue based on the projected ridership. The variation in annual revenue is due to the nature of the three services. Since the West Rail Corridor is an extension of existing service the revenues from each incremental rider all the way to Boston can be claimed by the service. However, since the other services are shuttle operations the revenue claimed can only be between the boarding station and Lawrence, the transfer station. These calculations are summarized in Table 8.5-4.

Table 8.5-4
Net Annual Costs (2000 Dollars)

	($Million)		
Alternative	**Total Annual Cost**	**Annual Revenue**	**Net Annual Cost**
West Rail Corridor (Nashua to Manchester) Moderate Service Scenario	$15.8	$0.9	$14.9
East Rail Corridor (Lawrence to Manchester) Tunnel Option Moderate Service Scenario	$48.5	$0.3	$48.2
East Rail Corridor (Lawrence to Manchester) Relocation Option Moderate Service Scenario	$13.4	$0.3	$13.1
I-93 Rail Corridor (Lawrence to Londonderry) Moderate Service Scenario	$19.6	$0.6	$19.0

8.5.4 Cost Effectiveness

Cost-effectiveness measures the extent to which alternative provides a level of benefits that is commensurate with its costs based on the following criteria:

- Capital costs of the improvement annualized over the life of the project.
- Annual operating costs.
- Change in systemwide linked transit trips.

Cost-effectiveness for each alternative was calculated using the revised formula specified by the FTA in the Federal Register Notice of December 19, 1996 and subsequent "Technical Guidance on Section 5309 New Starts Criteria" issued in September 1997. The formula, referred to as the Cost-Effectiveness Index, measures the net cost per new passenger attracted by the transit improvement. The net cost of the improvement (annualized capital cost + annual operating cost – annual revenues) as reported in Table 8.5-4 is divided by the net additional riders yielding a measure in dollars per new rider as shown below:

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Cost Per New Rider = $\frac{\$CAP + \$OP}{\text{Annual Trips}}$

Where:

$CAP = Total annual capital cost

$OP = Total annual operating cost less total annual revenues

Annual Trips = New annual transit trips (in comparison with the No-Build Alternative)

These calculations are summarized in Table 8.5-5.

Table 8.5-5
Cost Per Rider (2000 Dollars)

Alternative	Net Annual Cost ($Million)	Total Annual Trips	Cost Per Trip	Total New Transit Trips	Cost Per New Transit Trip
West Rail Corridor (Nashua to Manchester)	$14.9	294,270	$51	154,530	$96
East Rail Corridor (Lawrence to Manchester) Tunnel Option	$48.2	462,570	$104	225,930	$213
East Rail Corridor (Lawrence to Manchester) Relocation Option	$13.1	462,570	$28	225,930	$58
I-93 Rail Corridor (Lawrence to Londonderry)	$19.0	453,390	$42	236,130	$80

1800/Day

160,000

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8.6 Summary

This report has examined a number of different parameters associated with the implementation of rail service alternatives along the West, East and I-93 Rail Corridors. These parameters included operational requirements, infrastructure needs, operating costs, capital costs, and potential benefits. Table 8.6-1 summarizes these parameters in a convenient side-by-side comparison.

Table 8.6-1
Summary of Rail Alternatives

Evaluation Parameter	West Rail Corridor (Nashua to Manchester)	East Rail Corridor – Tunnel Option	East Rail Corridor – Relocation Option	I-93 Rail Corridor
Service Characteristics				
Route Length (Miles)	18.8	27.8	27.8	22.9
New Stations	3	4	3	4
Average Peak Direction Travel Time (Minutes)	83	94*	94*	83*
Type of Service	Through	Shuttle	Shuttle	Shuttle
Annual Trips	294,270	462,570	462,570	453,390
Locomotives/Coaches (Moderate)	6/42	3/9	3/9	0/9
Annual Train Miles (Moderate)	96,900	129,900	129,900	98,300
Infrastructure				
Grade Crossings	20	42	49	11
Undergrade Structures	18	16	16	21
Moderate Scenario Costs				
Infrastructure ($m)**	$51.7	$317.9	$97.1	$176.6
Equipment ($m)	$79.9	$24.1	$24.1	$36.7
Annual Operating ($m)	$4.5	$3.6	$3.6	$2.7
Total Annual Cost ($m)	$15.8	$48.5	$13.4	$19.6
Annual Revenues ($m)	$0.9	$0.3	$0.3	$0.6
Net Annual ($m)	$14.9	$48.2	$13.1	$19.0
Cost per Trip ($)	$51	$104	$28	$42
Cost per New Transit Trip ($)	$96	$213	$58	$80

* Includes 5 minute average transfer time during peak period in predominant direction of travel. Off-peak and reverse peak transfer times higher.

** Costs do not include real estate requirements

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APPENDICES

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Appendix A

West Rail Corridor: Schedules

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WEST RAIL CORRIDOR- LOWELL TO MANCHESTER
HIGH LEVEL OF SERVICE

WEEKDAY INBOUND SCHEDULE

Train No.:	302	304	306	308	310	312	314	316	328	334	336	338
Manchester	5:00 AM	5:45 AM	6:15 AM	6:47 AM	7:15 AM	7:50 AM	8:32 AM	9:32 AM	3:40 PM	5:10 PM	5:40 PM	6:40 PM
Manchester Airport	5:05 AM	5:50 AM	6:20 AM	6:52 AM	7:20 AM	7:55 AM	8:37 AM	9:37 AM	3:45 PM	5:15 PM	5:45 PM	6:45 PM
Merrimack- Star Drive	5:13 AM	5:58 AM	6:28 AM	7:00 AM	7:28 AM	8:03 AM	8:45 AM	9:45 AM	3:53 PM	5:23 PM	5:53 PM	6:53 PM
Nashua- NH 3/Exit 2	5:22 AM	6:07 AM	6:37 AM	7:09 AM	7:37 AM	8:12 AM	8:54 AM	9:54 AM	4:02 PM	5:32 PM	6:02 PM	7:02 PM
Lowell	5:34 AM	6:19 AM	6:49 AM	7:21 AM	7:49 AM	8:24 AM	9:06 AM	10:06 AM	4:14 PM	5:44 PM	6:14 PM	7:14 PM
North Station	6:20 AM	7:07 AM	7:39 AM	8:11 AM	8:38 AM	9:10 AM	9:51 AM	10:51 AM	4:59 PM	6:29 PM	7:00 PM	7:59 PM

WEEKDAY OUTBOUND SCHEDULE

Train No.:	305	307	315	319	325	327	329	331	333	335	337	343
North Station	6:35 AM	7:27 AM	10:10 AM	12:10 PM	3:10 PM	4:10 PM	4:40 PM	5:10 PM	5:45 PM	6:17 PM	7:30 PM	10:40 PM
Lowell	7:17 AM	8:11 AM	10:54 AM	12:54 PM	3:54 PM	4:58 PM	5:31 PM	5:59 PM	6:33 PM	7:02 PM	8:15 PM	11:24 PM
Nashua- NH 3/Exit 2	7:29 AM	8:23 AM	11:06 AM	1:06 PM	4:06 PM	5:10 PM	5:43 PM	6:11 PM	6:45 PM	7:14 PM	8:27 PM	11:36 PM
Merrimack- Star Drive	7:37 AM	8:31 AM	11:14 AM	1:14 PM	4:14 PM	5:18 PM	5:51 PM	6:19 PM	6:53 PM	7:22 PM	8:35 PM	11:44 PM
Manchester Airport	7:46 AM	8:40 AM	11:23 AM	1:23 PM	4:23 PM	5:27 PM	6:00 PM	6:28 PM	7:02 PM	7:31 PM	8:44 PM	11:53 PM
Manchester	7:51 AM	8:45 AM	11:28 AM	1:28 PM	4:28 PM	5:32 PM	6:05 PM	6:33 PM	7:07 PM	7:36 PM	8:49 PM	11:58 PM

WEEKEND INBOUND SCHEDULE

Train No.:	1302	1304	1306	1308	1310
Manchester	8:25 AM	10:25 AM	12:26 PM	2:26 PM	4:25 PM
Manchester Airport	8:30 AM	10:30 AM	12:31 PM	2:31 PM	4:30 PM
Merrimack- Star Drive	8:38 AM	10:38 AM	12:39 PM	2:39 PM	4:38 PM
Nashua- NH 3/Exit 2	8:47 AM	10:47 AM	12:48 PM	2:48 PM	4:47 PM
Lowell	8:59 AM	10:59 AM	1:00 PM	3:00 PM	4:59 PM
North Station	9:43 AM	11:43 AM	1:43 PM	3:43 PM	5:43 PM

WEEKEND OUTBOUND SCHEDULE

Train No.:	1307	1309	1311	1313	1315
North Station	2:00 PM	4:00 PM	6:00 PM	8:00 PM	11:00 PM
Lowell	2:43 PM	4:43 PM	6:43 PM	8:43 PM	11:43 PM
Nashua- NH 3/Exit 2	2:48 PM	4:48 PM	6:48 PM	8:48 PM	11:48 PM
Merrimack- Star Drive	2:56 PM	4:56 PM	6:56 PM	8:56 PM	11:56 PM
Manchester Airport	3:05 PM	5:05 PM	7:05 PM	9:05 PM	12:05 AM
Manchester	3:17 PM	5:17 PM	7:17 PM	9:17 PM	12:17 AM

Mabos\projects\50885\ssheets\NHML-Ops(Hi)

11/6/00

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WEST RAIL CORRIDOR- LOWELL TO MANCHESTER
MODERATE LEVEL OF SERVICE

WEEKDAY INBOUND SCHEDULE

Train No.:	304	306	308	310	312	314	336	338
Manchester	5:45 AM	6:15 AM	6:47 AM	7:15 AM	7:50 AM	8:32 AM	5:40 PM	6:40 PM
Manchester Airport	5:50 AM	6:20 AM	6:52 AM	7:20 AM	7:55 AM	8:37 AM	5:45 PM	6:45 PM
Merrimack- Star Drive	5:58 AM	6:28 AM	7:00 AM	7:28 AM	8:03 AM	8:45 AM	5:53 PM	6:53 PM
Nashua- NH 3/Exit 2	6:07 AM	6:37 AM	7:09 AM	7:37 AM	8:12 AM	8:54 AM	6:02 PM	7:02 PM
Lowell, MA	6:19 AM	6:49 AM	7:21 AM	7:49 AM	8:24 AM	9:06 AM	6:14 PM	7:14 PM
North Station	7:07 AM	7:39 AM	8:11 AM	8:38 AM	9:10 AM	9:51 AM	7:00 PM	7:59 PM

