Potential MBTA Fare Increase and Service Reductions in 2012: Impact Analysis

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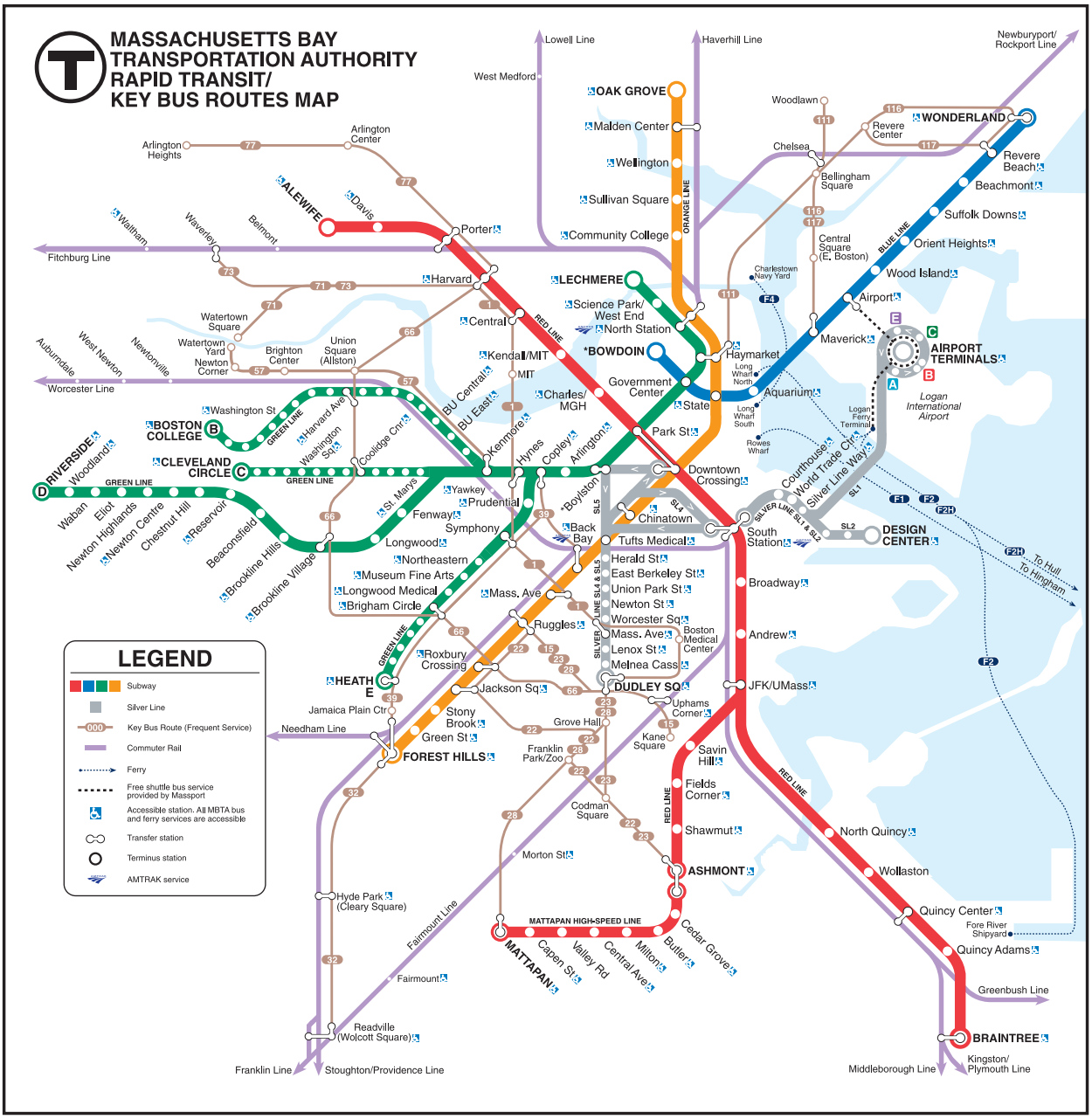

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ABSTRACT

This analysis estimates various impacts of two potential scenarios for MBTA pricing and service aimed at preventing a projected budget deficit. The two scenarios offer a choice between a greater reliance on a fare increase or on service reductions for reaching that objective. The ridership, revenue, air quality, and environmental justice impacts are estimated for both scenarios. Two different modeling methodologies are used to produce these projections. The two models are complementary; in addition, producing two sets of estimates provides a range of possible impacts.

Acknowledgments

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CONTENTS

	List of Exhibits	vii
	EXECUTIVE SUMMARY	xi
1	**INTRODUCTION**	1
2	**DESCRIPTION OF PROPOSED FARE INCREASE/SERVICE REDUCTION SCENARIOS**	3
2.1	Fare Structure Changes	3
2.2	Service Reductions and Revisions	4
2.2.1	Bus	4
2.2.2	Rapid Transit, Commuter Rail, Ferry, and THE RIDE	6
2.2.3	Summary of Service Changes	11
2.3	Fare Increase: Single-Ride Fares, Pass Prices, and Parking Rates	13
3	**METHODS USED TO ESTIMATE RIDERSHIP AND REVENUE**	19
3.1	CTPS Spreadsheet Model Approach	19
3.1.1	Modeling of Existing Ridership and Revenue	19
3.1.2	Estimation of Ridership Changes Resulting from a Fare Increase	20
3.2	Boston Region MPO Travel Demand Model Set Approach	21
3.3	Differences between the Two Estimation Methodologies	23
4	**RIDERSHIP AND REVENUE IMPACTS**	25
4.1	Overview of Results and Methodology	25
4.2	Spreadsheet Model Estimates	26
4.2.1	Scenario 1	26
4.2.2	Scenario 2	28
4.2.3	Comparison of Scenarios 1 and 2 Total Revenue Changes (Fare Revenue Changes Combined with Saved Operating Costs)	30
4.3	Regional Travel Demand Model Set Estimates	31

4.3.1	Scenario 1	31
4.3.2	Scenario 2	32
4.4	Comparison of Model Results: Ranges of Projected Impacts	34
4.4.1	Scenario 1	34
4.4.2	Scenario 2	36
5	**AIR QUALITY IMPACTS**	39
5.1	Background	39
5.2	Estimated Air Quality Impacts	40
6	**ENVIRONMENTAL JUSTICE IMPACTS**	43
6.1	Definition of Environmental Justice Communities	43
6.2	Equity Determination	43
6.2.1	Transit Equity Metrics	44
6.2.2	Highway Congestion and Air Quality Equity Metrics	46
6.2.3	Accessibility Equity Metrics	47
6.2.4	Summary of Equity Impacts	47
7	**CONCLUSIONS**	51
	APPENDIX: SPREADSHEET MODEL METHODOLOGY	
A.1	Apportionment of Existing Ridership	A-1
A.2	Price Elasticity Estimation	A-2
A.3	Price Elasticity	A-3
A.4	Diversion Factors	A-4
A.5	Examples of Ridership and Revenue Calculations	A-6

EXHIBITS

Figure

2-1	Scenario 1 Bus Route Cuts	7
2-2	Scenario 2 Bus Route Cuts	8
2-3	Percentages of Riders Affected and Unaffected by the Proposed Service Reductions, by Scenario	12

Table

E-1	Scenario 1: Range of Revenue and Ridership Projections for the Proposed Fare Increase and Service Reductions	xii
E-2	Scenario 2: Range of Revenue and Ridership Projections for the Proposed Fare Increase and Service Reductions	xii
2-1	MBTA-Operated Bus Routes: Proposed Status under Service-Reduction Scenarios, by Day of Week, with Average Net Cost per Passenger (Subsidy)	9
2-2	Percentage of Service Affected, by Scenario	13
2-3	Single-Ride Fares: Existing and Proposed, by Scenario	14
2-4	Pass Prices: Existing and Proposed, by Scenario	15
2-5	Park-and-Ride Facility Rates: Existing and Proposed, by Scenario	16
2-6	Weighted Average Percentage Change in Average Fares, by Scenario and Modal Category, for Unlinked Trips	17
3-1	Price Elasticity Ranges Used in the Spreadsheet Model	22
4-1	Scenario 1: Spreadsheet Model Estimates of Annual Ridership and Fare Revenue Impacts	26
4-2	Scenario 1: Spreadsheet Model Range of Estimates of Annual Ridership and Fare Revenue Impacts Using Low and High Range of Elasticities	27
4-3	Scenario 1: Spreadsheet Model Estimated of Total Revenue Change: Combined Fare Revenue Gains and Saved Operating Costs	28

4-4	Scenario 2: Spreadsheet Model Estimates of Annual Ridership and Fare Revenue Impacts	29
4-5	Scenario 2: Spreadsheet Model Range of Estimates of Annual Ridership and Fare Revenue Impacts Using Low and High Range of Elasticities	29
4-6	Scenario 2: Spreadsheet Model Estimates of Total Revenue Change: Combined Fare Revenue Changes and Saved Operating Costs	30
4-7	Comparison of Scenarios 1 and 2 Total Revenue Change: Combined Fare Revenue Changes and Saved Operating Costs	31
4-8	Scenario 1: Travel Demand Model Set Estimates of Annual Ridership and Fare Revenue Impacts	31
4-9	Scenario 1: Travel Demand Model Set Estimates of Total Revenue Change: Combined Fare Revenue Gains and Saved Operating Costs	32
4-10	Scenario 2: Travel Demand Model Set Estimates of Annual Ridership and Fare Revenue Impacts	33
4-11	Scenario 2: Travel Demand Model Set Estimates of Total Revenue Change: Combined Fare Revenue Changes and Saved Operating Costs	33
4-12	Scenario 1: Range of Ridership Projections	35
4-13	Scenario 1: Range of Fare Revenue Projections	35
4-14	Scenario 1: Range of Projections for Total Revenue: Combined Fare Revenue Gains and Saved Operating Costs	36
4-15	Scenario 2: Range of Ridership Projections	37
4-16	Scenario 2: Range of Fare Revenue Projections	37
4-17	Scenario 2: Range of Projections for Total Revenue: Combined Fare Revenue Gains and Saved Operating Costs	38
5-1	Projected Average Weekday Changes in Selected Pollutants (Regionwide)	41
6-1	Scenario 1: Existing and Projected Measures of Transit Equity Metrics	45
6-2	Scenario 2: Existing and Projected Measures of Transit Equity Metrics	45
6-3	Scenario 1: Existing and Projected Measures of Highway Congestion and Air Quality Equity Metrics	48
6-4	Scenario 2: Existing and Projected Measures of Highway Congestion and Air Quality Equity Metrics	48
6-5	Scenario 1: Existing and Projected Measures of Accessibility Equity Metrics	48
6-6	Scenario 2: Existing and Projected Measures of Accessibility Equity Metrics	48
A-1	AFC Fare Categories	A-1

A-2 AFC Modal Categories A-2
A-3 Single-Ride and Pass Elasticities by Mode A-3

KEYWORDS

ridership
revenue
air quality
environmental justice
fare increase
service reduction

EXECUTIVE SUMMARY

The Massachusetts Bay Transportation Authority (MBTA) faces a projected budget deficit for fiscal year (FY) 2013 (July 1, 2012–June 30, 2013) of $161 million. The MBTA has limited means by which to raise revenue sufficiently to close this budget deficit. The primary means are raising fares, reducing service, or a combination of both. The MBTA has developed two potential scenarios in which these means are employed in different ways in order to close the FY 2013 budget gap.

Scenario 1 raises the majority of the needed revenue through a fare increase, with the remainder of the deficit being covered by reducing service. Scenario 2 is split approximately evenly between revenue gains from a fare increase and saved operating costs from service reductions. This report documents the projection of the impacts of these potential fare increases and service reductions on ridership, revenue, air quality, and environmental justice communities.

The Central Transportation Planning Staff (CTPS) to the Boston Region Metropolitan Planning Organization (MPO), using a spreadsheet model, assisted the MBTA in determining the fare levels for each mode and fare category that would be needed in the context of each scenario to reach the revenue targets the MBTA had established. It then used several analysis techniques to estimate and evaluate the impacts of each scenario's proposed fare increase and service reductions. Both the spreadsheet model and the Boston Region MPO's regional travel demand model set were used to estimate the projected ridership loss associated with each scenario and the net revenue change that would result from the lower ridership and higher fares. By employing both techniques, CTPS produced a range of potential impacts on ridership and revenue for each scenario. The travel demand model set was also used to predict the effects of the fare increase on regional air quality and environmental justice.

Scenario 1 is projected to raise annual fare revenue by $123.2 million to $134.6 million through increasing fares by approximately 43.0 percent and to save approximately $38.3 million in operating costs through reducing service, for a total estimated gain in annual revenue of $161.5 million to $172.9 million.

Scenario 1 is projected to result in a ridership loss of 34.0 million to 48.6 million annual unlinked trips.

Scenario 2 is projected to raise annual fare revenue by $86.8 million to $104.0 million through increasing fares by approximately 34.7 percent and to save approximately $78.4 million in operating costs through reducing service, for a total estimated gain in annual revenue of $165.1 million to $182.4 million. Scenario 2 is projected to result in a ridership loss of 53.1 million to 64.2 million annual unlinked trips.

A summary of the total ridership and revenue projections for each scenario and estimation methodology is presented in the following tables. As the tables indicate, CTPS estimated a smaller decrease in ridership and a greater increase in revenue when using the travel demand model set than when using the spreadsheet approach. This relationship is generally consistent across all modes. The ridership and revenue estimates reflect the fact that, with a fare increase, a smaller ridership loss results in a greater revenue gain.

TABLE E-1
Scenario 1: Range of Revenue and Ridership Projections for the Proposed Fare Increase and Service Reductions

	Annual Revenue and Ridership*						
		Spreadsheet Approach			Travel Demand Model		
	Existing	Projected	Change	% Chg.	Projected	Change	% Chg.
Revenue	$477.5M	$639.0M	+$161.5M	+33.8%	$650.4M	+$172.9M	+36.2%
Ridership	386.4M	337.8M	-48.6M	-12.6%	352.4M	-34.0M	-8.8%

*Ridership figures are based on unlinked transit trips.

TABLE E-2
Scenario 2: Range of Revenue and Ridership Projections for the Proposed Fare Increase and Service Reductions

	Annual Revenue and Ridership*						
		Spreadsheet Approach			Travel Demand Model		
	Existing	Projected	Change	% Chg.	Projected	Change	% Chg.
Revenue	$477.5M	$642.6M	+$165.1M	+34.6%	$659.9M	+$182.4M	+38.2%
Ridership	386.4M	322.2M	-64.2M	-16.6%	333.4M	-53.1M	-13.7%

*Ridership figures are based on unlinked transit trips.

Both scenarios are projected to decrease air quality in terms of all pollutants except nitrogen oxides. Scenario 2's predicted increases in the levels of carbon monoxide and fine and coarse particulates exceed those of Scenario 1 by approximately 50 percent, and its predicted increases in the levels of volatile organic compounds exceed those of Scenario 1 by approximately 300 percent. The estimated magnitudes of the air quality impacts reflect the increases in vehicle-miles traveled (0.39 percent in Scenario 1 and 0.57 percent in Scenario 2) and vehicle-hours traveled (0.95 percent in Scenario 1 and 1.33 percent in Scenario 2) projected to occur as transit riders divert to automobile trips and congestion worsens as a result.

Equity was measured according to three categories of metrics: transit; highway congestion and air quality; and accessibility. The transit metrics are average fare, average walk-access time, average wait time, and total transit trips. Scenario 1 has smaller increases in the average fare and average walk-access and wait times for environmental justice (EJ) communities than non-EJ communities. Scenario 2 also has a smaller increase in the average fare for EJ communities than non-EJ communities but greater increases in the average walk-access and wait times. Scenario 1 has a greater estimated decrease in EJ transit riders than non-EJ transit riders, while in Scenario 2 the reverse is true; however, the total decrease in both EJ and non-EJ transit riders, along with increases in the average fare and average walk-access and wait times, is greater in Scenario 2. Both scenarios increase local congestion and air pollution in EJ communities more than non-EJ communities; Scenario 2 is projected to increase these two metrics more, overall, than Scenario 1. Finally, both scenarios are projected to result in worse overall access to jobs, healthcare, and educational opportunities, but this negative impact is projected to be worse for non-EJ communities than EJ communities. The negative impacts on access are projected to be worse, overall, in Scenario 2 than Scenario 1.

1 Introduction

The Massachusetts Bay Transportation Authority (MBTA) currently faces serious financial problems. Its fiscal year (FY) 2013 (July 1, 2012–June 30, 2013) budget deficit is projected to total $161 million, and given continued increases in operating expenses, projected decreases in revenue, and growing debt service costs for capital investments, the Authority will face continuous and growing deficits in future years.

The primary methods that the MBTA has at its disposal for reducing deficits are raising fares to increase revenue and reducing service to decrease operating expenses, though the MBTA can raise revenue through other, less significant means. The MBTA recently explored the impacts of various combinations of potential fare-increase and service-reduction levels and decided to model two scenarios with different combinations. The amount of the fare increase and service reductions proposed by the MBTA for each scenario was determined by the objective of closing the projected FY 2013 budget deficit.

The first step in the analysis process was for the Central Transportation Planning Staff (CTPS) to the Boston Region Metropolitan Planning Organization (MPO), in consultation with the MBTA, to determine, for each scenario, the fare level for each mode and fare category that would be needed to reach the MBTA's revenue targets given the estimated ridership loss due to the scenario's proposed service reductions. This was accomplished through an iterative process in which CTPS utilized a spreadsheet model that was specifically developed to analyze the degree to which ridership and revenue would change if fares were raised by any given amount. CTPS also produced alternative estimates of the impact on both ridership and revenue using the Boston Region MPO's regional travel demand model set. A comparison of the projections of each model provides a range of estimated impacts on ridership and revenue. The impacts on air quality and environmental justice were projected using the travel demand model set.

This report first presents detailed descriptions of the proposed scenarios. It then explains the estimation methods used by CTPS in its analysis and presents the projected impacts of each of the two scenarios on ridership, revenue, air quality, and environmental justice communities. A brief summary of findings concludes the report.

2 Description of the Proposed Fare Increase/Service Reduction Scenarios

CTPS modeled the impacts of two proposed scenarios that include varying levels of a fare increase and of service reductions. Generally, Scenario 1 has fewer service reductions but a greater fare increase, while Scenario 2 has a smaller fare increase but greater service reductions and revisions. The scenarios also include different changes to the fare structure.

This chapter describes first the scenarios' fare structures, then their service reductions, and finally their fare increases.

2.1 FARE STRUCTURE CHANGES

Significant time and effort were expended, as part of developing the last fare increase plan, implemented in 2007, to simplify the fare structure and to modify it in ways that encourage riders to use certain fare media. Zoned local bus routes were collapsed into a single local bus category. Fare zones and exit fares were eliminated on the rapid transit system. The number of express bus zones was reduced. The transfer price between bus and rapid transit was reduced for CharlieCard users. CharlieTicket fares were priced at a higher rate than CharlieCard fares. The Subway Pass was eliminated and the LinkPass was introduced for use on both local bus routes and rapid transit routes at a reduced price compared to the similar pass type that existed prior to the fare increase, the Combo Pass. While the two proposed scenarios for FY 2013 raise prices, eliminate services, and change the fare structure in different ways, the suggested changes do not conflict with or alter the structural changes or goals of the previous restructuring.

The differences between the two scenarios in terms of fare structure are in their senior and student fares and their pricing structures for THE RIDE, the MBTA paratransit service. In the current fare structure for local bus and rapid transit, the senior fare and student fare (regardless of whether a CharlieCard or CharlieTicket is used) are set at approximately 33 percent and 50 percent, respectively, of the adult CharlieCard fare. In Scenario 1, these ratios are set at approximately 50 percent for both seniors and students, and the adult CharlieTicket fare, rather than the CharlieCard fare, is used as the base rate. In Scenario 2, these ratios are again set at approximately 50 percent for both

seniors and students, but the CharlieCard fare is still used as the base rate.[1]

The current fare structure for THE RIDE charges a flat fare for any trip within THE RIDE's service area. THE RIDE currently serves riders living in any part of all the towns to which the MBTA provides fixed-route local or express bus or rapid transit service as well as riders living in some nearby towns that do not have any fixed-route service. In Scenario 1, THE RIDE's base fare increases to twice the adult local bus CharlieTicket fare and a premium fare is charged for trips to or from any area outside of the service area mandated by the Americans with Disabilities Act (ADA) (0.75-mile buffer from any local or express bus stop or rapid transit station), for trips before or after the service hours mandated by the ADA, and for same-day and will-call trips (which are outside the scope of the ADA). The fare structure for THE RIDE in Scenario 2 is the same as in Scenario 1 except that THE RIDE's base fare is based off of the adult local bus CharlieCard fare, instead of the CharlieTicket fare.

There are also several changes to the fare structure that are the same in both scenarios. Tokens (used for MBTA fares prior to 2007 and still accepted in fare vending machines) are no longer accepted; this reduces administrative costs. A $10.00 cash-to-CharlieCard upload minimum is instituted on fareboxes to improve the speed at which passengers board buses and surface light rail vehicles. A 7-day Student Pass is introduced to accompany the existing 5-day Student Pass. All multi-ride tickets, including the 12-ride ticket on commuter rail and the 10- and 60-ride tickets on the ferry, are eliminated. In addition, the duration of the validity of commuter rail tickets is reduced from 180 days to 14 days. These changes to tickets are intended to improve revenue collection on these modes. Finally, for both scenarios, a 25 percent discount off the single-ride fare is provided for all midday and reverse-commute commuter rail trips, and the surcharge for paying with cash onboard commuter rail trains is increased to $3.00.

