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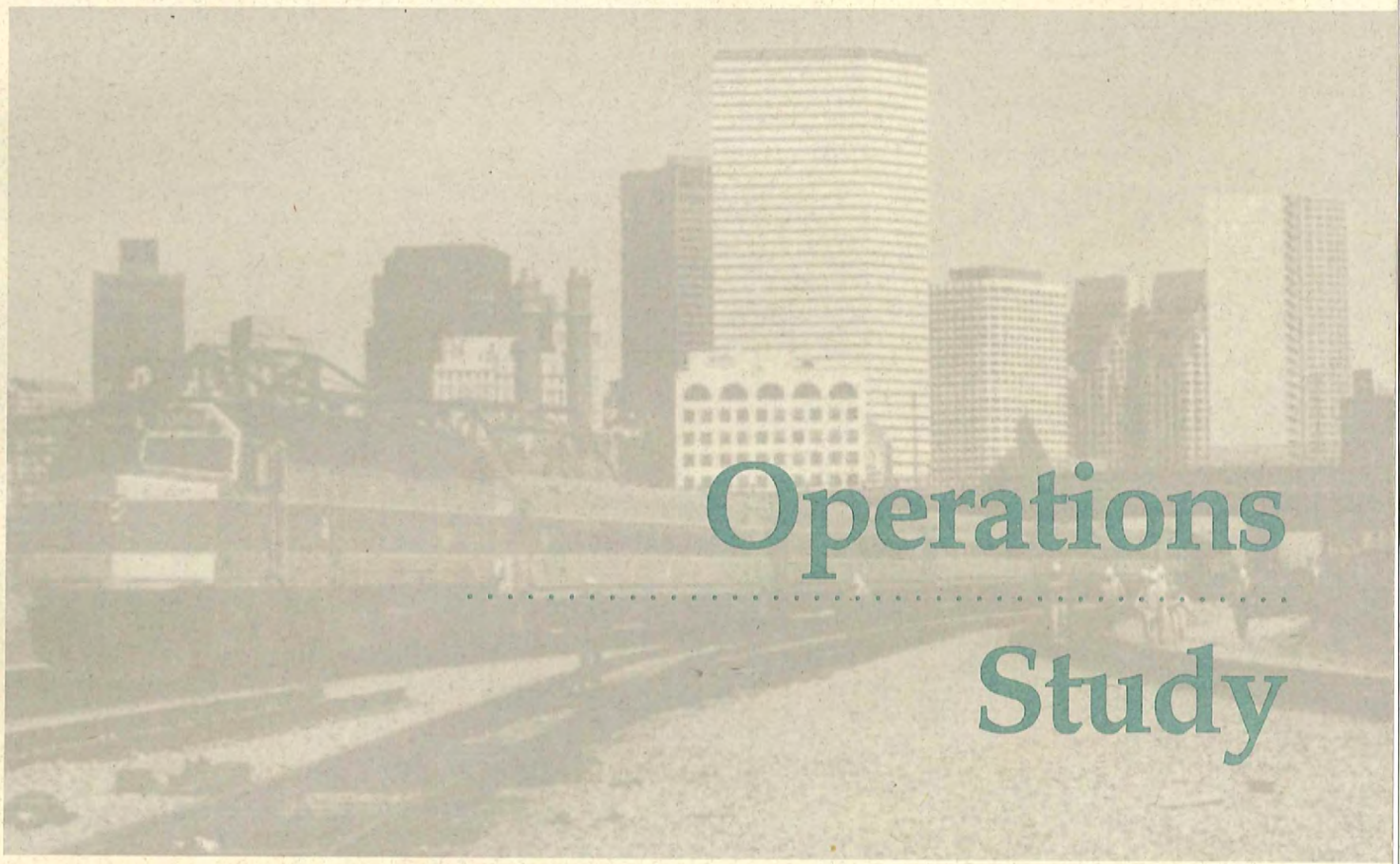
Technical Report No. 5

NorthSouthRailLink
PROJECT



Operations Study

Preface

The North-South Rail Link Study Phase 1 effort is focused on developing the operational analysis, conceptual engineering, and environmental studies necessary to evaluate the alternatives for connecting the North Side and South Side rail systems through downtown Boston. For the Build Alternative, a rail tunnel, these conceptual engineering and environmental documentation efforts are focused on the core tunnel segment. Future phases of the study will review and assess systemwide impacts of the selected alternative.

Phase 1 of this study is a cooperative effort of the following agencies (The Federal Transit Administration is the lead federal agency):

- Massachusetts Bay Transportation Authority
- Executive Office of Transportation and Construction
- Massachusetts Highway Department
- National Railroad Passenger Corporation (Amtrak)

This technical report is one in a series of documents prepared as part of the joint Major Investment Study/Environmental Impact Statement/ Environmental Impact Report process. The intent of this technical study is to evaluate the operational requirements of the No-Build and Build alternatives as they relate to the regional rail system.

The results of this document are intended to identify the operational characteristics and develop preliminary equipment and operating costs of the No-Build and Build alternatives. This document has been prepared for the North-South Rail Link Study by the VHB/FRH Joint Venture. Specific technical input has been provided by the following joint venture team members:

- Vanasse Hangen Brustlin, Inc.
- Frederic R. Harris, Inc.
- L.S. Transit Systems, Inc.
- Transit Safety Management, Inc.

In addition, the Central Transportation Planning Staff has provided the future No-Build and Build levels of ridership for the regional rail system. Throughout the development of this study, the MBTA's Rail Link Technical Committee and the Citizens Advisory Committee Operations Subcommittee provided review and input.

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EX.1 Introduction

The *Operations Study* is one of a series of technical reports prepared in support of the alternatives analysis for the North-South Rail Link study. The purpose of this technical report is to identify the operational characteristics and develop equipment and operating costs for the No-Build and Build alternatives under consideration as part of the North-South Rail Link Project. The cost data will then be used in support of the economic analysis and alternatives evaluation contained in the project's major investment study/draft environmental impact statement/draft environmental impact report (MIS/DEIS/DEIR) document.

The study effort included the following four key elements:

- the development of conceptual service schedules based on the patronage estimates reported in the ridership study,
- simulation of tunnel operations to test the operational flexibility of the four-track and two-track Build Alternatives,
- an evaluation of equipment needs and the estimation of annual train miles for the No-Build and Build Alternatives, and
- the development of annual operating and capital equipment costs for the Build Alternatives.

The alternatives considered included the No-Build, four-track Build, two-track Build (Back Bay Portal), and two-track Build (South Bay Portal). The No-Build Alternative considers the continued operation of the existing MBTA commuter rail system with the implementation of programmed capital and operating improvements and planned service extensions scheduled to be completed by the 2020 design year. Under the No-Build scenario, commuter rail service on the South Side will continue to terminate at South Station. North Station will continue to serve as the terminus for North Side service.

The Build Alternatives consider construction of a rail tunnel linking the MBTA's South Side and North Side commuter rail operations into one unified regional rail system. Commuter rail service, which now terminates at South and North stations on the fringe of the central business district, would be routed through downtown Boston, improving core area trip distribution and connections between the suburbs. The four-track Build Alternative proposes the construction of a 3-mile long rail tunnel with five portals connecting all of the existing South Side lines with all of the North Side lines. The tunnel will extend from a single portal (with two tracks) located east of Back Bay Station on the Northeast Corridor

and two portals located in the South Bay area (one connecting with the Old Colony lines and one connecting to the Dorchester Branch) to two North Side portals (a two-track portal connecting to the Fitchburg Line and a four-track portal connecting to the Lowell, Haverhill, and Rockport/Ipswich Lines. Either two or three underground stations located in downtown Boston are included: South Station, Central Station, and North Station. A more detailed discussion and corresponding figures of the tunnel alignment, stations, and portals is presented in the *Schematic Design Report*, Technical Report No. 3.

In addition to the "full-build" four-track Build Alternative, a "partial-build" two-track option was investigated. Similar to the four-track alternative, the two-track alternative links North and South stations and would change rail operations from a stub-end system to a run-through operations. Two options for the two-track tunnel were investigated: one with a two-track South Side portal at Back Bay, and one with two South Side portals located in South Bay. The Back Bay Portal option includes a single-track tunnel connection to the South Bay maintenance yard area for equipment movements. Both two-track tunnel options connect to all the North Side lines at the north end of the tunnel.

EX.2 Operational Analysis

The work carried out in the simulation of the rail link tunnel used parameters established in the following technical reports:

- Technical Report No. 3: the *Schematic Design Report*,
- Technical Report No. 4: the *Ridership Methodology and Forecasting Study*,
- Technical Report No. 6, the *Commuter Rail Railsim Simulation Study,*
- Technical Report No. 7, the *Equipment Engineering* Study, and
- the conceptual engineering plans developed as part of the *Schematic Design Report.*

The operational characteristics are based on the 2020 No-Build infrastructure with the addition of either a four-track or two-track downtown rail tunnel. Service levels were developed based on the patronage projections reported in the ridership study. Run-through pairings, the track layout of the tunnel, the underground interlockings, and the volume and headway of train operations were all combined to establish an initial simulation of the operations of the rail link tunnel. The simulation effort included the three Build options: four-track, two-track (Back Bay), and two-track (South Bay).

Based on the analysis completed, it can be concluded that the any of the three Build Alternatives would significantly change operation of the Boston metropolitan rail system. Instead of having two stub-end stations, the North Side and South Side systems would be linked into a regional rail system so that a train could pass through the center of

Boston from one side of the city to the other. The magnitude of this change varies, however, with the four-track alternative having the most significant impacts. Both of the two-track alternatives offer a significant, but less dramatic, change in system operations.

The existence of the rail link tunnel would also allow the MBTA the opportunity to significantly adjust the manner in which commuter rail equipment is serviced. It is assumed that the current pattern of servicing (either immediately after the completion of a morning peak period assignment, or around midday) will continue. The movement of the equipment, however, is expected to change. With the "run through" service, a southbound revenue train going out of service at either South Station or Back Bay Station could be operated by the road crew directly into a South Bay or Readville equipment maintenance facility for servicing. Similarly, northbound trainsets going out of service at North Station could be moved directly to the Boston Engine Terminal/Yard complex by the road crew. In both cases, this manner of operation:

- reduces the use of yard personnel to move equipment to facilities for servicing,
- reduces terminal congestion,
- eliminates "back-up" moves for service events, and
- decreases the amount of time spent getting to/from maintenance facilities.

In addition, the larger South Side equipment fleet would be moving directly into the major MBTA maintenance facility at BET. The smaller North Side fleet would then be utilizing the secondary South Side service facilities. The results of these simulation efforts are summarized in the following paragraphs.

No-Build Alternative

A key component of the future MBTA commuter rail system is the capacity of South and North Stations. Both facilities handle a large volume of trains and passengers during the peak periods of service each day. As ridership continues to grow, peak period terminal operations will become more congested.

At South Station, the 13 platform tracks currently (1995) handle 30 commuter rail trains during the peak period. This level of utilization, combined with the intercity service demands, place the terminal at 55 percent of rural capacity or 68 percent of effective capacity. With the anticipated growth in ridership, the number of commuter rail trains using South Station during the peak period is expected to exceed both total and effective capacity under the 2020 No-Build conditions. Additional terminal capacity will be required to handle volume of trains projected.

Similar terminal capacity issues exist at North Station. Under existing (1995) conditions, North Station services 24 trains on 10 tracks during

the peak period, placing the demand at 50 percent of effective capacity. With 2020 No-Build service levels, the terminal is expected to service 43 trains during the peak period. This level of utilization places the terminal at 90 percent of effective capacity.

Four Track Build Alternative

For planning purposes, it was assumed that all MBTA regional rail service would access the tunnel during the peak periods. One Northeast Corridor intercity train in each direction would operate through the tunnel during the peak period, stopping only at South Station.

Under 2020 design year conditions, the existing imbalance in ridership between the South Side and North Side lines is projected to continue. As a result, the South Side service is projected to require the largest volume of trains to meet ridership demands. This imbalance in service requirements presents challenges in operating the rail tunnel during peak periods. The simulation tested a system where three tracks of the tunnel are used for the higher volume of service. One track was reserved for the lower volume of service. The simulation results indicate that this 3/1 tunnel track arrangement is functional and sound for peak period operations.

The two-track Back Bay Portal presented operational challenges. With the majority of Northeast Corridor intercity passenger rail surface continuing to use the surface tracks at South Station, a complex interlocking arrangement is necessary to make all the tunnel/surface track connections at Back Bay. To reduce the potential for conflicting train movements and resultant congestion at the portal, it was proposed that rail operations along the Northeast Corridor between the Back Bay Portal and Route 128 Station and along the Boston Line to Beacon Park Yard be rearranged from "right-hand" operation to "left-hand" operation during the weekday morning peak period only. While there is nothing technically incorrect with "left-hand" operations, this segment of the Northeast Corridor would be the only segment with "left-hand" operation. The infrastructure solution is to provide a three-track portal at Back Bay.

In the South Bay area, the single-track Old Colony and Dorchester Line portals present potential points of constraint. The single-track connections could cause either a back-up outside the tunnel of inbound trains or a back-up of trains within the tunnel exiting to the South Side maintenance facility. The solution is to double track both portals.

While several changes in the conceptual design were recommended, no fatal flaws were identified. Simulation of operations along the NEC west of Route 128 Station and on the Boston Line should be developed as part of preliminary design to further test the morning peak period "left-hand" operations. The "left-hand" operation on the NEC and the Boston Line tracks are not standard practice but it is neither unreasonable or impractical. Combined with a schedule of peak period service that would

still terminate at South Station, the rail tunnel should add significant capacity to the regional rail system well into the 21st century.

Two Track Build Alternative (Back Bay Portal)

With the two-track Build Alternative (Back Bay Portal), it was assumed that all the North Side service and approximately half the South Side service would operate through the tunnel during peak periods. The tunnel service included: Needham-Rockport, Fitchburg-North Easton, Forge Park-Haverhill, South Attleboro-Lowell, and Framingham-Newburyport services. South Side lines terminating at South Station surface platforms included: Worcester Express, Providence Express, New Bedford/Fall River, Middleborough, Plymouth, Greenbush, and Fairmount services. One Northeast Corridor intercity train in each direction would operate through the tunnel during the peak period, stopping only at South Station.

This Build alternative results in the same operational considerations at the Back Bay Portal. "Left-hand" operations would be introduced on the Northeast Corridor and Boston Line to reduce the potential for conflicts and congestion at the Back Bay Portal. A third portal track would remove the need for "left-hand" operations on the surface. Unlike the four-track Build Alternative, however, the third track in this case would have to merge into the two tunnel tracks. This situation could result in inbound morning peak period trains from the South Side.

To make equipment movements easier, reduce potential tunnel congestion, and to reduce the number of trains using the Northeast Corridor, a single-track tunnel connection to the South Bay area is included as part of this alternative. This tunnel connection is necessary for equipment movements. Otherwise, all trains entering from the North Side lines that were headed for maintenance at the South Side facility would be forced to either use the Northeast Corridor to access Readville or reverse direction on the surface at Back Bay. Neither alternative is attractive from an operating perspective.

Two Track Build Alternative (South Bay Portal)

With the two-track Build Alternative (South Bay Portal), it was assumed that all the North Side service and approximately half the South Side service would operate through the tunnel during peak periods. The tunnel service included: Greenbush-Rockport, Plymouth-Fitchburg, Forge Park-Haverhill, South Attleboro-Lowell, and Middleborough-Newburyport services. South Side lines terminating at South Station surface platforms included: Worcester Express, Providence Express, New Bedford/Fall River, Needham, North Easton, and Fairmount services. One Northeast Corridor intercity train in each direction would operate through the tunnel during the peak period, stopping only at South Station.

This alternative includes the development of a transfer station at either Route 128 or Readville on the South Side. The transfer station is necessary because two of the South Side tunnel paired routes (Forge Park and Providence) serve Back Bay Station under No-Build conditions. With the two-track South Bay Portal alternative, these two lines would be rerouted over the Dorchester Branch to the tunnel, bypassing Back Bay Station. The Route 128 or Readville transfer facility would allow passengers to transfer between tunnel routes and South Station surface routes.

As with the four-track Alternative, both South Bay portals would need to be double tracked. The proposed single-track connections could cause either a back-up outside the tunnel of inbound trains or a back-up of trains within the tunnel exiting to the South Side.

EX.3 Fleet Requirements

The 2020 No-Build fleet requirements are based on the preliminary schedules developed by the MBTA for both North Side and South Side services. For each of the Build Alternatives, preliminary schedules were developed based on ridership projections and operational considerations. Table EX-1 summarizes the fleet requirements and projected annual train miles for all of the alternatives considered.

For 2020 No-build conditions, a total of 87 trainsets (31 on North Side and 56 on South Side) was forecast to provide the 663 trains each weekday. The 87 sets of equipment are projected to travel 6.35 million miles annually.

For all three Build Alternatives, the number of weekday trains and the total fleet requirements are projected to be less than the 2020 No-Build scenario. For both the Four-Track Build and the Two-Track (Back Bay) scenarios, the total number of trainsets is projected to decrease by 12 to 75 sets. These alternatives result in a reduction of 13 locomotives and 81 coaches as compared to the No-Build Alternative. The daily train miles are projected to be approximately 18,600 for the Four-Track Alternative and 14,577 for the Two-Track (Back Bay) Alternative.

Table EX-1 **Fleet Requirements**

	Existing (1995)	2020 No-Build	2020 Two-Track Build (Back Bay Portal	2020 Two-Track Build (South Bay Portal)	2020 Four-Track Build
FLEET REQUIREMENTS					
Total Trainsets	45	87	75	79	75
Locomotives	55	96	83	87	83
Coaches	358	600	519	544	519
DAILY WEEKDAY TRAINS	400	663	319	288	328
ANNUAL TRAIN MILES (million miles)	2.8	6.35	4.46	4.50	5.36

In the 2020 two-track Build (South Bay Portal) scenario, the total number of trainsets required to provide service is projected to decrease by 8 to 79 sets. This alternative results in a reduction of 9 locomotives and 56 coaches in comparison to the No-Build Alternative. Daily service for the South Bay Portal Alternative results in approximately 15,600 train miles.

EX.4 Summary of Annual Costs

One of the most significant benefits of a rail tunnel is the anticipated savings in both capital equipment and operating costs resulting from more efficient utilization of the locomotive and passenger car fleet. The capability to provide run-through service is expected to: 1) reduce non-revenue ("deadhead") movements of equipment, 2) reduce the number of equipment turns required under congested terminal conditions, 3) reduce the number of equipment sets required, and 4) provide direct access to equipment maintenance facilities. In addition, a rail tunnel would provide a significantly greater level of capacity to accommodate peak period train movements than the existing stub-end terminals at North and South stations.

A preliminary cost estimate was prepared for both future 2020 No-Build and Build operating and equipment costs. These estimates were based on existing (1995) MBTA cost experience. Any savings or additional costs expected as a result of a rail tunnel have been noted and incorporated into the cost estimate.

A key component of the cost estimate is the choice of motive power for the Build Alternatives. In Technical Report No. 7, the *Equipment Engineering Study*, the development of a high voltage, overhead catenary pick-up dual mode locomotive is recommended to power the MBTA fleet. This unit currently does not exist in the configuration identified in the study. In previous initiatives, issues regarding the

weight and size of such a unit have led to decisions not to pursue further development. In the case of this project, it was concluded that certain technological advances in locomotive components make the unit more feasible than it has been in the past endeavors. Should it not be available, however, the fleet requirements and associated capital and operating costs would have to be reconsidered.

Operating Cost

There are significant operating efficiencies associated with the run-through operation of the Rail Link. For all the three 2020 Build scenarios, both the transportation portion and the mechanical portion of the annual operating cost can be reduced because of these anticipated operating efficiencies. It has been estimated that the transportation portion can be reduced by 28 percent for the four-track Alternative, 19 percent for the Two-Track (Back Bay) and 14 percent for the Two-Track (South Bay) alternatives. This estimated savings is based on the reduction in the number of trainsets and an anticipated increase in daily average crew productivity. The mechanical portion of the operating cost can be reduced based on the reduction in coaches and locomotives and the improved efficiencies in maintenance of the equipment. The utilization of locomotives and coaches, based on average miles per unit per year, also decreases. These efficiencies also take into account that the dual-mode locomotive is expected to require more maintenance than the single-mode locomotives. As a result of these expected efficiencies, the mechanical portion was reduced by 4 percent for the four-track Build Alternative and the two-track Build (Back Bay Portal) Alternative. The mechanical portion was increased slightly for the two-track Build (South Bay Portal) Alternative because the higher number of dual mode locomotives to maintain compared to the other two Build alternatives. These anticipated unit operating costs are summarized in Table EX-2.

Table EX-2 Unit Operating Cost (1995 Dollars)

Component	Existing (1995)	2020 No-build	2020 Two-Track Build (Back Bay Portal)	2020 Two-Track Build (South Bay Portal)	2020 Four-Track Build
Transportation	$14.00	$14.00	$11.34	$12.04	$10.08
Mechanical	$10.23	$10.23	$ 9.83	$10.30	$ 9.83
Engineering	$ 8.71	$ 8.71	$ 8.71	$ 8.71	$ 8.71
Administrative	$ 4.92	$ 4.92	$ 4.92	$ 4.92	$ 4.92
Total	$37.86	$37.86	$34.80	$35.97	$33.54

Applying these estimated train mile costs to the anticipated annual train miles, results in an estimated annual operating cost of approximately $153.30 million for the two-track (Back Bay Portal) Alternative, $161.56 million for the two-track (South Bay Portal) Build Alternative, and $179.93 million for the four-track Build Alternative. These costs represent an annual savings of approximately $60.53 million for the Four-Track Alternative to $87.16 million for the Two-Track (Back Bay) Alternative. These savings are based on the more efficient use of crews and equipment and a reduction in the number of train miles traveled system-wide. Although the cost was not defined, it should also be noted that the reduced average miles per year could extend the useful life approximately two to three years for all vehicles.

Capital Equipment Cost

In addition to the operating cost savings there would also be an anticipated savings in equipment costs associated with the construction of a rail link tunnel. A run-through operation is expected to require from 8 to 12 fewer trainsets. This savings is estimated at $18.1 million for the four-track Build and two-track (Back Bay Portal) alternatives and is largely attributable to the reduction in number of coaches required. For the two-track (South Bay Portal) Alternative, the equipment requirements are expected to result in an additional $30.9 million cost. This additional cost is the result of the addition locomotives and coaches required.

The total annualized equipment cost for four alternative was estimated by amortizing the total costs over the useful life of the capital item in accordance with the Federal Transit Administration guidelines for capital projects. The amortization was performed using a discount rate of 7 percent, also in accordance with the latest federal guidelines and the National Transit Institute Training Program for Major Investment Studies by FTA/FHWA. The total capital costs and the annualized capital costs are also shown in Table EX-3.

Annual Cost Per Rider

The results of the annual operating and capital equipment cost estimates have provided a broad range of costs against which the four alternatives can be considered. The one factor not considered in either estimate is the number of people serviced by each alternative. To bring this factor into consideration, the weekday daily ridership forecasts prepared for the MBTA regional rail system and reported in Technical Report No. 4, the *Ridership Methodology and Forecasting Study,* were adjusted to an annual basis. Taking the total annual cost (operating and annualized equipment) and dividing by the annual ridership produces the total annual estimated cost per rider. These results are summarized in Table EX-4.

Table EX-3 **Annual Equipment and Operating Cost Summary (1995 Dollars)**

Alternative	Capital Equipment Cost (million $)	Annualized Capital Equipment Cost (million $)	Annual Operating Cost (million $)	Total Annual Cost (million $)	Comparison to No-Build (million $)
2020 No-Build	$1,037.90	$89.26	$240.46	$329.72	**NA**
2020 Two-Track Build (Back Bay Portal)	$1,019.80	$87.70	$153.30	$241.00	**($88.72)**
2020 Two-Track Build (South Bay Portal)	$1068.80	$91.92	$161.56	$253.48	**($76.24)**
2020 Four-Track Build	$1,019.80	$87.70	$179.93	$267.63	**($62.09)**

Table EX-4 **Annual Cost Per Rider (1995 Dollars)**

Alternative	Total Annual Cost (million $)	Projected Annual Ridership (millions)	Cost Per Rider ($)
2020 No-Build	$329.72	46.56	**$7.08**
2020 Two-Track Build (Back Bay Portal)	$241.00	53.62[1]	**$4.49**
		56.42[2]	**$4.27**
2020 Two-Track Build (South Bay Portal)	$253.48	50.25[1]	**$5.04**
		52.86[2]	**$4.80**
2020 Four-Track Build	$267.63	60.84[1]	**$4.40**
		63.63[2]	**$4.21**

Notes: (1) Two Station Alternative
(2) Three Station Alternative

As these results indicate, the most cost-effective Build Alternative is the four-track option. At $4.21 per rider, it represents a $2.87, or 41 percent, savings over the No-Build. Even the two-track (South Bay Portal) alternative at $5.04 per rider represents a 29 percent savings when compared to the No-Build operation.

EX.5 Summary of Findings

This operations study identified that the construction of a rail tunnel is a key component of the future commuter rail system in the Boston region. Without the tunnel, both downtown terminals will be at or over effective peak period capacity. Introduction of the tunnel connection address the terminal capacity issues and provides significant opportunity to both enhance system capacity and reduce annual operating costs.

Based on the operational analyses completed, the four-track tunnel provides many benefits over the two-track tunnel. One of the most significant benefits of a rail tunnel, specifically with the four-track tunnel, is the anticipated savings in both equipment and operating costs resulting from more efficient utilization of the locomotive and passenger car fleet. The capability to provide run-through service in either a four or two-track tunnel is expected to:

- reduce non-revenue ("deadhead") movements of equipment,
- reduce the number of equipment turns required under congested terminal conditions,
- reduce the number of equipment sets required,
- provide direct access to equipment maintenance facilities, and
- provide a significantly greater level of capacity to accommodate peak period train movements than the existing stub end terminals at North and South stations.

In addition, the operation of a four-track tunnel offers the following advantages over the two track tunnel:

- Four tracks provide the capability to run all of the MBTA's daily regional service, including "pull-ahead" equipment-servicing moves, through the tunnel.
- Increased equipment utilization adds to the overall operating efficiency and reduces the unit operating cost.
- Every outlying MBTA station would have improved peak period service.
- Operating patterns (such as zone express, skip-stop express, and tandem express) could be maximized to their fullest advantage.
- The four-track gives greater flexibility over the two-track tunnel, especially for any incidents or to get around the longer dwell times of the intercity trains.

EX.6 Recommended Actions

Based on the results of this study, it is recommended that the following actions be considered:

- In advancing the four-track alternative, consideration should be given to a three-track portal at Back Bay and two-track portals at both South Bay locations.
- The impact of "left hand" operations along both the NEC and the Boston Line should be investigated further if the Back Bay portal is not triple tracked.
- A systemwide simulation effort should be undertaken to evaluate the full impact of system constraints on No-Build operations.
- A detailed simulation of surface track operation be undertaken to determine capacity constraints for both South and North stations under 2020 No-Build in conjunction with a determination of the full 2020 No-Build service.
- Construction staging plans be developed for the five portal areas so that a full simulation can be conducted to assess the impacts of maintaining rail operations during construction.

Introduction

1

1.1 Background

The North-South Rail Link Study provides an evaluation of alternatives for improving the Boston metropolitan region's rail system by connecting North and South Stations in downtown Boston. These two stations are approximately one mile apart and each serves as a terminal for an independent sub-system of the regional rail system operated by the Massachusetts Bay Transportation Authority (MBTA). In addition, South Station serves as the terminus for Northeast Corridor intercity passenger rail service to Washington D.C. operated by Amtrak. North Station will serve as the terminus for future intercity passenger rail service to Portland, Maine.

The transportation improvements proposed by the North-South Rail Link Study require a Major Investment Study (MIS) under Federal Transit Administration (FTA) guidelines, as well as compliance with federal (NEPA) and state (MEPA) environmental processes. The purpose of an MIS is to develop and evaluate alternatives that meet identified transportation needs and objectives so that an investment decision may be made by the local metropolitan planning organization. The NEPA and MEPA processes require an objective consideration of all reasonable alternatives, full and open disclosure of environmental impacts of proposed actions, and the development of measures to mitigate adverse impacts.

In December 1994, the Massachusetts Bay Transportation Authority (MBTA), the Executive Office of Transportation and Construction (EOTC), the Massachusetts Highway Department (MHD), and Amtrak began the planning, design and environmental work required to prepare an MIS, as well as an Environmental Impact Statement/Report (EIS/R) for a connection between North and South Stations. This effort builds upon previous studies which examined the feasibility of constructing a connector, most notably the Central Artery Rail Link (CARL) Task Force study (1993), the Boston Society of Civil Engineers (BSCE) study (1994), the Central Transportation Planning Staff (CTPS) study (1994), and the Federal Transit Administration (FTA) study (1995). (See Chapter 1.0 of the MIS/DEIS/DEIR for a more detailed discussion of these studies).

The alternatives under consideration include a Build Alternative, which consists of a rail tunnel under downtown Boston connecting the two stations. Figure 1.1-1 shows the location of the project area. Various design options for the Build Alternative, including two or three downtown stations, a two or four-track tunnel and alignment variations were included in the evaluation. Other alternatives include two Transportation Systems Management (TSM) Alternatives consisting of 1) a dedicated shuttle bus or 2) a dedicated Orange Line shuttle. A No-Build Alternative, which provides the basis against which the other alternatives are evaluated, was also included. The alternatives evaluation included: conceptual design development; a technical analysis of operations, ridership and equipment; an assessment of environmental impacts and mitigation; the development of capital and operating costs, and a cost-benefit analysis. The analysis of these alternatives included existing conditions and a future conditions scenario in the year 2020.

As mentioned, a combined Major Investment Study/Draft Environmental Impact Statement/ Draft Environmental Impact Report (MIS/DEIS/DEIR) will be prepared for the North-South Rail Link Study. This *Operations Study* is one of a series of technical reports prepared in support of the alternatives analysis. Other technical reports include:

- *Build Alternative Alignment Corridors: Screening Analysis and Evaluation*
- *Ridership Methodology and Forecasting Study*
- *Equipment Engineering Study*
- *Commuter Rail RAILSIM Simulation Report*
- *Schematic Design Report*
- *Economic Briefing Paper*

1.2 Purpose and Scope of the Operations Study

The purpose of this technical report is to identify the operational characteristics and develop equipment and operating costs for the No-Build and Build alternative options under consideration. The TSM alternatives are addressed exclusively in Chapter 4 of the MIS/DEIS/DEIR document. The cost data will then be used in support of the economic and alternatives evaluations contained in the MIS/DEIS/DEIR document. The effort includes the development of conceptual service schedules based on the patronage estimates reported in the ridership study and unit cost data based on current operating experience.

With the 2020 No-Build Alternative, needs and cost are developed based on the current infrastructure and operating practices. Any programmed infrastructure improvements, service expansions, and planned changes in operating practices are also included. Service levels are developed based on the patronage estimates identified in the ridership study for the No-Build Alternative.

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Project Area Figure 1.1-1

In the Build Alternative, construction of a rail link tunnel would significantly change operations on the MBTA's existing commuter rail system. Instead of having two stub-end stations, the North Side and South Side systems would be linked into a regional rail system so that a train could pass through the center of Boston from one side of the city to the other. The operational characteristics and equipment and operating costs are based on the 2020 No-Build infrastructure with the addition of the downtown rail tunnel. Service levels have been developed based on the patronage projections reported in the ridership study.

1.2.1 Study Goals

The study goal was to evaluate the current system in light of increasing demands for commuter rail service. This study uses the evaluation of the existing and future rail system to define the operational problems which leads to some conclusions of how the Build alternatives could improve the operations of this system. Based on the following expectations, the North-South Rail Link *Operations Study* has been developed to address both systemwide operating characteristics of the regional rail system as well as operations within the core tunnel segment of the Build Alternative. The analysis is presented for both the four-track and the two-track rail tunnel Build Alternatives. Also, this report documents the operational characteristics of the No-Build Alternative to provide a basis for comparison with the Build Alternatives.

One of the most significant benefits of a rail tunnel is the anticipated savings in both equipment and operating costs resulting from more efficient utilization of the locomotive and passenger car fleet. The capability to provide run-through service is expected to: 1) reduce non-revenue ("deadhead") movements of equipment, 2) reduce the number of equipment turns required under congested terminal conditions, 3) reduce the number of equipment sets required, and 4) provide direct access to equipment maintenance facilities. In addition, a rail tunnel would provide a significantly greater level of capacity to accommodate peak period train movements than the existing stub-end terminals at North and South stations.

1.2.2 Study Objectives

To address the goal of documenting the operational characteristics of the No-Build and Build alternatives, the following specific objectives were established for this study effort:

- Determine the amount of service that could potentially be provided in the 2020 No-Build condition and the operating and capital equipment costs to provide that level of service.
- Estimate the equipment and operating costs for the 2020 four-track, two or three station options of the Build Alternative.
- estimate the equipment and operating costs for the 2020 two-track, two or three station options of the Build Alternative.

- Develop a broad assessment of the operational impact of the Build Alternative on the regional rail system.

1.2.3 Study Methodologies

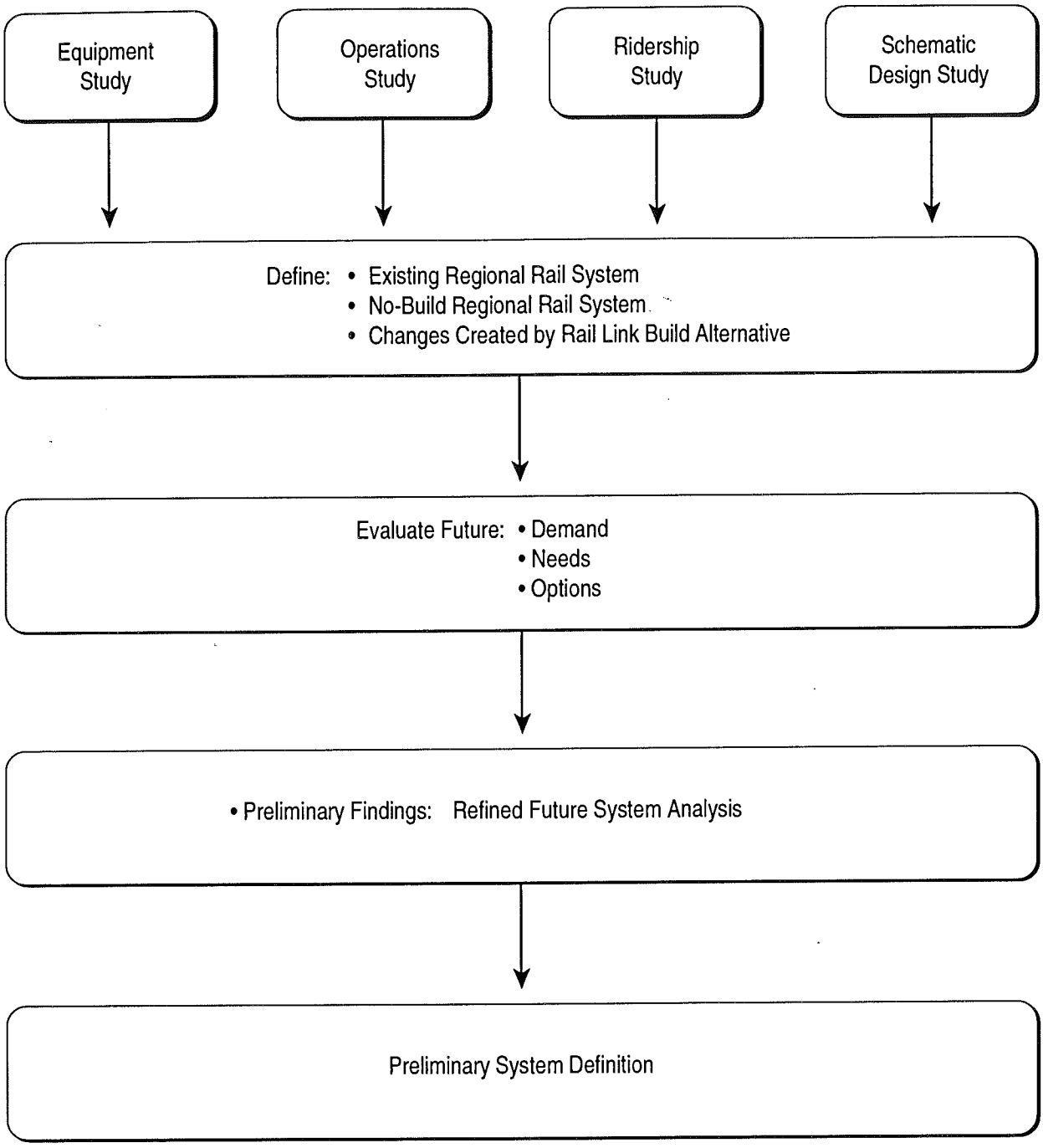
Overall Approach

The *Operations Study* represents one of the four major areas of effort within the Operations Analysis task of the North-South Rail Link Study. These four areas include studies of the equipment, ridership, schematic design, and operations. This study presents preliminary findings related to the operational aspects of the No-Build and Build alternatives. These findings served as input to the other components, including ridership and schematic design. No single element alone can identify the future operational program for the MBTA regional rail system. Rather, the preliminary efforts of each task were refined in a series of analyses to produce the final system definition for this project. Figure 1.2-1 illustrates this overall approach to the operational analysis. The specific elements are described below.

Regional Rail System Evaluation

The evaluation of the regional rail system involved a four-step process resulting in preliminary findings: 1) the existing rail infrastructure, equipment, operations, and costs were defined; 2) the future 2020 No-Build components of the rail system were identified; 3) operational changes resulting from the construction of a rail tunnel were defined; and 4) the impact of each alternative (No-Build, and both the four-track and two-track Build alternatives) were identified and assessed. The specific actions undertaken as part of this effort were:

- The existing commuter rail system including infrastructure, equipment, operations, and costs was reviewed and defined.
- The future 2020 regional rail system including infrastructure, equipment, operations, and costs was defined.
- The preliminary findings of the *Equipment Engineering Study* were incorporated.
- The results of the *Commuter Rail RAILSIM Calibration Report* were reviewed and incorporated into the system analysis.
- Operational requirements of both the four-track and two-track Build alternatives were developed.
- Activities were coordinated with Amtrak to ensure full compatibility of operations with the Northeast Corridor High Speed Rail project.
- Initial findings were developed for review.



Operational Analysis Process Figure 1.2-1

1.3 Study Assumptions

Based on the review of existing MBTA equipment and operations as documented in the *Equipment Engineering Study* and the *Commuter Rail RAILSIM Simulation Report* and the basic definition of the post-rail link regional rail system under the Build Alternative, a number of assumptions were developed to guide the operations evaluation tasks. These assumptions are:

- The 25KV Northeast Corridor electrification system will be extended through the rail link tunnel to a point of termination in Woburn at the proposed regional transportation center (RTC).
- The recommended motive power for Rail Link operations will be the high-voltage, overhead catenary pick-up, dual-mode locomotive as identified in the *Equipment Engineering Study*.
- The major commuter rail equipment maintenance facility will continue to be located at the Boston Engine Terminal.
- A second, smaller equipment maintenance facility will continue to be provided on the South Side system.
- To the extent possible, non-revenue movements of equipment from the tunnel for maintenance or storage will continue in the original direction of the revenue train movement. Reversing of train direction in the tunnel will not be considered as part of normal, daily operations. Southbound (westbound) trains going out of service for maintenance will continue south (west) to a service facility. Northbound (eastbound) trains will continue north (east) out of the tunnel to BET for servicing.
- Track changes in the tunnel will be kept to a single-track change wherever possible.
- Future No-Build service levels are based on schedules developed by the MBTA for the North Side and South Side systems. These schedules are based on existing average train lengths of five coaches for North Side and seven coaches for South Side services. It has been assumed, however, that passenger coaches will be predominately bi-levels.
- No-Build train consists were assumed to follow the existing practices of restrictions, at least one single-level coach per consist with restroom facilities.
- Future No-Build and Build rail service will continue to be provided by locomotive hauled trainsets.
- Northeast Corridor High Speed Rail Service will continue to operate from surface tracks at South Station.
- All programmed Northeast Corridor High Speed Rail improvements will be completed by 2020.
- For planning purposes it was assumed that the completed Northeast Corridor infrastructure can support up to 52 intercity trains a day (26 in each direction) between Boston and New York in 2020.

- The number of Northeast Corridor intercity daily trains will be:
  - Four Track Build Alternative
    - For a 52-train schedule, up to 18 Northeast Corridor intercity trains a day (nine in each direction) will use the tunnel and travel north to the proposed Regional Transportation Center in Woburn. Of these 18 trains, 12 will be Northeast Direct trains and 6 will be High Speed trains.
    - For a 34-train schedule, up to 12 Northeast Corridor intercity trains a day (6 in each direction) will use the tunnel and travel north to the proposed Regional Transportation Center in Woburn. Of these 12 trains, 6 will be Northeast Direct trains and 6 will be High Speed trains.
  - Two-Track Build Alternative
    - For both the 52- and 34-train schedule, up to 8 Northeast Corridor intercity trains a day (four in each direction) will use the tunnel and travel north to the proposed Regional Transportation Center in Woburn. Of these 8 trains, 4 will be Northeast Direct trains and 4 will be High Speed trains.
- Future Boston/Portland intercity service includes eight trains a day (four in each direction) which were assumed to originate/terminate at the surface tracks at North Station. Portland travelers traveling south of Boston will transfer at Woburn (RTC) to continue along the Northeast Corridor. Other options for service between Portland and points south of Boston have not been precluded in this study.
- Connections to the proposed Urban Ring transit system were assumed at Ruggles Station on the NEC, Yawkey Station on the Worcester Line, Community College on the Haverhill and Rockport/ Ipswich lines, and the BET for the Fitchburg and Lowell lines. This was based on the alignment option described in the Program for Mass Transit[1] and was included for the ridership sensitivity analysis.

1 Commuting in a New Century, The New Program for Mass Transportation, Executive Office of Transportation and Construction , Commonwealth of Massachusetts, March 1994.

1.3.1 Build Scenario Motive Power

In the *Equipment Engineering Study* (Technical Report No. 6), a full range of motive power options were explored for use on the regional rail system created by the linking of North and South Stations. The findings presented in Technical Report No. 6 identified the development of a high voltage, overhead catenary pick-up, dual-mode locomotive to meet the future Build system needs. As documented in Technical Report No.6, the high voltage overhead catenary pick-up applications will be a new development. A full research and development program will need to be undertaken to fully test and develop the proposed unit. While all the proposed technological advances cited in the Technical Report No. 6 such as lighter carbody materials, AC traction, and radial steering trucks currently exist and have established successful service records, they have not been combined into the dual mode unit recommended as the future motive power choice. These components have also not been substantially tested under the daily demands of a commuter rail service or the operating conditions that the rail link tunnel will present.

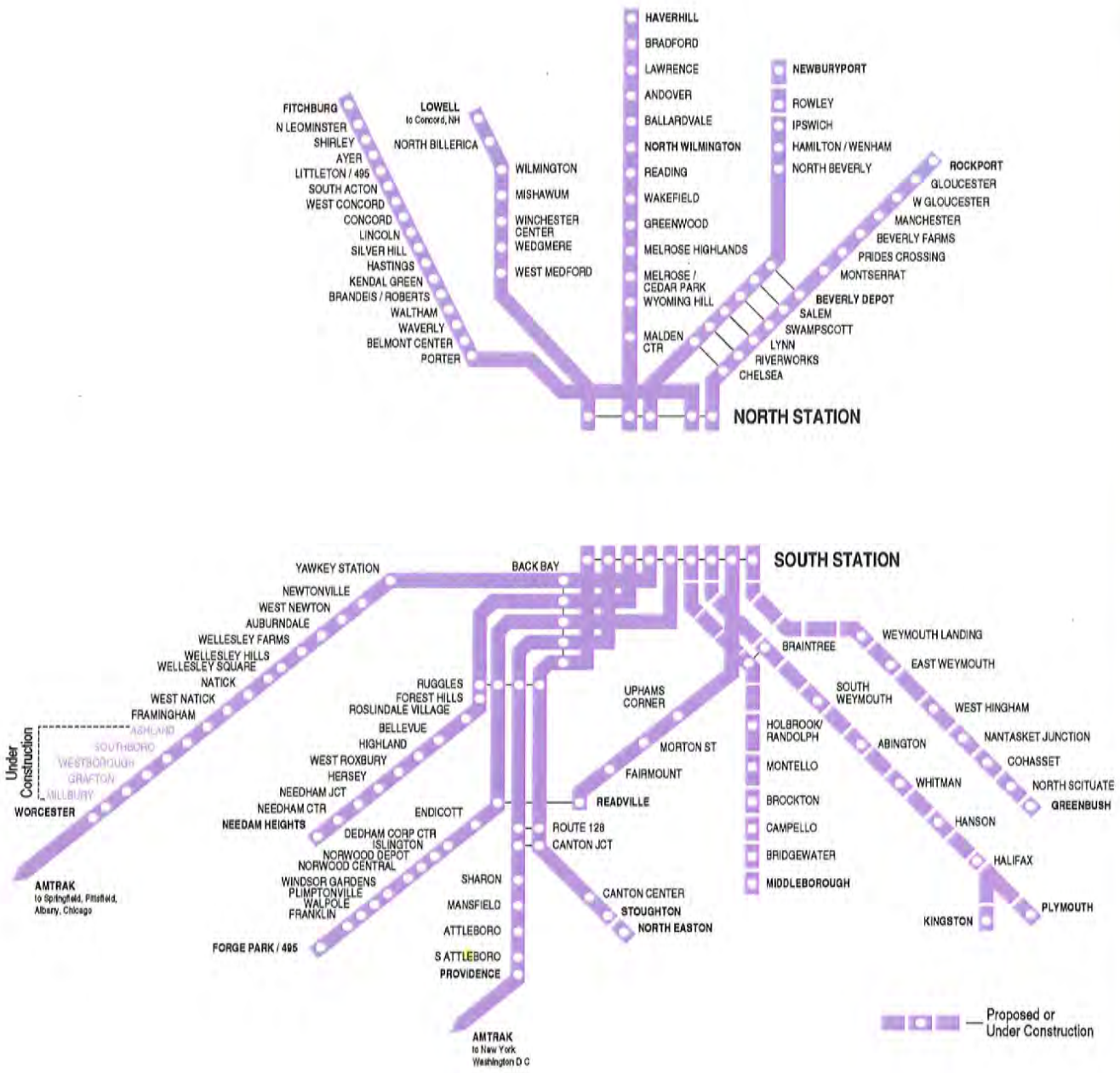
Existing Commuter Rail System Characteristics

2

The *Equipment Engineering Study* and the *Commuter Rail RAILSIM Simulation Report* provided a detailed description of the existing MBTA commuter rail system. The existing service, equipment fleet, and operations plan were described in the *Equipment Engineering Study*. The *Commuter Rail RAILSIM Simulation Report* addressed the existing track and signal systems. The information presented in these two technical studies has been summarized in this document in the following sections to set the framework for the operational analysis.

2.1 Infrastructure

The MBTA operates a 244-route-mile regional rail system in the Boston metropolitan area over eleven lines serving 101 stations. The existing system consists of two separate regional rail systems—a six-route southern system which terminates at South Station in Boston and a five-route northern system which terminates at North Station. Figure 2.1-1 illustrates the system. Regional rail service is operated southward (westward) from South Station to Worcester, Needham Heights, Forge Park, Readville, Stoughton, and Providence and northward (eastward) from North Station to terminals at Fitchburg, Lowell, Haverhill, Ipswich, and Rockport. Full-length, high-level platforms are located only at Lynn, Malden Center, Porter Square, and North Station on the North Side system, and South Station, Back Bay (Northeast Corridor tracks only), Ruggles, Forest Hills, and Providence on the South Side system. Short high-level platforms for wheelchair access are provided at 35 stations. A brief description of each line is provided in the following sections.



Source: Base Plan from Central Transportation Planning Staff.