WEEKDAY OUTBOUND SCHEDULE

Train No.:	325	327	329	331	333	335	337	343
North Station	3:10 PM	4:10 PM	4:40 PM	5:10 PM	5:45 PM	6:17 PM	7:30 PM	10:40 PM
Lowell, MA	3:54 PM	4:58 PM	5:31 PM	5:59 PM	6:33 PM	7:02 PM	8:15 PM	11:24 PM
Nashua- NH 3/Exit 2	4:06 PM	5:10 PM	5:43 PM	6:11 PM	6:45 PM	7:14 PM	8:27 PM	11:36 PM
Merrimack- Star Drive	4:14 PM	5:18 PM	5:51 PM	6:19 PM	6:53 PM	7:22 PM	8:35 PM	11:44 PM
Manchester Airport	4:23 PM	5:27 PM	6:00 PM	6:28 PM	7:02 PM	7:31 PM	8:44 PM	11:53 PM
Manchester	4:28 PM	5:32 PM	6:05 PM	6:33 PM	7:07 PM	7:36 PM	8:49 PM	11:58 PM

WEEKEND INBOUND SCHEDULE

Train No.:	1302	1304	1308	1310
Manchester	8:25 AM	10:25 AM	2:26 PM	4:25 PM
Manchester Airport	8:30 AM	10:30 AM	2:31 PM	4:30 PM
Merrimack- Star Drive	8:38 AM	10:38 AM	2:39 PM	4:38 PM
Nashua- NH 3/Exit 2	8:47 AM	10:47 AM	2:48 PM	4:47 PM
Lowell, MA	8:59 AM	10:59 AM	3:00 PM	4:59 PM
North Station	9:43 AM	11:43 AM	3:43 PM	5:43 PM

WEEKEND OUTBOUND SCHEDULE

Train No.:	1309	1310	1313	1315
North Station	4:00 PM	6:00 PM	8:00 PM	11:00 PM
Lowell, MA	4:43 PM	6:43 PM	8:43 PM	11:43 PM
Nashua- NH 3/Exit 2	4:48 PM	6:48 PM	8:48 PM	11:48 PM
Merrimack- Star Drive	4:56 PM	6:56 PM	8:56 PM	11:56 PM
Manchester Airport	5:05 PM	7:05 PM	9:05 PM	12:05 AM
Manchester	5:17 PM	7:17 PM	9:17 PM	12:17 AM

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WEST RAIL CORRIDOR-LOWELL TO MANCHESTER
LOW LEVEL OF SERVICE

WEEKDAY INBOUND SCHEDULE

Train No.:	304	306	308	310	316	338
Manchester	5:45 AM	6:15 AM	6:47 AM	7:15 AM	9:32 AM	6:40 PM
Manchester Airport	5:50 AM	6:20 AM	6:52 AM	7:20 AM	9:37 AM	6:45 PM
Merrimack- Star Drive	5:58 AM	6:28 AM	7:00 AM	7:28 AM	9:45 AM	6:53 PM
Nashua- NH 3/Exit 2	6:07 AM	6:37 AM	7:09 AM	7:37 AM	9:54 AM	7:02 PM
Lowell, MA	6:19 AM	6:49 AM	7:21 AM	7:49 AM	10:06 AM	7:14 PM
North Station	7:07 AM	7:39 AM	8:11 AM	8:38 AM	10:51 AM	7:59 AM

WEEKDAY OUTBOUND SCHEDULE

Train No.:	329	331	333	335	337	343
North Station	4:40 PM	5:10 PM	5:45 PM	6:17 PM	7:30 PM	10:40 PM
Lowell, MA	5:31 PM	5:59 PM	6:33 PM	7:02 PM	8:15 PM	11:24 PM
Nashua- NH 3/Exit 2	5:43 PM	6:11 PM	6:45 PM	7:14 PM	8:27 PM	11:36 PM
Merrimack- Star Drive	5:51 PM	6:19 PM	6:53 PM	7:22 PM	8:35 PM	11:44 PM
Manchester Airport	6:00 PM	6:28 PM	7:02 PM	7:31 PM	8:44 PM	11:53 PM
Manchester	6:05 PM	6:33 PM	7:07 PM	7:36 PM	8:49 PM	11:58 PM

SATURDAY INBOUND SCHEDULE

Train No.:	1302	1304	1310
Manchester	8:25 AM	10:25 AM	4:25 PM
Manchester Airport	8:30 AM	10:30 AM	4:30 PM
Merrimack- Star Drive	8:38 AM	10:38 AM	4:38 PM
Nashua- NH 3/Exit 2	8:47 AM	10:47 AM	4:47 PM
Lowell, MA	8:59 AM	10:59 AM	4:59 PM
North Station	9:43 AM	11:43 AM	5:43 PM

SATURDAY OUTBOUND SCHEDULE

Train No.:	1309	1313	1315
North Station	4:00 PM	8:00 PM	11:00 PM
Lowell, MA	4:43 PM	8:43 PM	11:43 PM
Nashua- NH 3/Exit 2	4:48 PM	8:48 PM	11:48 PM
Merrimack- Star Drive	4:56 PM	8:56 PM	11:56 PM
Manchester Airport	5:05 PM	9:05 PM	12:05 AM
Manchester	5:17 PM	9:17 PM	12:17 AM

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Appendix B

Ridership Projection Methodology

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The main data inputs used for the Rail Alternatives ridership forecasts were the 1990 Journey to Work data (JTW), population and employment forecasts, existing and future travel times, transit travel time, and auto and transit costs. The 2020 commuter population was determined by the following two steps.

1. Identify market/service area for each rail station. This was done by determining which towns or neighborhoods could reasonably access each station. The future roadway system, travel time and distances were considered.
2. 2020 commuter population for each market/service area was based on the trip patterns from 1990 JTW. These trips were then factored based on projected residential population growth and projected Boston employment growth. This resulted in a total number of trips projected in 2020 from each service area to Boston.

To determine the 2020 transit ridership percentage of this total commuter population, the total auto and rail impedances, for the same origin and destination pairs, were compared. Transit and automobile travel impedances are measured in minutes and include total travel time for each trip and out-of-pocket costs, which are converted to time (minutes) based on a rate of $25 per hour. The following list describes what times and costs were included for both autos and rail.

1. The auto impedance includes:
    a) Travel time from home to work place
    b) Cost of driving (at $.20 per mile)
    c) Average cost per day for parking ($5.00 in downtown Boston).
2. The transit impedance includes:
    a) Drive time to station
    b) Waiting time at station based on drive time to station (minimum of five minutes)
    c) Transfer at Lawrence Commuter Rail Stations for East Rail Corridor and I-93 Rail Corridor(5 minutes)
    d) Rail travel time based on service plan
    e) Average travel time from rail terminal to final work destination (15 minutes)
    f) Cost of driving to station (at $.20 per mile)
    g) Auto preference factor to account for general preference for auto use versus transit use (5 minutes)

The transit share was then calculated for each town by using the logit mode choice equation described in the NCHRP Report 187, "Quick-Response Urban Travel Estimation Techniques and Transferable Parameters" The equation is as follows:

$$ms_t = \frac{I_a^b}{I_t^b + I_a^b}$$

I_a	Auto Impedance
I_t	Transit Impedance
b	Exponent of trip impedance

The equation defines an S-shaped curve that represents the desirability of each mode based on its characteristics. The analysis was conducted using an exponent of trip impedance equal to 7, which had been calibrated through an iterative process during the Nashua Passenger Rail Service Study completed by the Nashua Regional Planning Commission (NRPC).

Finally, total boardings and alightings, based on the calculated ridership, were determined by assigning the ridership to the appropriate stations.

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WEST RAIL CORRIDOR
REVENUE ESTIMATES

Station	Merrimack - Star Drive	Bedford / Manchester Airport	Manchester
One-way Boardings	160	228	189
90% of Boardings	144	205	170
Monthly Pass Cost	$136	$136	$150
Monthly Pass Income	$19,584	$27,907	$25,515
10% of Boardings	16	23	19
Monthly Pass Cost*	$76	$76	$76
Monthly Income	$1,216	$1,733	$1,436
Total Monthly Income	$20,800	$29,640	$26,951
Total Annual Income	**$249,600**	**$355,680**	**$323,417**

* Assumes an Interzone Fare for travel across 5 zones

Total Annual Revenue	
West Rail Corridor	**$928,697**

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Appendix C

Revenue Estimates

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WEST RAIL CORRIDOR
REVENUE ESTIMATES

Station	Merrimack - Star Drive	Bedford / Manchester Airport	Manchester
One-way Boardings	160	228	189
90% of Boardings	144	205	170
Monthly Pass Cost	$136	$136	$150
Monthly Pass Income	$19,584	$27,907	$25,515
10% of Boardings	16	23	19
Monthly Pass Cost*	$76	$76	$76
Monthly Income	$1,216	$1,733	$1,436
Total Monthly Income	$20,800	$29,640	$26,951
Total Annual Income	**$249,600**	**$355,680**	**$323,417**

* Assumes an Interzone Fare for travel across 5 zones

Total Annual Revenue	
West Rail Corridor	**$928,697**

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Appendix C

Revenue Estimates

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EAST RAIL CORRIDOR
REVENUE ESTMATES

Station	I-93 Exit 1 Salem	I-93 Exit 5/Londonderry	Manchester
One-way Boardings	335	393	179
90% of Boardings	302	354	161
Monthly Pass Cost attributable	$8	$24	$38
Monthly Pass Income	$2,412	$8,489	$6,122
10% of Boardings	34	39	18
Monthly Pass Cost *	$48	$62	$69
Monthly Income	$1,608	$2,437	$1,235
Total Monthly Income	$4,020	$10,925	$7,357
Total Annual Income	**$48,240**	**$131,105**	**$88,283**

* Assumes an Interzone Fare for travel only to Lawrence

Total Annual Revenue	
Moderate Service Scenario	**$267,628**

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I-93 RAIL CORRIDOR
REVENUE ESTMATES