2.2 SERVICE REDUCTIONS AND REVISIONS

Both scenarios include some level of service reductions or revisions.

2.2.1 BUS

For the bus network, Scenario 1 proposes the elimination of all routes that currently fail the net-cost-per-passenger standard.[2] This standard is failed by any route with an average net cost (or subsidy) per passenger trip greater than three times the systemwide average; weekday, Saturday, and Sunday services are assessed separately. The systemwide averages are $1.42 on weekdays, $1.37 on Saturday, and $1.30 on Sunday, resulting in cost standards of $4.26 on weekdays, $4.11 on Saturday, and $3.90 on Sunday. According to these

[1] The MBTA's enabling legislation (MGL 161A, Section 5(e)) requires that student and senior fares cannot be set higher than 50 percent of the adult cash fare.

[2] For the purpose of this standard, which is found in the MBTA's Service Delivery Policy, net cost per passenger is the difference between the cost to operate the route and the average revenue collected on the route, divided by the number of passengers.

standards, 23 weekday bus routes, 19 Saturday bus routes, and 18 Sunday bus routes fail, and these routes are thus eliminated under Scenario 1. They collectively have an average net cost per passenger of approximately $5.63. The routes are listed in Table 2-1, along with all other MBTA bus routes; the net cost per passenger is given for each route. The eliminated routes carry approximately 2.1 million trips annually, or 1.6 percent of all MBTA bus trips.

In Scenario 1, the net-cost-per-passenger standard is also applied to private bus routes (routes that are part of the Private Carrier Bus Program or the Suburban Bus Program, under which bus service is funded by the MBTA but operated by a private contractor). Application of this standard eliminates two private-carrier routes serving Canton and Medford and all Suburban Bus Program routes. These routes collectively have an average net cost per passenger of approximately $3.38 to the MBTA, with additional subsidies provided by others for the suburban routes. They carry approximately 0.2 million trips annually, or 25.6 percent of all private bus trips. A map of MBTA and private bus service that shows Scenario 1's route eliminations is presented in Figure 2-1.

In Scenario 2, a much greater reduction in bus service is proposed with the objective of saving approximately $60.0 million in net operating costs. To do this, routes totaling approximately $71.7 million in operating costs are eliminated, with approximately $13.5 million of that being reinvested in the remaining routes in order to improve their frequency by 10 percent. Instead of using the MBTA's existing net-cost-per-passenger standard, a net cost per passenger of $2.00 was used to generally determine which routes would be eliminated. However, given the greater number of routes that would be eliminated under a $2.00 threshold if applied without exception, the proposed bus eliminations also take into account the geographic locations of the proposed cuts and the overlap of routes. Therefore, some routes with an average net cost per passenger greater than $2.00 are maintained, and some routes with an average net cost per passenger under $2.00 are eliminated.

Under Scenario 2, 101 weekday routes, 69 Saturday routes, and 50 Sunday routes are eliminated or revised. They are listed in Table 2-1, along with all other MBTA bus routes; the net cost per passenger is given for each route. Scenario 2 also eliminates all private bus routes. The proposed revisions of routes (for all days of the week in which these routes operate) are as follows:

- Route 34E terminates at the Walpole town line
- Route 70A terminates at Central Square, Waltham
- Route 134 terminates in West Medford
- Routes 214 and 216 are combined
- Routes 220, 221, and 222 terminate at Bicknell Square
- Route 225 terminates at Weymouth Landing
- Routes 426, 442, 450, and 455 terminate at Wonderland Station

The routes proposed for elimination in Scenario 2 have an average net cost per passenger trip of $2.37 and carry approximately 30.3 million trips annually, or

23.6 percent of all bus trips. The private bus routes, all of which would be eliminated under this scenario, have an average net cost per passenger trip of approximately $2.91 to the MBTA, with additional subsidies provided by others for the suburban routes. A map of MBTA and private bus service showing the proposed route eliminations and revisions is presented in Figure 2-2.

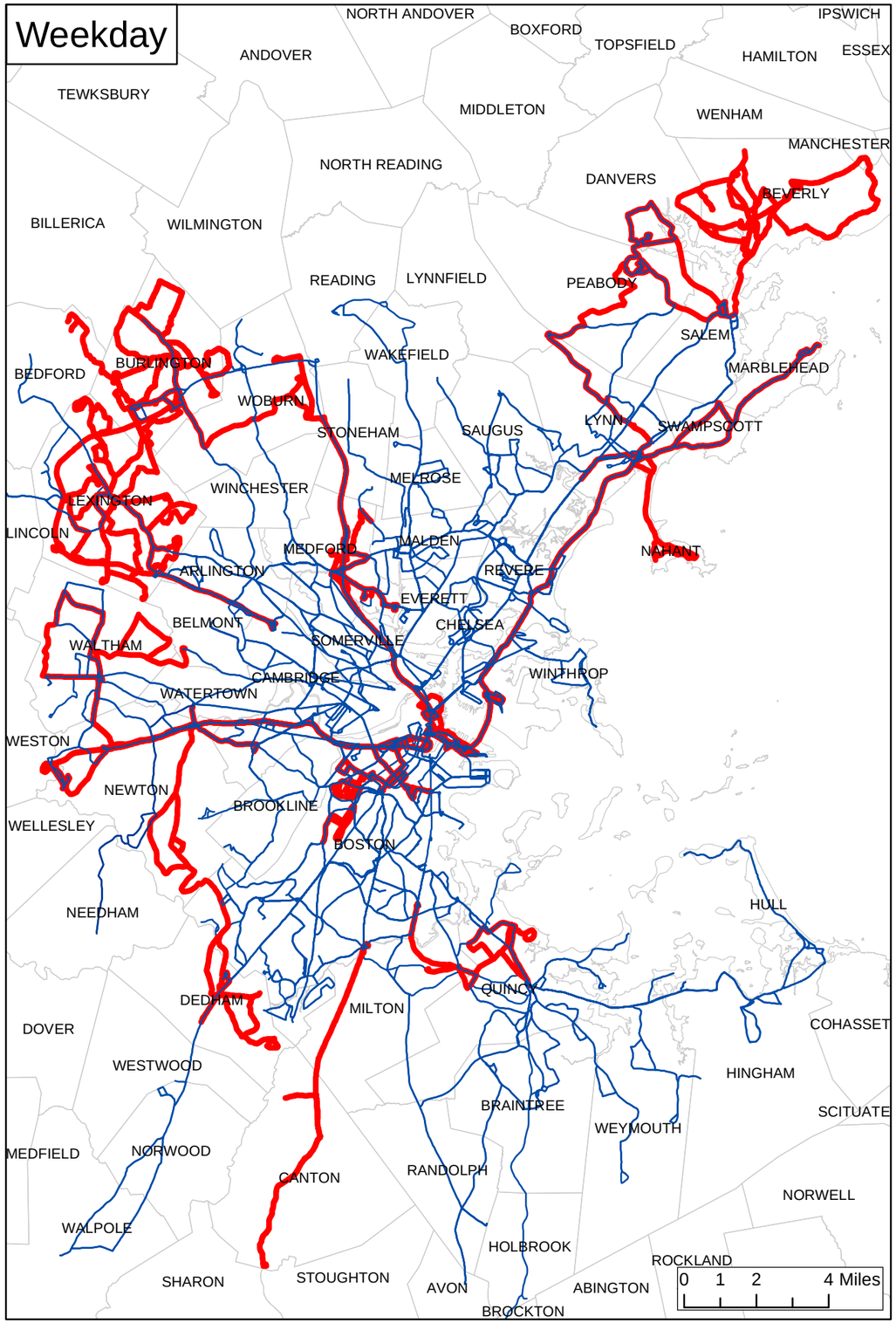
2.2.2 RAPID TRANSIT, COMMUTER RAIL, FERRY, AND THE RIDE

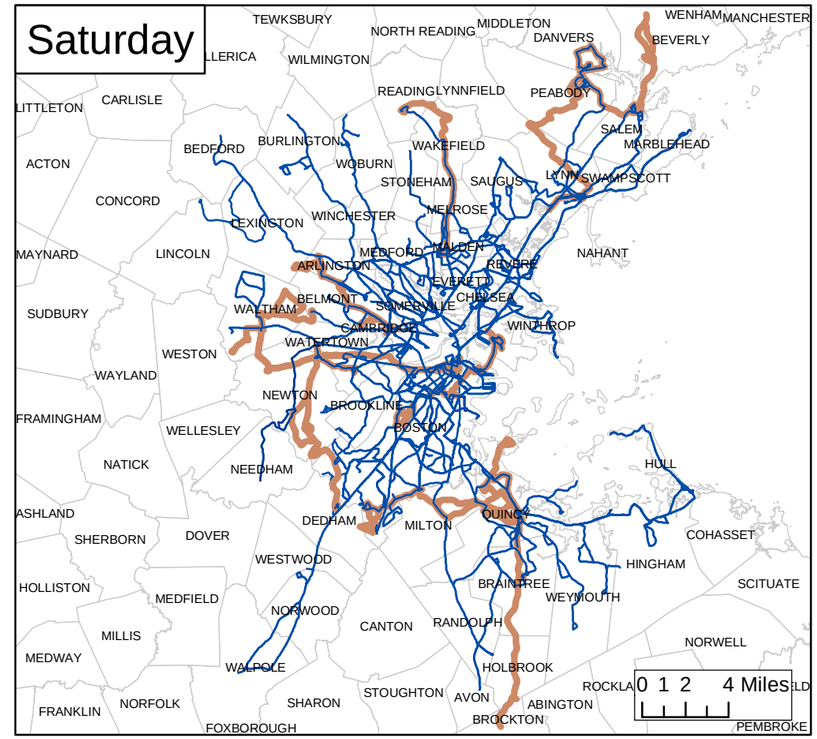
The only service reduction proposed for the rapid transit system is the elimination, in both Scenario 1 and Scenario 2, of weekend service on the Mattapan High-Speed Line and the E Branch of the Green Line. These two light rail services collectively have an average net cost per passenger of approximately $1.27. They carry approximately 1.3 million trips annually, or 2 percent of all light rail trips.

The change in commuter rail service, in both Scenario 1 and Scenario 2, is the elimination of all service after 10:00 PM as well as all Saturday and Sunday service. Commuter rail service after 10:00 PM has an estimated $1.99 average net cost per passenger and serves approximately 1.4 million trips annually, while Saturday service and Sunday service have an average net cost per passenger trip of $0.70 and $1.45 and annually serve approximately 1.7 million and 1.3 million trips, respectively. Therefore, these three service reductions on commuter rail affect an estimated 4.3 million annual trips. These trips represent approximately 11.7 percent of all annual trips on commuter rail.

In both Scenario 1 and Scenario 2, the entire $3.7 million Commuter Boat Program subsidy, which funds all commuter boat and ferry service, is eliminated. The average net cost per passenger on these services is $2.82.

Finally, while no service reductions per se are proposed for THE RIDE, the increase in fares and the institution of a premium-fare zone are estimated to reduce the demand for service under both scenarios, saving the MBTA the cost of serving the trips no longer made. These saved operating costs are estimated to be greater in Scenario 1, which has the greater fare increase and premium surcharge for THE RIDE.





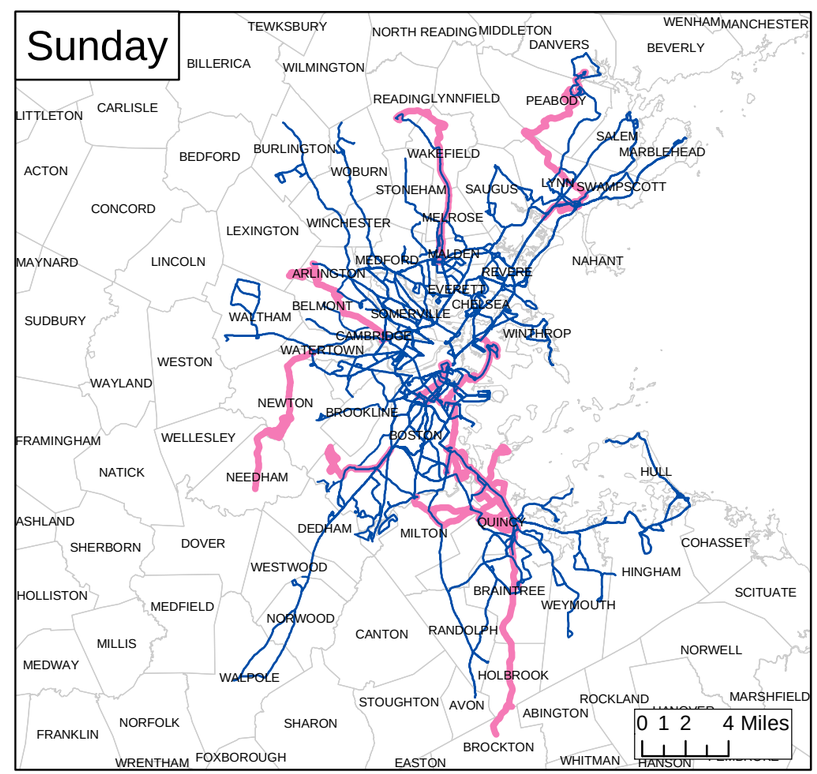


FIGURE 2-1
Scenario 1 Bus Route Cuts

Route Eliminations (2.1 million annual trips):
Eliminate Weekday Routes: 4, 48, 52, 170, 217, 275, 276, 277, 325, 351, 354, 355, 436, 439, 448, 449, 451, 465, 468, 500, 554, 555, and CT3
Eliminate Saturday Routes: 33, 48, 52, 72, 78, 136, 171, 211, 230, 245, 275, 276, 277, 436, 451, 465, 504, 553, and 554
Eliminate Sunday Routes: 18, 37/38, 43, 59, 78, 136, 137, 171, 201, 202, 211, 230, 245, 275, 276, 277, 431, and 436

Eliminate Private Carrier Bus Program in Canton and Medford and eliminate Suburban Bus Program subsidies to Bedford, Beverly, Boston, (Mission Hill), Burlington, Dedham, and Lexington (0.2 million annual trips)

Of the 128,948,230 existing annual bus trips:
2,282,543 (2%) are on eliminated routes
126,665,687 (98%) are not on eliminated routes

Legend

- Maintained Bus Route
- Eliminated Sunday Bus Route
- Eliminated Saturday Bus Route
- Eliminated Weekday Bus Route

N

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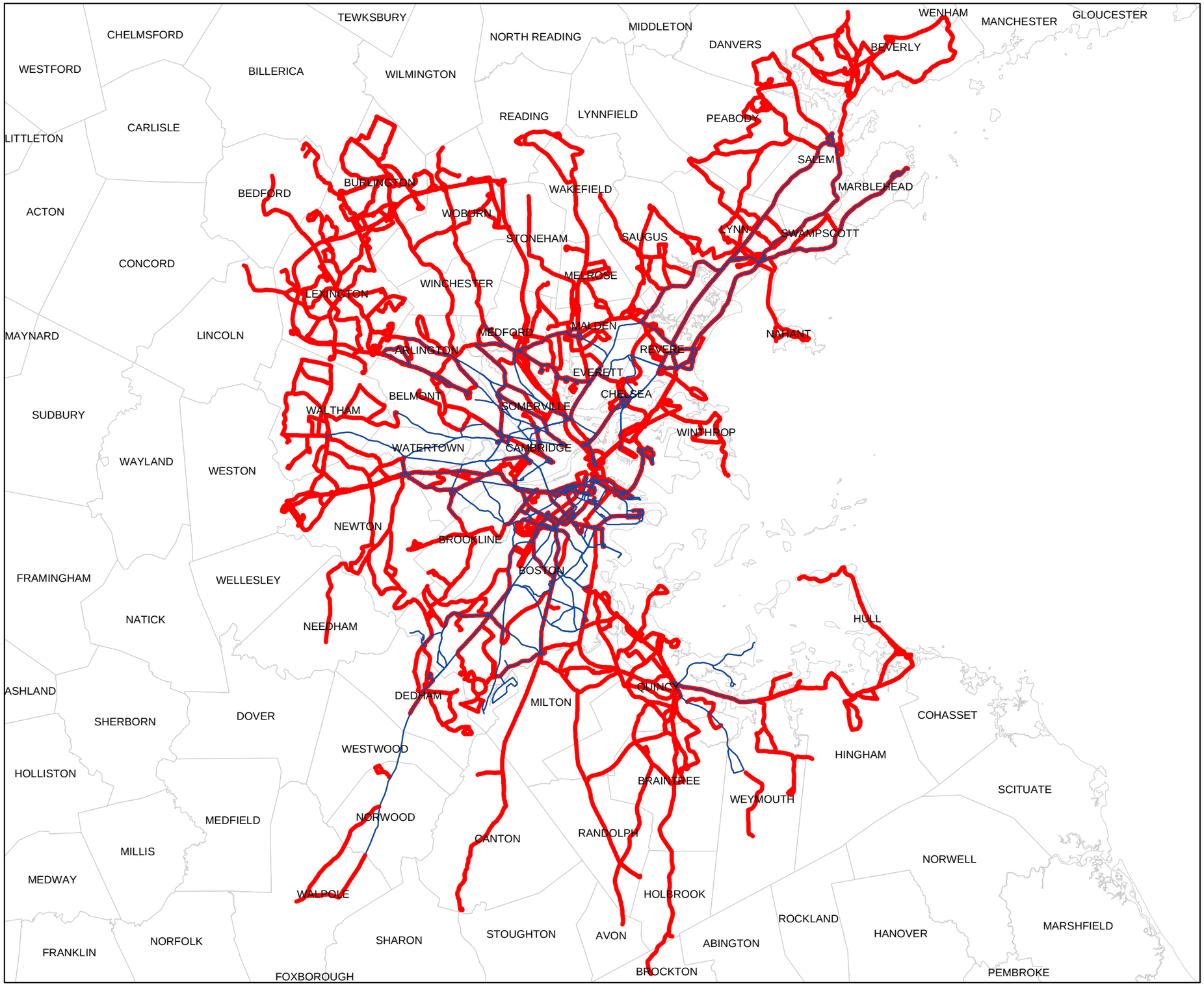

FIGURE 2-2
Scenario 2 Bus Route Cuts

Route Eliminations (31.0 million annual trips):
Eliminate Routes (all days): 4, 5, 14, 18, 27, 29, 33, 37, 38, 40, 43, 45, 48, 50, 51, 52, 55, 59, 60, 62, 64, 67, 68, 74, 75, 76, 78, 79, 80, 85, 90, 92, 95, 96, 97, 99, 100, 105, 106, 108, 112, 119, 120, 121, 131, 132, 136, 137, 170, 171, 201, 202, 210, 211, 212, 215, 217, 230, 236, 238, 240, 245, 275, 276, 277, 325, 326, 350, 351, 352, 354, 355, 411, 424, 428, 429, 430, 431, 434, 435, 436, 439, 441, 448, 449, 451, 456, 459, 465, 468, 500, 501, 502, 503, 505, 553, 554, 555, 556, 558, CT3, and all Private Carrier and Suburban Bus Routes
Route Revisions:
- **Cut 34E back to Walpole**
- **Cut 70A segment**
- **Cut 134 back to West Medford**
- **Combine 214 and 216**
- **Cut 220, 221, and 222 back to Bicknell Sq.**
- **Cut 225 back to Weymouth Landing**
- **Cut 426, 442, 450, and 455 to Wonderland**

Of the 128,948,230 existing annual bus trips:
31,000,371 (24%) are on eliminated routes
97,947,859 (76%) are not on eliminated routes

Legend

Maintained Bus Routes

Eliminated Bus Routes

N

0 2.5 5 10 Miles

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TABLE 2-1
MBTA-Operated Bus Routes: Proposed Status under Service-Reduction Scenarios, by Day of Week, with Average Net Cost per Passenger (Subsidy)