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Existing MBTA Commuter Rail System Figure 2.1-1

2.1.1 South Side Lines

2.1.1.1 Providence Line

MBTA commuter rail service is provided along the Northeast Corridor (NEC) for 43.6 miles from South Station to Providence, Rhode Island. Within Massachusetts, the MBTA owns the right-of-way and track. Amtrak owns the NEC within Rhode Island. There are three tracks on the line from South Station to Transfer Interlocking (a distance of 10.2 miles). The remainder of the line is double track with universal interlocked crossovers at periodic intervals. Several lines also diverge from the Northeast Corridor. The interlockings along the NEC include:

- Cove Interlocking, located 0.7 miles from South Station, recently was upgraded to provide full universal interlocked crossovers at this location.
- Plains and Forest Interlockings combine to create a universal interlocked crossover. At Plains Interlocking, located 4.4 miles from South Station, the Needham Line diverges from the NEC.
- Read Interlocking, located 9.1 miles from South Station, is the point of divergence from the NEC for the Franklin Line.
- Transfer Interlocking and Read Interlocking combine to create a universal series of crossovers. At Transfer Interlocking, located 10.2 miles from South Station, the triple-track NEC segment ends. A single-track connection from the inbound main to the Dorchester Branch (Hill Interlocking) is also provided.
- Canton Junction, located 14.8 miles from South Station, has a universal interlocked crossover and is the point of divergence for the Stoughton Branch. Another universal interlocked crossover is located at Mansfield Interlocking, 24.6 miles from South Station.
- A main line siding connected at each end to the inbound main exists between Holden Interlocking (30.7 miles) and Hebronville Interlocking (34.9 miles). Between these two locations are Boro Interlocking (31.5 miles) and Thatcher Interlocking (31.9 miles), which combine to provide for universal interlocked crossovers between the two main tracks and the siding. Attleboro Siding, Track 4, serves as the inbound station platform track. In addition, East Junction Yard, the outlying overnight coachyard for the Providence Line, is accessed from the siding. The present capital program of the Amtrak Northeast Corridor High Speed Rail Improvement project will add another main line siding (Track 3) along the westbound main (Track 1) at Attleboro Station. The siding will serve as the outbound station track.
- Lawn Interlocking, located 40.1 miles from South Station, and Orms Interlocking (43.1 miles) are the other two universal sets of crossovers. Orms Interlocking is also the point where the two Providence Station platform tracks diverge. At Providence Station, the platform between the two main tracks is used for Amtrak intercity through trains, while the platform between the two station tracks is for MBTA trains.

Passenger stations on the Providence Line and their mileage from South Station are:

- Back Bay 1.1 miles
- Ruggles Street 2.2 miles
- Hyde Park 8.4 miles
- Route 128 11.4 miles
- Canton Junction 14.8 miles
- Sharon 17.9 miles
- Mansfield 24.7 miles
- Attleboro 31.8 miles
- South Attleboro 36.8 miles
- Providence 43.6 miles

2.1.1.2 Stoughton Line

The Stoughton Line diverges from the Northeast Corridor at Canton Junction, 14.8 miles from South Station. The single-track branch is 4.6 miles long (including the tail tracks beyond Stoughton Station), and is protected by a dispatcher-controlled interlocking. Canton Center (15.4 miles from South Station) and Stoughton (18.7 miles from South Station) are the two passenger stations on the branch.

2.1.1.3 Fairmount Line

Fairmount Line service is operated along the Dorchester Branch, a 9.7-mile double-track system. From the Tower 1 Interlocking at South Station, the line extends south to Broadway Interlocking (0.4 miles), where a wye connection from the Northeast Corridor and Worcester Lines connects to the outbound track. South Bay Interlocking (1.2 miles from South Station) has two sets of universal interlocked crossovers and protects the entrance and exit tracks to the Amtrak South Bay Yard and the MBTA Southampton Street Yard. An employee flag stop at this location is served by all revenue trains on the branch.

Dana Interlocking (8.7 miles from South Station) provides a single crossover between the two tracks. Inbound moves can be made from the inbound track to the outbound, and outbound movements can be made from the outbound track to the inbound. Hill Interlocking (9.1 miles) marks the end of double track and the immediate division of the single track into two single-track lines: 1) to the Northeast Corridor (Transfer Interlocking) and 2) to the Franklin Line (Sprague Street Interlocking). Both interlockings are located 9.7 miles from South Station as measured via the branch.

The passenger stations on the Fairmount Line and their mileage from South Station are:

- Uphams Corner 2.4 miles
- Morton Street 5.2 miles
- Fairmount 7.7 miles
- Readville 9.5 miles (located on the single-track connection to the Franklin Line)

2.1.1.4 Franklin Line

Franklin Line service operates over the Northeast Corridor from South Station to Readville (Read Interlocking) a distance of 9.1 miles. A few peak period trains operate via the Dorchester Branch. A single-track connection from the NEC (Read Interlocking) to the Franklin Branch (Sprague Street Interlocking) is provided. The single-track lines from the Northeast Corridor and Dorchester Branch merge at Sprague Street Interlocking into a short, single-track segment that then becomes double track. The double-track segment extends to Norwood Central Interlocking (14.8 miles from South Station) where single track begins again. A passing siding on the single-track segment exists between mile posts 19.1 and 19.8.

The passenger stations and their distance from South Station include:

- Readville 9.5 miles (located on the connection to the Northeast Corridor)
- Endicott 10.9 miles (the first station on the double track segment)
- Dedham 11.8 miles
- Islington 12.5 miles
- Norwood 14.3 miles
- Norwood Central 14.8 miles (the last station on double-track)
- Windsor Gardens 16.6 miles
- Plimptonville 17.7 miles
- Walpole 19.1 miles
- Norfolk 23.0 miles
- Franklin 27.5 miles
- Forge Park 30.5 miles

2.1.1.5 Framingham/Worcester Line

Service on the Worcester Line is operated over 44 miles of the Boston Line (former Boston-Albany main line). The Boston Line departs from the Northeast Corridor at Back Bay Station. From Back Bay Station to Weston (I-95/Route 128), the Massachusetts Turnpike Authority owns the right-of-way. The Weston to Framingham segment is owned by the MBTA. From Framingham to Worcester, Conrail owns the right-of-way.

The line is a mostly double-track alignment that is adjacent to, but separate from, the Northeast Corridor for the first 1.1 miles to Back Bay Station. Cove Interlocking (0.7 miles from South Station) has a single set of crossovers between the two tracks of this route, as well as to the three tracks of the Northeast Corridor. Adjacent to Beacon Park Yard in Brighton (approximately 3 miles from South Station) the line is single track. The interlocking at the east end of the yard is 3.1 miles from South Station, while the resumption of double track at the west end interlocking is 4.8 miles from South Station. Universal interlocked crossovers exist at Riverside (CP11, 11.4 miles) and Framingham (CP 21, 21.4 miles) from South Station. The line is single track the last 10 miles to Worcester. All train movements along the line are controlled by Conrail.

The passenger stations and their mileage from South Station include:

- Yawkey 2.5 miles (seasonal facility serving Fenway Park)
- Newtonville 8.1 miles
- West Newton 9.5 miles
- Auburndale 10.2 miles
- Wellesley Farms 12.5 miles
- Wellesley Hills 13.5 miles
- Wellesley Square 14.8 miles
- Natick 17.5 miles
- West Natick 19.9 miles
- Framingham 21.3 miles
- Worcester 44.0 miles

2.1.1.6 Needham Line

Needham Line service operates over the Northeast Corridor from South Station to Plains Interlocking (4.4 miles). The single-track Needham Branch diverges at that point and is parallel to the Northeast Corridor through Forest Hills Station. Dale Siding diverges from the NEC Line at Forest Interlocking (the 5.2-mile point), where the two tracks of the Needham Line then turn away from the corridor. The siding converges into the main track at the 6.0-mile point. Other sidings, Roxbury Siding at the 8.4-mile point and the Needham Siding at the 11.6 mile point, exist along the single-track segment.

Passenger stations and their mileage from South Station include:

- Forest Hills 5.0 miles
- Roslindale Village 6.4 miles
- Bellevue 7.2 miles
- Highland 7.6 miles
- West Roxbury 8.0 miles

- Hersey 10.9 miles
- Needham Junction 12.0 miles
- Needham Center 12.7 miles
- Needham Heights 13.6 miles

2.1.2 North Side Lines

2.1.2.1 Haverhill Line

Service on the Haverhill Line operates over the West Route Main Line (WRML) for a distance of 32.9 miles from North Station to downtown Haverhill. It shares trackage with the Rockport/Ipswich Line from the North Station terminal to Reading Junction, a distance of 1.8 miles. At Reading Junction, the line diverges onto a single-track alignment. A passing siding is located at Foley Street at Sullivan Station (MP 2.0 to 2.2) in Somerville. The single-track alignment continues to Fells Interlocking (3.9 miles) in Melrose. Located within the WRML right-of-way along this segment is the MBTA's Orange Line rapid transit service. From Fells Interlocking, the line is double track to Ash Street in Reading (7.8 miles). A 13.9-mile single-track segment extends northerly to Andover Street interlocking in Lawrence. Along the single-track segment is Wilmington Junction (MP 17.8), where the Wildcat Branch connects to the Haverhill Line. The Wildcat Branch is a 3-mile long single-track connection to the Lowell Line and is used by the MBTA for reverse peak equipment position movements. From Andover Station Interlocking to Haverhill Station, the line is double track (7.3 miles).

The 13 stations located along the Haverhill Line and their distances from North Station are:

- Malden Center 4.3 miles
- Wyoming Hill 6.2 miles
- Melrose/Cedar Park 6.8 miles
- Melrose Highlands 7.5 miles
- Greenwood 8.5 miles
- Wakefield 9.9 miles
- Reading 11.9 miles
- North Wilmington 16.4 miles
- Ballardvale 20.5 miles
- Andover 22.9 miles
- Lawrence 26.2 miles
- Bradford 32.5 miles
- Haverhill 32.9 miles

2.1.2.2 Lowell Line

Service on the Lowell Line extends from North Station to downtown Lowell along the New Hampshire Main Line (NHML), a distance of 25.5 miles. From the Tower A terminal throat at North Station, the route immediately diverges onto its own alignment. Some trains serve Boston Engine Terminal (BET) employees at the flag stop in the Tower A plant, while other trains serve the employee flag stop at Mystic Junction (1.9 mile).

The NHML is double track throughout and has universal interlocked crossovers located on Somerville Junction (3.2 miles), Winchester Interlocking (7.8 miles), Mishawum (11.9 miles), Wilmington Interlocking (15.2 miles), Shop (20.3 miles), and Bleachery (24.7 miles). Wilmington Interlocking is also the point where the Wildcat Branch diverges from the NHML.

There are eight stations located along the line. Their location and mileage distance from North Station are:

- West Medford 5.5 miles
- Wedgemere 7.3 miles
- Winchester 7.8 miles
- Lechmere flag stop 11.0 miles
- Mishawum 11.6 miles
- Wilmington 15.2 miles
- North Billerica 21.8 miles
- Lowell 25.5 miles

2.1.2.3 Fitchburg Line

Service on the Fitchburg Main Line is provided from North Station to Fitchburg, a distance of 49.6 miles. The route shares trackage with the NHML through the Tower A interlocking plant at North Station. At Tower A, the line diverges to the northwest through Porter Square in Cambridge. The line is double track from Tower A to Newton Street (9.5 miles) in Waltham. After a short 0.4-mile stretch of single track, double track resumes to South Acton (25.3 miles). An 8.4-mile stretch of single track becomes double track again in Ayer (MP 33.8) for the last 15.9 miles to Fitchburg.

There are 17 stations located along the line. Their location and distance from North Station are:

- Porter Square 3.4 miles
- Belmont 6.4 miles
- Waverley 7.4 miles
- Waltham 9.9 miles
- Brandeis/Roberts 11.6 miles
- Kendal Green 13.3 miles

- Hastings 13.8 miles
- Lincoln 16.7 miles
- Concord 20.1 miles
- West Concord 21.9 miles
- South Acton 25.2 miles
- Littleton/I-495 30.2 miles
- Ayer 36.1 miles
- Shirley 39.2 miles
- North Leominster 45.3 miles
- Fitchburg 49.5 miles

Universal interlocked crossovers are located at Swift (1.4 miles), West Cambridge (3.4 miles), Ayer (Willows) (35.8 miles), and Fitchburg (48.1 miles). Two single crossovers exist at Hill Crossing (5.5 miles) and Clematis Brook (8.3 miles). Universal crossovers are located at Concord but they are not interlocked.

2.1.2.4 Rockport and Ipswich Line

The Rockport/Ipswich Line operates over shared trackage with the Haverhill Line from North Station to Reading Junction (1.8 miles). At Reading Junction, the Eastern Route Main Line (ERML) diverges to the east through Chelsea. There are two main line tracks from Reading Junction to Beverly Junction (17 miles) except for the 0.8-mile single-track segment through the Salem Tunnel. There are five universal interlocked crossovers on this segment located at FX (1.4 miles), Everett Junction (2.8 miles), Wonderland (7.0 miles), Brickyard (10.8 miles) and Castle Hill (15.1 miles). There are six stations located along this segment of the line. Their location and mileage from North Station are:

- Chelsea 4.6 miles
- River Works 9.8 miles
- Lynn 11.6 miles
- Swampscott 12.7 miles
- Salem 16.7 miles
- Beverly Depot 18.3 miles

At Beverly Junction, the line splits to service Ipswich to the north and Rockport to the east. Service on the Ipswich Line continues to operate over the ERML. Two main line tracks continue from Beverly Junction to North Beverly (2.6 miles). The rest of the line is single track to Ipswich Station (6.2 miles). There are three stations located north of Beverly Junction. Their location and distance from North Station are:

- North Beverly 20.9 miles
- Hamilton/Wenham 22.8 miles
- Ipswich 27.5 miles

The Gloucester Branch runs from Beverly Junction east to Rockport. Of the 16.7 mile route, all but the last four miles between Gloucester (CP Wilson) and Rockport are double track. There are seven stations located on the branch. Their location and distance from North Station are:

- Montserrat 19.8 miles
- Prides Crossing 22.2 miles
- Beverly Farms 23 miles
- Manchester 25.4 miles
- West Gloucester 29.7 miles
- Gloucester 31.7 miles
- Rockport 35.3 miles

2.2 Operations

2.2.1 Layover Facilities

Layover facilities are located at or near the ends of several lines, as presented in Table 2.2-1. These facilities are used primarily for the overnight storage of commuter rail trains. In addition, while these trains are being stored, maintenance personnel have in the past been assigned to perform light cleaning, inspection, and testing of equipment assuring readiness for morning operations.

Table 2.2-1 **Layover Facilities**

Line	Location	Storage Capacity (Number of Trains)	Tracks
North Side Service			
Rockport Line (Gloucester Branch)	Rockport	4	4
Ipswich Line (ERML)	Ipswich	4	2
Haverhill Line (WRML)	Bradford	4	2
Fitchburg Line (FML)	Fitchburg	4	3
South Side Service			
Worcester/Framingham Line (B&A)	Worcester	4	4
Franklin Line	Franklin	4	2
Providence Line (NEC)	Attleboro	4	3
Closed Facilities			
Lowell Line (NHML)	Lowell	4	2
Needham Line	Needham	4	3

2.2.2 Ridership and Service

The MBTA formally assumed operating control of the commuter rail service on the North Side lines in December 1976 and the South Side lines in March 1977. At the time the MBTA assumed this responsibility, ridership was suffering because of old equipment, unreliable service, and two decades of disinvestment in the physical plant. In 1978, the MBTA acquired its first new coaches as the beginning of a solution to the aging equipment issue. Also in 1978, the MBTA accepted delivery of the first new locomotives for the service since the mid-1950s. With these investments and the subsequent improvements in service, regional rail ridership started to increase. In fact, ridership has been growing steadily since late 1985.

Figure 2.2-1 summarizes systemwide ridership trends since the early 1970s. An MBTA train audit conducted in 1994 estimated the current ridership of the MBTA commuter system at about 45,750 inbound boardings a day (91,500 total trips), with approximately 17,275 on the northern system and 28,475 on the southern system. The 1995 ridership of the MBTA commuter system was estimated at approximately 93,400 total daily trips. Figure 2.2-2 illustrates the 1994 daily boardings by line and station.

The existing ridership is carried on a total of 397 daily weekday trains (June 1996). A reduced service schedule is operated on weekends. Weekday service is provided on headways as short as 15 minutes during peak periods and up to two hours during off-peak periods. On some lines, express or skip-stop service is offered. Limited Saturday service is provided on all lines except for the Stoughton and Fairmount (Readville) lines. Sunday service is provided on all lines except for the Stoughton, Fairmount, and Needham lines.

2.2.2.1 Service Capacity Utilization

During the existing weekday peak periods (6:30 AM to 9:00 AM and 4:00 PM to 6:30 PM), the MBTA provides a total of 54 trains in the peak direction during the morning or evening peak period; 30 for South Side services and 24 for North Side services. Based on the current equipment assignments during these periods, a total of approximately 45,000 seats are available (30,000 on the South Side and 15,000 on the North Side) in the peak direction. The existing service capacity utilization was determined based on the number of seats available on each line and the corresponding ridership. The estimated existing service capacity utilization of the commuter rail service during the morning or evening peak period for the North Side system is approximately 75 percent and the South Side is between 65 and 70 percent. The detailed calculations by line are presented in Appendix A.1. These calculations reflect excess capacity available on "shoulder" peak period trains while not fully reflecting the capacity conditions that exist on the majority of peak period trains.

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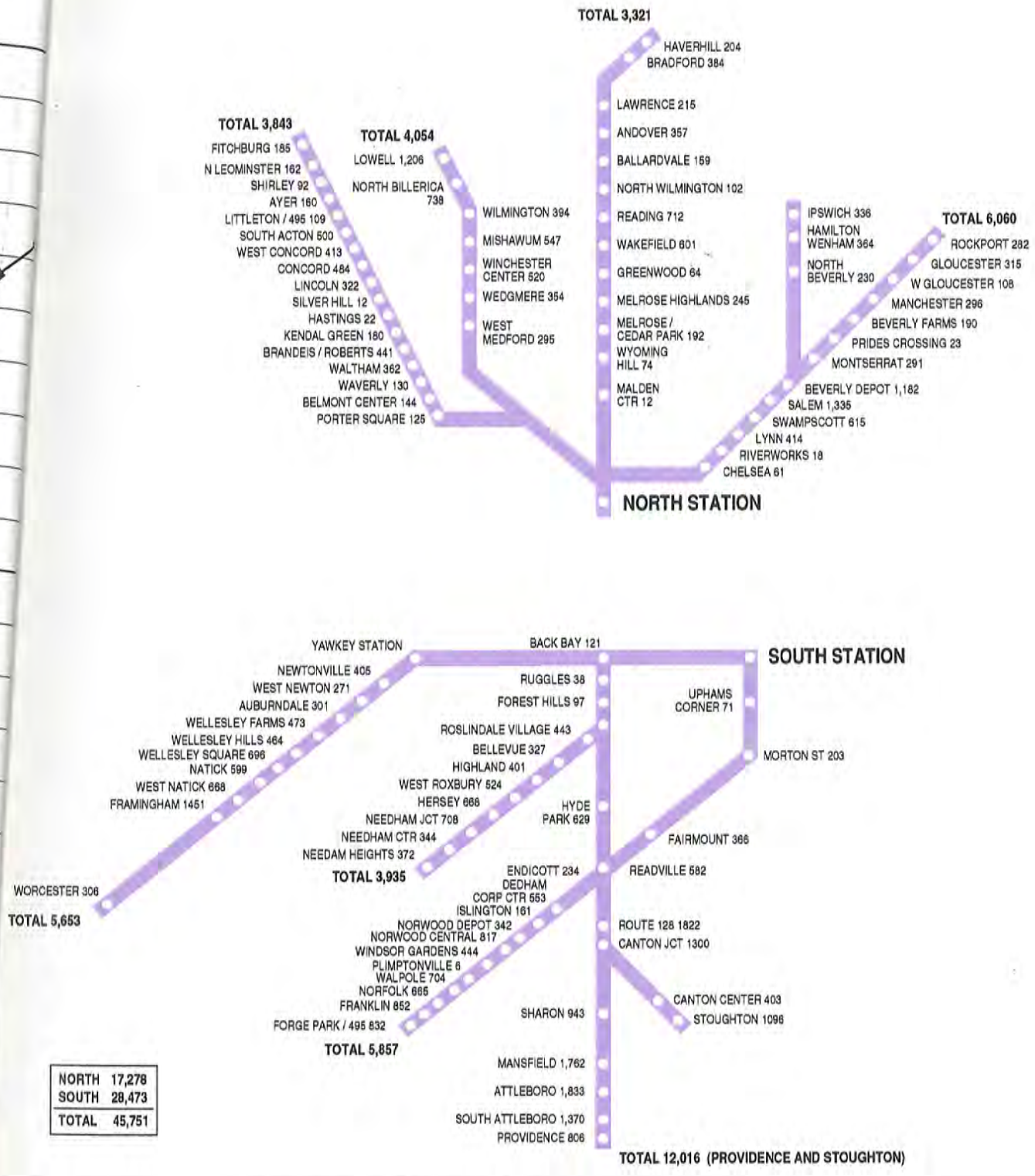
Systemwide Ridership Trends Figure 2.2-1



MBTA Commuter Rail
Daily Inbound Boardings (1994)

Figure 2.2-2

2.2.3 Equipment and Servicing

All existing commuter rail service is provided by locomotive-hauled coaches. The MBTA does not use any self-propelled equipment. Trains operate in the push/pull mode; a diesel-electric locomotive is on one end of the train and a control trailer (cab control) coach is located on the opposite end. Train lengths vary based on the demand, but the longest train at present is eight coaches. All lines except for the Gloucester Branch (Rockport Line), WRML (Haverhill Line) and the Fitchburg Main Line have sufficient platform length to accommodate nine-car trains. The train consist remains fixed throughout the day.

As of January 1, 1995 the MBTA owned 55 diesel-electric locomotives for revenue service. All the current locomotives used in revenue service are F40PH-2s, originally manufactured by General Motors Electro-Motive Division (EMD). The MBTA's passenger car fleet (as of January 1, 1995) includes a total of 358 coaches. This roster included 75 bi-level coaches and 283 single-level coaches. Of the 358 coaches, 230 are blind trailers (BTC) and 128 are control trailers (CTC) used for push/pull operations.

On a typical weekday, 45 locomotives and 255 coaches are assigned to daily service. The daily service equipment pool is divided into 45 trainsets (or consists), of which 21 sets are assigned to North Side service and 24 sets are assigned to South Side service. The 21 North Side service sets include 21 locomotives and 105 coaches while the 24 South Side service sets are comprised of 24 locomotives and 150 coaches. The current equipment cycles for both services are presented in Appendix A.1.3.

In the current operational configuration, each equipment set has a daily service "window" built into its schedule. These servicing windows, which include an opportunity to inspect the train, make minor or "running" repairs, and clean the coaches, generally run from 2½ to 5 hours. The majority of the trainsets are scheduled to undergo this servicing as early in the day as possible; in some cases, prior to 8:00 AM.

All major repairs and mandatory 91-day inspections are handled at the Boston Engine Terminal (BET) in Somerville. Daily cleaning and running repairs are accommodated at BET for North Side trains and at the Southampton Street Yard for South Side trains. It should be noted that the MBTA's lease for the Southampton Street Yard expires in 1999. The South Side maintenance facility may have to be relocated.

North Side trains must turn back from North Station to be serviced at BET. Similarly, South Side trains must turn back from South Station to the Southampton Street maintenance facility. In both cases, this "turnback" move must be accomplished while heavily loaded peak period trains are still arriving at the terminals, thus creating additional congestion within the terminal area.

2.2.4 Operational Constraints

The existing MBTA commuter rail system includes a number of constraints to be considered when developing service changes. These constraints include:

- the needs of the freight operator on the Boston Line (Framingham/ Worcester commuter rail line) and the limitations in the railway physical plant which include the single-track main line through the Beacon Park Yard, station platforms alongside only one of the main tracks at several locations, and infrequently spaced crossovers.
- stretches of single-track operation on the Stoughton, Needham, and Gloucester branches and the Fitchburg Main Line, Western Route Main Line, and Eastern Route Main Line.
- the mix of freight train and intercity passenger train activity also has to be considered on several lines.

2.3 Intercity Passenger Rail Services

Amtrak currently operates intercity rail service along the MBTA's Northeast Corridor. Intercity rail stations are located at South Station and Back Bay Station in Boston, Route 128 Station in Westwood, and at the Providence Station. Through service is offered to points along the Northeast Corridor in southern Connecticut, New York City, New Jersey, Pennsylvania, Delaware, Maryland, Washington D.C. and south. Connections to other Amtrak routes and regional rail systems are provided along the NEC.

From Boston, nine trains per day (April 1996) in each direction are scheduled to/from New York for a total of 18 trains. Travel time ranges between 4 hours 10 minutes to 4 hours 45 minutes between Boston and New York. Two trains a day (one in each direction) provide service between Boston and Chicago via Albany, New York. This service operates along the Boston Line. Station stops in Massachusetts along this route are located at Framingham, Worcester, Springfield, and Pittsfield.

2.4 Terminal Operations

The existing MBTA regional rail system terminates at two stub-end terminals in downtown Boston; South Station for the six South Side lines and North Station for the five North Side lines. Both terminals have a limited ability to handle additional trains during the weekday peak periods. There is no surface space presently available at either terminal to provide additional platform tracks. Therefore, the capacity of each terminal is determined by the efficient movement of trains. The following sections summarize the terminal capacity issues at both stations.

2.4.1 South Station

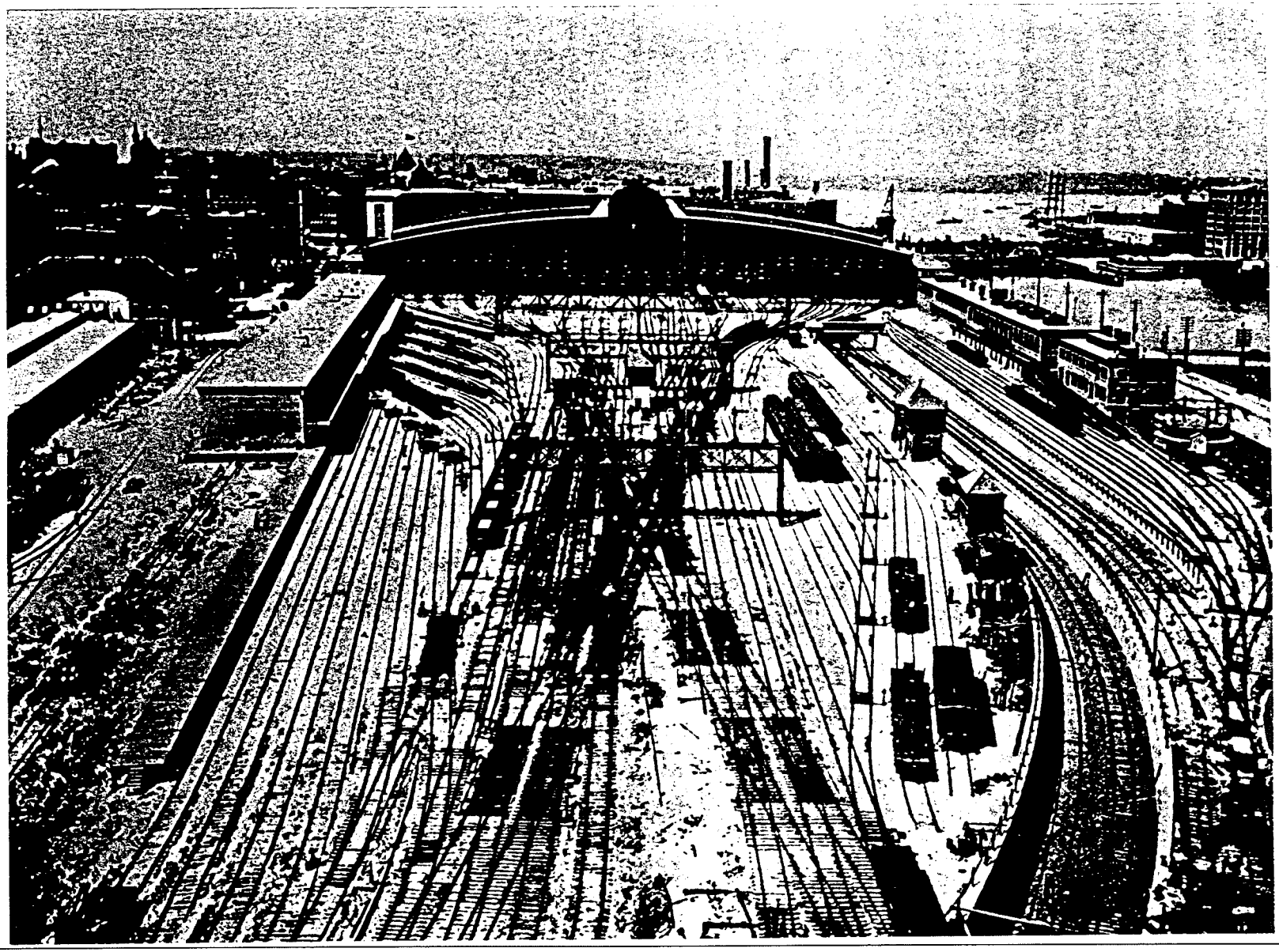
On December 30, 1898, the original South Union Station was dedicated and opened for operation. The new terminal was a result of the desire to consolidate four separate stations located on the South Side of the city into one terminal. The unified station contained 28 platform tracks which were capable of handling over 700 trains per day. Passenger activity peaked in 1945 when 46 million passengers (125,000 per day) used the facility. By the mid-1960s, the number of platform tracks had been reduced to 10 with the sale of a major portion of the terminal to the United States Postal Service. Figure 2.4-1 and 2.4-2 illustrate the original layout of South Station.

In 1984, work began on a six-year project to completely rebuild the terminal into the new South Station Transportation Center (SSTC). The program involved the rebuilding of the headhouse, reconstruction of 11 station tracks with high level platforms, and construction of a 630-space parking garage and bus terminal over the tracks.[2] Two additional platform tracks were completed in early 1996. Today, South Station contains 13 platform tracks as shown in Figure 2.4-3. Four of the platform tracks can accommodate up to thirteen coaches and two locomotives, two can hold ten coaches and two locomotives, two can serve nine coaches and one locomotive, three can accommodate eight coaches and one locomotive, one can hold seven coaches and one locomotive, and one can serve five coaches and one locomotive.[3] The lengths of each platform at South Station can be found in Appendix A.

While it is difficult to precisely quantify South Station Terminal capacity without completing a full terminal simulation, generally seven of the nine full-length tracks plus three shorter tracks are available to the MBTA. For purposes of estimating terminal capacity, it is assumed that the seven full-length tracks can handle six trains and the three shorter tracks can handle four trains each during the 2½-hour peak period (150 minutes). This assumption is based on a 25-minute time frame to platform, unload, and load a train and clear the platform track. Thirty percent of the South Side consists (7 of 24) cannot use the shorter platforms due to train length, so utilization is reduced by 30 percent. Therefore, South Station has an effective peak period capacity of 54 trains. While it can be argued at what point a terminal such as South Station reaches the saturation point, a utilization factor in excess of 80 percent certainly diminishes recovery capability in the event of delay and/or service disruption. This can create an operating scenario where normal daily operations will require capacity in excess of the existing physical plant. Therefore 80 percent of the capacity of 54 trains is equivalent to 44 trains. The current peak period services approximately 30 trains at South Station. South Station therefore is currently at 55 percent of total capacity (54), or 68 percent of the desirable capacity.

2 Nelligan, Tom: Boston South Station Revival, Trains, June 1989, pp38-42.

3 Operating Analysis Volume VI: Old Colony Service Impacts, Signal and Track Relocation CA/T South Station - D010A, Thomas K. Dyer, Inc., March 31, 1993



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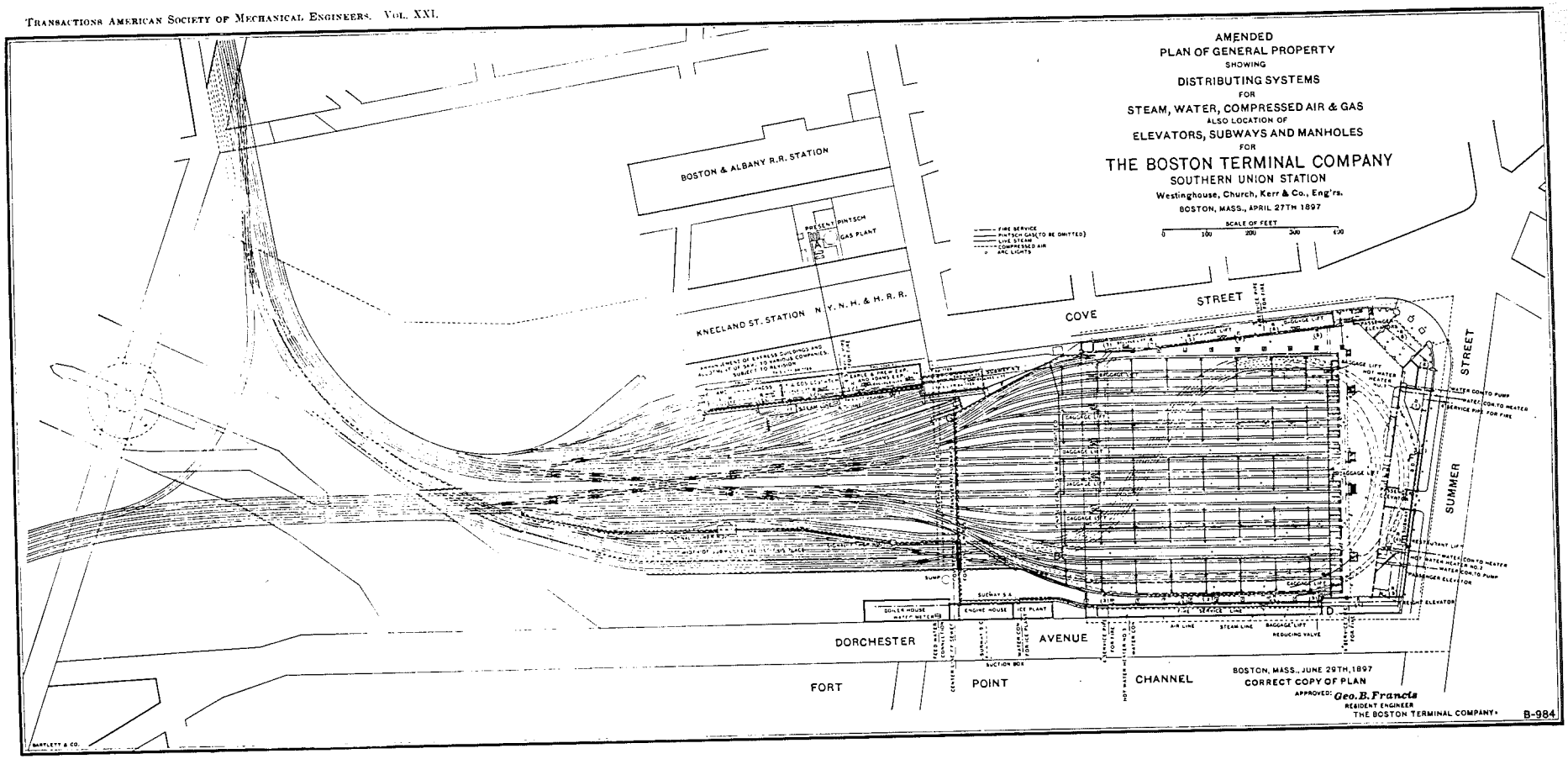
PROJECT

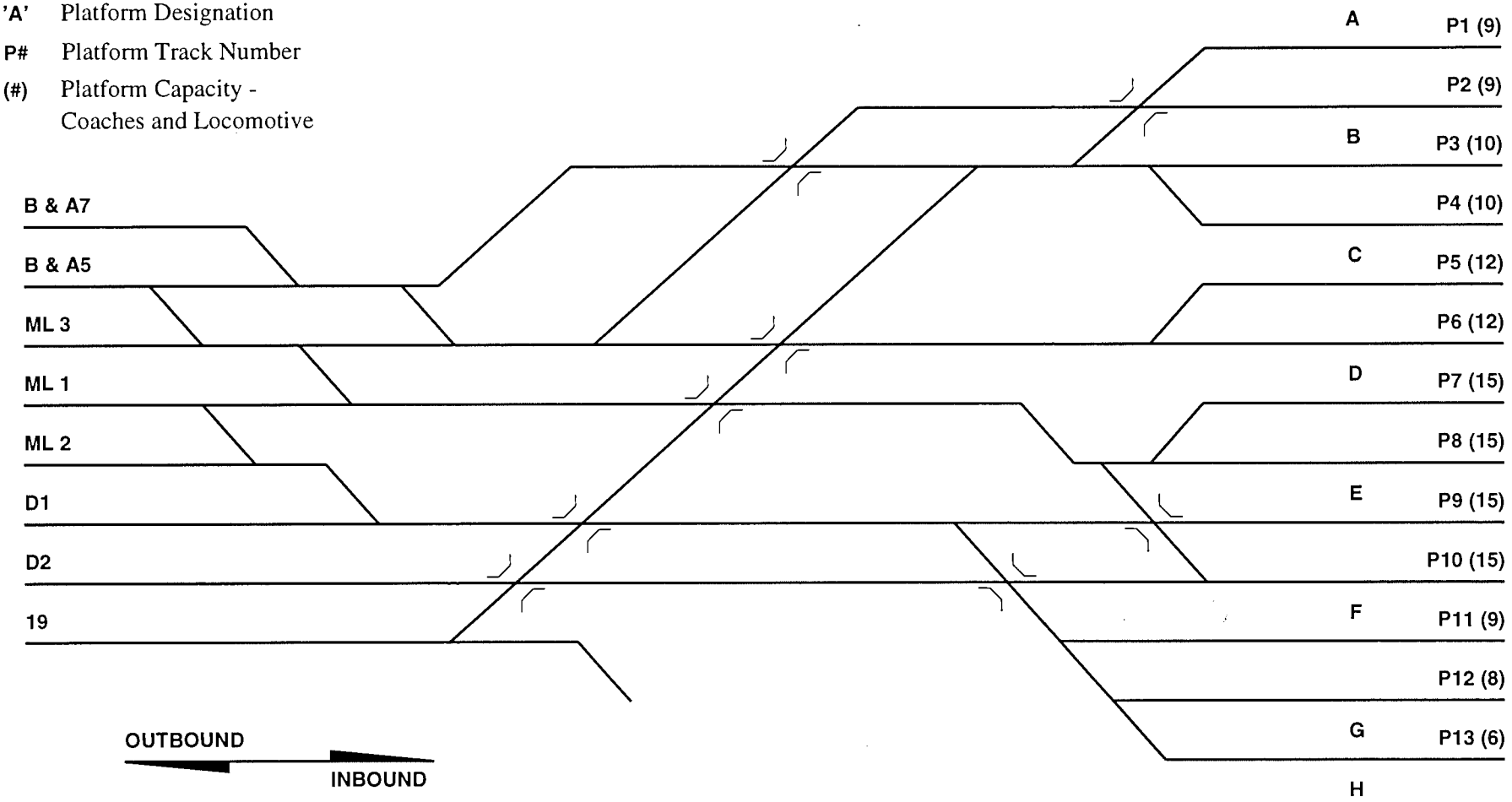
South Station, 1899

Figure 2.4-1



Original South Station Track Plan Figure 2.4-2

B & A	Boston & Albany (Boston Line)
ML	Main Line (Northeast Corridor)
D1, D2	Dorchester Branch
19	Running Track
'A'	Platform Designation
P#	Platform Track Number
(#)	Platform Capacity - Coaches and Locomotive



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Existing South Station Track Layout and Platform Capacity (1995)

Figure 2.4-3

Source: Thomas K. Dyer, Inc.

Based on current ridership and operating information, South Side service ridership is more than 50 percent higher than North Side service ridership on a typical weekday (56,515 compared to 36,725). In addition, South Side service provides over 18 percent more daily trains (215 as compared to 182 for the North Side service). Despite the greater service demands of the South Side service, South Station has only 11 platform tracks generally available for peak period service, as compared to 10 available tracks at North Station. Two of the South Station tracks are primarily used for the 18 intercity trains which operate into and out of South Station each day and are not available for commuter rail service. This effectively provides the MBTA with seven nine-car platform tracks and four shorter platforms under existing operating conditions at South Station.

2.4.2 North Station

Construction of the first North Side station (Union Station) was completed in 1889. Near the turn of the century, it was the largest railroad station in the United States, serving about 500 trains a day. By the early 1920s, however, the facilities operated by the Boston & Maine Railroad were inadequate to serve the large daily passenger load. Plans were developed to enlarge the train station and construct a sports arena. On November 14, 1928, the new North Station and Boston Garden sports arena were formally opened. The new North Station was designed to accommodate approximately 80,000 passengers per day. A total of 24 platform tracks were provided under the cover of the sports arena building which spanned the tracks. An aerial view of North Station in the 1930s is shown in Figure 2.4-4.

A number of changes have occurred at North Station since it opened in 1928. In the 1950s, a number of the train tracks were eliminated, the platforms were moved north toward the Charles River, and a parking lot was constructed in the area behind the North Station building. A covered walkway was constructed between the building and the platforms. Currently there is little remaining evidence of the original train waiting room fixtures and features.

The recent MBTA North Station Improvement Project, completed in conjunction with the construction of the new FleetCenter arena, includes a new public concourse and modern train facilities. Twelve station tracks are serviced by high level platforms which are connected to a modern passenger waiting area. At present, there are ten terminal tracks with platforms long enough to handle any train on the system during the service day. The longest train normally assigned to the North Side service is comprised of a locomotive and seven coaches, for a train length of approximately 660 feet. Figure 2.4-5 illustrates the existing North Station track layout.

Photograph Courtesy of Boston Public Library, Print Department

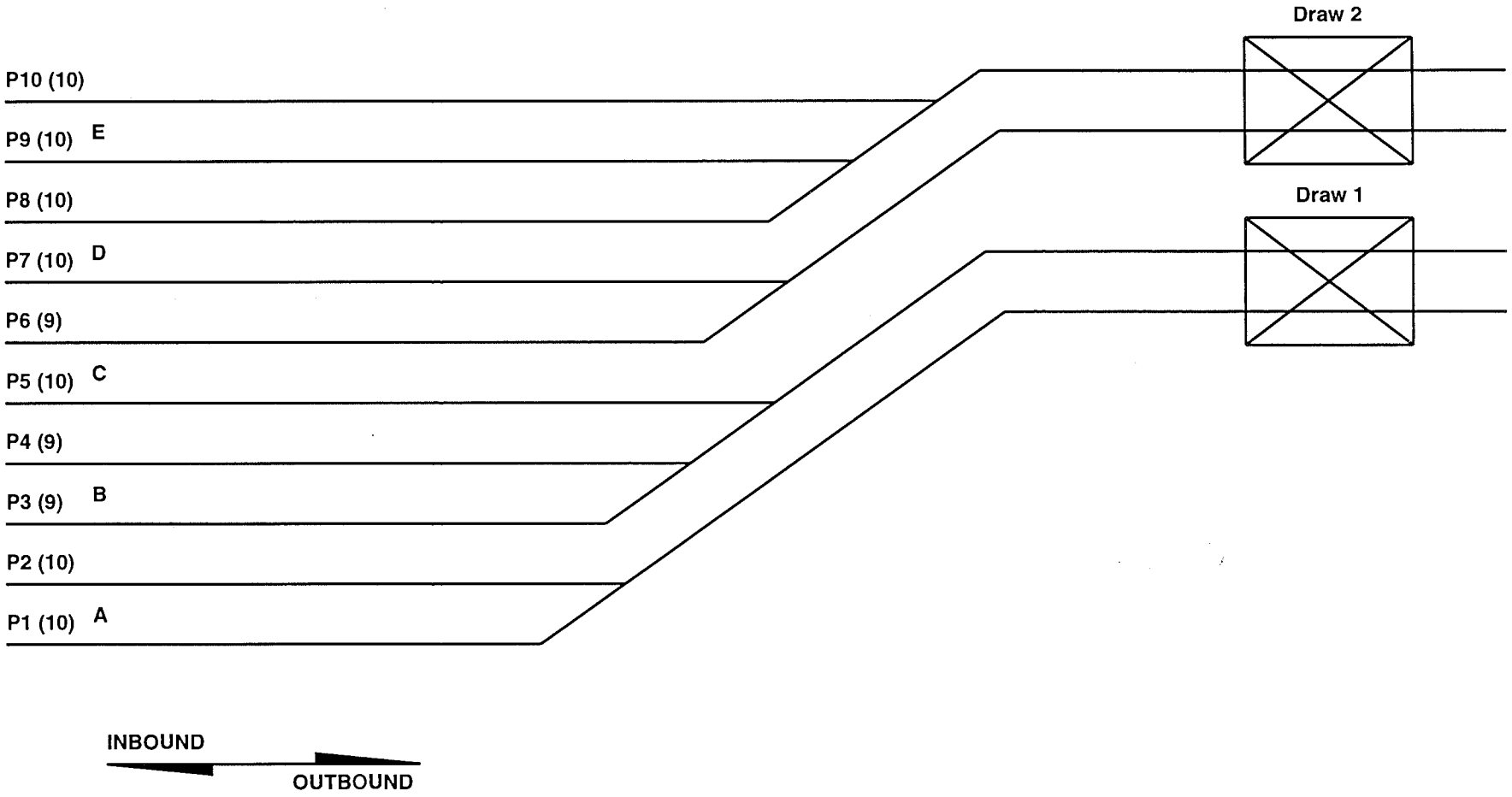
Aerial View of North Station (1930's) Looking South

Figure 2.4-4

P# Platform Track Number

(#) Platform Capacity
Coaches and Locomotive

'A' Platform Designation



NorthSouth**RailLink** PROJECT • *VHB/FRH, A JOINT VENTURE*

Existing North Station Track Layout and Platform Capacity (1995)

Figure 2.4-5

Sources: MBTA

Existing service during the peak period at North Station consists of approximately 24 inbound trains. During the morning peak period (6:30 AM to 9:00 AM), the 24 trains must be platformed and unloaded in a 2½-hour period. Allowing 25 minutes for this process for each train, the capacity of North Station is 60 trains during this period. Using the same 80 percent threshold as applied to South Station, this represents a maximum desirable capacity of 48 trains. North Station therefore is currently at 40 percent of total capacity (60 trains) or 50 percent of maximum desirable capacity.

Source: MBTA

2020 No-Build Alternative

3

The No-Build Alternative considers the continued operation of the existing MBTA commuter rail system with the implementation of programmed capital and operating improvements and planned service extensions scheduled to be completed by the 2020 design year. Under the No-Build scenario, commuter rail service on the South Side will continue to terminate at South Station. North Station will continue to serve as the terminus for North Side service.

This chapter of the *Operations Study* addresses operation of the No-Build scenario commuter rail service. The focus of the analysis is the core commuter rail network on both the South and North sides. A general summary of outlying system constraints is provided. These outlying constraints, however, will continue to exist with or without the implementation of a Build Alternative.

Sections 3.1 and 3.2 provide a summary of the planned service extensions and programmed plant improvements scheduled for implementation/completion by 2020. In Section 3.3, the ridership and operating plan are discussed. A discussion of potential terminal capacity issues at South and North stations is presented in Section 3.4. The final section, 3.5, presents the operating and capital (equipment) costs for the No-Build Alternative.

3.1 Planned Service Extensions

Extensive changes are planned for both commuter and intercity passenger rail services by the year 2010. The following sections summarize these planned service improvements and line extensions.

