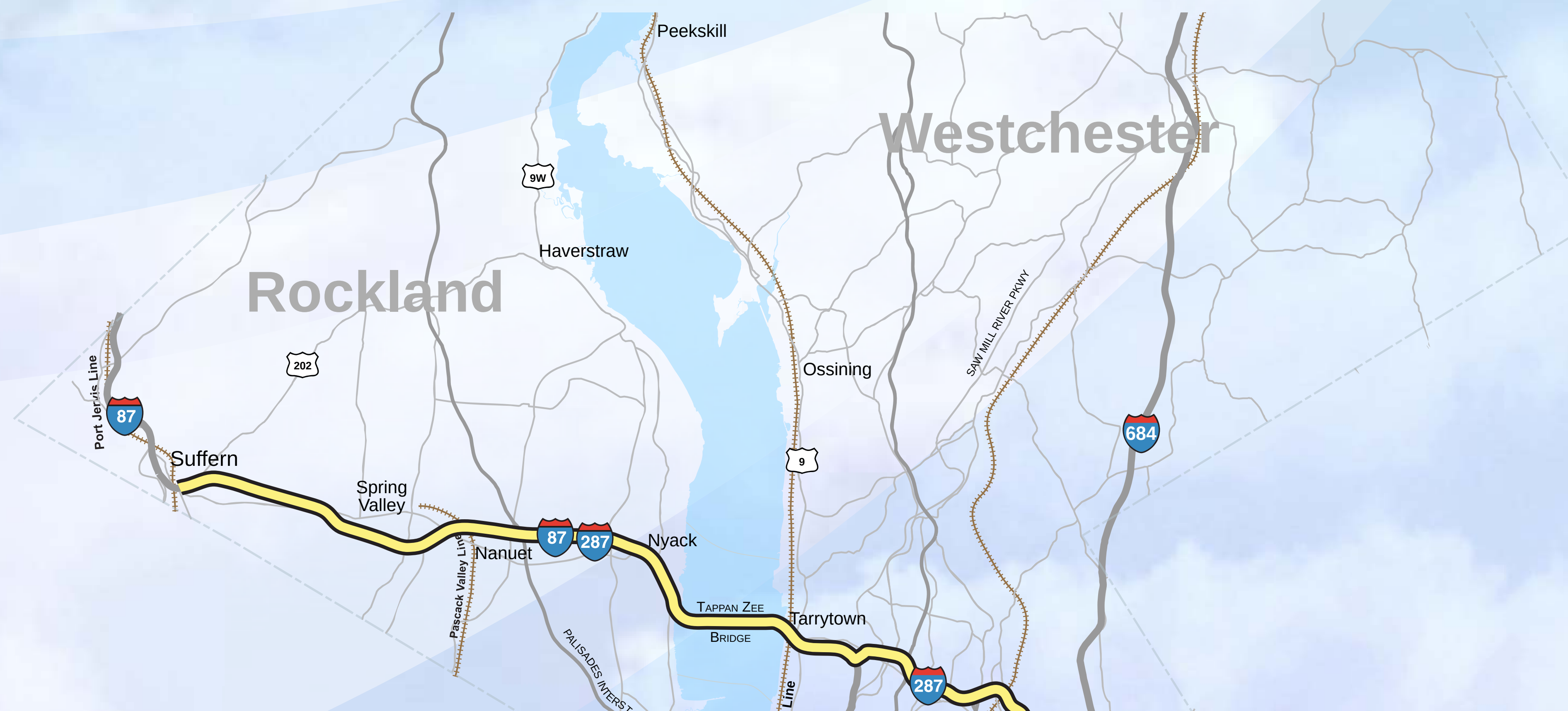
New York State Department of Transportation
New York State Thruway Authority
Metropolitan Transportation Authority/Metro-North Railroad

Tappan Zee Bridge/I-287
Environmental Review

Transit Mode Selection Report

May 2009



Thruway Authority

New York State Department of Transportation

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TAPPAN ZEE BRIDGE/I-287
ENVIRONMENTAL REVIEW

TRANSIT MODE SELECTION REPORT

PREPARED BY

This report was prepared for NYSDOT, MTA/MNR and NYSTA by EarthTech/AECOM.

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Description of Work Performed by Firm:
Provided cost estimates and engineering work to support the development of the transit alternatives and options.

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Thruway Authority

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

Metro-North Railroad

Executive Summary

The purpose of this *Transit Mode Selection Report* is to document the in-depth analysis, evaluation, and public and agency participation conducted to date for the Tappan Zee Bridge/I-287 Corridor Project and to make a transit mode recommendation that best meets the Project Purpose and Need, goals, and long-term public interest. Transit is needed in this corridor to address mobility and travel demand needs within the study area through 2035, principally focusing on accommodating both the cross-corridor and New York City metropolitan area travel markets. For example, as demonstrated in the *Alternatives Analysis* (January 2006) peak-period traffic in the already-congested corridor is projected to increase by 30 percent over a 30-year period. It was also demonstrated that the daily Vehicle Miles Traveled (VMT) would increase significantly over the same period, especially in the fast-growing counties of Orange (85 percent increase), Rockland (54 percent increase), and, to a lesser degree, Westchester (29 percent increase).

The need for this project and transit is demonstrated based on the forecasted population and employment growth in the region and corridor, and its resulting projected increase in travel. Based on the New York Metropolitan Transportation Council (NYMTC) Consensus Forecasts and Best Practice Model, the need for transit in this corridor to meet present and future travel demand needs is well documented. As noted in Chapter 5, between 2005 and 2035, population growth in Rockland County is expected to be 28 percent, and, in Orange County, 51 percent. The Westchester County population is expected to be more stable – growing by only 6 percent. All three counties are expected to exceed the forecasted regional employment growth of 20 percent: employment in Westchester will grow by 26 percent, in Rockland by 31 percent, and in Orange by 44 percent[1]. Without major transit investments, already-unacceptable levels of congestion are forecasted to occur in the corridor far into the future. It is the purpose of this document to present an analysis of which transit modes will best meet present and future needs. This report summarizes the results of the evaluation and analysis required to recommend a transit solution that will meet travel demand needs, minimize environmental impacts (to man made and natural environments), contribute to sustainable transportation and land use, and enhance quality of life in an energy-efficient and cost-effective manner.

S.1 Development of Preliminary Alternatives/Options

The Alternatives Analysis (AA) process for the project ended with the selection of six preliminary alternatives for analysis in the draft environmental impact statement (DEIS):

- Alternative 1 – No build.
- Alternative 2 – Rehabilitated bridge with transportation demand management/transportation system management (TDM/TSM) measures.
- Alternative 3 – Full-corridor bus rapid transit (BRT).
- Alternatives 4A, 4B, and 4C – Commuter rail transit (CRT) in Rockland and either CRT, light rail transit (LRT), or BRT in Westchester.

In the course of evaluating the six DEIS alternatives that had been developed in the AA process, several variations were developed during the scoping update process. Thus, the range of alternatives/options evaluated in this report is as follows[2] (Figure S-1):

- No Build – Alternative 1 is used as the baseline to measure impacts, where appropriate.
- Option 3A (Alternative 3 with enhanced service plan). Buses would use the high-occupancy vehicle/high-occupancy toll (HOV/HOT) lanes in Rockland County, and bus lanes integrated into the existing bus system and busway east of White Plains in Westchester County (WPTC).
- Option 3B (Alternative 3 with enhanced service plan and full-corridor busway). Buses would use the HOV/HOT lanes in Rockland County and exclusive busway in the I-287 right-of-way (ROW) in Westchester County.
- Option 4D (Option 3A plus CRT in Rockland County).
- Alternatives 4A, 4B, and 4C as developed in the AA process.
- Option 4A-X (4A without a Hudson Line connection) and cross-corridor LRT.

With such a wide scope of alternatives/options, this *Transit Mode Selection Report* was prepared to select a feasible transit mode or modes to carry forward into the DEIS. These analyses (1) enabled comparisons among the alternatives/options based on selective criteria; (2) determined whether there were significant differentiators among them; and (3) ascertained whether there were any major issues associated with any alternative/option.

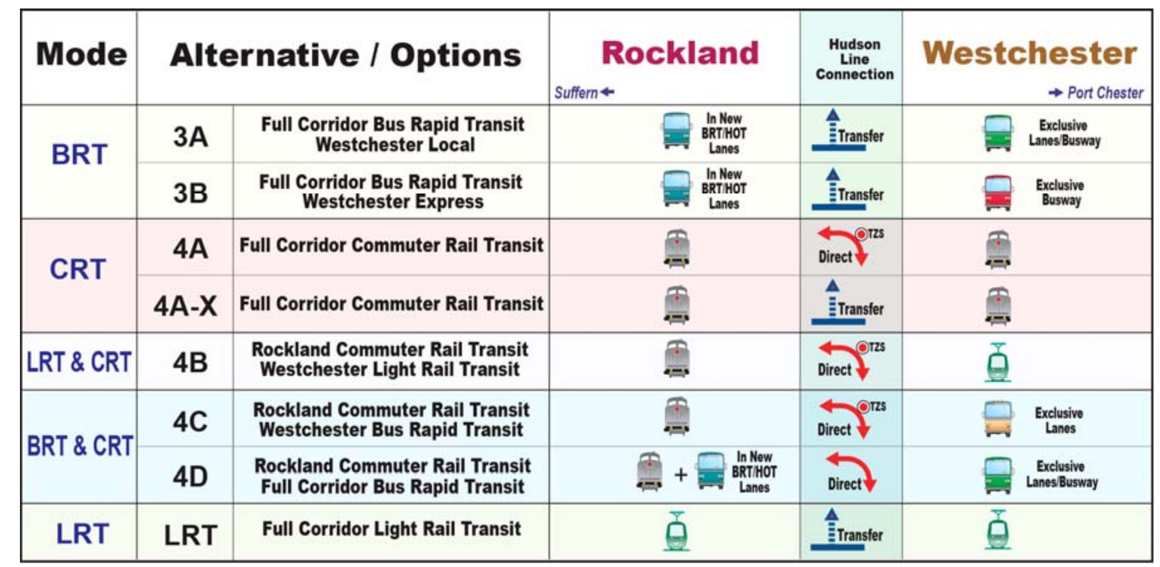


Figure S-1 Description of Alternatives/Options

S.2 Project Study Area

The study area consists of a linear 30-mile corridor that extends from the I-87/I-287 Interchange in Rockland County to the I-287/I-95 Interchange in Westchester County and includes the Tappan Zee Bridge (Figure S-2). The corridor is an important part of a regional transportation system.

[1] These population and employment projections will be updated in the Fall of 2008, when the NYMTC releases its new consensus forecasts as part of its long-range plan.

[2] Alternatives 1 and 2 have no transit component. However, while Alternative 2 has no transit component, and is thus not included in the analyses presented here, it should be noted that bridge rehabilitation concepts have been advanced that provide transit functionality comparable to that of replacement bridges. Thus, the analyses presented in this report are independent of whether the Tappan Zee Bridge is replaced or rehabilitated. The subject of whether to rehabilitate or replace the bridge is the subject of a separate report (*Alternatives Analysis for Rehabilitation and Replacement of the Tappan Zee Bridge*, March 2009), the recommendations of which will be included in the *Scoping Summary Report* (May 2009) for the project.