		Existing Subsidy			Scenario 1			Scenario 2		
Route #	**Route Description**	**Weekday**	**Saturday**	**Sunday**	**Weekday**	**Saturday**	**Sunday**	**Weekday**	**Saturday**	**Sunday**
1	Harvard Square - Dudley Station via Mass. Ave.	$0.63	$0.68	$0.68						
4	North Station - World Trade Center	$4.38			Eliminate			Eliminate		
5	City Point - McCormack Housing	$2.99	$4.02					Eliminate	Eliminate	
7	City Point - Otis & Summer Streets	$1.52	$2.83							
8	Harbor Point /U Mass - Kenmore Station	$2.02	$2.30	$2.72						
9	City Point - Copley Square via Broadway Station	$1.21	$1.00	$1.48						
10	City Point - Copley Square Via BU Med Center	$1.75	$2.04	$2.42						
11	City Point - Downtown	$1.84	$2.71	$2.64						
14	Roslindale Square - Heath Street Loop	$2.66	$3.40					Eliminate	Eliminate	
15	Kane Square - Ruggles Station	$1.11	$0.86	$1.18						
16	Forest Hills Station - U Mass.	$0.99	$0.72	$0.61						
17	Fields Corner Station - Andrew Station	$0.71	$1.15	$1.54						
18	Ashmont Station - Andrew Station	$2.71	$3.00	$5.51			Eliminate	Eliminate	Eliminate	Eliminate
19	Fields Corner Station - Ruggles or Kenmore Station	$1.07								
21	Ashmont Station - Forest Hills Station	$0.57	$0.55	$1.06						
22	Ashmont Station - Ruggles Station Via Talbot Ave	$1.05	$1.03	$1.29						
23	Ashmont Station - Ruggles Station via Washington Street	$1.00	$0.97	$1.15						
24	Wakefield Ave. - Mattapan Station or Ashmont	$1.30	$2.71	$2.02						
26	Ashmont Station - Norfolk & Wash. Belt	$0.80	$0.98	$1.10						
27	Mattapan Station - Ashmont Station	$1.13						Eliminate		
28	Mattapan Station - Ruggles Station	$0.80	$0.50	$0.86						
29	Mattapan Station - Jackson Sq Station	$1.71	$1.35					Eliminate	Eliminate	
30	Mattapan Station - Roslindale Square	$1.17	$1.36	$1.71						
31	Mattapan Station - Forest Hills Station	$1.07	$0.85	$1.01						
32	Wolcott Square or Cleary Square - Forest Hills Station	$1.02	$0.79	$0.75						
33	River & Milton Streets - Mattapan Station	$1.67	$4.64			Eliminate		Eliminate	Eliminate	
34	Dedham Line - Forest Hills Station	$2.43	$2.26	$1.44				Revise	Revise	Revise
35	Dedham Mall - Forest Hills Station	$1.75	$1.69	$1.87						
36	VA Hosp - Forest Hills Station Via Chas. River Loop	$1.47	$1.12	$1.37						
37	Baker & Vermont Streets - Forest Hills Station	$2.10	$2.14	$5.27			Eliminate	Eliminate	Eliminate	Eliminate
38	Wren Street - Forest Hills Station	$2.29	$4.03					Eliminate	Eliminate	
39	Forest Hills Station - Back Bay Station	$0.72	$1.01	$1.04						
40	Georgetowne - Forest Hills Station	$1.54	$1.86	$1.66				Eliminate	Eliminate	Eliminate
41	Centre & Eliot Streets - JFK U Mass Station	$1.84	$1.23	$2.14						
42	Forest Hills Station - Ruggles Station	$0.80	$1.23	$1.62						
43	Ruggles Station - Park & Tremont Streets	$1.93	$3.10	$4.02			Eliminate	Eliminate	Eliminate	Eliminate
44	Jackson Sq Station - Ruggles Station	$1.28	$1.68	$2.22						
45	Franklin Park - Ruggles Station	$1.53	$0.95	$1.70				Eliminate	Eliminate	Eliminate
47	Central Square Cambridge. - Broadway Station	$1.41	$2.65	$3.84						
48	Centre & Eliot Streets - Jamaica Plain Loop	$6.34	$6.14		Eliminate	Eliminate		Eliminate	Eliminate	
50	Cleary Sq - Forest Hills Station Via Metropolitan	$1.74	$1.35					Eliminate	Eliminate	
51	Cleveland Circle - Forest Hills Station	$1.95	$2.78					Eliminate	Eliminate	
52	Dedham Mall - Watertown Yard	$4.97	$7.17		Eliminate	Eliminate		Eliminate	Eliminate	
55	Queensberry Street - Park & Tremont Streets	$2.34	$2.26	$3.05				Eliminate	Eliminate	Eliminate
57	Watertown Yard - Kenmore Station	$0.86	$1.22	$0.91						
59	Needham Junction - Watertown Square	$2.71	$2.66	$4.74			Eliminate	Eliminate	Eliminate	Eliminate
60	Chestnut Hill - Kenmore Station	$2.99	$4.22	$3.78				Eliminate	Eliminate	Eliminate
62	Bedford V.A. Hospital - Alewife Station	$2.53	$3.75					Eliminate	Eliminate	
64	Oak Square - University Pk. Cambridge	$2.33	$2.40	$2.94				Eliminate	Eliminate	Eliminate
65	Brighton Center - Kenmore Station	$1.43	$2.39							
66	Harvard Square - Dudley Station via Brookline	$0.79	$0.73	$0.85						
67	Turkey Hill - Alewife Station	$2.98						Eliminate		
68	Harvard Square - Kendall MIT Station	$2.23						Eliminate		
69	Harvard Square - Lechmere Station	$0.82	$1.23	$1.09						
70	Cedarwood - Central Square Cambridge	$1.96	$1.87	$1.80				Revise	Revise	
71	Watertown Square - Harvard Station	$1.35	$1.71	$1.51						
72	Aberdeen & Mt. Auburn - Harvard Station	$3.05	$4.65	$3.32		Eliminate				
73	Waverley Square - Harvard Station	$1.75	$1.54	$1.71						
74	Belmont Center - Harvard Station via Concord Ave	$2.34	$3.36					Eliminate	Eliminate	
75	Belmont Center - Harvard Station via Fresh Pond Pkwy	$1.88	$2.49					Eliminate	Eliminate	
76	Hanscom Air Force Base - Alewife Station	$3.67						Eliminate		
77	Arlington Heights - Harvard Station	$1.95	$1.78	$1.67						
78	Arlmont Village - Harvard Station	$3.60	$4.43	$4.00		Eliminate	Eliminate	Eliminate	Eliminate	Eliminate
79	Arlington Heights - Alewife Station	$3.05						Eliminate		
80	Arlington Center - Lechmere Station	$2.35	$1.80	$1.80				Eliminate	Eliminate	Eliminate
83	Rindge Ave. - Central Square, Cambridge	$1.49	$1.82	$1.99						
84	Arlmont Loop - Alewife Station	$2.00								
85	Spring Hill - Kendall MIT Station	$1.82						Eliminate		
86	Sullivan Station - Cleveland Circle	$1.07	$1.05	$0.92						
87	Clarendon Hill - Lechmere Station via Somerville Avenue	$1.17	$1.03	$1.08						
88	Clarendon Hill - Lechmere Station via Highland Avenue	$0.89	$0.77	$0.89						
89	Clarendon Hill or Davis Square - Sullivan Station via Broadway	$1.01	$0.84	$1.01						
90	Davis Square Station - Wellington Station	$1.75	$1.69	$1.43				Eliminate	Eliminate	Eliminate
91	Sullivan Station - Central Square, Cambridge	$1.01	$1.26	$1.20						
92	Assembly Square Mall - Downtown Via Main Street	$2.68	$2.67					Eliminate	Eliminate	
93	Sullivan Station - Downtown Via Bunker Hill	$1.03	$1.09	$0.89						
94	Medford Square - Davis Square Station	$2.02	$2.10	$2.47						
95	West Medford - Sullivan Station	$2.20	$2.52	$2.78				Eliminate	Eliminate	Eliminate
96	Medford Sq - Harvard Station	$2.09	$2.22	$2.71				Eliminate	Eliminate	Eliminate
97	Malden Station - Wellington Station	$2.12	$2.36	$1.83				Eliminate	Eliminate	Eliminate
99	Boston Reg. Med Center Stoneham - Wellington Station	$2.45	$2.96	$2.66				Eliminate	Eliminate	Eliminate
100	Elm Street - Wellington Station	$2.31	$3.96	$3.48				Eliminate	Eliminate	Eliminate
101	Malden Station - Sullivan Station Via Medford Square	$1.04	$0.95	$0.88						
104	Malden Station - Sullivan Station Via Ferry Street	$0.90	$0.58	$0.56						
105	Malden Station - Sullivan Station Via Main Street	$1.91	$2.17	$2.40				Eliminate	Eliminate	Eliminate
106	Franklin Sq or Lebanon Street Loop - Wellington Station	$1.52	$1.67	$1.17				Eliminate	Eliminate	Eliminate
108	Linden Square - Wellington Station	$1.17	$1.50	$1.30				Eliminate	Eliminate	Eliminate
109	Linden Square - Sullivan Station	$1.04	$1.08	$0.51						
110	Wonderland Station - Wellington Station	$1.51	$1.27	$1.40						
111	Woodlawn or Bway & Park - Haymarket Station	$1.06	$0.91	$0.80						
112	Wellington Station - Wood Island Station	$2.98	$2.74	$3.31				Eliminate	Eliminate	Eliminate
114	Bellingham Square or Mystic Mall - Maverick Station	$0.83								
116	Wonderland Station - Maverick Station Via Revere	$0.88	$0.75	$0.85						
117	Wonderland Station - Maverick Station via Beach	$0.73	$0.73	$0.62						
119	Northgate Shopping Center - Beachmont Station	$2.16	$1.59	$2.26				Eliminate	Eliminate	Eliminate
120	Orient Heights Station - Maverick Station	$1.18	$1.46	$2.04				Eliminate	Eliminate	Eliminate
121	Wood Island Station - Maverick Station	$1.10						Eliminate		
131	Melrose Highlands - Malden Station	$3.12						Eliminate		
132	Redstone Shopping Center - Malden Station	$2.49	$3.63					Eliminate	Eliminate	
134	North Woburn - Wellington Station	$2.21	$2.71	$2.71				Revise	Revise	Revise
136	Reading Depot - Malden Station Via Lakeside	$3.18	$4.68	$4.09		Eliminate	Eliminate	Eliminate	Eliminate	Eliminate
137	Reading Depot - Malden Station Via North Ave	$2.91	$3.82	$3.95				Eliminate	Eliminate	Eliminate
170	Oak Park - Dudley Station (Limited Service)	$5.56			Eliminate			Eliminate		
171	Logan Airport - Dudley Station Sunrise	$3.23	$4.65	$5.07		Eliminate	Eliminate	Eliminate	Eliminate	Eliminate

TABLE 2-1 (continued)
MBTA-Operated Bus Routes: Proposed Status under Service-Reduction Scenarios, by Day of Week, with Average Net Cost per Passenger (Subsidy)

		Existing Subsidy			Scenario 1			Scenario 2		
Route #	**Route Description**	**Weekday**	**Saturday**	**Sunday**	**Weekday**	**Saturday**	**Sunday**	**Weekday**	**Saturday**	**Sunday**
201	Fields Corner Station - Fields Corner Station	$2.26	$3.74	$4.47				Eliminate	Eliminate	Eliminate
202	Fields Corner Station - Fields Corner Station	$2.26	$3.74	$4.47				Eliminate	Eliminate	Eliminate
210	Quincy Center Station - No. Quincy Station/Fields Corner Station	$3.06	$1.99	$0.00				Eliminate	Eliminate	Eliminate
211	Quincy Center Station - Squantum	$2.72	$4.78	$4.06		Eliminate	Eliminate	Eliminate	Eliminate	Eliminate
212	Quincy Center Station - North Quincy Station	$2.62	$1.53					Eliminate	Eliminate	
214	Quincy Center Station - Germantown	$1.35						Revise		
215	Quincy Center Station - Ashmont Station	$2.30	$2.88	$3.14				Eliminate	Eliminate	Eliminate
216	Quincy Center Station - Houghs Neck	$2.65	$1.90	$1.30				Revise	Revise	Revise
217	Wollaston Station - Ashmont Station via Wollaston Beach	$7.19			Eliminate			Eliminate		
220	Quincy Center Station - Hingham	$3.92	$3.05	$3.56				Revise	Revise	Revise
221	Quincy Center Station - Fort Point	$3.55						Revise		
222	Quincy Center Station - East Weymouth	$2.99	$3.11	$2.90				Revise	Revise	Revise
225	Quincy Center Station - Weymouth Landing	$1.86	$1.24	$1.96				Revise	Revise	Revise
230	Quincy Center Station - Montello Station	$3.30	$4.35	$4.13		Eliminate	Eliminate	Eliminate	Eliminate	Eliminate
236	Quincy Center Station - South Shore Plaza	$3.56	$2.48	$2.54				Eliminate	Eliminate	Eliminate
238	Quincy Center Station - Holbrook/Randolph Comm. Rail St	$2.15	$1.54	$2.33				Eliminate	Eliminate	Eliminate
240	Avon Line - Ashmont Station	$2.68	$2.56	$2.08				Eliminate	Eliminate	Eliminate
245	Quincy Center Station - Mattapan Station	$4.20	$7.14	$5.56		Eliminate	Eliminate	Eliminate	Eliminate	Eliminate
275*	Downtown Boston - Long Island Health Campus	$0.00	$0.00	$0.00	Eliminate	Eliminate	Eliminate	Eliminate	Eliminate	Eliminate
276*	Boston City Hospital - Long Island Health Campus	$0.00	$0.00	$0.00	Eliminate	Eliminate	Eliminate	Eliminate	Eliminate	Eliminate
277*	L. Shattuck Hospital - Park & Tremont Streets	$0.00	$0.00	$0.00	Eliminate	Eliminate	Eliminate	Eliminate	Eliminate	Eliminate
325	Elm Street - Haymarket Station	$7.17			Eliminate			Eliminate		
326	West Medford - Haymarket Station	$3.87						Eliminate		
350	North Burlington - Alewife Station	$3.36	$2.86	$3.26				Eliminate	Eliminate	Eliminate
351	Oak Park - Alewife Station	$6.33			Eliminate			Eliminate		
352	Burlington - State Street	$3.14						Eliminate		
354	Woburn Line - State Street	$5.16			Eliminate			Eliminate		
355	Mishawum Station - State Street	$13.14			Eliminate			Eliminate		
411	Malden Station - Revere/Jack Satter House	$1.91	$2.38					Eliminate	Eliminate	
424	Eastern & Essex - Haymarket or Wonderland	$2.35						Eliminate		
426	Central Sq Lynn - Haymarket or Wonderland Station Via	$2.14	$1.84	$2.65				Revise	Revise	Revise
428	Oaklandvale - Haymarket Station via Granada Highlands	$3.50						Eliminate		
429	Northgate Shopping Center - Central Sq Lynn	$3.11	$3.09	$3.61				Eliminate	Eliminate	Eliminate
430	Saugus, Appleton Street - Malden Station	$2.37	$1.68					Eliminate	Eliminate	
431	Neptune Towers - Central Sq Lynn	$1.74	$2.47	$4.12			Eliminate	Eliminate	Eliminate	Eliminate
434	Peabody - Haymarket Station	$2.17						Eliminate		
435	Liberty Tree Mall - Central Sq Lynn	$4.22	$3.03	$2.06				Eliminate	Eliminate	Eliminate
436	Danvers Sq - Central Sq Lynn	$4.44	$4.61	$5.40	Eliminate	Eliminate	Eliminate	Eliminate	Eliminate	Eliminate
439	Bass Point Nahant - Central Sq Lynn	$9.76			Eliminate			Eliminate		
441	Marblehead – Haymarket/Wonderland Station via Paradise Road	$1.86	$0.32	$1.17				Eliminate	Eliminate	Eliminate
442	Marblehead – Haymarket/Wonderland Station via Humphrey St.	$1.80	$0.86	$1.98				Revise	Revise	Revise
448	Marblehead - Downtown Crossing	$4.47			Eliminate			Eliminate		
449	Marblehead - Downtown Crossing	$4.71			Eliminate			Eliminate		
450	Salem Depot - Haymarket or Wonderland Station via Wes	$2.60	$1.68	$1.67				Revise	Revise	Revise
451	North Beverly - Salem Depot	$6.34	$6.82		Eliminate	Eliminate		Eliminate	Eliminate	
455	Salem Depot - Haymarket or Wonderland Station	$1.47	$1.83	$1.05						
456	Salem Depot - Central Sq Lynn	$3.38						Eliminate		
459	Salem Depot - Downtown Crossing	$2.75						Eliminate		
465	Liberty Tree Mall - Salem Depot	$4.90	$4.33		Eliminate	Eliminate		Eliminate	Eliminate	
468	Danvers Square - Salem Depot (Limited Service)	$5.89			Eliminate			Eliminate		
500	Riverside Station - Federal & Franklin Streets	$10.51			Eliminate			Eliminate		
501	Brighton Center - Federal & Franklin Streets	$2.68						Eliminate		
502	Watertown Yard - Copley Square	$1.34						Eliminate		
503	Brighton Center - Copley	$3.45						Eliminate		
504	Watertown Yard - Federal & Franklin Streets	$3.23	$4.23			Eliminate				
505	Waltham Center - Federal & Franklin Streets	$3.95						Eliminate		
553	Roberts - Federal & Franklin Streets	$3.23	$4.55			Eliminate		Eliminate	Eliminate	
554	Waverley Square - Federal & Franklin Streets	$4.95	$8.68		Eliminate	Eliminate		Eliminate	Eliminate	
555	Riverside Station - Federal & Franklin Streets Via Newton	$5.39			Eliminate			Eliminate		
556	Waltham Highlands - Federal & Franklin Streets	$3.66						Eliminate		
558	Auburndale - Federal & Franklin Streets	$4.11						Eliminate		
CT1	Central Square Cambridge. - South End Medical Area	$0.94								
CT2	Sullivan Station - Kendall MIT Station - Ruggles Station	$1.80								
CT3	Longwood Medical Area - Andrew Station	$5.11			Eliminate			Eliminate		
SL1	Logan Airport - South Station	-$0.07	$0.30	-$0.10						
SL2	Boston Marine Industrial Park - South Station	$0.30	-$0.14	$2.72						
SLWater	Silver Line Way - South Station	$0.17	$5.80	$2.62						
SL5	Dudley Station - Downtown Crossing at Temple Pl	-$0.03	$0.14	$0.35						
SL4	Dudley Station - South Station at Essex Street	$0.58	$1.08	$1.00						

* Routes 275, 276, and 277 do not collect any fare revenue. Therefore the average net cost per passenger is not applicable.

2.2.3 SUMMARY OF SERVICE CHANGES

In summary, the two scenarios include the following service changes:

Scenario 1

- **Bus:** Eliminate routes that fail the cost standard (greater than three times the systemwide average net cost per passenger):
  - **Weekday Routes:** 4, 48, 52, 170, 217, 275, 276, 277, 325, 351, 354, 355, 436, 439, 448, 449, 451, 465, 468, 500, 554, 555, and CT3
  - **Saturday Routes:** 33, 48, 52, 72, 78, 136, 171, 211, 230, 245, 275, 276, 277, 436, 451, 465, 504, 553, and 554
  - **Sunday Routes:** 18, 37/38, 43, 59, 78, 136, 137, 171, 201, 202, 211, 230, 245, 275, 276, 277, 431, and 436
- **Subway:** Eliminate weekend service on the Mattapan High-Speed Line and the E Branch of the Green Line.
- **Commuter Rail:** Eliminate all service after 10:00 PM and all Saturday and Sunday service.
- **Ferry:** Eliminate Commuter Boat Program (Charlestown, Hingham, Hull, and Quincy routes).
- **Private Bus:** Eliminate routes that fail the cost standard (greater than three times the systemwide average net cost per passenger):
  - Private Carrier Bus Program in Canton and Medford
  - All Suburban Bus Program subsidies (Bedford, Beverly, Boston [Mission Hill], Burlington, Dedham, and Lexington)

Scenario 2

- **Bus:** Eliminate and revise routes for approximately $60.0 million in savings, based on a consideration of both geographic coverage and average net cost per passenger; improve frequencies of remaining bus routes by 10 percent.
- **Subway:** Eliminate weekend service on the Mattapan High-Speed Line and the E Branch of the Green Line.
- **Commuter Rail:** Eliminate all service after 10:00 PM and all Saturday and Sunday service.
- **Ferry:** Eliminate Commuter Boat Program (Charlestown, Hingham, Hull, and Quincy routes).
- **Private Bus:** Eliminate all routes:
  - Private Carrier Bus Program in Canton, Hull, Medford, and Winthrop
  - All Suburban Bus Program subsidies (Bedford, Beverly, Boston [Mission Hill], Burlington, Dedham, and Lexington)

Figure 2-3 shows the relative percentages of riders on each mode that are affected by the proposed service reductions in each scenario. As seen in the figure, Scenario 2 affects the greater percentages of MBTA and private bus

riders and users of THE RIDE, and all ferry riders are affected by the elimination of ferry services in Scenarios 1 and 2.

Table 2-2 summarizes four measures of service that are affected by both of the proposed scenarios. The four measures are unlinked trips (the number of trips riders take on each transit vehicle), passenger miles (the total number of miles traveled on those unlinked trips), vehicle revenue hours (the total number of hours all transit vehicles are in service), and vehicle revenue miles (the total number of miles traveled by those transit vehicles in service). The table also presents the number of MBTA jobs that are estimated to be lost and the number of MBTA buses that could be removed from service under each scenario.