3.1.1 Commuter Rail Services

Of the major commuter rail services currently in operation in North America, none is undergoing such a dynamic period of sustained change as the MBTA service. Current plans call for extending the rail system as well as expanding and improving service on existing lines in the near

future. Limited service westward to Worcester opened in late 1994, and additional service to this western terminus is already being planned. Construction is in progress on a project that will restore commuter rail service to Middleborough, Plymouth, and Scituate southeast of Boston. Other extensions in active planning or construction include an extension of the Stoughton Line to North Easton, service to New Bedford and Fall River from South Station, and an extension to Newburyport on the North Side. These planned service extensions are illustrated in Figure 3.1-1 and summarized in the following sections. All of the service extensions discussed are included in the 2020 No-Build scenario.

3.1.1.1 Worcester Service

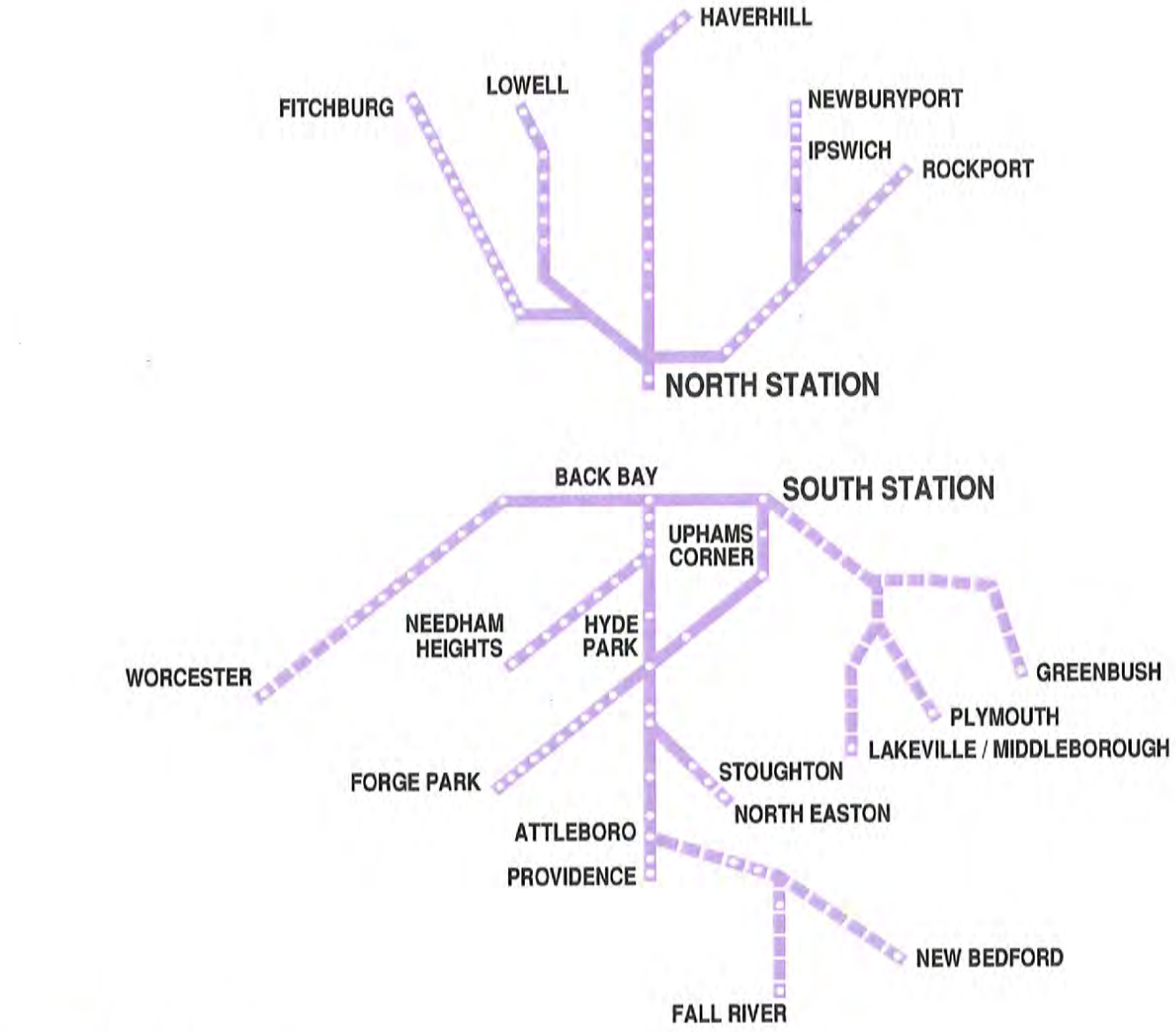
Limited express service to Worcester, consisting of six trains a day (three inbound during the morning peak period and three outbound during the evening peak period), began in September 1994. In December 1996, the service was expanded to 10 weekday trains and 6 weekend trains. This interim service plan provides for one inbound and two outbound express trains weekdays to/from Worcester, with stops only at Framingham and West Natick. Additional station stops between Worcester and Framingham are planned at Millbury, North Grafton, Westborough, Southborough, and Ashland. The full service plan provides for 20 total trains on a weekday (10 inbound and 10 outbound) servicing Worcester and the five additional stations.

3.1.1.2 Old Colony Lines

The Old Colony project will bring regional rail service to Lakeville/ Middleborough and Plymouth by late 1997. Service on a third line to Scituate (Greenbush) is being planned. Operating schedules for Old Colony service will be comparable to existing lines in the metropolitan Boston region. On each of the three branches, trains will run approximately every half hour during the peak hours and approximately every two hours during off-peak hours. The travel times will be under an hour from the outer terminals to South Station.

To restore service on the Old Colony system, all lines from Braintree to Middleborough, Plymouth, and Greenbush (Scituate), along with the Old Colony Main Line between South Station in Boston and Braintree will be reconstructed. New track, ties, ballast and signals, and 22 new stations will be constructed. Each of the three lines will also have its own layover facility. These facilities will each accommodate five trainsets at or near the end terminals, and are planned at Greenbush, Kingston and Middleborough.

Commuter rail equipment will consist of single and bi-level coaches powered by diesel locomotives in a push-pull configuration. Regional rail stations will be accessible to handicapped and elderly persons and would include parking, pick-up/drop-off areas, canopy-type shelters, landscaping and lighting.



Planned Service Extensions Figure 3.1-1

3.1.1.3 North Easton Service

A third South Side service improvement proposed by the MBTA is the three-mile extension of the Stoughton Line to North Easton. The 30 trains a day currently serving Stoughton would be extended to a new park-and-ride station to be constructed. The new station is proposed at the Stoughton/North Easton town line immediately west of Route 138.

3.1.1.4 New Bedford/Fall River Service

The MBTA proposes to provide commuter rail services to the southeastern Massachusetts communities located along existing rail lines to New Bedford and Fall River. Several routing options are being considered for the service including: 1) an extension of the Stoughton Line through Easton, Raynham, and Taunton; 2) an extension of the Middleborough Line; and 3) service along the Northeast Corridor to Attleboro where trains would access the Attleboro Secondary to Taunton. In East Taunton, the line would split with one line accessing Fall River and the other New Bedford. The first and second options would primarily involve the extension of existing trains. The third option, via the Northeast Corridor and the Attleboro Secondary, will require up to 30 additional trains a day to be scheduled. As of July 1997, no decision had been reached regarding the routing of this proposed service.

For analysis purposes for the North-South Rail Link Study, the MBTA has directed that the third alternative, via the NEC and Attleboro Secondary, be used. This alternative introduces the greatest number of additional trains into future operations. In this scenario, trains are planned to depart from Boston's South Station, with stops at Back Bay, Sharon, Mansfield, Taunton, East Taunton, and New Bedford on the New Bedford Line, and at Back Bay, Mansfield, Taunton, East Taunton, Freetown, and Fall River on the Fall River Line. Rail service to Fall River and New Bedford is anticipated to take 1 hour and 23 minutes and 1 hour and 21 minutes, respectively. At full service, the MBTA anticipates a maximum of 30 trains per day to each end point, with trains at approximately 30-minute intervals during the morning and evening commuter hours and at 2-hour intervals at off-peak times. Trains would travel at speeds up to 79 mph. Lower speeds are anticipated in congested areas and in the vicinity of stations.

3.1.1.5 Newburyport Service

The restoration of regional rail service between Ipswich and Newburyport along the Eastern Route Main Line will require the rehabilitation of existing track, roadbed and structures along an 8.7-mile segment of right-of-way. New station sites will be provided at Rowley and Newburyport with parking for approximately 230 and 760 cars, respectively. The existing train storage/layover facility at Ipswich will be relocated to a new facility immediately southeast of Route 1 and the Newburyport Station. The project also entails the replacement of the now-closed Route 1 railroad overpass in Newburyport.

When restored, this service will provide 24 daily trips between Newburyport and Boston, a distance of approximately 36 miles. Trip time from end point to end point is expected to be approximately 65 to 68 minutes. This service extension is scheduled to be implemented by the fall of 1998.

3.1.2 Intercity Passenger Rail Services

Travel on high speed trains between Boston and New York is expected to be available by 1999. To provide a three hour travel time along this segment of the NEC, the existing rail infrastructure is being upgraded and new, high speed trainsets are being procured. Amtrak's Northeast Corridor Electrification Project extends the overhead catenary system from its present terminus in New Haven, Connecticut to South Station in Boston, a distance of 157 miles. Other track improvements are also being constructed to reduce the overall travel time. In April 1996, the equipment procurement contract for the NEC high speed trains was awarded. By 2010, 34 trains a day (17 in each direction) are planned between Boston and New York, with the infrastructure to provide for 52 trains a day (26 in each direction).

In addition to the Northeast Corridor improvements, the State of Maine is preparing to provide intercity rail service between North Station and Portland, Maine. The initial level of service, which may begin in 1999, is six trains a day (three in each direction). By 2010 it is expected that eight trains a day (four round trips) will be operating between Boston and Portland.

3.2 Infrastructure

As a result of both the Northeast Corridor high speed rail service and planned commuter rail system service expansions, a number of changes in the existing commuter rail system infrastructure are anticipated by the 2020 horizon year. These programmed improvements are summarized below by commuter rail line and facility.

3.2.1 Northeast Corridor

By 2000 the following improvements are expected to be complete:

- A high density signal system between Cove and Canton Junction will be in operation.
- The Canton Junction station stop will be relocated to the Stoughton Branch. The existing low-level platforms will be maintained at Canton Junction on the NEC as auxiliary platforms.
- A double track 30 mph junction will be installed at Canton Junction to facilitate moves to/from the Stoughton Branch.

- The Track 3 passing siding will be re-installed at Attleboro Station.
- The Track 4 passing siding in Attleboro will be upgraded to a 79 mph operation including eastbound diverting moves from Track 2.
- High speed turnouts will be placed between the main line and passing sidings at Hebronville and Holden.
- MBTA will modify its cab signal capabilities to nine aspects.
- A new midday equipment storage yard is to be completed in Readville.
- Curves exceeding 1 degree 15 minutes will be adjusted for 100 mph operation.

By 2010, the following improvements are expected to be complete:

- Full length, high-level platforms capable of handling a nine-car train will be provided at all MBTA stations except Canton Junction.
- An inbound high-level platform to service Track 2 is programmed at Ruggles Station.
- The turnouts and crossovers at Read Interlocking (MP 220) will be upgraded to allow 45 mph diverging train movements.
- Track 3 will be extended from Transfer interlocking (MP 219) to one mile beyond the Route 128 Station.
- The Dorchester Branch Junction with NEC Track 2 at Transfer Interlocking will be upgraded.
- A passing siding is programmed for the inbound direction at Sharon Station. The Sharon passing siding will extend from approximately three miles west of the station to 500 feet east of the station and will be known as Track 4.
- The upgrade and relocation of the crossover turnouts at Mansfield interlocking will be complete (completed in 1997).
- The full crossovers located at Thatcher and Boro interlockings (MP 197) in Attleboro will be removed. The Holden (MP 199) interlocking will become the crossover for outbound trains, Hebronville (MP 193) for inbound trains.
- The turnout from East Junction Yard (MP 194.5) to Track 4 will be interlocked.
- A new remote overnight layover yard for storage of MBTA trains will be developed in Providence.
- MBTA will begin utilization of electric locomotives for NEC services.

3.2.2 The Boston Line (Worcester/Framingham Service)

By 2000, the following improvements are scheduled for completion:

- The eastbound main line track will be reconstructed between Worcester (MP 44) and Westborough (MP 33), restoring two-track operations along this segment of the Boston Line.

3.2.3 Stoughton Branch

By 2010, the following improvements are expected to be complete:

- A single track will be constructed, extending the Stoughton Branch from Stoughton Center (MP 18.9) to the North Easton town line (MP 22).

3.2.4 Dorchester Branch

The following improvements are scheduled for the Dorchester Branch by 2000:

- The signal system will be upgraded.
- Electrification will be extended from South Station to the South Bay Yard.

3.2.5 Eastern Route Main Line

By 2000, the following improvements are expected to be complete:

- A single track will be constructed, extending the Ipswich Line from Ipswich (MP 27.6) to Newburyport (MP 36.2).

3.2.6 South Station Terminal

By 2000, the following improvements are programmed for completion at South Station:

- Platform tracks 11, 12 and 13 are to be constructed (completed in 1996).
- All 13 platform tracks will be electrified.
- An inside ladder lead in the terminal plant will be built.
- Full crossover capabilities will be added at Cove interlocking (completed in 1996).
- Fort Point Channel Bridge will be upgraded for 15 mph simultaneous operation on three tracks.

By 2010, the following improvements are expected to be complete:

- The new permanent Fort Point Channel Bridge will be complete with four tracks by 2002.

3.2.7 Boston Engine Terminal

By 2000, the following programmed improvements are scheduled to be complete:

- The new equipment maintenance facility and midday storage yard will be in service.

3.3 Operations

This section of the report presents the projected service plans for the commuter rail system in the Boston area for the 2020 No-Build scenario. Included in the 2020 No-Build operating plans are the expected improvements and changes from the existing commuter rail system (1995) in methods of operations, physical improvements, and expansions.

3.3.1 Service Plans

The 2020 No-Build commuter rail service plans are based on scheduling efforts previously completed by the MBTA for 2020 and CTPS ridership projections. It has been assumed that the MBTA will maintain current equipment servicing practices. Daily running maintenance for the North Side fleet will continue to be performed at the Boston Engine Terminal and for the South Side fleet at a facility located in South Bay. All major maintenance and repairs for both fleets will continue to be performed at BET.

3.3.1.1 South Side Service

The *Ridership Methodology and Forecasting Study* (Technical Report No. 4) reports a total projected daily ridership for the MBTA commuter rail system for the 2020 No-Build scenario of 160,235 passengers which includes the North Side and South Side systems. Of this, 74,375 will be using existing South Side services (i.e., Worcester/Framingham, Needham, Franklin, Fairmount and Providence/Stoughton services) and 33,255 will be using new South Side services currently under development (i.e., Fall River/New Bedford and Old Colony Lines), for a total daily South Side ridership of 107,630.

While a 2020 draft schedule for the South Side services has not been fully developed by the MBTA, some preliminary work has been completed to address the level of additional service which can be anticipated to satisfy the projected growth in ridership. This effort, developed jointly by the MBTA and Amtrak (the present contract operator of the MBTA services) has examined the number of daily weekday trains that may need to be operated. This preliminary exercise suggests that service would increase to 399 daily trains provided by 56 trainsets. With a 10 percent spare ratio, the South Side fleet is projected to include 62 locomotives and 431 coaches. Following current practices,

approximately 75 percent of the coaches will be trailer cars and 25 percent control cars, which is equivalent to 323 trailer cars and 108 control cars.

The MBTA's most recent draft of a 2020 South Side service schedule is included in Appendix A-1. The 2020 No-Build South Side service plan is for each by line segment is provided in Table 3.3-1.

Table 3.3-1 **2020 No-Build South Side Daily Weekday Service**

Line	Miles from Boston	Projected Number of Daily Trains*	Projected Daily Train Miles
Fall River	60	30	1,800
New Bedford	60	30	1,800
Middleborough	36	24	864
Plymouth	36	24	864
Greenbush	28	24	672
North Easton	23	65	1,495
Providence	44	72	3,168
Worcester	44	20	880
Framingham	22	14	308
Forge Park	31	54	1,674
Needham	13	40	520
Projected Total Number of Daily Trains =		399	
Projected Total Number of Daily Train miles =			14,045

* Number of daily trains (originating/terminating) based on the projected year 2020 schedules presented in the Appendix A-1.

3.3.1.2 North Side Service

Forecasts for 2020 North Side service prepared by CTPS project that ridership will grow to 51,380 daily riders. Service is expected to increase to 264 daily trains provided by 31 trainsets to meet the increased demand. The anticipated fleet requirement is 34 locomotives and 171 coaches, including the 10 percent spare ratio. It is assumed that approximately 75 percent of the coaches will be trailer cars and 25 percent control cars, which is equivalent to 128 trailer cars and 43 control cars.

The MBTA's most recent draft of a 2020 North Side service schedule is included in Appendix A-2. The number of trains per line projected for future operations for the North Side service is presented in Table 3.3-2. The schedules presented in Appendix A-2 include the potential exten-

sions of existing service to Plaistow and Nashua, New Hampshire. Table 3.3-2 does not include these extensions in order to be consistent with the CTPS ridership model and operations simulation assumptions for the NSRL Study.

Table 3.3-2 **2020 No-Build North Side Daily Weekday Service**

Line	Miles From Boston	Projected Number of Daily Trains*	Projected Daily Train Miles
Beverly	18	16	288
Ipswich	28	2	56
Rockport	35	38	1,330
Newburyport	37	34	1,258
Reading	12	24	288
Haverhill	32	38	1,216
Mishawum (RTC)	12	8	96
Lowell	25	46	1,150
South Acton	25	24	600
Fitchburg	50	34	1,700
Projected Total Number of Daily Trains =		264	
Projected Total Number of Daily Train Miles =			7,982

* Number of daily trains (originating/terminating) based on the projected year 2020 schedules presented in Appendix A-2 without the Nashua and Plaistow extensions.

3.3.2 System Wide Scheduling Constraints

As the demand for commuter rail service grows, the lines that the MBTA shares with other operators will present increased scheduling conflicts. The ability to schedule additional regional rail service on the Boston Line (Worcester/Framingham service) is also contingent on meeting demands for increased freight and intercity passenger rail service. On the NEC, High Speed Rail service will introduce new scheduling constraints. The lines with single-track operation will continue to be limited in their ability to accommodate trains moving in opposite directions. In the future, these constraints and others will challenge the scheduling of additional service.

In the 2020 No-Build scenario, the most significant set of constraints will exist on the South Side. In addition to the constraints noted previously, new constraints introduced by the 2020 scenario include:

- long stretches of single track on the New Bedford/Fall River, Middleborough, Plymouth, Greenbush, and Newburyport lines.

- the single-track Old Colony main line segment between South Station and Braintree.

3.3.3 Service Capacity

The future No-Build service capacity utilization was determined based on the number of seats available on each line and the corresponding ridership. During future weekday peak periods the MBTA is expected to provide a total of 90 trains in the peak direction during the morning or evening peak period; 55 for South Side services and 35 for North Side services. The equipment assignments were based on the average current equipment assignments as follows: six bi-levels and one single-level for the South Side system and four bi-levels and one single-level coach for the North Side system during this period. Assuming 180 seats per bi-level coach and 114 for the single level, a total of approximately 95,000 seats are available (65,000 on the South Side and 30,000 on the North Side) during the morning or evening peak period, in the peak direction. The estimated future service capacity utilization of the commuter rail service during the morning or evening peak period for the South Side system is approximately 91 percent and the North Side system is approximately 82 percent. The detailed calculations by line are presented in Appendix A.1.

It should be noted that these calculations assume an equal proportional increase in ridership and trains by line. In reality, certain lines carry a heavier demand than others, necessitating additional trains during the peak periods. The ability of the MBTA to provide the appropriate number of trains to meet ridership demands is controlled by the line haul capacity of each individual branch and the terminal capacity at South Station and North Station. A systemwide simulation of peak period operations is required to address the line haul capacity issue. Likewise a simulation of peak period terminal operations is necessary to address to the ability of South Station and North Station to handle additional trains. Neither of these simulation exercises is part of the current North-South Rail Link Study efforts. The following section summarizes an estimation of future demands and capacities at the station terminals.

3.4 Terminal Capacity Issues

In Section 2.4 of this study, the existing terminal track layouts, platform lengths, and peak period capacities were discussed. The following sections consider the capital improvements programmed for implementation by 2020 as discussed in Section 3.2 and the planned service extensions discussed in Section 3.1. The impact of these improvements and service expansions is then considered in the evaluation of future 2020 No-Build terminal operations.

3.4.1 South Station

Three major improvements are programmed for the South Station terminal by 2010. They are: 1) the installation of an inside ladder track lead in the terminal plant; 2) a new four-track Fort Point Channel Bridge; and 3) electrification of all 13 platform tracks. The future 2020 No-Build track layout for South Station is illustrated in Figure 3.4-1.

As previously noted, the future will bring more trains into South Station. By 2010, the number of daily intercity trains is expected to increase from 18 to the planned 34 trains a day, with the infrastructure to provide up to 52 trains. While specific schedules have not been fully developed, a minimum of two full-length platform tracks will likely be required at all times. This assumes that a typical service day will extend from approximately 5:00 AM to 10:00 PM for departures from South Station and the service will be directionally balanced (50 percent departing trains, 50 percent arriving trains). Given the longer platform dwell times required for intercity trains (i.e., loading baggage, mail, express packages, commissary requirements, etc.) there may be times when intercity trains are occupying three terminal tracks at South Station.

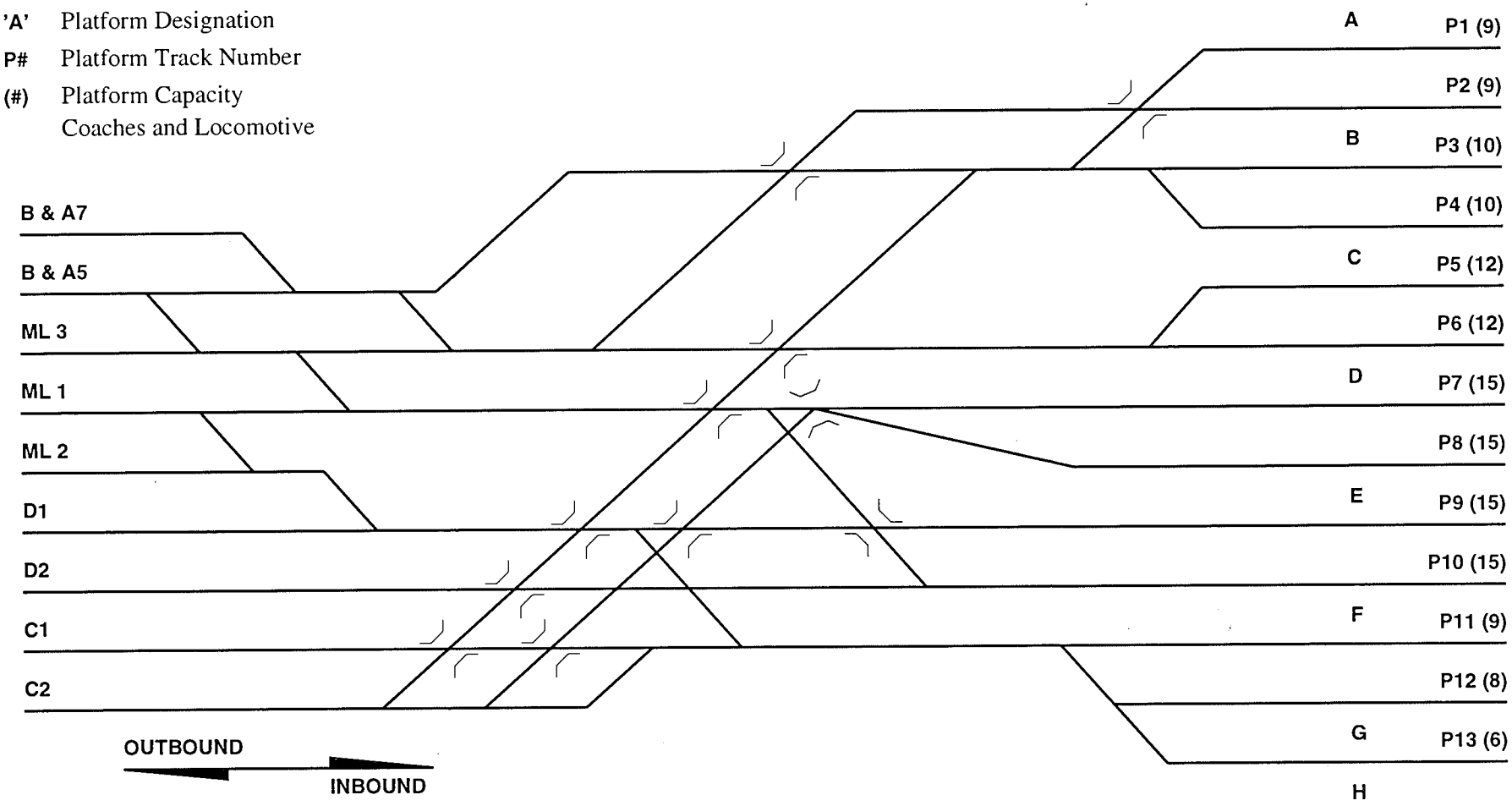
The MBTA's opening of two Old Colony rail lines in 1997 and the third at a future date will create the need to platform an additional 13 trains per peak period at South Station. Adding these trains to the existing service will increase overall terminal utilization to 44 MBTA trains during the peak period. It will result in a programmed utilization of South Station of almost 82 percent of total capacity for regional rail trains (i.e., 44 trains scheduled into a 54-train facility as calculated above) and at 100 percent of effective capacity (44 trains). By 2020, approximately 400 daily trains are scheduled for South Side service. Based on existing peak period service patterns, this _____ results in up to 60 trains scheduled to use South Station. Both the actual and effective capacities of the terminal would be exceeded.

While it can be argued at what point a terminal such as South Station reaches the saturation point, a utilization factor in excess of 80 percent certainly diminishes recovery capability in the event of delay and/or service disruption. This can create an operating scenario where normal daily operations will require capacity in excess of the existing physical plant. Both a systemwide and terminal simulation should be undertaken after future 2020 schedules are more closely correlated to anticipated ridership growth to determine if South Station capacity will be exceeded.

3.4.2 North Station

Currently North Station has ten active platforms and two additional inactive platforms. The North Station Improvement Project, which was completed in 1995, included the construction of the two additional platform tracks, Track 11 and Track 12. These two tracks, however, are not presently connected to the terminal plant. It is assumed that these two tracks will be connected in the future, becoming part of the 2020 No-Build terminal infrastructure, as shown in Figure 3.4-2.

B & A Boston & Albany
ML Amtrak - Back Bay
D Dorchester
C Old Colony
'A' Platform Designation
P# Platform Track Number
(#) Platform Capacity
Coaches and Locomotive



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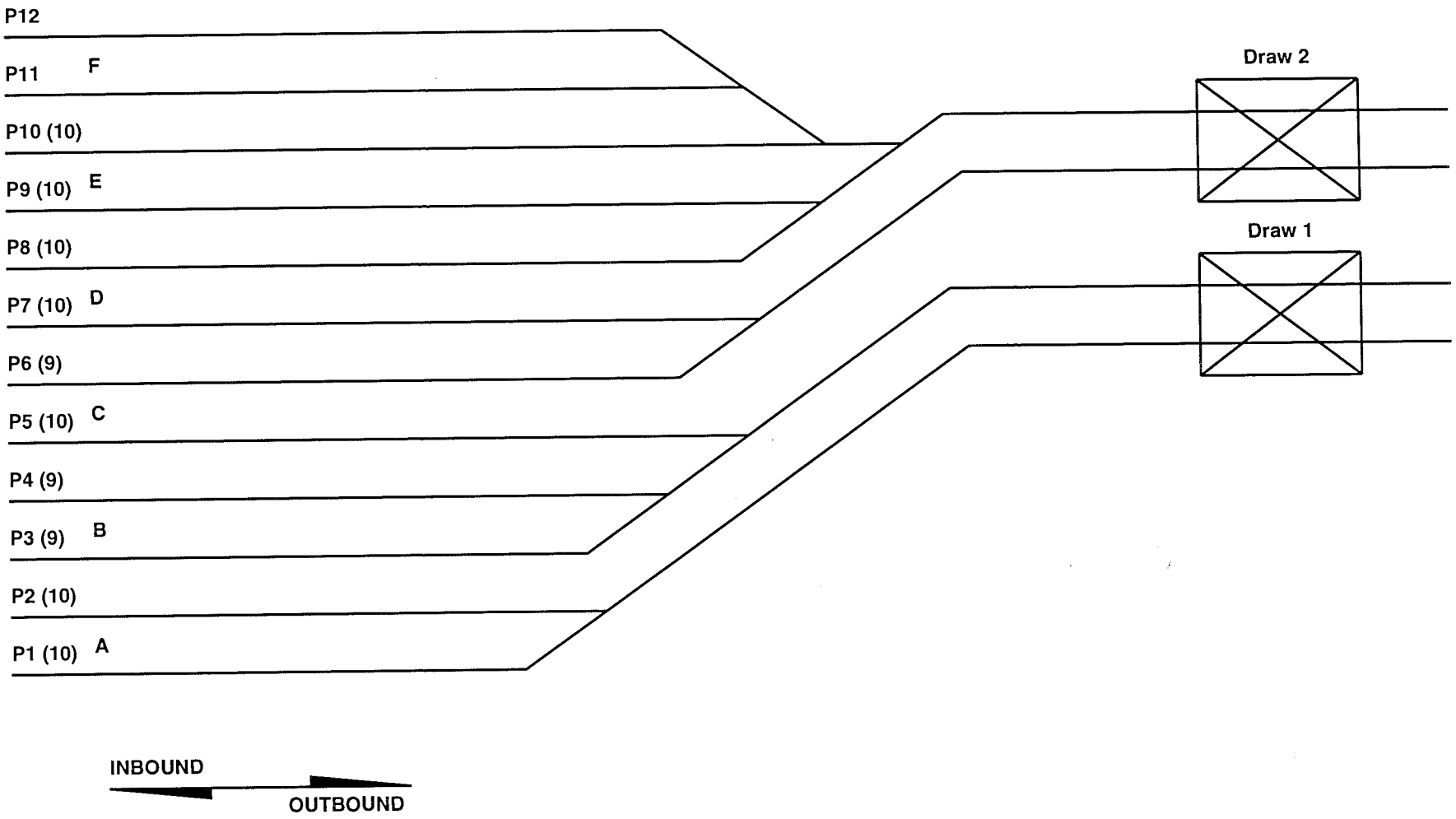
Future South Station Track Layout and Platform Capacity (2020)

Figure 3.4-1

Sources: Thomas K. Dyer, Inc.

P# Platform Track Number
(#) Platform Capacity
Coaches and Locomotive



Future North Station Track Layout and Platform Capacity (2020)

Figure 3.4-2

Source: MBTA

In the future, the number of trains utilizing North Station is also expected to grow. Intercity service between Portland, Maine and Boston is expected to commence by 1999. The initial level of service is six trains a day (three in each direction). By 2010, this is expected to grow to eight trains a day. The MBTA is presently constructing an extension of the Ipswich service to Newburyport. This service extension, however, is not expected to increase the number of trains initially. Analysis completed for the MBTA by others indicated that between the years 2000 and 2003 the North Station operation will require 12 tracks with a Maine service and 11 tracks without.

Ridership forecasts for the year 2020 for the North Side service indicate that ridership will grow to 51,380 daily riders. Service is expected to increase to 264 daily trains provided by 31 trainsets. Maximum peak utilization of the North Station terminal under the 2020 No-Build scenario will grow to approximately 43 trains arriving prior to 9:00 AM. From a capacity perspective, the projected 43 trains during the morning peak period is under both the 60-train peak period capacity and 48-train maximum desirable capacity limitation. This would seem to indicate adequate terminal capacity will be available at North Station. There is a concern based on analysis done by others, however, that the North Station terminal may require two additional tracks to service the 2020 schedule. Similar to South Station, a systemwide and terminal simulation should be undertaken after future 2020 are more closely correlated to anticipated ridership growth to determine if North Station capacity will be exceeded.

4 Build Alternatives

The Build Alternative considers construction of a rail tunnel linking the MBTA's South Side and North Side commuter rail operations into one unified regional rail system. Commuter rail service, which now terminates at South and North stations located on the fringe of the central business district, would be routed through downtown Boston, improving core area trip distribution and connections between the inner suburbs.

Implementation of a rail tunnel linking the two independent commuter rail systems into a unified regional rail system will significantly change operations. It will transform the commuter rail network into a true regional rail system similar to services operated in many European cities and Japan. Philadelphia, which opened a downtown rail tunnel in 1983 linking two separate systems, is the only US city operating a similar regional rail service. The only other North American example is in Toronto, Ontario. With the regional service concept, the system can be transformed from a predominately commuter peak period service to an all-day service. The ridership was grown from existing travel patterns but it should be realized that the potential for additional trips during the day is possible. The three primary attributes of the regional service concept are:

- inbound trains from one side of the city become outbound trains on the opposite side;
- more frequent service can be provided to make it more accessible to non-commuters; and
- the through-service operation combined with more frequent service makes transfers between rail lines easier and more attractive.

This chapter of the Operations Study will address the key components of creating a regional rail system in the Boston metropolitan area: the designation of line pairs forming regional service lines; the development of a preliminary operations plan for the rail tunnel; and simulation of operations through the rail tunnel. Following Section 4.1, which provides a brief summary of the Build Alternatives considered in this analysis and Section 4.2 which summarizes the *Equipment Engineering Study* (Technical Report No. 7), are Sections 4.3 and 4.4 which contain the detailed operational analysis and results for each of the Build Alternatives.

4.1 Summary of Build Alternatives

The rail tunnel corridor for the Build Alternative extends from Back Bay Station and the South Bay maintenance area on the South Side, through South Station and North Station, to the Boston Engine Terminal on the North Side. Up to three new underground stations are being considered: one in the general vicinity of the existing South Station; one between Broad and State streets under the new Central Artery tunnel; and another under the consolidated MBTA Orange and Green line SuperStation at North Station.

Within this general alignment corridor, several build alternative options are being considered based on the number of tunnel tracks and stations provided. These alternatives include:

- Four-track, two-station option
- Four-track, three-station option
- Two-track, two-station option
- Two-track, three-station option

Figure 4.1-1 shows the general alignment of the tunnel corridor. Technical Report No. 3, the *Schematic Design Report*, provides a detailed description of the Build Alternative options.

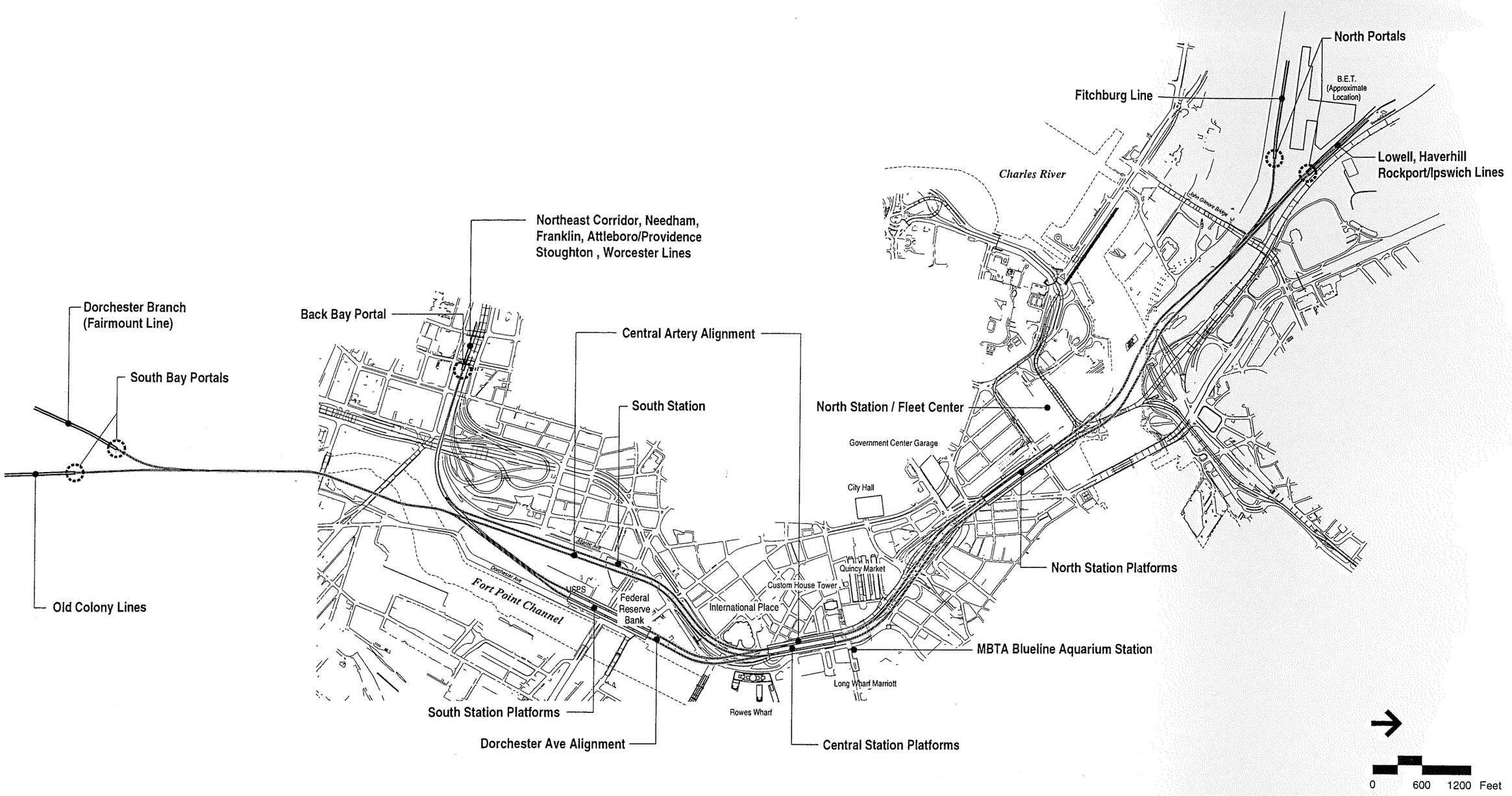
4.1.1 Four-Track Tunnel Alternative

The four-track Build Alternative proposes the construction of a three-mile long rail tunnel through downtown Boston. There would be five portals connecting all of the existing South Side lines with all of the North Side lines. Two alignments through the South Station area are being considered: the Dorchester Avenue and South Station alignments. A summary of the tunnel portal and alignment information is provided in the following sections.

4.1.1.1 Portal Locations

The proposed portal locations are the same for all Build Alternative options. A total of five portals are proposed: three on the South Side and two on the North Side. These portals include:

- South Bay Portals—These two portals would be located in the South Bay service facility in the general vicinity of the Southampton Street overpass and the MBTA commuter rail service and inspection (S&I) building. The MBTA's Old Colony Lines (Middleborough/Lakeville, Kingston/Plymouth, and Greenbush) would be serviced by one portal and the Fairmount Line (Dorchester Branch) would be serviced by another. Both portals provide single-track connections between the surface and the tunnel.



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Tunnel Alignment

Figure 4.1-1

- Back Bay Portal—This portal would be located approximately 100 feet east of the Washington Street overpass. It would connect the three Northeast Corridor tracks that service Providence and points south (Stoughton, Franklin and Needham lines and the proposed Fall River/ New Bedford Line) and the Conrail main line tracks to Albany, New York, also servicing the MBTA's Worcester service. In the final configuration, seven tracks would be operational in the area of the portal; five at-grade tracks joined by two emerging from the rail tunnel.
- North Portals—These two portals would be located to the north of the Gilmore Bridge and west of the I-93 viaduct in Somerville. The easterly portal on the North Side would service the majority of the North Side MBTA rail lines (the Lowell, Reading, Haverhill, Beverly, Newburyport, and Rockport lines) as well as the extension of NEC intercity rail service to Woburn. The westerly portal would service the MBTA's Fitchburg Line and the MBTA's new Boston Engine Terminal. A four track connection is proposed at the easterly portal and a two-track connection at the westerly portal.

4.1.1.2 Alignment Geometrics

There are two alignments being investigated in the vicinity of South Station based on the location of the proposed rail link at South Station.

- Dorchester Avenue—With this option, the underground South Station would be located to the northeast of the existing surface facility. The proposed station would be located adjacent to the Fort Point Channel, and could be shifted as far north as Russia Wharf.
- Central Artery/Tunnel (Atlantic Avenue)—With this option, the underground South Station would be located directly below the existing surface tracks and would extend from the existing South Station headhouse to the rear of the South Station Transportation Center.

The overall length of the alignment along the main line from the Back Bay portal to the North Side portals is approximately 14,725 feet. The maximum horizontal curvature for this alignment would be 8 degrees. The steepest vertical grade would be approximately 3 percent, which would occur in the tunnel section between the Back Bay Portal and South Station. This grade would become the ruling grade for Northeast Corridor intercity passenger operations.

Dorchester Avenue Alignment

Back Bay Portal to South Station. From Back Bay Station, two tracks would diverge from the surface tracks and enter a portal just east of the station and the Orange Line portal. The track configuration would allow a train on any of the five Back Bay Station tracks to access either the northbound or southbound track in the two-track tunnel approach. Just east of the portal area the tracks would separate into two single-track tunnels. As the two tunnels approach the Post Office building, they are joined by the Old Colony/Dorchester tunnel.

South Bay Portals to South Station. Both the Dorchester Branch and the Old Colony Line would have portals in the vicinity of the Southampton Yard Maintenance Facility. The Old Colony Line would diverge from a single surface track and enter a portal approximately 200 feet north of the Southampton Street Bridge. The single-track tunnel would then continue to its junction with the Dorchester Branch tunnel.

The Dorchester Branch tunnel track would diverge from the surface tracks west of I-93 and run parallel to and just south of the surface tracks. Crossovers would provide universal access between all tracks. The tunnel track would cross over I-93 and continue to the junction with the Old Colony tunnel. This junction will be just north of the South Boston Bypass Road, east of the Red Line surface tracks, and will have crossovers for universal access between all tracks. From this point, the combined lines will continue in a two-track tunnel to an intersection with the Back Bay tunnels in the vicinity of the Fort Point channel bascule bridges.

At this point the four tracks join into single alignment of two, two-track tunnels. Crossovers placed south of the platforms at South Station make any of the four station tracks accessible from any of the four tunnel tracks. After the crossovers, the tracks turn and run parallel to the Fort Point Channel and enter South Station, flattening to a 0.6 percent grade.

The station platforms would be aligned parallel to the Fort Point Channel and extend from the U.S. Postal Service property under Summer Street and the Red Line, beneath the open area behind the Federal Reserve Bank, and under Congress Street. There would be three 1,050 foot platforms at the station. As proposed, the station would be located adjacent to the west edge of the Fort Point Channel and run from approximately 500 feet south of Summer Street to Congress Street. The final location of the station would be determined during the preliminary engineering phase.

South Station to North Station. From the north end of South Station, the tracks continue to Rowes Wharf, where they enter the limits of the Central Artery slurry walls. From this point, the two tunnels travel north to three 800-foot long platforms at Central Station. These platforms run from Broad Street to State Street. From Central Station, the two tunnels travel north beneath the Central Artery to North Station. At North Station, the two tunnels open onto three 800-foot long platforms which extend from North Washington Street to the FleetCenter.

North Station to North Portals. The two tunnels continue in parallel north from North Station. At the new I-93 Charles River Crossing bridge, they diverge with one tunnel passing to the east of the bridge's south tower foundation system. The westerly tunnel passes between the bridge's caissons. The two tunnels then converge beneath the north end of the CA/T north area ramps and Boston Sand and Gravel. Crossovers would be placed at this location, allowing all four tunnel tracks to access all surface tracks.

Four tracks ascend to the easterly portal. The Rockport/Ipswich, Haverhill/ Reading, and Lowell lines would be connected through this portal. The two westernmost tracks continue northward as the Lowell Line inbound and outbound tracks, ascending at the portal to meet the existing alignment just south of the existing High Bridge that crosses over the Grand Junction Branch. The two easterly tracks become the Haverhill/Rockport/ Ipswich inbound and outbound tracks, ascending to meet the existing alignment approximately 2,000 feet north of the Gilmore Bridge.

A double-track tunnel would diverge from the westernmost tunnel approximately 300 feet south of the Gilmore Bridge and ascend to the west side of the Boston Engine Terminal (BET) facility. This westerly portal would service the MBTA's Fitchburg Line and the BET facility. Crossovers would make both tracks accessible from all four tunnel tracks. These two tracks would turn west and be the Fitchburg Line inbound and outbound tracks. They would ascend to the second northern portal, which would be on the existing Fitchburg Line alignment, south of the BET, approximately 1,200 feet north of the Gilmore Bridge. The Fitchburg Line single surface track would converge with the Fitchburg Line inbound track at this point. A new right-hand crossover would be built to access the Fitchburg Line outbound track.

Central Artery/Tunnel Alignment

The Central Artery/Tunnel alignment is similar to the Dorchester Avenue alignment except in the area of South Station. The specific differences would be as follows:

- Approaching from the Back Bay portal, the curve would be extended to bring the two single-track tunnels beneath the existing South Station tracks.
- South Station would be built on a 1 percent descending grade beneath the South Station Transportation Center, the surface South Station, Summer Street, the Red Line, and the Federal Reserve tower. If full flexibility is maintained between all four tunnel tracks south of the station, it will result in slower train operations through shorter turnouts. It may be possible to place the station south of the Federal Reserve building, but this would eliminate or reduce track connections south of the station (This issue is addressed in more detail in Technical Report No. 3).
- From the north end of the South Station platforms, the two tunnels would descend and pass beneath the Federal Reserve building, Congress Street, and Russia Wharf. They would meet the Dorchester Avenue alignment in the vicinity of Northern Avenue.

4.1.2 Two-Track Tunnel Alternatives

The two-track Build Alternative is similar, but consists of one tunnel containing two tracks. One variation of this alternative consists of a tunnel connecting the NEC and the Boston Line tracks in Back Bay with the all the North Side lines. The other two-track tunnel alternative connects the Old Colony Main Line and Dorchester Branch tracks in South Bay with all four North Side lines.

4.2 Summary of the Equipment Engineering Study

As part of the North-South Rail Link Study, a separate study was prepared that evaluated current MBTA commuter rail equipment and assessed how a rail link tunnel could potentially impact future equipment needs. The study evaluated both locomotives and coaches as well as train crew operating practices. A summary of the study findings is presented in the following sections. The more detailed equipment evaluation is presented in Technical Report No. 7, the *Equipment Engineering Study*.

4.2.1 Motive Power

Early investigations into tunnel ventilation systems indicated that it would not be possible to provide sufficient ventilation along the three-mile tunnel route to allow fossil fuel powered locomotives to operate. Therefore, for tunnel operations, trains would have to rely on either electric third rail or overhead catenary power systems.

The existing MBTA fleet of locomotives are all diesel-electric. Given the preliminary tunnel ventilation system findings, the *Equipment Engineering Study* focused on the replacement and/or re-engineering of these units in whole or part to maximize use of the tunnel. In addition to the traction power requirements, locomotives on a commuter rail service must have good acceleration characteristics because of frequent stops and the need to maintain on-time schedule performance. The steep grades (3 percent) in the rail link tunnel immediately after the stations also create a requirement that the locomotive be able to start a nine-car train, or approximately 755 trailing tons, from zero speed.

The motive power alternatives that were identified as reasonable choices for operation on a rail link tunnel included dual-mode locomotives, electric locomotives, and electric multiple units. Of these alternatives, the dual-mode locomotive, given the ongoing advances in the technology, presents the greatest potential degree of operating flexibility and utilization. This locomotive would be compatible with the Northeast Corridor electrification. It would also allow the MBTA to run trains through the tunnel without having to first electrify the entire regional rail system to maximize the return on the investment in the tunnel infrastructure. Therefore, the Equipment Engineering Study concluded that an AC traction, dual-mode locomotive capable of running over electrified and non-electrified lines in either the

diesel-electric or high voltage (25KV) overhead electrified mode should be developed for rail link operations.