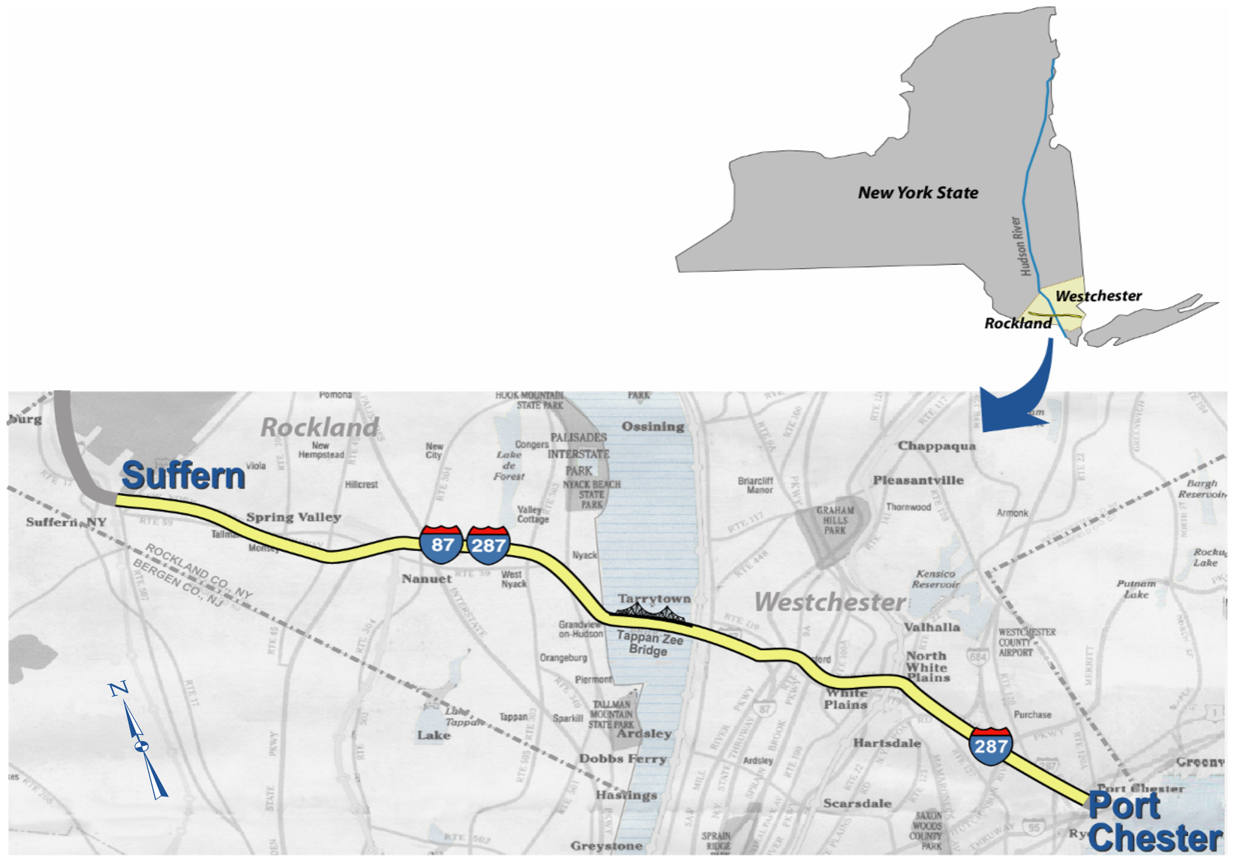


Figure S-2 Tappan Zee Bridge- I-287 Corridor

S.3 Purpose and Need

Studies have shown that several transportation improvements, including mobility, transit options, and safety, are needed in order to meet the growing travel demands of the corridor. The corridor experiences significant delays due to congestion and is often operating at or near capacity, particularly in the vicinity of the Tappan Zee Bridge. Rockland County is one of the fastest-growing communities in the Metropolitan Region and Westchester County is experiencing employment growth in areas around White Plains and the Platinum Mile. The Tappan Zee Bridge and the corridor provide an important link between these communities as well as to the overall regional transportation network. In addition to the capacity constraints of the corridor, the Tappan Zee Bridge is aging and in need of a regular and extensive maintenance program. As the region grows, travel demand will increase on an already-strained roadway network. Thus, the Purpose and Need for this project is to:

- Preserve the river crossing as a vital link in the regional and national transportation network.
- Provide a river crossing that has structural integrity, meets current design criteria and standards, and accommodates transit.
- Improve highway safety, mobility, and capacity throughout the corridor.
- Improve transit mobility and capacity throughout the corridor and travel connections to the existing north-south and east-west transit network.

In order to meet the Project Purpose and Need, five goals have been established to address the bridge, highway and transit needs of the corridor:

- Improve the mobility of people, goods and services for travel markets served by the Tappan Zee Bridge.
- Maximize the flexibility and adaptability of new transportation infrastructure to accommodate changing long-term demand.
- Maintain and preserve vital elements of the transportation infrastructure.
- Improve the safety and security of the transportation system.
- Avoid, minimize, and/or mitigate any significant adverse environmental impacts caused by feasible and prudent improvements.

S.4 Criteria Evaluated

Transportation, environmental, and cost criteria were developed in order to assist in making the transit mode decision. These criteria were derived from the evaluation criteria developed in the AA process. The criteria were presented at the scoping update meetings in February 2008 and at a number of Stakeholders' Advisory Working Group (SAWG) meetings. Four transportation evaluation criteria were used in the evaluation of the transit modes:

- Transit ridership
- Capacity
- Transit travel time
- Roadway congestion

Eight environmental evaluation criteria were used in the evaluation of the transit modes:

- Consistency with land use plans
- Transit-oriented development potential
- Parklands and recreational areas
- Hudson River habitat disturbance
- Wetlands
- Residential and commercial acquisitions and displacements
- Historic and archaeological resources
- Air quality and energy

Five cost evaluation criteria were used in the evaluation of the transit modes:

- Capital costs
- Annual operating costs
- Fare revenue
- Costs/net costs per passenger and per passenger mile
- Transit travel-time benefits

Many of the criteria used in the evaluation turned out not to be differentiators – that is, they were not sufficiently different among the alternatives/options to be used as a basis for choosing one mode over another. While all of them are important criteria for full evaluation in the DEIS, their importance to the analyses of a particular transit mode was minimal. Regional roadway congestion, for example, is not a differentiator among transit modes, as all of the transit alternatives/options result in lower total VMT than under the No Build conditions, but the range is between one and two percent.

S.5 Analysis Results

The results of the analyses are summarized in Table S-1. In general, environmental factors were not differentiators, costs were greater for modes that included CRT, and cost-effectiveness was better for those modes that included BRT. Travel-time savings were most dramatic in those modes that provided a means of avoiding congestion for the greatest number of travelers, whether rail or bus. Travel-time savings across the corridor were generally greater than were time savings to Manhattan.

The transit mode analyses concluded that:

- **Option 3A** (Full-Corridor BRT Enhanced) had the lowest capital cost, the lowest operating cost, the lowest net annual transit cost, the lowest net cost per passenger, and the lowest net cost per passenger-mile. However, Option 3A also had the lowest annual passenger miles and was in the bottom third for weekday daily ridership compared to the rail alternatives, with the exception of the LRT alternative.

- **Option 3B** (Variation of Option 3A) closely trailed Option 3A in all categories, having slightly higher costs (capital and operating, overall project, and transit only), fewer passengers or passenger miles, and a higher net cost per passenger and per passenger-mile. Option 3B is, however, significantly ahead of the other alternatives/options on these measures. As with Option 3A, Option 3B provides far fewer ridership or passenger-mile benefits than the other transit alternatives.

- **Alternative 4A** (Full-Corridor CRT) had the highest cost of the alternatives in terms of capital costs, operating costs, and annual project costs and annual transit costs, while delivering the most passenger miles and ridership benefits in the upper range of all alternatives/options. The cost per passenger was high (second-highest of all alternatives) but the net cost per passenger-mile was in the mid range of the alternatives/options.

- **Option 4A-X** (Full-Corridor CRT without a Hudson Line Connection) was the second-most costly alternative after Alternative 4A in terms of capital costs, but was substantially lower cost in terms of operating costs, coming in the bottom third of the range on project and transit operating costs. It had the highest net cost per net passenger and the highest cost per passenger-mile. It also had the lowest number of new riders and total riders and the second lowest number of diverted riders, the second-lowest travel time benefits, and the fewest annual passenger miles on new facilities.

- **Alternative 4B** (Manhattan-Bound CRT with LRT in Westchester County) was mid-range in capital cost measures but was in the upper third on operating costs. Alternative 4B was in the mid range on weekday daily ridership and on the high end of the range for passenger-miles. Alternative 4B was in the mid range on net cost per passenger and per passenger-mile.

- **Alternative 4C** (Manhattan-Bound CRT with BRT in Westchester County) was in the mid range in capital cost measures but had the third-highest operating cost. It had the highest annual passenger miles on existing facilities of the alternatives. It also had the second-highest daily ridership, the third-highest annual passenger-miles, and was tied with Alternative 4B for the most annual passenger miles on existing facilities. In terms of the net cost per passenger and the net cost per passenger-mile, Alternative 4C was in the bottom third.

Table S-1

Cost Criteria – Transit Costs

Criterion	Mode by Alternative/Option							
	BRT		CRT		LRT/CRT	BRT/CRT		LRT
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Transit Capital Cost ($ Millions)	897	2,548	15,111	13,022	10,372	8,775	8,869	5,561
Annual Transit Costs ($ Millions)	140	266	1,389	1,105	974	901	911	483
Fare Revenue ($ Millions)	40	39	105	34	98	113	127	27
Net Annual Transit Costs ($ Millions)	100	227	1,284	1,071	876	788	784	456
Travel-Time Benefits ($ Millions)	110	112	184	97	154	149	202	95
Weekday Daily Ridership								
New	23,400	23,800	21,800	13,800	21,000	21,400	31,200	16,900
Diverted From Other Transit Routes	30,600	29,800	40,100	23,100	32,200	44,800	48,700	21,400
Total	54,000	53,600	61,900	36,900	53,200	66,200	79,900	38,300
Annual Passenger-Miles (Millions)								
In Corridor	100	90	190	80	160	176	207	90
On Existing Facilities Beyond Corridor	40	60	360	120	340	346	332	100
Total	140	150	550	200	500	522	539	190
Cost per Passenger	$8.92	$17.03	$77.16	$103.23	$62.87	$46.68	$39.08	$43.51
Net Cost per Passenger	$6.39	$14.55	$71.36	$100.13	$56.52	$40.81	$33.66	$41.13
Cost per Passenger-Mile*	$1.00	$1.77	$2.53	$5.52	$1.95	$1.73	$1.69	$2.54
Net Cost per Passenger-Mile	$0.72	$1.51	$2.34	$5.36	$1.75	$1.51	$1.45	$2.40

*Notes: Based on Year 2012 dollars. Net cost per passenger-mile is calculated based on total passenger-miles (in-corridor and on existing facilities beyond corridor).

- **Option 4D** (Variation of Alternative 4C and Option 3A) was in the mid-range for all costs, both capital and operating. It was highest in travel-time benefits, fare revenue, new ridership, and total riders. It was second-highest in total annual passenger miles and had the most annual passenger-miles on new facilities of all the alternatives/options. Option 4D's net cost per passenger was the third lowest and its net cost per passenger-mile the second lowest of all the alternatives/options.

- **Full-Corridor LRT** was in the bottom third of the alternatives/options in terms of capital costs. Its operating costs were the second lowest of the alternatives. It had the lowest fare revenue and lowest travel-time benefits of all the alternatives, the second-lowest total weekday daily ridership, and was among the lowest in annual passenger-miles (on new facilities, on existing facilities, and total). Full-corridor LRT had a mid-range net cost per passenger and was the second highest in net cost per passenger-mile.