Station	I-93 Exit 2 Salem	I-93 Exit 3	I-93 Exit 4	I-93 Exit 5 Londonderry
One-way Boardings	196	95	209	389
70% of Boardings	137	86	188	350
Monthly Pass Cost	$55	$62	$69	$69
Monthly Pass Income	$7,546	$5,301	$12,979	$24,157
30% of Boardings	59	29	63	117
Round Trip Tickets	$4	$4	$5	$5
Monthly Income	$206	$114	$282	$525
Total Monthly Income	$7,752	$5,415	$13,261	$24,682
Total Annual Income	**$93,022**	**$64,980**	**$159,133**	**$296,185**

Total Annual Revenue	
Service to Exit 5/Londonderry	**$613,319**

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Appendix D

West Rail Corridor: Prior Cost Estimates

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The prior capital infrastructure programs and cost estimating efforts reviewed were documented in the following studies and memoranda:

- Memorandum from Clay Schofield, P.E. Massachusetts Bay Transportation Authority to Andrew Singelakis/Greg Lantos Nashua Regional Planning Commission dated July 29, 1998
- *Commuter Rail Service Feasibility Study for Manchester, NH* prepared for the Southern New Hampshire Planning Commission by Vanasse Hangen Brustlin, Inc., August 1994
- *The New Hampshire Route I-93 Alternatives Study Rail Infrastructure Analysis* prepared for the New Hampshire DOT by Parsons Brinkerhoff Quade & Douglas, December 1992
- *The Passenger Rail Feasibility Study Phase II: Development of Implementation Strategies* prepared by the Nashua Regional Planning Commission, September 1990
- *The Southern New Hampshire and Northern Middlesex Commuter Rail Preliminary Feasibility Study* completed by Guilford Transportation Industries, January 1986 and November 1986 (revised)

Each report provided capital investment estimates for restoring passenger service along to the Nashua/Manchester corridor. The 1986 and 1990 studies and the 1998 MBTA memorandum only examined bringing service to Nashua, while the 1992 study considered the entire corridor from Lowell to Manchester. The 1994 study examined the portion of the corridor from New Hampshire State line to Manchester.

Capital Infrastructure Cost Estimates

Table B-1 summarizes the capital investment amounts that each study concluded would be required to restore passenger service along this line.

As shown in the table, the average cost per mile ranges from approximately $390,000 to $2,600,000. These average costs must be viewed cautiously as they represent a variety of improvement assumptions. Both the 1986 and 1994 studies assumed that the existing rail could be reused for up to 60 MPH operating speeds. They also assumed a fairly low tie replacement ratio. Conversely, the 1990 and 1992 efforts assumed new rail and a high tie replacement ratio for up to 79 MPH operating speeds. The 1990 and 1992 estimates also assumed major signal and communications system enhancements while the 1986 and 1994 efforts assumed minor modifications to the existing system.

It should be noted that of the $11.4 m included in the July 1998 MBTA estimate, approximately $2.7 M is for track improvements (10.2 miles) along the Lowell to Nashua (Exit 2) segment. The MBTA estimate is for tie replacement, surfacing, and ballast replacement to meet FRA Class 3 standards. For tie replacement, the MBTA assumed a 65 percent defect ratio. The MBTA estimate does not include new rail, switch timbers, or bridge timbers.

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Table B-1: Summary of Prior Capital Investment Estimates

Item/Issue	MBTA (1998)	SNHPC (1994)	NHDOT (1992)	NRPC (1988/90)	GTI (1986)
Corridor Examined	Lowell to Nashua	State Line to Manchester	Lowell to Manchester	Lowell to Nashua	Lowell to Nashua
Miles	10.2	21	30	13	13
FRA Class	3	3 or 4	N/A	4	3
Stations	2*	3	N/A	1	2
Ridership (Trips)	N/A	600-920	N/A	540-900	1,000
Infrastructure Costs ($M)	$11.4	$8.1-15.8	$46	$34	$5
Cost/Mile ($M)	$1.12	$0.39-0.75	$1.50	$2.60	$0.39
Standards	MBTA	General	MBTA	MBTA	GTI

* The MBTA estimate included a station in Chelmsford, MA

There are also several caveats regarding the August 1994 SNHPC study that identified improvements to upgrade the 21.2-mile line from the Massachusetts state line to Manchester. At the time the fieldwork for the 1994 study was completed, the 21.2-mile corridor was in relatively good condition. Two estimates for track improvements were prepared. The first estimate, totaling approximately $3 M, considered maintaining the upgraded facility to FRA Class 3 standards. It assumed that the existing sectional rail was adequate for 60-MPH service. The estimate also assumed minimal tie replacement was required (approximately 500 per mile). The second estimate, totaling approximately $10.4 M, considered maintaining the upgraded facility to FRA Class 4 standards. It assumed that the existing sectional rail was replaced with continuously welded rail (CWR) at a cost of $5.85 M ($250,000 per track mile). The estimate also assumed approximately 1,200 ties per mile were replaced (37 percent defective ratio). The primary difference between the two estimates was the cost of rail. The remainder of the difference is in the cost of additional ties and track surfacing.

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Appendix E

West Rail Corridor: Capital Cost Estimate

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COST ESTIMATE - WEST RAIL CORRIDOR

Item	Quantity	Unit Price	Unit	Price
TRACK STRUCTURE				
Install New Track Structure				
Exit 2 Station Track	1,500	$ 145	track foot	$ 217,500
Star Drive Station Track	1,500	$ 145	track foot	$ 217,500
Airport Station Track	1,500	$ 145	track foot	$ 217,500
Manchester Station Track	1,500	$ 145	track foot	$ 217,500
Chelmsford Wye	5,280	$ 145	track foot	$ 765,600
Install New rail and ties				
Lowell to Manchester (30.6 miles)	159,984	$ 85	track foot	$ 13,598,640
Merrimack Siding	11,616	$ 85	track foot	$ 987,360
Upgrade existing rail				
Lowell to Chelmsford Wye (freight)	18,480	$ 21	track foot	$ 378,840
Manchester Yard Layover	3,000	$ 21	track foot	$ 61,500
Turnouts				
Install #10 Turnout	12	$ 95,000	each	$ 1,140,000
Install #20 Turnout	4	$ 140,000	each	$ 560,000
Sub-Total				**$ 18,361,940**
GRADE CROSSINGS				
Single track - New crossing surface	18	$ 33,000	lump sum	$ 594,000
Double track - New crossing surface	1	$ 50,000	lump sum	$ 50,000
Grade Crossing Protection	18	$ 275,000	each	$ 4,950,000
Grade Crossing Protection-double	1	$ 300,000	each	$ 300,000
Intersection Signal Improvement	4	$ 500,000	LS	$ 2,000,000
Fence/gate/timber crossing (Farm MP 33.1)	1	$ 10,000	LS	$ 10,000
Sub-Total				**$ 7,904,000**
CIVIL				
Clearing Grubbing	15,840	$ 15	linear foot	$ 237,600
Fencing	10,560	$ 20	linear foot	$ 211,200
Grade crossing removal	1,000	$ 15	l.f.	$ 15,000
New road	2,000	$ 82	l.f.	$ 164,000
Sub-Total				**$ 627,800**

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COST ESTIMATE - WEST RAIL CORRIDOR

Item	Quantity	Unit Price	Unit	Price
STRUCTURES				
Undergrade Structures				
Canal	1	$ 80,000	LS	$ 80,000
Red Bridge	1	$ 100,000	LS	$ 100,000
Stony Brook	1	$ 10,000	LS	$ 10,000
Adams Pass	1	$ 15,000	LS	$ 15,000
Ferry (remove and fill-in)	1	$ 50,000	LS	$ 50,000
Mill Brook	1	$ 20,000	LS	$ 20,000
Salmon Brook	1	$ 10,000	LS	$ 10,000
Nashua River	1	$ 100,000	LS	$ 100,000
Locke St	1	$ 20,000	LS	$ 20,000
Pennichuck River	1	$ 20,000	LS	$ 20,000
North Ferry	1	$ 20,000	LS	$ 20,000
Natiook Brook	1	$ 60,000	LS	$ 60,000
Soughegan River	1	$ 40,000	LS	$ 40,000
Ferry Rd.	1	$ 15,000	LS	$ 15,000
Merrimack River	1	$ 300,000	LS	$ 300,000
Cemetery Brook	1	$ 15,000	LS	$ 15,000
Retaining Walls				
Tyngsboro Wall	1	$ 250,000	LS	$ 250,000
Bridge Timbers				
Bridge timbers	750	$ 620	each	$ 465,000
Sub-Total				**$ 1,590,000**
FACILITIES				
Stations				
Nashua - Exit 2	1	$ 2,500,000	LS	$ 2,500,000
Merrimack - Star Drive	1	$ 2,000,000	LS	$ 2,000,000
Bedford - Airport Station	1	$ 2,000,000	LS	$ 2,000,000
Manchester - Downtown	1	$ 1,000,000	LS	$ 1,000,000
Layover				
Manchester	1	$ 500,000	LS	$ 500,000
Sub-Total				**$ 8,000,000**
SIGNAL SYSTEM				
New Signaling System	28.1	$ 300,000	mile	$ 8,430,000
New Signaling System (enhanced)	2.5	$ 450,000	mile	$ 1,125,000
Reconfiguration Chelmsford Wye	1	$ 1,300,000	LS	$ 1,300,000
Station Interlockings	6	$ 750,000	LS	$ 4,500,000
Merrimack Siding Interlockings	2	$ 750,000	LS	$ 1,500,000
Rationalize Lowell Interlocking	1	$ 350,000	LS	$ 350,000
Control Center Improvements	1	$ 80,000	LS	$ 80,000
Reconstruct Manchester Yard	1	$ 450,000	LS	$ 450,000
Sub-Total				**$ 17,735,000**
SUM				**$ 54,218,740**
Contingency @20%				$ 10,843,748
Design & Construction Services @15%				$ 8,132,811
TOTAL				**$ 73,195,299**