It should be noted that the high voltage overhead catenary pick-up application for the dual mode locomotive will be a new development as documented in Technical Report No. 7. A full research and development program will need to be undertaken to fully test and develop the proposed unit. While all the proposed technological advances cited in the Technical Report No. 7 such as lighter carbody materials, AC traction, and radial steering trucks currently exist and have established successful service records, they have not been combined into the dual mode unit recommended as the future motive power choice. These components have also not been substantially tested under the daily demands of a commuter rail system or the operating conditions that the rail link tunnel will present.

4.2.2 Coaches

The purpose of the passenger/coach interface evaluation was to review the interaction between passengers and train operations, particularly at the proposed rail tunnel stations. The success of the future regional rail system depends on the efficient and timely movement of passengers to their destination. To achieve this success, key characteristics for coaches to be used in a run-through operation include: 1) the ability to discharge large passenger loads with the shortest average dwell time possible for the highest ridership trains at key stations in the rail link portion of the system (Back Bay, South, Central and North Stations); 2) the ability to use automatic door systems on high-level platforms, yet still be operated universally on a system with a mixture of high and low-level platforms; and 3) full ADA accessibility and compliance.

A review of the existing operational characteristics of the MBTA regional rail system was conducted, including an analysis of dwell times, platform configuration, train lengths, and passenger coach attributes. At Back Bay Station, which is the site most comparable to projected operations at rail link stations, it was observed that single-level cars load/unload in 35 to 50 seconds on a consistent basis, and that the bi-level coaches consistently load/unload in 95 to 105 seconds. It was concluded that existing MBTA coaches appear to load/unload with sufficient ease and in a short enough time frame that they would be suitable for use in a run-through rail operation.

4.3 Build Alternative No. 1: Four-Track Tunnel

Construction of a rail tunnel connecting North and South stations would significantly change operations on the MBTA's existing commuter rail system. Linking the two stations would change rail operations from a stub-end system to a run-through operation, where a train could pass through the center of Boston from one side to the other. A preliminary study of the operations of a four-track tunnel is presented below. The results are presented in four parts: the line pairings, the operating plan, simulation

results, and equipment requirements. The cost estimates and analysis are presented in Chapter 5.

4.3.1 Line Pairings

Initial pairings of the existing regional lines were developed for study purposes based primarily on potential ridership. The Central Transportation Planning Staff's regional transportation model used to project future commuter rail ridership divided the study area into seven zones or corridors. The regional trip data was organized to develop origin-destination pairs between these corridors. One of the assumptions made for the initial model run was that the rail system is "unconstrained." This assumption means that the infrastructure along the lines at North Station and South Station are capable of accommodating future operations. As described in Section 3.4, there are concerns that this infrastructure will not be able to meet future demands. Potential future constraints, however, were not built into the model.

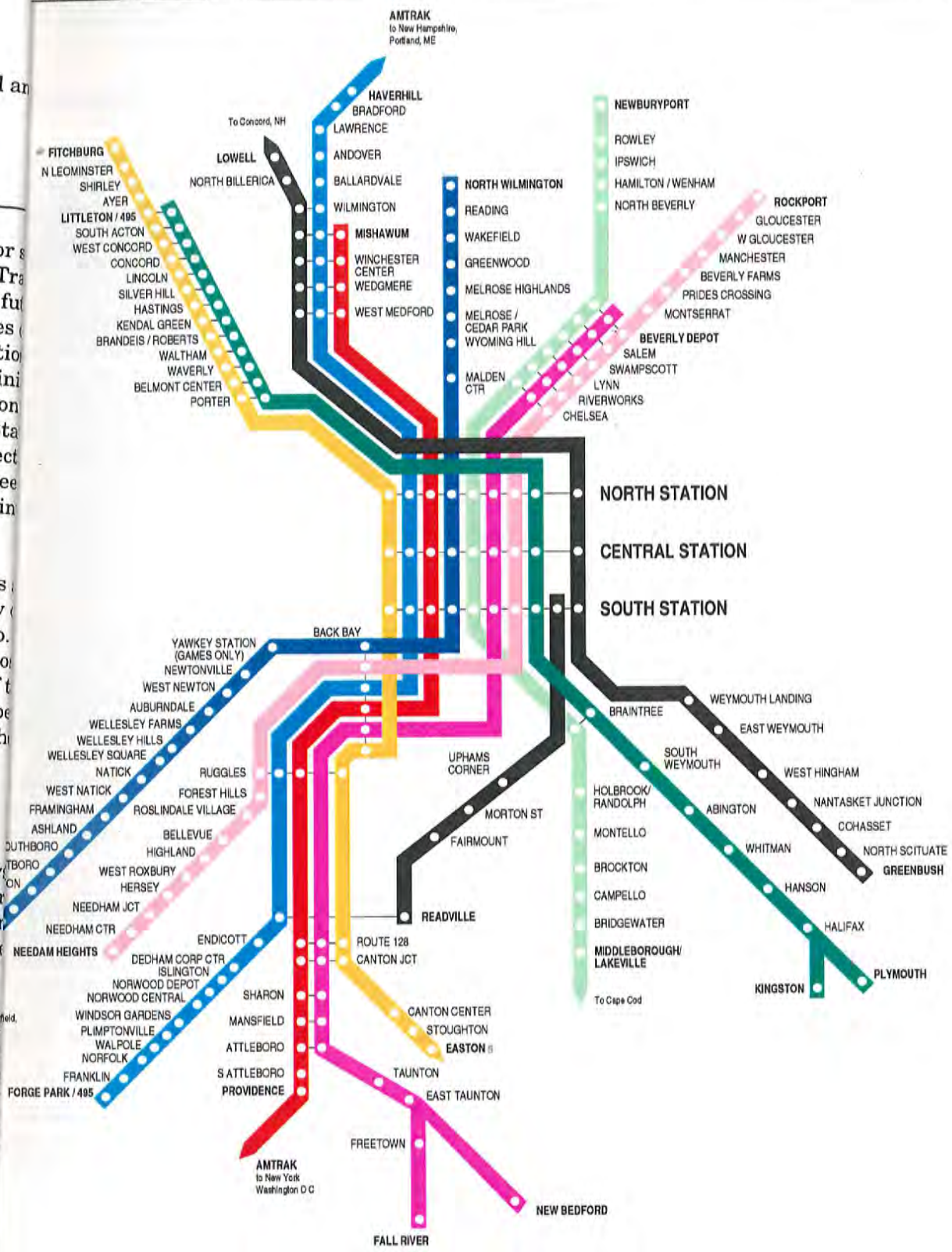
The CTPS model reflects the ridership potential if all of the lines are paired except for the Fairmont Line. This gives a good general overview of which lines should be paired to attract the maximum levels of ridership. The operating conditions discussed reflect an initial estimation of a possible operating scenario based on the paired lines developed as part of the ridership modeling effort. At the preliminary design stage, the operating line pairs and corresponding riderhip should be refined based on further development of an operating plan.

4.3.1.1 Operational Considerations

For planning purposes, it was initially assumed that all the rail system could access the tunnel during peak periods. In developing a more comprehensive operating plan for simulation, some peak period service was terminated at the surface track facilities located at South and North stations. The set of line pairs developed for planning purposes is shown in Figure 4.3-1.

South Station would remain as the base for Northeast Corridor (NEC) intercity high speed rail and conventional intercity passenger rail service operations. For planning purposes, it was assumed that up to 52 trains a day (26 in each direction) could operate between Boston and New York.[4] Of the 52 trains, 18 trains (9 in each direction) would continue through the tunnel to the new Regional Transportation Center Station in Woburn and/or to Portland, Maine.

4 Amtrak's current plans are for 34 trains by 2010; however, 52 were used for planning purposes, which is consistent with NECIP infrastructure planning.



Source: Base Plan from Central Transportation Planning Staff.

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Proposed Rail Line Pairs
Four Track Alternative

Figure 4.3-1

In reviewing the line pairs developed, several considerations were identified, including:

- Individual trainset sizes will need to be considered to assure that a trainset assigned to run through service will have sufficient seating capacity to handle the expected passenger loadings on both ends of the trip. This consideration should not result in major operational impacts or the need for additional coaches, other than those already outlined for the future No-Build service (see Section 3.4.2).
- As the MBTA's equipment servicing plan for the post-BET rebuild period (i.e., the future of West Cambridge and Readville, and the capacity of the new BET for servicing, etc.) is not finalized, it is not yet possible to determine the full impact that line pairings could potentially have on servicing. These impacts will have to be considered into a more detailed schedule building exercise once facility availability and service assignment assumptions are formulated by the MBTA.
- The Old Colony service extension may present operational difficulties. These lines are planned to have unique service characteristics which will make run-through service somewhat challenging. In particular, these unique characteristics are:
  - A Proof-of-Payment (POP) fare collection system, eliminating the current system of selling tickets on the trains. This type of fare collection system, which is used on other regional rail systems, allows for 2 two-man crews (engineer and conductor) to be used. The current MBTA practice is to assign one ticket collector (conductor and trainmen) for every two coaches in a consist.
  - Full length high-level platforms will be built at all stations allowing the use of the automatic door systems. This system cannot be used on other MBTA lines that employ a mix of low and high-level platforms.

If Old Colony is developed in this fashion, the process of blending a high-level platform/automatic door/reduced crew operation with a traditional manual door/larger crew approach will present operational and management challenges. Particular attention will need to be paid to the automatic door systems and whether it is operationally and mechanically feasible, or desirable, to attempt to alter the use of the door systems in the middle of a run.

Given these factors, there may be a line pairing scenario without the Old Colony lines included if the above-mentioned operational considerations point to a self-contained Old Colony service as more desirable. It should be stressed, however, that these are considerations, not "fatal flaws."

4.3.1.2 Ridership Considerations

A second methodology employed to check the potential line pairings was to assess the attractiveness of various line combinations from the ridership perspective. The first step in this assessment was to examine total trip flows between regions in eastern Massachusetts. Subsequent steps looked at the magnitude of total trips between various combinations of these regions surrounding Boston. Based on this gross assessment of regional travel patterns, the initial set of line pairs, previously shown in Figure 4.3-1, were established. Table 4.3-1 summarizes the projected 2020 Build daily trips by line pair. The details of this assessment are contained in Technical Report No. 4, the *Ridership Methodology and Forecasting Study*.

Table 4.3-1 **Potential Line Pairings and Projected Ridership**

Line Pair	Projected Daily One-Way Trips by Line	
	4-Track, 2-Station	4-Track, 3-Station
Fairmount (not through tunnel)	2,850	2,800
Worcester-North Wilmington	26,450	27,585
Plymouth-Littleton	15,950	17,335
Greenbush-Lowell	15,700	16,770
Middleborough-Newburyport	22,950	23,950
Needham-Rockport	20,500	21,435
North Easton-Fitchburg	27,850	29,950
Providence-Woburn	22,750	23,510
Franklin-Haverhill	29,800	30,935
New Bedford/Fall River-Beverly	21,700	22,300
Logan Trips	3,300	2,850
Total	209,800	219,420

4.3.2 Operating Plan

The decision to pair any given set of lines can be made primarily on demand rather than operational criteria. These pairings can be changed as experience and ridership patterns start to identify trends after the opening of the rail tunnel. For planning purposes, the line pairings presented previously were utilized to develop a draft operating plan for the 2020 Build scenario. This section presents the projected number of daily weekday trains and the corresponding daily train miles. These were estimated based on typical train schedules for the 2020 Build level of service which are presented in Appendix A.3.

4.3.2.1 Weekday Service

Table 4.3-2 presents the number of daily trains provided for service with the four-track scenario. For simulation purposes, some of the route patterns were consolidated to maximize the capacity of the tunnel. As shown in Table 4.3-2, the 2020 four-track Build scenario would have approximately 328 daily trains as compared to the 663 daily trains provided for in the 2020 No-Build scenario. This represents a reduction of 50 percent in the number of daily trains as a result of the run-through service. Of the 328 daily trains, 194 daily trains are paired routes and the remaining 134 will originate or terminate in downtown Boston. Based on the estimated length of each route, the 328 daily trains will result in approximately 18,600 daily train miles.

Table 4.3-2 **Four-Track Build Daily Weekday Service**

Route	Projected Daily Trains	Projected Route Miles	Daily Train Miles
Origin/Destination for Paired Routes			
Haverhill-Forge Park	48	64	3,072
Newburyport-Middleborough-	26	74	1,924
Rockport-Needham	26	49	1,274
Lowell-Worcester/Providence	48	70	3,360
Fitchburg-North Easton	23	70	1,610
Fitchburg-Plymouth	23	87	2,001
	194		13,241
Origin for Boston Only Trains			
Forge Park	12	31	372
Needham	6	13	78
Worcester	15	44	660
Providence	17	44	748
Greenbush	34	28	952
Plymouth	14	36	504
New Bedford/Fall River	36	57	2,052
	134		5,366
Four Track Totals	**328**		**18,607**

4.3.2.2 Peak Period Service

Table 4.3-3 presents the number of trains scheduled through the tunnel during the morning peak period (from approximately 6:00 AM to 9:00 AM) in the peak direction (toward downtown Boston). North Side lines were scheduled assuming the use of one track for inbound service, leaving three tracks for inbound trains from South Side lines. The corridors (e.g., Fitchburg Corridor) are divided into the various route patterns with the associated stops included as part of the route (e.g., Fitchburg Local, Acton Local, and Fitchburg Express). The morning peak period service is expected to include 35 trains on the North Side and 61 trains on the South Side.

4.3.2.3 Advantages

The operating plan developed offers the following advantages:

- An increased number of route patterns per corridor which would improve peak period service to every outlying MBTA station.
- All trains, including the Fairmount Line service (as a byproduct of the split of the Franklin line for zone express service) fit into the tunnel.
- Through operations would provide flexibility and maximize the use of operating patterns to its advantage, such as zone express, skip-stop express, and tandem express.
- Capacity to handle the projected ridership volumes.
- Flexibility when incidents occur in tunnel or to get around intercity trains with longer dwell times due to the additional tracks.

4.3.2.4 Considerations

This analysis presents a preliminary review of the proposed operations of a rail link tunnel. As the studies progress, the following issues will need to be examined in more detail:

- Operational considerations outside of the tunnel indicate the need to simplify service patterns.
- Single-track segments on many routes will prevent intensive headways from being operated against the current of the peak direction (Haverhill, North Easton, and Old Colony lines are particularly affected).
- The volume of trains programmed on the Northeast Corridor for both intercity and regional rail services, together with the speed differential between them, could potentialy constrain the capacity of that part of the system.
- The Boston Line has a limited capacity to handle additional service.

Table 4.3-3 Four-Track Service — Morning Peak Period*

Corridor/Route Pattern	Number of Inbound AM Arrivals	Notes
North Side Lines		
Fitchburg Corridor		
Fitchburg Local	2	All stops from Fitchburg
Acton Local	2	All stops from Acton
Fitchburg Express	2	Skips Silver Hill through Porter Square
Lowell Corridor		
Lowell Local	6	All Stops from Lowell
Lowell Express	1	Skips Wilmington, Wedgemere
Haverhill Corridor		
Haverhill Local	5	All stops from Haverhill
North Wilmington Local	1	All stops from North Wilmington
Haverhill Express (via NHML and Wildcat)**	1	see Lowell corridor
North Shore Corridor***		
Rockport	6	
Newburyport	5	
Intercity Passenger Rail Services	3	Peak hour has two per hour
Total North Side Lines	**35**	
South Side Lines		
Worcester Corridor		
Worcester Local	2	All stops from Worcester
Worcester Express	4	All stops Worcester through West Natick
Framingham	4	All stops from Framingham
Needham Corridor		
Needham Heights Local	5	All stops from Needham Heights
Franklin/Dorchester Corridor		
Forge Park Local	1	All stops from Forge Park via Dorchester
Forge Park Express	6	All stops from Forge Park via Back Bay
Norwood Central Local	6	All stops from Norwood Central via Dorchester
Providence/Northeast Corridor		
Providence Local	1	All stops from Providence
Providence Express	6	All stops from Providence through Sharon
North Easton Local	6	All stops from North Easton
Middleborough/Plymouth Corridor		
Middleborough	5	All stops, plus Braintree
Plymouth (Kingston)	4	All stops, plus Braintree
Greenbush Corridor		
Greenbush	6	All stops, plus Quincy
Fall River/New Bedford Corridor		
Fall River	3	stop at Sharon
New Bedford	2	stop at Sharon
Intercity Passenger Rail Services	0	
Total South Side Lines	**61**	

* The morning peak period is defined as the hours between 6:00 AM and 9:00 AM.

** Both tandem express trains stop at Woburn/Route 128 and make all stops on their respective segments north of Wilmington

*** Above trains make all stops on respective branches, with selected trains skipping Lynn, River Works, and Chelsea stations.

4.3.3 Simulation of Operations

As part of the North-South Rail Link Study, a railroad simulation model was developed to replicate existing operations and to model future system operations with a rail link tunnel. It does not include the entire regional rail network but does encompass the key trunk line segments on the South and North sides. A detailed description of the steps used to develop the base condition and simulate existing regional rail operations can be found in the *Commuter Rail RAILSIM Simulation Report* (Technical Report No. 6). The following sections summarize the application and the results of the simulation model for the four-track Build Alternative.

4.3.3.1 Modeling Assumptions

The simulation model was limited to the core system area as defined in Technical Report No. 6. It is recognized, however, that there are existing and future constraints on many of the lines that figure prominently in the scheduling of service. These constraints, previously identified and discussed in Chapter 3 of this document, were considered in the development of the Build Alternative simulation. These system wide scheduling constraints will exist whether or not a Build Alternative is selected for implementation.

The schematic tunnel track and interlocking layout developed as part of the *Schematic Design Report* (TR No. 3) was incorporated into the model. A conceptual layout of signal control lines was developed and coded into the simulation. Rail operating patterns were established that varied in direction by time of day, both in the tunnel and on above-ground main lines. All tunnel tracks were assumed to be signaled for bi-directional operations allowing maximum usage. A desirable headway of four minutes and a minimum headway of three minutes were used. Dwell times at the three tunnel stations were assumed to be 90 seconds for regional commuter rail service. A five-minute dwell time for intercity passenger rail service was assumed at South Station.

Immediately beyond the underground North and South stations, crossovers have been provided, allowing universal access between all four tunnel and all surface tracks. These two interlocking plants, located at opposite ends of the tunnel, have been designated as GAR Interlocking and TUN Interlocking. Within the main tunnel segment between North and South stations, no crossovers are planned.

4.3.3.2 Simulation Analysis Assumptions

Under 2020 design year conditions, the existing imbalance in ridership between the South Side and North Side lines is projected to continue. As a result, the largest volume of trains will continue to service South Side lines. This results in an imbalance of service entering the tunnel, particularly during peak periods. Initial simulation runs suggested that three tunnel tracks should be operated in the prevailing peak direction for South Side lines and one track for the prevailing peak direction for the North Side lines. During the morning peak period, three tracks were designated to operate northbound and one track southbound. For the evening peak period, one

track for northbound and three tracks for southbound trains were designated. At all other times of the day the tunnel will be able to operate with two northbound and two southbound tracks. Figures 4.3-2 and 4.3-3 illustrate tunnel operating patterns during the morning and evening peak periods.

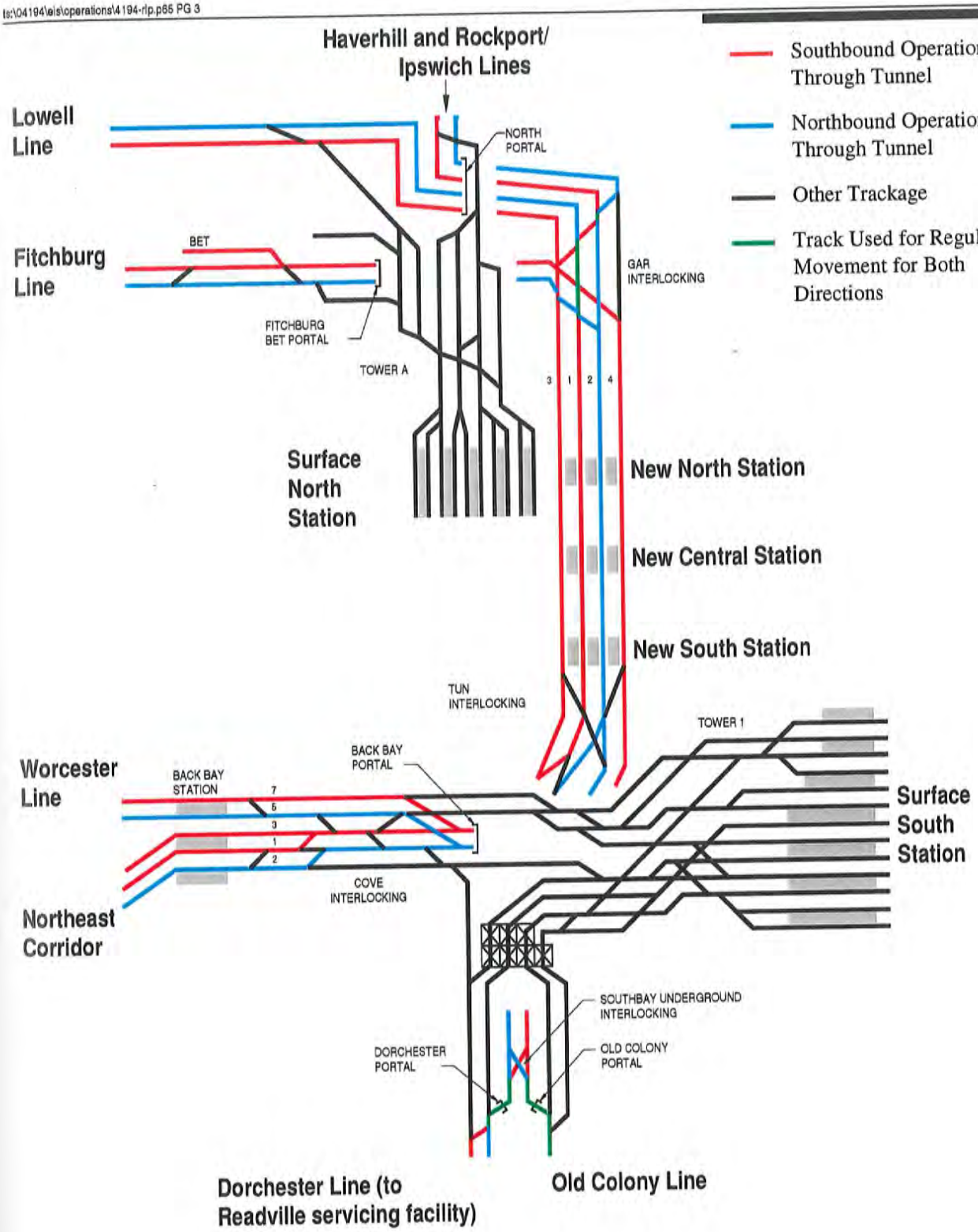
Following additional simulation of potential tunnel traffic patterns, it was further determined that Track 2 would be the most suitable track for the single-track North Side peak period operations. Track 2 was proposed because it connects to all three South Side portals without conflicting movements at TUN Interlocking. The direction of Track 2 was proposed to be reversed during the evening peak period to carry all outbound North Side trains.

Back Bay Portal. At Back Bay Portal, Track 2 emerges from the tunnel and connects to the center track, Track 1, on the Northeast Corridor. Track 1 connects to the northernmost track, Track 3, outside the portal. A new Cove Interlocking is proposed to facilitate movements between the two tunnel tracks at the portal and NEC tracks 1, 2, and 3 and the Boston Line tracks 5 and 7.

The present operating pattern on the Northeast Corridor is for Track 2 to be used for inbound trains. Track 1, the center track, is used by outbound trains. Track 3, the northern track, is presently a reversible track; inbound trains operate on it during the morning peak period and outbound during the evening peak period. The two Boston Line tracks are used on an as needed basis to move trains in either direction.

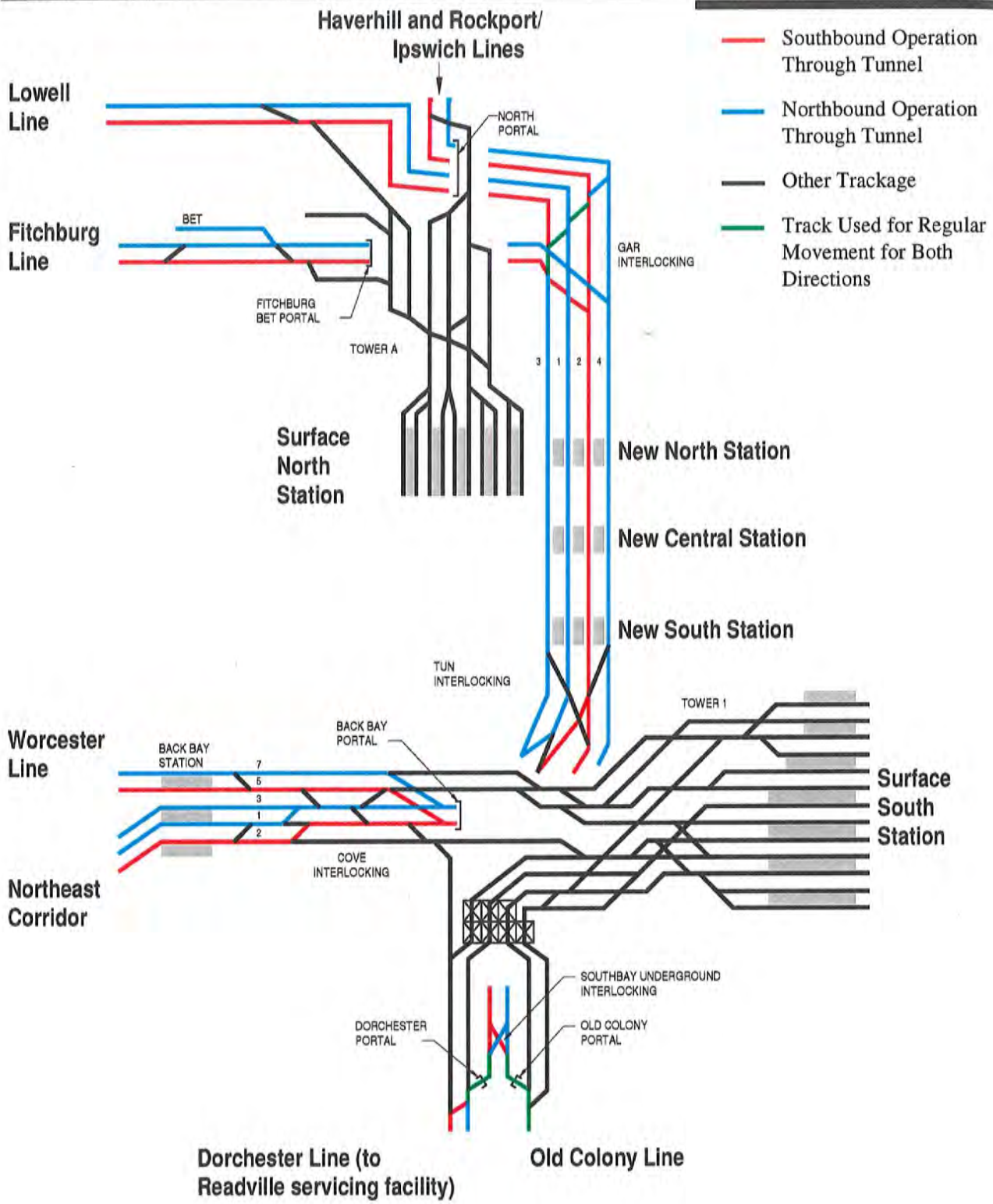
During the morning peak period, the designation of Track 2 for North Side peak direction movements will change operating patterns on the Northeast Corridor between the Back Bay Portal and Route 128 Station and on the Boston Line between the portal and Beacon Park Yard in Allston. Evening peak period operations outside the tunnel will not be affected by the designation. Operating patterns during the morning peak period will be impacted because operations could become heavily congested by crossover moves at the new Cove Interlocking. Based on present NEC and proposed tunnel operations, all outbound tunnel trains would exit directly from Tunnel Track 2 onto NEC Track 1. Inbound trains would enter directly from NEC Track 3 onto Tunnel Track 1 or cross over from NEC Track 2 onto Tunnel Track 1 before entering the portal. Trains to and from the Boston Line will further complicate the interlocking plant operations.

As a result, rail operations on the NEC and the Boston Line were rearranged during the morning peak period to facilitate train movements at the Back Bay portal. The changes resulted in possible "left-hand" operations on both lines. During the morning peak period, NEC Tracks 1 and 3 will be for inbound trains and Track 2 for outbound trains. Normal operating patterns, where Track 2 will be used for inbound trains, Track 1 for outbound trains, and Track 3 for both except during the evening peak period when it handles outbound traffic, were assumed to prevail. A new universal interlocking one mile west of Route 128 Station, at the future No-build limit of the third main track, was required. Similar changes were simulated on the Boston Line. Track 2 (the southerly track), designated as Track 5 in Cove Interlocking, was designated to operate outbound during the morning peak period and inbound



Four Track Alternative
Morning Peak Hour
Operating Pattern

Figure 4.3-2



Four Track Alternative
Evening Peak Hour
Operating Pattern

Figure 4.3-3

during the evening peak period. The northern track, Track 1, (Track 7 in Cove Interlocking), is proposed to be inbound in the morning and outbound in the evening.

South Bay Portals. During the morning peak period, a steady flow of outbound trains headed for the South Bay or Readville maintenance yards is expected. This flow of outbound traffic will conflict with inbound revenue movements, particularly at the single-track Old Colony portal. If priority is given to inbound Old Colony trains in the morning peak period, trains on the outbound track will get backed up from Bay Interlocking past TUN Interlocking. This back-up could bring southbound tunnel operations to a standstill. The solution is to double track the portal connection.

North Side Portal. The TUN Interlocking plant will function primarily as a divide between the tunnel tracks and the tracks to the South Side portals. The role of routing trains between tunnel tracks and surface tracks will be performed by the GAR Interlocking plant. This plant will function as the set-up interlocking for train routings and will have universal interlocked crossover capability with the possibility for parallel moves.

As a result of the operations at GAR Interlocking, operating patterns during the evening peak period on the Fitchburg Line were changed to avoid potential conflicts with the coach yard moves to BET. At present, inbound trains use Track 2 and outbound trains Track 1. During the evening peak period, left-hand operations were proposed which will place inbound trains on Track 1 and outbound trains on Track 2. Trains will resume normal operations at either Swift Interlocking or West Cambridge Interlocking.

4.3.3.3 Findings

There are significant operating efficiencies associated with the run-through operation of the Rail Link including fewer trainsets and a potential increase in daily average crew productivity. As noted in the introduction to this section of the chapter, existing system constraints result in tightly coordinated schedules for the particular routes on which they occur. Other physical plant improvements scheduled for implementation by 2020 may also introduce additional scheduling conflicts. With the Build Alternative, each peak period run-through train has a narrow window in the rail link tunnel. These three sets of constraints provide a challenge in the development of run-through schedules.

The simulation results for the four-track Build Alternative identified a number of changes in the tunnel track system and surface track connections that should be considered during the development of Preliminary Design. The greatest challenge presented is balancing tunnel operations to accommodate the higher volume of trains from South Side lines than from North Side lines. The tunnel track layout presented in the *Schematic Design Report* includes six tracks at the two North Side portals (two at the Fitchburg Line portal and four at the main portal) and four tracks at the three South Side portals (two at the Back Bay Portal and one each at the Old Colony and Dorchester Line portals). The fewer surface track connections proposed on the South Side could potentially result in higher levels of congestion both outside the tunnel and within the tunnel system.

The reversal of current traffic on the main tracks on both the NEC and the Boston Line tracks during the morning peak period was modeled to eliminate conflicts between trains moving in opposite directions at Cove Interlocking. Congestion still occurs, however, because three inbound tracks (two from the NEC and one from the Boston Line) would funnel into one inbound track at Back Bay Portal. During the evening peak period, southbound trains would back up on tunnel Tracks 1 and 3 waiting for their turn to use the one outbound track to Cove.

4.3.3.4 Conclusions

The work carried out in the simulation of the rail link tunnel used parameters established in the *Schematic Design Report*, the *Ridership Methodology and Forecasting Study*, and conceptual engineering plans. Run-through pairings, the track layout of the tunnel, the underground interlockings, and the volume and headway of train operations were all combined to establish an initial simulation of the operations of the rail link tunnel.

Based on this analysis, it can be concluded that the four-track Build Alternative would significantly change operation of the Boston metropolitan rail system. While the simulation noted a number of suggested design changes in the concept, no fatal flaws were identified. The "left hand" operation on the NEC and the Boston Line tracks may not be a standard practice but it is neither unreasonable nor impractical. Combined with a reasonable schedule of peak period service that would still terminate at the surface terminals, the rail tunnel should add significant capacity to the rail system.

As a result of the findings presented in this section, the following recommendations are made for development of the four-track Build Alternative should it be advanced to the Preliminary Design phase:

- either a full analysis of the "left hand" operations on NEC and Boston Line services be completed or the Back Bay Portal be modified to accommodate three tunnel track connections.
- the two South Bay portals be modified to accommodate two tunnel track connections.
- a full draft system wide run-through schedule be developed including the scheduling of trains terminating at the surface terminals. All surface line constraints should be considered in the development of the draft schedule.
- the tunnel track layout and physical plants be modified to accommodate additional flexibility in route assignments.

4.3.4 Equipment Requirements

Based on the operating plan for the 2020 Build scenario, the total number of trainsets required to provide service is projected to decrease from the 87 sets required for the No-Build service to 75 sets. Applying a 10 percent spare ratio, the overall required fleet size under the 2020 Build scenario would be 83 locomotives. Based on the train lengths developed for the No-Build scenario, an average of 6.25 coaches per trainset was assumed, which results in a need for 519 coaches for the 2020 Build scenario. This is a reduction of 13 locomotives and 81 coaches as compared to the No-Build. The number of trainsets for each line is shown in Table 4.3-4. A comparison of the No-Build and four-track Build Alternative equipment utilization is summarized in Table 4.3-5.

Table 4.3-4 **Trainsets 2020 Four-Track Build Service**

Originating Terminal	Trainsets	Notes
Fitchburg	5	Acton turns covered by through-running from South Side
Haverhill	6	North Wilmington covered by through-running from South Side
Lowell	6	Possibly some early morning deadheading from Boston
North Shore	5	Newburyport
	4	Rockport
		Beverly turn protected by through-running from South Side trains
Providence	7	Stored overnight at Providence, East Junction yard, or both
Fall River/New Bedford	5	Assumes routing via NEC
North Easton	5	If reverse peak service can be fit in, this number can be reduced
Franklin	7	For proposed zone express service
Norwood via Dorchester	2	
Needham	3	
Worcester/Framingham	7	
Greenbush	4	
Plymouth	4	
Middleborough	5	Extra consist can be a floater between all Old Colony lines
Total Trainsets	**75**	

Table 4.3-5 **Equipment Utilization for Four-Track Build Service**

	No-Build	Four-Track Build	Difference
Train Miles	6,351,195	5,365,018	986,177
Coach Miles	39,694,969	33,531,365	6,163,604
Number of Required			
Locomotives	96	83	13
Coaches	600	519	81
Average Miles per Year			
Locomotives	66,158	64,638	1,520
Coaches	66,158	64,608	1,550

In addition to the expected savings in equipment, the rail tunnel would also provide the opportunity to significantly adjust the manner in which commuter rail equipment is serviced. It is assumed that the current pattern of servicing (either immediately after the completion of an AM peak period assignment, or around midday) will remain. The movement of the equipment, however, is expected to change. With the run-through service, a southbound revenue train going out of service at either South Station or Back Bay Station could be operated by the road crew directly into the Southampton Street or Readville facility on the South Side for servicing. Similarly, northbound trainsets going out of service at North Station could be moved directly to the Boston Engine Terminal/Yard complex on the North Side by the road crew. In both cases, this manner of operation:

- reduces the use of yard personnel to move equipment to facilities for servicing,
- reduces terminal congestion,
- eliminates "back-up" moves for service events, and
- decreases the amount of time spent getting to/from maintenance facilities.

4.4 Build Alternative No. 2: Two-Track Tunnel

In addition to the "full-build" four-track Build Alternative, a "partial-build" two-track option was also investigated. The analysis considered the ridership forecasts, operations analysis, equipment engineering recommendations, and station design/access needs. Similar to the four-track alternative, the two-track alternative links North and South stations and would change rail operations from a stub-end system to run-through operations. Two options for the two-track tunnel were investigated: one with the South Side portal at Back Bay, and one with the South Side portal in South Bay. Both two-track tunnel options have the same portal layout at the north end.

A preliminary study of the operations of a two-track tunnel is presented below. The results are presented in four parts: the line pairings, the operating plan, simulation results, and equipment requirements. The preliminary cost estimates and analysis is presented in Chapter 5.

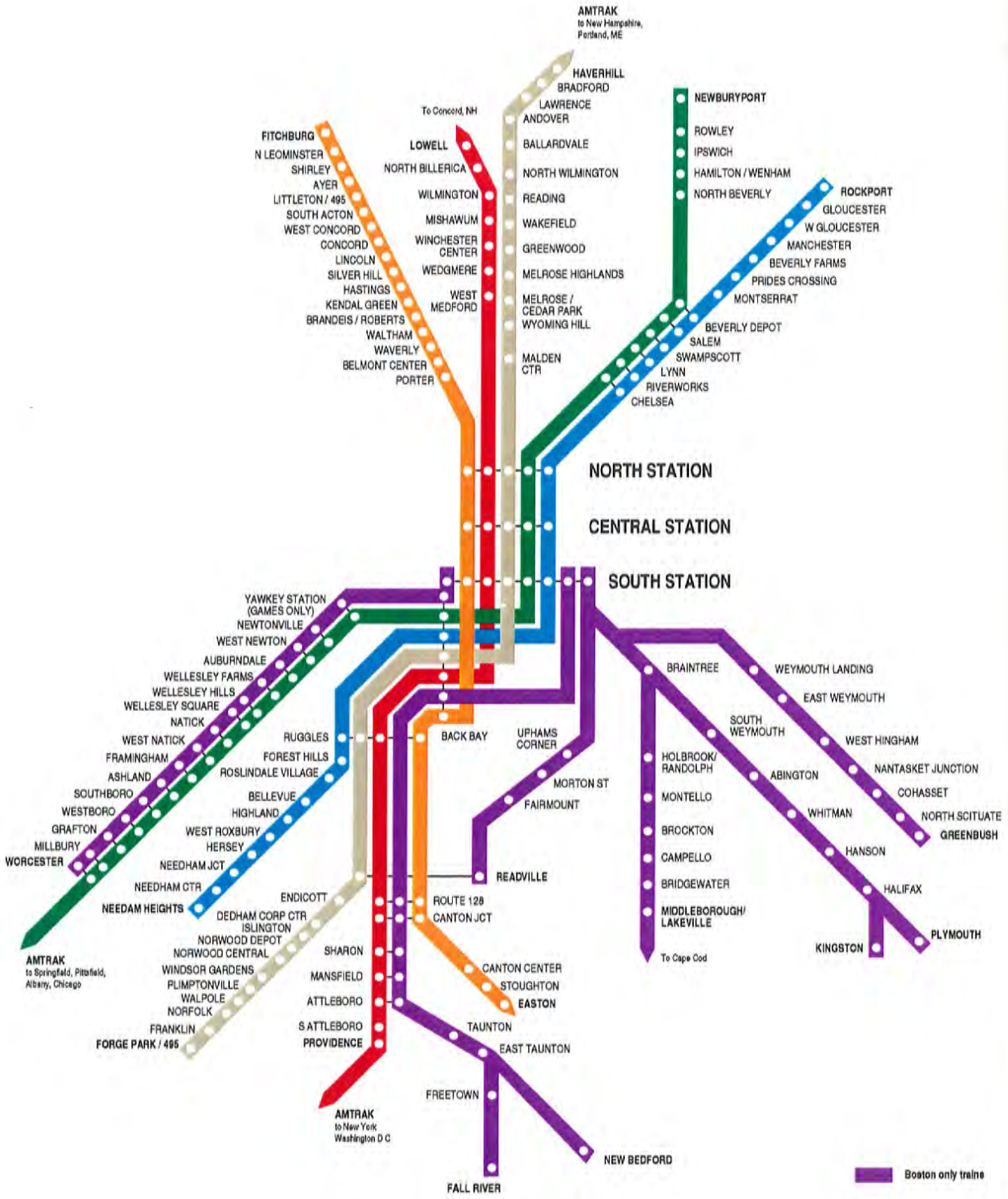
4.4.1 Line Pairings

The two-track Build Alternative has two options for connection to the existing South Side system: at a Back Bay portal connecting directly with the Northeast Corridor or a South Bay Portal connecting to the Dorchester Branch and Old Colony Lines. The potential line pairings, operations, and ridership of these two options is detailed in the following sections. Table 4.4-1 presents the projected weekday daily service for the two-track alternatives. Figures 4.4-1 and 4.4-2 present a set of line pairings that were developed for the purposes of this study for the two-track alternatives: Back Bay Portal and South Bay Portal.

4.4.1.1 Operational Considerations: Back Bay Portal

The assumptions associated with the two-track rail link tunnel via the Back Bay portal are:

- Two-track core tunnel from the Back Bay portal on the South Side connecting with both North Side portals. Entrance at the North Side will likely consist of four tracks, reducing to two tracks before entering the core section of the rail link tunnel. A single-track tunnel is provided to the South Bay maintenance area facilitating movement of equipment.
- The majority of the NEC intercity passenger rail service terminates at South Station surface. Some service will continue to Woburn. For a 52- and 34-train schedule, up to eight Northeast Corridor intercity trains a day (four in each direction), will use the tunnel and travel north to the proposed Regional Transportation Center in Woburn. Of these eight trains, four will be Northeast Direct trains and four will be High Speed trains.
- Intercity Portland trains terminate at North Station. Other options for service south of Portland have not been precluded in this study. For simplicity reasons the above was assumed.
- All of the MBTA's North Side service trains and about half of the South Side service trains run through the rail link tunnel. One possible approach to line pairings which was used for the study of the Two-Track Alternative (Back Bay Portal) operations is as follows:
  - Needham-Rockport
  - Fitchburg-North Easton
  - Forge Park (Franklin)-Haverhill
  - Providence-Lowell
  - Framingham-Newburyport



Source: Base Plan from Central Transportation Planning Staff.

NorthSouth**RailLink** PROJECT • *VHB/FRH, A JOINT VENTURE*

Proposed Rail Line Pairs
Two Track (Back Bay Portal)
Alternatives

Figure 4.4-1

Source: Base Plan from Central Transportation Planning Staff.

NorthSouthRailLink PROJECT • *VHB/FRH, A JOINT VENTURE*

Proposed Rail Line Pairs
Two Track (South Bay Portal)
Alternatives

Figure 4.4-2

- Non-tunnel South Side service terminating at South Station surface are:
  - Worcester Express
  - New Bedford/Fall River
  - Middleborough
  - Plymouth
  - Greenbush
  - Fairmount

4.4.1.2 Operational Considerations: South Bay Portal

The assumptions associated with the two-track rail link tunnel via the South Bay portal option are:

- A two-track core tunnel from the two South Bay portals to the two North Side portals. The entrance at the North Side would likely consist of four tracks, reducing to two tracks before entering the core section of the rail link tunnel. All trains operating through the rail link tunnel will travel via the Midland Division (Dorchester Branch), joining the NEC at Readville.
- NEC intercity passenger rail service terminates at South Station surface.
- Intercity Portland trains run through the rail link tunnel. Other options for service south of Portland have not been precluded in this study. For simplicity reasons the above was assumed.
- All MBTA North Side trains run through the tunnel and about half of the MBTA South Side service trains run through the tunnel. The line pairs for a two-track rail link tunnel operation are:
  - Plymouth-Fitchburg
  - Greenbush-Rockport
  - Forge Park (Franklin)-Haverhill
  - Providence-Lowell
  - Middleborough-Newburyport
- The Haverhill and Rockport services to South Station underground assume that a turnback can be developed at South Bay or on the Dorchester Line.
- Two of the potential South Side line pairs, South Attleboro and Forge Park (Franklin), currently serve Back Bay Station. The other three proposed South Side line pairs (Greenbush, Plymouth, Middleborough) do not stop at Back Bay under No-Build conditions.
- The following non-tunnel South Side services would terminate at South Station surface:
  - Worcester (Express and Local)
  - New Bedford/Fall River
  - Needham
  - Providence Express
  - North Easton

- Readville (or Route 128) would become a transfer station (i.e., Long Island Railroad's Jamaica Station) for MBTA service, allowing NEC passengers who want to continue northbound through the tunnel to do so by transferring to the appropriate train at Readville (or Route 128). The following two South Side lines would operate through the tunnel and service Readville (or Route 128) and connect with other NEC regional rail lines:
  - Providence
  - Forge Park

4.4.1.3 Ridership Considerations

Given the absence of operational constraints to line pairings, it was determined that the most beneficial approach for the system will be to determine which line pairings have the greatest potential to attract riders to the system. This issue has been analyzed with the results presented in the *Ridership Forecasting Study* (Technical Report No. 4). The regional ridership model indicates that the Back Bay Portal option would results in a slightly higher (about 5 percent) level of commuter rail ridership than the South Bay Portal option, with corresponding decreases in rapid transit ridership. Based on these findings, an initial set of line pairings was configured for each two-track alternative as presented in Table 4.4-1 (with daily by-pair ridership forecasts).

4.4.2 Operating Plan

The two-track tunnel has been proposed in two variations, each involving two of the four tracks of the four-track tunnel build alternative. Each two-track tunnel alternative has different South Side portals. Both two-track tunnel options have the same portal layout at the north end. The two two-track alternatives are described as follows:

- The two-track tunnel/South Bay alternative would use Tracks 2 and 4 in the tunnel and connect to both single-track portals (Dorchester and Old Colony) at the present site of Southampton Street Yard.
- The two-track tunnel/Back Bay alternative would use Tracks 1 and 3 and connect to the double-track Back Bay portal and also to the single-track Dorchester portal (to be used for coach yard moves only).

Both two-track alternatives have simpler operating plans than the four-track alternative because they do not involve changes in tunnel track direction to accommodate peak hour traffic. "Right-hand running" will be the practice for both options. GAR Interlocking would be modified to have universal interlocked crossover capability. The changes in track direction outside the tunnel are previously discussed under the four-track alternative for both two-track options.

Table 4.4-1 **Potential Line Pairings and Projected Ridership**
Two-Track Build Alternative

Portal Option	2-Track/ 3-Station	2-Track/ 2-Station
Back Bay Portal		
Origin/Destination for Paired Routes		
Needham-Rockport	25,755	24,020
Fitchburg-North Easton	31,400	29,000
Forge Park (Franklin)-Haverhill	25,960	24,200
Providence-Lowell	32,260	34,260
Framingham-Newburyport	25,200	23,110
Origin/Destination for Boston Only Trains		
Worcester Express	10,465	10,510
New Bedford/Fall River	7,880	7,880
Middleborough	10,550	10,460
Plymouth	10,300	10,200
Greenbush	5,780	5,740
Fairmount	2,890	2,900
Total Back Bay Portal Option	194,560	184,880
South Bay Portal		
Origin/Destination for Paired Routes		
Greenbush-Rockport	21,760	20,130
Plymouth-Fitchburg	22,560	20,335
Forge Park (Franklin)-Haverhill	23,520	22,000
Providence-Lowell	27,940	25,845
Middleborough-Newburyport	27,340	25,600
Origin/Destination for Boston Only Trains		
Worcester	18,100	18,100
New Bedford/Fall River	15,730	15,810
Needham	7,160	7,140
Providence	10,300	10,420
North Easton	15,730	15,810
Total South Bay Portal Option	182,290	173,260

The capacity constraints on the South Side portals discussed in the four-track tunnel alternative are also applicable to the two-track tunnel. With the operations projected in the South Bay portal area, the two-track South Bay alternative encounters problems, as a large number of trains from the NEC are routed to the tunnel via the Dorchester Line. The limited number of portal tracks at South Bay, combined with the large number of trains and coach yard moves using the Dorchester Line, indicate that the two-track South Bay alternative would likely present operational issues. The double tracking of both South Bay portals addresses these issues.