S.6 Transit Mode Recommendation

The recommendation of a transit mode has been developed within the context of the goals adopted for this study in the Scoping Process:

- **Goal 1**: Improve the mobility and accessibility of people, goods and services for the travel markets served by the Tappan Zee Bridge/I-287 Corridor. *All modes improve personal mobility – to differing degrees.*

- **Goal 2**: Maximize the flexibility and adaptability of new transportation infrastructure to accommodate changing long-term travel demand. *BRT is the most flexible mode, preserving CRT options provides maximum ability to meet changing demand.*

- **Goal 3**: Maintain and preserve vital elements of the transportation infrastructure. *Utilization of existing infrastructure enhances its preservation (e.g., Hudson and Port Jervis Lines).*

- **Goal 4**: Improve the safety and security of the transportation system. *CRT is the safest mode, followed by LRT and BRT. It has been established that CRT is the safest surface transportation mode (Federal Transit Administration, Commuter Rail Safety Study, November 2006), by virtue of its minimal interaction with other surface transportation modes and pedestrians.*

- **Goal 5**: Avoid, minimize, and/or mitigate any significant adverse environmental impacts caused by corridor improvements. *Initial environmental analysis indicated that none of the modes have significant unmitigatable environmental impacts and that environmental factors are not differentiators among the modes. (A more detailed environmental impacts analysis will be performed in the Environmental Impact Statement [EIS].)*

- **Goal 6**: Develop feasible, cost-effective solutions that can be implemented within a reasonable time horizon. *Starting with BRT, while preserving the options for CRT, best meets this goal.*

Table S-2 assigns a performance rating to each of the measures presented in the preceding analysis to arrive at an overall recommendation. The solid circles represent the highest rated performers, while the three-quarter hollow circles represent the lowest performers. The largest differences in the performance of the modes came in the financial measures with the BRT mode able to be implemented and operated for far less of an investment than the rail modes. However, the BRT mode was also much lower on the revenue side. The combination of BRT/CRT was a consistently high performing mode.

Table S-2

Summary Performance Ratings

Mode	BRT		CRT		LRT & CRT	BRT & CRT		LRT
Alternative/Option No.	3A	3B	4A	4A-X	4B	4C	4D	Full LRT
Goal 1: *Improve Mobility*	◕	◕	●	◔	◑	◕	●	◑
Goal 2: *Flexibility and Adaptability*	●	●	◕	◔	◑	◕	●	◑
Goal 3: *Vital Elements of the Transportation Infrastructure*	◕	◕	●	◑	◑	◕	◕	◑
Goal 4: *Improve Safety and Security*	◑	◑	●	◑	◑	●	●	◑
Goal 5: *Environmental Impacts*	◕	◕	◑	◑	◑	◕	◕	◑
Goal 6: *Feasible Cost - effective Alternatives*	●	◕	◑	◔	◑	◕	◕	◔
Daily Transit Trips for Selected Markets	◑	◑	◑	◑	◑	◑	◕	◑
Daily Transit Ridership on New Service	◑	◑	◕	◔	◑	◕	◕	◔
Capital Cost Estimate	●	◕	◔	◔	◔	◑	◑	◕
Cost/Passenger Mile	●	◕	◑	◔	◔	◑	◕	◔
Aggregate travel-time savings	◑	◑	◕	◔	◕	◕	●	◔

Legend *Very Good* ● *Good* ◕ *Fair* ◑ *Poor* ◔

The two major travel markets that will be affected by the project are the east-west market, confined largely to the study corridor, and the market of those commuting to or from Manhattan. The east-west market comprises inter-county and intra-county riders as well as cross-Hudson riders. With populations of Rockland and Orange Counties expected to grow at rates higher than the regional average, the corridor will benefit from having a mass transit system that serves these rapidly growing areas. The key characteristic of the cross corridor market is many trip origins coupled with many trip destinations – "many to many." Serving population and employment spread out within these counties can best be accomplished by adopting a flexible mode such as a BRT to serve areas that are not in the immediate proximity of a trunk route, while providing a high level of service typical of such modes. BRT best serves these circumferential movements, as it has the flexibility to reach destinations on and off the corridor.

The other market that has potential in terms of attracting workers from areas served by the proposed transit system is Manhattan. The key characteristic of the Manhattan market is many trip origins with one destination – "many to one." Given the large potential demand for travel to Manhattan, the already strained highway network and the existing transit infrastructure, along the Port Jervis Line and the Hudson Line into Manhattan, CRT would serve this market well. CRT functions best when it uses existing infrastructure to reach Manhattan destinations. The combined BRT/CRT mode takes advantage of both, resulting in the highest forecasted daily transit trips of 79,900.

The transit mode selection analysis, therefore, concludes that the BRT mode offers the best opportunity to improve transit service and ridership in the corridor at the lowest cost. However, implementing the combined BRT/CRT mode offers further significant benefits for the reasons outlined above. Both the CRT and BRT modes were less effective alone than when complemented by each other, as is evidenced by the transit ridership projections. The LRT mode did not provide sufficient benefits to warrant further consideration for either of the two major markets.

Therefore, full-corridor BRT in combination with CRT from Suffern connected to the Hudson Line is the recommended transit mode because that combination best meets present and future travel demand and mobility needs. The combined BRT/CRT mode provides the most flexibility to accommodate many markets, especially the key cross-corridor and New York City travel markets. The BRT/CRT recommendation is the transit solution that will fulfill the goals of this study by:

- Meeting corridor travel demand needs.
- Minimizing environmental impacts.
- Contributing to sustainable transportation and land use.
- Providing a flexible and adaptable transportation system with excess capacity to meet changing needs in the corridor.
- Enhancing quality of life in an energy-efficient and cost-effective manner.

S.7 Transit Components to be Studied in the DEIS

Based on the previous analyses, full-corridor BRT from Suffern to Port Chester and CRT from Orange/Rockland Counties to Grand Central Terminal will be studied in the DEIS. As the project is multimodal in nature with proposed bridge, highway, and transit improvements, the EIS will be conducted using a tiered analysis approach to allow each project component to advance at its own appropriate pace. Thus, two levels of analysis will be conducted in the DEIS:

- **Tier 1 Transit Analysis**: Tier 1 transit analysis is the first step of a two-step process to comply with environmental review under NEPA. The Tier 1 transit analysis will provide a broad evaluation of planning level alternatives to determine the general effects on the human and natural environment resulting from the mode choices, alignments, locations and termini of facilities and services under consideration in the EIS. In addition, the general locations of suggested station areas will be identified and evaluated. These conceptual, planning level alternatives will be further evaluated in more detail in a future Tier 2 Transit Environmental Process based on more refined engineering design.

- **Tier 2 Bridge and Highway Analysis**: The Tier 2 bridge and highway analysis will evaluate the potential effects of alternative engineering designs for proposed facilities on the human and natural environment. The analysis of alternatives will focus on the potential site specific impacts of the bridge and highway alternatives along the corridor and identify potential mitigation measures. This analysis will incorporate and be consistent with decisions made as part of the Tier 1 transit analysis.

The future Tier 2 Transit Environmental Process will build upon the Tier 1 transit analysis and the Tier 2 bridge and highway analysis. During the future Tier 2 transit environmental analysis, the work completed during the Tier 1 transit analysis will be further refined and decisions advanced based upon more detailed engineering design. The Tier 2 transit analysis will focus in greater detail on specific elements of the transit system such as station locations and site plans, vehicle types, and storage facilities with respect to site specific impacts and mitigation measures.

The DEIS analysis will include a range of reasonable alternatives likely to include the following components:

- **Bus Rapid Transit**
  - BRT/HOV/HOT Lanes in I-287 median, from Suffern and across the Tappan Zee Bridge.
  - BRT in a busway in I-287 ROW in Rockland with options of using north side, south side, or the median.
  - BRT integrated in existing street system in Westchester.
  - BRT in a busway in Westchester.

- **Commuter Rail Transit**
  - CRT in I-287 median; from Suffern and across the Tappan Zee Bridge, connecting to the Hudson Line.
  - CRT on south side I 287 ROW; from Suffern and across the Tappan Zee Bridge, connecting to the Hudson Line.

BRT

LRT

CRT

List of Figures

List of Figures (con't)

List of Tables

List of Tables (con't)

List of Acronyms and Abbreviations

3A	Option 3A (Full-Corridor BRT) – Alternative 3 (full-corridor BRT in high-occupancy vehicle/high-occupancy toll [HOV/HOT] lanes in Rockland) but with an enhanced service plan (including additional stations), extended bus lanes on Westchester Avenue, and connection to Port Chester Station. Option 3A includes both bus lanes as well as busways.
3B	Option 3B (Full-Corridor BRT) – combined HOV/HOT and BRT lanes in Rockland County and a busway across Westchester County.
4A	Alternative 4A (Full-Corridor CRT) - as developed to date for the project, with a direct connection to the Hudson Line.
4A-X	Option 4A-X (Full-Corridor CRT) - as developed to date for the project, but without a direct connection to the Hudson Line. A new local Tarrytown Station at the Tappan Zee Bridge is assumed, with a shuttle bus connection to the existing Tarrytown Station.
4B	Alternative 4B (CRT/LRT) - as developed to date for the project, with CRT in Rockland with a direct CRT connection to the Hudson Line and LRT in Westchester.
4C	Alternative 4C (CRT/BRT) - as developed to date for the project, with CRT in Rockland with a direct CRT connection to the Hudson Line and BRT in Westchester.
4D	Option 4D (CRT/BRT) – CRT from Suffern with a direct connection to the Hudson Line and full-corridor BRT as per Option 3A above. However, the Airmont and Tappan Zee CRT Stations of Alternatives 4A, 4B, and 4C are eliminated.
AA	Alternatives Analysis
ACHP	Advisory Council on Historic Preservation
AGT	Automated Guideway Transit
APE	Area of Potential Effect
APTA	American Public Transportation Association
ARC	Access to the Region's Core
AVL	Automated Vehicle Locator
BPM	Best Practice Model
BRT	Bus Rapid Transit
BTU	British Thermal Unit
CBD	Central Business District
CCTV	Closed-Circuit Television
CO	Carbon Monoxide
CO_2	Carbon Dioxide
ConnDOT	Connecticut Department of Transportation
CRT	Commuter Rail Transit
CSI	Construction Specifications Institute

List of Acronyms and Abbreviations (con't)

DEIS	Draft Environmental Impact Statement
DMU	Diesel Multiple Unit
EIS	Environmental Impact Statement
EMU	Electric Multiple Unit
FHWA	Federal Highway Administration
FRA	Federal Rail Administration
FTA	Federal Transit Administration
GCT	Grand Central Terminal
GIS	Geographic Information System
GPS	Global Positioning System
GSP	Garden State Parkway
HAJ	Household Auto-Journey
HOT	High-Occupancy Toll
HOV	High-Occupancy Vehicle
HOV+3	High-Occupancy Vehicle-3
ITS	Intelligent Transportation System
LRT	Light Rail Transit
MDSC	Mode Destination Stops Choice
MPO	Metropolitan Planning Organization
MTA	Metropolitan Transportation Authority
µm	micrometer
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NHL	National Historic Landmark
NHPA	National Historic Preservation Act
NJT	New Jersey Transit
NO_x	Nitrogen Oxides
NOI	Notice of Intent
NRE	National Register Eligible
NRL	National Register Listed
NYC	New York City
NYMTC	New York Metropolitan Transportation Council
NYCT	New York City Transit
NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
NYSHPO	New York State Historic Preservation Office
NYSM	New York State Museum
NYSTA	New York State Thruway Authority

List of Acronyms and Abbreviations (con't)

O_3	Ozone
PAP	Pre-Assignment Processor
Pb	Lead
PM	Particulate Matter
PM_{10}	Particulate Matter with Diameters up to 10 µm
$PM_{2.5}$	Particulate Matter with Diameters up to 2.5 µm
ROD	Record of Decision
ROI	Return on Investment
ROW	Right of Way
RRT	Rail Rapid Transit
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SAWG	Stakeholder Advisory Working Group
SEQRA	New York State Environmental Quality Review Act
SHPA	State Historic Preservation Act
SHPO	State Historic Preservation Office
SO_2	Sulfur Dioxide
SOV	Single-Occupant Vehicle
TDM/TSM	Transportation Demand Management/Transportation Systems Management
TIP	Transportation Improvement Program
TOD	Transit-Oriented Development
TZB	Tappan Zee Bridge
USEPA	US Environmental Protection Agency
VMT	Vehicle Miles Traveled
WPTC	White Plains Transportation Center

BRT

LRT

CRT

1 Introduction

Since the environmental review process for the Tappan Zee Bridge/I-287 Corridor Project began in 2002, one of the most critical focuses of the study has been on the development of transit solutions to accommodate future growth in the corridor (from Suffern in Rockland County to Port Chester in Westchester County) with a reasonable degree of dependability and without dependence on the automobile as the sole means of travel within the corridor. Improving the mobility of people, goods, and services for travel markets served by the Tappan Zee Bridge/I-287 Corridor is part of the Project Purpose and Need.