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Appendix F

East Rail Corridor: Schedules

F

EAST RAIL CORRIDOR- LAWRENCE TO MANCHESTER
HIGH LEVEL OF SERVICE

WEEKDAY INBOUND SCHEDULE													
East Rail Service	Manchester	5:03 AM	6:02 AM	6:57 AM	8:14 AM	9:55 AM	11:34 AM	2:19 PM	4:00 PM	5:27 PM	6:15 PM	7:05 PM	7:53 PM
	Exit 5 / Londonderry	5:14 AM	6:13 AM	7:08 AM	8:25 AM	10:06 AM	11:45 AM	2:30 PM	4:11 PM	5:38 PM	6:26 PM	7:16 PM	8:04 PM
	Salem	5:27 AM	6:26 AM	7:21 AM	8:38 AM	10:19 AM	11:58 AM	2:43 PM	4:24 PM	5:51 PM	6:39 PM	7:29 PM	8:17 PM
	Lawrence, MA	5:37 AM	6:36 AM	7:31 AM	8:48 AM	10:29 AM	12:08 PM	2:53 PM	4:34 PM	6:01 PM	6:49 PM	7:39 PM	8:27 PM
MBTA	Haverhill Line Train No.:	202	206	212	214	218	220	226	232	236			238
	Lawrence, MA	5:42 AM	6:41 AM	7:36 AM	8:54 AM	10:34 AM	12:14 PM	2:59 PM	4:41 PM	6:11 PM			8:32 PM
	North Station	6:33 AM	7:36 AM	8:35 AM	9:45 AM	11:28 AM	1:06 PM	3:50 PM	5:31 PM	7:05 PM			9:23 PM

WEEKDAY OUTBOUND SCHEDULE													
MBTA	Haverhill Line Train No.:			209		213	217	223	227	231	233	237	239
	North Station			7:19 AM		10:35 AM	1:20 PM	3:00 PM	4:25 PM	5:15 PM	5:52 PM	6:55 PM	8:32 PM
	Lawrence, MA			8:07 AM		11:27 AM	2:12 PM	3:52 PM	5:20 PM	6:08 PM	6:47 PM	7:45 PM	9:24 PM
East Rail Service	Lawrence, MA	6:00 AM	6:55 AM	8:12 AM	9:53 AM	11:32 AM	2:17 PM	3:58 PM	5:25 PM	6:13 PM	7:03 PM	7:51 PM	9:30 PM
	Salem	6:09 AM	7:04 AM	8:21 AM	10:02 AM	11:41 AM	2:26 PM	4:07 PM	5:34 PM	6:22 PM	7:12 PM	8:00 PM	9:39 PM
	Exit 5 / Londonderry	6:22 AM	7:17 AM	8:34 AM	10:15 AM	11:54 AM	2:39 PM	4:20 PM	5:47 PM	6:35 PM	7:25 PM	8:13 PM	9:52 PM
	Manchester	6:34 AM	7:29 AM	8:46 AM	10:27 AM	12:06 PM	2:51 PM	4:32 PM	5:59 PM	6:47 PM	7:37 PM	8:25 PM	10:04 PM

WEEKEND INBOUND SCHEDULE					
East Rail Service	Manchester	6:45 AM	9:45 AM	3:50 PM	6:50 PM
	Exit 5 / Londonderry	6:56 AM	9:56 AM	4:01 PM	7:01 PM
	Salem	7:09 AM	10:09 AM	4:14 PM	7:14 PM
	Lawrence, MA	7:19 AM	10:19 AM	4:24 PM	7:24 PM
MBTA	Haverhill Line Train No.:	1204	1208	1216	1220
	Lawrence, MA	7:26 AM	10:26 AM	4:26 PM	7:26 PM
	North Station	8:19 AM	11:19 AM	5:19 PM	8:19 PM

WEEKEND OUTBOUND SCHEDULE					
MBTA	Haverhill Line Train No.:		1209	1217	1221
	North Station		11:45 AM	5:45 PM	8:45 PM
	Lawrence, MA		12:38 PM	6:38 PM	9:38 PM
East Rail Service	Lawrence, MA	7:30 AM	12:43 PM	6:45 PM	9:43 PM
	Salem	7:39 AM	12:52 PM	6:54 PM	9:52 PM
	Exit 5 / Londonderry	7:52 AM	1:05 PM	7:07 PM	10:05 PM
	Manchester	8:04 AM	1:17 PM	7:19 PM	10:17 PM

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EAST RAIL CORRIDOR- LAWRENCE TO MANCHESTER
MODERATE LEVEL OF SERVICE

WEEKDAY INBOUND SCHEDULE

East Rail Service	Manchester	5:03 AM	6:02 AM	6:57 AM	9:55 AM	4:00 PM	5:27 PM	6:15 PM	7:53 PM
	Exit 5 / Londonderry	5:14 AM	6:13 AM	7:08 AM	10:06 AM	4:11 PM	5:38 PM	6:26 PM	8:04 PM
	Salem	5:27 AM	6:26 AM	7:21 AM	10:19 AM	4:24 PM	5:51 PM	6:39 PM	8:17 PM
	Lawrence, MA	5:37 AM	6:36 AM	7:31 AM	10:29 AM	4:34 PM	6:01 PM	6:49 PM	8:27 PM
MBTA	Haverhill Line Train No.:	202	206	212	218	232	236		238
	Lawrence, MA	5:42 AM	6:41 AM	7:36 AM	10:34 AM	4:41 PM	6:11 PM		8:32 PM
	North Station	6:33 AM	7:36 AM	8:35 AM	11:28 AM	5:31 PM	7:05 PM		9:23 PM

WEEKDAY OUTBOUND SCHEDULE

MBTA	Haverhill Line Train No.:			209	213	227	231	233	239
	North Station			7:19 AM	10:35 AM	4:25 PM	5:15 PM	5:52 PM	8:32 PM
	Lawrence, MA			8:07 AM	11:27 AM	5:20 PM	6:08 PM	6:47 PM	9:24 PM
East Rail Service	Lawrence, MA	6:00 AM	6:55 AM	8:12 AM	11:32 AM	5:25 PM	6:13 PM	7:03 PM	9:30 PM
	Salem	6:09 AM	7:04 AM	8:21 AM	11:41 AM	5:34 PM	6:22 PM	7:12 PM	9:39 PM
	Exit 5 / Londonderry	6:22 AM	7:17 AM	8:34 AM	11:54 AM	5:47 PM	6:35 PM	7:25 PM	9:52 PM
	Manchester	6:34 AM	7:29 AM	8:46 AM	12:06 PM	5:59 PM	6:47 PM	7:37 PM	10:04 PM

WEEKEND INBOUND SCHEDULE

East Rail Service	Manchester	6:45 AM	9:45 AM	6:50 PM
	Exit 5 / Londonderry	6:56 AM	9:56 AM	7:01 PM
	Salem	7:09 AM	10:09 AM	7:14 PM
	Lawrence, MA	7:19 AM	10:19 AM	7:24 PM
MBTA	Haverhill Line Train No.:	1204	1208	1220
	Lawrence, MA	7:26 AM	10:26 AM	7:26 PM
	North Station	8:19 AM	11:19 AM	8:19 PM

WEEKEND OUTBOUND SCHEDULE

MBTA	Haverhill Line Train No.:		1209	1221
	North Station		11:45 AM	8:45 PM
	Lawrence, MA		12:38 PM	9:38 PM
East Rail Service	Lawrence, MA	7:30 AM	12:43 PM	9:43 PM
	Salem	7:39 AM	12:52 PM	9:52 PM
	Exit 5 / Londonderry	7:52 AM	1:05 PM	10:05 PM
	Manchester	8:04 AM	1:17 PM	10:17 PM

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EAST RAIL CORRIDOR- LAWRENCE TO MANCHESTER
LOW LEVEL OF SERVICE

WEEKDAY INBOUND SCHEDULE							
East Rail Service	Manchester	5:03 AM	6:57 AM	9:55 AM	4:00 PM	6:15 PM	7:53 PM
	Exit 5 / Londonderry	5:14 AM	7:08 AM	10:06 AM	4:11 PM	6:26 PM	8:04 PM
	Salem	5:27 AM	7:21 AM	10:19 AM	4:24 PM	6:39 PM	8:17 PM
	Lawrence, MA	5:37 AM	7:31 AM	10:29 AM	4:34 PM	6:49 PM	8:27 PM
MBTA	Haverhill Line Train No.:	202	212	218	232		238
	Lawrence, MA	5:42 AM	7:36 AM	10:34 AM	4:41 PM		8:32 PM
	North Station	6:33 AM	8:35 AM	11:28 AM	5:31 PM		9:23 PM

WEEKDAY OUTBOUND SCHEDULE							
MBTA	Haverhill Line Train No.:		209	213	227	233	239
	North Station		7:19 AM	10:35 AM	4:25 PM	5:52 PM	8:32 PM
	Lawrence, MA		8:07 AM	11:27 AM	5:20 PM	6:47 PM	9:24 PM
East Rail Service	Lawrence, MA	6:00 AM	8:12 AM	11:32 AM	5:25 PM	7:03 PM	9:30 PM
	Salem	6:09 AM	8:21 AM	11:41 AM	5:34 PM	7:12 PM	9:39 PM
	Exit 5 / Londonderry	6:22 AM	8:34 AM	11:54 AM	5:47 PM	7:25 PM	9:52 PM
	Manchester	6:34 AM	8:46 AM	12:06 PM	5:59 PM	7:37 PM	10:04 PM

WEEKEND INBOUND SCHEDULE				
East Rail Service	Manchester	6:45 AM	9:45 AM	6:50 PM
	Exit 5 / Londonderry	6:56 AM	9:56 AM	7:01 PM
	Salem	7:09 AM	10:09 AM	7:14 PM
	Lawrence, MA	7:19 AM	10:19 AM	7:24 PM
MBTA	Haverhill Line Train No.:	1204	1208	1220
	Lawrence, MA	7:26 AM	10:26 AM	7:26 PM
	North Station	8:19 AM	11:19 AM	8:19 PM

WEEKEND OUTBOUND SCHEDULE				
MBTA	Haverhill Line Train No.:		1209	1221
	North Station		11:45 AM	8:45 PM
	Lawrence, MA		12:38 PM	9:38 PM
East Rail Service	Lawrence, MA	7:30 AM	12:43 PM	9:43 PM
	Salem	7:39 AM	12:52 PM	9:52 PM
	Exit 5 / Londonderry	7:52 AM	1:05 PM	10:05 PM
	Manchester	8:04 AM	1:17 PM	10:17 PM