As previously discussed, not all of the South Side lines were paired. The additional South Side services were terminated at South Station surface. The capacity of the tunnel was tested to make sure that all of the potentially paired trains could operate through during the peak periods. The results indicate that the tunnel could service the potential demand.

There are other considerations besides peak period capacity when examining the operation of a two-track tunnel. If any incidents were to occur within the tunnel, the four-track alternative provides more flexibility in working around the incident. The other potential considerations discussed in the four-track Build Alternative are all applicable to the two-track tunnel (see Section 4.3.1.1).

Table 4.4-2 presents the line pairs for each two-track alternative and the corresponding number of daily trains and daily train miles. Table 4.4-3 presents a breakdown of the morning peak period service that would be provided with the two-track (Back Bay Portal) alternative and Table 4.4-4 for the two-track (South Bay Portal) alternative.

4.4.3 Equipment Requirements

In the 2020 No-Build scenario, a total of 87 trainsets, consisting of one locomotive and five coaches (31 sets) on the North Side and seven (56 sets) coaches each on the South Side, was forecast to provide the intended level of service. The total fleet size, including 10 percent spares, would be 96 locomotives and 600 coaches.

4.4.3.1 Back Bay Portal

In the 2020 two-track Build (Back Bay Portal) scenario, the total number of trainsets required to provide service is projected to decrease from 87 sets under No-Build conditions to 75 sets from 87 in the No-Build Alternative. Applying a 10 percent spare ratio, the overall fleet size under this scenario would need to be 83 locomotives. Assuming an average of 6.25 coaches per trainset, 519 coaches would be needed for the 2020 two-track Build (Back Bay Portal) scenario. This is a reduction of 13 locomotives and 81 coaches in comparison to the No-Build Alternative.

Table 4.4-2 **2020 Daily Weekday Service — Two-Track Build Alternative**

	Projected Number of Daily Trains	Number of Miles per Route	Projected Daily Train Miles
Back Bay Portal			
Origin/Destination for Paired Routes			
Needham-Rockport	26	49	1,274
Fitchburg-North Easton	23	70	1,610
Forge Park (Franklin)-Haverhill	42	64	2,688
Providence-Lowell	48	70	3,360
Framingham-Newburyport	22	59	1,298
	161		10,230
Origin/Destination for Boston Only Trains			
Worcester Express	6	44	264
New Bedford/Fall River	36	57	2,052
Middleborough	26	36	936
Plymouth	24	36	864
Greenbush	26	28	728
Fairmount	40	10	400
	158		5,247
Total Back Bay Portal	319		15,477
South Bay Portal			
Origin/Destination for Paired Routes			
Greenbush-Rockport	26	64	1,664
Plymouth-Fitchburg	24	70	1,680
Forge Park (Franklin)-Haverhill	42	64	2,688
South Attleboro-Lowell	48	70	3,360
Middleborough-Newburyport	26	74	1,924
	166		11,316
Origin/Destination for Boston Only Trains			
Worcester	6	44	264
New Bedford/Fall River	36	57	2,052
Needham	32	13	416
Providence	24	44	1,056
North Easton	24	21	504
	122		4,292
Total South Bay Portal	288		15,608

Table 4.4-3 Two-Track (Back Bay Portal) Service — Morning Peak Period*

Corridor/Route Pattern	Number of Southbound AM Arrivals	Notes
North Side Lines		
Fitchburg Corridor		
Fitchburg Local	2	All stops from Fitchburg
Acton Local	2	All stops from Acton
Fitchburg Express	2	Skips Silver Hill through Porter Square
Lowell Corridor		
Lowell Local	6	All stops from Lowell
Lowell Express	1	Skips Wilmington and Wedgemere
Haverhill Corridor		
Haverhill Local	5	All stops from Haverhill
North Wilmington Local	1	All stops from North Wilmington
Haverhill Express (via NHML and Wildcat)**	1	Stops at Woburn RTC on NHML
North Shore Corridor***		
Rockport	5	
Newburyport	5	
Intercity Passenger Rail Service	3	Through-routed corridor trains
Total North Side Lines	33	
South Side Lines		
Worcester Corridor		
Worcester Express	3	All stops Worcester through West Natick
Framingham Local	5	
Needham Corridor		
Needham Heights Local	5	All stops from Needham Heights
Franklin/Dorchester Corridor		
Forge Park Express	5	All stops from Forge Park via Back Bay
Providence/Northeast Corridor		
Providence Express	6	All stops from Providence through Sharon ski
North Easton Local	6	All stops from North Easton
Fall River/New Bedford Service		
Fall River/New Bedford Express	6	
Intercity Passenger Rail Service	0	
Total South Side Lines	36	

* The morning peak period is defined as the hours between 6:00 AM and 9:00 AM. This includes stub-end and tunnel service.
** Both tandem express trains stop at Woburn/Route 128 and make all stops on their respective segments north of Wilmington.
*** Above trains make all stops on respective branches, with selected trains skipping Lynn, River Works, and Chelsea stations.

Table 4.4-4 Two-Track (South Bay Portal) Service — Morning Peak Period*

Corridor/Route Pattern	Number of Inbound AM Arrivals	Notes
North Side Lines		
Fitchburg Corridor		
Fitchburg Local	2	All stops from Fitchburg
Acton Local	2	All stops from Acton
Fitchburg Express	2	Skips Silver Hill through Porter Square
Lowell Corridor		
Lowell Local	6	All stops from Lowell
Lowell Express	1	Skips Wilmington and Wedgemere
Haverhill Corridor		
Haverhill Local	5	All stops from Haverhill
North Wilmington Local	1	All stops from North Wilmington
Haverhill Express (via NHML and Wildcat)	1	Stops at Woburn RTC on NHML
North Shore Corridor***		
Rockport	5	
Newburyport	5	
Intercity Passenger Rail Service	3	Peak hour has two trains per hour
Total North Side Lines	33	
South Side Lines		
Franklin/Dorchester Corridor		
Forge Park Local	2	All stops via Dorchester Branch
Norwood Central	5	
Providence/Northeast Corridor		
Providence Express	10	
Middleborough/Plymouth Corridor		
Middleborough	5	All stops, plus Braintree
Plymouth (Kingston)	4	All stops, plus Braintree
Greenbush Corridor		
Greenbush	5	All stops, plus Quincy
Intercity Passenger Rail Service	3	
Total South Side Lines	34	

* The morning peak period is defined as the hours between 6:00 AM and 9:00 AM. This includes stub-end and tunnel service.
** Both tandem express trains stop at Woburn/Route 128 and make all stops on their respective segments north of Wilmington.
*** Above trains make all stops on respective branches, with selected trains skipping Lynn, River Works, and Chelsea stations.

4.4.3.2 South Bay Portal

In the 2020 two-track Build (South Bay Portal) scenario, the total number of trainsets required to provide service is projected to decrease from 87 sets under No-Build conditions to 79 sets. Applying a 10 percent spare ratio, the overall fleet size under this scenario will need to be 87 locomotives. Assuming an average of 6.25 coaches per trainset, 544 coaches will be needed for the 2020 two-track Build (South Bay Portal) scenario. This is a reduction of 9 locomotives and 56 coaches in comparison to the No-Build Alternative. Table 4.4-5 summarizes the projected two-track Build Alternative equipment needs for the Back Bay and South Bay portal options. A comparison of the No-Build and Two-Track Build Alternatives equipment utilization is summarized in Table 4.4-6.

Table 4.4-5 Trainsets for Two-Track Build Service

Originating Terminal	Back Bay Portal Trainsets	South Bay Portal Trainsets	Notes
Fitchburg	5	5	Acton turns covered by through-running from South Side
Haverhill	6	6	North Wilmington covered by through-running from South Side
Lowell	6	6	Possibly some early morning deadheading from Boston
North Shore	5	5	Newburyport
	4	4	Rockport
	--	--	Beverly turn protected by through-running from South Side trains
Providence	7	11	Stored overnight, either at Providence, East Junction yard, or both
Fall River/New Bedford	5	5	Assumes routing via NEC
North Easton	5	5	If reverse peak service can be fit in, this number can be reduced
Franklin	7	7	For proposed zone express service
Norwood via Dorchester	2	2	
Needham	3	3	
Worcester/Framingham	7	7	
Greenbush	4	4	
Plymouth	4	4	
Middleborough	5	5	Extra consist can be a floater between all Old Colony lines
Total Trainsets	**75**	**79**	

Table 4.4-6 **Equipment Utilization for Two-Track Build Service**

	No-Build	Back Bay Portal	Difference	South Bay Portal	Difference
Train Miles*	6,351,195	4,462,535	1,888,660	4,500,307	1,850,888
Coach Miles	39,694,969	27,890,844	11,804,125	28,126,917	11,568,052
Equipment Requirements					
Locomotives	96	83	13	87	9
Coaches	600	519	81	544	56
Average Miles per Year					
Locomotives	66,158	53,765	12,393	51,728	14,430
Coaches	66,158	53,740	13,418	51,418	14,454

* Train miles calculated in Tables 3.2-2 and 4.4-2.

Cost Analysis

5

One of the most significant benefits of a rail tunnel is the anticipated savings in both capital equipment and annual operating costs resulting from more efficient utilization of the locomotive and passenger car fleet. The capability to provide run-through service is expected to:

- reduce non-revenue ("deadhead") movements of equipment,
- reduce the number of equipment turns required under congested terminal conditions,
- reduce the number of equipment sets required,
- provide direct access to equipment maintenance facilities, and
- improve utilization of train crews.

In addition, a rail tunnel would provide a significantly greater level of capacity to accommodate peak period train movements than the existing stub-end terminals at North and South stations.

The following sections of this chapter discuss the operating and capital equipment costs of the existing service and assess the impact on these costs associated with the No-Build and each of the Build Alternatives. The preliminary cost estimates prepared for the future 2020 No-Build and Build Alternatives are based on existing (1995) MBTA cost experience. Any savings or additional costs expected as a result of a rail tunnel have been noted and incorporated into the cost estimate.

5.1 Operating Costs

5.1.1 Unit Operating Cost

The annual operating cost reflects the total cost to provide the service. The MBTA commuter rail operating cost includes four components:

- Transportation—The costs associated with the personnel directly involved in the movement of trains and the cost to move (operate) the trains. This cost includes the salaries of locomotive engineers and conductors, train dispatchers, and other operating personnel.

- Mechanical—The costs to maintain the equipment. This cost includes the daily cleaning and maintenance of the equipment and all major overhaul and repair work.
- Engineering—The right-of-way and track maintenance costs. It includes items such as tie renewal, ballast cleaning, rail replacement, grade crossing maitenance, etc.
- Administrative—The costs to administer the service.

For the base year (1995), a fleet of 55 locomotives and 358 coaches, of which 45 locomotives and 255 coaches are in daily operation, provide this service. This fleet logged approximately 2.8 million train miles annually while providing 400 trains each weekday. The annual cost to operate this service is approximately $106 million, which equates to $37.86 per train mile. The $37.86 cost is apportioned among the four cost components as follows:

Transportation	37%	$14.00
Mechanical	27%	10.23
Engineering	23%	8.71
Administrative	13%	4.92
	100%	$37.86

For the 2020 No-Build Alternative, existing operating practices are assumed to continue. Therefore, the $37.86 per mile cost to operate the service was applied. With the Build alternatives, however, there are significant operating efficiencies expected with the run-through operation. For both the Four-Track Alternative and the Two-Track (Back Bay) Alternatives, these efficiencies include 12 fewer trainsets (13 locomotives and 81 coaches) and 328 daily trains as opposed to 663 under the 2020 No-Build Alternative. The Two-Track (South Bay) Alternative includes 8 fewer trainsets (87 locomotives and 544 coaches) and 288 daily trains. Based on these efficiencies, both the transportation and mechanical components of the unit operating cost can be reduced. It has been assumed that the engineering and administrative components will remain constant.

The reduction in the transportation component is directly related to the fewer sets of equipment and the expected increase in crew efficiency associated with the run-through service. As shown in Table 5.1-1, the number of trainsets is reduced by 14 percent for both the Four-Track and Two-Track (Back Bay) alternatives. The reduction is 9 percent for the Two-Track (South Bay) Alternative. In all three cases, crew efficiency is also expected to improve. With the Four-Track Alternative, a 14 percent increase in efficiency is expected. Both two-track alternatives are expected to experience approximately a 5 percent increase.

The reduction in the maintenance cost component is also related to the reduction in the number of trainsets and improved equipment utilization. In addition, this component needs to consider the increased cost of maintaining the dual mode locomotive rather than the existing fleet of diesel locomotives. To reflect these changes, the maintenance

component was adjusted based on the degree of difficulty associated with maintaining a particular piece of equipment. Each trailer coach was assumed to be equivalent to one maintenance unit, a control coach (1.5 units), diesel locomotives (2 units), and the dual mode locomotives (3 units). This maintenance unit assignment assumes that the dual mode locomotive requires 50 percent more maintenance than a diesel locomotive (2 units versus 3 units). This assumption is based on Amtrak's and Metro North Railroad's experience with maintaining both the first generation dual mode FL-9s and the second generation Genesis units. As a result, the maintenance component of the operating is projected to decrease by 4 percent for the Four-Track and Two-Track (Back Bay) Alternatives and increase by 1 percent for the Two-Track (South Bay) Alternative). Table 5.1-1 summarizes the changes in the unit operating costs for each alternative.

Table 5.1-1 **Unit Operating Cost Adjustments**

	No-Build		4-Track Build		2-Track Build (Back Bay)		2-Track Build (South Bay)	
	No.	Change	No.	Change	No.	Change	No.	Change
Transportation Component								
Number of Trainsets	87	--	75	14%	75	14%	79	9%
Increased Crew Efficiency	--	--	--	14%	--	5%	--	5%
Total	--	--	--	-28%	--	-19%		-14%
Mechancial Component								
Maitenance Units								
Diesel Locomotives	192		--		--		--	
Dual Mode Locomotives	---		249		249		261	
Trailer Coaches	450		389		389		408	
Control Coaches	225		195		195		204	
Total	867	--	833	-4%	833	-4%	873	+1%
Total Operating Cost								
Transportation (adjusted)	$14.00	37%	$10.08	30%	$11.34	34%	$12.04	33%
Mechanical (adjusted)	10.23	27%	9.83	29%	9.83	28%	10.30	29%
Engineering	8.71	23%	8.71	26%	8.71	25%	8.71	24%
Administrative	4.92	13%	4.92	15%	4.92	14%	4.92	14%
Total Unit Cost	$37.86	100%	$33.54	100%	$34.80	100%	$35.97	100%

With the adjustments summarized in the table, the total unit operating cost per train mile ranges from a high of $37.86 for the No-Build Alternative to $33.54 for the Four Track Build Alternative. The $33.54 unit cost represents an overall 13 percent reduction in the unit operating cost under the Full-Build Alternative. As noted, the single largest adjustment is reflected within the transportation component. The resultant transportation component share of 30 to 34 percent for the Build alternatives is resonable when compared to other commuter rail systems' cost experience. These other systems, as summarized in

Table 5.1-2, have a transportation component that ranges from 14 to 26 percent of the total operating cost.

Table 5.1-2 **Transportation Component Cost Comparison**

Property	Operating Expense (Million $)	Transportation Portion (Million $)	Transportation Portion of Operating Expense
SEPTA	--	--	26%
Southern California Regional Rail Authority (SCRRA)	$72 m	$12 m	17%
Tri-Rail	$21 m	$3 m	14%
Virginia Railway Express	$4 m	$0.5 m	13%
Metro North Railroad	$480 m	$82 m	17%
New Jersey Transit	$350 m	$80 m	23%

5.1.2 Preliminary Operating Cost Estimates

Preliminary annual operating costs were developed for the No-Build and three Build alternatives using the unit operating costs summarized in Table 5.1-1. The annual train miles used to develop the operating costs were previously reported in Chapter 3 for the No-Build Alternative and Chapter 4 for the Build alternatives. The results of the operating cost calculations are summarized in Table 5.1-3.

As shown in the Table 5.1-3, the total estimated annual operating cost for the 2020 No-Build scenario is $240.46 (1995 dollars). This is based on the projected daily train mileage of 6,351,195 miles and the unit operating cost of $37.85. Of the three Build alternatives, the Two-Track (Back Bay) Alternative yields the greatest anticipated annual savings of $86.72 million. The Four Track Alternative results in a projected savings of $62.09 million annually.

5.2 Capital Equipment Costs

The capital costs presented in this report represent only the equipment required to meet future 2020 No-Build and Build service. Capital costs for infrastructure are presented in Technical Report No. 3, *The Schematic Design Report*. The full financial analysis of each alternative is presented in the project's major investment study/draft envoronmental impact satatement/draft environmental impact report document (MIS/DEIS/DEIR).

Table 5.1-3 **Annual Operating Cost Summary (1995 Dollars)**

Alternative	Number of Service Days	Daily Train Miles*	Annual Train Miles	Unit Cost** ($/Train Mile)	Annual Operating Cost
No Build					
South Side Service					
Weekday Services	250	14,045	3,511,250		
Weekend Services	115	4,682	538,430		
North Side Service					
Weekday Services	250	7,982	1,995,550		
Weekend Services	115	2,661	306,015		
Totals			6,351,195	$37.86	$240,456,243
Two-Track (Back Bay)					
Weekday Services	250	15,477	3,869,250		
Weekend Services	115	5,159	593,285		
Totals			4,462,535	$34.80	$155,296,000
Two-Track (South Bay)					
Weekday Services	250	15,608	3,902,000		
Weekend Services	115	5,203	598,307		
Totals			4,500,307	$35.97	$161,561,000
Four-Track					
Weekday Services	250	18,607	4,651,750		
Weekend Services	115	6,202	713,268		
Totals			5,365,018	$33.54	$179,928,500

* Based on calculations in Table 4.4-2; weekend service is one third of weekday train miles.

** Based on existing MBTA cost experience and expected reductions in cost resulting from operational efficiencies.

Unit cost data used in this estimate included $4 million per dual-mode locomotive, $2.5 million per diesel locomotive, $1.2 million per trailer car, and $1.7 million per control car. The annualized cost was estimated by amortizing the capital costs over the useful life of the capital item. The amortization was performed using a discount rate of 7 percent in accordance with the latest federal guidelines for major investment studies. These costs are summarized in Table 5.2-1.

The No-Build Alternative requires 96 locomotives and 602 coaches. It is assumed that of the 602 coaches, 25 percent will be control cars and 75 percent trailer cars. The estimated capital equipment acquisition cost is approximately $1,037,900,000 (1995 dollars). The annualized cost of this purchase is $89.2 million.

Table 5.2-1 Equipment Cost Summary (1995 Dollars)

Unit	Number of Units	Unit Cost (millions)	Total Cost (millions)	Useful Life (years)	Annualization Factor	Annualized Capital Cost (millions)
No-Build						
Diesel Locomotives	96	$2.5	$240.0	25	0.086	$20.64
Coaches:						
➤ Trailer Cars	451	$1.2	541.2	25	0.086	46.54
➤ Control Cars	151	$1.7	256.7	25	0.086	22.08
Total			$1,037.9			$89.26
Two-Track Build (Back Bay)						
Dual Mode Locomotives	83	$4.0	$332.0	25	0.086	$28.55
Coaches:						
➤ Trailer Cars (75%)	389	$1.2	$466.8	25	0.086	$40.14
➤ Control Cars (25%)	130	$1.7	$221.0	25	0.086	$19.01
Total			$1,019.8			$87.7
Two-Track Build (South Bay)						
Dual Mode Locomotives	87	$4.0	$348.0	25	0.086	$29.93
Coaches						
➤ Trailer Cars (75%)	408	$1.2	$489.6	25	0.086	$42.11
➤ Control Cars (25%)	136	$1.7	$231.2	25	0.086	$19.88
Total			$1,068.8			$91.92
Four-Track Build						
Dual Mode Locomotives	83	$4.0	$332.0	25	0.086	$28.5
Coaches:						
➤ Trailer Cars (75%)	389	$1.2	$467.1	25	0.086	$19.0
➤ Control Cars (25%)	130	$1.7	$220.6	25	0.086	$40.2
Total			$1,019.8			$87.7

A run-through operation is expected to require 13 fewer locomotives and 81 coaches with the implementation of either the Four-Track or Two-Track (Back Bay) alternatives. This savings is estimated at $15.3 million, which is largely attributable to the reduction in number of coaches required. The total annualized capital cost is estimated at $87.7 million, which is $1.3 million less than the 2020 No-Build annualized cost of $89.2 million.

For the Two-Track (South Bay) Alternative, the equipment required to operate service is expected to cost approximately $33.8 million more than the 2020 No-Build Alternative and $49.1 million more than the Four-Track and Two-Track (Back Bay Portal) alternatives. There is a savings in the cost of the passenger cars because there is a reduction in the number of coaches and trailers required. Unlike the Four-Track and Two-Track (Back Bay Portal) alternatives, the savings in coach cost is outweighed by the increase in the cost of purchasing four additional dual-mode locomotives.

5.3 Summary of Costs

Both annual operating and equipment costs for the No-Build and three Build alternatives was presented in the previous sections of this chapter. The key cost numbers are summarized in Table 5.3-1. From an annual cost perspective, the Two-Track (Back Bay) Alternative yields the largest savings compared to the No-Build costs at an estimated $88.72 million. This savings is reflected in a $1.56 million reduction in annual capital equipment expenditures and a $87.16 million savings in operating costs. Although it yields an overall net savings of $76.24 million, the equipment costs for the Two-Track (South Bay) Alternative are $2.66 million higher than the No-Build. The Four-Track Alternative yields an annual cost savings of $62.09 million of which $1.56 million represents equipment cost savings and $60.53 million is savings in operations.

Table 5.3-1 Annual Equipment and Operating Cost Summary (1995 Dollars)

Alternative	Capital Equipment Cost (million $)	Annualized Capital Equipment Cost (million $)	Annual Operating Cost (million $)	Total Annual Cost (million $)	Comparison to No-Build (million $)
2020 No-Build	$1,037.90	$89.26	$240.46	$329.72	**NA**
2020 Two-Track Build (Back Bay Portal)	$1,019.80	$87.70	$153.30	$241.00	**($88.72)**
2020 Two-Track Build (South Bay Portal)	$1068.80	$91.92	$161.56	$253.48	**($76.24)**
2020 Four-Track Build	$1,019.80	$87.70	$179.93	$267.63	**($62.09)**

These results have provided a broad range of costs against which the four alternatives can be considered. The raw cost comparisons are skewed, however, because they represent different levels of service. One factor which can provide for a more equitable comparison is to examine

the cost per rider for each alternative. To bring this factor into consideration, the weekday daily ridership forecasts prepared for the MBTA regional rail system and reported in the *Ridership Methodology and Forecasting Study* were adjusted to an annual basis. Taking the total annual cost (operating and annualized equipment) and dividing by the annual ridership produces the total annual estimated cost per rider. These results are summarized in Table 5.3-2.

Table 5.3-2 **Annual Cost Per Rider (1995 Dollars)**

Alternative	Total Annual Cost (million $)	Projected Annual Ridership (millions)	Cost Per Rider ($)
2020 No-Build	$329.72	46.56	**$7.08**
2020 Two-Track Build (Back Bay Portal)	$241.00	53.62[1] 56.42[2]	**$4.49** **$4.27**
2020 Two-Track Build (South Bay Portal)	$253.48	50.25[1] 52.86[2]	**$5.04** **$4.80**
2020 Four-Track Build	$267.63	60.84[1] 63.63[2]	**$4.40** **$4.21**

Notes: (1) Two Station Alternative
(2) Three Station Alternative

As these results indicate, the Four-Track Alternative is the most cost-effective at $4.21 per annual rider. The $4.21 cost represents a $2.87 savings, or 40 percent reduction, compared to the No-Build Alternative. The Two-Track (Back Bay) Alternative is also quite cost-efficient at $4.31 per annual rider. This cost represents a 39 percent savings ($2.77) compared to the No-Build.

Summary

6

6.1 Summary of Findings

This report was prepared to identify the operational characteristics and develop equipment and operating costs for the No-Build and Build alternatives under consideration for the North-South Rail Link Study. A number of findings were identified relative to the equipment, operations, and cost of the future commuter rail system and the project alternatives. Among these findings are several critical considerations related to the No-Build Alternative including terminal capacity, infrastructure, and operational issues. The key findings relative to all the alternatives considered include the following:

1. Both major terminals, North Station and South Station, will develop significant capacity issues over the next ten years. While it is difficult to conclude at what point a railroad terminal reaches capacity, the study has pointed out that South Station capacity is a limiting factor in the development of the MBTA's South Side regional rail service. MBTA service planning for the South Side service, when considered in concert with Amtrak's proposed high-speed rail service increases, would put South Station at a utilization level in excess of 80 percent of peak-hour capacity and create a situation where: occupancy of the South Station terminal and interlocking would have to be very precisely timed, and delays would "cascade" rapidly into following trains and schedule recovery during a peak-hour period would be virtually impossible. The current size and physical inability to expand the South Station terminal limits the options to respond fully to ridership growth and market demand.

   North Station capacity appears to be a much less limiting factor for service development on the North Side. Current schedule planning for the North Side service for the 2020 No-Build scenario should be accommodated by the physical capacity present in North Station. The MBTA, however, may have the opportunity to retain two additional terminal tracks in North Station at the conclusion of ongoing construction work and should give careful consideration to taking advantage of that opportunity.

2. A positive impact is on the MBTA's ability to maintain and service its commuter rail equipment fleet. Current 2020 No-Build service

planning foresees 87 trainsets in daily service; 56 on the South Side and 31 on the North Side. The MBTA's major maintenance facility, the Boston Engine Terminal (BET), is located on the North Side of the city. A rail tunnel will create a direct "pull-ahead" rail connection for South Side service trainsets into BET for maintenance purposes and will eliminate the cumbersome process whereby equipment from the South Side fleet is taken out of service and/or returned to service via the costly late-night movements across the Grand Junction route through Cambridge.

3. Replacement of two stub-end terminal operation with a fully linked, North Side and South Side system allowing a train to pass through the center of Boston. The system changes from a commuter rail system to a regional rail system and will potentially move from a peak service to an all-day service.

4. Elimination of pull-back movements from the two stub-end terminals for servicing. Each trainset providing service in the regional rail system is scheduled for a service event each day. At the present time these service events also involve pull-back train movement, from North Station to the Boston Engine Terminal (BET)/Yard 14 facility on the North Side, and from South Station to the Southampton Street Service and Inspection (S&I) facility on the South Side. With construction of the tunnel, this pattern can be altered so that equipment servicing becomes a more efficient pull-ahead movement with trainsets operating in revenue service on the South Side going to the BET facility, and trainsets on the North Side going to a South Side facility.

5. This altered servicing opportunity also allows for a more balanced utilization of equipment maintenance resources, facilities and personnel. Boston Engine Terminal is currently undergoing a complete reconstruction and, when complete, will be the MBTA's primary commuter rail rolling stock maintenance facility. Sixty (60) percent of the rolling stock used in the system is assigned to the South Side service and this is expected to grow to 65 percent over the next 20 years service pattern which places the larger fleet into BET for servicing benefits the MBTA's use of maintenance facilities, and is only possible because of the existence of the tunnel.

   The existence of the tunnel would allow users of the system to move from any given point on the system to any other point on the system without changing to a different mode of transportation. For example, if a rider under today's conditions, wants to go from Attleboro, Massachusetts on the South Side to Rockport, Massachusetts on the North Side, that rider must use at least two commuter rail trains and two modes of transportation (i.e., commuter rail and Orange Line) with two transfers to complete a single journey. For the new Old Colony services, three transfers are required (commuter rail, Red Line, Orange Line, commuter rail). In transit planning, trying to sell a "three-seat" or "four-seat ride" is difficult. With the tunnel, the

entire journey is possible on one or two trains, given the set of north-south line pairings which would be implemented.

6. All aspects of service planning can be driven primarily by demand rather than by operations constraints with the tunnel.

7. Terminal capacity constraints, which are particularly severe at South Station, are significantly reduced by the introduction of "run-through" as opposed to "stub-end" terminal operations. This change reduces the amount of time that any given train occupies a terminal interlocking/station platform facility by approximately 60 percent (from the existing time of approximately 25 minutes to go through the interlocking, unload, load, reverse direction (or "change ends") and clear to the projected 10 minutes with the rail link tunnel). This is because in a run-through operation a train can unload its passengers and pull ahead into the rail line tunnel ahead of any following trains coming into the terminal interlocking/station. In "stub-end" operation, every train, once empty of its passengers, must pull back through the terminal interlocking into the face of oncoming inbound trains to begin its next assignment.

8. The operating plan assessed within this study presents a set of potential line pairings. The pairings can be changed as experience and developing ridership patterns indicate other line groupings that can attract higher numbers of riders. For the most part these pairings are based on demand-driven rather than operationally driven criteria. As discussed earlier these line pairs, furthermore, are relevant only for the construction of a four-track tunnel. If a rail link tunnel is constructed as a two-track tunnel with a two-track portal, only about half of the South Side service trains will run through the rail link tunnel, with the remainder continuing to operate on the surface into South Station due to the capacity constraints identified in the *Commuter Rail RAILSIM Report* (Technical Report No.6). All of the North Side trains would be scheduled through the tunnel in the two-track scenario.

6.2 Recommended Actions

This operations study identified that the four-track tunnel provides many benefits over the two-track tunnel from an operations standpoint. One of the most significant benefits of a rail tunnel, specifically with the four-track tunnel, is the anticipated savings in both equipment and operating costs resulting from more efficient utilization of the locomotive and passenger car fleet. The capability to provide run-through service is expected to: 1) reduce non-revenue ("deadhead") movements of equipment, 2) reduce the number of equipment turns required under congested terminal conditions, 3) reduce the number of equipment sets required, and 4) provide direct access to equipment maintenance facilities. In addition, a rail tunnel would provide a significantly greater

level of capacity to accommodate peak period train movements than the existing stub-end terminals at North and South stations.

In addition, the operations of a four-track tunnel offers the following advantages:

- Four tracks provide the capability to run more of the MBTA's daily regional service, including "pull-ahead" equipment-servicing moves through the tunnel.
- Increased equipment utilization adds to the overall operating efficiency and lowers operating cost.
- Every outlying MBTA station would have improved peak period service.
- The proposed operation could fit all existing service including the Dorchester Branch.
- Railroad operating patterns (such as zone express, skip-stop express, and tandem express) could be maximized to their fullest advantage.
- The four-track gives greater flexibility over the two-track tunnel, especially for any incidents or to get around the longer dwell times of the intercity trains.

Based on the results of this study, it is recommended that the following actions be considered:

- In advancing the four-track alternative, consideration should be given to a three-track portal at Back Bay and two-track portals in South Bay.
- A systemwide simulation including the Northeast Corridor should be undertaken to evaluate the full input of system constraints on No-Build and the selected Build Alternative operations.
- A detailed simulation of surface track operation be undertaken to determine capacity constraints for both South and North stations under 2020 No-Build in conjunction with a determination of the full 2020 No-Build service.
- Construction staging plans be developed for the five portal areas so that a full simulation can be conducted to assess the impacts of maintaining rail operations during construction.

Appendix

A.1 Existing Conditions (cont.)

A.1.1 Current MBTA Operations

The following page presents the number of trains that are operated on the MBTA system on a typical weekday[1].

[1] MBTA Railroad Operations Department

COMMUTER TRAIN PERFORMANCE

	TODAY NUMBER OPERATED	TODAY NUMBER ON TIME	TODAY PERCENT ON TIME	MONTH TO DATE NUMBER OPERATED	MONTH TO DATE NUMBER ON TIME	PERCENT CURRENT MO.	PERCENT PREVIOUS MO.
3 ATTLE/PVD	32	29	90.63	512	472	92.19	94
0 FRANKLIN	38	38	100	590	561	95.08	92
1 STOUGHTON	36	35	97.22	468	454	97.01	94
3 FRAMINGHAM	34	31	91.18	538	454	84.39	92
1 NEEDHAM	35	34	97.14	509	489	96.07	94
0 FAIRMONT	40	40	100	520	513	98.65	97
TOTAL TODAY	215	207	96.28	MIN. LATE 0-5	NO. TRAINS 207	MIN. LATE 16-20	NO. TRAINS 0
THIS MONTH	3137	2943	93.82	6-10 III	8	over 20	0
				11-15	0		

	TODAY NUMBER OPERATED	TODAY NUMBER ON TIME	TODAY PERCENT ON TIME	MONTH TO DATE NUMBER OPERATED	MONTH TO DATE NUMBER ON TIME	PERCENT CURRENT MO.	PERCENT PREVIOUS MO.
EASTERN	64	62	96.88	946	919	97.15	97
READING	44	44	100	644	614	95.34	93
NEW HAMP.	42	41	97.62	642	604	94.08	72
FITCHBURG	32	24	75.00	507	383	75.54	72
TOTAL TODAY	182	171	93.96	MIN. LATE 0-5	NO. TRAINS 171	MIN. LATE 16-20	NO. TRAINS 4
THIS MONTH	2739	2520	92.00	6-10	5	over 20	1
				11-15	1		

TOTAL MBTA TRAINS...NORTH & SOUTH...

	TODAY NUMBER OPERATED	TODAY NUMBER ON TIME	TODAY PER CENT ON TIME	MONTH TO DATE NUMBER OPERATED	MONTH TO DATE NUMBER ON TIME	PERCENT CURRENT MO.	PERCENT PREVIOUS MO.
TOTALS	397	378	95.21	5876	5463	92.97	90

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A.1 Existing Conditions (cont.)

A.1.2 Current Equipment Cycles

Existing equipment cycles for northside and southside trains are shown in Table A.1-1 and A.1-2, respectively. For the northside service, the letter "H" which appears in the daily assignment for each trainset indicates the place in this trainset's assignment when it is sent to BET (or the "House" denoted as "H") for servicing. For the southside service assignment sheet, the daily servicing event is denoted as "SH" for Southampton Street, the site of the MBTA's southside service maintenance facility.

A.1 Existing Conditions (cont.)

Table A.1-1 **Weekday Equipment Cycles for Northside Commuter Service Effective June 1994**

Set	Consist		Next Day
A	E/4K	102-151-160-H-169-176-177-182-185	152
B	E/5C	106-H-215-222-175-180-093-094-475-476-439	408
C	E/6C	108-H-321-324-325-328-333	308
D	E/4K	110-H-117-124-467-468-433	404
E	E/4K	152-153-162-319-322-323-326-327-330-335-338-H-401	412
F	E/5C	154-061-062-SER-217-226-227-236-287-290-291-292-293-294-245-200-201	202
G	E/6C	156-157-164-H-431	410
H	E/5C	158-063-064-113-120-465-466-471-472-437-438-H	105
I	E/5C	202-203-214-H-125-128-131	106
J	E/5C	204-255-260-209-218-H-277-280-183	158
K	E/5C	206-257-262-261-266-263-270-H-331-336-337-340-341-344-345	302
L	E/6C	208-109-116-423-424-429-434-H	301
M	E/6C	H-301-306-314-165-172-129	108
N	E/5C	302-305-310-311-316-317-320-H-281-284-285-288-239	204
O	E/4K	304-307-312-315-318-067-068-H137-142-145	102
P	E/6C	308-161-168-H-133-136-191-O96-O95	156
Q	E/4K	404-453-454-H-269-274-127-134-187-188-143	110
R	E/5C	408-455-456-H-065-066-181	154
S	E/6C	410-417-418-H-231	208
T	E/4K	412-419-420-SER-329-334-H-339-342-343	304
U	E/5C	H-105-112-421-422-275-278-279-282-233	206

A.1 Existing Conditions (cont.)

Table A.1-2 Weekday Equipment Cycles for Southside Commuter Service Effective April 1995

Set	Consist		
A	E-	(East Jct.)	DH So Attle-800-503-510-611-612-SH-811-818-515-522-527-526-531-530-530-SH
B	E-9	(East Jct.)	DH Prov-802-505-512-SH-SH-815-822-725-726-827-PX-PX
C	E-9	(East Jct.)	DH-Prov-804-SH511-518-875-876-817-DH East Jct.
D	E-9	(East Jct.)	DH SoAttle-808-507-514-509-516-SH-919-922-727-728-731-PX
E	E-9	(Franklin)	DH FrPk-704-753-754-SH-711-718-719-DH-Franklin
F	E-9	(Franklin)	DH FrPk-706-SH-915-918-879-880-721-724-SH
G	E-8	(Franklin)	DH FrPk-708-SH-SH-715-715-PX-FRANK
H	E-6	(Boston)	DH-PX-602-907-908-SH-619-620-625-625-DH-PX
I	E-7	(Boston)	DH-PX-604-609-610-610-SH-SH615-616-623-624-631-630-635-634-SH
J	E-7	(Worces)	PX-PX-550-751-752-752-SH-617-617-618-571-571-PX-PX
K	E-7	(Worces)	PX-PX-552-705-712-712-SH-SH-513-513-520-567-PX-PX
L	E-5	(Worces)	PX-PX-558-707-714-714-SH-SH-977-978-573-PX
M	E-7	(Boston)	SH-501-504-831-832-613-614-614-SH-SH-921-921-924-529-528-528-SH
N	E-7	(Boston)	SH-501-501-506-506-SH-SH-759-759-760-923-926-926-SH
O	E-6	(Boston)	SH-PX-Fram-PXSH-SH-621-621-622-835-836-825-826-SH
P	E-6	(Boston)	SH-803-810-807-814-814-SH-SH-519-519-524-SH
Q	E-6	(Boston)	SH-901-901-904-805-812-812-SH-SH-525-525-526-526-SH
R	E-7	(Boston)	SH-903-903-902-645-652-709-716-716-SH-Sh-917-917-920-627-626-823-824-SH
S	E-7	(Boston)	SH-801-801-806-909-910-910-SH-SH-713-713-720-819-PX-PX
T	E-7	(Boston)	SH-701-701-710-710-SH-SH-913-913-916-717-722-925-928-729-730-730-SH
U	E-6	(Boston)	SH-643-650-605-608-912-912-809-8126-816-SH-821-PX-PX
V	E-7	(Boston)	SH-701-701-702-905-906-906-SH-SH-813-813-820-723-724-633-632-632-SH
W	E-4	(Boston)	SH-703-703-700-025-026-029-030-037-038-041-042-043-044-044-SH-SH-055-055-056-059-070-073-074-629-628-927-930-533-532-532-SH
X	E-4	(Boston)	SH-023-023-024-027-028 031-032-032-SH-SH045-045-046-047-048-049-050-053-054-071-072-075-076-077-078-079-080-081-082-929-932-932-SH

A.1 Existing Conditions (cont.)

A.1.3 South Station and North Station Platforms

The following tables and figures present the lengths and capacities of the existing South Station and North Station platforms and platform tracks.

Table A.1-3 South Station Platforms and Platform Tracks

Track Number	Platform	Platform Length: Length (feet)	Platform Length: Bumper To South End (1)	Track Capacity: Maximum Train Length (2)	Track Capacity: Design Capacity	Track Capacity: Observed (3)
	A	740				
1			728	7	1E+8C+72'	NA
2			801	8	1E+8C+77'	NA
	B	860				
3			840	9	1E+10C+38'	NA
4			986	9+	1E+10C+43'	NA
	C	1,025				
5			1,023	9+	2E+12C+53'	NA
6			983	9+	2E+12C+58'	NA
	D	1,140				
7			1,018	9+	2E+14C+38'	2E+11C
8			1,223	9+	2E+14C+28'	2E+11C
	E	1,225				
9			1,261	9+	2E+14C+56'	2E+13C
10			1,256	9+	2E+13C+76'	2E+13C
	F	1,245				
11			1,056	9+	2E+13C+45'	1E+7C
12			704	7	1E+8C+35'	1E+7C
	G	715				
13			588	6	1E+6C+75'	1E+6C
	H	540				

Note 1: Field observations recorded June 11, 1996 by VHB. Measurement is from the face of the track bumper to the south end of the platform.

Note 2: Based on bumper to end of platform measurement and locomotive length of 65 feet, coach length of 85 feet (1E/9C=830', 1E/8C=745', 1E/7C=660', 1E/6C=575', 1E/5C=490')

Note 3: Field observations recorded April 26, 1996 by CTPS.

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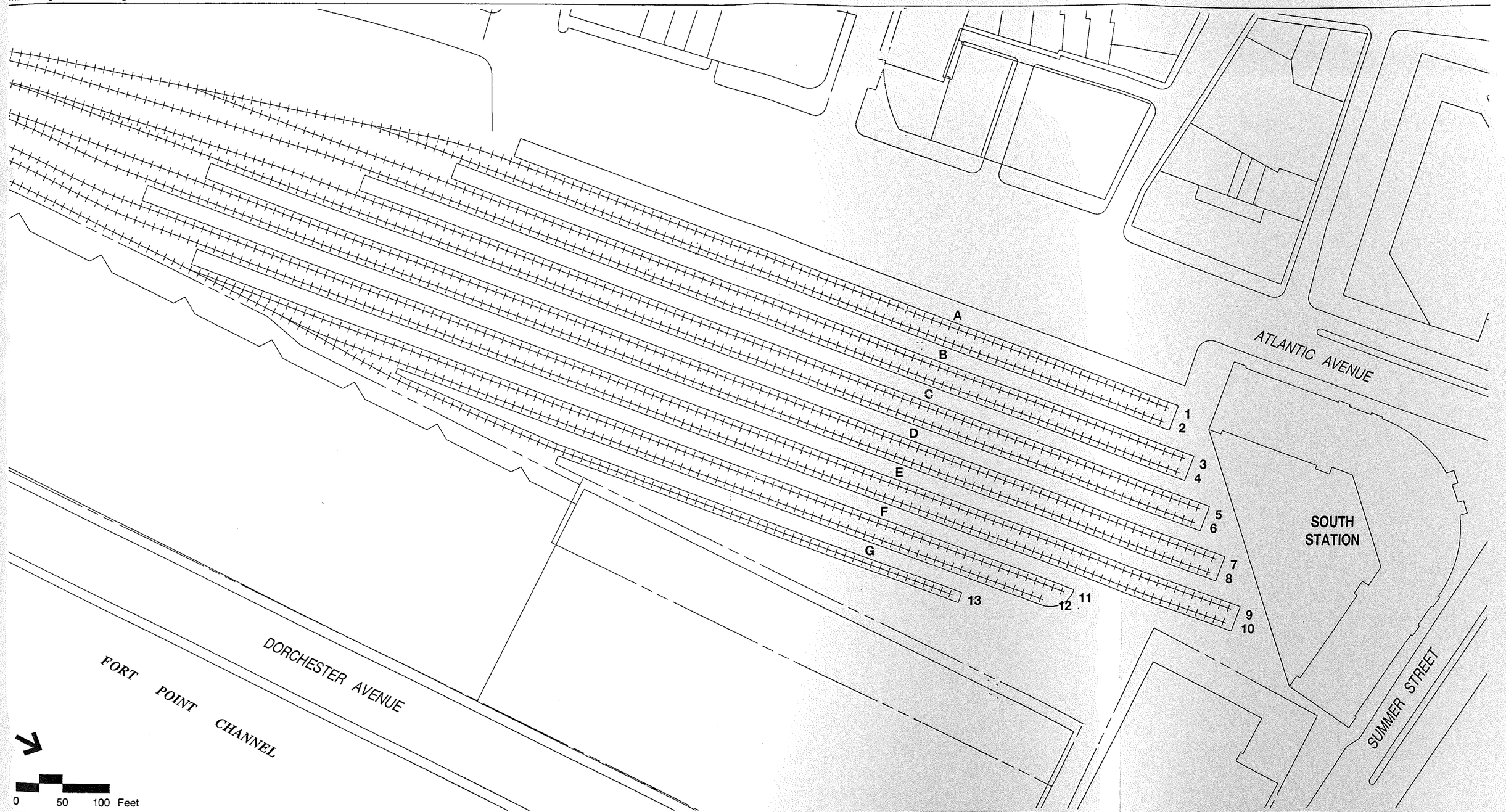

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South Station Layout

Figure A.1-1

A.1 Existing Conditions (cont.)

Table A.1-4 North Station Platforms and Platform Tracks

Track Number	Platform	Length (feet)	Track Capacity: Maximum Train Length	Track Capacity: Design	Track Capacity: Observed (1)
1				1E+9C	
	A	717			
2			7	1E+9C	NA
3			8	1E+8C	NA
	B	794			
4			9	1E+8C	NA
5			9+	1E+9C	NA
	C	827			
6			9+	1E+8C	NA
7			9+	1E+9C	NA
	D	901			
8			9+	1E+9C	2E+11C
9			9+	1E+9C	2E+11C
	E	916			
10			9+	1E+9C	2E+13C
11			9+	1E+8C	2E+13C
	F	832			
12			9+	1E+8C	1E+7C

Note 1: Field observations recorded April 26, 1996 by CTPS.

A.1 Existing Conditions (cont.)

A.1.4 MBTA System Utilization

The following presents the estimated existing MBTA System Utilization for the north and southside systems. The methods used to estimate the utilization is as follows:

- The peak hour train numbers were taken from the MBTA commuter rail schedules (based on the April 15, 1996 schedules). The morning peak hour was assumed to be 6:30 Am to 9:00AM and the evening peak hour was assumed to be 4:00PM to 6:30PM.

- An average number of seats for single-level and bi-level coaches were estimated based on the existing MBTA equipment.

- The train consists that correspond to the trains number produced above were developed based on the existing MBTA equipment schedules (Appendix A.1.2).

- The average number of seats per train was calculated based on the consist and the average number of seats per coach.

- This number of seats available was then compared to the existing ridership to develop the percent utilization. The existing ridership was estimated by finding the ridership on each train number described above from the May 1995 MBTA Commuter Rail Ridership Survey.