The study of transit alternatives and options has been conducted in several stages, culminating in this report, which determines the transit mode or modes to be analyzed in detail in the draft environmental impact statement (DEIS) being prepared pursuant to the National Environmental Policy Act (NEPA) and the New York State Environmental Quality Review Act (SEQRA). This introductory chapter describes the multi-step analytic process, which has included significant public involvement, as well as travel patterns in the study area that affect the modes and extent of possible transit solutions.

In accordance with this process, this report describes the results of the analyses of transit modes that have been conducted in order to select a feasible transit mode or modes to carry forward into the DEIS. The methodology adopted for this analysis was to:

- Conduct sufficient engineering to determine suitable, cost-efficient alignment options, possible station locations, right-of-way (ROW) acquisition requirements, roadway design requirements, major structural requirements, and construction costs.
- Conduct sufficient service planning to determine routes, headways, possible stations, travel times, equipment requirements, and operating costs.
- Incorporate the resulting network and service decisions into the recalibrated Best Practice Model (BPM) model and test for the year 2035, using New York Metropolitan Transportation Council (NYMTC) population and employment forecasts as the basis for the tests. Adjust costs to reflect 2012 values and incorporate all budgeted capital improvements expected to be completed by 2035.
- Test each alternative/option using the BPM and analyze the results.
- Conduct the environmental analysis at the level of detail sufficient to permit comparison among, and determine any possible fatal flaws of, the alternatives/options.

1.1 Background

1.1.1 Project Study Area

The study area consists of a linear 30-mile corridor that extends from the I-87/I-287 Interchange in Rockland County to the I-287/I-95 Interchange in Westchester County and includes the Tappan Zee Bridge (Figure 1-1). The corridor is an important part of a regional transportation system.

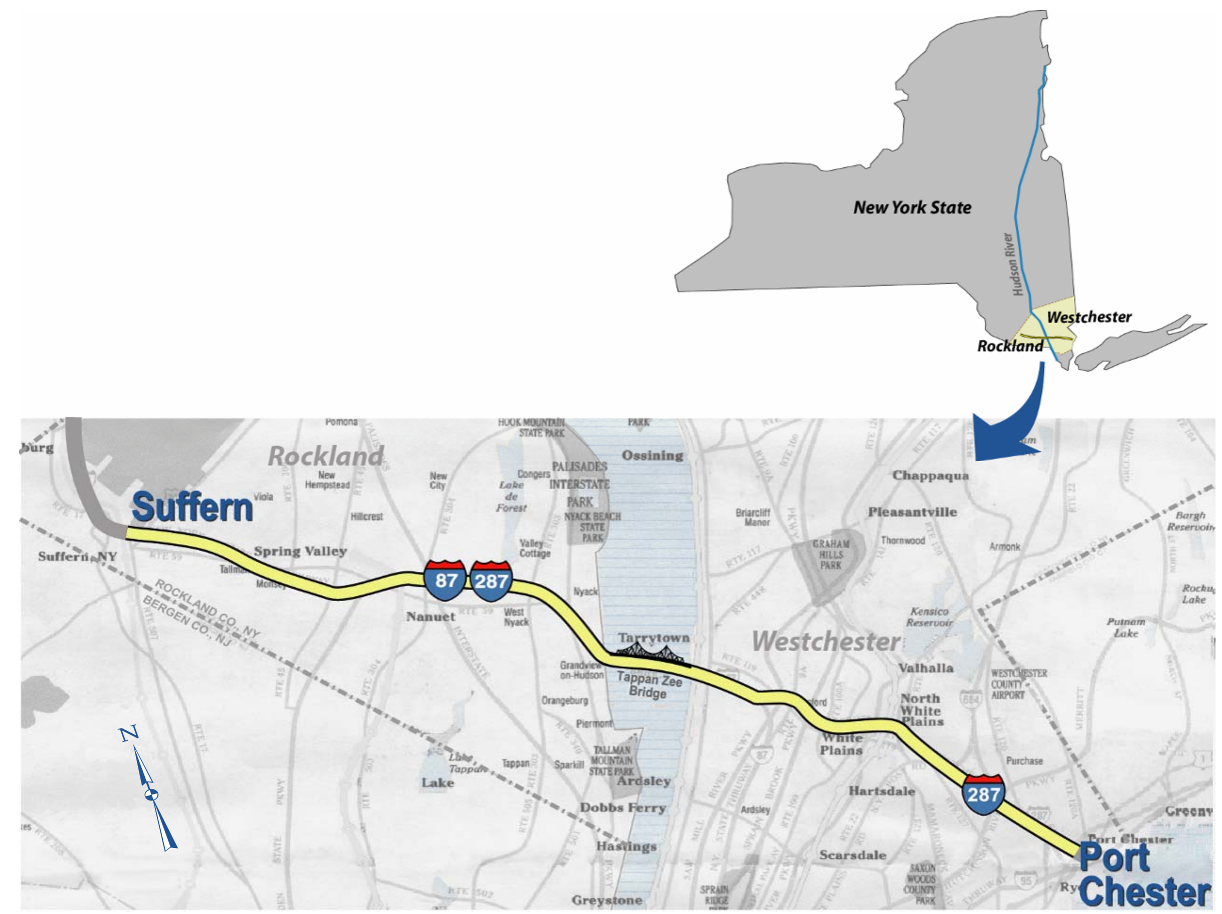


Figure 1-1 Tappan Zee Bridge/I-287 Corridor

In Rockland County, which lies just west of the Hudson River, the population has more than tripled, from 89,276 in 1950 to 286,753 in 2000. In Westchester County, which is just east of the Hudson River, the population has had a more modest increase, from 625,816 in 1950 to 808,991 in 2000. However, Westchester County saw a major increase in commercial development in the 1950s and 1960s with the completion of interstate highways I-95, I-87, I-287, and I-684. This led to a surge in corporate headquarter relocations to the area, resulting in the Platinum Mile section of I-287 in the Town of Harrison.

According to NYMTC – the Metropolitan Planning Organization (MPO) for New York City, Long Island and the Lower Hudson Valley – outlying counties of the region are expected to have significant increases in both population and employment over the next 20 years. Between 2000 and 2025, New York City Metropolitan area regional household population, as defined by the US 2000 Census, is expected to grow by 12 percent, while Rockland County is expected to grow by 18 percent and Orange County by 27 percent. Westchester, the most-developed county in the study area, is projected to have a more stable population, with growth at only four percent. In addition to population growth, employment is also projected to increase within the corridor. All three counties are expected to exceed the forecasted New York City Metropolitan area regional employment growth of 17 percent: Westchester County will grow by 19 percent, Rockland County by 29 percent and Orange County by 35 percent. This increase in population and employment will continue to place demands on the Tappan Zee Bridge/I-287 Corridor.

1.1.2 Purpose and Need

Studies have shown that several transportation improvements, including mobility, transit options, and safety, are needed in order to meet the growing travel demands of the corridor. The corridor experiences significant delays due to congestion and is often operating at or near capacity, particularly in the vicinity of the Tappan Zee Bridge. Rockland County is one of the fastest-growing communities in the Metropolitan Region, and Westchester County is experiencing employment growth in areas around White Plains and the Platinum Mile. The Tappan Zee Bridge and the corridor provide an important link between these communities, as well as to the overall regional transportation network. In addition to the capacity constraints of the corridor, the Tappan Zee Bridge is aging and in need of a regular and extensive maintenance program. As the region grows, travel demand will increase on an already-strained roadway network. The Purpose and Need for this project is:

- Preserve the existing river crossing as a vital link in the regional and national transportation network.
- Provide a river crossing that has structural integrity, meets current design criteria and standards, and accommodates transit.
- Improve highway safety, mobility, and capacity throughout the corridor.
- Improve transit mobility and capacity throughout the corridor and travel connections to the existing north-south and east-west transit network.

In order to meet the Project Purpose and Need, the following five goals have been established to address the bridge, highway and transit needs of the corridor.

Improve the mobility of people, goods and services for travel markets served by the Tappan Zee Bridge:

- Reduce traffic congestion levels.
- Improve travel times for local trips.
- Improve travel times for regional trips.
- Provide modal travel alternatives not subject to roadway congestion.
- Increase the share of travel demand accommodated by transit and ridesharing.
- Provide a non-motorized means of travel, such as bicycle and pedestrian throughout the corridor.

Maximize the flexibility and adaptability of new transportation infrastructure to accommodate changing long-term demand:

- Maximize the ability to accommodate increases in travel demand.
- Minimize constraints to serving future travel patterns and markets.
- Encourage smart growth linked to transit.

Maintain and preserve vital elements of the transportation infrastructure:

- Ensure that the corridor's transportation infrastructure meets applicable standards for structural design and integrity.

Improve the safety and security of the transportation system:

- Reduce motor-vehicle-accident severity and rates.
- Improve roadway geometrics to applicable standards.
- Improve the likelihood that the bridge would withstand a severe natural or manmade event.

Avoid, minimize and/or mitigate any significant adverse environmental impacts caused by feasible and prudent improvements:

- Minimize community disruption, displacements, and relocations, as well as adverse impacts to public parks, visual resources, and aesthetics in the corridor.
- Minimize adverse impacts to the natural environment, including the Hudson River estuary.
- Implement mitigation measures that are feasible, constructible, innovative, sustainable, cost-effective and that address regulatory requirements.

1.1.3 Notice of Intent and Alternatives Analysis

On December 23, 2002, the Notice of Intent (NOI) to prepare an Alternatives Analysis (AA) and an Environmental Impact Statement (EIS) for the I-287 Corridor between Suffern, New York (Rockland County) and Port Chester, New York (Westchester County) was published in the *Federal Register* (Volume 67, No. 246). A series of scoping meetings was then held in January 2003 and preparation of the AA commenced.

Two levels of screening analyses were conducted in the AA process. In the Level 1 screening, 150 elements – or building blocks of corridor transportation solutions – were evaluated. These 150 elements included transit, river crossing, highway, and transportation demand management/transportation system (TDM/TSM) measures. The result of this first level of screening was the elimination of roughly half of the 150 elements based on a set of transportation, environmental, engineering, and cost screening criteria that were developed with public input. The remaining elements were combined into 16 scenarios for testing to optimize their effectiveness in improving mobility within the corridor (Figure 1-2), as follows:

- No Build.
- Rehabilitation of the bridge with TDM/TSM measures.
- A highway-improvement scenario with a replacement bridge.
- Seven single-mode transit scenarios consisting of full-corridor bus rapid transit (BRT), light rail transit (LRT), or commuter rail transit (CRT) options along with a variety of river-crossing options.
- Six multi-modal scenarios that combined various transit elements with a variety of river-crossing and highway-improvement elements.

These 16 scenarios were subjected to Level 2 screening analyses using the transportation, environmental, engineering, and cost screening criteria, which resulted in the selection of six alternatives for further consideration in the DEIS. For a detailed description of each scenario and the related screening processes, see the *Alternatives Analysis Report* (January 2006). The six alternatives were Alternative 1 (No Build), Alternative 2 (Bridge Rehabilitation), and Alternatives 3 (BRT), 4A (CRT), 4B (CRT/LRT), and 4C (CRT/BRT).