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Appendix G

East Rail Corridor: Capital Cost Estimate

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COST ESTIMATE - EAST RAIL CORRIDOR
TUNNEL OPTION

Item	Quantity	Unit Price	Unit	Price
TRACK STRUCTURE				
Install New Track Structure				
Lawrence to Manchester (27.25 miles)	143,880	$ 145	track foot	$ 20,862,600
Passing Siding	10,560	$ 145	track foot	$ 1,531,200
Upgrade existing rail				
Manchester Yard Layover	3,000	$ 21	track foot	$ 61,500
Turnouts				
Install #10 Turnout	5	$ 95,000	each	$ 475,000
Install #20 Turnout	3	$ 140,000	each	$ 420,000
Sub-Total				**$ 23,350,300**
GRADE CROSSINGS				
Single track - New crossing surface	41	$ 33,000	lump sum	$ 1,353,000
Double track - New crossing surface	5	$ 50,000	lump sum	$ 250,000
Grade Crossing Protection	41	$ 275,000	each	$ 11,275,000
Grade Crossing Protection-double	5	$ 300,000	each	$ 1,500,000
Intersection Signal Improvement	2	$ 500,000	LS	$ 1,000,000
Sub-Total				**$ 15,378,000**
CIVIL				
Clearing Grubbing	143,880	$ 15	linear foot	$ 2,158,200
Earthwork	2,374,020	$0.17	cubic feet	$ 403,583
Fencing	10,560	$ 20	linear foot	$ 211,200
Sub-Total				**$ 2,772,983**
STRUCTURES				
Undergrade Structures				
Replacements				
South Canal	1	$ 661,050	LS	$ 661,050
Merrimack River	1	$ 3,780,000	LS	$ 3,780,000
North Canal	1	$ 559,350	LS	$ 559,350
Manchester Street	1	$ 559,350	LS	$ 559,350
Spickett River	1	$ 244,800	LS	$ 244,800
Spickett River	1	$ 244,800	LS	$ 244,800
Brook	1	$ 367,200	LS	$ 367,200
Abandoned Road	1	$ 508,500	LS	$ 508,500
Beaver Brook	1	$ 306,000	LS	$ 306,000
Little Cohas Brook (crossing 1)	1	$ 306,000	LS	$ 306,000
Little Cohas Brook (crossing 2)	1	$ 306,000	LS	$ 306,000
Rehabilitation				
Abandoned Road	1	$ 50,000	LS	$ 50,000
Beaver Brook	1	$ 50,000	LS	$ 50,000
Hornse/Hood Pond	1	$ 50,000	LS	$ 50,000
Tunnel/Boat Section				
Boat Section	1	$ 135,406,050	LS	$ 135,406,050
Tunnel	1	$ 25,174,900	LS	$ 25,174,900
New Overhead Bridges	1	$ 1,920,000	LS	$ 1,920,000
Culvert - Cohas Brook	1	$ 244,800	LS	$ 244,800
Overhead Structures				
Bowers Sreet, Madden Road	2	$ 1,000,000	LS	$ 2,000,000
Bridge Timbers				
Bridge timbers	1,000	$ 620	each	$ 620,000
Sub-Total				**$ 173,358,800**

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COST ESTIMATE - EAST RAIL CORRIDOR
TUNNEL OPTION

Item	Quantity	Unit Price	Unit	Price
FACILITIES				
Stations				
Salem	1	$ 1,500,000	LS	$ 1,500,000
I-93/Rt.28	1	$ 1,000,000	LS	$ 1,000,000
Airport Station	1	$ 5,000,000	LS	$ 5,000,000
Manchester	1	$ 1,000,000	LS	$ 1,000,000
Layover				$ -
Manchester	1	$ 500,000	LS	$ 500,000
Sub-Total				**$ 9,000,000**
SIGNAL SYSTEM				
New Signaling System	24.75	$ 300,000	mile	$ 7,425,000
New Signaling System (enhanced)	2.5	$ 450,000	mile	$ 1,125,000
Passing Siding/Station Interlocking	3	$ 750,000	each	$ 2,250,000
Rationalize Lawrence Interlocking	1	$ 350,000	LS	$ 350,000
Control Center Improvements	1	$ 80,000	LS	$ 80,000
Reconstruct Manchester Yard	1	$ 450,000	LS	$ 450,000
Sub-Total				**$ 11,680,000**
SUM				**$ 235,540,083**
Contingency @20%				$ 47,108,017
Design & Construction Services @15%				$ 35,331,013
TOTAL				**$ 317,979,113**

COST ESTIMATE - EAST RAIL CORRIDOR
RELOCATION OPTION

Item	Quantity	Unit Price	Unit	Price
TRACK STRUCTURE				
Install New Track Structure				
Lawrence to Manchester (27.25 miles)	143,880	$ 145	track foot	$ 20,862,600
Passing Siding	10,560	$ 145	track foot	$ 1,531,200
Upgrade existing rail				
Manchester Yard Layover	3,000	$ 21	track foot	$ 61,500
Turnouts				
Install #10 Turnout	5	$ 95,000	each	$ 475,000
Install #20 Turnout	3	$ 140,000	each	$ 420,000
Sub-Total				**$ 23,350,300**
GRADE CROSSINGS				
Single track - New crossing surface	39	$ 33,000	LS	$ 1,287,000
Double track - New crossing surface	5	$ 50,000	LS	$ 250,000
Single Track - New Crossings	7	$ 100,000	LS	$ 700,000
Grade Crossing Protection	46	$ 275,000	each	$ 12,650,000
Grade Crossing Protection-double	5	$ 300,000	each	$ 1,500,000
Intersection Signal Improvement	2	$ 500,000	LS	$ 1,000,000
Sub-Total				**$ 17,387,000**
CIVIL				
Clearing Grubbing	143,880	$ 15	linear foot	$ 2,158,200
Earthwork	2,373,951	$0.17	cubic foot	$ 403,572
Earthwork - Relocation	2,927,232	$0.17	cubic foot	$ 497,629
Fencing	10,560	$ 20	linear foot	$ 211,200
Sub-Total				**$ 3,270,601**
STRUCTURES				
Undergrade Structures				
Replacements				
South Canal	1	$ 661,050	LS	$ 661,050
Merrimack River	1	$ 3,780,000	LS	$ 3,780,000
North Canal	1	$ 559,350	LS	$ 559,350
Manchester Street	1	$ 559,350	LS	$ 559,350
Spickett River	1	$ 244,800	LS	$ 244,800
Spickett River	1	$ 244,800	LS	$ 244,800
Brook	1	$ 367,200	LS	$ 367,200
Abandoned Road	1	$ 508,500	LS	$ 508,500
Beaver Brook	1	$ 306,000	LS	$ 306,000
Little Cohas Brook (crossing 1)	1	$ 306,000	LS	$ 306,000
Little Cohas Brook (crossing 2)	1	$ 306,000	LS	$ 306,000
Cohas Brook	1	$ 1,627,200	LS	$ 1,627,200
Rehabilitation				
Abandoned Road	1	$ 50,000	LS	$ 50,000
Beaver Brook	1	$ 50,000	LS	$ 50,000
Hornse/Hood Pond	1	$ 50,000	LS	$ 50,000
Overhead Structures				
Bowers Sreet, Madden Road	2	$ 1,000,000	LS	$ 2,000,000
Bridge Timbers				
Bridge timbers	1,000	$ 620	each	$ 620,000
Sub-Total				**$ 12,240,250**

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COST ESTIMATE - EAST RAIL CORRIDOR
RELOCATION OPTION

Item	Quantity	Unit Price	Unit	Price
FACILITIES				
Stations				
Salem	1	$ 1,500,000	LS	$ 1,500,000
I-93/Rt.28	1	$ 1,000,000	LS	$ 1,000,000
Manchester	1	$ 1,000,000	LS	$ 1,000,000
Layover				
Manchester	1	$ 500,000	LS	$ 500,000
Sub-Total				**$ 4,000,000**
SIGNAL SYSTEM				
New Signaling System	24.75	$ 300,000	mile	$ 7,425,000
New Signaling System (enhanced)	2.5	$ 450,000	mile	$ 1,125,000
Passing Sidings/Station Interlockings	3	$ 750,000	each	$ 2,250,000
Rationalize Lawrence Interlocking	1	$ 350,000	LS	$ 350,000
Control Center Improvements	1	$ 80,000	LS	$ 80,000
Reconstruct Manchester Yard	1	$ 450,000	LS	$ 450,000
Sub-Total				**$ 11,680,000**
SUM				**$ 71,928,151**
Contingency @20%				$ 14,385,630
Design & Construction Services @15%				$ 10,789,223
TOTAL				**$ 97,103,004**

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Appendix H

I-93 Rail Corridor: Schedules

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I-93 LIGHT RAIL CORRIDOR LAWRENCE TO MANCHESTER
HIGH LEVEL OF SERVICE

WEEKDAY INBOUND SCHEDULE

I-93 Rail Service	Manchester Airport	5:07 AM	5:41 AM	6:31 AM	7:01 AM	8:19 AM	9:59 AM	11:39 AM	2:24 PM	4:06 PM	6:12 PM	7:00 PM	7:57 PM
	I-93 - Exit 5	5:12 AM	5:46 AM	6:36 AM	7:06 AM	8:24 AM	10:04 AM	11:44 AM	2:29 PM	4:11 PM	6:17 PM	7:05 PM	8:02 PM
	I-93 - Exit 4	5:16 AM	5:50 AM	6:40 AM	7:10 AM	8:28 AM	10:08 AM	11:48 AM	2:33 PM	4:15 PM	6:21 PM	7:09 PM	8:06 PM
	I-93 - Exit 3	5:24 AM	5:58 AM	6:48 AM	7:18 AM	8:36 AM	10:16 AM	11:56 AM	2:41 PM	4:23 PM	6:29 PM	7:17 PM	8:14 PM
	I-93 - Exit 2	5:28 AM	6:02 AM	6:52 AM	7:22 AM	8:40 AM	10:20 AM	12:00 PM	2:45 PM	4:27 PM	6:33 PM	7:21 PM	8:18 PM
	Lawrence, MA	5:37 AM	6:11 AM	7:01 AM	7:31 AM	8:49 AM	10:29 AM	12:09 PM	2:54 PM	4:36 PM	6:42 PM	7:30 PM	8:27 PM
MBTA	Haverhill Line Train No.:	202	204	208	212	214	218	220	226	232			238
	Lawrence, MA	5:42 AM	6:16 AM	7:06 AM	7:36 AM	8:54 AM	10:34 AM	12:14 PM	2:59 PM	4:41 PM			8:32 PM
	North Station	6:33 AM	7:09 AM	7:54 AM	8:35 AM	9:45 AM	11:28 AM	1:06 PM	3:50 PM	5:31 PM			9:23 PM