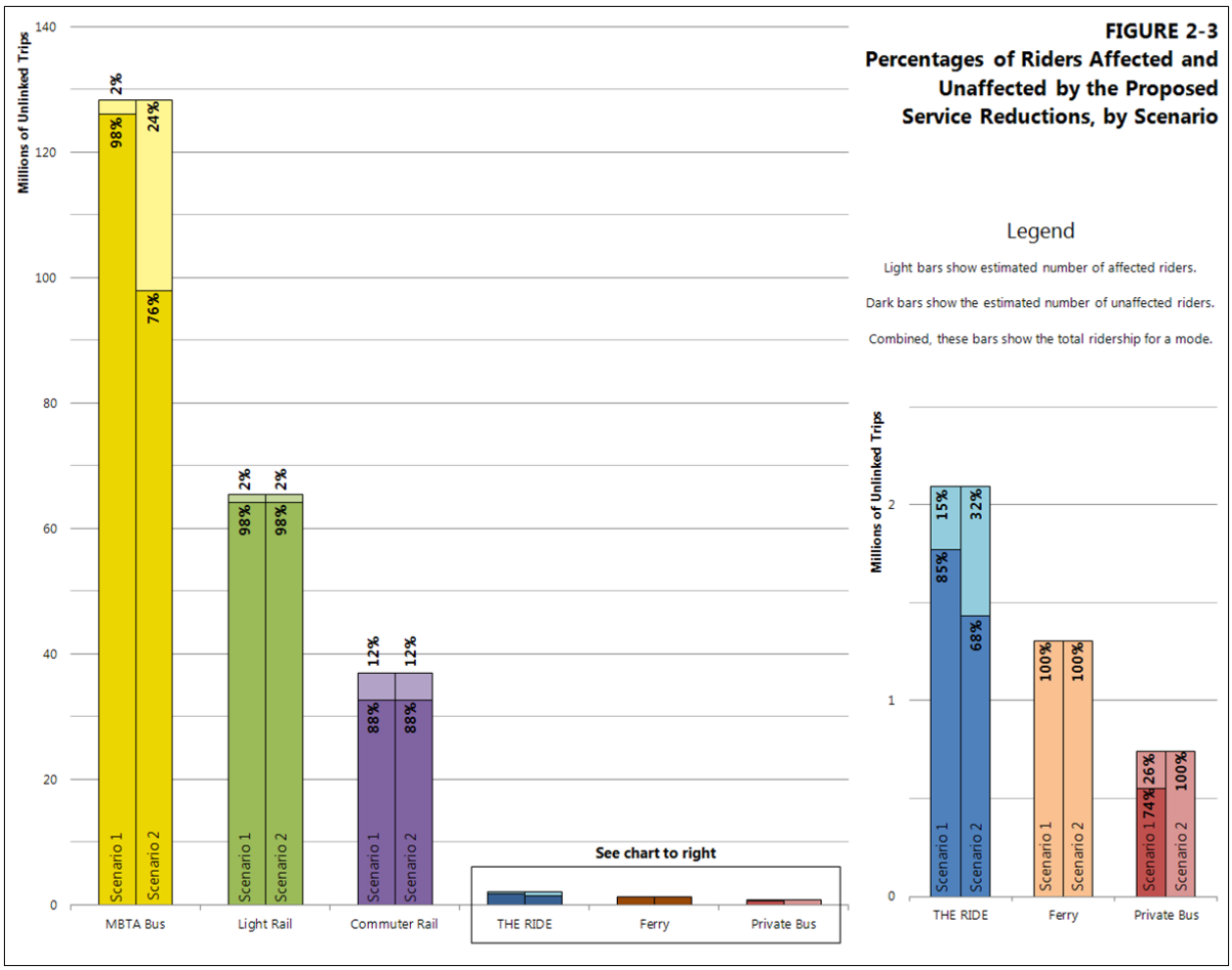

TABLE 2-2
Percentage of Service Affected, by Scenario

Measure	Scenario 1	Scenario 2
Unlinked Trips		
Number	9,182,790	37,900,618
Percent	2.6%	10.7%
Passenger Miles		
Number	106,505,536	179,777,486
Percent	6.2%	10.7%
Vehicle Revenue Hours		
Number	556,138	1,237,071
Percent	10.6%	23.6%
Vehicle Revenue Miles		
Number	13,135,964	22,179,777
Percent	16.8%	28.3%
MBTA Jobs Lost		
Number	110	564
Buses Removed		
Number	48	261

As shown in the table, Scenario 2 affects the greater percentage of existing service regardless of the measure. Scenario 2 also results in the greater numbers of MBTA jobs lost and buses removed from service. Both scenarios generally reduce bus and commuter rail service on routes with longer distances, which is why the percentages of passenger miles, vehicle revenue hours, and vehicle revenue miles affected are greater than the percentage of unlinked trips.

2.3 FARE INCREASE: SINGLE-RIDE FARES, PASS PRICES, AND PARKING RATES

Table 2-3 presents the existing and proposed single-ride fares under each proposed scenario for each fare category, along with the percentage change in price from the existing to the proposed price. Table 2-4 presents the existing and proposed pass prices under each proposed scenario for each pass category, along with the percentage change in price from the existing to the proposed price. Table 2-5 presents the existing and proposed parking rates under each proposed scenario for each parking facility, along with the percentage change in price from the existing to the proposed price.

The overall price increase across all modes and fare categories is approximately 43.5 percent for Scenario 1 and 35.0 percent for Scenario 2. These weighted averages were calculated by multiplying the percentage change in price for each fare/pass category by the existing ridership in that category and dividing by total existing ridership. Table 2-6 presents the weighted average percentage change by modal category. Note that the percentage changes in price can differ between modes that are similarly priced (such as local bus and the Silver Line–Washington Street or subway and surface light rail) because of differences in how the riders on these modes pay for their trips.

TABLE 2-3
Single-Ride Fares: Existing and Proposed, by Scenario

Fare Category		Scenario 1		Scenario 2	
	Existing	Proposed	% Chg.	Proposed	% Chg.
CharlieCard					
Adult					
Local Bus	$1.25	$1.75	40.0%	$1.50	20.0%
Rapid Transit	$1.70	$2.40	41.2%	$2.25	32.4%
Bus + RT*	$1.70	$2.40	41.2%	$2.25	32.4%
Inner Express	$2.80	$4.00	42.9%	$3.50	25.0%
Outer Express	$4.00	$5.50	37.5%	N/A**	N/A**
Senior					
Local Bus	$0.40	$1.10	175.0%	$0.75	87.5%
Rapid Transit	$0.60	$1.50	150.0%	$1.10	83.3%
Bus + RT*	$0.60	$1.50	150.0%	$1.10	83.3%
Student					
Local Bus	$0.60	$1.10	83.3%	$0.75	25.0%
Rapid Transit	$0.85	$1.50	76.5%	$1.10	29.4%
Bus + RT*	$0.85	$1.50	76.5%	$1.10	29.4%
CharlieTicket					
Adult					
Local Bus	$1.50	$2.25	50.0%	$2.00	33.3%
Rapid Transit	$2.00	$3.00	50.0%	$3.00	50.0%
Bus + RT*	$3.50	$5.25	50.0%	$5.00	42.9%
Inner Express	$3.50	$5.00	42.9%	$4.50	28.6%
Outer Express	$5.00	$7.00	40.0%	N/A**	N/A**
Commuter Rail					
Zone 1A	$1.70	$2.40	41.2%	$2.25	32.4%
Zone 1	$4.25	$6.50	52.9%	$6.00	41.2%
Zone 2	$4.75	$7.00	47.4%	$6.50	36.8%
Zone 3	$5.25	$7.50	42.9%	$7.00	33.3%
Zone 4	$5.75	$8.25	43.5%	$7.50	30.4%
Zone 5	$6.25	$9.00	44.0%	$8.25	32.0%
Zone 6	$6.75	$9.75	44.4%	$9.00	33.3%
Zone 7	$7.25	$10.50	44.8%	$9.75	34.5%
Zone 8	$7.75	$11.25	45.2%	$10.50	35.5%
InterZone 1	$2.00	$3.00	50.0%	$2.75	37.5%
InterZone 2	$2.25	$3.25	44.4%	$3.00	33.3%
InterZone 3	$2.50	$3.50	40.0%	$3.25	30.0%
InterZone 4	$2.75	$4.00	45.5%	$3.50	27.3%
InterZone 5	$3.00	$4.50	50.0%	$4.00	33.3%
InterZone 6	$3.50	$5.00	42.9%	$4.50	28.6%
InterZone 7	$4.00	$5.75	43.8%	$5.25	31.3%
InterZone 8	$4.50	$6.50	44.4%	$6.00	33.3%
Ferry					
F1	$6.00	N/A**	N/A**	N/A**	N/A**
F2: Boston	$6.00	N/A**	N/A**	N/A**	N/A**
F2: X-Harbor	$10.00	N/A**	N/A**	N/A**	N/A**
F2: Logan	$12.00	N/A**	N/A**	N/A**	N/A**
Inner Harbor	$1.70	N/A**	N/A**	N/A**	N/A**
THE RIDE					
ADA Territory	$2.00	$4.50	125.0%	$3.00	50.0%
Premium Territory	$2.00	$12.00	500.0%	$5.00	150.0%

* "Bus + RT" indicates the linked-trip price of a trip on both local bus and rapid transit.
** "N/A" indicates a service that has been eliminated.

TABLE 2-4
Pass Prices: Existing and Proposed, by Scenario

		Scenario 1		Scenario 2	
Pass Category	**Existing**	**Proposed**	**% Chg.**	**Proposed**	**% Chg.**
Local Bus	$40.00	$55.00	37.5%	$48.00	20.0%
LinkPass	$59.00	$80.00	35.6%	$78.00	32.2%
Senior/TAP	$20.00	$40.00	100.0%	$39.00	95.0%
Student**	$20.00	$40.00	100.0%	$39.00	95.0%
1-Day	$9.00	$12.00	33.3%	$12.00	33.3%
7-Day	$15.00	$20.00	33.3%	$20.00	33.3%
Inner Express	$89.00	$127.00	42.7%	$114.00	28.1%
Outer Express	$129.00	$177.00	37.2%	N/A*	N/A*
Commuter Rail					
Zone 1A	$59.00	$80.00	35.6%	$78.00	32.2%
Zone 1	$135.00	$196.00	45.2%	$188.00	39.3%
Zone 2	$151.00	$215.00	42.4%	$204.00	35.1%
Zone 3	$163.00	$234.00	43.6%	$219.00	34.4%
Zone 4	$186.00	$258.00	38.7%	$235.00	26.3%
Zone 5	$210.00	$282.00	34.3%	$259.00	23.3%
Zone 6	$223.00	$306.00	37.2%	$282.00	26.5%
Zone 7	$235.00	$330.00	40.4%	$306.00	30.2%
Zone 8	$250.00	$354.00	41.6%	$329.00	31.6%
InterZone 1	$65.00	$88.00	35.4%	$86.00	32.3%
InterZone 2	$77.00	$102.00	32.5%	$102.00	32.5%
InterZone 3	$89.00	$116.00	30.3%	$118.00	32.6%
InterZone 4	$101.00	$132.00	30.7%	$134.00	32.7%
InterZone 5	$113.00	$148.00	31.0%	$150.00	32.7%
InterZone 6	$125.00	$164.00	31.2%	$166.00	32.8%
InterZone 7	$137.00	$182.00	32.8%	$182.00	32.8%
InterZone 8	$149.00	$200.00	34.2%	$198.00	32.9%
Commuter Boat	$198.00	N/A*	N/A*	N/A*	N/A*

* "N/A" indicates a service that has been eliminated.
** A 7-Day Student Pass will be introduced to accompany the existing 5-Day Student Pass. A price for this 7-Day Student Pass has not yet been determined.

In Scenario 1, the percentage change in prices (Table 2-6) is largely consistent across modal categories except for THE RIDE, which faces a significant price increase with the introduction of the premium fare and the change in how the base fare is calculated. In Scenario 2, the bus mode receives the smallest percentage price increase, with rapid transit and commuter rail facing greater relative price changes to compensate. This difference in modal price increases is meant to compensate in a manner for the fact that the bus mode in Scenario 2 faces a much greater service reduction than rapid transit and commuter rail. Once again, THE RIDE faces the greatest percentage price increases due to the premium fare and the change in how the base fare is calculated.

In both scenarios, the percentage change in prices (Table 2-6) for parking is less than the percentage changes in single-ride fares and pass prices. This is because the only parking rate increases are proposed for subway and surface light rail parking facilities (to compensate in a manner for the fact that relatively minor service reductions are proposed for rapid transit compared to commuter rail and express bus). The zero percent changes for the other modal

TABLE 2-5
Park-and-Ride Facility Rates: Existing and Proposed, by Scenario

Park-and-Ride Facility	Existing	Scenario 1 Proposed	Scenario 1 % Chg.	Scenario 2 Proposed	Scenario 2 % Chg.
Alewife	$7.00	$10.00	42.9%	$9.00	28.6%
Beachmont	$5.00	$7.00	40.0%	$6.50	30.0%
Braintree	$7.00	$10.00	42.9%	$9.00	28.6%
Chestnut Hill	$5.50	$7.50	36.4%	$7.00	27.3%
Eliot	$5.50	$7.50	36.4%	$7.00	27.3%
Forest Hills	$6.00	$8.50	41.7%	$7.50	25.0%
Lechmere	$5.50	$7.50	36.4%	$7.00	27.3%
Malden	$5.50	$7.50	36.4%	$7.00	27.3%
Mattapan	$4.50	$6.50	44.4%	$5.50	22.2%
Milton	$5.00	$7.00	40.0%	$6.50	30.0%
North Quincy	$5.00	$7.00	40.0%	$6.50	30.0%
Oak Grove	$5.50	$7.50	36.4%	$7.00	27.3%
Orient Heights	$5.00	$7.00	40.0%	$6.50	30.0%
Quincy Adams	$7.00	$10.00	42.9%	$9.00	28.6%
Quincy Center	$7.00	$10.00	42.9%	$9.00	28.6%
Riverside	$6.00	$8.50	41.7%	$7.50	25.0%
Suffolk Downs	$5.00	$7.00	40.0%	$6.50	30.0%
Sullivan	$5.50	$7.50	36.4%	$7.00	27.3%
Waban	$5.50	$7.50	36.4%	$7.00	27.3%
Wellington	$5.50	$7.50	36.4%	$7.00	27.3%
Wollaston	$5.00	$7.00	40.0%	$6.50	30.0%
Woodland	$6.00	$8.50	41.7%	$7.50	25.0%
Wonderland	$5.00	$7.00	40.0%	$6.50	30.0%
Express Bus**	$5.00	$5.00	0.0%	$5.00	0.0%
Commuter Rail**	$4.00	$4.00	0.0%	$4.00	0.0%
Ferry**	$3.00	N/A*	N/A*	N/A*	N/A*

* "N/A" indicates a service that has been eliminated.
** Park-and-ride facility rates are the same for all facilities serving these modes.

categories bring down the overall percentage change in parking price. Note that the average "fares" (in this case, the parking rates) for park-and-ride facility modal categories, as in all the other modal categories, reflect the unlinked-trip price rather than the linked-trip price.

In both scenarios, the largest proposed percentage increases in price (Table 2-6) within a modal category are generally for CharlieTicket and onboard cash fares. These increases are greater than the more modest increases in the CharlieCard fares, due to the greater price increases assessed to CharlieTicket and onboard cash fares for the local bus, express bus, and rapid transit modes. The increase in CharlieTicket and onboard cash fares is most apparent when comparing those fare categories with the CharlieCard with respect to the price for transfers between local bus and rapid transit service. Under Scenario 1, for example, with a CharlieCard, a "step-up" transfer between those modes would make the total price for a linked trip $2.40. The "step-up" transfer benefit is not available on CharlieTickets, however, resulting in a total proposed linked-trip price of $5.25 using CharlieTickets or onboard cash.

The percentage increase in pass prices is generally less than that in the respective single-ride fares in both scenarios. Pass prices increase by various amounts in order to maintain or revise certain cash-fare equivalents (based on

TABLE 2-6
Weighted Average Percentage Change in Average Fares, by Scenario and Modal Category, for Unlinked Trips

Modal Category	Scenario 1	Scenario 2
Bus	**44.6%**	**27.1%**
Local Bus	44.5%	27.1%
Inner Express	44.8%	25.8%
Outer Express	37.1%	N/A*
Rapid Transit	**41.8%**	**37.5%**
Subway	41.6%	37.6%
SL Washington	47.1%	29.0%
SL Waterfront	42.7%	38.6%
Surface Light Rail	42.9%	37.9%
Commuter Rail	**43.1%**	**34.5%**
Zone 1A	34.8%	35.6%
Zone 1	47.8%	40.6%
Zone 2	41.8%	34.1%
Zone 3	41.2%	32.2%
Zone 4	37.8%	25.3%
Zone 5	35.7%	24.4%
Zone 6	38.0%	27.1%
Zone 7	40.6%	30.2%
Zone 8	41.0%	31.4%
InterZone	37.9%	33.7%
Onboard	87.0%	80.1%
Ferry	**N/A***	**N/A***
F1	N/A*	N/A*
F2: Boston	N/A*	N/A*
F2: X-Harbor	N/A*	N/A*
F2: Logan	N/A*	N/A*
Inner Harbor	N/A*	N/A*
THE RIDE	**138.8%**	**71.9%**
ADA Territory	117.7%	48.2%
Premium Territory	366.6%	140.0%
Parking	**28.2%**	**19.5%**
Express Bus	0.0%	0.0%
Subway	40.8%	28.5%
Surface Light Rail	40.8%	25.3%
Commuter Rail	0%	0%
Ferry	N/A*	N/A*
Total System	**43.0%**	**34.7%**

* "N/A" indicates a service that has been eliminated.

the lowest-priced respective single-ride fare), which are the number of single-ride trips equivalent to the total pass price. In both scenarios, the difference between the lowest and highest cash-fare-equivalent values of the various commuter rail passes is reduced. The cash-fare equivalents of commuter rail passes currently range from 31.05 to 33.60 trips per pass; under the proposed fare increase in Scenario 1, the cash-fare equivalent would range from 30.15 to 31.47 trips per pass, while in Scenario 2, the cash-fare equivalent would range from 31.29 to 31.39 trips per pass. For local bus, express bus, and rapid transit passes, the cash-fare equivalent would decrease or remain virtually the same in both scenarios.

3 Methods Used to Estimate Ridership and Revenue

Two separate approaches were used in this analysis to project the impact of the proposed fare increase and service reductions on MBTA ridership and revenue. One approach utilized a set of spreadsheets created by CTPS in consultation with the MBTA specifically for the purpose of such calculations. The second approach consisted of applying the Boston Region MPO's regional travel demand model set to estimate demand for each MBTA mode using the existing and proposed fare levels.

The travel demand model set was also employed as a complement to the spreadsheet model in the 2007 Pre–Fare Increase Impacts Analysis, with the two models together providing an indication of the potential range of impacts on ridership and revenue. In addition, unlike the spreadsheet model, the travel demand model set can also be used to conduct the air quality and environmental justice impact analyses.

3.1 CTPS SPREADSHEET MODEL APPROACH

The spreadsheet model was used to estimate the revenue and ridership impacts of the fare increase component of both proposed scenarios. This model reflects the many fare-payment categories of the MBTA pricing system and applies price elasticities to analyze various changes across these categories. The accuracy of this methodology was proven to be satisfactory through the 2007 Post–Fare Increase Impacts Analysis, which included an analysis of its effectiveness in predicting the impacts of the proposed 2007 fare increase.

3.1.1 MODELING OF EXISTING RIDERSHIP AND REVENUE

Inputs to the spreadsheet model included existing ridership in the form of unlinked trips by mode, by fare-payment method, and by fare-media type. An unlinked trip is an individual trip on any one transit vehicle; any trip using multiple vehicles—so-called "linked" trips—is counted as multiple unlinked trips.

Existing ridership (to which the spreadsheet model applies price elasticity figures – see Section 3.1.2) for the local bus, express bus, and rapid transit networks was provided in the form of automated fare-collection (AFC) data. Data were provided by month, with subtotals of transactions (unlinked trips) by

the various possible combinations of product type (single-ride fare or pass) and stock (smart card, magnetic-stripe ticket, etc.). AFC data were also provided at the modal level at which each transaction occurs. More detailed information on AFC fare types, modes, and media can be found in the appendix.

Because AFC equipment has not yet been deployed on commuter rail and commuter boat, the number of trips on these modes was estimated using sales figures. Single-ride trips on commuter rail and ferry were set equal to the number of single-ride fares sold, while pass trips on these modes were estimated by dividing the number of pass sales by the estimated average number of trips made using the respective pass type, calculated as part of the 2007 Post–Fare Increase Impacts Analysis. Dividing the number of pass sales by the estimated number of trips per pass resulted in an estimate of the total number of pass trips for each pass type.

Other data used were estimates of the number of trips currently made using THE RIDE and the number of cars currently parked at transit stations. These data were provided to CTPS directly by the MBTA.

Because the spreadsheet model cannot estimate the ridership impacts of eliminating or revising service, estimates of the ridership changes that would be associated with service changes without a fare increase were first calculated separately in order to adjust the existing ridership numbers to reflect a post-service-change situation. The spreadsheet model then estimated the ridership and revenue impacts of a fare increase using the revised existing ridership as the baseline. The MBTA estimated the ridership loss associated with the service changes in each scenario and provided those estimates to CTPS.

Revenue for single-ride trips was calculated in the spreadsheet model by multiplying the number of trips in each fare/modal category by that category's price. Revenue for pass trips was calculated for each pass type by multiplying the number of pass sales by the pass price. Pass revenue was then distributed between modal categories based on each category's ridership and weighted by each category's single-ride fare.

3.1.2 ESTIMATION OF RIDERSHIP CHANGES RESULTING FROM A FARE INCREASE

Fares are one of many factors that influence the level of ridership on transit services. Price elasticity is the measure of either the expected or observed rate of change in ridership relative to a change in fares if all other factors remain constant. On a traditional demand curve that describes the relationship between price, on the y-axis, and demand, on the x-axis, elasticities are equivalent to the slope along that curve. As such, price elasticities are generally expected to be negative, meaning that a price increase will lead to a decrease in demand (with a price decrease having the opposite effect). The larger the negative value of the price elasticity (the greater its distance from zero), the greater the projected impact on demand. Larger (more negative) price elasticities are said to be relatively "elastic," while smaller negative values, closer to zero, are said to be

relatively "inelastic." Thus, if the price elasticity of the demand for transit were relatively elastic, a given fare increase would cause a greater loss of ridership than if demand were relatively inelastic. An example of the application of price elasticities is demonstrated in the appendix.