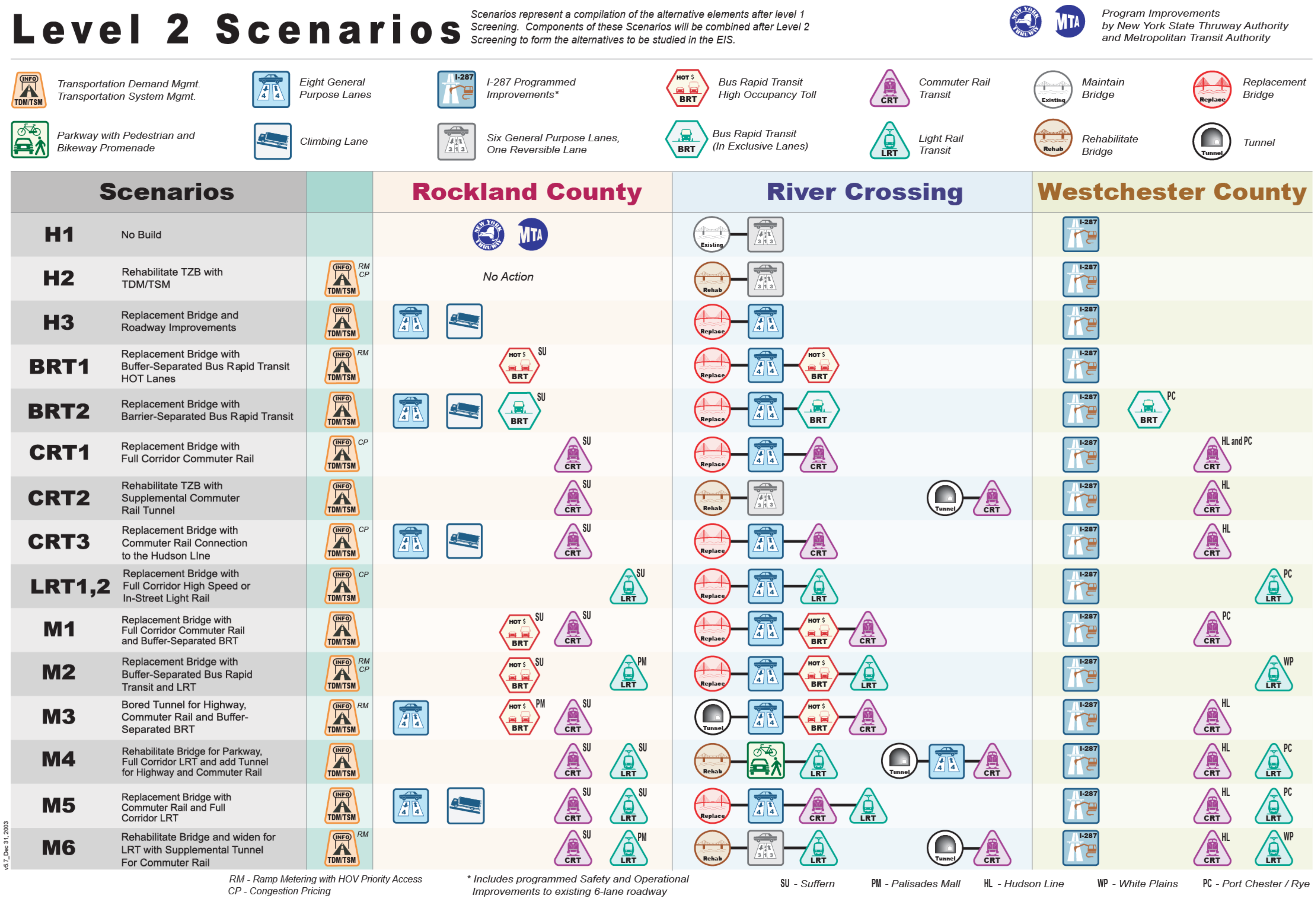


Figure 1-2 Corridor-Wide Scenarios

1.1.4 Revised Notice of Intent

Although extensive scoping, AA, and public involvement activities have been conducted since publication of the original NOI, because of New York State Department of Transportation's (NYSDOT) increased involvement and the new provisions of the recently enacted (August 2005) Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), it was deemed appropriate by the lead agencies to prepare a revised NOI, which was published in the *Federal Register* in February 2008. The lead agencies are the Federal Partners - the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) - and the Project Sponsors - NYSDOT, the NYS Thruway Authority (NYSTA), and Metro-North Railroad (Metro-North).

The purpose of the revised NOI was to define the realignment of project management, including the addition of NYSDOT as a Project Sponsor; to acknowledge adherence to the provisions of SAFETEA-LU Section 6002; and to update interested parties regarding the plan to prepare an EIS. The revised NOI also presented the opportunity for the public and agencies to review and comment on project purpose and need; the range of alternatives; the *SAFETEA-LU Section 6002 Coordination Plan*; and evaluation methodologies.

The revised NOI provided the public with updated information on the proposed project, its Purpose and Need, and the range of alternatives. As part of the provisions of SAFETEA-LU Section 6002, the public was also re-invited to participate in the NEPA process, which included providing comments on the refined scope of the EIS proposed in the revised NOI. Scoping Update Meetings were conducted in February 2008 that offered information on the project and its new direction.

1.1.5 Tiered Analysis Approach

Based on the previous analyses, full-corridor BRT from Suffern to Port Chester and CRT from Orange/Rockland Counties to Grand Central Terminal will be studied in the DEIS. As the project is multimodal in nature with proposed bridge, highway, and transit improvements, the EIS will be conducted using a tiered analysis approach to allow each project component to advance at its own appropriate pace. Thus, two levels of analysis will be conducted in the DEIS:

- **Tier 1 Transit Analysis**: Tier 1 transit analysis is the first step of a two-step process to comply with environmental review under NEPA. The Tier 1 transit analysis will provide a broad evaluation of planning level alternatives to determine the general effects on the human and natural environment resulting from the mode choices, alignments, locations and termini of facilities and services under consideration in the EIS. In addition, the general locations of suggested station areas will be identified and evaluated. These conceptual, planning level alternatives will be further evaluated in more detail in a future Tier 2 Transit Environmental Process based on more refined engineering design.

- **Tier 2 Bridge and Highway Analysis**: The Tier 2 bridge and highway analysis will evaluate the potential effects of alternative engineering designs for proposed facilities on the human and natural environment. The analysis of alternatives will focus on the potential site specific impacts of the bridge and highway alternatives along the corridor and identify potential mitigation measures. This analysis will incorporate and be consistent with decisions made as part of the Tier 1 transit analysis.

The future Tier 2 Transit Environmental Process will build upon the Tier 1 transit analysis and the Tier 2 bridge and highway analysis. During the future Tier 2 transit environmental analysis, the work completed during the Tier 1 transit analysis will be further refined and decisions advanced based upon more detailed engineering design. The Tier 2 transit analysis will focus in greater detail on specific elements of the transit system such as station locations and site plans, vehicle types, and storage facilities with respect to site specific impacts and mitigation measures.

1.1.6 Level 3 Screening

One of the outcomes of the decision to pursue a tiered analysis approach to preparation of the DEIS was the decision to conduct a third level of screening with respect to transit modes in order to narrow the range of transit modes being analyzed to a mode or modes that would best meet the transportation demands of the corridor. The transit mode analyses were conducted to (1) enable comparisons among the modes based on selective criteria; (2) determine whether there are significant differentiators among them; and (3) determine whether there were any major issues associated with any mode. The transit-mode selection analysis presented here is based on several principles:

- It builds upon the existing AA work with additional data and analyses.
- It uses a set of transportation, environmental, and cost criteria (comparable to those used in the two levels of screening in the AA for consistency) to determine if there are critical differences and/or benefits among transit modes.
- It uses a series of quantitative and qualitative measures to support the evaluation criteria. For example, if environmental impacts to wetlands were found to be a differentiator, that determination would be based upon the significance of the wetlands as well as on the numeric difference between the total area of wetlands involved in each mode.

In order to assess the impacts of the various transit modes, the following transportation, environmental, and cost criteria were used (see Chapters 5, 6, and 7 for detailed descriptions of the criteria):

- Transportation:
  - Transit Ridership.
  - Transit Travel Time.
  - Transit Capacity.
  - Roadway Congestion.
- Environmental:
  - Consistency with land use plans.
  - Residential and commercial acquisitions/displacements.
  - Transit-oriented development (TOD) potential.
  - Wetlands.
  - Parklands.
  - Historic and archaeological resources.
  - Hudson River habitat disturbance.
  - Air quality.
  - Energy/greenhouse gases.
- Cost:
  - Capital cost.
  - Annual operating costs.
  - Fare revenue.
  - Net cost per passenger and passenger-mile.
  - Transit travel-time benefits.

1.1.7 Mode Alternatives/Options Under Study

In the course of further evaluation of the six DEIS alternatives that had been developed in the *Alternatives Analysis Report* (January 2006), three variations of the alternatives were developed based on comments received from the public, the results of a project BRT Workshop (September 2007, and other analyses; these are referred to as Options 3A, 3B, and 4D, and are described below. In addition, two other options were reconsidered based on public input: 4A without a Hudson Line connection (designated as 4A-X) and a full-corridor LRT. These variations are also included in this transit-mode selection analysis (Figure 1-3).

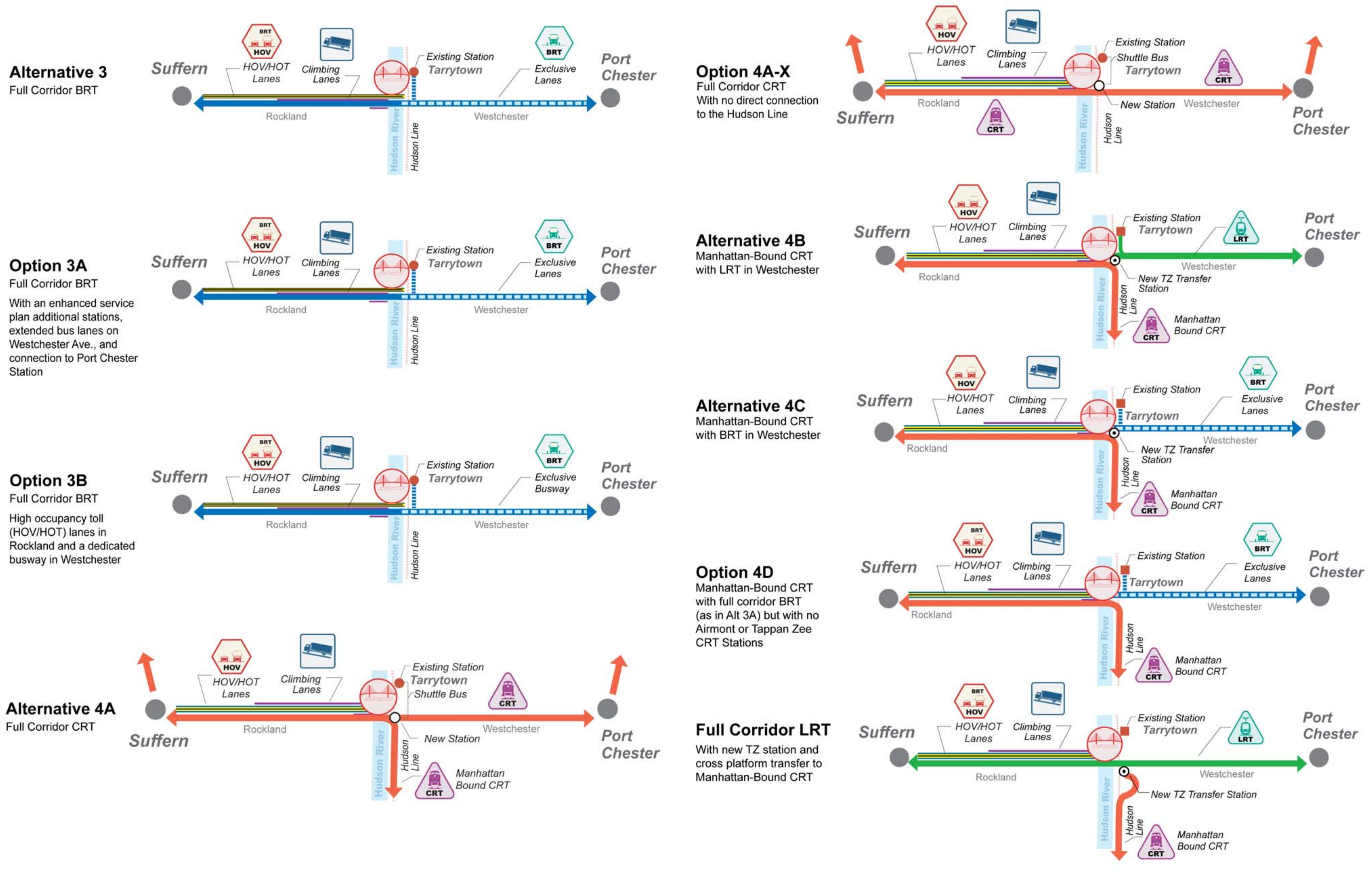


Figure 1-3 Alternatives/Options

Thus, the alternatives/options subjected to Level 3 screening analyses include some of the original AA alternatives (4A, 4B, 4C), several new options (3A, 3B, 4A-X, 4D) developed for this study, and a full-corridor LRT (Alternatives 1 and 2 have no transit component[1]), as follows:

No Build – Alternative 1 is used as the baseline to measure impacts, where appropriate.