Existing MBTA System Utilization

North System

Morning Peak Period

	Number of Seats	Peak Period Ridership	Percent Utilization
Fitchburg	2,694	2,217	82%
Lowell	2,658	2,443	92%
Haverhill	3,534	2,350	66%
Ipswich	4,554	2,621	58%
Rockport	1,974	1,517	77%
	15,414	11,148	75%

Evening Peak Period

Fitchburg	3,394	2,653	78%
Lowell	3,438	2,810	82%
Haverhill	4,262	3,141	74%
Ipswich	1,868	1,521	81%
Rockport	2,666	1,823	68%
	15,628	11,948	77%

South System

Morning Peak Period

Worcester	5,672	4,285	76%
Needham	4,736	2,890	61%
Franklin	7,646	4,839	63%
Fairmont	2,280	958	42%
Attleboro	7,214	5,546	77%
Stoughton	3,028	2,907	96%
	30,576	21,425	69%

Evening Peak Period

Worcester	6,124	4,635	76%
Needham	4,396	3,217	73%
Franklin	7,238	4,601	64%
Fairmont	1,824	705	39%
Attleboro	5,234	4,688	90%
Stoughton	5,398	3,059	57%
	30,214	20,905	66%

Assumptions:

Morning Peak Period Arrivals: 6:30AM-9:00AM
Evening Peak Period Arrivals: 4:00PM-6:30PM
Trains based on April 15, 1996 MBTA Schedules
Consists based on the Weekday Equipment Cycles from the MBTA (effective April 1995)
Ridership based on Commuter Rail Ridership Survey May 1995 from the MBTA

Average Number of Seats on Single- and Bi-Level Coaches

	Type of Coach	Number of Coaches	Number of Seats/Coach	Total Number of Seats
Single level				
Bombardier	Blind	54	122	6,588
Bombardier	Control	53	122	6,466
MBB	Blind	33	96	3,168
MBB	Control	34	94	3,196
Bombardier	Blind	39	127	4,953
TOTAL:		213	561	24,371
Average Number of Seats:				114
Bi-level				
Kawasaki	Blind	50	185	9,250
Kawasaki	Control	25	175	4,375
TOTAL:		75	360	13,625
Average Number of Seats:				182

Existing MBTA System Utilization

North System

Morning Peak Period (Arrivals)

(Train #)		Train Consist: Number of Bi-Levels	Train Consist: Number of Single Levels	Number of Seats: Bi-Levels (182 seat) 180	Number of Seats: Single Levels (114 seats) 114	Number of Seats: Total	Ridership by Train: Average
160	Ipswich	4		720	0	720	367
106	Rockport		5	0	570	570	470
108	Rockport		6	0	684	684	569
110	Rockport	4		720	0	720	478
152	Ipswich	4		720	0	720	247
162	Ipswich	4		720	0	720	310
154	Ipswich		5	0	570	570	310
62	Beverly (?)		5	0	570	570	306
156	Ipswich		6	0	684	684	481
158	Ipswich		5	0	570	570	600
202	Haverhill		5	0	570	570	274
204	Haverhill		5	0	570	570	390
260	Reading		5	0	570	570	403
206	Haverhill		5	0	570	570	448
262	Reading		5	0	570	570	127
208	Haverhill		6	0	684	684	708
306	Lowell		6	0	684	684	732
310	Lowell		5	0	570	570	580
304	Lowell	4		720	0	720	500
308	Lowell		6	0	684	684	631
404	Fitchburg	4		720	0	720	470
408	Fitchburg		5	0	570	570	647
410	Fitchburg		6	0	684	684	692
412	Fitchburg	4		720	0	720	408
24				5,040	10,374	15,414	11,148

	Number of Seats	Peak Period Ridership	Percent Utilization
Fitchburg	2,694	2,217	82%
Lowell	2,658	2,443	92%
Haverhill	3,534	2,350	66%
Ipswich	4,554	2,621	58%
Rockport	1,974	1,517	77%
	15,414		75%

Assumptions: Morning Peak Period Arrivals: 6:30AM-9:00AM
Evening Peak Period Arrivals: 4:00PM-6:30PM
Trains based on April 15, 1996 MBTA Schedules
Consists based on the Weekday Equipment Cycles from the MBTA (effective June 1994)
Ridership based on Commuter Rail Ridership Survey May 1995 from the MBTA

Existing MBTA System Utilization

North System

Evening Peak Period (Departures)

(Train #)		Consist: Number of Bi Levels	Consist: Number of Single Levels	Number of Seats: Bi-Levels (182 seat) 182	Number of Seats: Single Levels (114 seats) 114	Number of Seats: Total	Ridership by Train: Average
177	Ipswich	4		728	0	728	421
93	Haverhill		5	0	570	570	300
333	Lowell		6	0	684	684	740
467	Fitchburg	4		728	0	728	254
433	Fitchburg	4		728	0	728	709
327	Lowell	4		728	0	728	503
335	Lowell	4		728	0	728	433
227	Haverhill		5	0	570	570	529
431	Fitchburg		6	0	684	684	709
471	Fitchburg		5	0	570	570	388
131	Rockport		5	0	570	570	533
183	Ipswich		5	0	570	570	612
331	Lowell		5	0	570	570	602
429	Fitchburg		6	0	684	684	593
129	Rockport		6	0	684	684	512
281	Haverhill		5	0	570	570	506
67	Haverhill	4		728	0	728	229
133	Rockport		6	0	684	684	406
127	Rockport	4		728	0	728	372
181	Ipswich		5	0	570	570	488
231	Haverhill		6	0	684	684	737
329	Lowell	4		728	0	728	532
279	Haverhill		5	0	570	570	313
233	Haverhill		5	0	570	570	527
24				5,824	9,804	15,628	11,948

	Number of Seats	Peak Period Ridership	Percent Utilization
Fitchburg	3,394	2,653	78%
Lowell	3,438	2,810	82%
Haverhill	4,262	3,141	74%
Ipswich	1,868	1,521	81%
Rockport	2,666	1,823	68%
	15,628		77%

Assumptions:

Morning Peak Period Arrivals: 6:30AM-9:00AM

Evening Peak Period Arrivals: 4:00PM-6:30PM

Trains based on April 15, 1996 MBTA Schedules

Consists based on the Weekday Equipment Cycles from the MBTA (effective June 1994)

Ridership based on Commuter Rail Ridership Survey May 1995 from the MBTA

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North PM

Existing MBTA System Utilization

South System

Morning Peak Period (Arrivals)

(Train #)		Train Consist: Number of Bi-Levels	Train Consist: Number of Single Levels	Number of Seats: Bi-Levels (182 seat) 182	Number of Seats: Single Levels (114 seats) 114	Number of Seats: Total	Ridership by Train: Average
800	Attleboro	7	2	1,274	228	1,502	716
510	Worcester	7	2	1,274	228	1,502	873
802	Attleboro	7	2	1,274	228	1,502	1227
804	Attleboro	7	2	1,274	228	1,502	1309
808	Attleboro	7	2	1,274	228	1,502	1147
704	Franklin	6	1	1,092	114	1,206	856
706	Franklin	7	2	1,274	228	1,502	1078
708	Franklin	6	2	1,092	228	1,320	1328
602	Needham		6	0	684	684	760
604	Needham	6	1	1,092	114	1,206	816
550	Worcester	6	1	1,092	114	1,206	664
752	Franklin	6	1	1,092	114	1,206	25
552	Worcester		7	0	798	798	486
558	Worcester		5	0	570	570	579
504	Worcester		7	0	798	798	803
506	Worcester		7	0	798	798	880
904	Stoughton	5	1	910	114	1,024	1164
902	Stoughton		7	0	798	798	673
652	Needham		7	0	798	798	539
806	Attleboro	6	1	1,092	114	1,206	1147
710	Franklin	6	1	1,092	114	1,206	1098
650	Needham	5	1	910	114	1,024	334
608	Needham	5	1	910	114	1,024	441
702	Franklin	6	1	1,092	114	1,206	454
906	Stoughton	6	1	1,092	114	1,206	1070
26	Fairmont		4	0	456	456	146
30	Fairmont		4	0	456	456	206
24	Fairmont		4	0	456	456	134
28	Fairmont		4	0	456	456	309
32	Fairmont		4	0	456	456	163
30				20,202	10,374	30,576	21,425

	Number of Seats	Peak Period Ridership	Percent Utilization
Worcester	5,672	4,285	76%
Needham	4,736	2,890	61%
Franklin	7,646	4,839	63%
Fairmont	2,280	958	42%
Attleboro	7,214	5,546	77%
Stoughton	3,028	2,907	96%
	30,576		69%

Assumptions:

Morning Peak Period Arrivals: 6:30AM-9:00AM

Evening Peak Period Arriv. Morning Peak Period Arrivals: 6:30AM-9:00AM

Trains based on April 15, 1 Evening Peak Period Arrivals: 4:00PM-6:30PM

Consists based on the Weekday Equipment Cycles from the MBTA (effective April 1995)

Ridership based on Comm Based on April 15, 1996 MBTA Schedules

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Existing MBTA System Utilization

South System

Evening Peak Period (Departures)

(Train #)		Train Consist: Number of Bi-Levels	Train Consist: Number of Single Levels	Number of Seats: Bi-Levels (182 seat) 182	Number of Seats: Single Levels (114 seats) 114	Total	Ridership by Train Average
515	Worcester	7	2	1,274	228	1,502	643
815	Attleboro	7	2	1,274	228	1,502	1185
817	Attleboro	7	2	1,274	228	1,502	1367
919	Stoughton	7	2	1,274	228	1,502	1014
719	Franklin	6	1	1,092	114	1,206	1215
879	Stoughton	7	2	1,274	228	1,502	352
721	Franklin	7	2	1,274	228	1,502	1027
715	Franklin	6	2	1,092	228	1,320	848
619	Needham		6	0	684	684	510
625	Needham		6	0	684	684	812
623	Needham	6	1	1,092	114	1,206	882
571	Worcester	6	1	1,092	114	1,206	1242
567	Worcester		7	0	798	798	667
573	Worcester		5	0	570	570	471
921	Stoughton		7	0	798	798	658
759	Franklin		7	0	798	798	555
923	Stoughton		7	0	798	798	356
621	Needham	5	1	910	114	1,024	675
519	Worcester	5	1	910	114	1,024	768
525	Worcester	5	1	910	114	1,024	844
917	Stoughton		7	0	798	798	679
627	Needham		7	0	798	798	338
819	Attleboro	6	1	1,092	114	1,206	1304
717	Franklin/Fairmont	6	1	1,092	114	1,206	401
821	Attleboro	5	1	910	114	1,024	832
723	Franklin	6	1	1,092	114	1,206	555
55	Fairmont		4	0	456	456	124
59	Fairmont		4	0	456	456	221
73	Fairmont		4	0	456	456	102
71	Fairmont		4	0	456	456	258
30				18,928	11,286	30,214	20,905

	Number of Seats	Peak Period Ridership	Percent Utilization
Worcester	6,124	4,635	76%
Needham	4,396	3,217	73%
Franklin	7,238	4,601	64%
Fairmont	1,824	705	39%
Attleboro	5,234	4,688	90%
Stoughton	5,398	3,059	57%
	30,214		66%

Assumptions:
Morning Peak Period Arrivals: 6:30AM-9:00AM
Evening Peak Period Arrivals: 4:00PM-6:30PM
Trains based on April 15, 1996 MBTA Schedules
Consists based on the Weekday Equipment Cycles from the MBTA (effective April 1995)
Ridership based on Commuter Rail Ridership Survey May 1995 from the MBTA

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A.1 Existing Conditions (cont.)

A.1.5 Existing Crew Schedules

The following presents the existing crew schedules for the commuter rail system. These represent the average hours worked on a typical weekday for the assistant conductors and conductors. These hours are based on 1994 crew schedules received from the MBTA.

Summary of MBTA Commuter Rail System
Crew Work Schedules

Commuter Rail Assistant Conductors

Average Hours Worked on a Typical Weekday (Northside System):	8:03
Average Hours Worked on a Typical Weekday (Southside System):	6:36
Average Hours Worked on a Typical Weekday for Assistant Conductors on the Entire System:	7:10

Commuter Rail Conductors

Average Hours Worked on a Typical Weekday (Northside System):	8:33
Average Hours Worked on a Typical Weekday (Southside System):	9:26
Average Hours Worked on a Typical Weekday for Conductors on the Entire System:	8:59

Average Hours Worked on a Typical Weekday for Crews on the MBTA Commuter Rail System:	8:04

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MBTA Commuter Rail Crew Work Schedules

Northside System
Assistant Conductors

	Time 1		Time 2		Time 3		Hours 1	Hours 2	Hours 3	Total Hours
1	5:30 AM	10:11 AM	4:20 PM	6:50 PM			4:41	2:30	0:00	7:11
	5:30 AM	10:11 AM	4:20 PM	6:50 PM			4:41	2:30	0:00	7:11
	5:30 AM	10:11 AM	4:20 PM	6:50 PM			4:41	2:30	0:00	7:11
	5:30 AM	10:11 AM	4:20 PM	6:50 PM			4:41	2:30	0:00	7:11
	5:30 AM	10:11 AM	4:20 PM	6:50 PM			4:41	2:30	0:00	7:11
2	5:07 AM	9:34 AM	4:10 PM	6:07 PM			4:27	1:57	0:00	6:24
	5:07 AM	9:34 AM	4:10 PM	6:07 PM			4:27	1:57	0:00	6:24
	5:07 AM	9:34 AM	4:10 PM	6:07 PM			4:27	1:57	0:00	6:24
	5:07 AM	9:34 AM	4:10 PM	6:07 PM			4:27	1:57	0:00	6:24
	5:07 AM	9:34 AM	4:10 PM	6:07 PM			4:27	1:57	0:00	6:24
3	5:40 AM	11:46 AM	4:10 PM	6:48 PM			6:06	2:38	0:00	8:44
	5:07 AM	9:34 AM	4:10 PM	6:07 PM			4:27	1:57	0:00	6:24
	5:07 AM	9:34 AM	4:10 PM	6:07 PM			4:27	1:57	0:00	6:24
	5:07 AM	9:34 AM	4:10 PM	6:07 PM			4:27	1:57	0:00	6:24
	5:07 AM	9:34 AM	4:10 PM	6:07 PM			4:27	1:57	0:00	6:24
4	5:32 AM	12:46 PM	5:00 PM	6:48 PM			7:14	1:48	0:00	9:02
	5:32 AM	12:46 PM	5:00 PM	6:48 PM			7:14	1:48	0:00	9:02
	5:32 AM	12:46 PM	5:00 PM	6:48 PM			7:14	1:48	0:00	9:02
	5:32 AM	12:46 PM	5:00 PM	6:48 PM			7:14	1:48	0:00	9:02
	10:40 AM	7:43 PM					9:03	0:00	0:00	9:03
5	6:00 AM	8:28 AM	1:50 PM	7:21 PM			2:28	5:31	0:00	7:59
	6:00 AM	8:28 AM	1:50 PM	7:21 PM			2:28	5:31	0:00	7:59
	6:00 AM	8:28 AM	1:50 PM	7:21 PM			2:28	5:31	0:00	7:59
	6:00 AM	8:28 AM	1:50 PM	7:21 PM			2:28	5:31	0:00	7:59
	6:00 AM	8:28 AM	1:50 PM	7:21 PM			2:28	5:31	0:00	7:59
6	6:32 AM	11:30 AM	4:35 PM	8:22 PM			4:58	3:47	0:00	8:45
	6:32 AM	11:30 AM	4:35 PM	8:22 PM			4:58	3:47	0:00	8:45
	6:32 AM	11:30 AM	4:35 PM	8:22 PM			4:58	3:47	0:00	8:45
	6:32 AM	11:30 AM	4:35 PM	8:22 PM			4:58	3:47	0:00	8:45
	6:32 AM	11:30 AM	4:35 PM	8:22 PM			4:58	3:47	0:00	8:45
7	3:06 PM	11:59 PM	12:00 AM	12:47 AM			8:53	0:47	0:00	9:40
	3:06 PM	11:59 PM	12:00 AM	12:47 AM			8:53	0:47	0:00	9:40
	3:06 PM	11:59 PM	12:00 AM	12:47 AM			8:53	0:47	0:00	9:40
	3:06 PM	11:59 PM	12:00 AM	12:47 AM			8:53	0:47	0:00	9:40
	9:57 AM	7:20 PM					9:23	0:00	0:00	9:23
8	6:14 AM	7:59 AM	3:00 PM	7:40 PM			1:45	4:40	0:00	6:25
	6:14 AM	7:59 AM	3:00 PM	7:40 PM			1:45	4:40	0:00	6:25
	6:14 AM	7:59 AM	3:00 PM	7:40 PM			1:45	4:40	0:00	6:25
	8:40 AM	2:03 PM	3:40 PM	5:03 PM			5:23	1:23	0:00	6:46
	9:55 AM	7:00 PM					9:05	0:00	0:00	9:05
9	3:06 AM	11:59 PM	12:00 AM	12:47 AM			20:53	0:47	0:00	21:40
	6:14 AM	7:59 AM	3:00 PM	7:40 PM			1:45	4:40	0:00	6:25
	6:14 AM	7:59 AM	3:00 PM	7:40 PM			1:45	4:40	0:00	6:25
	3:57 PM	11:59 PM	12:00 PM	12:52 AM			8:02	12:52	0:00	20:54
	1:40 PM	3:30 PM	8:10 PM	11:59 PM	1:00 PM	2:01 PM	1:50	3:49	1:01	6:40
10	4:41 AM	9:05 AM	11:55 AM	1:45 PM			4:24	1:50	0:00	6:14
	4:41 AM	9:05 AM	11:55 AM	1:45 PM			4:24	1:50	0:00	6:14
	4:41 AM	9:05 AM	11:55 AM	1:45 PM			4:24	1:50	0:00	6:14
	4:41 AM	9:05 AM	11:55 AM	1:45 PM			4:24	1:50	0:00	6:14
	4:41 AM	9:05 AM	11:55 AM	1:45 PM			4:24	1:50	0:00	6:14
11	5:31 AM	10:37 AM	4:40 PM	6:35 PM			5:06	1:55	0:00	7:01
	5:31 AM	10:37 AM	4:40 PM	6:35 PM			5:06	1:55	0:00	7:01
	5:31 AM	10:37 AM	4:40 PM	6:35 PM			5:06	1:55	0:00	7:01
	5:31 AM	10:37 AM	4:40 PM	6:35 PM			5:06	1:55	0:00	7:01
	5:31 AM	10:37 AM	4:40 PM	6:35 PM			5:06	1:55	0:00	7:01
12	5:31 AM	7:44 AM	12:55 PM	6:35 PM			2:13	5:40	0:00	7:53
	5:31 AM	7:44 AM	12:55 PM	6:35 PM			2:13	5:40	0:00	7:53
	5:31 AM	7:44 AM	12:55 PM	6:35 PM			2:13	5:40	0:00	7:53
	5:31 AM	7:44 AM	12:55 PM	6:35 PM			2:13	5:40	0:00	7:53
	5:31 AM	7:44 AM	12:55 PM	6:35 PM			2:13	5:40	0:00	7:53
13	6:13 AM	8:19 AM	1:55 PM	7:00 PM			2:06	5:05	0:00	7:11
	5:31 AM	7:44 AM	12:55 PM	6:35 PM			2:13	5:40	0:00	7:53
	5:31 AM	7:44 AM	12:55 PM	6:35 PM			2:13	5:40	0:00	7:53
	5:31 AM	7:44 AM	12:55 PM	6:35 PM			2:13	5:40	0:00	7:53
	5:31 AM	7:44 AM	12:55 PM	6:35 PM			2:13	5:40	0:00	7:53
14	6:33 AM	8:19 AM	2:55 PM	7:37 PM			1:46	4:42	0:00	6:28
	6:33 AM	8:19 AM	2:55 PM	7:37 PM			1:46	4:42	0:00	6:28

MBTA Commuter Rail Crew Work Schedules

Assistant Conductors

	Time 1		Time 2		Time 3	Hours 1	Hours 2	Hours 3	Total Hours
	6:33 AM	8:19 AM	2:55 PM	7:37 PM		1:46	4:42	0:00	6:28
	6:33 AM	8:19 AM	2:55 PM	7:37 PM		1:46	4:42	0:00	6:28
	6:33 AM	8:19 AM	2:55 PM	7:37 PM		1:46	4:42	0:00	6:28
15	6:42 AM	8:48 AM	1:00 PM	7:00 PM		2:06	6:00	0:00	8:06
	6:42 AM	8:48 AM	1:00 PM	7:00 PM		2:06	6:00	0:00	8:06
	6:42 AM	8:48 AM	1:00 PM	7:00 PM		2:06	6:00	0:00	8:06
	6:42 AM	8:48 AM	1:00 PM	7:00 PM		2:06	6:00	0:00	8:06
	8:30 AM	5:53 PM				9:23	0:00	0:00	9:23
16	1:40 PM	11:59 PM	12:00 AM	12:36 AM		10:19	0:36	0:00	10:55
	1:40 PM	11:59 PM	12:00 AM	12:36 AM		10:19	0:36	0:00	10:55
	1:40 PM	11:59 PM	12:00 AM	12:36 AM		10:19	0:36	0:00	10:55
	1:40 PM	11:59 PM	12:00 AM	12:36 AM		10:19	0:36	0:00	10:55
	1:40 PM	11:59 PM	12:00 AM	12:36 AM		10:19	0:36	0:00	10:55
17	5:14 PM	11:59 PM	12:00 AM	1:39 AM		6:45	1:39	0:00	8:24
	5:14 PM	11:59 PM	12:00 AM	1:39 AM		6:45	1:39	0:00	8:24
	5:14 PM	11:59 PM	12:00 AM	1:39 AM		6:45	1:39	0:00	8:24
	5:14 PM	11:59 PM	12:00 AM	1:39 AM		6:45	1:39	0:00	8:24
	5:14 PM	11:59 PM	12:00 AM	1:39 AM		6:45	1:39	0:00	8:24
18	5:32 AM	9:23 AM	4:50 PM	6:33 PM		3:51	1:43	0:00	5:34
	5:32 AM	9:23 AM	4:50 PM	6:33 PM		3:51	1:43	0:00	5:34
	5:32 AM	9:23 AM	4:50 PM	6:33 PM		3:51	1:43	0:00	5:34
	5:32 AM	9:23 AM	4:50 PM	6:33 PM		3:51	1:43	0:00	5:34
	5:32 AM	9:23 AM	4:50 PM	6:33 PM		3:51	1:43	0:00	5:34
19	6:22 AM	11:00 AM	4:50 PM	6:33 PM		4:38	1:43	0:00	6:21
	6:22 AM	11:00 AM	4:50 PM	6:33 PM		4:38	1:43	0:00	6:21
	6:22 AM	11:00 AM	4:50 PM	6:33 PM		4:38	1:43	0:00	6:21
	6:22 AM	11:00 AM	4:50 PM	6:33 PM		4:38	1:43	0:00	6:21
	6:22 AM	11:00 AM	4:50 PM	6:33 PM		4:38	1:43	0:00	6:21
20	6:52 AM	12:30 PM	5:15 PM	7:09 PM		5:38	1:54	0:00	7:32
	6:52 AM	12:30 PM	5:15 PM	7:09 PM		5:38	1:54	0:00	7:32
	6:52 AM	12:30 PM	5:15 PM	7:09 PM		5:38	1:54	0:00	7:32
	6:52 AM	12:30 PM	5:15 PM	7:09 PM		5:38	1:54	0:00	7:32
	6:52 AM	12:30 PM	5:15 PM	7:09 PM		5:38	1:54	0:00	7:32
21	6:38 AM	8:48 AM	1:00 PM	7:00 PM		2:10	6:00	0:00	8:10
	6:48 AM	8:07 AM	12:50 PM	6:29 PM		1:19	5:39	0:00	6:58
	6:48 AM	8:07 AM	12:50 PM	6:29 PM		1:19	5:39	0:00	6:58
	6:30 AM	3:36 PM				9:06	0:00	0:00	9:06
	6:30 AM	1:46 PM				7:16	0:00	0:00	7:16
22	6:48 AM	8:07 AM	12:50 PM	6:29 PM		1:19	5:39	0:00	6:58
	6:48 AM	8:07 AM	12:50 PM	6:29 PM		1:19	5:39	0:00	6:58
	6:48 AM	8:07 AM	12:50 PM	6:29 PM		1:19	5:39	0:00	6:58
	6:39 AM	5:04 PM				10:25	0:00	0:00	10:25
	8:11 AM	4:08 PM	5:10 PM	6:42 PM		7:57	1:32	0:00	9:29
23	5:05 AM	3:14 PM				10:09	0:00	0:00	10:09
	5:05 AM	3:14 PM				10:09	0:00	0:00	10:09
	5:05 AM	3:14 PM				10:09	0:00	0:00	10:09
	5:05 AM	3:14 PM				10:09	0:00	0:00	10:09
	5:05 AM	3:14 PM				10:09	0:00	0:00	10:09
24	5:45 AM	1:30 PM	2:50 PM	4:14 PM		7:45	1:24	0:00	9:09
	5:45 AM	1:30 PM	2:50 PM	4:14 PM		7:45	1:24	0:00	9:09
	5:45 AM	1:30 PM	2:50 PM	4:14 PM		7:45	1:24	0:00	9:09
	5:45 AM	1:30 PM	2:50 PM	4:14 PM		7:45	1:24	0:00	9:09
	5:45 AM	1:30 PM	2:50 PM	4:14 PM		7:45	1:24	0:00	9:09
25	5:45 AM	12:14 PM	4:50 PM	6:20 PM		6:29	1:30	0:00	7:59
	5:45 AM	12:14 PM	4:50 PM	6:20 PM		6:29	1:30	0:00	7:59
	5:45 AM	12:14 PM	4:50 PM	6:20 PM		6:29	1:30	0:00	7:59
	5:45 AM	12:14 PM	4:50 PM	6:20 PM		6:29	1:30	0:00	7:59
	5:45 AM	12:14 PM	4:50 PM	6:20 PM		6:29	1:30	0:00	7:59
26	6:30 AM	7:59 AM	1:00 PM	7:03 PM		1:29	6:03	0:00	7:32
	6:30 AM	7:59 AM	1:00 PM	7:03 PM		1:29	6:03	0:00	7:32
	6:30 AM	7:59 AM	1:00 PM	7:03 PM		1:29	6:03	0:00	7:32
	6:30 AM	7:59 AM	1:00 PM	7:03 PM		1:29	6:03	0:00	7:32
	6:30 AM	7:59 AM	1:00 PM	7:03 PM		1:29	6:03	0:00	7:32
27	6:50 AM	1:15 PM	5:25 PM	7:03 PM		6:25	1:38	0:00	8:03
	6:50 AM	1:15 PM	5:25 PM	7:03 PM		6:25	1:38	0:00	8:03
	6:50 AM	1:15 PM	5:25 PM	7:03 PM		6:25	1:38	0:00	8:03
	6:50 AM	1:15 PM	5:25 PM	7:03 PM		6:25	1:38	0:00	8:03
	6:50 AM	1:15 PM	5:25 PM	7:03 PM		6:25	1:38	0:00	8:03

MBTA Commuter Rail Crew Work Schedules

Assistant Conductors

	Time 1		Time 2		Time 3	Hours 1	Hours 2	Hours 3	Total Hours
28	6:50 AM	8:29 AM	10:55 AM	5:51 PM		1:39	6:56	0:00	8:35
	6:50 AM	8:29 AM	10:55 AM	5:51 PM		1:39	6:56	0:00	8:35
	3:50 PM	11:59 PM	12:00 AM	1:13 AM		8:09	1:13	0:00	9:22
	3:50 PM	11:59 PM	12:00 AM	1:13 AM		8:09	1:13	0:00	9:22
	4:55 PM	11:59 PM	12:00 AM	1:13 AM		7:04	1:13	0:00	8:17
29	6:50 AM	8:29 AM	10:55 AM	5:51 PM		1:39	6:56	0:00	8:35
	6:50 AM	8:29 AM	10:55 AM	5:51 PM		1:39	6:56	0:00	8:35
	6:50 AM	8:29 AM	10:55 AM	5:51 PM		1:39	6:56	0:00	8:35
	6:30 AM	2:03 PM	3:40 PM	5:03 PM		7:33	1:23	0:00	8:56
	8:40 AM	5:03 PM				8:23	0:00	0:00	8:23
30	2:47 PM	11:54 PM				9:07	0:00	0:00	9:07
	2:47 PM	11:54 PM				9:07	0:00	0:00	9:07
	2:47 PM	11:54 PM				9:07	0:00	0:00	9:07
	2:47 PM	11:54 PM				9:07	0:00	0:00	9:07
	2:47 PM	11:54 PM				9:07	0:00	0:00	9:07
31	3:50 PM	11:59 PM	12:00 AM	1:13 AM		8:09	1:13	0:00	9:22
	3:50 PM	11:59 PM	12:00 AM	1:13 AM		8:09	1:13	0:00	9:22
	3:50 PM	11:59 PM	12:00 AM	1:13 AM		8:09	1:13	0:00	9:22
	4:40 PM	11:59 PM	12:00 AM	12:13 AM		7:19	0:13	0:00	7:32
	4:40 PM	11:59 PM	12:00 AM	12:13 AM		7:19	0:13	0:00	7:32
32	6:06 AM	1:14 PM	5:55 PM	7:29 PM		7:08	1:34	0:00	8:42
	6:06 AM	1:14 PM	5:55 PM	7:29 PM		7:08	1:34	0:00	8:42
	6:06 AM	1:14 PM	5:55 PM	7:29 PM		7:08	1:34	0:00	8:42
	6:06 AM	1:14 PM	5:55 PM	7:29 PM		7:08	1:34	0:00	8:42
	6:06 AM	1:14 PM	5:55 PM	7:29 PM		7:08	1:34	0:00	8:42
33	6:10 AM	10:35 AM	4:30 PM	6:47 PM		4:25	2:17	0:00	6:42
	6:10 AM	10:35 AM	4:30 PM	6:47 PM		4:25	2:17	0:00	6:42
	6:10 AM	10:35 AM	4:30 PM	6:47 PM		4:25	2:17	0:00	6:42
	6:10 AM	10:35 AM	4:30 PM	6:47 PM		4:25	2:17	0:00	6:42
	6:10 AM	10:35 AM	4:30 PM	6:47 PM		4:25	2:17	0:00	6:42
34	6:35 AM	8:40 AM	2:40 PM	7:10 PM		2:05	4:30	0:00	6:35
	6:10 AM	10:35 AM	4:30 PM	6:47 PM		4:25	2:17	0:00	6:42
	6:10 AM	10:35 AM	4:30 PM	6:47 PM		4:25	2:17	0:00	6:42
	6:10 AM	10:35 AM	4:30 PM	6:47 PM		4:25	2:17	0:00	6:42
	6:10 AM	10:35 AM	4:30 PM	6:47 PM		4:25	2:17	0:00	6:42
35	6:51 AM	12:20 PM	5:00 PM	6:28 PM		5:29	1:28	0:00	6:57
	6:51 AM	12:20 PM	5:00 PM	6:28 PM		5:29	1:28	0:00	6:57
	6:51 AM	12:20 PM	5:00 PM	6:28 PM		5:29	1:28	0:00	6:57
	6:51 AM	12:20 PM	5:00 PM	6:28 PM		5:29	1:28	0:00	6:57
	6:51 AM	12:20 PM	5:00 PM	6:28 PM		5:29	1:28	0:00	6:57
36	6:55 AM	9:06 AM	3:40 PM	8:11 PM		2:11	4:31	0:00	6:42
	6:55 AM	9:06 AM	3:40 PM	8:11 PM		2:11	4:31	0:00	6:42
	6:55 AM	9:06 AM	3:40 PM	8:11 PM		2:11	4:31	0:00	6:42
	6:55 AM	9:06 AM	3:40 PM	8:11 PM		2:11	4:31	0:00	6:42
	6:55 AM	9:06 AM	3:40 PM	8:11 PM		2:11	4:31	0:00	6:42
37	7:16 AM	8:40 AM	11:00 AM	6:03 PM		1:24	7:03	0:00	8:27
	7:16 AM	8:40 AM	11:00 AM	6:03 PM		1:24	7:03	0:00	8:27
	7:16 AM	8:40 AM	11:00 AM	6:03 PM		1:24	7:03	0:00	8:27
	7:16 AM	8:40 AM	11:00 AM	6:03 PM		1:24	7:03	0:00	8:27
	7:16 AM	8:40 AM	11:00 AM	6:03 PM		1:24	7:03	0:00	8:27
38	3:26 PM	11:42 PM				8:16	0:00	0:00	8:16
	3:26 PM	11:42 PM				8:16	0:00	0:00	8:16
	3:26 PM	11:42 PM				8:16	0:00	0:00	8:16
	2:25 PM	11:59 PM	12:00 AM	12:54 AM		9:34	0:54	0:00	10:28
	11:51 AM	1:21 PM	2:40 PM	10:47 PM		1:30	8:07	0:00	9:37
39	5:32 AM	12:46 PM	5:00 PM	6:48 PM		7:14	1:48	0:00	9:02
	3:26 PM	11:42 PM				8:16	0:00	0:00	8:16
	3:26 PM	11:42 PM				8:16	0:00	0:00	8:16
	9:00 AM	7:24 PM				10:24	0:00	0:00	10:24
	8:57 AM	7:07 PM				10:10	0:00	0:00	10:10

South System
Assistant Conductors

	Time 1		Time 2		Time 3	Hours 1	Hours 2	Hours 3	Total Hours
1	3:10 AM	10:47 AM				7:37	0:00	0:00	7:37
	3:10 AM	10:47 AM				7:37	0:00	0:00	7:37

MBTA Commuter Rail Crew Work Schedules

Assistant Conductors

	Time 1		Time 2		Time 3		Hours 1	Hours 2	Hours 3	Total Hours
	3:10 AM	10:47 AM					7:37	0:00	0:00	7:37
	3:10 AM	10:47 AM					7:37	0:00	0:00	7:37
	3:10 AM	10:47 AM					7:37	0:00	0:00	7:37
2	4:20 AM	10:30 AM	4:55 PM	7:57 PM			6:10	3:02	0:00	9:12
	4:20 AM	10:30 AM	4:55 PM	7:57 PM			6:10	3:02	0:00	9:12
	4:20 AM	10:30 AM	4:55 PM	7:57 PM			6:10	3:02	0:00	9:12
	4:20 AM	10:30 AM	4:55 PM	7:57 PM			6:10	3:02	0:00	9:12
	4:20 AM	10:30 AM	4:55 PM	7:57 PM			6:10	3:02	0:00	9:12
3	4:45 AM	9:00 AM	4:40 PM	8:24 PM			4:15	3:44	0:00	7:59
	4:45 AM	9:00 AM	4:40 PM	8:24 PM			4:15	3:44	0:00	7:59
	4:45 AM	9:00 AM	4:40 PM	8:24 PM			4:15	3:44	0:00	7:59
	4:45 AM	9:00 AM	4:40 PM	8:24 PM			4:15	3:44	0:00	7:59
	4:45 AM	9:00 AM	4:40 PM	8:24 PM			4:15	3:44	0:00	7:59
4	5:05 AM	8:30 AM	4:15 PM	7:57 PM			3:25	3:42	0:00	7:07
	5:05 AM	8:30 AM	4:15 PM	7:57 PM			3:25	3:42	0:00	7:07
	5:05 AM	8:30 AM	4:15 PM	7:57 PM			3:25	3:42	0:00	7:07
	5:05 AM	8:30 AM	4:15 PM	7:57 PM			3:25	3:42	0:00	7:07
	5:05 AM	8:30 AM	4:15 PM	7:57 PM			3:25	3:42	0:00	7:07
5	6:03 AM	9:09 AM	5:45 PM	9:35 PM			3:06	3:50	0:00	6:56
	6:03 AM	9:09 AM	5:45 PM	9:35 PM			3:06	3:50	0:00	6:56
	6:03 AM	9:09 AM	5:45 PM	9:35 PM			3:06	3:50	0:00	6:56
	6:03 AM	9:09 AM	5:45 PM	9:35 PM			3:06	3:50	0:00	6:56
	6:03 AM	9:09 AM	5:45 PM	9:35 PM			3:06	3:50	0:00	6:56
6	3:30 PM	11:59 PM	12:00 AM	2:25 AM			8:29	2:25	0:00	10:54
	3:30 PM	11:59 PM	12:00 AM	2:25 AM			8:29	2:25	0:00	10:54
	3:30 PM	11:59 PM	12:00 AM	2:25 AM			8:29	2:25	0:00	10:54
	3:30 PM	11:59 PM	12:00 AM	2:25 AM			8:29	2:25	0:00	10:54
	3:30 PM	11:59 PM	12:00 AM	2:25 AM			8:29	2:25	0:00	10:54
7	4:03 PM	11:59 PM	12:00 AM	1:07 AM			7:56	1:07	0:00	9:03
	4:03 PM	11:59 PM	12:00 AM	1:07 AM			7:56	1:07	0:00	9:03
	4:03 PM	11:59 PM	12:00 AM	1:07 AM			7:56	1:07	0:00	9:03
	4:03 PM	11:59 PM	12:00 AM	1:07 AM			7:56	1:07	0:00	9:03
	4:03 PM	11:59 PM	12:00 AM	1:07 AM			7:56	1:07	0:00	9:03
8	4:03 PM	11:59 PM	12:00 AM	1:01 AM			7:56	1:01	0:00	8:57
	4:03 PM	11:59 PM	12:00 AM	1:01 AM			7:56	1:01	0:00	8:57
	4:03 PM	11:59 PM	12:00 AM	1:01 AM			7:56	1:01	0:00	8:57
	4:03 PM	11:59 PM	12:00 AM	1:01 AM			7:56	1:01	0:00	8:57
	4:03 PM	11:59 PM	12:00 AM	1:01 AM			7:56	1:01	0:00	8:57
9	4:20 AM	10:33 AM	12:50 PM	3:25 PM			6:13	2:35	0:00	8:48
	4:20 AM	10:33 AM	12:50 PM	3:25 PM			6:13	2:35	0:00	8:48
	4:20 AM	10:33 AM	12:50 PM	3:25 PM			6:13	2:35	0:00	8:48
	4:20 AM	10:33 AM	12:50 PM	3:25 PM			6:13	2:35	0:00	8:48
	6:15 AM	7:50 AM	12:25 PM	6:15 PM			1:35	5:50	0:00	7:25
10	6:03 AM	11:45 AM					5:42	0:00	0:00	5:42
	6:03 AM	11:45 AM					5:42	0:00	0:00	5:42
	6:03 AM	11:45 AM					5:42	0:00	0:00	5:42
	8:40 AM	12:50 PM	3:00 PM	7:35 PM			4:10	4:35	0:00	8:45
	11:10 AM	7:35 PM					8:25	0:00	0:00	8:25
11	6:03 AM	11:45 AM					5:42	0:00	0:00	5:42
	6:03 AM	11:45 AM					5:42	0:00	0:00	5:42
	4:25 PM	7:34 PM	8:35 PM	11:59 PM	12:00 AM	1:18	3:09	3:24	1:18	7:51
	11:17 AM	7:58 PM					8:41	0:00	0:00	8:41
	11:17 AM	12:50 PM	4:25 PM	7:58 PM			1:33	3:33	0:00	5:06
12	3:55 PM	11:04 PM					7:09	0:00	0:00	7:09
	3:55 PM	11:04 PM					7:09	0:00	0:00	7:09
	3:55 PM	11:04 PM					7:09	0:00	0:00	7:09
	10:15 AM	11:50 AM	4:25 PM	10:35 PM			1:35	6:10	0:00	7:45
	11:15 AM	12:50 PM	3:00 PM	8:35 PM			1:35	5:35	0:00	7:10
13	4:25 PM	7:34 PM	8:35 PM	11:59 PM	12:00 AM	1:18 AM	3:09	3:24	1:18	7:51
	4:25 PM	7:34 PM	8:35 PM	11:59 PM	12:00 AM	1:18 AM	3:09	3:24	1:18	7:51
	4:25 PM	7:34 PM	8:35 PM	11:59 PM	12:00 AM	1:18 AM	3:09	3:24	1:18	7:51
	4:25 PM	7:34 PM	8:35 PM	11:59 PM	12:00 AM	1:18 AM	3:09	3:24	1:18	7:51
	12:27 PM	9:58 PM					9:31	0:00	0:00	9:31
14	4:20 AM	10:33 AM	12:50 PM	3:25 PM			6:13	2:35	0:00	8:48
	3:55 PM	11:04 PM					7:09	0:00	0:00	7:09
	3:55 PM	11:04 PM					7:09	0:00	0:00	7:09
	8:15 AM	2:35 PM	7:00 PM	8:35 PM			6:20	1:35	0:00	7:55
	10:15 AM	6:15 PM					8:00	0:00	0:00	8:00

MBTA Commuter Rail Crew Work Schedules

Assistant Conductors

	Time 1		Time 2		Time 3		Hours 1	Hours 2	Hours 3	Total Hours
15	5:19 AM	9:39 AM	3:25 PM	4:57 PM			4:20	1:32	0:00	5:52
	5:19 AM	9:39 AM	3:25 PM	4:57 PM			4:20	1:32	0:00	5:52
	5:19 AM	9:39 AM	3:25 PM	4:57 PM			4:20	1:32	0:00	5:52
	5:19 AM	9:39 AM	3:25 PM	4:57 PM			4:20	1:32	0:00	5:52
	5:19 AM	9:39 AM	3:25 PM	4:57 PM			4:20	1:32	0:00	5:52
16	7:20 AM	9:05 AM	12:00 PM	4:57 PM			1:45	4:57	0:00	6:42
	7:20 AM	9:05 AM	12:00 PM	4:57 PM			1:45	4:57	0:00	6:42
	7:20 AM	9:05 AM	12:00 PM	4:57 PM			1:45	4:57	0:00	6:42
	7:20 AM	9:05 AM	12:00 PM	4:57 PM			1:45	4:57	0:00	6:42
	7:20 AM	9:05 AM	12:00 PM	4:57 PM			1:45	4:57	0:00	6:42
17	7:20 AM	9:05 AM	3:55 PM	7:35 PM			1:45	3:40	0:00	5:25
	7:20 AM	9:05 AM	3:55 PM	7:35 PM			1:45	3:40	0:00	5:25
	7:20 AM	9:05 AM	3:55 PM	7:35 PM			1:45	3:40	0:00	5:25
	7:20 AM	9:05 AM	3:55 PM	7:35 PM			1:45	3:40	0:00	5:25
	7:20 AM	9:05 AM	3:55 PM	7:35 PM			1:45	3:40	0:00	5:25
18	4:13 AM	9:39 AM	4:45 PM	7:23 PM			5:26	2:38	0:00	8:04
	4:13 AM	9:39 AM	4:45 PM	7:23 PM			5:26	2:38	0:00	8:04
	4:13 AM	9:39 AM	4:45 PM	7:23 PM			5:26	2:38	0:00	8:04
	4:13 AM	9:39 AM	4:45 PM	7:23 PM			5:26	2:38	0:00	8:04
	4:13 AM	9:39 AM	4:45 PM	7:23 PM			5:26	2:38	0:00	8:04
19	4:55 AM	10:04 AM	11:50 AM	3:48 PM			5:09	3:58	0:00	9:07
	4:55 AM	10:04 AM	11:50 AM	3:48 PM			5:09	3:58	0:00	9:07
	4:55 AM	10:04 AM	11:50 AM	3:48 PM			5:09	3:58	0:00	9:07
	4:55 AM	10:04 AM	11:50 AM	3:48 PM			5:09	3:58	0:00	9:07
	4:55 AM	10:04 AM	11:50 AM	3:48 PM			5:09	3:58	0:00	9:07
20	5:18 AM	11:11 AM	4:45 PM	7:23 PM			5:53	2:38	0:00	8:31
	5:18 AM	11:11 AM	4:45 PM	7:23 PM			5:53	2:38	0:00	8:31
	5:18 AM	11:11 AM	4:45 PM	7:23 PM			5:53	2:38	0:00	8:31
	5:18 AM	11:11 AM	4:45 PM	7:23 PM			5:53	2:38	0:00	8:31
	5:18 AM	11:11 AM	4:45 PM	7:23 PM			5:53	2:38	0:00	8:31
21	5:18 AM	8:18 AM	5:15 PM	7:48 PM			3:00	2:33	0:00	5:33
	5:18 AM	8:18 AM	5:15 PM	7:48 PM			3:00	2:33	0:00	5:33
	5:18 AM	8:18 AM	5:15 PM	7:48 PM			3:00	2:33	0:00	5:33
	5:18 AM	8:18 AM	5:15 PM	7:48 PM			3:00	2:33	0:00	5:33
	5:18 AM	8:18 AM	5:15 PM	7:48 PM			3:00	2:33	0:00	5:33
22	5:50 AM	9:05 AM	2:20 PM	8:41 PM			3:15	6:21	0:00	9:36
	5:50 AM	9:05 AM	2:20 PM	8:41 PM			3:15	6:21	0:00	9:36
	5:50 AM	9:05 AM	2:20 PM	8:41 PM			3:15	6:21	0:00	9:36
	5:50 AM	9:05 AM	2:20 PM	8:41 PM			3:15	6:21	0:00	9:36
	5:50 AM	9:05 AM	2:20 PM	8:41 PM			3:15	6:21	0:00	9:36
23	2:18 PM	11:59 PM	12:00 AM	12:08 AM			9:41	0:08	0:00	9:49
	2:18 PM	11:59 PM	12:00 AM	12:08 AM			9:41	0:08	0:00	9:49
	2:18 PM	11:59 PM	12:00 AM	12:08 AM			9:41	0:08	0:00	9:49
	2:18 PM	11:59 PM	12:00 AM	12:08 AM			9:41	0:08	0:00	9:49
	2:18 PM	11:59 PM	12:00 AM	12:08 AM			9:41	0:08	0:00	9:49
24	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
25	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
	5:53 AM	9:40 AM	2:55 PM	6:00 PM			3:47	3:05	0:00	6:52
26	5:53 AM	9:23 AM	4:45 PM	6:28 PM			3:30	1:43	0:00	5:13
	5:53 AM	9:23 AM	4:45 PM	6:28 PM			3:30	1:43	0:00	5:13
	5:53 AM	9:23 AM	4:45 PM	6:28 PM			3:30	1:43	0:00	5:13
	5:53 AM	9:23 AM	4:45 PM	6:28 PM			3:30	1:43	0:00	5:13
	5:53 AM	9:23 AM	4:45 PM	6:28 PM			3:30	1:43	0:00	5:13
27	6:31 AM	8:18 AM	12:35 PM	6:28 PM			1:47	5:53	0:00	7:40
	6:31 AM	8:18 AM	12:35 PM	6:28 PM			1:47	5:53	0:00	7:40
	6:31 AM	8:18 AM	12:35 PM	6:28 PM			1:47	5:53	0:00	7:40
	6:31 AM	8:18 AM	12:35 PM	6:28 PM			1:47	5:53	0:00	7:40
	6:31 AM	8:18 AM	12:35 PM	6:28 PM			1:47	5:53	0:00	7:40
28	6:30 AM	8:18 AM	4:15 PM	6:00 PM			1:48	1:45	0:00	3:33
	6:30 AM	8:18 AM	4:15 PM	6:00 PM			1:48	1:45	0:00	3:33
	6:30 AM	8:18 AM	4:15 PM	6:00 PM			1:48	1:45	0:00	3:33