The spreadsheet model permits the use of various ranges of elasticities to estimate different possible ridership impacts of price increases. Performing calculations in the spreadsheet model with the same prices but with a range of higher and lower elasticities provides a range of estimates. In the present analysis, the model was generally set to use the middle range of elasticities, as these represent the best estimate of where the elasticities should be set based on past experiences. However, estimates were also made using more inelastic and elastic elasticities, as a sensitivity analysis of the model's projections of the ridership losses and revenue gains. Such a sensitivity analysis may be particularly relevant for this analysis given the lack of any contemporary experiences at the MBTA with fare increases and service reductions as large as those in Scenarios 1 and 2. Table 3-1 presents the three elasticity ranges used in the spreadsheet model for this study's analysis. For a description of how these elasticity values were determined, see the appendix.

An additional complexity of the spreadsheet model that provides increased accuracy is its use of ridership diversion factors. These factors reflect estimates of the likelihood of a switch in demand from one MBTA product type or mode to another as a result of a change in the relative prices. The diversion factors essentially work to redistribute demand between the two product types or modes after the respective price elasticities have been applied. The appendix provides examples of the application of diversion factors and the methodology for combining the use of price elasticities and diversion factors. These examples reflect the methodology used in the present analysis. While diversion factors estimate the diversion of riders between MBTA product types and modes based on their price, the spreadsheet model can only estimate the total loss of riders from the MBTA transit system, not the diversion of riders to specific non-MBTA modes such as driving or walking.

3.2 BOSTON REGION MPO TRAVEL DEMAND MODEL SET APPROACH

The regional travel demand model set used by CTPS simulates travel on the transportation network in eastern Massachusetts, including both the transit and highway systems. It covers all MBTA commuter rail, rapid transit, and bus services, as well as all private express bus services. The model set reflects service frequency (how often trains and buses arrive at a given transit stop), routing, travel time, and fares for all of these services. In the modeling of the highway system, all express highways, all principal arterial roadways, and many minor arterial and local roadways are included.

TABLE 3-1
Price Elasticity Ranges Used in the Spreadsheet Model

	Elasticity Range		
Modal Category	**Low**	**Medium**	**High**
Cash Elasticities			
Bus	-0.10	-0.20	-0.30
Adult	-0.10	-0.20	-0.30
Senior	-0.05	-0.15	-0.25
Student	-0.05	-0.15	-0.25
Subway	-0.15	-0.25	-0.35
Adult	-0.15	-0.25	-0.35
Senior	-0.05	-0.15	-0.25
Student	-0.05	-0.15	-0.25
Surface Light Rail	-0.15	-0.25	-0.35
Adult	-0.15	-0.25	-0.35
Senior	-0.10	-0.20	-0.30
Student	-0.10	-0.20	-0.30
Commuter Rail	-0.25	-0.35	-0.45
Adult	-0.25	-0.35	-0.45
Half-Fare	-0.15	-0.25	-0.35
Ferry	-0.20	-0.30	-0.40
Adult	-0.20	-0.30	-0.40
Half-Fare	-0.10	-0.20	-0.30
THE RIDE	-0.08	-0.12	-0.16
Parking	-0.10	-0.20	-0.30
Pass Elasticities			
Bus	-0.20	-0.30	-0.40
Inner Express	-0.10	-0.20	-0.30
Outer Express	-0.10	-0.20	-0.30
LinkPass	-0.20	-0.30	-0.40
1-Day LinkPass	-0.25	-0.35	-0.45
7-Day LinkPass	-0.25	-0.35	-0.45
Commuter Rail	-0.05	-0.10	-0.20
Ferry	-0.15	-0.25	-0.35
Senior	-0.05	-0.15	-0.25
Student	-0.05	-0.15	-0.25

The travel demand forecasting procedure used in this analysis is based on a traditional four-step, sequential process: trip generation, trip distribution, mode choice, and trip assignment. This process may be used to estimate average daily transit ridership, primarily on the basis of estimates of population and employment, projected highway travel conditions (including downtown parking costs), and projected transit service to be provided. Such a process was used to analyze MBTA ridership and revenue impacts due to the fare increase and service reductions proposed in each of the two scenarios.

The eastern Massachusetts geographic area represented in the model set is divided into several hundred areas known as transportation analysis zones (TAZs). The model set employs sophisticated and complex techniques in each of the four steps of the process. These steps can be very briefly summarized as follows.

Trip Generation: This step estimates the number of trips produced in and attracted to each TAZ. This is done using estimates of the population, employment, and other socioeconomic and household characteristics of each zone.

Trip Distribution: This step links the trip ends estimated in the trip generation step to form zonal trip interchanges (movements between pairs of zones). The output of this step is a trip table, which is a matrix containing the number of trips occurring in every origin-zone-to-destination-zone combination.

Mode Choice: This step allocates the person trips estimated in the trip distribution step to the two primary competing modes, automobile and transit, and to walking and biking. This allocation is based on the desirability or utility of each choice a traveler can opt for, based on the attributes of that choice and the characteristics of the individual. The resulting output of this step includes the percentage of trips that use automobiles and the percentage that use transit for all trips that have been generated.

Trip Assignment: This final step assigns the transit trips to the various transit modes, such as subway, commuter rail, local bus, or express bus. This is done by assigning each trip to one of several possible transit paths from one zone to another; each of these assignments is based on minimizing the generalized "cost" (including not only the transit fare, but also in-vehicle travel time, number of transfers, etc.). These paths may involve just one mode, such as express bus or commuter rail, or multiple modes, such as a local bus and a transfer to the subway. The trip assignment step also assigns the highway trips to the highway network. Thus, the traffic volumes on the highways and the ridership on the transit lines can be obtained from the outputs of this step.

Population and employment data are key inputs to the demand forecasting process; those used in this study were obtained from the Metropolitan Area Planning Council (MAPC). The highway travel times used in the analysis are those used in recent CTPS transit and highway studies. Downtown parking costs were obtained from recent CTPS studies. The travel demand model set assumes that, in general, people wish to minimize transfers. It also assumes that they may wish to minimize travel time, even if doing so costs more.

Note that the travel demand model set does not possess the capability of modeling THE RIDE, given the nature of paratransit service. As a result, the ridership and revenue impacts on THE RIDE that are included with the travel demand model set results are taken from the spreadsheet model results.

Existing revenue was estimated by multiplying the trips estimated by the model set for each mode by the average fare for that mode. The average fares were based on calculations in the spreadsheet model. The revenue impact was estimated by taking the ratio from the spreadsheet model of each mode's change in revenue divided by the change in unlinked trips and applying this to the travel demand model set's estimate of the change in that mode's unlinked trips.

3.3 DIFFERENCES BETWEEN THE TWO ESTIMATION METHODOLOGIES

There are several differences between the two methodologies. The spreadsheet model is primarily used to estimate the impacts of a fare change (though the

estimated ridership impacts of service changes can be added to the model as an adjustment to existing ridership, so that the spreadsheet model's projections will reflect the impacts of a simultaneous change in fare and service). On the other hand, the travel demand model set can forecast both impacts caused by fare changes and those caused by service changes.

The chief strengths of the spreadsheet model are that it accounts for every distinct type of fare that can be paid for an MBTA transit mode and that it assigns the fare to the correct number of passengers who are in that fare-payment/modal category. In comparison, the travel demand model set does not permit analysis of fares at this detailed level, but assumes for each more-generalized modal category an average fare for all fare types. However, unlike the travel demand model set, the spreadsheet model cannot predict how many riders who leave the system due to a fare increase are switching to modes other than transit (driving alone, carpooling, bicycling, or walking). The travel demand model set also provides the outputs necessary for conducting the air quality and environmental justice impact analyses.

There is another key difference between the two approaches in how they estimate ridership changes. The use of elasticities in the spreadsheet model has a relatively simple premise: the greater the percent change in price, the greater the percent change in demand. In the travel demand model set, while a greater percent change in fares will undoubtedly trigger a greater decline in transit ridership, it is not so much the percent change in transit fares that is important for determining the overall ridership change. Rather, it is the comparison of the resulting transit fares to the comparable cost of making the same trip via a different mode. For example, if the price of transit increases relative to the cost of driving, the travel demand model set will show transit diversions to driving.

4 Ridership and Revenue Impacts

4.1 OVERVIEW OF RESULTS AND METHODOLOGY

Scenario 1 is projected to result in a gain in annual revenue of between $161.5 million using the spreadsheet model and $172.9 million using the travel demand model set. The corresponding estimated annual ridership losses are 48.6 million and 34.0 million unlinked trips. Scenario 2 is projected to result in a gain in annual revenue of between $165.1 million using the spreadsheet model and $182.4 million using the travel demand model set. The corresponding estimated annual ridership losses are 64.2 million and 53.1 million unlinked trips. For both scenarios, these revenue projections are in keeping with the target amount that the MBTA has identified as needed to meet the FY 2013 budget deficit.

The 2007 Post–Fare Increase Impacts Analysis shows the projections from the spreadsheet model, which uses elasticities to project ridership and revenue changes based on a detailed analysis by mode and fare category, to be close to the actual changes in ridership and revenue that occurred after that fare increase was implemented. In addition, through the 2007 Post–Fare Increase Impacts Analysis, CTPS was able to adjust the elasticities in the spreadsheet model to even better reflect the changes that occurred. This presumably improved the capability of the spreadsheet model to accurately project the ridership and revenue impacts of other fare increases. However, the greater size of the fare increases and service reductions proposed for 2012 under both scenarios increases the uncertainty involved in forecasting. In addition, this marks the first time that CTPS has modeled the combined impacts of both a fare increase and service reductions. The travel demand model set is capable of incorporating both a fare increase and service reductions into its projections, whereas in the case of the spreadsheet model, the ridership losses associated with service reductions must be made independently and then added to the model. Therefore, it was appropriate to use both models in combination as well as to conduct a sensitivity analysis of the spreadsheet model using different elasticity values to help to define a range of probable outcomes of the changes in fares and service.

4.2 SPREADSHEET MODEL ESTIMATES

4.2.1 SCENARIO 1

Scenario 1 Projections

Table 4-1 presents CTPS's estimates of the ridership and fare revenue impacts of the Scenario 1 fare increase and service reductions produced using the spreadsheet model and its medium range of elasticities. The existing ridership and fare revenue numbers, also presented, represent existing conditions before any adjustments are made to account for the estimated ridership lost due to the service reductions in this scenario. All figures are annual.

The total projected fare revenue increase from Scenario 1 comes to $123.2 million, or a 25.8 percent increase. The total projected ridership loss is estimated at 48.6 million annual unlinked trips, or a 12.6 percent decrease. For the Scenario 1 fare increase, the greatest absolute fare revenue increase is projected for the heavy rail (Blue, Orange, and Red Lines) category ($41.8 million). This is due partly to the fact that heavy rail riders take 39.7 percent of all annual unlinked trips, the largest percentage of any category. However, heavy rail riders, who are not affected by any service reductions, also have one of the smallest projected percentage decreases in ridership, at 11.0 percent. The commuter rail category provides the second-greatest projected absolute revenue increase ($32.3 million), followed by the bus category ($23.9 million). However, commuter rail riders are projected to decrease by a much greater percentage (20.4 percent) than bus riders (12.2 percent), though the projected absolute number of lost riders is greater for bus than for commuter rail (13.6 million versus 6.7 million unlinked trips). The relative overall fare revenue gains for these two modes reflect the much greater average fare paid by commuter rail riders compared to bus riders. Finally, note that fare revenue is collected by ferry operators and not by the MBTA. As a result, the change in ridership but not revenue on the ferry mode is reported.

TABLE 4-1
Scenario 1: Spreadsheet Model Estimates of Annual Ridership and Fare Revenue Impacts

	Existing		Fare Revenue Change		Ridership Change	
Modal Category	**Fare Revenue**	**Ridership**	**$**	**%**	**#**	**%**
Bus	$84,943,538	111,903,868	$23,933,063	28.2%	-13,646,904	-12.2%
Heavy Rail	$150,317,103	153,439,900	$41,781,853	27.8%	-16,855,647	-11.0%
Light Rail	$61,940,438	77,659,524	$16,908,813	27.3%	-8,688,834	-11.2%
Commuter Rail	$139,373,877	32,802,960	$32,268,780	23.2%	-6,684,772	-20.4%
Ferry*	$0	1,309,167	$0	0.0%	-1,309,167	-100.0%
THE RIDE	$3,820,407	2,359,966	$3,741,277	143.7%	-404,295	-17.1%
Parking	$37,092,637	6,948,420	$4,575,853	12.3%	-999,827	-14.4%
Total System	**$477,488,002**	**386,423,805**	**$123,209,637**	**25.8%**	**-48,589,445**	**-12.6%**

* Ferry fare revenue is not collected by the MBTA, so the loss in ferry fare revenue is not counted in the total revenue change.

Scenario 1 Sensitivity Analysis

The Scenario 1 results reported in Table 4-1 were produced using the medium

range of elasticities. Table 4-2 presents a sensitivity analysis of the spreadsheet model, showing the range of Scenario 1's estimated ridership and fare revenue impacts from the fare increase and service reductions using the lower and higher ranges of elasticities presented in Table 3-1. In the ranges of ridership-loss estimates in the table, the greater losses are those resulting from the higher range of elasticities, while in the ranges of fare-revenue-increase estimates, the greater increases are those resulting from the lower range of elasticities.

The use of the higher range of elasticities results in much greater estimates of ridership losses: 65.8 million unlinked trips, compared to 32.0 million using the lower range of elasticities; using the medium range of elasticities results in a loss of 48.6 million unlinked trips. As a result, the projected revenue gain from the fare increase estimated using the higher range of elasticities is approximately $30.7 million less than that estimated using the medium range of elasticities ($92.5 million versus $123.2 million) and $58.5 million less than that estimated using the lower range of elasticities.

TABLE 4-2
Scenario 1: Spreadsheet Model Ranges of Estimates of Annual Ridership and Fare Revenue Impacts Using Low and High Ranges of Elasticities

	Range of Fare Revenue Increases			Range of Ridership Losses		
Modal Category	**$ (millions)**	**%**	**$ Range (millions)**	**# (millions)**	**%**	**# Range (millions)**
Bus	$17.9–$30.0	21.0%–35.3%	$12.1	8.2–19.1	7.4%–17.0%	10.8
Heavy Rail	$32.5–$50.8	21.6%–33.8%	$18.4	10.2–23.6	6.7%–15.4%	13.4
Light Rail	$13.1–$20.7	21.1%–33.4%	$7.6	5.3–12.1	6.8%–15.6%	6.8
Commuter Rail	$23.5–$38.8	16.9%–27.8%	$15.3	5.8–7.9	17.6%–24.0%	2.1
Ferry	$0.0	0.0%	$0.0	1.3	100.0%	0.0
THE RIDE	$2.7–$4.7	71.8%–124.1%	$2.0	0.3–0.5	11.4%–22.8%	0.3
Parking	$2.9–$6.1	7.9%–16.3%	$3.1	0.8–1.2	11.7%–17.6%	0.4
Total System	**$92.5–$151.1**	**19.4%–31.6%**	**$58.5**	**32.0–65.8**	**8.3%–17.0%**	**33.8**

Scenario 1 Total Revenue Estimate

Table 4-3 adds the MBTA's estimates of saved operating costs from Scenario 1's service reductions to the spreadsheet model's estimates of the gains in fare revenue from Scenario 1's fare increase and service reductions reported in Table 4-1 to obtain an estimate of the change in total revenue. While heavy rail again represents the greatest revenue gain, the saved operating costs for the bus and commuter rail modes place their total revenue gain close to that of heavy rail, which only incurs a fare increase. THE RIDE also has a significant revenue increase. Again note that when the ferry service is eliminated, the MBTA saves money (as represented by the saved operating costs) by not providing the subsidy to operate the service.

TABLE 4-3
Scenario 1: Spreadsheet Model Estimates of Total Revenue Change: Combined Fare Revenue Gains and Saved Operating Costs

Modal Category	Fare Revenue Gain	Saved Operating Costs	Fare Revenue Gain + Saved Operating Costs
Bus	$23,933,063	$12,417,864	$36,350,927
Heavy Rail	$41,781,853	$0	$41,781,853
Light Rail	$16,908,813	$1,489,024	$18,397,837
Commuter Rail	$32,268,780	$5,736,219	$38,004,999
Ferry*	$0	$3,676,569	$3,676,569
THE RIDE	$3,741,277	$14,949,038	$18,690,315
Parking	$4,575,853	$0	$4,575,853
Total System	**$123,209,637**	**$38,268,714**	**$161,478,351**

* Ferry fare revenue is not collected by the MBTA, so the loss in fare revenue is not counted in the total revenue change but the saved operating costs of eliminating the Commuter Boat Subsidy are counted.

4.2.2 SCENARIO 2

Scenario 2 Projections

Table 4-4 presents CTPS's estimates of the ridership and fare revenue impacts of the Scenario 2 fare increase and service reductions produced using the spreadsheet model and its medium range of elasticities. As with Scenario 1, the existing ridership and fare revenue numbers, also presented, represent existing conditions before any adjustments are made to account for the estimated ridership lost due to the service reductions in this scenario. All figures are annual.

The total projected fare revenue increase from Scenario 2 comes to $86.8 million, or an 18.2 percent increase. The total projected ridership loss is estimated at 64.2 million annual unlinked trips, or a 16.6 percent decrease. For the Scenario 2 fare increase, the greatest absolute fare revenue increase is projected for the heavy rail category ($45.4 million). This is due partly to the fact that heavy rail riders take 39.7 percent of all annual unlinked trips, the largest percentage of any category. However, heavy rail riders, who are not affected by any service reductions, also have one of the smallest projected percentage decreases in ridership, at 10.0 percent. The commuter rail category provides the second-greatest projected absolute revenue increase ($25.2 million), followed by the light rail category ($17.8 million). The fare increase on buses is not enough to compensate for the lost bus fare revenue that results from the reduction in the number of bus routes; note, however, that overall bus revenue does increase because of the saved operating costs on these eliminated routes, as will be detailed subsequently. Finally, note that fare revenue is collected by ferry operators and not by the MBTA. As a result, the change in ridership but not revenue on the ferry mode is reported.

TABLE 4-4
Scenario 2: Spreadsheet Model Estimates of Annual Ridership and Fare Revenue Impacts

	Existing		Fare Revenue Change		Ridership Change	
Modal Category	**Fare Revenue**	**Ridership**	**$**	**%**	**#**	**%**
Bus	$84,943,538	111,903,868	-$6,044,895	-7.1%	-32,425,169	-29.0%
Heavy Rail	$150,317,103	153,439,900	$45,371,424	30.2%	-15,285,778	-10.0%
Light Rail	$61,940,438	77,659,524	$17,838,297	28.8%	-7,771,487	-10.0%
Commuter Rail	$139,373,877	32,802,960	$25,217,949	18.1%	-6,310,916	-19.2%
Ferry*	$0	1,309,167	$0	0.0%	-1,309,167	-100.0%
THE RIDE	$3,820,407	2,359,966	$2,250,984	58.9%	-178,795	-7.6%
Parking	$37,092,637	6,948,420	$2,154,262	5.8%	-937,897	-13.5%
Total System	**$477,488,002**	**386,423,805**	**$86,788,020**	**18.2%**	**-64,219,210**	**-16.6%**

* Ferry fare revenue is not collected by the MBTA, so the loss in ferry fare revenue is not counted in the total revenue change.

Scenario 2 Sensitivity Analysis

The Scenario 2 results reported in Table 4-4 used the medium range of elasticities. Table 4-5 presents a sensitivity analysis of the spreadsheet model, showing the range of Scenario 2's estimated ridership and revenue impacts from the fare increase and service reductions using the lower and higher ranges of elasticities presented in Table 3-1. In the ranges of ridership-loss estimates in the table, the greater losses are those resulting from the higher range of elasticities, while in the ranges of fare-revenue-increase estimates, the greater increases are those resulting from the lower range of elasticities.

The use of the higher range of elasticities results in much greater estimates of ridership losses: 77.5 million unlinked trips compared to 51.4 million using the lower range of elasticities; using the medium range of elasticities results in a loss of 64.2 million unlinked trips. As a result, the projected revenue gain from the fare increase estimated using the higher range of elasticities is approximately $22.5 million less than that estimated using the medium range of elasticities ($64.3 million versus $86.8 million) and $42.9 million less than that estimated using the lower range of elasticities.

TABLE 4-5
Scenario 2: Spreadsheet Model Ranges of Estimates of Annual Ridership and Fare Revenue Impacts Using Low and High Ranges of Elasticities

	Range of Fare Revenue Increases			Range of Ridership Losses		
Modal Category	**$ (millions)**	**%**	**$ Range (millions)**	**# (millions)**	**%**	**# Range (millions)**
Bus	(-$9.0)–(-$3.1)	(-10.6%)–(-3.7%)	$5.9	29.3–35.6	26.2%–31.8%	6.2
Heavy Rail	$37.3–$53.2	24.8%–35.4%	$15.9	9.5–21.2	6.2%–13.8%	11.7
Light Rail	$14.5–$21.1	23.5%–34.0%	$6.5	4.8–10.7	6.2%–13.8%	5.9
Commuter Rail	$18.5–$30.3	13.3%–21.7%	$11.8	5.5–7.3	16.9%–22.3%	1.8
Ferry	$0.0	0.0%	$0.0	1.3	100.0%	0.0
THE RIDE	$2.0–$2.5	52.6%–65.3%	$0.5	0.1–0.2	5.1%–10.1%	0.1
Parking	$0.9–$3.3	2.5%–8.8%	$2.3	0.8–1.1	11.3%–16.1%	0.3
Total System	**$64.3–$107.3**	**13.5%–22.5%**	**$42.9**	**51.4–77.5**	**13.3%–20.0%**	**26.1**

Scenario 2 Total Revenue Estimate

Table 4-6 adds the MBTA's estimates of saved operating costs from Scenario 2's service reductions to the spreadsheet model's estimates of the changes in fare revenue from Scenario 2's fare increase and service reductions reported in Table 4-4 to obtain an estimate of the change in total revenue. Under this scenario, while heavy rail has the greatest fare revenue gain, the saved operating costs for the bus mode place its total revenue gain above that of heavy rail, and the saved operating costs for the commuter rail mode place its total revenue gain close to that of heavy rail, which only incurs a fare increase. THE RIDE also has a significant total revenue increase. Again note that when the ferry service is eliminated, the MBTA saves money (as represented by the saved operating costs) by not providing the subsidy to operate the service.