Bus Rapid Transit

- **Option 3A** (Full-Corridor BRT) – Alternative 3 (full-corridor BRT in high-occupancy vehicle/high-occupancy toll (HOV/[HOT) lanes in Rockland County) but with an enhanced service plan (including additional stations), extended bus lanes on Westchester Avenue, and connection to Port Chester Station. Option 3A includes both bus lanes as well as busways. The bus lanes use lane segments of existing roadways, such as Route 119 and Westchester Ave. The busways are new lanes in exclusive ROWs.

- **Option 3B** (Full-Corridor BRT) – combined HOV/HOT and BRT lanes in Rockland County and a busway across Westchester.

Commuter Rail Transit

- **Alternative 4A** (Full-Corridor CRT) - as developed to date for the project, with a direct connection to the Hudson Line.

- **Option 4A-X** (Full-Corridor CRT) - as developed to date for the project, but without a direct connection to the Hudson Line. A new local Tarrytown Station at the Tappan Zee Bridge is assumed, with a shuttle bus connection to the existing Tarrytown Station.

- **Alternative 4B** (CRT/LRT) - as developed to date for the project, with CRT in Rockland Countywith a direct CRT connection to the Hudson Line and LRT in Westchester County.

- **Alternative 4C** (CRT/BRT) - as developed to date for the project, with CRT in Rockland County with a direct CRT connection to the Hudson Line and BRT in Westchester County.

- **Option 4D** (CRT/BRT) – CRT from Suffern with a direct connection to the Hudson Line and full-corridor BRT as per Option 3A above. However, the Airmont and Tappan Zee CRT Stations of Alternatives 4A, 4B, and 4C are eliminated.

Light Rail Transit

- This is the hybrid of the LRT developed in the AA, with a cross-platform transfer to a Hudson Line connection at a new Tappan Zee Station. LRT is in both exclusive ROWs and dedicated in-street lanes.

[1] While Alternative 2 has no transit component, and is thus not included in the analyses presented here, it should be noted that bridge rehabilitation concepts have been advanced that provide transit functionality comparable to that of replacement bridges. Thus, the analyses presented in this report are independent of whether the Tappan Zee Bridge is replaced or rehabilitated. The subject of whether to rehabilitate or replace the bridge is the subject of a separate report (*Alternatives Analysis for Rehabilitation or Replacement of the Tappan Zee Bridge*, March 2009), the recommendations of which will be included in the *Scoping Summary Report* (May 2009) for the project.

1.2 Public Involvement Process

A robust public participation process has been carried out throughout the study, and has included briefings, meetings, creation of Stakeholder Advisory Working Groups (SAWGs), development of a project web site, community outreach centers, and scoping meetings, as described below.

1.2.1 Briefings and Meetings

Briefings and meetings were held with public officials, agencies and interest groups throughout the corridor and region – some at our request, some at theirs. Each presentation was tailored to the audience's interest, and was followed by a question-and-answer period. Numerous meetings were held between the completion of the AA and the preparation of this report. Major public meetings included:

- Open House Pre-Scoping Meeting (October 2001).
- First Public Scoping Meeting (January 2003).
- Public Workshop 1 - Introduction of Level 1 Elements (April 2003).
- Public Workshop 2 - Introduction of Level 2 Scenarios (July 2003).
- Public Workshop 3– Results of the AA Process (December 2005).
- Project Update and Development of Alternatives/Options (February 2007).
- Second Scoping Meeting (February 2008).

Meetings were also held with such entities as:

- **The Inter-Metropolitan Planning Organization (IMPO).** IMPO was created to provide continuous and comprehensive input into the study. The IMPO committee is chaired by NYSDOT. It includes members such as the FHWA, FTA, and county planning organizations. Meeting regularly since 2002, IMPO assists the Federal Partners and the Project Sponsors in identifying key regional issues and proposed solutions, and provides technical review of project materials.

- **Westchester Rockland Tappan Zee Futures Task Force.** In 2005, the county executives of Westchester and Rockland Counties established an inter-county task force to raise the awareness of the Tappan Zee Bridge/I-287 Project, engage key groups and the public in the process, and provide guidance to the project team on presentation materials and outreach activities.

- **Environmental and Regulatory Agencies.** A central element in the outreach program has been communication with various federal, state, and local agencies that will be involved in the project's environmental review process, such as the US Coast Guard, US Army Corps of Engineers, National Oceanographic and Atmospheric Administration – Fisheries, US Environmental Protection Agency, US Fish and Wildlife Service, NYS Department of Environmental Conservation, NYS State Historic Preservation Office, and the NYS Department of State.

- **County and Local Agencies.** The Project Sponsors held meetings with municipal representatives throughout the corridor to gain understanding of local perspectives on project-related issues. These agencies included Rockland, Westchester and Orange County planning departments, and representatives of localities such as Clarkstown, Orangetown, Spring Valley, New Hempstead, the City of White Plains, the Town of Greenburgh, the Town of Ramapo, and the villages of Suffern, Montebello, and Sloatsburg.

- **Non-Governmental Organizations.** The Project Sponsors met with individual organizational members of the Stakeholder Committee and other organizations, such as the East-West Rail Coalition, the Palisades Mall, the Regional Plan Association, the Tri-State Transportation Campaign, and Riverkeeper, to engage in more-detailed discussions of particular areas of interest.

The public provided input on a variety of factors, including the screening criteria used to assess alternatives/options, the alternatives being studied (e.g., public input led to the analysis of three new options [3A, 3B, and 4D] as described earlier), and on the scope of environmental studies to be conducted.

1.2.2 Project Web Site

A project web site (www.tzbsite.com) has been developed where the public can learn about the project. Visitors can sign up for the mailing list on the web site and submit comments via e-mail, which are directed to the Project Sponsors. The site is updated regularly and includes many project reports and meeting materials.

1.2.3 Community Outreach Centers

Community outreach centers in Westchester and Rockland Counties were established in 2003 to serve as local meeting places and to provide opportunities for community groups and individuals to obtain study information and provide feedback. The sites are equipped with copies of handouts and materials and with high-speed Internet access to the Project's web site. Knowledgeable staff is on hand to answer questions. Community outreach centers are located at the following locations:

– 660 White Plains Road, Suite 340, Tarrytown, New York 10591
Telephone: (914) 358-0612; Fax: (914) 524-0288
Hours: Monday through Friday 9:00 a.m. – 5:00 p.m.

– 203 Main Street, Nyack, New York 10960
Telephone: (845) 348-7714; Fax: (845) 348-7768
Hours: Wednesday and Thursday 4:00 p.m. – 8:00 p.m.
Saturday 11:00 a.m. – 4:00 p.m.

1.2.4 Stakeholder Advisory Working Groups (SAWGs)

Stakeholders had been identified during the AA process, and regular stakeholder meetings were held throughout that process, during which information and results were presented. It was later decided that stakeholders should be separated into working groups based on their particular areas of interest, and that meetings should be held regularly with each group. Four SAWGs were created: bridge; environmental; land use; and traffic and transit.

Seven rounds of meetings have been held since the inception of this concept. Each of the SAWG meetings has concentrated on a single topic, and meeting results have been disseminated to the public through timely publication of meeting minutes that include copies of the presentations (including posting in the project Web site).

The Traffic and Transit SAWG has held meetings that concentrated on:

- Existing Conditions.
- The Forecasting Process.
- HOV/HOT Lanes.
- BRT.
- CRT.
- LRT.

Both the existing conditions and the forecasting process were also presented to the Land Use SAWG. Meetings will continue into the future on other transportation topics.

1.2.5 Scoping Meetings

In mid-January 2003, three Public Scoping Meetings were held, one each in Westchester, Rockland, and Orange Counties, to invite public comment on the scope of the study, including its Purpose and Need and goals and objectives. Some 282 persons attended the three scoping meetings. In addition, the public was asked to submit their suggestions for improvements to the corridor. By the close of the scoping period in March 2003, the NYSTA and Metro-North had received more than 150 ideas for improvements to the corridor as part of this process. Approximately 460 comments were received from 107 agencies, groups, and individuals.

The Project Sponsors updated the scoping process as a result of the publication of a revised NOI in the *Federal Register* on February 14, 2008. Based on this revised NOI, a new public comment period was opened, a *Scoping Update Packet* (February 2008) was widely distributed, and three public Scoping Update Meetings were held in Westchester, Rockland and Orange Counties in February 2008. The public comment period concluded on March 31, 2008. Approximately 620 comments were received from 290 agencies, groups, and individuals.

The comments given addressed a wide range of issues about the project, the scoping document, the proposed alternatives, and community concern. The comments fell into four major categories: transportation, environment, river crossing and process. With respect to a specific transit mode:

- About 68 percent of specific transit-mode-related comments advocate CRT across the corridor and/or a one-seat ride to New York City (NYC) (Alternative 4A or Option 4D).
- About 18 percent of specific transit-mode-related comments advocate LRT. These are split between support for Full-Corridor LRT and those who advocate Alternative 4B.
- About 14 percent of specific transit-mode-related comments advocate BRT service in the corridor.

With the release of the draft *Transit Mode Selection Report* (September 2008) and the draft *Alternatives Analysis for Bridge Rehabilitation or Replacement* Report (September 2008), the Project Sponsors conducted a series of Public Information Meetings in October 2008 in Westchester, Rockland, and Orange Counties to explain the recommendations resulting from the two reports. Approximately 255 comments were received from 84 agencies, groups, and individuals at the meetings and during the public comment period. This final version of the *Transit Mode Selection Report* incorporates the relevant comments received.

1.3 Existing Travel Patterns

Prior to introducing modal descriptions in Chapters 2, 3, and 4 and the analyses presented in Chapters 5, 6, and 7, it is useful for the reader to understand existing travel patterns in the corridor.

1.3.1 Journey-to-Work Patterns of Rockland County Residents

The majority of Rockland County residents work within the county. However, large numbers also travel to NYC, New Jersey, and Westchester County (Table 1-1; note that in this and subsequent tables, percentages may not total to 100 percent due to rounding). Of these, Westchester County, Connecticut, and most Bronx-bound trips are served exclusively by the corridor and are concentrated at the Tappan Zee Bridge. Trips to Manhattan can be served by the corridor, though they may also be served by the George Washington Bridge, Lincoln Tunnel, the tunnels into Penn Station, or Port Authority Trans-Hudson (PATH) tunnels. Trips between Rockland County and New Jersey would, for the most part, not be served by the corridor. Finally it should be noted that although intra-Rockland County trips account for the highest percentage of all Rockland County trips, most of these are north-south trips and would not be particularly well-served by a cross-corridor line-haul transit service. A majority of Rockland County resident trips are auto trips. The transit share to Manhattan (34 percent) and the rest of NYC (13 percent) are worth noting.