MBTA Commuter Rail Crew Work Schedules

Assistant Conductors

	Time 1		Time 2		Time 3		Hours 1	Hours 2	Hours 3	Total Hours
	6:30 AM	8:18 AM	4:15 PM	6:00 PM			1:48	1:45	0:00	3:33
	6:30 AM	8:18 AM	4:15 PM	6:00 PM			1:48	1:45	0:00	3:33
29	6:51 AM	12:05 PM	5:05 PM	6:56 PM			5:14	1:51	0:00	7:05
	6:51 AM	12:05 PM	5:05 PM	6:56 PM			5:14	1:51	0:00	7:05
	6:51 AM	12:05 PM	5:05 PM	6:56 PM			5:14	1:51	0:00	7:05
	6:51 AM	12:05 PM	5:05 PM	6:56 PM			5:14	1:51	0:00	7:05
	6:51 AM	12:05 PM	5:05 PM	6:56 PM			5:14	1:51	0:00	7:05
30	6:51 AM	8:30 AM	2:10 PM	6:56 PM			1:39	4:46	0:00	6:25
	6:51 AM	8:30 AM	2:10 PM	6:56 PM			1:39	4:46	0:00	6:25
	6:51 AM	8:30 AM	2:10 PM	6:56 PM			1:39	4:46	0:00	6:25
	6:51 AM	8:30 AM	2:10 PM	6:56 PM			1:39	4:46	0:00	6:25
	6:51 AM	8:30 AM	2:10 PM	6:56 PM			1:39	4:46	0:00	6:25
31	3:48 PM	5:20 PM	8:25 PM	11:59 PM	12:00 AM	1:41 AM	1:32	3:34	1:41	6:47
	3:48 PM	5:20 PM	8:25 PM	11:59 PM	12:00 AM	1:41 AM	1:32	3:34	1:41	6:47
	3:48 PM	5:20 PM	8:25 PM	11:59 PM	12:00 AM	1:41 AM	1:32	3:34	1:41	6:47
	3:48 PM	5:20 PM	8:25 PM	11:59 PM	12:00 AM	1:41 AM	1:32	3:34	1:41	6:47
	3:48 PM	5:20 PM	8:25 PM	11:59 PM	12:00 AM	1:41 AM	1:32	3:34	1:41	6:47
32	5:25 AM	8:50 AM	3:40 PM	5:27 PM			3:25	1:47	0:00	5:12
	5:25 AM	8:50 AM	3:40 PM	5:27 PM			3:25	1:47	0:00	5:12
	5:25 AM	8:50 AM	3:40 PM	5:27 PM			3:25	1:47	0:00	5:12
	5:25 AM	8:50 AM	3:40 PM	5:27 PM			3:25	1:47	0:00	5:12
	5:25 AM	8:50 AM	3:40 PM	5:27 PM			3:25	1:47	0:00	5:12
33	6:15 AM	9:09 AM	4:30 PM	6:35 PM			2:54	2:05	0:00	4:59
	6:15 AM	9:09 AM	4:30 PM	6:35 PM			2:54	2:05	0:00	4:59
	6:15 AM	9:09 AM	4:30 PM	6:35 PM			2:54	2:05	0:00	4:59
	6:15 AM	9:09 AM	4:30 PM	6:35 PM			2:54	2:05	0:00	4:59
	6:15 AM	9:09 AM	4:30 PM	6:35 PM			2:54	2:05	0:00	4:59
34	5:08 AM	7:29 AM	1:55 PM	7:07 PM			2:21	5:12	0:00	7:33
	5:08 AM	7:29 AM	1:55 PM	7:07 PM			2:21	5:12	0:00	7:33
	5:08 AM	7:29 AM	1:55 PM	7:07 PM			2:21	5:12	0:00	7:33
	5:08 AM	7:29 AM	1:55 PM	7:07 PM			2:21	5:12	0:00	7:33
	5:08 AM	7:29 AM	1:55 PM	7:07 PM			2:21	5:12	0:00	7:33
35	5:55 AM	9:39 AM	4:50 PM	6:35 PM			3:44	1:45	0:00	5:29
	5:55 AM	9:39 AM	4:50 PM	6:35 PM			3:44	1:45	0:00	5:29
	5:55 AM	9:39 AM	4:50 PM	6:35 PM			3:44	1:45	0:00	5:29
	5:55 AM	9:39 AM	4:50 PM	6:35 PM			3:44	1:45	0:00	5:29
	5:55 AM	9:39 AM	4:50 PM	6:35 PM			3:44	1:45	0:00	5:29
36	6:15 AM	8:01 AM	4:50 PM	6:35 PM			1:46	1:45	0:00	3:31
	6:15 AM	8:01 AM	4:50 PM	6:35 PM			1:46	1:45	0:00	3:31
	6:15 AM	8:01 AM	4:50 PM	6:35 PM			1:46	1:45	0:00	3:31
	6:15 AM	8:01 AM	4:50 PM	6:35 PM			1:46	1:45	0:00	3:31
	6:15 AM	8:01 AM	4:50 PM	6:35 PM			1:46	1:45	0:00	3:31
37	6:50 AM	8:28 AM	2:25 PM	7:05 PM			1:38	4:40	0:00	6:18
	6:50 AM	8:28 AM	2:25 PM	7:05 PM			1:38	4:40	0:00	6:18
	6:50 AM	8:28 AM	2:25 PM	7:05 PM			1:38	4:40	0:00	6:18
	6:50 AM	8:28 AM	2:25 PM	7:05 PM			1:38	4:40	0:00	6:18
	6:50 AM	8:28 AM	2:25 PM	7:05 PM			1:38	4:40	0:00	6:18
38	5:08 AM	8:10 AM	2:45 PM	7:37 PM			3:02	4:52	0:00	7:54
	5:08 AM	8:10 AM	2:45 PM	7:37 PM			3:02	4:52	0:00	7:54
	5:08 AM	8:10 AM	2:45 PM	7:37 PM			3:02	4:52	0:00	7:54
	5:08 AM	8:10 AM	2:45 PM	7:37 PM			3:02	4:52	0:00	7:54
	5:08 AM	8:10 AM	2:45 PM	7:37 PM			3:02	4:52	0:00	7:54
39	6:15 AM	8:01 AM	3:30 PM	7:05 PM			1:46	3:35	0:00	5:21
	6:15 AM	8:01 AM	3:30 PM	7:05 PM			1:46	3:35	0:00	5:21
	6:15 AM	8:01 AM	3:30 PM	7:05 PM			1:46	3:35	0:00	5:21
	6:15 AM	8:01 AM	3:30 PM	7:05 PM			1:46	3:35	0:00	5:21
	6:15 AM	8:01 AM	3:30 PM	7:05 PM			1:46	3:35	0:00	5:21
40	6:50 AM	8:29 AM	3:25 PM	7:40 PM			1:39	4:15	0:00	5:54
	6:50 AM	8:29 AM	3:25 PM	7:40 PM			1:39	4:15	0:00	5:54
	6:50 AM	8:29 AM	3:25 PM	7:40 PM			1:39	4:15	0:00	5:54
	6:50 AM	8:29 AM	3:25 PM	7:40 PM			1:39	4:15	0:00	5:54
	6:50 AM	8:29 AM	3:25 PM	7:40 PM			1:39	4:15	0:00	5:54
41	6:08 AM	8:29 AM	3:40 PM	6:02 PM			2:21	2:22	0:00	4:43
	6:08 AM	8:29 AM	3:40 PM	6:02 PM			2:21	2:22	0:00	4:43
	6:08 AM	8:29 AM	3:40 PM	6:02 PM			2:21	2:22	0:00	4:43
	6:08 AM	8:29 AM	3:40 PM	6:02 PM			2:21	2:22	0:00	4:43
	6:08 AM	8:29 AM	3:40 PM	6:02 PM			2:21	2:22	0:00	4:43
42	6:50 AM	8:29 AM	4:30 PM	7:40 PM			1:39	3:10	0:00	4:49

MBTA Commuter Rail Crew Work Schedules

Assistant Conductors

	Time 1		Time 2		Time 3	Hours 1	Hours 2	Hours 3	Total Hours
	6:50 AM	8:29 AM	4:30 PM	7:40 PM		1:39	3:10	0:00	4:49
	6:50 AM	8:29 AM	4:30 PM	7:40 PM		1:39	3:10	0:00	4:49
	6:50 AM	8:29 AM	4:30 PM	7:40 PM		1:39	3:10	0:00	4:49
	6:50 AM	8:29 AM	4:30 PM	7:40 PM		1:39	3:10	0:00	4:49
43	7:25 AM	9:09 AM	2:25 PM	4:11 PM		1:44	1:46	0:00	3:30
	7:25 AM	9:09 AM	2:25 PM	4:11 PM		1:44	1:46	0:00	3:30
	7:25 AM	9:09 AM	2:25 PM	4:11 PM		1:44	1:46	0:00	3:30
	7:25 AM	9:09 AM	2:25 PM	4:11 PM		1:44	1:46	0:00	3:30
	7:25 AM	9:09 AM	2:25 PM	4:11 PM		1:44	1:46	0:00	3:30
44	5:55 AM	9:20 AM	4:40 PM	6:10 PM		3:25	1:30	0:00	4:55
	5:55 AM	9:20 AM	4:40 PM	6:10 PM		3:25	1:30	0:00	4:55
	5:55 AM	9:20 AM	4:40 PM	6:10 PM		3:25	1:30	0:00	4:55
	5:55 AM	9:20 AM	4:40 PM	6:10 PM		3:25	1:30	0:00	4:55
	5:55 AM	9:20 AM	4:40 PM	6:10 PM		3:25	1:30	0:00	4:55
45	6:40 AM	1:10 PM	5:10 PM	6:39 PM		6:30	1:29	0:00	7:59
	6:40 AM	1:10 PM	5:10 PM	6:39 PM		6:30	1:29	0:00	7:59
	6:40 AM	1:10 PM	5:10 PM	6:39 PM		6:30	1:29	0:00	7:59
	6:40 AM	1:10 PM	5:10 PM	6:39 PM		6:30	1:29	0:00	7:59
	6:40 AM	1:10 PM	5:10 PM	6:39 PM		6:30	1:29	0:00	7:59
46	7:10 AM	8:40 AM	1:45 PM	6:39 PM		1:30	4:54	0:00	6:24
	7:10 AM	8:40 AM	1:45 PM	6:39 PM		1:30	4:54	0:00	6:24
	7:10 AM	8:40 AM	1:45 PM	6:39 PM		1:30	4:54	0:00	6:24
	7:10 AM	8:40 AM	1:45 PM	6:39 PM		1:30	4:54	0:00	6:24
	7:10 AM	8:40 AM	1:45 PM	6:39 PM		1:30	4:54	0:00	6:24
47	7:10 AM	11:50 AM	5:45 PM	7:15 PM		4:40	1:30	0:00	6:10
	7:10 AM	11:50 AM	5:45 PM	7:15 PM		4:40	1:30	0:00	6:10
	7:10 AM	11:50 AM	5:45 PM	7:15 PM		4:40	1:30	0:00	6:10
	7:10 AM	11:50 AM	5:45 PM	7:15 PM		4:40	1:30	0:00	6:10
	7:10 AM	11:50 AM	5:45 PM	7:15 PM		4:40	1:30	0:00	6:10
48	7:10 AM	11:38 AM	5:10 PM	6:40 PM		4:28	1:30	0:00	5:58
	7:10 AM	11:38 AM	5:10 PM	6:40 PM		4:28	1:30	0:00	5:58
	7:10 AM	11:38 AM	5:10 PM	6:40 PM		4:28	1:30	0:00	5:58
	7:10 AM	11:38 AM	5:10 PM	6:40 PM		4:28	1:30	0:00	5:58
	7:10 AM	11:38 AM	5:10 PM	6:40 PM		4:28	1:30	0:00	5:58
49	7:40 AM	9:09 AM	4:10 PM	8:04 PM		1:29	3:54	0:00	5:23
	7:40 AM	9:09 AM	4:10 PM	8:04 PM		1:29	3:54	0:00	5:23
	7:40 AM	9:09 AM	4:10 PM	8:04 PM		1:29	3:54	0:00	5:23
	7:40 AM	9:09 AM	4:10 PM	8:04 PM		1:29	3:54	0:00	5:23
	7:40 AM	9:09 AM	4:10 PM	8:04 PM		1:29	3:54	0:00	5:23
50	6:40 AM	11:38 AM	4:40 PM	6:08 PM		4:58	1:28	0:00	6:26
	6:40 AM	11:38 AM	4:40 PM	6:08 PM		4:58	1:28	0:00	6:26
	6:40 AM	11:38 AM	4:40 PM	6:08 PM		4:58	1:28	0:00	6:26
	6:40 AM	11:38 AM	4:40 PM	6:08 PM		4:58	1:28	0:00	6:26
	6:40 AM	11:38 AM	4:40 PM	6:08 PM		4:58	1:28	0:00	6:26
51	5:58 AM	9:20 AM	4:20 PM	8:28 PM		3:22	4:08	0:00	7:30
	5:58 AM	9:20 AM	4:20 PM	8:28 PM		3:22	4:08	0:00	7:30
	5:58 AM	9:20 AM	4:20 PM	8:28 PM		3:22	4:08	0:00	7:30
	5:58 AM	9:20 AM	4:20 PM	8:28 PM		3:22	4:08	0:00	7:30
	5:58 AM	9:20 AM	4:20 PM	8:28 PM		3:22	4:08	0:00	7:30
52	6:03 AM	9:23 AM	4:20 PM	5:42 PM		3:20	1:22	0:00	4:42
	6:03 AM	9:23 AM	4:20 PM	5:42 PM		3:20	1:22	0:00	4:42
	6:03 AM	9:23 AM	4:20 PM	5:42 PM		3:20	1:22	0:00	4:42
	6:03 AM	9:23 AM	4:20 PM	5:42 PM		3:20	1:22	0:00	4:42
	6:03 AM	9:23 AM	4:20 PM	5:42 PM		3:20	1:22	0:00	4:42
53	6:28 AM	10:30 AM	4:55 PM	6:23 PM		4:02	1:28	0:00	5:30
	6:28 AM	10:30 AM	4:55 PM	6:23 PM		4:02	1:28	0:00	5:30
	6:28 AM	10:30 AM	4:55 PM	6:23 PM		4:02	1:28	0:00	5:30
	6:28 AM	10:30 AM	4:55 PM	6:23 PM		4:02	1:28	0:00	5:30
	6:28 AM	10:30 AM	4:55 PM	6:23 PM		4:02	1:28	0:00	5:30
54	6:51 AM	8:38 AM	3:30 PM	7:12 PM		1:47	3:42	0:00	5:29
	6:51 AM	8:38 AM	3:30 PM	7:12 PM		1:47	3:42	0:00	5:29
	6:51 AM	8:38 AM	3:30 PM	7:12 PM		1:47	3:42	0:00	5:29
	6:51 AM	8:38 AM	3:30 PM	7:12 PM		1:47	3:42	0:00	5:29
	6:51 AM	8:38 AM	3:30 PM	7:12 PM		1:47	3:42	0:00	5:29
55	7:16 AM	1:25 PM	6:05 PM	7:25 PM		6:09	1:20	0:00	7:29
	7:16 AM	1:25 PM	6:05 PM	7:25 PM		6:09	1:20	0:00	7:29
	7:16 AM	1:25 PM	6:05 PM	7:25 PM		6:09	1:20	0:00	7:29
	7:16 AM	1:25 PM	6:05 PM	7:25 PM		6:09	1:20	0:00	7:29

MBTA Commuter Rail Crew Work Schedules

Assistant Conductors

	Time 1		Time 2		Time 3	Hours 1	Hours 2	Hours 3	Total Hours
	7:16 AM	1:25 PM	6:05 PM	7:25 PM		6:09	1:20	0:00	7:29
56	6:10 AM	9:19 AM	3:10 PM	6:16 PM		3:09	3:06	0:00	6:15
	6:10 AM	9:19 AM	3:10 PM	6:16 PM		3:09	3:06	0:00	6:15
	6:10 AM	9:19 AM	3:10 PM	6:16 PM		3:09	3:06	0:00	6:15
	6:10 AM	9:19 AM	3:10 PM	6:16 PM		3:09	3:06	0:00	6:15
	6:10 AM	9:19 AM	3:10 PM	6:16 PM		3:09	3:06	0:00	6:15
57	6:14 AM	9:00 AM	3:40 PM	6:20 PM		2:46	2:40	0:00	5:26
	6:14 AM	9:00 AM	3:40 PM	6:20 PM		2:46	2:40	0:00	5:26
	6:14 AM	9:00 AM	3:40 PM	6:20 PM		2:46	2:40	0:00	5:26
	6:14 AM	9:00 AM	3:40 PM	6:20 PM		2:46	2:40	0:00	5:26
	6:14 AM	9:00 AM	3:40 PM	6:20 PM		2:46	2:40	0:00	5:26
58	6:43 AM	8:00 AM	12:25 PM	6:20 PM		1:17	5:55	0:00	7:12
	6:43 AM	8:00 AM	12:25 PM	6:20 PM		1:17	5:55	0:00	7:12
	6:43 AM	8:00 AM	12:25 PM	6:20 PM		1:17	5:55	0:00	7:12
	6:43 AM	8:00 AM	12:25 PM	6:20 PM		1:17	5:55	0:00	7:12
	6:43 AM	8:00 AM	12:25 PM	6:20 PM		1:17	5:55	0:00	7:12
59	6:43 AM	11:05 AM	4:55 PM	6:20 PM		4:22	1:25	0:00	5:47
	6:43 AM	11:05 AM	4:55 PM	6:20 PM		4:22	1:25	0:00	5:47
	6:43 AM	11:05 AM	4:55 PM	6:20 PM		4:22	1:25	0:00	5:47
	6:43 AM	11:05 AM	4:55 PM	6:20 PM		4:22	1:25	0:00	5:47
	6:43 AM	11:05 AM	4:55 PM	6:20 PM		4:22	1:25	0:00	5:47
60	6:43 AM	8:00 AM	5:25 PM	6:43 PM		1:17	1:18	0:00	2:35
	6:43 AM	8:00 AM	5:25 PM	6:43 PM		1:17	1:18	0:00	2:35
	6:43 AM	8:00 AM	5:25 PM	6:43 PM		1:17	1:18	0:00	2:35
	6:43 AM	8:00 AM	5:25 PM	6:43 PM		1:17	1:18	0:00	2:35
	6:43 AM	8:00 AM	5:25 PM	6:43 PM		1:17	1:18	0:00	2:35
61	7:26 AM	8:50 AM	5:25 PM	6:43 PM		1:24	1:18	0:00	2:42
	7:26 AM	8:50 AM	5:25 PM	6:43 PM		1:24	1:18	0:00	2:42
	7:26 AM	8:50 AM	5:25 PM	6:43 PM		1:24	1:18	0:00	2:42
	7:26 AM	8:50 AM	5:25 PM	6:43 PM		1:24	1:18	0:00	2:42
	7:26 AM	8:50 AM	5:25 PM	6:43 PM		1:24	1:18	0:00	2:42
62	6:27 AM	11:50 AM	4:25 PM	5:58 PM		5:23	1:33	0:00	6:56
	8:27 AM	4:50 PM	8:25 PM	9:58 PM		8:23	1:33	0:00	9:56
	8:25 AM	6:00 PM				9:35	0:00	0:00	9:35
	9:38 AM	8:07 PM				10:29	0:00	0:00	10:29

Commuter Rail Assistant Conductors

Average Hours Worked on a Typical Weekday (Northside System): 8:03

Average Hours Worked on a Typical Weekday (Southside System): 6:36

Average Hours for Assistant Conductors on the Entire System: 7:10

MBTA Commuter Rail Crew Work Schedules

Northside System
Conductors

	Time 1		Time 2		Time 3	Hours 1	Hours 2	Hours 3	Total Hours
1	4:50 AM	10:11 AM	4:10 PM	7:15 PM		5:21	3:05	0:00	8:26
	4:50 AM	10:11 AM	4:10 PM	7:15 PM		5:21	3:05	0:00	8:26
	4:50 AM	10:11 AM	4:10 PM	7:15 PM		5:21	3:05	0:00	8:26
	4:50 AM	10:11 AM	4:10 PM	7:15 PM		5:21	3:05	0:00	8:26
	4:50 AM	10:11 AM	4:10 PM	7:15 PM		5:21	3:05	0:00	8:26
2	3:15 AM	9:43 AM				6:28	0:00	0:00	6:28
	3:15 AM	9:43 AM				6:28	0:00	0:00	6:28
	3:15 AM	9:43 AM				6:28	0:00	0:00	6:28
	5:00 AM	1:06 PM				8:06	0:00	0:00	8:06
	5:00 AM	12:03 PM				7:03	0:00	0:00	7:03
3	2:30 PM	11:59 PM	12:00 AM	12:17 AM		9:29	0:17	0:00	9:46
	2:30 PM	11:59 PM	12:00 AM	12:17 AM		9:29	0:17	0:00	9:46
	2:30 PM	11:59 PM	12:00 AM	12:17 AM		9:29	0:17	0:00	9:46
	11:15 AM	8:39 PM				9:24	0:00	0:00	9:24
	8:15 AM	6:03 PM				9:48	0:00	0:00	9:48
4	9:55 AM	11:46 AM	2:50 PM	8:22 PM		1:51	5:32	0:00	7:23
	4:40 PM	11:54 PM				7:14	0:00	0:00	7:14
	11:30 AM	9:30 PM				10:00	0:00	0:00	10:00
	11:30 AM	9:30 PM				10:00	0:00	0:00	10:00
	2:15 PM	9:00 PM				6:45	0:00	0:00	6:45
5	4:00 PM	11:59 PM	12:00 AM	2:50 AM		7:59	2:50	0:00	10:49
	4:00 PM	11:59 PM	12:00 AM	2:50 AM		7:59	2:50	0:00	10:49
	4:00 PM	11:59 PM	12:00 AM	2:50 AM		7:59	2:50	0:00	10:49
	4:00 PM	11:59 PM	12:00 AM	2:50 AM		7:59	2:50	0:00	10:49
	4:00 PM	11:59 PM	12:00 AM	2:50 AM		7:59	2:50	0:00	10:49
6	4:40 PM	11:54 PM				7:14	0:00	0:00	7:14
	2:30 PM	11:59 PM	12:00 AM	12:17 AM		9:29	0:17	0:00	9:46
	2:30 PM	11:59 PM	12:00 AM	12:17 AM		9:29	0:17	0:00	9:46
	5:30 PM	11:59 PM	12:00 AM	2:30 AM		6:29	2:30	0:00	8:59
	5:15 PM	11:59 PM	12:00 AM	2:30 AM		6:44	2:30	0:00	9:14
7	5:08 AM	10:55 AM				5:47	0:00	0:00	5:47
	5:08 AM	10:55 AM				5:47	0:00	0:00	5:47
	5:08 AM	10:55 AM				5:47	0:00	0:00	5:47
	5:08 AM	10:55 AM				5:47	0:00	0:00	5:47
	5:08 AM	10:55 AM				5:47	0:00	0:00	5:47
8	5:32 AM	2:51 PM				9:19	0:00	0:00	9:19
	5:32 AM	2:51 PM				9:19	0:00	0:00	9:19
	5:32 AM	2:51 PM				9:19	0:00	0:00	9:19
	5:32 AM	2:51 PM				9:19	0:00	0:00	9:19
	5:32 AM	2:51 PM				9:19	0:00	0:00	9:19
9	6:00 AM	11:30 AM	4:45 PM	7:21 PM		5:30	2:36	0:00	8:06
	6:00 AM	11:30 AM	4:45 PM	7:21 PM		5:30	2:36	0:00	8:06
	6:00 AM	11:30 AM	4:45 PM	7:21 PM		5:30	2:36	0:00	8:06
	6:00 AM	11:30 AM	4:45 PM	7:21 PM		5:30	2:36	0:00	8:06
	6:00 AM	11:30 AM	4:45 PM	7:21 PM		5:30	2:36	0:00	8:06
10	9:55 AM	11:46 AM	2:50 PM	8:22 PM		1:51	5:32	0:00	7:23
	9:55 AM	11:46 AM	2:50 PM	8:22 PM		1:51	5:32	0:00	7:23
	9:55 AM	11:46 AM	2:50 PM	8:22 PM		1:51	5:32	0:00	7:23
	9:55 AM	11:46 AM	2:50 PM	8:22 PM		1:51	5:32	0:00	7:23
	9:55 AM	11:46 AM	2:50 PM	8:22 PM		1:51	5:32	0:00	7:23
11	1:51 PM	10:25 PM				8:34	0:00	0:00	8:34
	1:51 PM	10:25 PM				8:34	0:00	0:00	8:34
	1:51 PM	10:25 PM				8:34	0:00	0:00	8:34
	1:51 PM	10:25 PM				8:34	0:00	0:00	8:34
	1:51 PM	10:25 PM				8:34	0:00	0:00	8:34
12	4:11 AM	11:45 AM				7:34	0:00	0:00	7:34
	4:11 AM	11:45 AM				7:34	0:00	0:00	7:34
	4:11 AM	11:45 AM				7:34	0:00	0:00	7:34
	6:00 AM	3:36 PM				9:36	0:00	0:00	9:36
	6:00 AM	1:46 PM				7:46	0:00	0:00	7:46
13	5:11 AM	1:45 PM				8:34	0:00	0:00	8:34
	5:11 AM	1:45 PM				8:34	0:00	0:00	8:34
	5:11 AM	1:45 PM				8:34	0:00	0:00	8:34
	5:11 AM	1:45 PM				8:34	0:00	0:00	8:34
	5:11 AM	1:45 PM				8:34	0:00	0:00	8:34
14	5:53 AM	8:19 AM	12:45 PM	6:50 PM		2:26	6:05	0:00	8:31
	5:53 AM	8:19 AM	12:45 PM	6:50 PM		2:26	6:05	0:00	8:31

MBTA Commuter Rail Crew Work Schedules

Conductors

	Time 1		Time 2		Time 3		Hours 1	Hours 2	Hours 3	Total Hours
	5:53 AM	8:19 AM	12:45 PM	6:50 PM			2:26	6:05	0:00	8:31
	5:53 AM	8:19 AM	12:45 PM	6:50 PM			2:26	6:05	0:00	8:31
	5:53 AM	8:19 AM	12:45 PM	6:50 PM			2:26	6:05	0:00	8:31
15	6:22 AM	3:46 PM					9:24	0:00	0:00	9:24
	6:22 AM	3:46 PM					9:24	0:00	0:00	9:24
	6:22 AM	3:46 PM					9:24	0:00	0:00	9:24
	6:22 AM	3:46 PM					9:24	0:00	0:00	9:24
	6:22 AM	3:46 PM					9:24	0:00	0:00	9:24
16	11:30 AM	9:30 PM					10:00	0:00	0:00	10:00
	11:30 AM	9:30 PM					10:00	0:00	0:00	10:00
	11:30 AM	9:30 PM					10:00	0:00	0:00	10:00
	4:45 PM	11:59 PM	12:00 AM	1:11 AM			7:14	1:11	0:00	8:25
	1:30 PM	3:30 PM	8:00 PM	11:59 PM	12:00 AM	1:11 AM	2:00	3:59	1:11	7:10
17	1:30 PM	11:59 PM	12:00 AM	12:36 AM			10:29	0:36	0:00	11:05
	1:30 PM	11:59 PM	12:00 AM	12:36 AM			10:29	0:36	0:00	11:05
	1:30 PM	11:59 PM	12:00 AM	12:36 AM			10:29	0:36	0:00	11:05
	1:30 PM	11:59 PM	12:00 AM	12:36 AM			10:29	0:36	0:00	11:05
	1:30 PM	11:59 PM	12:00 AM	12:36 AM			10:29	0:36	0:00	11:05
18	3:14 PM	11:59 PM	12:00 AM	1:39 AM			8:45	1:39	0:00	10:24
	3:14 PM	11:59 PM	12:00 AM	1:39 AM			8:45	1:39	0:00	10:24
	3:14 PM	11:59 PM	12:00 AM	1:39 AM			8:45	1:39	0:00	10:24
	3:14 PM	11:59 PM	12:00 AM	1:39 AM			8:45	1:39	0:00	10:24
	3:14 PM	11:59 PM	12:00 AM	1:39 AM			8:45	1:39	0:00	10:24
19	5:02 AM	12:57 PM					7:55	0:00	0:00	7:55
	4:11 AM	11:45 AM					7:34	0:00	0:00	7:34
	4:11 AM	11:45 AM					7:34	0:00	0:00	7:34
	10:50 AM	9:00 PM					10:10	0:00	0:00	10:10
	9:45 AM	6:45 PM					9:00	0:00	0:00	9:00
20	5:02 AM	4:38 PM					11:36	0:00	0:00	11:36
	5:02 AM	4:38 PM					11:36	0:00	0:00	11:36
	5:02 AM	4:38 PM					11:36	0:00	0:00	11:36
	5:02 AM	4:38 PM					11:36	0:00	0:00	11:36
	5:02 AM	4:38 PM					11:36	0:00	0:00	11:36
21	5:52 AM	4:38 PM					10:46	0:00	0:00	10:46
	5:52 AM	4:38 PM					10:46	0:00	0:00	10:46
	5:52 AM	4:38 PM					10:46	0:00	0:00	10:46
	5:52 AM	4:38 PM					10:46	0:00	0:00	10:46
	5:52 AM	4:38 PM					10:46	0:00	0:00	10:46
22	6:20 AM	8:35 AM	1:20 PM	7:09 PM			2:15	5:49	0:00	8:04
	6:20 AM	8:35 AM	1:20 PM	7:09 PM			2:15	5:49	0:00	8:04
	6:20 AM	8:35 AM	1:20 PM	7:09 PM			2:15	5:49	0:00	8:04
	6:20 AM	8:35 AM	1:20 PM	7:09 PM			2:15	5:49	0:00	8:04
	6:20 AM	8:35 AM	1:20 PM	7:09 PM			2:15	5:49	0:00	8:04
23	12:38 PM	8:07 PM					7:29	0:00	0:00	7:29
	12:38 PM	8:07 PM					7:29	0:00	0:00	7:29
	12:38 PM	8:07 PM					7:29	0:00	0:00	7:29
	12:38 PM	8:07 PM					7:29	0:00	0:00	7:29
	12:38 PM	8:07 PM					7:29	0:00	0:00	7:29
24	3:57 PM	11:59 PM	12:00 AM	12:31 AM			8:02	0:31	0:00	8:33
	3:57 PM	11:59 PM	12:00 AM	12:31 AM			8:02	0:31	0:00	8:33
	3:57 PM	11:59 PM	12:00 AM	12:31 AM			8:02	0:31	0:00	8:33
	3:57 PM	11:59 PM	12:00 AM	12:31 AM			8:02	0:31	0:00	8:33
	3:57 PM	11:59 PM	12:00 AM	12:31 AM			8:02	0:31	0:00	8:33
25	4:35 AM	12:14 PM					7:39	0:00	0:00	7:39
	4:35 AM	12:14 PM					7:39	0:00	0:00	7:39
	4:35 AM	12:14 PM					7:39	0:00	0:00	7:39
	4:35 AM	12:14 PM					7:39	0:00	0:00	7:39
	4:35 AM	12:14 PM					7:39	0:00	0:00	7:39
26	5:15 AM	12:11 PM	4:40 PM	6:18 PM			6:56	1:38	0:00	8:34
	5:15 AM	12:11 PM	4:40 PM	6:18 PM			6:56	1:38	0:00	8:34
	5:15 AM	12:11 PM	4:40 PM	6:18 PM			6:56	1:38	0:00	8:34
	5:15 AM	12:11 PM	4:40 PM	6:18 PM			6:56	1:38	0:00	8:34
	5:15 AM	12:11 PM	4:40 PM	6:18 PM			6:56	1:38	0:00	8:34
27	5:45 PM	11:59 PM	12:00 AM	1:13 AM			6:14	1:13	0:00	7:27
	5:45 PM	11:59 PM	12:00 AM	1:13 AM			6:14	1:13	0:00	7:27
	5:45 PM	11:59 PM	12:00 AM	1:13 AM			6:14	1:13	0:00	7:27
	5:45 PM	11:59 PM	12:00 AM	1:13 AM			6:14	1:13	0:00	7:27
	5:45 PM	11:59 PM	12:00 AM	1:13 AM			6:14	1:13	0:00	7:27

MBTA Commuter Rail Crew Work Schedules

Conductors

	Time 1		Time 2		Time 3		Hours 1	Hours 2	Hours 3	Total Hours
28	6:20 AM	8:29 AM	11:40 AM	5:18 PM			2:09	5:38	0:00	7:47
	6:20 AM	8:29 AM	11:40 AM	5:18 PM			2:09	5:38	0:00	7:47
	6:20 AM	8:29 AM	11:40 AM	5:18 PM			2:09	5:38	0:00	7:47
	6:20 AM	8:29 AM	11:40 AM	5:18 PM			2:09	5:38	0:00	7:47
	6:20 AM	8:29 AM	11:40 AM	5:18 PM			2:09	5:38	0:00	7:47
29	11:37 AM	7:03 PM					7:26	0:00	0:00	7:26
	11:37 AM	7:03 PM					7:26	0:00	0:00	7:26
	11:37 AM	7:03 PM					7:26	0:00	0:00	7:26
	11:37 AM	7:03 PM					7:26	0:00	0:00	7:26
	11:37 AM	9:24 PM					9:47	0:00	0:00	9:47
30	4:40 PM	11:54 PM					7:14	0:00	0:00	7:14
	4:40 PM	11:54 PM					7:14	0:00	0:00	7:14
	4:40 PM	11:54 PM					7:14	0:00	0:00	7:14
	2:30 PM	6:03 PM	7:30 PM	11:59 PM	12:00 AM	12:13 AM	3:33	4:29	0:13	8:15
	2:30 PM	6:03 PM	7:30 PM	11:59 PM	12:00 AM	12:13 AM	3:33	4:29	0:13	8:15
31	4:45 AM	9:39 AM	10:50 AM	1:09 PM			4:54	2:19	0:00	7:13
	4:45 AM	9:39 AM	10:50 AM	1:09 PM			4:54	2:19	0:00	7:13
	4:45 AM	9:39 AM	10:50 AM	1:09 PM			4:54	2:19	0:00	7:13
	4:45 AM	9:39 AM	10:50 AM	1:09 PM			4:54	2:19	0:00	7:13
	4:45 AM	9:39 AM	10:50 AM	1:09 PM			4:54	2:19	0:00	7:13
32	6:15 AM	1:30 PM	4:50 PM	7:35 PM			7:15	2:45	0:00	10:00
	6:15 AM	1:30 PM	4:50 PM	7:35 PM			7:15	2:45	0:00	10:00
	6:15 AM	1:30 PM	4:50 PM	7:35 PM			7:15	2:45	0:00	10:00
	6:15 AM	1:30 PM	4:50 PM	7:35 PM			7:15	2:45	0:00	10:00
	6:15 AM	1:30 PM	4:50 PM	7:35 PM			7:15	2:45	0:00	10:00
33	5:55 AM	3:13 PM					9:18	0:00	0:00	9:18
	5:55 AM	3:13 PM					9:18	0:00	0:00	9:18
	5:55 AM	3:13 PM					9:18	0:00	0:00	9:18
	5:55 AM	3:13 PM					9:18	0:00	0:00	9:18
	5:55 AM	3:13 PM					9:18	0:00	0:00	9:18
34	5:30 AM	10:35 AM	4:20 PM	6:45 PM			5:05	2:25	0:00	7:30
	5:30 AM	10:35 AM	4:20 PM	6:45 PM			5:05	2:25	0:00	7:30
	5:30 AM	10:35 AM	4:20 PM	6:45 PM			5:05	2:25	0:00	7:30
	5:40 AM	11:39 AM	5:00 PM	7:47 PM			5:59	2:47	0:00	8:46
	10:00 AM	1:21 PM	2:30 PM	7:49 PM			3:21	5:19	0:00	8:40
35	12:19 PM	8:36 PM					8:17	0:00	0:00	8:17
	12:19 PM	8:36 PM					8:17	0:00	0:00	8:17
	12:19 PM	8:36 PM					8:17	0:00	0:00	8:17
	12:19 PM	8:36 PM					8:17	0:00	0:00	8:17
	12:19 PM	8:36 PM					8:17	0:00	0:00	8:17
36	2:23 PM	4:53 PM	7:05 PM	11:59 PM	12:00 AM	12:49 AM	2:30	4:54	0:49	8:13
	2:23 PM	4:53 PM	7:05 PM	11:59 PM	12:00 AM	12:49 AM	2:30	4:54	0:49	8:13
	2:23 PM	4:53 PM	7:05 PM	11:59 PM	12:00 AM	12:49 AM	2:30	4:54	0:49	8:13
	2:23 PM	4:53 PM	7:05 PM	11:59 PM	12:00 AM	12:49 AM	2:30	4:54	0:49	8:13
	1:49 PM	4:08 PM	7:00 PM	11:54 PM			2:19	4:54	0:00	7:13
37	5:55 PM	11:59 PM	12:00 AM	2:29 AM			6:04	2:29	0:00	8:33
	5:55 PM	11:59 PM	12:00 AM	2:29 AM			6:04	2:29	0:00	8:33
	5:55 PM	11:59 PM	12:00 AM	2:29 AM			6:04	2:29	0:00	8:33
	5:55 PM	11:59 PM	12:00 AM	2:29 AM			6:04	2:29	0:00	8:33
	5:55 PM	11:59 PM	12:00 AM	2:29 AM			6:04	2:29	0:00	8:33
38	5:30 AM	10:35 AM	4:20 PM	6:45 PM			5:05	2:25	0:00	7:30
	5:30 AM	10:35 AM	4:20 PM	6:45 PM			5:05	2:25	0:00	7:30
	5:30 AM	10:35 AM	4:20 PM	6:45 PM			5:05	2:25	0:00	7:30
	8:20 AM	11:11 AM	12:50 PM	5:24 PM			2:51	4:34	0:00	7:25
	6:50 AM	2:39 PM					7:49	0:00	0:00	7:49
39	3:15 AM	9:43 AM					6:28	0:00	0:00	6:28
	3:15 AM	9:43 AM					6:28	0:00	0:00	6:28
	2:23 PM	4:53 PM	7:05 PM	11:59 PM	12:00 AM	12:49 AM	2:30	4:54	0:49	8:13
	4:34 PM	11:59 PM	12:00 AM	12:49 AM			7:25	0:49	0:00	8:14
	3:55 PM	11:59 PM	12:00 AM	1:19 AM			8:04	1:19	0:00	9:23

Southside System
Conductors

	Time 1		Time 2		Time 3		Hours 1	Hours 2	Hours 3	Total Hours
1	3:10 AM	1:10 PM					10:00	0:00	0:00	10:00
	3:10 AM	1:10 PM					10:00	0:00	0:00	10:00

MBTA Commuter Rail Crew Work Schedules

Conductors

	Time 1		Time 2		Time 3	Hours 1	Hours 2	Hours 3	Total Hours
	3:10 AM	1:10 PM				10:00	0:00	0:00	10:00
	3:10 AM	1:10 PM				10:00	0:00	0:00	10:00
	3:10 AM	1:10 PM				10:00	0:00	0:00	10:00
2	4:10 AM	2:20 PM				10:10	0:00	0:00	10:10
	4:10 AM	2:20 PM				10:10	0:00	0:00	10:10
	4:10 AM	2:20 PM				10:10	0:00	0:00	10:10
	4:10 AM	2:20 PM				10:10	0:00	0:00	10:10
	4:10 AM	2:20 PM				10:10	0:00	0:00	10:10
3	4:10 AM	9:07 AM	1:45 PM	6:53 PM		4:57	5:08	0:00	10:05
	4:10 AM	9:07 AM	1:45 PM	6:53 PM		4:57	5:08	0:00	10:05
	4:10 AM	9:07 AM	1:45 PM	6:53 PM		4:57	5:08	0:00	10:05
	4:10 AM	9:07 AM	1:45 PM	6:53 PM		4:57	5:08	0:00	10:05
	4:10 AM	9:07 AM	1:45 PM	6:53 PM		4:57	5:08	0:00	10:05
4	4:10 AM	9:44 AM	3:53 PM	7:57 PM		5:34	4:04	0:00	9:38
	4:10 AM	9:44 AM	3:53 PM	7:57 PM		5:34	4:04	0:00	9:38
	4:10 AM	9:44 AM	3:53 PM	7:57 PM		5:34	4:04	0:00	9:38
	4:10 AM	9:44 AM	3:53 PM	7:57 PM		5:34	4:04	0:00	9:38
	4:10 AM	9:44 AM	3:53 PM	7:57 PM		5:34	4:04	0:00	9:38
5	4:35 AM	3:25 PM				10:50	0:00	0:00	10:50
	4:35 AM	3:25 PM				10:50	0:00	0:00	10:50
	4:35 AM	3:25 PM				10:50	0:00	0:00	10:50
	4:35 AM	3:25 PM				10:50	0:00	0:00	10:50
	4:35 AM	3:25 PM				10:50	0:00	0:00	10:50
6	4:40 AM	3:25 PM				10:45	0:00	0:00	10:45
	4:40 AM	3:25 PM				10:45	0:00	0:00	10:45
	4:40 AM	3:25 PM				10:45	0:00	0:00	10:45
	4:40 AM	3:25 PM				10:45	0:00	0:00	10:45
	4:40 AM	3:25 PM				10:45	0:00	0:00	10:45
7	4:45 AM	3:25 PM				10:40	0:00	0:00	10:40
	4:45 AM	3:25 PM				10:40	0:00	0:00	10:40
	4:45 AM	3:25 PM				10:40	0:00	0:00	10:40
	4:45 AM	3:25 PM				10:40	0:00	0:00	10:40
	4:45 AM	3:25 PM				10:40	0:00	0:00	10:40
8	5:05 AM	8:57 AM	3:35 PM	8:54 PM		3:52	5:19	0:00	9:11
	5:05 AM	8:57 AM	3:35 PM	8:54 PM		3:52	5:19	0:00	9:11
	5:05 AM	8:57 AM	3:35 PM	8:54 PM		3:52	5:19	0:00	9:11
	5:05 AM	8:57 AM	3:35 PM	8:54 PM		3:52	5:19	0:00	9:11
	5:05 AM	8:57 AM	3:35 PM	8:54 PM		3:52	5:19	0:00	9:11
9	5:53 AM	9:09 AM	2:45 PM	8:57 PM		3:16	6:12	0:00	9:28
	5:53 AM	9:09 AM	2:45 PM	8:57 PM		3:16	6:12	0:00	9:28
	5:53 AM	9:09 AM	2:45 PM	8:57 PM		3:16	6:12	0:00	9:28
	5:53 AM	9:09 AM	2:45 PM	8:57 PM		3:16	6:12	0:00	9:28
	5:53 AM	9:09 AM	2:45 PM	8:57 PM		3:16	6:12	0:00	9:28
10	11:35 AM	10:40 PM				11:05	0:00	0:00	11:05
	11:35 AM	10:40 PM				11:05	0:00	0:00	11:05
	11:35 AM	10:40 PM				11:05	0:00	0:00	11:05
	11:35 AM	10:40 PM				11:05	0:00	0:00	11:05
	11:35 AM	10:40 PM				11:05	0:00	0:00	11:05
11	3:10 PM	10:59 PM	12:00 AM	1:33 AM		7:49	1:33	0:00	9:22
	3:10 PM	10:59 PM	12:00 AM	1:33 AM		7:49	1:33	0:00	9:22
	3:10 PM	10:59 PM	12:00 AM	1:33 AM		7:49	1:33	0:00	9:22
	3:10 PM	10:59 PM	12:00 AM	1:33 AM		7:49	1:33	0:00	9:22
	3:10 PM	10:59 PM	12:00 AM	1:33 AM		7:49	1:33	0:00	9:22
12	2:58 PM	11:59 PM	12:00 AM	1:07 AM		9:01	1:07	0:00	10:08
	2:58 PM	11:59 PM	12:00 AM	1:07 AM		9:01	1:07	0:00	10:08
	2:58 PM	11:59 PM	12:00 AM	1:07 AM		9:01	1:07	0:00	10:08
	2:58 PM	11:59 PM	12:00 AM	1:07 AM		9:01	1:07	0:00	10:08
	2:58 PM	11:59 PM	12:00 AM	1:07 AM		9:01	1:07	0:00	10:08
13	3:15 PM	11:59 PM	12:00 AM	1:11 AM		8:44	1:11	0:00	9:55
	3:15 PM	11:59 PM	12:00 AM	1:11 AM		8:44	1:11	0:00	9:55
	1:35 PM	11:32 PM				9:57	0:00	0:00	9:57
	3:52 PM	11:07 PM				7:15	0:00	0:00	7:15
	3:35 PM	11:59 PM	12:00 AM	12:15 AM		8:24	0:15	0:00	8:39
14	5:10 PM	11:59 PM	12:00 AM	2:37 AM		6:49	2:37	0:00	9:26
	5:10 PM	11:59 PM	12:00 AM	2:37 AM		6:49	2:37	0:00	9:26
	3:52 PM	11:07 PM				7:15	0:00	0:00	7:15
	1:35 PM	11:32 PM				9:57	0:00	0:00	9:57
	4:05 PM	11:59 PM	12:00 AM	12:42 AM		7:54	0:42	0:00	8:36

MBTA Commuter Rail Crew Work Schedules

Conductors

	Time 1		Time 2		Time 3	Hours 1	Hours 2	Hours 3	Total Hours
15	2:50 AM	9:40 AM				6:50	0:00	0:00	6:50
	2:50 AM	9:40 AM				6:50	0:00	0:00	6:50
	2:50 AM	9:40 AM				6:50	0:00	0:00	6:50
	5:05 AM	4:15 PM				11:10	0:00	0:00	11:10
	8:35 AM	6:15 PM				9:40	0:00	0:00	9:40
16	3:15 PM	11:59 PM	12:00 AM	1:11 AM		8:44	1:11	0:00	9:55
	3:15 PM	11:59 PM	12:00 AM	1:11 AM		8:44	1:11	0:00	9:55
	3:15 PM	11:59 PM	12:00 AM	1:11 AM		8:44	1:11	0:00	9:55
	4:00 PM	11:59 PM	12:00 AM	12:30 AM		7:59	0:30	0:00	8:29
	4:00 PM	11:59 PM	12:00 AM	12:30 AM		7:59	0:30	0:00	8:29
17	5:10 PM	11:59 PM	12:00 AM	2:37 AM		6:49	2:37	0:00	9:26
	5:10 PM	11:59 PM	12:00 AM	2:37 AM		6:49	2:37	0:00	9:26
	5:10 PM	11:59 PM	12:00 AM	2:37 AM		6:49	2:37	0:00	9:26
	3:45 PM	11:59 PM	12:00 AM	12:05 AM		8:14	0:05	0:00	8:19
	3:45 PM	11:59 PM	12:00 AM	2:00 AM		8:14	2:00	0:00	10:14
18	2:50 AM	9:40 AM				6:50	0:00	0:00	6:50
	2:50 AM	9:40 AM				6:50	0:00	0:00	6:50
	11:45 AM	9:57 PM				10:12	0:00	0:00	10:12
	6:15 AM	5:20 PM				11:05	0:00	0:00	11:05
	9:50 AM	6:25 PM				8:35	0:00	0:00	8:35
19	11:45 AM	9:57 PM				10:12	0:00	0:00	10:12
	11:45 AM	9:57 PM				10:12	0:00	0:00	10:12
	11:45 AM	9:57 PM				10:12	0:00	0:00	10:12
	5:50 AM	4:25 PM				10:35	0:00	0:00	10:35
	5:50 PM	11:59 PM	12:00 AM	1:42 AM		6:09	1:42	0:00	7:51
20	3:52 PM	11:07 PM				7:15	0:00	0:00	7:15
	3:52 PM	11:07 PM				7:15	0:00	0:00	7:15
	3:52 PM	11:07 PM				7:15	0:00	0:00	7:15
	6:25 AM	5:10 PM				10:45	0:00	0:00	10:45
	5:35 PM	11:59 PM	12:00 AM	12:05 AM		6:24	0:05	0:00	6:29
21	4:13 AM	9:39 AM	4:35 PM	7:20 PM		5:26	2:45	0:00	8:11
	4:13 AM	9:39 AM	4:35 PM	7:20 PM		5:26	2:45	0:00	8:11
	4:13 AM	9:39 AM	4:35 PM	7:20 PM		5:26	2:45	0:00	8:11
	4:13 AM	9:39 AM	4:35 PM	7:20 PM		5:26	2:45	0:00	8:11
	4:13 AM	9:39 AM	4:35 PM	7:20 PM		5:26	2:45	0:00	8:11
22	4:55 AM	3:48 PM				10:53	0:00	0:00	10:53
	4:55 AM	3:48 PM				10:53	0:00	0:00	10:53
	4:55 AM	3:48 PM				10:53	0:00	0:00	10:53
	4:55 AM	3:48 PM				10:53	0:00	0:00	10:53
	4:55 AM	3:48 PM				10:53	0:00	0:00	10:53
23	5:18 AM	8:57 AM	3:05 PM	7:48 PM		3:39	4:43	0:00	8:22
	5:18 AM	8:57 AM	3:05 PM	7:48 PM		3:39	4:43	0:00	8:22
	5:18 AM	8:57 AM	3:05 PM	7:48 PM		3:39	4:43	0:00	8:22
	5:18 AM	8:57 AM	3:05 PM	7:48 PM		3:39	4:43	0:00	8:22
	5:18 AM	8:57 AM	3:05 PM	7:48 PM		3:39	4:43	0:00	8:22
24	5:50 AM	11:05 AM	5:50 PM	8:41 PM		5:15	2:51	0:00	8:06
	5:50 AM	11:05 AM	5:50 PM	8:41 PM		5:15	2:51	0:00	8:06
	5:50 AM	11:05 AM	5:50 PM	8:41 PM		5:15	2:51	0:00	8:06
	5:50 AM	11:05 AM	5:50 PM	8:41 PM		5:15	2:51	0:00	8:06
	5:50 AM	11:05 AM	5:50 PM	8:41 PM		5:15	2:51	0:00	8:06
25	2:18 PM	11:59 PM	12:00 AM	12:08 AM		9:41	0:08	0:00	9:49
	2:18 PM	11:59 PM	12:00 AM	12:08 AM		9:41	0:08	0:00	9:49
	2:18 PM	11:59 PM	12:00 AM	12:08 AM		9:41	0:08	0:00	9:49
	2:18 PM	11:59 PM	12:00 AM	12:08 AM		9:41	0:08	0:00	9:49
	2:18 PM	11:59 PM	12:00 AM	12:08 AM		9:41	0:08	0:00	9:49
26	4:10 AM	1:50 PM				9:40	0:00	0:00	9:40
	4:10 AM	1:50 PM				9:40	0:00	0:00	9:40
	4:10 AM	1:50 PM				9:40	0:00	0:00	9:40
	4:10 AM	1:50 PM				9:40	0:00	0:00	9:40
	4:10 AM	1:50 PM				9:40	0:00	0:00	9:40
27	5:08 AM	2:01 PM				8:53	0:00	0:00	8:53
	5:08 AM	2:01 PM				8:53	0:00	0:00	8:53
	5:08 AM	2:01 PM				8:53	0:00	0:00	8:53
	5:08 AM	2:01 PM				8:53	0:00	0:00	8:53
	5:08 AM	2:01 PM				8:53	0:00	0:00	8:53
28	5:13 AM	10:30 AM	4:40 PM	7:07 PM		5:17	2:27	0:00	7:44
	5:13 AM	10:30 AM	4:40 PM	7:07 PM		5:17	2:27	0:00	7:44
	5:13 AM	10:30 AM	4:40 PM	7:07 PM		5:17	2:27	0:00	7:44

MBTA Commuter Rail Crew Work Schedules

Conductors

	Time 1		Time 2		Time 3	Hours 1	Hours 2	Hours 3	Total Hours
	5:13 AM	10:30 AM	4:40 PM	7:07 PM		5:17	2:27	0:00	7:44
	5:13 AM	10:30 AM	4:40 PM	7:07 PM		5:17	2:27	0:00	7:44
29	6:08 AM	11:00 AM	1:15 PM	7:37 PM		4:52	6:22	0:00	11:14
	6:08 AM	11:00 AM	1:15 PM	7:37 PM		4:52	6:22	0:00	11:14
	6:08 AM	11:00 AM	1:15 PM	7:37 PM		4:52	6:22	0:00	11:14
	6:08 AM	11:00 AM	1:15 PM	7:37 PM		4:52	6:22	0:00	11:14
	6:08 AM	11:00 AM	1:15 PM	7:37 PM		4:52	6:22	0:00	11:14
30	3:11 PM	11:59 PM	12:00 AM	1:41 AM		8:48	1:41	0:00	10:29
	3:11 PM	11:59 PM	12:00 AM	1:41 AM		8:48	1:41	0:00	10:29
	3:11 PM	11:59 PM	12:00 AM	1:41 AM		8:48	1:41	0:00	10:29
	3:11 PM	11:59 PM	12:00 AM	1:41 AM		8:48	1:41	0:00	10:29
	3:11 PM	11:59 PM	12:00 AM	1:41 AM		8:48	1:41	0:00	10:29
31	1:35 PM	11:32 PM				9:57	0:00	0:00	9:57
	1:35 PM	11:32 PM				9:57	0:00	0:00	9:57
	1:35 PM	11:32 PM				9:57	0:00	0:00	9:57
	3:38 PM	11:59 PM	12:00 AM	1:07 AM		8:21	1:07	0:00	9:28
	4:05 PM	11:59 PM	12:00 AM	12:15 AM		7:54	0:15	0:00	8:09
32	6:15 AM	9:43 AM	2:35 PM	7:00 PM		3:28	4:25	0:00	7:53
	6:15 AM	9:43 AM	2:35 PM	7:00 PM		3:28	4:25	0:00	7:53
	6:15 AM	9:43 AM	2:35 PM	7:00 PM		3:28	4:25	0:00	7:53
	6:15 AM	9:43 AM	2:35 PM	7:00 PM		3:28	4:25	0:00	7:53
	6:15 AM	9:43 AM	2:35 PM	7:00 PM		3:28	4:25	0:00	7:53
33	6:03 AM	3:03 PM				9:00	0:00	0:00	9:00
	6:03 AM	3:03 PM				9:00	0:00	0:00	9:00
	6:03 AM	3:03 PM				9:00	0:00	0:00	9:00
	6:03 AM	3:03 PM				9:00	0:00	0:00	9:00
	6:03 AM	3:03 PM				9:00	0:00	0:00	9:00
34	6:51 AM	10:20 AM	3:15 PM	7:12 PM		3:29	3:57	0:00	7:26
	6:51 AM	10:20 AM	3:15 PM	7:12 PM		3:29	3:57	0:00	7:26
	6:51 AM	10:20 AM	3:15 PM	7:12 PM		3:29	3:57	0:00	7:26
	6:51 AM	10:20 AM	3:15 PM	7:12 PM		3:29	3:57	0:00	7:26
	6:51 AM	10:20 AM	3:15 PM	7:12 PM		3:29	3:57	0:00	7:26
35	2:23 PM	11:44 PM				9:21	0:00	0:00	9:21
	2:23 PM	11:44 PM				9:21	0:00	0:00	9:21
	2:23 PM	11:44 PM				9:21	0:00	0:00	9:21
	2:23 PM	11:44 PM				9:21	0:00	0:00	9:21
	2:23 PM	11:44 PM				9:21	0:00	0:00	9:21
36	9:30 AM	5:30 PM				8:00	0:00	0:00	8:00
	9:30 AM	5:30 PM				8:00	0:00	0:00	8:00
	9:30 AM	5:30 PM				8:00	0:00	0:00	8:00
	9:30 AM	5:30 PM				8:00	0:00	0:00	8:00
	9:30 AM	5:30 PM				8:00	0:00	0:00	8:00
37	10:00 AM	12:12 PM	6:00 PM	11:33 PM		2:12	5:33	0:00	7:45
	7:00 PM	11:59 PM	12:00 AM	11:33 PM		4:59	23:33	0:00	4:32
	6:00 AM	10:03 AM	11:30 AM	3:03 PM		4:03	3:33	0:00	7:36
	11:45 AM	9:57 PM				10:12	0:00	0:00	10:12
	9:20 AM	4:15 PM				6:55	0:00	0:00	6:55
	9:25 AM	4:25 PM				7:00	0:00	0:00	7:00
	9:35 AM	6:05 PM				8:30	0:00	0:00	8:30
	5:20 AM	4:14 PM				10:54	0:00	0:00	10:54
	2:34 PM	11:59 PM	12:00 AM	1:14 AM		9:25	1:14	0:00	10:39
	5:30 AM	4:28 PM				10:58	0:00	0:00	10:58
	9:00 AM	5:00 PM				8:00	0:00	0:00	8:00

Commuter Rail Conductors

Average Hours Worked on a Typical Weekday (Northside System):	8:33
Average Hours Worked on a Typical Weekday (Southside System):	9:26
Average Hours for Conductors on the Entire System:	8:59

A.2 2020 No-Build Scenario

A.2.1 Southside Schedules

The following presents the projected Southside schedules and the proposed Old Colony schedules for the year 2020 without the construction of a rail link tunnel.