TABLE 4-6
Scenario 2: Spreadsheet Model Estimates of Total Revenue Change
(Combined Fare Revenue Changes and Saved Operating Costs)

Modal Category	Fare Revenue Change	Saved Operating Costs	Fare Revenue Change + Saved Operating Costs
Bus	-$6,044,895	$60,358,388	$54,313,493
Heavy Rail	$45,371,424	$0	$45,371,424
Light Rail	$17,838,297	$1,489,024	$19,327,321
Commuter Rail	$25,217,949	$5,736,219	$30,954,168
Ferry*	$0	$3,676,569	$3,676,569
THE RIDE	$2,250,984	$7,094,175	$9,345,159
Parking	$2,154,262	$0	$2,154,262
Total System	**$86,788,020**	**$78,354,375**	**$165,142,395**

* Ferry fare revenue is not collected by the MBTA, so the loss in fare revenue is not counted in the total revenue change but the saved operating costs of eliminating the Commuter Boat Subsidy are counted.

4.2.3 COMPARISON OF SCENARIOS 1 AND 2 TOTAL REVENUE CHANGES: FARE REVENUE CHANGES COMBINED WITH SAVED OPERATING COSTS

Finally, Table 4-7 compares the total estimated revenue impacts of fare revenue changes and saved operating costs from service reductions under Scenarios 1 and 2. As in Tables 4-3 and 4-6, the total revenue changes equal the projected revenue gain from the fare increase plus the saved operating costs from the service reductions. As seen in Table 4-7, the greatest differences between Scenarios 1 and 2 in terms of the percentage of the total revenue increase represented by each modal category occur for bus, commuter rail, and THE RIDE. In Scenario 1, commuter rail and THE RIDE contribute greater percentages than the other modes of the total revenue increase, because of the large percentage price increases on these modes and their already more expensive starting points. In Scenario 2, the bus mode contributes the greatest percentage of the revenue increase because of the significant level of service reductions and the resulting saved operating costs.

TABLE 4-7
Comparison of Scenarios 1 and 2 Total Revenue Change:
Combined Fare Revenue Changes and Saved Operating Costs

	Scenario 1		Scenario 2	
Modal Category	**$ Change**	**% of Total**	**$ Change**	**% of Total**
Bus	$36,350,927	22.5%	$54,313,493	32.9%
Heavy Rail	$41,781,853	25.9%	$45,371,424	27.5%
Light Rail	$18,397,837	11.4%	$19,327,321	11.7%
Commuter Rail	$38,004,999	23.5%	$30,954,168	18.7%
Ferry	$3,676,569	2.3%	$3,676,569	2.2%
THE RIDE	$18,690,315	11.6%	$9,345,159	5.7%
Parking	$4,575,853	2.8%	$2,154,262	1.3%
Total System	**$161,478,351**	**100.0%**	**$165,142,395**	**100.0%**

4.3 REGIONAL TRAVEL DEMAND MODEL SET ESTIMATES

4.3.1 SCENARIO 1

Scenario 1 Projections

Table 4-8 presents CTPS's estimates, produced using the travel demand model set, of the ridership and fare revenue impacts of the fare increase and service reductions proposed in Scenario 1. All figures are annual. The travel demand model set projects that the greatest absolute increase in fare revenue will occur on heavy rail and the greatest percentage increase in fare revenue will occur on THE RIDE. These projected impacts reflect the fact that no service reductions are proposed for heavy rail and the fact that THE RIDE faces the greatest percentage price increase of any mode. In terms of ridership, the greatest projected absolute decrease is estimated on the bus mode because of the elimination of several bus routes. The greatest percentage decrease in ridership, aside from the ferry mode, which is eliminated, is on commuter rail. This is likely caused by a more elastic response to the fare increase given the already high prices of commuter rail fares and passes as well as the diversion of commuter rail riders to the less expensive heavy rail and light rail modes.

TABLE 4-8
Scenario 1: Travel Demand Model Set Estimates of Annual Ridership and Fare Revenue Impacts

	Existing		Fare Revenue Change		Ridership Change	
Modal Category	**Fare Revenue**	**Ridership**	**$**	**%**	**#**	**%**
Bus	$84,943,538	111,903,868	$29,786,338	35.1%	-12,055,868	-10.8%
Heavy Rail	$150,317,103	153,439,900	$55,990,847	37.2%	-6,739,900	-4.4%
Light Rail	$61,940,438	77,659,524	$22,682,434	36.6%	-3,649,524	-4.7%
Commuter Rail	$139,373,877	32,802,960	$17,477,421	12.5%	-8,922,960	-27.2%
Ferry*	$0	1,309,167	$0	0.0%	-1,309,167	-100.0%
THE RIDE	$3,820,407	2,359,966	$3,741,277	97.9%	-404,295	-17.1%
Parking	$37,092,637	6,948,420	$4,965,899	13.4%	-948,420	-13.6%
Total System	**$477,488,002**	**386,423,805**	**$134,644,215**	**28.2%**	**-34,030,134**	**-8.8%**

* Ferry fare revenue is not collected by the MBTA, so the loss in ferry fare revenue is not counted in the total revenue change.

Scenario 1 Total Revenue Estimate

Table 4-9 adds the MBTA's estimates of saved operating costs from Scenario 1's service reductions to the travel demand model set's estimates of the changes in fare revenue resulting from Scenario 1's fare increase and service reductions. Under this scenario, while heavy rail has the greatest revenue gain, the saved operating costs for the bus and commuter rail modes place their total revenue gain closer to that of heavy rail, which only incurs a fare increase. THE RIDE also has a significant revenue increase because of its large price increase. Again note that when ferry service is eliminated, the MBTA saves money (as represented by the saved operating costs) by not providing the subsidy to operate the service, but does not lose fare revenue because it does not collect the fares.

TABLE 4-9
Scenario 1: Travel Demand Model Set Estimates of Total Revenue Change: Combined Fare Revenue Gains and Saved Operating Costs

Modal Category	Fare Revenue Gain	Saved Operating Costs	Fare Revenue Gain + Saved Operating Costs
Bus	$29,786,338	$12,417,864	$42,204,202
Heavy Rail	$55,990,847	$0	$55,990,847
Light Rail	$22,682,434	$1,489,024	$24,171,458
Commuter Rail	$17,477,421	$5,736,219	$23,213,640
Ferry*	$0	$3,676,569	$3,676,569
THE RIDE	$3,741,277	$14,949,038	$18,690,315
Parking	$4,965,899	$0	$4,965,899
Total System	**$134,644,215**	**$38,268,714**	**$172,912,929**

* Ferry fare revenue is not collected by the MBTA, so the loss in ferry fare revenue is not counted in the total revenue change but the saved operating costs of eliminating the Commuter Boat Subsidy are counted.

4.3.2 SCENARIO 2

Scenario 2 Projections

Table 4-10 presents CTPS's estimates, produced using the travel demand model set, of the ridership and fare revenue impacts of the fare increase and service reductions proposed in Scenario 2. All figures are annual. The travel demand model set projects that the greatest absolute increase in fare revenue will occur on heavy rail and the greatest percentage increase in fare revenue will occur on THE RIDE. These projected impacts reflect the fact that no service reductions are proposed for heavy rail and the fact that THE RIDE faces the greatest percentage price increase of any mode. The fare increase on buses is not enough to compensate for the lost bus fare revenue that results from the reduction in the number of bus routes; note, however, that overall bus revenue does increase because of the saved operating costs on these eliminated routes. In terms of ridership, the greatest projected absolute decrease is estimated on the bus mode because of the elimination of several bus routes. The greatest percentage decrease in ridership, aside from the ferry mode, which

is eliminated, is also on the bus mode. It appears that the diversion of commuter rail riders is less in Scenario 2 than in Scenario 1.

TABLE 4-10
Scenario 2: Travel Demand Model Set Estimates of Annual Ridership and Fare Revenue Impacts

	Existing		Fare Revenue Change		Ridership Change	
Modal Category	**Fare Revenue**	**Ridership**	**$**	**%**	**#**	**%**
Bus	$84,943,538	111,903,868	-$3,936,759	-4.6%	-24,483,868	-21.9%
Heavy Rail	$150,317,103	153,439,900	$53,276,987	35.4%	-9,709,900	-6.3%
Light Rail	$61,940,438	77,659,524	$12,899,570	20.8%	-12,079,524	-15.6%
Commuter Rail	$139,373,877	32,802,960	$36,389,362	26.1%	-4,512,960	-13.8%
Ferry*	$0	1,309,167	$0	0.0%	-1,309,167	-100.0%
THE RIDE	$3,820,407	2,359,966	$2,250,984	58.9%	-178,795	-7.6%
Parking	$37,092,637	6,948,420	$3,128,363	8.4%	-798,795	-7.6%
Total System	**$477,488,002**	**386,423,805**	**$104,008,508**	**21.8%**	**-53,072,634**	**-13.7%**

* Ferry fare revenue is not collected by the MBTA, so the loss in ferry fare revenue is not counted in the total revenue change.

Scenario 2 Total Revenue Estimate

Table 4-11 adds the MBTA's estimates of saved operating costs from Scenario 2's service reductions to the travel demand model set's estimates of the changes in fare revenue resulting from Scenario 2's fare increase and service reductions. Under this scenario, the bus mode has the greatest revenue gain, due to the saved operating costs, in spite of the lost fare revenue. Heavy rail, which only incurs a fare increase, has the second-greatest revenue gain. The saved operating costs for commuter rail and THE RIDE also increase their total revenue gain. Again note that when ferry service is eliminated, the MBTA saves money (as represented by the saved operating costs) by not providing the subsidy to operate the service, but does not lose fare revenue because it does not collect the fares.

TABLE 4-11
Scenario 2: Travel Demand Model Set Estimates of Total Revenue Change: Combined Fare Revenue Changes and Saved Operating Costs

Modal Category	Fare Revenue Change	Saved Operating Costs	Fare Revenue Change + Saved Operating Costs
Bus	-$3,936,759	$60,358,388	$56,421,629
Heavy Rail	$53,276,987	$0	$53,276,987
Light Rail	$12,899,570	$1,489,024	$14,388,595
Commuter Rail	$36,389,362	$5,736,219	$42,125,581
Ferry*	$0	$3,676,569	$3,676,569
THE RIDE	$2,250,984	$7,094,175	$9,345,159
Parking	$3,128,363	$0	$3,128,363
Total System	**$104,008,508**	**$78,354,375**	**$182,362,883**

* Ferry fare revenue is not collected by the MBTA, so the loss in ferry fare revenue is not counted in the total revenue change but the saved operating costs of eliminating the Commuter Boat Subsidy are counted.

4.4 COMPARISON OF MODEL RESULTS: RANGES OF PROJECTED IMPACTS

4.4.1 SCENARIO 1

Projected ranges of ridership impacts and fare revenue impacts of the proposed Scenario 1 fare increase and service reductions are presented, respectively, in Tables 4-12 and 4-13. Probable ranges of impacts have been projected, as discussed above, by using both the spreadsheet model and the travel demand model set. As can be seen, the projections from the travel demand model set show a smaller overall decrease in ridership and a greater overall increase in fare revenue than are projected using the spreadsheet model (with medium-range elasticities).

Using the travel demand model set, CTPS projects a decrease of 34.0 million unlinked trips, or an 8.8 percent decrease, compared to a decrease of 48.6 million unlinked trips, or a 12.6 percent decrease, using the spreadsheet model. The projections from the travel demand model set show smaller ridership decreases in the bus, heavy rail, and light rail modal categories and larger ridership decreases in the commuter rail category compared to the spreadsheet model.

Overall, the travel demand model set appears to estimate a less elastic response of riders to the fare increase than the spreadsheet model. This explains the difference in estimates for the bus mode. However, the differences in heavy rail and light rail estimates may be caused by a combination of factors. It appears that, in addition to generally projecting a less elastic response, the travel demand model set is also estimating that a significant number of commuter rail riders will divert to heavy and light rail. This diversion occurs to a greater extent on commuter rail than other modes because its cost is already high, and the fare increase brings prices to a level where riders will search for less expensive travel options. The proposed service reductions would also encourage riders to switch to heavy and light rail at those times when commuter rail is no longer in service. In addition, the decline in commuter rail ridership is likely caused by a number of riders switching to the automobile mode as the already high cost of commuter rail makes driving relatively more competitive with commuter rail than it is for users of other transit modes. It appears that as much as one-third of the decrease in commuter rail riders and one-half of the increase in heavy rail and light rail riders could be diversions from commuter rail to heavy and light rail.

In terms of annual fare revenue, projections from the travel demand model set show a gain of $134.6 million, or a 28.2 percent increase, compared to a gain of $123.2 million, or a 25.8 percent increase, from the spreadsheet model. The smaller estimates of ridership loss from the travel demand model set result in greater estimates of fare revenue gains given the size of the proposed fare increase in Scenario 1. The greater ridership losses estimated by the spreadsheet model are correlated with smaller estimated fare revenue gains. When comparing modes, these differences are most apparent for heavy and

light rail. However, as was the case in the ridership projections, it appears that this difference, as well as that for commuter rail fare revenue, can be at least partly explained by the diversion of commuter rail riders to heavy rail and light rail apparently projected by the travel demand model set. Overall, this diversion would represent a loss in fare revenue, as riders switch from the higher-priced mode to lower-priced modes.

Taken together, the projections shown in these tables provide a probable range of outcomes from the proposed fare increase and service reductions in terms of ridership and fare revenue impacts.

TABLE 4-12
Scenario 1: Range of Ridership Projections

	Annual Ridership						
		Spreadsheet Model			Travel Demand Model Set		
Modal Category	**Existing**	**Projected**	**# Chg.**	**% Chg.**	**Projected**	**# Chg.**	**% Chg.**
Bus	111.9M	98.3M	-13.6M	-12.2%	99.8M	-12.1M	-10.8%
Heavy Rail	153.4M	136.6M	-16.9M	-11.0%	146.7M	-6.7M	-4.4%
Light Rail	77.7M	69.0M	-8.7M	-11.2%	74.0M	-3.6M	-4.7%
Commuter Rail	32.8M	26.1M	-6.7M	-20.4%	23.9M	-8.9M	-27.2%
Ferry	1.3M	0	-1.3M	-100.0%	0	-1.3M	-100.0%
THE RIDE	2.4M	2.0M	-0.4M	-17.1%	2.0M	-0.4M	-17.1%
Parking	6.9M	5.9M	-1.0M	-14.4%	6.0M	-0.9M	-13.6%
Total System	**386.4M**	**337.8M**	**-48.6M**	**-12.6%**	**352.4M**	**-34.0M**	**-8.8%**

TABLE 4-13
Scenario 1: Range of Fare Revenue Projections

	Annual Fare Revenue						
		Spreadsheet Model			Travel Demand Model Set		
Mode	**Existing**	**Projected**	**$ Chg.**	**% Chg.**	**Projected**	**$ Chg.**	**% Chg.**
Bus	$84.9M	$108.9M	+$23.9M	+28.2%	$114.7M	+$29.8M	+35.1%
Heavy Rail	$150.3M	$192.1M	+$41.8M	+27.8%	$206.3M	+$56.0M	+37.2%
Light Rail	$61.9M	$78.8M	+$16.9M	+27.3%	$84.6M	+$22.7M	+36.6%
Commuter Rail	$139.4M	$171.6M	+$32.3M	+23.2%	$156.9M	+$17.5M	+12.5%
Ferry	$0	$0	$0	0.0%	$0	$0	0.0%
THE RIDE	$3.8M	$7.6M	+$3.7M	+97.9%	$7.6M	+$3.7M	+97.9%
Parking	$37.1M	$41.7M	+$4.6M	+12.3%	$42.1M	+$5.0M	+13.4%
Total System	**$477.5M**	**$600.7M**	**+$123.2M**	**+25.8%**	**$612.1M**	**+$134.6M**	**+28.2%**

* Ferry fare revenue is not collected by the MBTA, so the loss in fare revenue is not counted in the total revenue change.

Table 4-14 adds the projected saved operating costs from service reductions to the two models' estimates of the revenue change from the fare increase. Therefore, this table presents a range of projections for the total estimated revenue change resulting from Scenario 1. The total change in revenue is projected to be an increase ranging between $161.5 million and $172.9 million, or between a 33.8 percent and a 36.2 percent increase.

TABLE 4-14
Scenario 1: Range of Projections for Total Revenue:
Combined Fare Revenue Gains and Saved Operating Costs

	Annual Total Revenue						
		Spreadsheet Model			Travel Demand Model Set		
Mode	**Existing**	**Projected**	**$ Chg.**	**% Chg.**	**Projected**	**$ Chg.**	**% Chg.**
Bus	$84.9M	$121.3M	+$36.4M	+42.8%	$127.1M	+$42.2M	+49.7%
Heavy Rail	$150.3M	$192.1M	+$41.8M	+27.8%	$206.3M	+$56.0M	+37.2%
Light Rail	$61.9M	$80.3M	+$18.4M	+29.7%	$86.1M	+$24.2M	+39.0%
Commuter Rail	$139.4M	$177.4M	+$38.0M	+27.3%	$162.6M	+$23.2M	+16.7%
Ferry	$0	$3.7M	+$3.7M	+100.0%	$3.7M	+$3.7M	+100.0%
THE RIDE	$3.8M	$22.5M	+$18.7M	+489.2%	$22.5M	+$18.7M	+489.2%
Parking	$37.1M	$41.7M	+$4.6M	+12.3%	$42.1M	$5.0M	+13.4%
Total System	**$477.5M**	**$639.0M**	**+$161.5M**	**+33.8%**	**$650.4M**	**+$172.9M**	**+36.2%**

* Ferry fare revenue is not collected by the MBTA, so the loss in ferry fare revenue is not counted in the total revenue change.

4.4.2 SCENARIO 2

Projected ranges of ridership impacts and fare revenue impacts, respectively, of the proposed Scenario 2 fare increase and service reductions are presented in Tables 4-15 and 4-16. Probable ranges of impacts have been projected, as discussed above, by using both the spreadsheet model and the travel demand model set. As can be seen, as with Scenario 1, the projections from the travel demand model set show a smaller overall decrease in ridership and a greater overall increase in fare revenue than are projected using the spreadsheet model.

Using the travel demand model set, CTPS projects a decrease of 53.1 million unlinked trips, or a 13.7 percent decrease, compared to a decrease of 64.2 million unlinked trips, or a 16.6 percent decrease, using the spreadsheet model. The projections from the travel demand model set show smaller ridership decreases in the bus, heavy rail, and commuter rail modal categories and larger ridership decreases in the light rail category compared to the spreadsheet model.

Overall, the travel demand model set appears to estimate a less elastic response of riders to the fare increase than the spreadsheet model. This is the case for the difference in estimates for the bus mode. It is likely that, as in Scenario 1, the travel demand model set estimates that some commuter rail riders are switching to heavy rail and light rail, as evidenced by the greater decrease in commuter rail trips compared to heavy rail trips, but this diversion does not appear to be as large in Scenario 2. In addition, the travel demand model set's estimate of light rail trips actually represents a greater percentage decrease than the spreadsheet model's estimate. This is explained by the fact that, in the travel demand model set's estimates, several bus routes that act as feeder services to the Green Line are eliminated in Scenario 2, which, in turn, reduces the number of trips on the Green Line. In addition, several bus routes that parallel portions of the Green Line have improved frequencies in Scenario 2, which further reduces ridership on the Green Line.

In terms of annual fare revenue, projections from the travel demand model set show a gain of $104.0 million, or a 21.8 percent increase, compared to a gain

of $86.8 million, or an 18.2 percent increase, from the spreadsheet model. The smaller estimates of ridership loss from the travel demand model set result in greater estimates of fare revenue gains, given the size of the proposed fare increase in Scenario 2. The greater ridership losses estimated by the spreadsheet model are correlated with smaller estimated fare revenue gains. When comparing modes, these differences are most apparent for heavy and light rail and commuter rail. However, as was the case in the ridership projections, it appears that these differences can be at least partly explained by the diversion of commuter rail riders to heavy rail and by the loss of light rail riders, which is likely caused by the elimination of feeder bus routes to Green Line stations and the improved frequencies of competing bus routes to the Green Line. The diversion from commuter rail to heavy rail would represent a loss in fare revenue, as riders switch from the higher-priced mode to the lower-priced mode.

Taken together, the projections shown in these tables provide a probable range of outcomes from the proposed fare increase and service reductions in terms of ridership and fare revenue impacts.