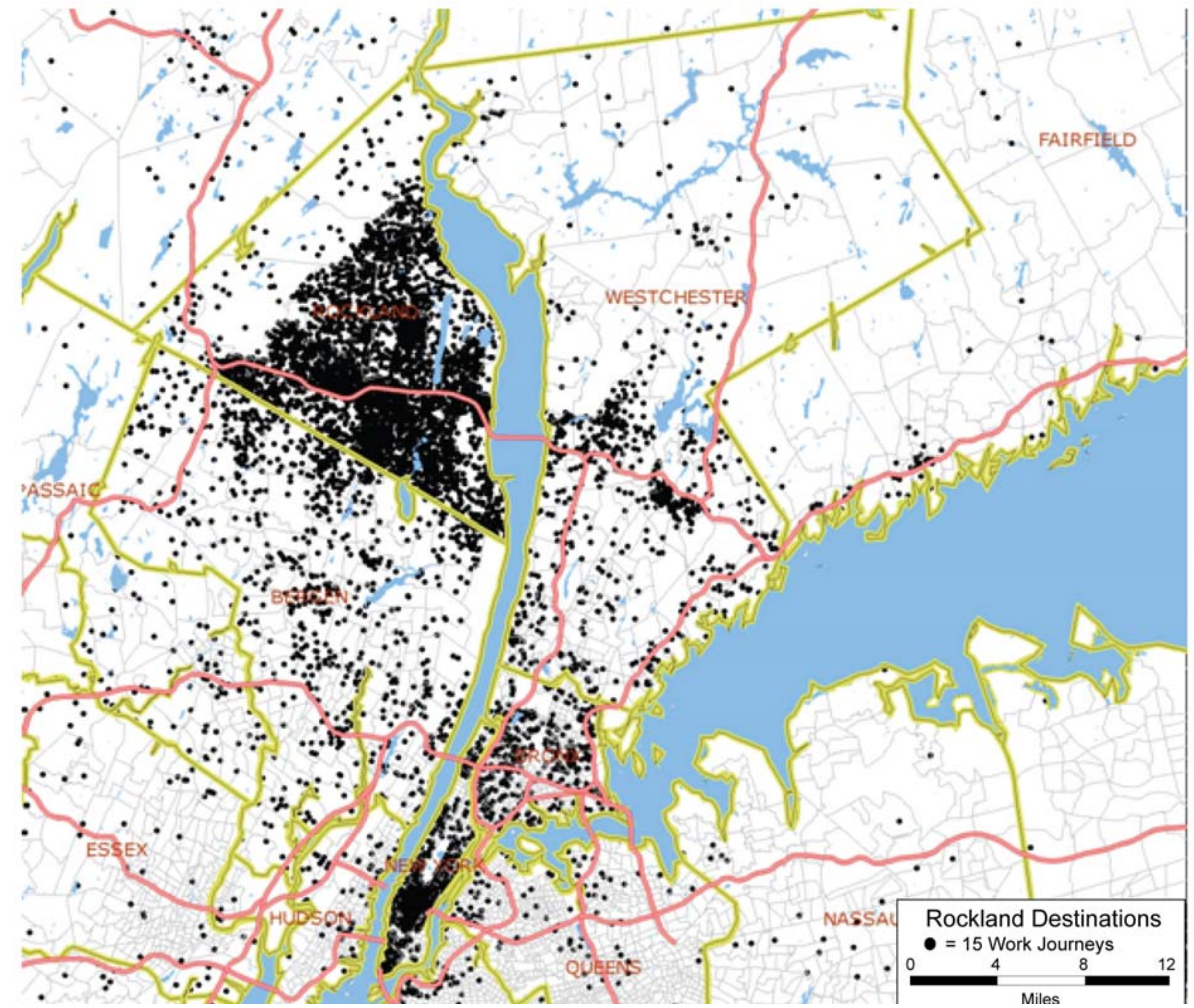
Table 1-1

Work Destinations of Rockland County Residents

Destination	Subtotal	Percent by Destination	Total	Auto	Transit	Other*
				Mode Share		
Rockland			**72,000**	85%	4%	12%
Manhattan	17,000	13%		66%	34%	0%
Bronx	6,300	5%		97%	2%	1%
Rest of NYC and Long Island	4,000	3%		85%	13%	3%
Total Cross-Hudson South			**27,300**	76%	24%	0%
Westchester	11,000	8%		98%	1%	0%
Putnam & Dutchess	1,000	1%		100%	0%	0%
Connecticut	1,170	1%		98%	1%	1%
Total Cross-Hudson, N. of NYC			**13,170**	98%	1%	0%
Bergen	12,700	10%		97%	2%	1%
Rest of NJ	4,800	4%		94%	5%	1%
Total NJ			**17,500**	96%	3%	1%
Orange	1,700	1%		98%	2%	0%
Ulster & Sullivan	400	0%		88%	8%	5%
Total West-of-Hudson, North			**2,100**	98%	3%	0%
Total			**132,070**	86%	7%	7%

Note: * Includes Walk/Bike/Work from Home.
Source: 2000 Census Journey-to-Work Data.

With respect to Rockland County to East-of-Hudson journeys, Figure 1-4 shows work destinations of all Rockland County residents. Examining the destinations outside Rockland County, it shows relatively dense concentrations in White Plains, in the areas along Route 9A north of Elmsford, and along the Broadway corridor in Tarrytown. The substantial Bronx-bound market can also be observed. The Manhattan-bound journeys are distributed relatively evenly, not considering the valley district (between Midtown and Downtown), with Midtown West capturing a higher number of journeys, as indicated in Table 1-2. A sizeable percentage of Rockland County residents work on the East Side, since they have relatively good access to the Hudson Line.



Source: 2000 Census Journey-to-Work Data.

Figure 1-4 Work Destinations of Rockland County Residents

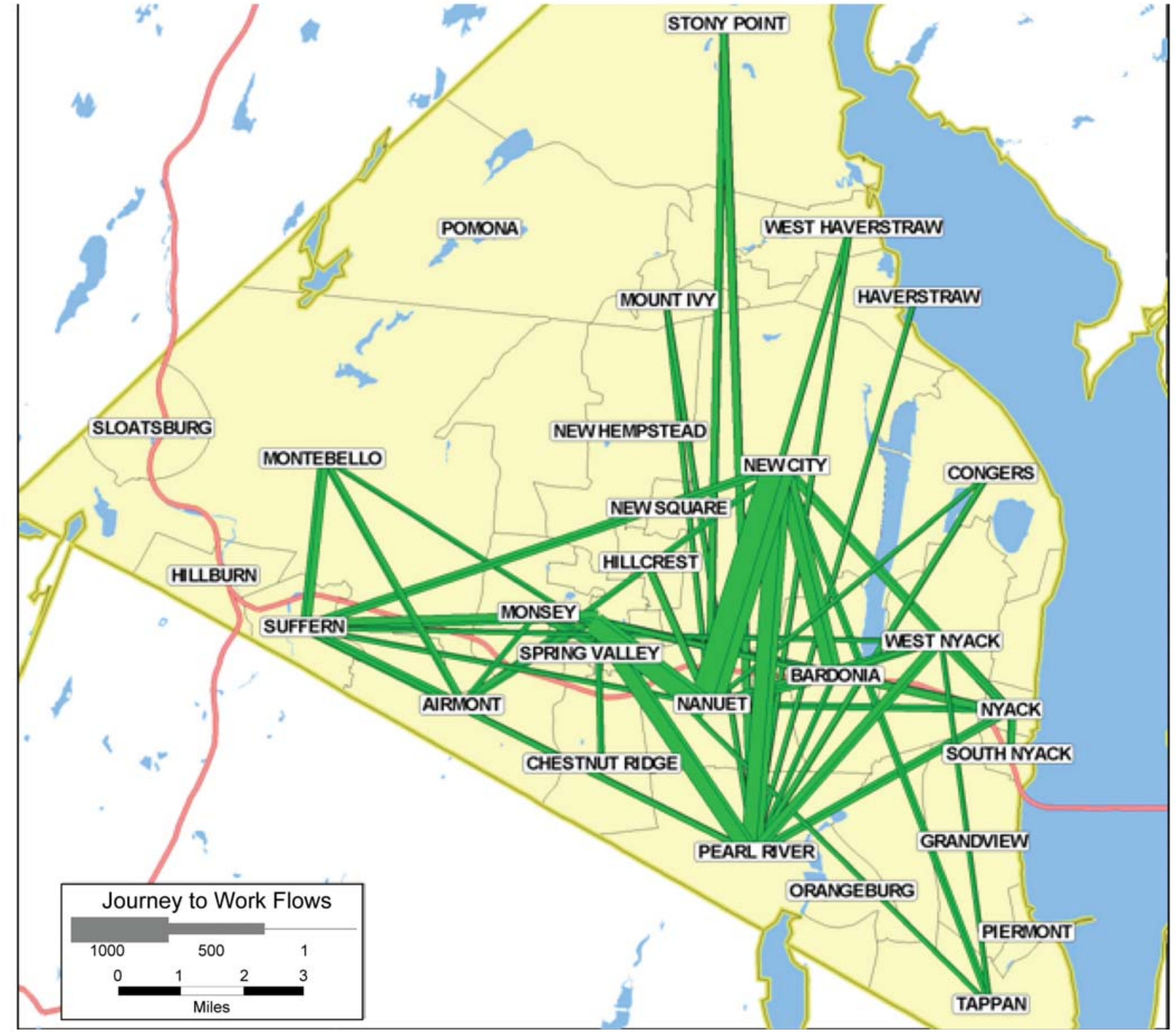
Table 1-2

Distribution of Manhattan-Bound Work Journeys of Rockland County Residents

Lower Manhattan	Valley	Midtown East	Midtown West	Uptown
20%	13%	20%	25%	23%
Source: 2000 Census Journey-to-Work Data.				

Relatively small numbers of people currently travel from Rockland County to Connecticut, though most destinations are concentrated in Stamford. A goal of any regional transit service plan, therefore, would be to serve these areas with concentrations of trip ends, either directly with a stop along a trunk line; by means of a route that comes off the trunk line to directly serve these perpendicular corridors; or by providing easy transfers to another route that serves these corridors.

Most intra-Rockland County journeys would not easily be served by transit service across the corridor. The majority do not even come near the corridor. A Geographic Information System (GIS)-based analysis shows that about 34,000 (or 47 percent) of all intra-Rockland County trips follow paths that intersect or come within half a mile of the corridor. However, even among these trips, many are either very short (e.g., from Monsey to Monsey), not likely to be served by any sort of line-haul transit service, or cross the corridor along a north-south axis (such as that between New City and Pearl River), rather than travel along the corridor. Figure 1-5 illustrates that north-south movements predominate over east-west movements. Note that work trips that stay within a single town are not shown. Table 1-3 lists such trips, and highlights in bold those trip pairs that have the greatest potential to be served by a cross-corridor transit service for at least a portion of the trip.



Note: Trips within a single town are not shown.
Source: 2000 Census Journey-to-Work Data.

Figure 1-5 Major Intra-Rockland Work Journeys Crossing the Corridor

Table 1-3

Major Intra-Rockland Work Journeys Crossing the Corridor

From	To	Journeys
Monsey	Monsey	1,200
Spring Valley	Spring Valley	1,130
New City	Nanuet	930
Nanuet	Nanuet	910
Spring Valley	**Nanuet**	**760**
New City	Pearl River	620
Suffern	Suffern	600
Spring Valley	**Pearl River**	**590**
West Nyack	West Nyack	550
New City	Bardonia	460
Nanuet	New City	450
New City	**West Nyack**	**410**
Spring Valley	**West Nyack**	**360**
West Nyack	**New City**	**360**
Bardonia	Bardonia	340
Spring Valley	**Nyack**	**330**
Spring Valley	**Suffern**	**330**
Stony Point	Pearl River	310
West Nyack	**Pearl River**	**300**
Bardonia	New City	290
Hillcrest	Nanuet	290
Airmont	Airmont	280
Suffern	Montebello	280
New City	**Nyack**	**280**
Monsey	**Nanuet**	**270**
Pearl River	New City	270
Stony Point	Nanuet	270
Spring Valley	**Airmont**	**260**
Source: 2000 Census Journey-to-Work Data.		