WEEKDAY OUTBOUND SCHEDULE

MBTA	Haverhill Line Train No.:				205	209	213	217	223	227	233	237	239
	North Station				7:19 AM	8:55 AM	10:35 AM	1:20 PM	4:25 PM	5:15 PM	5:52 PM	6:55 PM	8:32 PM
	Lawrence, MA				8:07 AM	9:47 AM	11:27 AM	2:12 PM	5:20 PM	6:08 PM	6:47 PM	7:45 PM	9:24 PM
I-93 Rail Service	Lawrence, MA	5:51 AM	6:21 AM	7:11 AM	8:12 AM	9:52 AM	11:32 AM	2:17 PM	5:25 PM	6:13 PM	6:52 PM	7:50 PM	9:29 PM
	I-93 - Exit 2	6:00 AM	6:30 AM	7:20 AM	8:21 AM	10:01 AM	11:41 AM	2:26 PM	5:34 PM	6:22 PM	7:01 PM	7:59 PM	9:38 PM
	I-93 - Exit 3	6:04 AM	6:34 AM	7:24 AM	8:25 AM	10:05 AM	11:45 AM	2:30 PM	5:38 PM	6:26 PM	7:05 PM	8:03 PM	9:42 PM
	I-93 - Exit 4	6:12 AM	6:42 AM	7:32 AM	8:33 AM	10:13 AM	11:53 AM	2:38 PM	5:46 PM	6:34 PM	7:13 PM	8:11 PM	9:50 PM
	I-93 - Exit 5	6:16 AM	6:46 AM	7:36 AM	8:37 AM	10:17 AM	11:57 AM	2:42 PM	5:50 PM	6:38 PM	7:17 PM	8:15 PM	9:54 PM
	Manchester Airport	6:21 AM	6:51 AM	7:41 AM	8:42 AM	10:22 AM	12:02 PM	2:47 PM	5:55 PM	6:43 PM	7:22 PM	8:20 PM	9:59 PM

WEEKEND INBOUND SCHEDULE

I-93 Rail Service	Manchester Airport	6:51 AM	9:51 AM	3:51 PM	9:51 AM
	I-93 - Exit 5	6:56 AM	9:56 AM	3:56 PM	9:56 AM
	I-93 - Exit 4	7:00 AM	10:00 AM	4:00 PM	10:00 AM
	I-93 - Exit 3	7:08 AM	10:08 AM	4:08 PM	10:08 AM
	I-93 - Exit 2	7:12 AM	10:12 AM	4:12 PM	10:12 AM
	Lawrence, MA	7:21 AM	10:21 AM	4:21 PM	10:21 AM
MBTA	Haverhill Line Train No.:	1204	1208	1216	1220
	Lawrence, MA	7:26 AM	10:26 AM	4:26 PM	10:26 AM
	North Station	8:19 AM	11:19 AM	5:19 PM	8:19 PM

WEEKEND OUTBOUND SCHEDULE

MBTA	Haverhill Line Train No.:	1205	1209	1217	1221
	North Station	8:45 AM	11:45 AM	5:45 PM	8:45 PM
	Lawrence, MA	9:38 AM	12:38 PM	6:38 PM	9:38 PM
I-93 Rail Service	Lawrence, MA	9:43 AM	12:43 PM	6:43 PM	9:43 PM
	I-93 - Exit 2	9:52 AM	12:52 PM	6:52 PM	9:52 PM
	I-93 - Exit 3	9:56 AM	12:56 PM	6:56 PM	9:56 PM
	I-93 - Exit 4	10:04 AM	1:04 PM	7:04 PM	10:04 PM
	I-93 - Exit 5	10:08 AM	1:08 PM	7:08 PM	10:08 PM
	Manchester Airport	10:13 AM	1:13 PM	7:13 PM	10:13 PM

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I-93 LIGHT RAILCORRIDOR - LAWRENCE TO MANCHESTER
MODERATE LEVEL OF SERVICE

WEEKDAY INBOUND SCHEDULE									
I-93 Rail Service	Manchester Airport	5:42 AM	6:32 AM	7:02 AM	10:00 AM	11:40 AM	4:07 PM	6:05 PM	7:58 PM
	I-93 - Exit 5	5:46 AM	6:36 AM	7:06 AM	10:04 AM	11:44 AM	4:11 PM	6:10 PM	8:02 PM
	I-93 - Exit 4	5:50 AM	6:40 AM	7:10 AM	10:08 AM	11:48 AM	4:15 PM	6:14 PM	8:06 PM
	I-93 - Exit 3	5:58 AM	6:48 AM	7:18 AM	10:16 AM	11:56 AM	4:23 PM	6:22 PM	8:14 PM
	I-93 - Exit 2	6:02 AM	6:52 AM	7:22 AM	10:20 AM	12:00 PM	4:27 PM	6:26 PM	8:18 PM
	Lawrence, MA	6:11 AM	7:01 AM	7:31 AM	10:29 AM	12:09 PM	4:36 PM	6:35 PM	8:27 PM
MBTA	Haverhill Line Train No.:	204	208	212	218	220	232	220	238
	Lawrence, MA	6:16 AM	7:06 AM	7:36 AM	10:34 AM	12:14 PM	4:41 PM		8:32 PM
	North Station	7:09 AM	7:54 AM	8:35 AM	11:28 AM	1:06 PM	5:31 PM		9:23 PM
WEEKDAY OUTBOUND SCHEDULE									
MBTA	Haverhill Line Train No.:			205	217	227	233	237	239
	North Station			7:19 AM	1:20 PM	4:25 PM	5:52 PM	6:55 PM	8:32 PM
	Lawrence, MA			8:07 AM	2:12 PM	5:20 PM	6:47 PM	7:45 PM	9:24 PM
I-93 Rail Service	Lawrence, MA	6:21 AM	7:11 AM	8:12 AM	2:17 PM	5:25 PM	6:52 PM	7:50 PM	9:29 PM
	I-93 - Exit 2	6:30 AM	7:20 AM	8:21 AM	2:26 PM	5:34 PM	7:01 PM	7:59 PM	9:38 PM
	I-93 - Exit 3	6:34 AM	7:24 AM	8:25 AM	2:30 PM	5:38 PM	7:05 PM	8:03 PM	9:42 PM
	I-93 - Exit 4	6:42 AM	7:32 AM	8:33 AM	2:38 PM	5:46 PM	7:13 PM	8:11 PM	9:50 PM
	I-93 - Exit 5	6:46 AM	7:36 AM	8:37 AM	2:42 PM	5:50 PM	7:17 PM	8:15 PM	9:54 PM
	Manchester Airport	6:51 AM	7:41 AM	8:42 AM	2:47 PM	5:55 PM	7:22 PM	8:20 PM	9:59 PM

WEEKEND INBOUND SCHEDULE				
I-93 Rail Service	Manchester Airport	6:51 AM	12:51 PM	6:51 PM
	I-93 - Exit 5	6:56 AM	12:56 PM	6:56 PM
	I-93 - Exit 4	7:00 AM	1:00 PM	7:00 PM
	I-93 - Exit 3	7:08 AM	1:08 PM	7:08 PM
	I-93 - Exit 2	7:12 AM	1:12 PM	7:12 PM
	Lawrence, MA	7:21 AM	1:21 PM	7:21 PM
MBTA	Haverhill Line Train No.:	1208	1212	1216
	Lawrence, MA	7:26 AM	1:26 PM	7:26 PM
	North Station	8:19 AM	2:19 PM	8:19 PM
WEEKEND OUTBOUND SCHEDULE				
MBTA	Haverhill Line Train No.:	1209	1213	1217
	North Station	8:45 AM	2:45 PM	8:45 PM
	Lawrence, MA	9:38 AM	3:38 PM	9:38 PM
I-93 Rail Service	Lawrence, MA	9:43 AM	3:43 PM	9:43 PM
	I-93 - Exit 2	9:52 AM	3:52 PM	9:52 PM
	I-93 - Exit 3	9:56 AM	3:56 PM	9:56 PM
	I-93 - Exit 4	10:04 AM	4:04 PM	10:04 PM
	I-93 - Exit 5	10:08 AM	4:08 PM	10:08 PM
	Manchester Airport	10:13 AM	4:13 PM	10:13 PM

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I-93 LIGHT RAIL CORRIDOR - LAWRENCE TO MANCHESTER
LOW LEVEL OF SERVICE

WEEKDAY INBOUND SCHEDULE							
I-93 Rail Service	Manchester Airport	5:42 AM	7:02 AM	10:00 AM	2:25 PM	6:06 PM	7:58 PM
	I-93 - Exit 5	5:46 AM	7:06 AM	10:04 AM	2:29 PM	6:11 PM	8:02 PM
	I-93 - Exit 4	5:50 AM	7:10 AM	10:08 AM	2:33 PM	6:15 PM	8:06 PM
	I-93 - Exit 3	5:58 AM	7:18 AM	10:16 AM	2:41 PM	6:23 PM	8:14 PM
	I-93 - Exit 2	6:02 AM	7:22 AM	10:20 AM	2:45 PM	6:27 PM	8:18 PM
	Lawrence, MA	6:11 AM	7:31 AM	10:29 AM	2:54 PM	6:36 PM	8:27 PM
MBTA	Haverhill Line Train No.:	204	212	218	226		238
	Lawrence, MA	6:16 AM	7:36 AM	10:34 AM	2:59 PM		8:32 PM
	North Station	7:09 AM	8:35 AM	11:28 AM	3:50 PM		9:23 PM

WEEKDAY OUTBOUND SCHEDULE							
MBTA	Haverhill Line Train No.:		205	213	227	233	239
	North Station		7:19 AM	10:35 AM	4:25 PM	5:52 PM	8:32 PM
	Lawrence, MA		8:07 AM	11:27 AM	5:20 PM	6:47 PM	9:24 PM
I-93 Rail Service	Lawrence, MA	6:21 AM	8:12 AM	11:32 AM	5:25 PM	6:52 PM	9:29 PM
	I-93 - Exit 2	6:30 AM	8:21 AM	11:41 AM	5:34 PM	7:01 PM	9:38 PM
	I-93 - Exit 3	6:34 AM	8:25 AM	11:45 AM	5:38 PM	7:05 PM	9:42 PM
	I-93 - Exit 4	6:42 AM	8:33 AM	11:53 AM	5:46 PM	7:13 PM	9:50 PM
	I-93 - Exit 5	6:46 AM	8:38 AM	11:58 AM	5:51 PM	7:18 PM	9:55 PM
	Manchester Airport	6:51 AM	8:43 AM	12:03 PM	5:56 PM	7:23 PM	10:00 PM