TABLE 4-15
Scenario 2: Range of Ridership Projections

	Annual Ridership						
		Spreadsheet Model			Travel Demand Model Set		
Modal Category	**Existing**	**Projected**	**# Chg.**	**% Chg.**	**Projected**	**# Chg.**	**% Chg.**
Bus	111.9M	79.5M	-32.4M	-29.0%	87.4M	-24.5M	-21.9%
Heavy Rail	153.4M	138.2M	-15.3M	-10.0%	143.7M	-9.7M	-6.3%
Light Rail	77.7M	69.9M	-7.8M	-10.0%	65.6M	-12.1M	-15.6%
Commuter Rail	32.8M	26.5M	-6.3M	-19.2%	28.3M	-4.5M	-13.8%
Ferry	1.3M	0	-1.3M	-100.0%	0	-1.3M	-100.0%
THE RIDE	2.4M	2.2M	-0.2M	-7.6%	2.2M	-0.2M	-7.6%
Parking	6.9M	6.1M	-0.9M	-13.5%	6.2M	-0.8M	-11.5%
Total System	**386.4M**	**322.2M**	**-64.2M**	**-16.6%**	**333.4M**	**-53.1M**	**-13.7%**

TABLE 4-16
Scenario 2: Range of Fare Revenue Projections

	Annual Fare Revenue						
		Spreadsheet Model			Travel Demand Model Set		
Mode	**Existing**	**Projected**	**$ Chg.**	**% Chg.**	**Projected**	**$ Chg.**	**% Chg.**
Bus	$84.9M	$78.9M	-$6.0M	-7.1%	$81.0M	-$3.9M	-4.6%
Heavy Rail	$150.3M	$195.7M	+$45.4M	+30.2%	$203.6M	+$53.3M	+35.4%
Light Rail	$61.9M	$79.8M	+$17.8M	+28.8%	$74.8M	+$12.9M	+20.8%
Commuter Rail	$139.4M	$164.6M	+$25.2M	+18.1%	$175.8M	+$36.4M	+26.1%
Ferry	$0	$0	$0	0.0%	$0	$0	0.0%
THE RIDE	$3.8M	$6.1M	+$2.3M	+58.9%	$6.1M	+$2.3M	+58.9%
Parking	$37.1M	$39.2M	+$2.2M	+5.8%	$40.2M	$3.1M	+8.4%
Total System	**$477.5M**	**$564.3M**	**+$86.8M**	**+18.2%**	**$581.5M**	**+$104.0M**	**+21.8%**

* Ferry fare revenue is not collected by the MBTA, so the loss in ferry fare revenue is not counted in the total revenue change.

Table 4-17 adds the projected saved operating costs from service reductions to the two models' estimates of the revenue change from the fare increase. Therefore, this table presents a range of projections for the total revenue

change resulting from Scenario 2. The total change in revenue is projected to be an increase ranging between $165.1 million and $182.4 million, or between a 34.6 percent and a 38.2 percent increase.

TABLE 4-17
Scenario 2: Range of Projections for Total Revenue:
Combined Fare Revenue Gains and Saved Operating Costs

	Annual Total Revenue						
		Spreadsheet Model			Travel Demand Model Set		
Mode	**Existing**	**Projected**	**$ Chg.**	**% Chg.**	**Projected**	**$ Chg.**	**% Chg.**
Bus	$84.9M	$139.3M	+$54.3M	+63.9%	$141.4M	+$56.4M	+66.4%
Heavy Rail	$150.3M	$195.7M	+$45.2M	+30.2%	$203.6M	+$53.3M	+35.4%
Light Rail	$61.9M	$81.3M	+$19.3M	+31.2%	$76.3M	+$14.4M	+23.2%
Commuter Rail	$139.4M	$170.3M	+$31.0M	+22.2%	$181.5M	+$42.1M	+30.2%
Ferry	$0	$3.7M	+$3.7M	+100.0%	$3.7M	+$3.7M	+100.0%
THE RIDE	$3.8M	$13.2M	+$9.3M	+244.6%	$13.2M	+$9.3M	+244.6%
Parking	$37.1M	$39.2M	+$2.2M	+5.8%	$40.2M	$3.1M	+8.4%
Total	**$477.5M**	**$642.6M**	**+$165.1M**	**+34.6%**	**$659.9M**	**+$182.4M**	**+38.2%**

* Ferry fare revenue is not collected by the MBTA, so the loss in ferry fare revenue is not counted in the total revenue change.

5 Air Quality Impacts

5.1 BACKGROUND

The air quality impacts of alternative transportation scenarios can be analyzed using standard transportation-forecasting models, including the Boston Region MPO's travel demand model set. The travel demand model set can be used to estimate future traffic characteristics within the region's transportation network: traffic volumes, average highway speeds, and vehicle-miles and vehicle-hours traveled. Since the amount of air pollution emitted by highway traffic depends on the prevailing highway speeds and vehicle-miles traveled, it is possible to estimate these air quality impacts with reasonable accuracy.

Air pollutants produced by vehicles generally fall into two groups: gaseous and particulate. Examples of gaseous pollutants include carbon monoxide (CO), volatile organic compounds (VOC, also known as hydrocarbons), nitrogen oxides (NOx), and carbon dioxide (CO_2). In addition, there are the photochemical oxidants (such as ozone), which are not directly emitted from vehicles but are formed when VOC and NOx chemically react in the presence of sunlight and warm temperatures. Particulate pollutants produced by vehicles are commonly broken into two categories: fine particulates—those with a diameter of 2.5 micrometers or less, and coarse particulates—those with a diameter between 2.5 and 10 micrometers.

Under the Clean Air Act, the U.S. Environmental Protection Agency (EPA) sets standards for various types of emissions. Historically, EPA has regulated particulates, CO, and ground-level ozone, all of which are hazardous to human health. The Boston Region MPO is currently required to report the amount of CO, NOx, and VOC produced by the regional transportation system in such documents as the Transportation Improvement Program and the Long-Range Transportation Plan. Due to its contribution to climate change, CO_2 is also an important type of emission to measure.

CTPS employs EPA MOBILE 6.2 emission factors for calculating the amounts of pollutants. For each link within the highway network, the travel demand model set applies the MOBILE 6.2 emission factors corresponding to the link's average speed and estimates the emissions of pollutants based on the vehicle-miles traveled on that link. The total amount of emissions of a pollutant in the

entire region is obtained by summing the amounts associated with the individual links in the system.

5.2 ESTIMATED AIR QUALITY IMPACTS

With respect to the fare increase and service reductions proposed under Scenarios 1 and 2, the air quality impacts are primarily those associated with existing transit users who choose to drive to their destinations instead of using transit. A reduction in transit trips and addition of automobile trips generally causes increases in the generation of CO, VOC, NOx, CO_2, and particulates, and these increases can be measured in the manner described in the preceding section. It should be noted that as the numbers of automobile trips and vehicle hours increase, the congestion on area roadways also increases. This additional congestion results in lower travel speeds (which are associated with higher emissions of pollutants) for all vehicles, not just those of former transit users. While air quality will typically worsen in response to fare increases and service reductions, the elimination of transit vehicle trips does represent a reduction in emissions, and this reduction is included in the estimates produced using the travel demand model set.

After calculating the ridership impacts of each scenario as described earlier in this report, CTPS used the model set to estimate the change in regional vehicle-miles traveled and average miles per hour for private automobiles and transit vehicles. Specifically, for automobiles, the path of each automobile trip made by a former transit user was identified and the travel times for all automobile trips were estimated. For transit vehicles, the paths and travel times for all eliminated trips were identified. CTPS applied to these data the emission factors provided by the EPA that are associated with each of the pollutants identified above.

As shown in Table 5-1, automobile vehicle-miles and vehicle-hours traveled are estimated to increase and average miles per hour are estimated to decrease because of the proposed fare increase and service reductions in either Scenario 1 or Scenario 2. Transit vehicle-miles traveled are estimated to decrease in both scenarios, though the decrease is greater in Scenario 2. The projected regional change in emissions per weekday of each of the selected pollutants is reported for the sum of automobile and transit emissions under each scenario.

The decreases in transit emissions are greater for all pollutants in Scenario 2, but greater increases in automobile emissions in that scenario result in worse air quality for all of the pollutants other than NOx compared to Scenario 1. Scenario 2's percentage increases in emissions for CO, VOC, and fine and coarse particulates all exceed those of Scenario 1; its percentage increase in CO_2 is only slightly less than Scenario 1's.

Both scenarios result in decreases in NOx emissions; the decrease is greater in Scenario 2 than in Scenario 1 because of a larger decrease in transit-vehicle emissions of NOx. However, despite these decreases, both scenarios bear out a general rule that usually applies in air quality analyses of this kind: any loss in

transit ridership that results in an increase in auto vehicle-miles and vehicle-hours traveled will lead to some level of increase in pollutants.

In summary, under both scenarios, air quality worsens. A margin of error is associated with the estimation process, but the results are well beyond that margin.

TABLE 5-1
Projected Average Weekday Changes in Selected Pollutants (Regionwide)

	Scenario 1		Scenario 2	
Indicator/Pollutant	**Absolute Change**	**Percent Change**	**Absolute Change**	**Percent Change**
Auto vehicle-miles traveled	+430,837	+0.39%	+626,060	+0.57%
Auto vehicle-hours traveled	+31,808	+0.95%	+44,383	+1.33%
Auto average miles-per-hour	-0.18	-0.55%	-0.24	-0.75%
Transit vehicle-miles traveled	-11,117	-10.86%	-39,187	-38.27%
Carbon monoxide (kg)	+4,917	+0.39%	+7,146	+0.57%
Nitrogen oxides (kg)	-696	-0.61%	-916	-0.80%
Volatile organic compounds (kg)	+31	+0.07%	+123	+0.30%
Carbon dioxide (kg)	+194,990	+0.33%	+174,852	+0.30%
Fine particulates (kg)	+10	+0.41%	+15	+0.60%
Coarse particulates (kg)	+17	+0.41%	+25	+0.60%

6 Environmental Justice Impacts

6.1 DEFINITION OF ENVIRONMENTAL JUSTICE COMMUNITIES

To assess the impacts of each proposed scenario's fare increase and service reductions on minority and low-income communities, CTPS conducted an environmental justice (EJ) impacts analysis. Environmental justice communities were identified based on a methodology developed from Federal Transit Administration guidance to the MBTA's ongoing Title VI program and on past practice of CTPS. For the purposes of Title VI analyses, the MBTA has defined two service areas with different demographic characteristics: one for the urban fixed-route transit system and another for the commuter rail system. Therefore, the Authority has two sets of criteria for identifying EJ communities, one for each service area.

For each of the two service areas, the average annual income and the percentage of minority population were identified for each transportation analysis zone (TAZ). A TAZ was then defined as low-income if its income level was at or below 60 percent of the median household income in the service area; this meant at or below $40,766 in the urban fixed-route transit service area and $41,636 in the commuter rail service area. Minority TAZs were defined as those in which the percentage of the non-white population (including the Hispanic population) was greater than the average for the service area. The average percentage of minority residents is 31.3 percent in the urban fixed-route transit service area and 26.2 percent in the commuter rail service area. Any TAZ which qualifies as either minority or low-income is considered an EJ community.[3]

6.2 EQUITY DETERMINATION

After identifying the EJ communities in both service areas, CTPS analyzed, for each service area (except where noted otherwise), areawide equity in terms of both the existing and proposed conditions for both scenarios using the Boston Region MPO's travel demand model set. Each TAZ's "score" in terms of various metrics was estimated by the model set for both the existing system

[3] Median household income was determined based on the 2006-2010 American Community Survey. Minority percentages were determined based on the 2010 U.S. Census.

and each projected scenario. To measure the areawide results, averages across TAZs (for EJ and non-EJ communities) were calculated; in this calculation, each TAZ's score was weighted according to its existing transit trips.

Three general categories of metrics were analyzed with respect to their projected equity impacts. Note that this analysis used data for the weekday AM peak time period, as this represents the greatest number of transit trips in any time period.

For the first category, transit equity, the measures were the average fare, the average walk-access time, the average wait time, and the total number of transit trips. The average fare and average walk-access and wait times for a given TAZ were measured based on the trips originating from that TAZ (as opposed to the trips destined for that TAZ). The total number of transit trips was only calculated for the commuter rail service area, as this area represents the entire transit market.

The second category was highway congestion and air quality. Average vehicle-miles traveled per square mile was the metric for representing local levels of congestion. Average carbon monoxide emissions per square mile was the metric representing the local level of air pollution (since carbon monoxide is a local pollutant).

The third category was accessibility. The travel demand model set was utilized to produce measures of transit accessibility to various types of destinations; accessibility was measured relative to the ability to access the desired destination by transit within at least 40 minutes, which is based on the average commute trip time for the Boston region. Jobs were one of the destination types included in the measurement of transit accessibility; specifically, service sector jobs were used in this analysis, as the results tended to mirror those for the other job sectors. Accessibility to healthcare (as measured by the total number of beds at the accessible health facilities) and accessibility to post-secondary education (as measured by the total enrollment at the accessible colleges) were also measured by the travel demand model set.

6.2.1 TRANSIT EQUITY METRICS

Table 6-1 and Table 6-2 present, for Scenario 1 and Scenario 2, respectively, the existing and projected values for the four transit equity metrics: average fare ($ per trip), average walk-access time (minutes), average wait time (minutes), and total number of transit trips. As seen in the tables, in both the commuter rail and urban fixed-route service areas, the existing average fare is less for EJ communities than for non-EJ communities, as are the average walk-access time and wait time. This reflects the greater concentration of EJ communities in areas currently well-served by transit, which also tend to be more urban and densely developed. For these same reasons, EJ communities have more than twice the number of transit trips compared to non-EJ communities. These relationships between the EJ and non-EJ existing conditions remain consistent in the projected conditions.

TABLE 6-1
Scenario 1: Existing and Projected Measures of Transit Equity Metrics

		Existing		Projected		Absolute Change		Percentage Change	
Service Area	**Metric**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**
Commuter Rail	Average Fare	$2.11	$2.20	$2.84	$3.01	+$0.73	+$0.81	+34.6%	+36.7%
	Walk-Access Time (min.)	19.4	21.1	19.5	21.2	+0.06	+0.10	+0.3%	+0.5%
	Wait Time (min.)	16.9	18.2	17.0	18.4	+0.09	+0.14	+0.5%	+0.8%
	Total Transit Trips	126,182	58,951	121,856	54,924	-4,326	-4,027	-3.4%	-6.8%
Urban Fixed-Route	Average Fare	$1.81	$2.09	$2.38	$2.85	+$0.57	+$0.76	+31.4%	+36.2%
	Walk-Access Time (min.)	19.2	20.5	19.3	20.6	+0.08	+0.13	+0.4%	+0.6%
	Wait Time (min.)	16.6	17.2	16.7	17.4	+0.08	+0.11	+0.5%	+0.6%

TABLE 6-2
Scenario 2: Existing and Projected Measures of Transit Equity Metrics

		Existing		Projected		Absolute Change		Percentage Change	
Service Area	**Metric**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**
Commuter Rail	Average Fare	$2.11	$2.20	$2.74	$3.06	+$0.63	+$0.86	+30.0%	+39.1%
	Walk-Access Time (min.)	19.4	21.1	20.3	21.8	+0.86	+0.74	+4.4%	+3.5%
	Wait Time (min.)	16.9	18.2	17.6	18.5	+0.72	+0.23	+4.3%	+1.3%
	Total Transit Trips	126,182	58,951	117,218	49,142	-8,964	-9,808	-7.1%	-16.6%
Urban Fixed-Route	Average Fare	$1.81	$2.09	$2.39	$2.89	+$0.58	+$0.80	+32.3%	+38.1%
	Walk-Access Time (min.)	19.2	20.5	20.1	21.3	+0.88	+0.79	+4.6%	+3.9%
	Wait Time (min.)	16.6	17.2	17.3	17.5	+0.73	+0.25	+4.4%	+1.5%

Looking at the projected changes, both the absolute and percentage increases in Scenario 1 are less for EJ communities than non-EJ communities for average fare, average walk-access time, and average wait time. This reflects the fact that in Scenario 1 the service reductions are generally located outside the urban core. However, because EJ communities have a greater number of existing transit riders, the absolute decrease in transit trips in Scenario 1 is greater for EJ communities than non-EJ communities, although the percentage decrease for EJ communities is less.

In Scenario 2, both the absolute and percentage increases in average walk-access and wait time are greater for EJ communities than non-EJ communities, although the projected averages for EJ communities are still less than the projected averages for non-EJ communities. As with Scenario 1, both the absolute and percentage increases for average fare are less for EJ communities than non-EJ communities. Because more of the service reductions in Scenario 2 affect areas outside the urban core, the absolute decrease in transit trips in Scenario 2 is greater for non-EJ communities than non-EJ communities. As in Scenario 1, the percentage decrease in transit trips in Scenario 2 is less for EJ communities than non-EJ communities.

When the two scenarios are compared, it is apparent that Scenario 2 provides worse service generally, as the average walk-access and wait times increase by a greater number and percentage for both EJ and non-EJ communities in Scenario 2 compared to Scenario 1. The loss in transit riders for both EJ and non-EJ communities reflects this, as the decreases in Scenario 2 are more than double those in Scenario 1.

Interestingly, although Scenario 1 has the greater overall price increase, the non-EJ average fare is estimated to increase by a smaller percentage in Scenario 1 than Scenario 2. This is caused by the diversion of commuter rail riders to heavy and light rail in Scenario 1, as these riders seek a less costly mode of travel. In terms of comparing the impacts on EJ and non-EJ communities, Scenario 1 generally has smaller EJ impacts than non-EJ impacts for all metrics. In Scenario 2, EJ communities fare much better than non-EJ communities in terms of the increase in average fare and the decrease in transit trips, but EJ communities have greater increases in average walk-access and wait times.

6.2.2 HIGHWAY CONGESTION AND AIR QUALITY EQUITY METRICS

Table 6-3 and Table 6-4 present, for Scenario 1 and Scenario 2, respectively, the existing and projected measures of average vehicle-miles traveled (VMT) per square mile and average kilograms of carbon monoxide (CO) emissions per square mile. The first metric was used to represent impacts on local congestion, and the second was used to represent impacts on local air pollution.

As shown in the table, the average existing-conditions measures of both VMT and CO emissions are greater for EJ communities than non-EJ communities. This is a reflection of the much greater traffic levels in the more urban areas,

which is where EJ communities are typically located. In the urban fixed-route service area, EJ communities have existing averages for VMT and average CO per square mile that are more than twice the averages for non-EJ communities. In the commuter rail service area, this ratio is more than 2.75 for both metrics.

Unlike the transit equity metrics, the highway congestion and air quality metrics show a greater negative impact on EJ communities compared to non-EJ communities, a further exacerbation of the difference in local congestion and air quality that already exists. In Scenario 1, for the urban fixed-route service area, the absolute increase in the average VMT per square mile for EJ communities is more than five times that for non-EJ communities, and the absolute increase in the average CO per square mile for EJ communities is more than six times that for non-EJ communities. Similar ratios hold for Scenario 2, and the increases are larger than those in Scenario 1. As percentage changes, Scenario 1 has slightly greater increases in both metrics for EJ communities compared to non-EJ communities, while Scenario 2 has much greater increases in both metrics for EJ communities compared to non-EJ communities.

6.2.3 ACCESSIBILITY EQUITY METRICS

Table 6-5 and Table 6-6 present, for Scenario 1 and Scenario 2, respectively, the existing and projected accessibility measures. Access to jobs is measured by the number of accessible jobs in the service employment category. The changes in accessibility to service jobs largely match those for retail and other jobs; therefore, service jobs are presented in the table as a proxy for all jobs. Access to healthcare is measured by the number of beds at accessible hospitals. Access to higher education is measured by the number of enrolled students at accessible colleges. These metrics indicate the accessibility of EJ and non-EJ communities to high-demand destinations.

As seen in the table, in both the commuter rail and urban fixed-route service areas, EJ communities have a greater level of existing access in terms of all three metrics compared to non-EJ communities. This basic difference between EJ and non-EJ accessibility is not projected to change in either Scenario 1 or Scenario 2. While accessibility is projected to decrease overall, the loss in access to jobs, healthcare, and higher education is estimated to be greater for non-EJ communities than EJ communities, in terms of both the absolute and percentage changes. Comparing the two scenarios, the decrease in accessibility is projected to be greater in Scenario 2 than Scenario 1.