LATENESS REPORT FOR A SINGLE STATION

FOR A SEVERAL DAY PERIOD
PERFORMANCE VS TPC NOT SCHED
10-16-92 RUN 4 TRKS READ TO FOREST
4 TRKS AT GUILFORD
FORHILLS -- Departures

Lateness Distribution for 1 Days

CLASS	TOTAL TRAINS	ON TIME	1-5	6-10	11-15	16-20	21-25	26-30	31+
WWD COMMUTER	20	3	14	1	0	0	0	0	2
TOTALS	20	3	14	1	0	0	0	0	2
% OF TOTAL		15.0	70.0	5.0	.0	.0	.0	.0	10.0

40 WESTBOUND TO
NEEDHAM BRIDGE

LATENESS REPORT FOR A SINGLE STATION

FOR A SEVERAL DAY PERIOD
10-28-92 RUN SHARON 3RD TRK
PERFORMANCE VS TPC NOT SCHED

BOSTON

Lateness Distribution for 1 Days

CLASS	TOTAL TRAINS	ON TIME	1-5	6-10	11-15	16-20	21-25	26-30	31+
EWD COMMUTER	123	27	57	18	13	3	2	3	0
TOTALS	123	27	57	18	13	3	2	3	0
% OF TOTAL		22.0	46.3	14.6	10.6	2.4	1.6	2.4	.0
CUMULATIVE %		22.0	68.3	82.9	93.5				

123 BB To Boston not incl Framingham or Old Colony

123

LATENESS REPORT FOR A SINGLE STATION

FOR A SEVERAL DAY PERIOD
PERFORMANCE VS TPC NOT SCHED
10-16-92 RUN 4 TRKS READ TO FOREST
4 TRKS AT GUILFORD
CANTJCT -- Departures

Lateness Distribution for 1 Days

CLASS	TOTAL TRAINS	ON TIME	1-5	6-10	11-15	16-20	21-25	26-30	31+
WWD COMMUTER	43	22	9	10	2	0	0	0	0
TOTALS	43	22	9	10	2	0	0	0	0
% OF TOTAL		51.2	20.9	23.3	4.7	.0	.0	.0	.0

NB to Stoughton MA.

LATENESS REPORT FOR A SINGLE STATION

FOR A SEVERAL DAY PERIOD
10-28-92 RUN SHARON 3RD TRK
PERFORMANCE VS TPC NOT SCHED

PROVID

Lateness Distribution for 1 Days

CLASS	TOTAL TRAINS	ON TIME	1-5	6-10	11-15	16-20	21-25	26-30	31+
WWD COMMUTER	36	5	13	8	7	0	1	1	1
TOTALS	36	5	13	8	7	0	1	1	1
% OF TOTAL		13.9	36.1	22.2	19.4	.0	2.8	2.8	2.8
CUMULATIVE %		13.9	50.0	72.2	91.6				

WB To Providence

LATENESS REPORT FOR A SINGLE STATION

FOR A SEVERAL DAY PERIOD
PERFORMANCE VS TPC NOT SCHED
10-16-92 RUN 4 TRKS READ TO FOREST
4 TRKS GUILFORD
READVILLE -- Departures

Lateness Distribution for 1 Days

CLASS	TOTAL TRAINS	ON TIME	1-5	6-10	11-15	16-20	21-25	26-30	31+
WWD COMMUTER	27	6	18	3	0	0	0	0	0
TOTALS	27	6	18	3	0	0	0	0	0
% OF TOTAL		22.2	66.7	11.1	.0	.0	.0	.0	.0

Westbound To Readville/Franklin Bl

OLD COLONY RAILROAD REHABILITATION PROJECT

YEAR 2000 WEEKDAY TIMTETABLE - 4 TRAINSETS PER LINE

OLD COLONY

INBOUND:

	SET	A	B	C	D	E	F	G	H	I	J	K	L	A
	TRAIN	MZ	PZ	GZ	M4	G4	P4	M6	G6	P6	M8	G8	P8	M10
	Middleborough	5:37A			6:37A			6:56 A			7:23 A			8:03 A
	Bridgewater	5:48 A			6:48 A			7:07 A			7:34 A			8:14 A
	Campello	5:57 A			6:57 A			7:16 A			7:43 A			8:23 A
	Brockton	6:01 A			7:01 A			7:20 A			7:47 A			8:27 A
	Montello	6:05 A			7:05 A			7:24 A			7:51 A			8:31 A
	Holbrook/Randolph	6:11 A			7:11 A			7:30 A			7:57 A			8:37 A
	Kingston		5:42A				6:51 A			7:18A			7:38 A	
	Plymouth													
	Halifax		5:52A				7:01 A			7:28A			7:48 A	
	Hanson		5:58A				7:07 A			7:34A			7:54 A	
	Whitman		6:04A				7:13 A			7:40 A			8:00 A	
	Abington		6:09A				7:18 A			7:45 A			8:05 A	
	South Weymouth		6:15 A				7:24 A			7:51 A			8:11 A	
	Greenbush			5:47A		6:42A			7:09A			7:36A		
	North Scituate			5:55 A		6:50A			7:17 A			7:44 A		
	Cohasset			6:03 A		6:58A			7:25 A			7:54A		
	Nantasket Junction			6:07 A		7:02 A			7:29 A			7:58A		
	West Hingham			6:13 A		7:08 A			7:35 A			8:04 A		
	East Weymouth			6:18 A		7:13 A			7:40A			8:09A		
	Weymouth Landing			6:24 A		7:19 A			7:46 A			8:15A		
	Braintree	6:18A	6:23A		7:18A		7:32A	7:37A		7:59A	8:04A		8:24A	8:44 A
	South Station	6:36A	6:40A	6:45 A	7:35A	7:40 A	7:49 A	7:54A	8:07A	8:16 A	8:21A	8:36 A	8:47A	9:01 A

June 1991

YEAR 2000 WEEKDAY TIMTETABLE - 4 TRAINSETS PER LINE

INBOUND:

*

	SET	B	C	G	K	I	D	F	H	J	L	E	A	B
	TRAIN	P 10	G 10	M 12	G 12	P 12	M 14	P 14	G 14	M 16	P 16	G 16	M 18	P 18
Middleborough				9:37A			11:07A			12:55 P			2:30 P	
Bridgewater				9:48 A			11:18 A			1:06 P			2:41 P	
Campello				9:57A			11:27A			1:15 P			2:50 P	
Brockton				10:01A			11:31A			1:19 P			2:54P	
Montello				10:05A			11:35 A			1:23 P			2:58 P	
Holbrook/Randolph				10:11 A			11:41 A			1:29 P			3:04 P	
Kingston		8:42A				10:10A		11:42 A			1:18 P			2:42P
Plymouth						10:36A								
Halifax		8:52A				10:46A		11:52 A			1:28 P			2:52 P
Hanson		8:58A				10:52A		11:58 A			1:34 P			2:58 P
Whitman		9:04A				11:00A		12:04 P			1:40 P			3:04 P
Abington		9:09A				11:05A		12:09 P			1:45 P			3:09 P
South Weymouth		9:15A				11:11 A		12:15 P			1:51 P			3:15 P
Greenbush			8:50A		10:20A				11:38A			1:36P		
North Scituate			8:58A		10:28A				11:45 A			1:44 P		
Cohasset			9:06A		10:36A				12:03 P			1:52 P		
Nantasket Junction			9:10A		10:40A				12:07P			1:56 P		
West Hingham			9:16A		10:46A				12:13 P			2:02 P		
East Weymouth			9:21A		10:51A				12:18 P			2:07 P		
Weymouth Landing			9:27A		10:57A				12:24P			2:13 P		
Braintree		9:23A		10:18A		11:19A	11:48A	12:23P		1:36 P	1:59 P		3:11P	3:23 P
South Station		9:40A	9:48A	10:35A	11:18A	11:36A	12:05 P	12:40P	12:45P	1:53 P	2:16 P	2:34P	3:28P	3:40 P

June 1991

* PLYMOUTH SERVICE

OLD COLONY RAILROAD REHABILITATION PROJECT

YEAR 2000 WEEKDAY TIMTETABLE - 4 TRAINSETS PER LINE

INBOUND:

DRAFT

	SET	C	D	G	F	E	J	H	A	I	K	D	L	
	TRAIN	G18	M20	M22	P20	G20	M24	G22	M26	P22	G22	M28	P24	
Middleborough			3:09P	4:58P			5:54P		7:20P			8:50P		
Bridgewater			3:20P	5:09P			6:07P		7:31P			9:01P		
Campello			3:29P	5:22P			6:19P		7:40P			9:10P		
Brockton			3:33P	5:26P			6:23P		7:44P			9:14P		
Montello			3:37P	5:32P			6:27P		7:48P			9:18P		
Holbrook/Randolph			3:43P	5:38P			6:33P		7:54P			9:24P		
Kingston					5:10P					7:33P			8:43P	
Plymouth					5:42P								9:09P	
Halifax					5:52P					7:43P			9:19P	
Hanson					5:58P					7:49P			9:25P	
Whitman					6:06P					7:55P			9:34P	
Abington					6:11P					8:00P			9:39P	
South Weymouth					6:17P					8:06P			9:45P	
Greenbush		2:55P				5:17P		7:11P			8:24P			
North Scituate		3:03P				5:25P		7:19P			8:32P			
Cohasset		3:11P				5:35P		7:29P			8:40P			
Nantasket Junction		3:15P				5:39P		7:33P			8:44P			
West Hingham		3:21P				5:45P		7:39P			8:50P			
East Weymouth		3:26P				5:50P		7:44P			8:58P			
Weymouth Landing		3:32P				5:56P		7:50P			9:04P			
Braintree			3:50P	5:45P	6:32P		6:44P		8:01P	8:14P		9:31P	9:53P	
South Station		3:53P	4:07P	6:02P	6:49P	6:18P	7:02P	8:11P	8:18P	8:31P	9:25P	9:48P	10:10P	

June 1991

* PLYMOUTH SERVICE

OLD COLONY RAILROAD REHABILITATION PROJECT

YEAR 2000 WEEKDAY TIMTETABLE - 4 TRAINSETS PER LINE

OUTBOUND:

	SET	A	B	C	G	I	K	D	F	H	J	L	E	A
	TRAIN	M1	P1	G1	M3	P3	G3	M5	P5	G5	M7	P7	G7	M9
South Station		6:45A	6:50A	6:59A	8:14A	8:41A	9:05A	9:45A	10:13A	10:38A	11:30A	12:04P	12:19P	12:45P
Braintree		7:04A	7:09A		8:43A	9:00A		10:03A	10:35A		11:49A	12:23P		1:03P
Weymouth Landing				7:24A			9:33A			11:02A			12:45P	
East Weymouth				7:30A			9:39A			11:08A			12:51P	
West Hingham				7:35A			9:44A			11:13A			12:56P	
Nantasket Junction				7:41A			9:50A			11:19A			1:02P	
Cohasset				7:45A			9:54A			11:23A			1:06P	
North Scituate				7:52A			10:01A			11:30A			1:13P	
Greenbush				7:58A			10:07A			11:36A			1:19P	
South Weymouth			7:17A			9:08A			10:43A			12:31P		
Abington			7:26A			9:15A			10:49A			12:37P		
Whitman			7:30A			9:19A			10:53A			12:41P		
Hanson			7:38A			9:25A			10:59A			12:47P		
Halifax			7:44A			9:31A			11:05A			12:53P		
Plymouth														
Kingston			7:55A			9:40A			11:14A			1:02P		
Holbrook/Randolph		7:14A			8:50A			10:14A			11:56A			1:10P
Montello		7:21A			8:57A			10:21A			12:03P			1:17P
Brockton		7:25A			9:01A			10:25A			12:07P			1:21P
Campello		7:29A			9:05A			10:29A			12:11P			1:25P
Bridgewater		7:43A			9:14A			10:38A			12:20P			1:34P
Middleborough		7:53A			9:24A			10:48A			12:30P			1:44P

June 1991

OLD COLONY RAILROAD REHABILITATION PROJECT

YEAR 2000 WEEKDAY TIMTETABLE - 4 TRAINSETS PER LINE

OUTBOUND:

	SET	B	C	D	G	F	E	J	I	H	A	K	L	D
	TRAIN	P9	G9	M11	M13	P11	G11	M15	P13	G13	M17	G15	P15	M19
South Station		1:17 P	1:33 P	1:56 P	3:48P	4:02 P	1:07 P	4:30 P	4:43 P	4:48 P	5:00P	5:17 P	5:22 P	5:27 P
Braintree		1:36 P		2:15 P	4:07 P	4:21 P		4:48 P	5:02 P		5:19 P		5:41 P	5:46 P
Weymouth Landing			1:55 P				4:29 P			5:10 P		5:39P		
East Weymouth			2:01 P				4:35 P			5:16 P		5:45P		
West Hingham			2:06 P				4:40 P			5:21 P		5:50 P		
Nantasket Junction			2:12 P				4:46 P			5:27 P		5:56 P		
Cohasset			2:16 P				4:50 P			5:31 P		6:00P		
North Scituate			2:23 P				4:57P			5:38 P		6:07 P		
Greenbush			2:29 P				5:03P			5:44 P		6:13 P		
South Weymouth		1:44 P				4:29 P			5:10 P				5:49 P	
Abington		1:52 P				4:35 P			5:16 P				5:55 P	
Whitman		1:56 P				4:39 P			5:20 P				5:59 P	
Hanson		2:02 P				4:45 P			5:26 P				6:05 P	
Halifax		2:08 P				4:51 P			5:32 P				6:11 P	
Plymouth						5:26P								
Kingston		2:17 P				5:00P			5:41 P				6:20P	
Holbrook/Randolph				2:22 P	4:14 P			4:55 P			5:26 P			5:53P
Montello				2:29 P	4:21 P			5:02 P			5:33 P			6:00P
Brockton				2:33 P	4:25 P			5:06 P			5:37 P			6:04 P
Campello				2:37 P	4:29 P			5:10 P			5:41 P			6:08 P
Bridgewater				2:50P	4:38P			5:19 P			5:50P			6:17 P
Middleborough				3:00P	4:48P			5:29 P			6:00P			6:27P

June 1991

* PLYMOUTH SERVICE

OLD COLONY RAILROAD REHABILITATION PROJECT

YEAR 2000 WEEKDAY TIMTETABLE - 4 TRAINSETS PER LINE

OUTBOUND:

	SET	C	B	G	E	F	J	H	A	I	K	D	L	
	TRAIN	G17	P17	M21	G19	R19	M23	G21	M25	P21	G23	M27	P23	
South Station		5:41 P	6:09 P	6:14 P	6:41 P	6:54 P	7:12 P	8:25 P	8:40 P	8:50 P	9:50 P	10:10 P	10:30 P	
Braintree			6:28 P	6:33 P		7:13 P	7:31 P		8:59 P	9:09 P		10:29 P	10:49 P	
Weymouth Landing		6:03 P			7:03 P			8:47 P			10:12 P			
East Weymouth		6:09 P			7:09 P			8:53 P			10:18 P			
West Hingham		6:14 P			7:14 P			8:58 P			10:23 P			
Nantasket Junction		6:20 P			7:20 P			9:04 P			10:29 P			
Cohasset		6:24 P			7:24 P			9:08 P			10:33 P			
North Scituate		6:31 P			7:31 P			9:15 P			10:40 P			
Greenbush		6:37 P			7:37 P			9:21 P			10:46 P			
South Weymouth			6:36 P			7:21 P				9:17 P			10:57 P	
Abington			6:42 P			7:27 P				9:23 P			11:03 P	
Whitman			6:46 P			7:31 P				9:27 P			11:08 P	
Hanson			6:52 P			7:37 P				9:33 P			11:13 P	
Halifax			6:58 P			7:43 P				9:39 P			11:19 P	
Plymouth													11:28 P	
Kingston			7:07 P			7:52 P				9:48 P			11:54 P	
Holbrook/Randolph				6:40 P			7:38 P		9:06 P			10:36 P		
Montello				6:47 P			7:45 P		9:13 P			10:43 P		
Brockton				6:51 P			7:49 P		9:17 P			10:47 P		
Campello				6:55 P			7:53 P		9:21 P			10:51 P		
Bridgewater				7:04 P			8:02 P		9:30 P			11:00 P		
Middleborough				7:14 P			8:12 P		9:40 P			11:10 P		

June 1991

* PLYMOUTH SERVICE

A.2 2020 No-Build Scenario (cont.)

A.2.2 Northside Schedules

The following presents the projected Northside schedules for the year 2020 without the construction of a rail link tunnel.

2020 Schedule

TRAIN	LV BOS	FROM	TO	AR	MAKE
061	06:20	100	B	06:50	062
063	06:55	150	B	07:25	064
105	07:05	102	R	08:05	110
065	07:25	152	B	07:55	066
155	07:40	062	I	08:25	160
067	07:55	104	B	08:25	068
107	08:00	154	R	09:00	112
157	08:30	156	N	09:30	162
109	09:00	108	R	10:00	114
159	09:30	110	N	10:30	164
111	10:00	160	R	11:00	116
161	10:30	H	N	11:30	166
113	11:00	162	R	12:00	118
163	11:30	114	N	12:30	168
115	12:00	164	R	01:00	120
165	12:30	H	N	01:30	170
117	01:00	166	R	02:00	122
167	01:25	H	N	02:25	172
119	02:00	168	R	03:00	124
169	02:30	H	N	03:30	174
121	03:00	170	R	04:00	126
171	03:30	122	N	04:30	176
091	03:45	172	B	04:15	092
123	04:00	H	R	05:00	PU
173	04:25	124	N	05:25	178
093	04:35	H	B	05:05	094
125	05:00	174	R	06:00	128
095	05:05	092	B	05:35	096
175	05:20	126	N	06:20	PU
127	05:35	H	R	06:35	PU
177	05:40	H	N	06:40	PU
097	05:50	176	B	06:20	098
129	06:00	094	R	07:00	132
179	06:30	096	N	07:30	182
131	07:00	H	R	08:00	134
181	07:30	128	N	08:30	PU
133	08:00	098	R	09:00	136
183	08:30	132	N	09:30	186
135	09:00	182	R	10:00	138
185	09:30	134	N	10:30	188
137	10:00	H	R	11:00	PU
187	10:30	136	N	11:30	PU
139	11:00	186	R	12:00	PU
189	11:30	138	N	12:30	PU
141	12:00	188	R	01:00	PU

TRAIN	FROM	LV	FROM	AR BOS	MAKE
100	R	05:10	Y	06:10	061
150	N	05:40	Y	06:40	063
102	R	05:55	Y	06:55	105
152	N	06:15	Y	07:15	065
062	B	07:00	061	07:30	155
104	R	06:40	Y	07:40	067
154	N	06:50	Y	07:50	107
064	B	07:35	063	08:05	H
106	R	07:10	Y	08:10	H
156	N	07:20	Y	08:20	157
066	B	08:05	065	08:35	H
108	R	07:40	Y	08:40	109
158	N	07:55	Y	08:55	H
068	B	08:35	067	09:05	H
110	R	08:15	105	09:15	159
160	I	08:55	155	09:40	111
112	R	09:10	107	10:10	H
162	N	09:40	157	10:40	113
114	R	10:10	109	11:10	163
164	N	10:40	159	11:40	115
116	R	11:10	111	12:10	H
166	N	11:40	161	12:40	117
118	R	12:10	113	01:10	H
168	N	12:40	163	01:40	119
120	R	01:10	115	02:10	H
170	N	01:40	165	02:40	121
122	R	02:10	117	03:10	171
172	N	02:35	167	03:35	091
124	R	03:10	119	04:10	173
174	N	03:40	169	04:40	125
092	B	04:25	091	04:55	095
126	R	04:10	121	05:10	175
176	N	04:40	171	05:40	097
094	B	05:15	093	05:45	129
096	B	05:45	095	06:15	179
178	N	05:35	173	06:35	H
128	R	06:10	125	07:10	181
098	B	06:45	097	07:15	133
132	R	07:10	129	08:10	183
182	N	07:40	179	08:40	135
134	R	08:10	131	09:10	185
136	R	09:10	133	10:10	187
186	N	09:40	183	10:40	139
138	R	10:10	135	11:10	189
188	N	10:40	185	11:40	141

A	RKPT	100-061-062-155-160-111-116-H-177-PU
B		102-105-110-159-164-115-120-H-131-134-185-188-141-PU
C		104-067-068-H-169-174-125-128-181-PU
D		106-H-167-172-091-092-095-096-179-182-135-138-189-PU
E		108-109-114-163-168-119-124-173-178-H-137-PU
F	NBPT	150-063-064-H-161-166-117-122-171-176-097-098-133-136-187-PU
G		152-065-066-H-165-170-121-126-175-PU
H		154-107-112-H-123-PU
I		156-157-162-113-118-H-127-PU
J		158-H-093-094-129-132-183-186-139-PU

B = Beverly
R = Rockport
I = Ipswich
N = Newburyport

11-28-95

2020 Schedule

TRAIN	LV BOS	FROM	TO	AR	MAKE
251	05:10	HR	R	05:40	252
253	06:20	200	R	06:50	256
*203	06:30	HR	P	07:30	214
255	06:40	252	R	07:10	258
*207	07:05	202	P	08:05	216
257	07:30	204	R	08:00	262
209	08:10	258	P	09:10	218
211	08:50	262	P	09:50	220
213	09:50	216	P	10:50	222
215	10:50	218	P	11:50	224
217	11:55	H	P	12:55	226
219	12:50	H	P	01:50	228
221	01:50	224	P	02:50	230
223	02:50	226	P	03:50	234
225	03:20	H	P	04:20	236
267	03:40	228	R	04:10	272
229	04:00	H	P	05:00	PU
271	04:20	H	R	04:50	274
*231	04:40	230	P	05:40	242
273	04:50	H	R	05:20	278
*233	05:05	272	P	06:05	PU
275	05:20	234	R	05:50	280
*235	05:40	274	P	06:40	PU
277	06:00	236	R	06:30	282
237	06:30	278	P	07:30	PU
279	07:00	280	R	07:30	284
241	08:00	282	P	09:00	246
281	09:00	284	R	09:30	286
245	10:00	H	P	11:00	PU
295	11:00	286	R	11:30	288
247	12:01	246	P	01:01	PU

TRAIN	FROM	LV	FROM	AR BOS	MAKE
200	P	05:10	Y	06:10	253
252	R	06:00	251	06:30	255
202	P	05:50	Y	06:50	207
204	P	06:20	Y	07:20	257
256	R	07:00	253	07:30	H
*206	P	06:35	Y	07:35	H
*208	P	06:50	Y	07:50	H
258	R	07:30	255	08:00	209
210	P	07:15	Y	08:15	H
262	R	08:10	257	08:40	211
214	P	07:50	203	08:50	H
216	P	08:30	207	09:30	213
218	P	09:30	209	10:30	215
220	P	10:30	211	11:30	H
222	P	11:30	213	12:30	H
224	P	12:25	215	01:25	221
226	P	01:30	217	02:30	223
228	P	02:30	219	03:30	267
230	P	03:10	221	04:10	231
272	R	04:20	267	04:50	233
*234	P	04:10	223	05:10	275
274	R	05:00	271	05:30	235
*236	P	04:40	225	05:40	277
278	R	05:30	273	06:00	237
280	R	06:00	275	06:30	279
242	P	06:00	231	07:00	HR
282	R	06:40	277	07:10	241
284	R	07:40	289	08:10	281
286	R	09:40	293	10:10	295
246	P	09:20	241	10:20	247
288	R	11:40	295	12:10	HR

K 200-253-256-H-219-228-267-272-233-PU
L 202-207-216-213-222-H-245-PU
M 204-257-262-211-220-H-229-PU
N 206-H-217-226-223-234-275-280-279-284-281-286-295-288-HR
O 208-H-271-274-235-PU
P 210-H-273-278-237-PU
Q HR-251-252-255-258-209-218-215-224-221-230-231-242-HR
R HR-203-214-H-225-236-277-282-241-246-247-PU

R = Reading
P = Plaistow
Y = Yard
H = House
PU = Put Up

* OPERATE VIA N. H. DIVN + WILDCAT

SCHED4.WK4

11-28-95

2020 Schedule

TRAIN	LV BOS	FROM	TO	AR	MAKE
351	05:35	HR	M	06:00	352
353	06:25	300	M	06:45	354
383	06:45	352	L	07:25	386
305	07:10	302	N	08:10	310
385	07:30	354	L	08:10	388
309	07:50	304	N	08:50	312
311	08:30	386	N	09:30	314
313	09:35	310	N	10:35	316
315	10:30	312	N	11:30	318
317	11:30	314	N	12:30	320
319	12:30	H	N	01:30	322
321	01:30	H	N	02:30	324
323	02:30	320	N	03:30	326
325	03:30	322	N	04:30	328
387	04:00	324	L	04:40	396
357	04:10	H	M	04:45	366
327	04:30	H	N	05:30	PU
329	04:50	H	N	05:50	340
361	05:15	326	M	05:40	368
393	05:30	366	L	06:10	398
335	05:50	396	N	06:50	PU
337	06:10	328	N	07:10	342
339	07:10	398	N	08:10	344
341	08:10	340	N	09:10	346
343	09:10	342	N	10:10	348
345	10:10	344	N	11:10	PU
347	11:10	346	N	12:10	PU
349	12:10	348	N	01:10	PU

TRAIN	FROM	LV	FROM	AR BOS	MAKE
300	N	05:15	Y	06:15	353
352	M	06:10	351	06:35	383
302	N	05:55	Y	06:55	305
354	M	06:55	353	07:20	385
304	N	06:40	Y	07:40	309
306	N	07:00	Y	08:00	H
386	L	07:40	383	08:20	311
308	N	07:40	Y	08:40	H
388	L	08:20	385	09:00	H
310	N	08:20	305	09:20	313
312	N	09:00	309	10:00	315
314	N	09:40	311	10:40	317
316	N	10:45	313	11:45	H
318	N	11:40	315	12:40	H
320	N	12:40	317	01:40	323
322	N	01:40	319	02:40	325
324	N	02:40	321	03:40	387
326	N	03:40	323	04:40	361
366	M	04:55	357	05:15	397
396	L	04:50	387	05:30	335
328	N	04:40	325	05:45	337
368	M	05:50	361	06:15	H
398	L	06:20	393	07:00	339
340	N	06:20	329	07:20	341
342	N	07:20	337	08:20	343
344	N	08:20	339	09:20	345
346	N	09:20	341	10:20	347
348	N	10:20	343	11:20	349

S	300-353-354-385-388-H-327-PU
T	351-352-383-386-311-314-317-320-323-326-361-368-H
U	302-305-310-313-316-H-329-340-341-346-347-PU
V	304-309-312-315-318-H-357-366-393-398-339-344-345-PU
W	306-H-319-322-325-328-337-342-343-348-349-PU
X	308-H-321-324-387-396-335-PU

M = Mishawum
L = Lowell
N = Nashua

Woburn/Nashua - FP

SCHED2.WK4

10-19-95

2020 Schedule

TRAIN	LV BOS	FROM	TO	AR	MAKE
451	05:00	HR	SA	05:45	450
453	05:40	HR	SA	06:25	452
455	06:20	HR	SA	07:05	454
407	06:30	400	F	07:50	410
457	06:50	450	SA	07:35	456
459	07:20	402	SA	08:05	458
409	08:30	406	F	09:50	412
461	08:40	456	SA	09:25	460
411	09:30	458	F	10:50	414
413	10:30	460	F	11:50	416
415	11:30	412	F	12:50	418
417	12:30	414	F	01:50	420
419	01:30	416	F	02:50	422
421	02:30	418	F	03:50	424
423	03:30	420	F	04:50	426
463	03:50	H	SA	04:35	464
425	04:10	H	F	05:30	428
465	04:30	422	SA	05:15	466
427	04:50	H	F	06:10	430
429	05:10	H	F	06:30	PU
431	05:30	424	F	06:50	PU
471	05:50	464	SA	06:35	468
433	06:10	H	F	07:30	PU
473	07:10	428	SA	07:55	470
435	08:10	468	F	09:30	432
475	09:10	430	SA	09:55	472
437	10:10	470	F	11:30	PU
477	11:10	472	SA	11:55	474
401	12:10	432	F	01:30	PU

TRAIN	FROM	LV	FROM	AR BOS	MAKE
400	F	05:00	Y	06:20	407
450	SA	05:55	451	06:40	457
402	F	05:40	Y	07:00	459
452	SA	06:35	453	07:20	H
404	F	06:20	Y	07:40	H
454	SA	07:15	455	08:00	H
406	F	07:00	Y	08:20	409
456	SA	07:45	457	08:30	461
408	F	07:20	Y	08:40	H
458	SA	08:15	459	09:00	411
410	F	08:00	407	09:20	H
460	SA	09:35	461	10:20	413
412	F	10:00	409	11:20	415
414	F	11:00	411	12:20	417
416	F	12:00	413	01:20	419
418	F	01:00	415	02:20	421
420	F	02:00	417	03:20	423
422	F	03:00	419	04:20	465
424	F	04:00	421	05:20	431
464	SA	04:45	463	05:30	471
466	SA	05:25	465	06:10	HR
426	F	05:00	423	06:20	HR
428	F	05:40	425	07:00	473
468	SA	06:45	471	07:30	435
430	F	06:20	427	07:40	475
470	SA	08:05	473	08:50	437
472	SA	10:05	475	10:40	477
432	F	09:40	435	11:00	401
474	SA	12:05	477	12:40	HR

Y HR-451-450-457-456-461-460-413-416-419-422-465-466-HR
Z HR-453-452-H-463-464-471-468-435-432-401-PU
AA HR-455-454-H-427-430-475-472-477-474-HR
BB 400-407-410-H-433-PU
CC 402-459-458-411-414-417-420-423-426-HR
DD 404-H-425-428-473-470-437-PU
EE 406-409-412-415-418-421-424-431-PU
FF 408-H-429-PU

SA = South Acton
F = Fitchburg

10-19-95

2020 Schedule

8	12	14	16	18	20				11	15	17	19	21	23
06:15	08:15	11:05	01:35	04:20	06:50	LV	Portland	AR	11:50	02:20	05:05	07:35	10:00	12:40
		11:25	01:55	04:40	07:10		Ocean Park/Surf		11:25	01:55	04:40	07:05		
06:35	08:35	11:30	02:00	04:45	07:15	S	Saco	S	11:20	01:50	04:35	07:00	09:35	12:15
06:50	08:50	11:45	02:15	05:00	07:30	S	Wells	S	11:05	01:35	04:20	06:45	09:20	12:00
07:08	09:08	12:03	02:33	05:18	07:48	S	Dover	S	10:47	01:17	04:02	06:27	09:02	11:42
07:25	09:25	12:20	02:50	05:35	08:05	S	Exeter	S	10:30	01:00	03:45	06:10	08:45	11:25
07:40	09:40	12:35	03:05	05:50	08:20		Plaistow		10:15	12:45	03:30	05:55	08:30	11:10
07:45	09:45	12:40	03:10	05:55	08:25	S	Bradford	S	10:10	12:40	03:25	05:45	08:25	11:05
08:00	10:00	12:55	03:25	06:10	08:40		CPF-WJ		09:55	12:25	03:10	05:30	08:10	10:50
08:05	10:05	01:00	03:30	06:15	08:45		Wilmington		09:50	12:20	03:05	05:25	08:05	10:45
08:30	10:35	01:30	04:00	06:45	09:15	AR	Boston	LV	09:30	12:00	02:45	05:05	07:45	10:25

GG 8-11-16-19
HH 12-15-18-21
II 14-17-20-23
One Set Swapped
Daily in Boston

A.2 2020 No-Build Scenario (cont.)

A.2.3 Southside Service Equipment Assignment

The following presents the projected southside service equipment assignments for the 2020 No-Build scenario. As shown the equipment will increase from 24 to 56 trainsets.

Table A.2-2 Southside Service Equipment Assignment

Terminal	1996	2020	Terminal
Boston	3	7	Worcester
Worcester	3		
Franklin	3	8	Milford
Boston	2		
Boston	2	5	Providence
East Jct. - Readville	4	4	East Jct.
Boston	2	4	No. Easton
Boston/Shuttles	2	3	Readville Shuttles
Boston (Needham)	3	5	Millis
	24 sets	4	Fall River
		4	New Bedford
		4	Middleborough
		4	Kingston
		4	Greenbush
		56 sets	

A.2 2020 No-Build Scenario (cont.)

A.2.4 Peak Period Service Capacity Utilization

The future No-Build peak period service capacity utilization was determined based on the number of seats available on each line and the corresponding ridership.

		Train Consist		Number of Seats				
	Number of Peak Period Trains	Number of Bi-Level Coaches	Number of Single Level Coaches	Bi-Levels (180 seats)	Single Level (114 seats)	Total Number of Seats	Peak Period Ridership	Utilization
Total System	90			84,600	10,260	94,860	80,268	84.6%
Northside	35	4	1	25,200	3,990	29,190	26,453	90.6%
Southside	55	6	1	59,400	6,270	65,670	53,815	81.9%

A.3 2020 Build Scenario

A.3.1 Typical Train Schedules

The following represent typical train schedules that could be combined to develop a draft operating plan.

Table A.3-1 **Draft Run-Through Schedule**
North Wilmington-Worcester (63 miles)

Southbound read down	Station	Northbound read up	Express
7:30A	North Wilmington	9:20A	
7:38A	Reading	9:12A	
7:43A	Wakefield	9:07A	
7:46A	Greenwood	9:04A	
7:48A	Melrose Highlands	9:02A	
7:50A	Melrose-Cedar Park	9:00A	
7:52A	Wyoming Hill	8:58A	
7:55A	Malden	8:55A	
8:04A	North Station	8:45A	8:50A
8:08A	Central Station	8:41A	8:46A
8:12A	South Station	8:37A	8:42A
8:17A	Back Bay Station	8:33A	8:38A
8:27A	Newtonville	8:23A	↑
8:30A	West Newton	8:20A	↑
8:33A	Auburndale	8:17A	↑
8:36A	Wellesley Farms	8:14A	↑
8:39A	Wellesley Hills	8:11A	↑
8:42A	Wellesley Square	8:08A	↑
8:46A	Natick	8:04A	↑
8:50A	West Natick	8:00A	8:16A
8:54A	Framingham	7:56A	8:12A
8:57A	Ashland		8:09A
8:59A	Southborough		8:07A
9:03A	Westborough		8:03A
9:12A	North Grafton		7:54A
9:16A	Millbury		7:50A
9:22A	Worcester		7:46A

Table A.3-2 **Draft Run-Through Schedule**
Littleton-Plymouth (66 miles)

Southbound read down	Station	Northbound read up
7:30A	Littleton	9:10A
7:39A	Acton	9:01A
7:44A	West Concord	8:56A
7:47A	Concord	8:53A
7:52A	Lincoln	8:48A
7:54A	Silver Hill	8:46A
7:57A	Hastings Road	8:43A
7:59A	Kendal Green	8:41A
8:02A	Brandeis University	8:38A
8:05A	Waltham	8:35A
8:10A	Waverley	8:30A
8:12A	Belmont	8:28A
8:16A	Porter Square-Cambridge	8:24A
8:25A	North Station	8:14A
8:29A	Central Station	8:10A
8:33A	South Station	8:06A
8:46A	Braintree	7:54A
8:50A	South Weymouth	7:50A
8:54A	North Abington	7:46A
8:58A	Whitman	7:42A
9:02A	South Hanson	7:38A
9:06A	Halifax	7:34A
9:10A	Kingston	7:30A

Table A.3-3 **Draft Run-Through Schedule**
Lowell-Greenbush (54 miles)

Southbound read down	Station	Northbound read up
7:30A	Lowell	8:44A
7:37A	Billerica	8:37A
7:44A	Wilmington	8:30A
7:49A	Woburn/128	8:25A
8:05A	North Station	8:08A
8:09A	Central Station	8:04A
8:13A	South Station	8:00A
	Weymouth Landing	
	East Weymouth	
	West Hingham	
	Nantasket Jct.	
	Cohasset	
	North Scituate	
	Greenbush	

Table A.3-4 **Draft Run-Through Schedule**
Newburyport-Middleborough/Lakeville (72 miles)

Southbound read down	Station	Northbound read up
7:30A	Newburyport	9:17A
7:37A	Rowley	9:10A
7:42A	Ipswich	9:05A
7:48A	Hamilton/Wenham	8:59A
7:51A	North Beverly	8:56A
7:55A	Beverly	8:52A
7:58A	Salem	8:49A
8:04A	Swampscott	8:43A
8:07A	Lynn	8:40A
8:10A	River Works	8:37A
8:17A	Chelsea	8:30A
8:27A	North Station	8:19A
8:31A	Central Station	8:15A
8:35A	South Station	8:11A
8:48A	Braintree	7:59A
8:53A	Holbrook/Randolph	7:54A
8:57A	Montello	7:50A
9:00A	Brockton	7:47A
9:03A	Campello	7:44A
9:09A	Bridgewater	7:38A
9:17A	Middleborough/Lakeville	7:30A

Table A.3-5 **Draft Run-Through Schedule**
Rockport-Needham (50 miles)

Southbound read down	Station	Northbound read up
7:30A	Rockport	9:17A
7:37A	Gloucester	9:10A
7:41A	West Gloucester	9:06A
7:47A	Manchester	9:00A
7:51A	Beverly Farms	8:56A
7:53A	Prides Crossing	8:54A
7:57A	Montserrat	8:50A
8:00A	Beverly	8:47A
8:03A	Salem	8:44A
8:09A	Swampscott	8:38A
8:12A	Lynn	8:35A
8:15A	River Works	8:32A
8:22A	Chelsea	8:25A
8:32A	North Station	8:14A
8:36A	Central Station	8:10A
8:40A	South Station	8:06A
8:45A	Back Bay Station	8:02A
8:48A	Ruggles Street	7:59A
8:52A	Forest Hills	7:55A
8:55A	Roslindale Village	7:52A
8:58A	Bellevue	7:49A
9:01A	Highland	7:46A
9:04A	West Roxbury	7:43A
9:08A	Hersey	7:39A
9:11A	Neeham Jct.	7:36A
9:14A	Needham Center	7:33A
9:17A	Needham Heights	7:30A

Table A.3-6 **Draft Run-Through Schedule**
Fitchburg-North Easton (73 miles)

Southbound read down	Station	Northbound read up
7:30A	Fitchburg	9:25A
7:36A	North Leominster	9:19A
7:42A	Shirley	9:13A
7:46A	Ayer	9:09A
7:55A	Littleton	9:00A
8:04A	Acton	8:51A
8:09A	West Concord	8:46A
8:12A	Concord	8:43A
8:17A	Lincoln	8:38A
8:25A	Waltham	8:30A
8:34A	Porter Square-Cambridge	8:21A
8:43A	North Station	8:11A
8:47A	Central Station	8:07A
8:51A	South Station	8:03A
8:56A	Back Bay Station	7:59A
8:59A	Ruggles Street	7:56A
9:06A	Hyde Park	7:49A
9:10A	Westwood/128	7:45A
9:15A	Canton Jct.	7:40A
9:18A	Canton Center	7:37A
9:25A	Stoughton	7:30A
	North Easton	

Table A.3-7 **Draft Run-Through Schedule**
Woburn-Providence (57 miles)

Southbound read down	Station	Northbound read up
7:30A	Woburn/128	8:53A
7:36A	Winchester	8:47A
7:38A	Wedgemere	8:45A
7:42A	West Medford	8:41A
7:52A	North Station	8:30A
7:56A	Central Station	8:26A
8:00A	South Station	8:22A
8:05A	Back Bay Station	8:18A
8:08A	Ruggles Street	8:15A
8:38A	Attleboro	7:45A
8:45A	South Attleboro	7:38A
8:53A	Providence	7:30A

Table A.3-8 **Draft Run-Through Schedule**
Haverhill-Forge Park (64 miles)

Southbound read down	Station	Northbound read up	Express
7:30A	Haverhill	9:10A	
7:32A	Bradford	9:08A	
7:40A	Lawrence	9:00A	
7:45A	Andover	8:55A	
7:48A	Ballardvale	8:52A	
8:08A	Woburn/128	8:32A	
8:24A	North Station	8:15A	8:24A
8:28A	Central Station	8:11A	8:20A
8:32A	South Station	8:07A	8:16A
8:37A	Back Bay Station	8:03A	8:12A
8:40A	Ruggles Street	8:00A	8:09A
8:49A	Readville	7:51A	↑
8:52A	Endicott	7:48A	
8:55A	Dedham	7:45A	
8:58A	Islington	7:42A	
9:01A	Norwood Depot	7:39A	
9:04A	Norwood Central	7:36A	
9:07A	Windsor Gardens	7:33A	
9:10A	Plimptonville	7:30A	
9:13A	Walpole		7:47A
9:18A	Norfolk		7:42A
9:24A	Franklin		7:36A
9:30A	Forge Park		7:30A

Table A.3-9 **Draft Run-Through Schedule**
Beverly-Fall River/New Bedford (80 miles)

Southbound read down	Station	Northbound read up
7:30A	Beverly	8:41A
7:33A	Salem	8:38A
7:39A	Swampscott	8:32A
7:42A	Lynn	8:29A
7:45A	River Works	8:26A
7:52A	Chelsea	8:19A
8:02A	North Station	8:08A
8:06A	Central Station	8:04A
8:10A	South Station	8:00A
8:15A	Back Bay Station	7:56A
8:18A	Ruggles Street	7:53A
8:33A	Sharon	7:38A
8:41A	Mansfield	7:30A
	Taunton	
	East Taunton	
	Freetown	
	Fall River	
	New Bedford	