WEEKEND INBOUND SCHEDULE				
I-93 Rail Service	Manchester Airport	6:51 AM	12:51 PM	6:51 PM
	I-93 - Exit 5	6:56 AM	12:56 PM	6:56 PM
	I-93 - Exit 4	7:00 AM	1:00 PM	7:00 PM
	I-93 - Exit 3	7:08 AM	1:08 PM	7:08 PM
	I-93 - Exit 2	7:12 AM	1:12 PM	7:12 PM
	Lawrence, MA	7:21 AM	1:21 PM	7:21 PM
MBTA	Haverhill Line Train No.:	1208	1212	1216
	Lawrence, MA	7:26 AM	1:26 PM	7:26 PM
	North Station	8:19 AM	2:19 PM	8:19 PM

WEEKEND OUTBOUND SCHEDULE				
MBTA	Haverhill Line Train No.:	1209	1213	1217
	North Station	8:45 AM	2:45 PM	8:45 PM
	Lawrence, MA	9:38 AM	3:38 PM	9:38 PM
I-93 Rail Service	Lawrence, MA	9:43 AM	3:43 PM	9:43 PM
	I-93 - Exit 2	9:52 AM	3:52 PM	9:52 PM
	I-93 - Exit 3	9:56 AM	3:56 PM	9:56 PM
	I-93 - Exit 4	10:04 AM	4:04 PM	10:04 PM
	I-93 - Exit 5	10:09 AM	4:09 PM	10:09 PM
	Manchester Airport	10:14 AM	4:14 PM	10:14 PM

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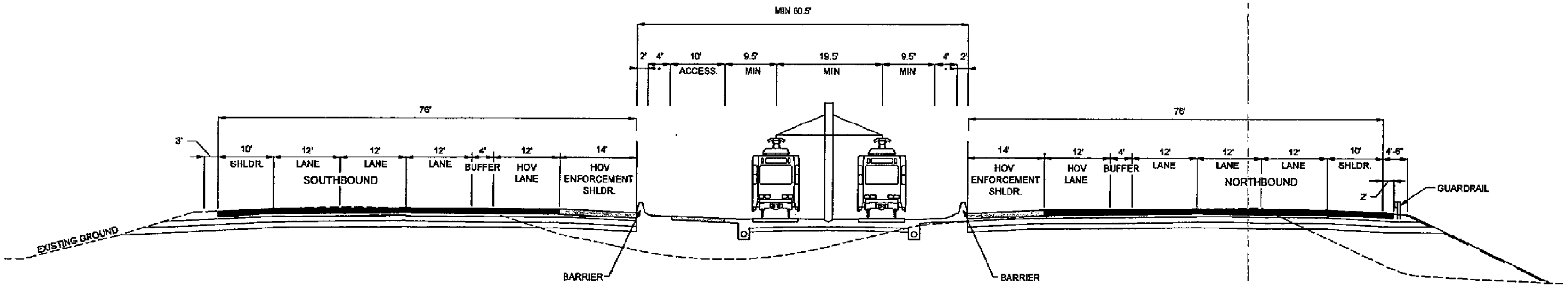
Appendix I

Typical Sections
I-93 Rail Corridor



* Appurtenance

Vanasse Hangen Brustlin, Inc.

Figure I-1

Double Track in Median w/Access Road and Closed Drainage System

09 NOV 2000
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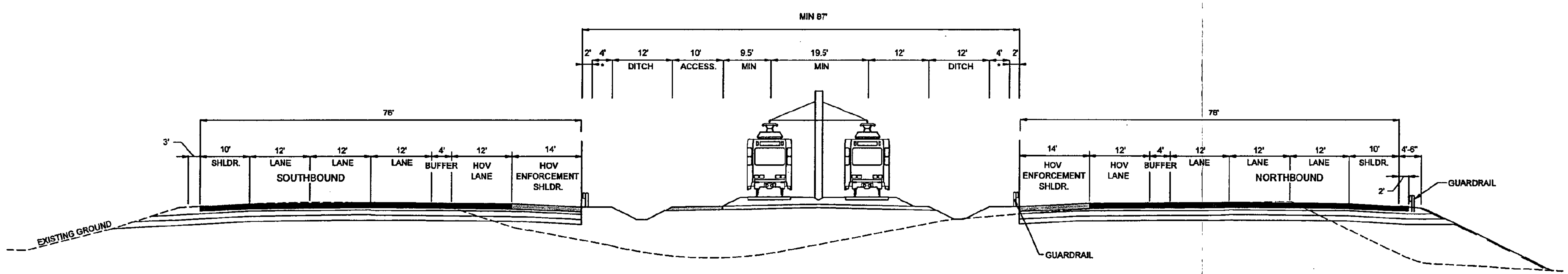

* Appurtenance

Vanasse Hangen Brustlin, Inc.

Figure I-2

Double Track in Median w/Access Road and Open Drainage System

09 NOV 2000
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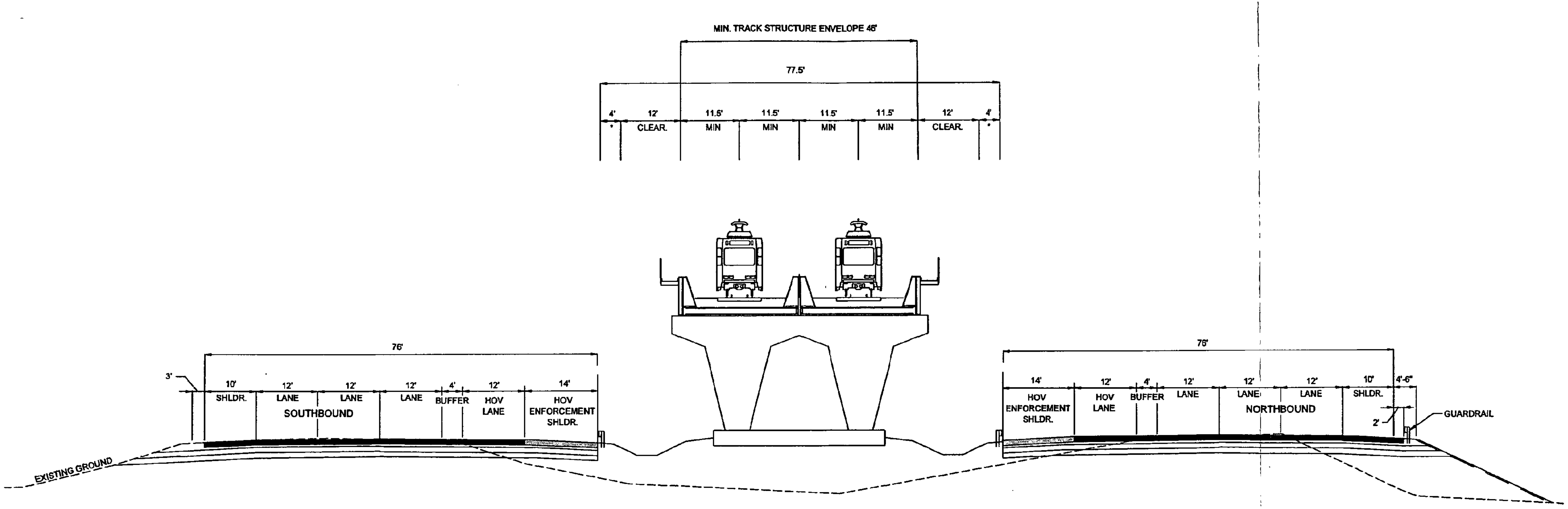

* Appurtenance

Vanasse Hangen Brustlin, Inc.

Figure I-3

Double Track on Structure

09 NOV 2000
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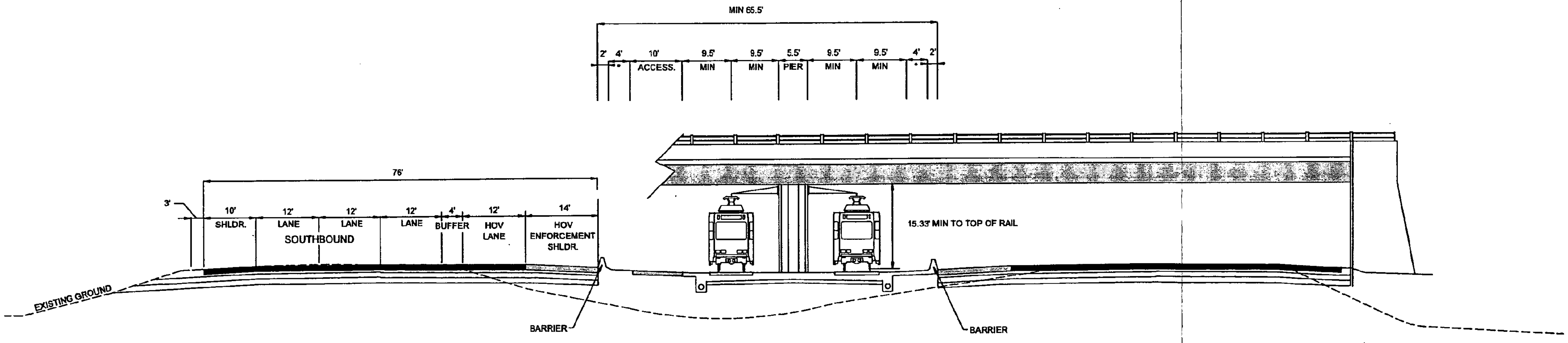

* Appurtenance

Vanasse Hangen Brustlin, Inc.