6.2.4 SUMMARY OF EQUITY IMPACTS

In Scenario 1 and Scenario 2, the impacts on equity follow a similar pattern that depends on the metric. In general, for the metrics in which EJ communities have better existing “scores” than non-EJ communities, that is, for the transit and accessibility equity measures, both Scenario 1 and Scenario 2, while making the scores worse overall, degrade the scores less for EJ versus non-EJ communities. For example, the existing EJ average fare is less than the non-EJ

TABLE 6-3
Scenario 1: Existing and Projected Measures of Highway Congestion and Air Quality Equity Metrics

		Existing		Projected		Absolute Change		Percentage Change	
Service Area	**Metric**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**
Commuter Rail	Avg. VMT per Sq. Mile	40,123	14,375	40,529	14,446	+407	+71	+1.0%	+0.5%
	Avg. CO per Sq. Mile (kg)	457,055	164,662	462,295	165,497	+5,240	+835	+1.1%	+0.5%
Urban Fixed-Route	Avg. VMT per Sq. Mile	54,112	25,848	54,904	26,087	+792	+240	+1.5%	+0.9%
	Avg. CO per Sq. Mile (kg)	617,539	292,673	627,913	295,619	+10,375	+2,946	+1.7%	+1.0%

TABLE 6-4
Scenario 2: Existing and Projected Measures of Highway Congestion and Air Quality Equity Metrics

		Existing		Projected		Absolute Change		Percentage Change	
Service Area	**Metric**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**
Commuter Rail	Avg. VMT per Sq. Mile	40,123	14,375	40,676	14,467	+553	+92	+1.4%	+0.6%
	Avg. CO per Sq. Mile (kg)	457,055	164,662	464,096	165,749	+7,041	+1,087	+1.5%	+0.7%
Urban Fixed-Route	Avg. VMT per Sq. Mile	54,112	25,848	55,199	26,181	+1,087	+337	+2.0%	+1.3%
	Avg. CO per Sq. Mile (kg)	617,539	292,673	631,582	296,757	+14,043	+4,085	+2.3%	+1.4%

TABLE 6-5
Scenario 1: Existing and Projected Measures of Accessibility Equity Metrics

		Existing		Projected		Absolute Change		Percentage Change	
Service Area	**Metric**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**
Commuter Rail	Service Jobs	291,455	192,299	288,990	187,841	-2,466	-4,459	-0.8%	-2.3%
	Hospital Beds	3,053	2,009	3,023	1,955	-30	-55	-1.0%	-2.7%
	College Enrollment	45,575	33,790	45,360	33,394	-215	-396	-0.5%	-1.2%
Urban Fixed-Route	Service Jobs	302,852	231,313	300,851	226,093	-2,001	-5,220	-0.7%	-2.3%
	Hospital Beds	3,171	2,419	3,140	2,365	-31	-55	-1.0%	-2.3%
	College Enrollment	46,552	40,560	46,360	40,124	-191	-435	-0.4%	-1.1%

TABLE 6-6
Scenario 2: Existing and Projected Measures of Accessibility Equity Metrics

		Existing		Projected		Absolute Change		Percentage Change	
Service Area	**Metric**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**	**EJ**	**Non-EJ**
Commuter Rail	Service Jobs	291,455	192,299	283,645	181,383	-7,811	-10,917	-2.7%	-5.7%
	Hospital Beds	3,053	2,009	2,974	1,876	-79	-133	-2.6%	-6.6%
	College Enrollment	45,575	33,790	45,347	33,297	-228	-493	-0.5%	-1.5%
Urban Fixed-Route	Service Jobs	302,852	231,313	297,018	216,734	-5,834	-14,579	-1.9%	-6.3%
	Hospital Beds	3,171	2,419	3,094	2,280	-77	-139	-2.4%	-5.8%
	College Enrollment	46,552	40,560	46,406	39,949	-145	-611	-0.3%	-1.5%

average fare and both scenarios result in greater absolute and percentage increases in the non-EJ average fare, further increasing the difference. For the metrics in which EJ communities have worse existing scores than non-EJ communities, that is, for the highway congestion and air quality equity measures, both scenarios result in larger negative impacts on EJ communities than non-EJ communities.

As for differences between the impacts of Scenario 1 and Scenario 2, the transit equity metrics reflect a difference between the basic characteristics of the scenarios that has already been noted: Scenario 1 has a greater fare increase and smaller service reductions, while Scenario 2 has a smaller fare increase and greater service reductions. The increase in the EJ average fare is accordingly less in Scenario 2 than in Scenario 1, and the difference between the resulting EJ and non-EJ average fares in Scenario 2 is greater than the difference in Scenario 1. Again reflecting basic differences between the scenarios, Scenario 2 has greater increases in the average walk-access and wait times for EJ communities than Scenario 1 does. Scenario 2 also has a much greater estimated decrease in both EJ and non-EJ transit trips than Scenario 1.

Similar to the pattern demonstrated by the transit equity metrics, in comparison to Scenario 1, Scenario 2 results in greater overall increases in congestion and CO emissions and greater decreases in access to jobs, hospitals, and educational opportunities for both EJ and non-EJ communities. In both scenarios, the increase in congestion and CO emissions is greater for EJ communities than non-EJ communities, while the decrease in access affects a greater relative number of transit riders living in non-EJ communities.

7 Conclusions

The means available to the MBTA for addressing the $161.0 million projected budget deficit for FY 2013 are limited to increasing fares and reducing service; the two proposed scenarios analyzed in this report offer a choice between different ways of combining those two means. Scenario 1 raises the majority of the needed revenue through a fare increase, with the remainder of the deficit being covered by reducing service. Scenario 2 is split approximately evenly between revenue gains from a fare increase and saved operating costs from service reductions.

Closing the budget deficit employing only a fare increase or only service reductions is untenable. Modeling exercises done with the spreadsheet model show that it is not feasible to increase fares to an extent that would raise $161.0 million: the ridership losses estimated to result are so substantial under any fare increase above 60 percent that the fare revenue increases become minimal. Similarly, cutting $161.0 million from operating expenses is also infeasible, as the necessary service reductions would likely reduce ridership to such an extent that the already low average revenue per passenger would decrease even further.

Scenarios 1 and 2 are projected to produce roughly equivalent gains in revenue, and either would close the projected budget deficit. The sensitivity analysis using different fare elasticity values in the spreadsheet model shows that this model projects a greater range of potential fare revenue impacts for Scenario 1 than Scenario 2; however, in terms of range of results between the travel demand model and the spreadsheet model, Scenario 1 has a smaller range of estimated revenue impacts.

Scenario 1 maintains most of the existing system while eliminating services with the greatest net cost (or subsidy) per passenger and increasing fares by the amount necessary to reach the revenue target. While this scenario reduces the systemwide net cost per passenger, in the long run it does not change the situation currently faced by the MBTA, namely, operating too many services that cost too much money given the size of the MBTA's dedicated revenue stream. Scenario 2 essentially re-envisions the scope of the MBTA, streamlining its operations to focus on serving the most cost-efficient routes, which are largely in the urban core. However, Scenario 2 eliminates services in

many areas where no other transit options exist and is projected to result in a greater ridership loss than Scenario 1.

Neither fare increases nor service reductions present an appealing choice, but the primary methods that the MBTA has at its disposal for reducing deficits are these two measures, barring any additional sources of revenue. This report's projections of the impacts of each scenario on ridership, revenue, air quality, and environmental justice communities will inform the Authority's decision making. It is based on these data—and on a vision of what shape the MBTA will take in the future—that a course of action must be chosen.

APPENDIX
Spreadsheet Model Methodology

A.1 APPORTIONMENT OF EXISTING RIDERSHIP

Automated fare-collection (AFC) data are provided on a monthly basis, including subtotals of transactions (unlinked trips) for the various combinations of fare type, fare mode, and fare media (Table A-1).

TABLE A-1
AFC Fare Categories

Fare Type	Fare Mode	Fare Media
Adult/Senior/TAP/Student/Free	Single-Ride	CharlieCard CharlieTicket Onboard Cash
Adult/Senior/TAP/Student	Transfer	CharlieCard CharlieTicket
Short (fares below the full value)	Single-Ride	Onboard Cash
Bus/Inner Express/Outer Express	Pass	CharlieCard CharlieTicket
LinkPass: Monthly/1-Day/7-Day	Pass	CharlieCard CharlieTicket
Commuter Rail Zone and Interzone/Commuter Boat	Pass	CharlieTicket
Senior/TAP/Student	Pass	CharlieCard CharlieTicket

AFC data are also provided at the modal level at which each transaction occurs. Table A-2 lists the modal and summary categories used in the Post–Fare Increase Impacts Analysis that was conducted for the 2007 MBTA fare increase.

A.2 PRICE ELASTICITY ESTIMATION

Subsequent to the 2007 fare increase, CTPS conducted a Post–Fare Increase Impacts Analysis, which was intended, in part, to test the accuracy of the elasticities used for the Pre–Fare Increase Impacts Analysis that had been conducted to project changes in ridership that would result from higher fares.

TABLE A-2
AFC Modal Categories

Mode		AFC Equipment
Bus/ Trackless Trolley	Local Bus	Farebox
	Inner Express Bus	Farebox
	Outer Express Bus	Farebox
Rapid Transit	Red, Orange, Blue, Green, Silver Waterfront Subway	Faregate
	Silver Line Waterfront Surface	Farebox
	Silver Line Washington Street	Farebox
	Green Line Surface B, C, D, E	Farebox/Validator
	Mattapan High-Speed Line	Farebox

The price elasticities used in the spreadsheet model for the present analysis of a potential 2012 fare increase are based on the elasticities that the 2007 Post–Fare Increase Impacts Analysis found to have been demonstrated in the actual ridership impacts of the 2007 increase. In that analysis, CTPS used the percentage change in trips and price for each fare payment category and calculated the price elasticities. While the elasticities of smaller, individual categories were likely unreliable, CTPS was able to determine realistic elasticity figures for larger and more general categories. Those figures were generally found to be more elastic than the elasticity inputs used in the 2007 Pre–Fare Increase Impacts Analysis, which had underestimated the ridership loss from the 2007 fare increase.

It is admittedly difficult to isolate the effects of price elasticity on changes in demand. Over the course of a year (in which time it is assumed that the effects of price changes are largely internalized by the population), economic, demographic, and other factors may play as much, if not more, of a role in influencing transit demand than price. Indeed, the upcoming year promises to be characterized by significant uncertainty with regard to these larger trends.

Table A-3 presents the elasticities used in the spreadsheet model categorized by type of fare payment and mode. The types of fare payment are divided into two categories: “single-ride” (or pay-per-ride) and “pass.” Elasticities are further divided into several modal categories: bus, subway, surface light rail, commuter rail, ferry, and THE RIDE. All modes have both single-ride and pass price elasticities except for THE RIDE, which has only single-ride customers.

Based on the 2007 Post–Fare Increase Impacts Analysis, single-ride price elasticities are assumed to be as or less elastic than pass price elasticities, signifying that the spreadsheet model projects single-ride customers to be slightly less responsive to changes in price than pass customers. The least elastic of the single-ride modal price elasticities is that for THE RIDE, followed by bus, parking, subway and surface light rail, ferry, and, finally, commuter rail. Elasticities for seniors and students are also assumed to be less elastic than those for adults. For pass price elasticities, commuter rail is the least elastic of the modes. Express bus passes are the next-least elastic, followed by the Senior and Student Pass, the Commuter Boat Pass, the monthly Bus Pass and LinkPass, and the 1- and 7-Day LinkPasses.

TABLE A-3
Single-Ride and Pass Elasticities by Fare Type and Mode

Fare Type/Mode	Elasticity
Single-Ride	
Bus	-0.20
Adult	-0.20
Senior	-0.15
Student	-0.15
Subway	-0.25
Adult	-0.25
Senior	-0.15
Student	-0.15
Surface Light Rail	-0.25
Adult	-0.25
Senior	-0.20
Student	-0.20
Commuter Rail	-0.35
Adult	-0.35
Half-Fare	-0.25
Ferry	-0.30
Adult	-0.30
Half-Fare	-0.20
THE RIDE	-0.12
Parking	-0.20
Pass	
Bus	-0.30
Inner Express	-0.20
Outer Express	-0.20
LinkPass	-0.30
1-Day LinkPass	-0.35
7-Day LinkPass	-0.35
Commuter Rail	-0.10
Ferry	-0.25
Senior	-0.15
Student	-0.15

A.3 PRICE ELASTICITY

Price elasticity is the measure of either the expected or observed rate of change in ridership relative to a change in fares if all other factors remain constant. On a traditional demand curve that describes the relationship between price, on the y-axis, and demand, on the x-axis, elasticities are equivalent to the slope along that curve. Therefore, price elasticities are generally expected to be negative, meaning that a positive price increase will lead to a decrease in demand (with a price decrease having the opposite effect). The more negative (farther from zero) the value of a price elasticity, the larger the projected decrease in demand. More negative price elasticities are said to be relatively “elastic,” while smaller negative values, closer to zero, are said to be relatively “inelastic.” Thus, if the price elasticity of the demand for transit is assumed to be elastic, a given fare increase would cause a greater loss of ridership than if demand were assumed to be inelastic.

At its most elemental level, the spreadsheet model is based on this simple price elasticity relationship, and requires four inputs: original demand, original fare, new fare, and the price elasticity. The formula for calculating new demand is:

New Demand = Original Demand × [1 + Price Elasticity × (New Fare / Old Fare - 1)]

As an example, assume that original demand equals 100 and that the impact that is being modeled is a 10 percent fare increase from $1.00 to $1.10. Also assume that the price elasticity is -0.25.

New Demand = 100 × [1 + -0.25 × ($1.10 / $1.00 - 1)] = 97.50

Thus, using an elasticity of -0.25, a simple price elasticity model projects that a 10 percent increase in price will lead to a 2.50 percent decrease in demand. With the fare increased from $1.00 to $1.10, this simplified model projects a 7.25 percent increase in revenue ($100.00 to $107.25).

A.4 DIVERSION FACTORS

The spreadsheet model's calculations are more complex—and therefore more accurate—than a simple elasticity calculation. Its greater complexity lies in its use of ridership diversion factors. Diversion factors reflect estimates of the likelihood of a switch in demand for one type of good to another as a result of a change in the relative prices of those goods. In the spreadsheet model, such factors are used for estimating the number of riders choosing to divert from one fare/modal category to another.

Using cash tickets and passes as an example, assume that original ridership equals 100 cash riders and 1,000 pass riders. Also assume that original prices for cash tickets and passes equal $2.00 and $100.00, respectively, and that the new prices are set at $1.50 for cash tickets and $50.00 for passes, representing price decreases of 25 percent and 50 percent. Assume that the cash price elasticity equals -0.35 and the pass price elasticity equals -0.25. Finally, assume a cash-to-pass diversion factor of 0.05 and a pass-to-cash diversion factor of 0.00.

In these calculations of diversion, one of the diversion factors must always equal zero, indicating that the diversion is expected to occur in one direction only. The direction of the diversion, and thus the diversion factor value, depends on the respective price changes of the two types of goods. The category with the greater relative price decrease (or the smaller relative price increase)—in this case, pass, for which the price decrease is 50 percent, compared to 25 percent for cash tickets—would gain riders from the diversion, while the other category, with the smaller relative price decrease (or the greater relative price increase), would lose riders from the diversion. One would therefore expect that cash customers would switch to passes, but not that pass customers would switch to cash tickets: hence the 0.05 cash-to-pass and 0.00 pass-to-cash diversion factors.

The diversion factors essentially work to redistribute demand between the two categories after the respective price elasticities have been applied. For instance, after the cash fare is decreased from $2.00 to $1.50, the projected effect of price elasticity is that cash demand grows to 108.75 riders. Similarly, the pass price decrease from $100 to $50 leads to a projected increase in pass demand, due to price elasticity, to 1,125, for a total ridership of 1,233.75. However, the

percentage decrease in the pass price is larger than that in cash fares (50 percent versus 25 percent); thus, one would expect some customers to switch from cash to pass.

This diversion is estimated by taking the ratio of new-to-original cash prices ($1.50/$2.00, or 75 percent), dividing that ratio by the ratio of new-to-original pass prices ($50/$100, or 50 percent), subtracting 1, and multiplying this result by the 0.05 diversion factor and the price-elasticity-estimated cash ridership (108.75). The number of riders "diverted" from cash to pass equals 2.72, giving final ridership estimates of 106.03 for cash and 1,127.72 for pass (still summing, of course, to a total ridership of 1,233.75).

New Cash Demand (Price Effect), Cp = 100 [1 + -0.35 × ($1.50 / $2.00 - 1)] = 108.75

New Pass Demand (Price Effect), Pp = 1,000 [1 + -0.25 × ($50 / $100 - 1)] = 1,125.00

Total Demand = 108.75 + 1,125.00 = 1,233.75

$$\textit{Diverted Riders from Cash to Pass} = \left[\left(\frac{\$NewCash / \$OldCash}{\$NewPass / \$OldPass}\right) - 1\right] \times Diversion \times \mathbf{C^P}$$

$$\textit{Diverted Riders from Cash to Pass} = \left[\left(\frac{\$1.50 / \$2.00}{\$50 / \$100}\right) - 1\right] \times 0.05 \times \mathbf{C^P} = 2.72$$

New Cash Demand = Cp – Diverted Riders from Cash to Pass = 106.03

New Pass Demand = Pp + Diverted Riders from Cash to Pass = 1,127.72

Total Demand = 106.03 + 1,127.72 = 1,233.75

In the present impact analysis, diversion factors were used to estimate diversions between cash and pass categories (for example, bus cash versus bus pass, subway cash versus subway pass, etc.), between bus and rapid transit (in other words, bus cash versus subway cash, bus pass versus subway pass, etc.), and between CharlieTicket/onboard cash and CharlieCard (for example, bus onboard cash versus bus CharlieCard, subway CharlieTicket versus subway CharlieCard, etc.). The factors were determined based on the 2007 Post–Fare Increase Impacts Analysis.

A.5 EXAMPLES OF RIDERSHIP AND REVENUE CALCULATIONS

A.5.1 SIMPLE EXAMPLE: PRICE ELASTICITY ONLY

- *Original Demand*: 100,000
- *Original Fare*: $1.50
- *New Fare*: $2.50
- *Price Elasticity*: -0.05

New Demand = 100,000 [1 + -0.05 × ($2.50 / $1.50 - 1)] = 96,666.67

A.5.2 MORE COMPLEX EXAMPLE: PRICE ELASTICITY PLUS RIDERSHIP DIVERSION – CASH TO PASS

- *Original Cash Demand*: 10,000
- *Original Cash Fare*: $2.25
- *New Cash Fare*: $2.00
- *Cash Price Elasticity*: -0.30

New Cash Demand (Price Effect), **Cp** = 10,000 [1 + -0.30 × ($2.00 / $2.25 - 1)]
= 10,333.33

- Original Pass Demand: 5,000
- Original Pass Price: $71.00
- New Pass Price: $50.00
- Pass Price Elasticity: -0.25

New Pass Demand (Price Effect), **Pp** = 5,000 [1 + -0.25 × ($50 / $71 - 1)]
= 5,369.72

Total Demand = 10,333.33 + 5,369.72 = 15,703.05

- Percentage Change in Cash Price: $2.25 to $2.00: -11%
- Percentage Change in Pass Price: $71 to $50: -30%
- Cash to Pass Diversion Factor: 0.05
- Pass to Cash Diversion Factor: 0.00

Diverted Riders from Cash to Pass = $\left[\left(\frac{\$2.00/\$2.25}{\$50/\$71}\right)-1\right]\times 0.05\times \mathbf{C^P}$ = 135.48

New Cash Demand = **Cp** – *Diverted Riders from Cash to Pass* = 10,197.85

New Pass Demand = **Pp** + *Diverted Riders from Cash to Pass* = 5,505.20

Total Demand = 10,197.85 + 5,505.20 = 15,703.05

A.5.3 ADDITIONALLY COMPLEX EXAMPLE: PRICE ELASTICITY PLUS TWO RIDERSHIP DIVERSIONS – SINGLE-RIDE CHARLIECARD (SR-CC) TO PASS, AND SINGLE-RIDE CHARLIETICKET (SR-CT) TO SINGLE-RIDE CHARLIECARD (SR-CC)

- Original Single-Ride CharlieCard Demand: 10,000
- Original Single-Ride CharlieCard Fare: $2.20
- New Single-Ride CharlieCard Fare: $3.50
- Single-Ride CharlieCard Price Elasticity: -0.30

New SR-CC Demand (Price Effect), **CCp** = 10,000 [1 + -0.30 × ($3.50 / $2.20 - 1)]
= 8,227.27

- Original Pass Demand: 50,000
- Original Pass Price: $71.00
- New Pass Price: $90.00
- Pass Price Elasticity: -0.25

New Pass Demand (Price Effect), **Pp** = 50,000 [1 + -0.25 × ($90 / $71 - 1)]
= 46,654.93

- Original Single-Ride CharlieTicket Demand: 5,000
- Original Single-Ride CharlieTicket Fare: $2.50
- New Single-Ride CharlieTicket Fare: $4.50
- Single-Ride CharlieTicket Price Elasticity: -0.30

New SR-CT Demand (Price Effect), **CTp** = 5,000 [1 + -0.30 × ($4.50 / $2.50 - 1)]
= 3,800.00

Total Demand = 8227.27 + 46,654.93 + 3,800.00 = 58,682.20

- Percentage Change in Single-Ride CharlieCard Fare: $2.20 to $3.50: 59.09%
- Percentage Change in Pass Price: $71 to $90: 26.76%
- Percentage Change in Single-Ride CharlieTicket Fare: $2.50 to $4.50: 80.00%
- Single-Ride CharlieCard to Pass Diversion Factor: 0.05
- Pass to Single-Ride CharlieCard Diversion Factor: 0.00
- Single-Ride CharlieCard to Single-Ride CharlieTicket Diversion Factor: 0.00
- Single-Ride CharlieTicket to Single-Ride CharlieCard Diversion Factor: 0.25

Diverted Riders from SR-CC to Pass = $\left[\left(\frac{\$3.50/\$2.20}{\$90/\$71}\right)-1\right] \times 0.05 \times$ **CCp** = 104.92

Diverted Riders from SR-CT to SR-CC = $\left[\left(\frac{\$4.50/\$3.50}{\$3.50/\$2.20}\right)-1\right] \times 0.25 \times$ **CTp** = 79.80

New Single-Ride CharlieCard Demand = **CCp** – *Diverted Riders from SR-CC to Pass + Diverted Riders from SR-CT to SR-CC* = 8,202.15

New Pass Demand = **Pp** + *Diverted Riders from SR-CC to Pass* = 46,759.85

New Single-Ride CharlieTicket Demand = **CTp** – *Diverted Riders from SR-CT to SR-CC* = 3,720.20

Total Demand = 8,202.15 + 46,759.85 + 3,720.20 = 58,682.20

Note that as each additional ridership diversion factor is introduced, and more and more cells in the spreadsheet become linked, the complexity of the spreadsheet model increases significantly. However, the basics of the methodology explained above with regard to price elasticities and ridership diversion factors remain the same.