Figure I-4

Double Track in Median at Overpass

09 NOV 2000
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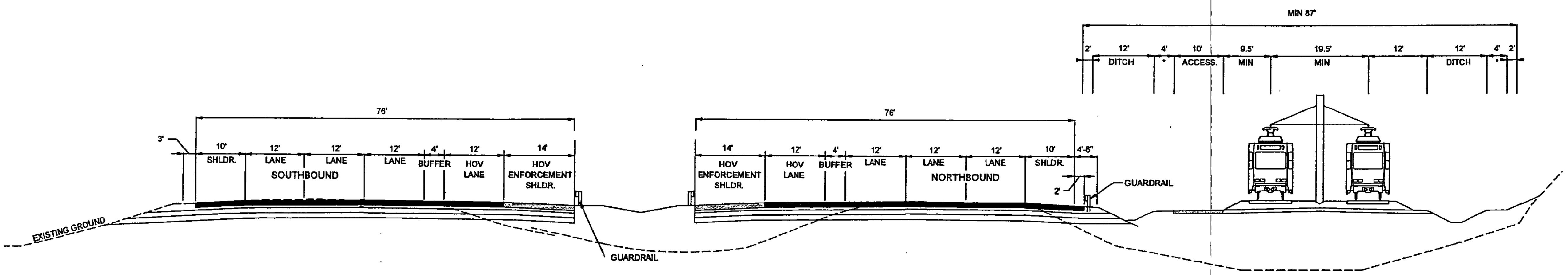

* Appurtenance

Vanasse Hangen Brustlin, Inc.

Figure I-5

Double Track Outside TravelWay

09 NOV 2000
K:\50885\graphics\FIGURES\RailReports\AltsEvalReport001012\50885raibcs.dgn

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Appendix J

I-93 Rail Corridor: Capital Cost Estimate

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COST ESTIMATE - I-93 RAIL CORRIDOR

Item	Quantity	Unit Price	Unit	Price
TRACK STRUCTURE				
Install New Track Structure				
Rt. 213 to State Line	6,864	$ 145	track foot	$ 995,280
State Line to Rt. 28 (I-93 ROW)	81,840	$ 145	track foot	$ 11,866,800
Rt. 28 to end (existing rail corridor)	15,840	$ 145	track foot	$ 2,296,800
Passing Sidings	5,280	$ 145	track foot	$ 765,600
Upgrade existing rail				
Lawrence to Rt. 213 (existing rail corridor)	17,424	$ 145	track foot	$ 2,526,480
Turnouts				
Install #10 Turnout	4	$ 95,000	each	$ 380,000
Install #20 Turnout	1	$ 140,000	each	$ 140,000
Sub-Total				**$ 18,970,960**
GRADE CROSSINGS				
Single track - New crossing surface	10	$ 33,000	LS	$ 330,000
Single Track - New Crossings	8	$ 100,000	LS	$ 800,000
Double track - New crossing surface	1	$ 275,000	LS	$ 275,000
Double Track - New Crossings	1	$ 300,000	LS	$ 300,000
Grade Crossing Protection	10	$ 275,000	each	$ 2,750,000
Intersection Signal Improvement	2	$ 500,000	LS	$ 1,000,000
Sub-Total				**$ 5,455,000**
CIVIL				
Clearing Grubbing	105,600	$ 15	linear foot	$ 1,584,000
Earthwork	1,742,331	$ 1	cubic foot	$ 967,962
Fencing	6,000	$ 20	linear foot	$ 120,000
Sub-Total				**$ 2,671,962**
STRUCTURES				
Undergrade Structures				
	Replacements			
South Canal	1	$ 661,050	LS	$ 661,050
Merrimack River	1	$ 3,780,000	LS	$ 3,780,000
North Canal	1	$ 559,350	LS	$ 559,350
Manchester Street	1	$ 559,350	LS	$ 559,350
Spickett River	1	$ 244,800	LS	$ 244,800
Little Cohas Brook	1	$ 306,000	LS	$ 306,000
Little Cohas Brook	1	$ 306,000	LS	$ 306,000
				$ 6,416,550
	New Construction			
Policy River	1	$ 3,500,000	LS	$ 3,500,000
I-93 (NR & SB)	1	$ 6,000,000	LS	$ 6,000,000
Hampshire Road	1	$ 1,700,000	LS	$ 1,700,000
I-93 (SB)	1	$ 3,200,000	LS	$ 3,200,000
Lowell Road	1	$ 1,100,000	LS	$ 1,100,000
Porcupine Brook Viaduct	1	$ 35,000,000	LS	$ 35,000,000
Pelham Road	1	$ 1,100,000	LS	$ 1,100,000
Range Road	1	$ 980,000	LS	$ 980,000
Indian Rock Road	1	$ 1,700,000	LS	$ 1,700,000
N. Lowell Road	1	$ 1,300,000	LS	$ 1,300,000
Fordway Extension	1	$ 1,100,000	LS	$ 1,100,000
Kendall Pond Road	1	$ 940,000	LS	$ 940,000
Pond	1	$ 3,500,000	LS	$ 3,500,000
Stonehenge Road	1	$ 940,000	LS	$ 940,000
Rockingham Road	1	$ 1,400,000	LS	$ 1,400,000
				$ 63,460,000
Structures Sub-Total				**$ 69,876,550**

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COST ESTIMATE - I-93 RAIL CORRIDOR

Item	Quantity	Unit Price	Unit	Price
FACILITIES				
Stations				
Salem/Exit 2	1	$ 1,700,000	LS	$ 1,700,000
Exit 3	1	$ 1,200,000	LS	$ 1,200,000
Exit 4	1	$ 2,000,000	LS	$ 2,000,000
Exit 5	1	$ 1,200,000	LS	$ 1,200,000
Lawrence	1	$ 1,000,000	LS	$ 1,000,000
Layover				
Manchester Layover/Maintenance Facility	1	$ 1,050,000	LS	$ 1,050,000
Sub-Total				**$ 8,150,000**
SIGNAL SYSTEM				
New Signaling System	23	$ 1,000,000	mile	$ 23,000,000
Passing Sidings/Station Interlockings	3	$ 750,000	each	$ 2,250,000
Rationalize Lawrence Interlocking	1	$ 350,000	LS	$ 350,000
Control Center Improvements	1	$ 80,000	LS	$ 80,000
Sub-Total				**$ 25,680,000**
SUM				**$ 130,804,472**
Contingency @20%				$ 26,160,894
Design & Construction Services @15%				$ 19,620,671
TOTAL				**$ 176,586,037**

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Appendix K

Cost Analysis

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ANNUAL COSTS
WEST RAIL CORRIDOR
(Nashua to Manchester)

Item	Total Cost*	Life Cycle	Annualization Factor	Annual Cost
Track Structure	$15,818,436	30	0.0806	$ 1,274,751
Grade Crossings	$8,993,700	30	0.0806	$ 724,770
Earthwork and Roadway	$611,955	30	0.0806	$ 49,315
Structures	1,437,750	5	0.2439	$ 350,654
Facilities	7,425,000	30	0.0806	$ 598,354
Signal System	17,388,000	30	0.0806	$ 1,401,236
TOTAL				**$ 4,399,080**

* Costs include a continency of 20% and a construction and engineering fee of 15%

Equipment

Item	Total Cost**	Life Cycle	Annualization Factor	Annual Cost
Low Service Scenario	$53,280,000	25	0.0858	**$ 4,571,984**
Moderate Service Scenario	$79,920,000	25	0.0858	**$ 6,857,977**
High Service Scenario	$106,560,000	25	0.0858	**$ 9,143,969**

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ANNUAL COSTS
EAST RAIL CORRIDOR

Tunnel/Boat Section

Item	Total Cost*	Life Cycle	Annualization Factor	Annual Cost
Track Structure	$31,522,905	30	0.0806	$ 2,540,318
Grade Crossings	$20,760,300	30	0.0806	$ 1,672,998
Earthwork and Roadway	$3,743,528	30	0.0806	$ 301,677
Structures (Replacement)	$14,125,118	40	0.0750	$ 1,059,513
Structures (Rehab)	$202,500	5	0.2439	$ 49,388
Strucures (Tunnel/Boat Section/ Station)	$467,403,143	40	0.0750	$ 35,059,507
Facilities	$12,150,000	30	0.0806	$ 979,125
Signal System	$15,768,000	30	0.0806	$ 1,270,686
TOTAL				**$ 42,933,212**

* Costs include a continency of 20% and a construction and engineering fee of 15%

Relocation

Item	Total Cost*	Life Cycle	Annualization Factor	Annual Cost
Track Structure	$31,522,905	30	0.0806	$ 2,540,318
Grade Crossings	$23,472,450	30	0.0806	$ 1,891,560
Earthwork and Roadway	$4,415,311	30	0.0806	$ 355,814
Structures (Replacement)	$16,321,838	40	0.0750	$ 1,224,287
Structures (Rehab)	$202,500	5	0.2439	$ 49,388
Facilities	$5,400,000	30	0.0806	$ 435,167
Signal System	$15,768,000	30	0.0806	$ 1,270,686
TOTAL				**$ 7,767,220**

* Costs include a continency of 20% and a construction and engineering fee of 15%

Equipment

Item	Total Cost**	Life Cycle	Annualization Factor	Annual Cost
Low Service Scenario	$16,080,000	25	0.0858	**$ 1,379,833**
Moderate Service Scenario	$24,120,000	25	0.0858	**$ 2,069,750**
High Service Scenario	$24,120,000	25	0.0858	**$ 2,069,750**

** Costs include a continency of 20%

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ANNUAL COSTS
I-93 RAIL CORRIDOR

Item	Total Cost*	Life Cycle	Annualization Factor	Annual Cost
Track Structure	$25,610,796	30	0.0806	$ 2,063,882
Grade Crossings	$7,364,250	30	0.0806	$ 593,458
Earthwork and Roadway	$3,607,148	30	0.0806	$ 290,687
Structures (Replacement)	$8,662,343	40	0.0750	$ 649,755
Structures (New)	$85,671,000	40	0.0750	$ 6,426,108
Facilities	$11,002,500	30	0.0806	$ 886,652
Signal System	$34,668,000	30	0.0806	$ 2,793,769
TOTAL				**$ 13,704,312**

* Costs include a continency of 20% and a construction and engineering fee of 15%

Equipment

Item	Total Cost**	Life Cycle	Annualization Factor	Annual Cost
Low Service Scenario	$24,480,000	25	0.0858	**$ 2,100,641**
Moderate Service Scenario	$36,720,000	25	0.0858	**$ 3,150,962**
High Service Scenario	$36,720,000	25	0.0858	**$ 3,150,962**

** Costs include a continency of 20%

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