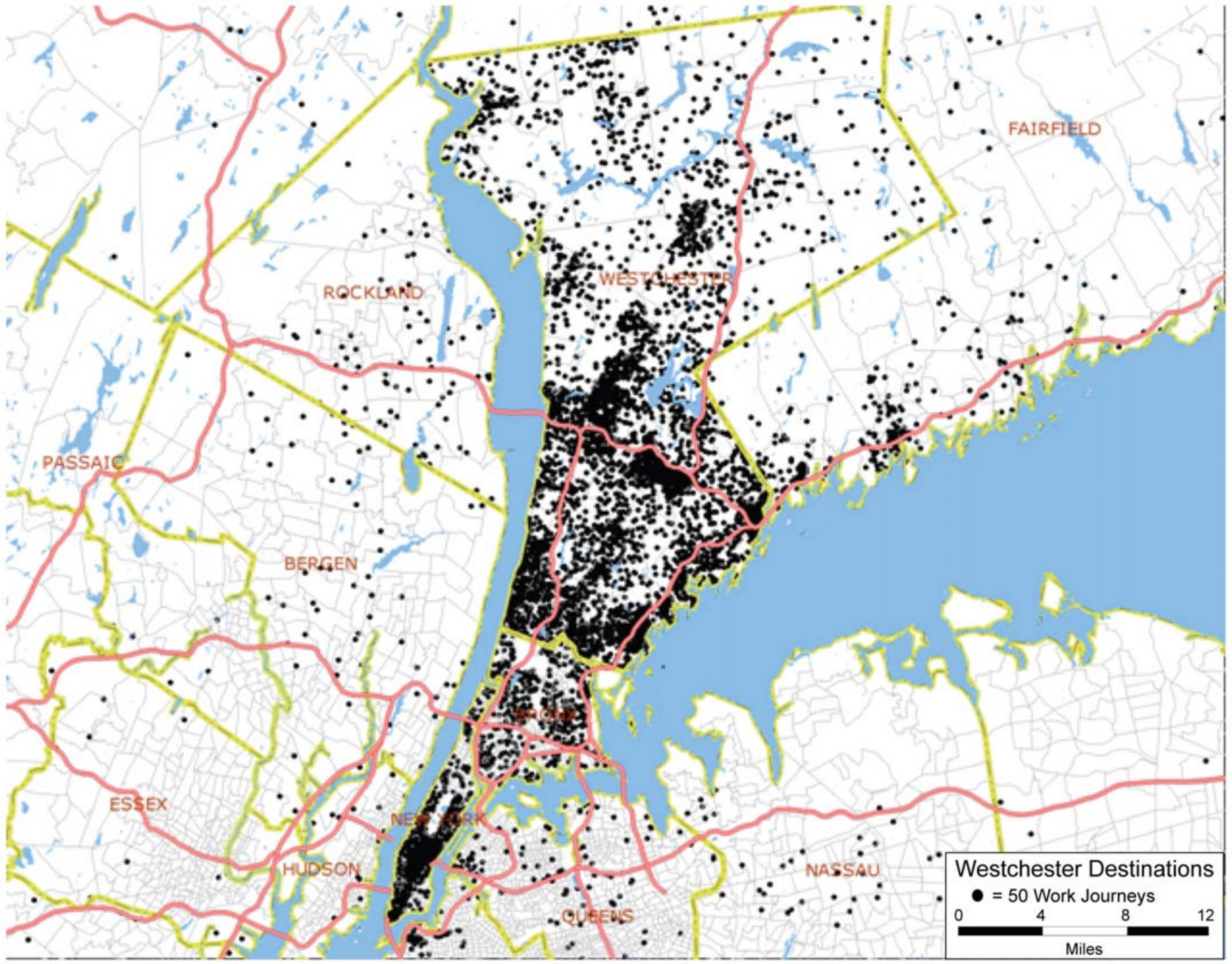
1.3.2 Journey-to-Work Patterns of Westchester County Residents

As is the case with Rockland County, the majority of Westchester County residents work within the county, with large numbers also traveling to Manhattan and the Bronx (Table 1-4). The transit share, especially to Manhattan (71 percent), is significant due to the robust transit network east of the Hudson. Figure 1-6 illustrates destinations of Westchester County residents at the census-tract level. The majority (57 percent) of Manhattan-bound journeys are destined to midtown (Table 1-5). The largest percentage of Manhattan-bound Westchester County residents work in Midtown East (31 percent). This trend can be explained by the superior access to Grand Central Terminal (GCT) from the Hudson, Harlem and New Haven lines. Even though the Metro-North trains are destined to GCT, there are several opportunities for passengers to transfer to subways at points north of 125th Street, making Midtown West almost as attractive (26 percent).

Table 1-4

Work Destinations of Westchester County Residents

Destination	Total	Percent by Destination	Auto	Transit	Other
			Mode Share		
Westchester	267,000	63	79%	8%	12%
Manhattan	79,600	19	29%	71%	0%
Bronx	27,100	6	91%	7%	1%
Rest of NYC and Long Island	13,800	3	76%	22%	1%
Rockland and Orange	4,900	1	96%	2%	2%
Putnam and Dutchess	3,800	1	95%	2%	3%
Fairfield, CT	18,200	4	93%	5%	1%
NJ	6,200	1	91%	8%	1%
Rest of Upstate NY	1,200	0	83%	11%	6%
Rest of CT	700	0	93%	7%	0%
Total	422,500	100	72%	20%	8%
Note: * Walk/Bike/Work from Home. Source: 2000 Census Journey-to-Work Data.					



Source: 2000 Census Journey-to-Work Data.

Figure 1-6 Work Destinations of Westchester County Residents

Table 1-5

Distribution of Manhattan-Bound Work Journeys of Westchester County Residents

Lower Manhattan	Valley	Midtown East	Midtown West	Uptown
15%	12%	31%	26%	16%
Source: 2000 Census Journey-to-Work Data.				

As with Rockland County, most intra-Westchester County journeys do not involve the corridor. Roughly 100,000 (about 37 percent) of the 267,000 intra-Westchester County trips have one or both ends in municipalities along the corridor. The largest of these movements are listed in Table 1-6 and illustrated in Figure 1-7. As expected, shorter-distance trips within a single municipality, such as White Plains-to-White Plains or Port Chester-to-Port Chester, are at the top of the list. Among mid-distance trips across municipalities, White Plains emerges as the major destination along the corridor, with Harrison (which includes the Platinum Mile) the second-leading destination. On intra-Westchester trips, more workers are traveling into the corridor than out of it; for example, the Yonkers-to-White Plains move far outnumbers the White Plains-to-Yonkers move.

Table 1-6

Major Intra-Westchester Work Journeys within the Corridor

From	To	Journeys
White Plains	White Plains	7,420
Yonkers	**White Plains**	**5,420**
Port Chester	Port Chester	3,010
Mount Vernon	White Plains	2,790
New Rochelle	White Plains	1,890
Harrison	Harrison	1,730
Yonkers	**Harrison**	**1,430**
White Plains	**Harrison**	**1,350**
Harrison	**White Plains**	**1,180**
Yorktown	**White Plains**	**1,180**
Yonkers	**Greenburgh**	**1,130**
Tarrytown	Tarrytown	1,050
Rye	Rye	960
Port Chester	**White Plains**	**940**
Mamaroneck	White Plains	900
Greenburgh	**White Plains**	**870**
White Plains	**Yonkers**	**850**
New Rochelle	Harrison	850
Yonkers	Tarrytown	780
Cortlandt	White Plains	770
Ossining	**White Plains**	**730**
White Plains	Mt Pleasant	720
Port Chester	**Harrison**	**710**
Source: 2000 Census Journey-to-Work Data.		

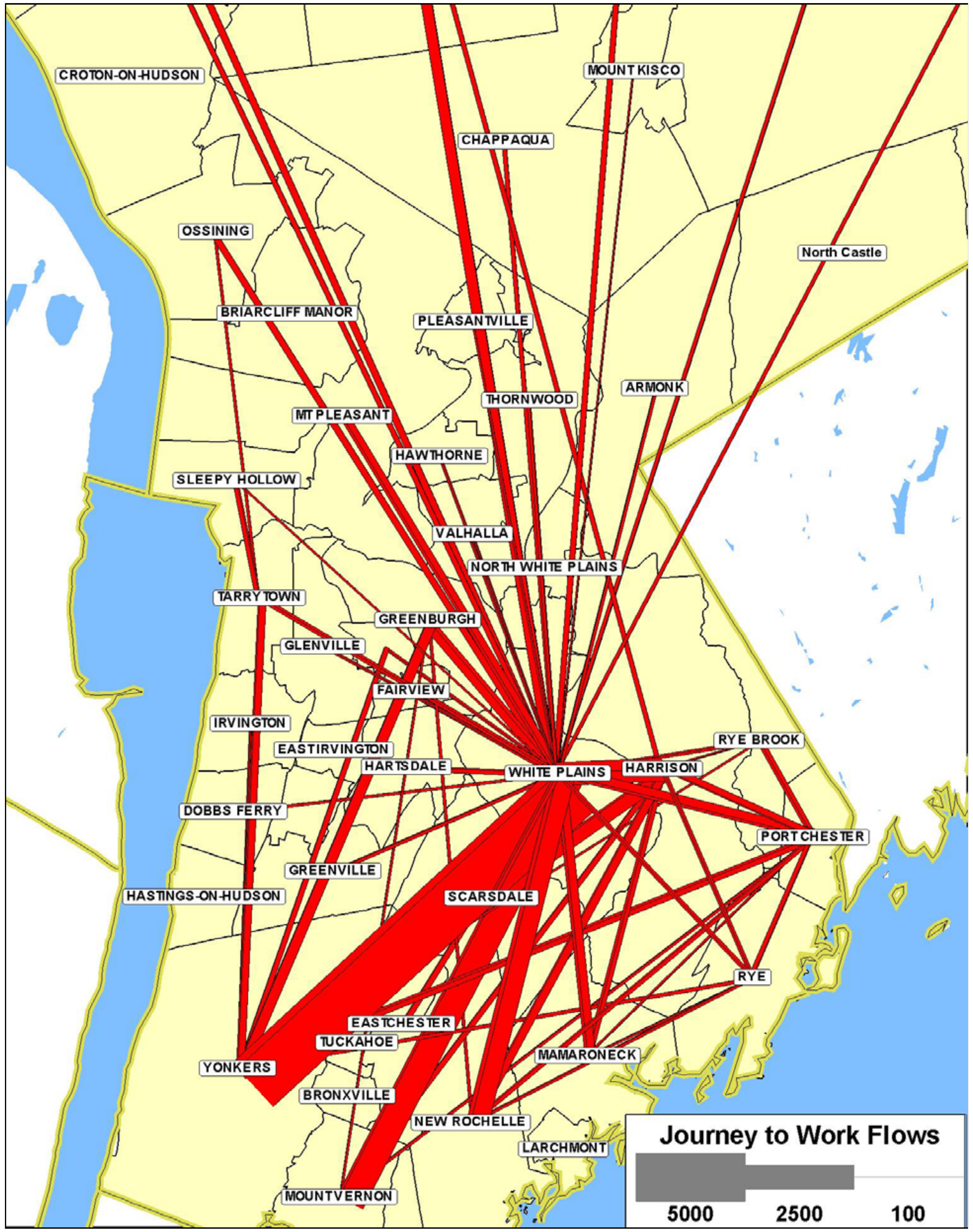
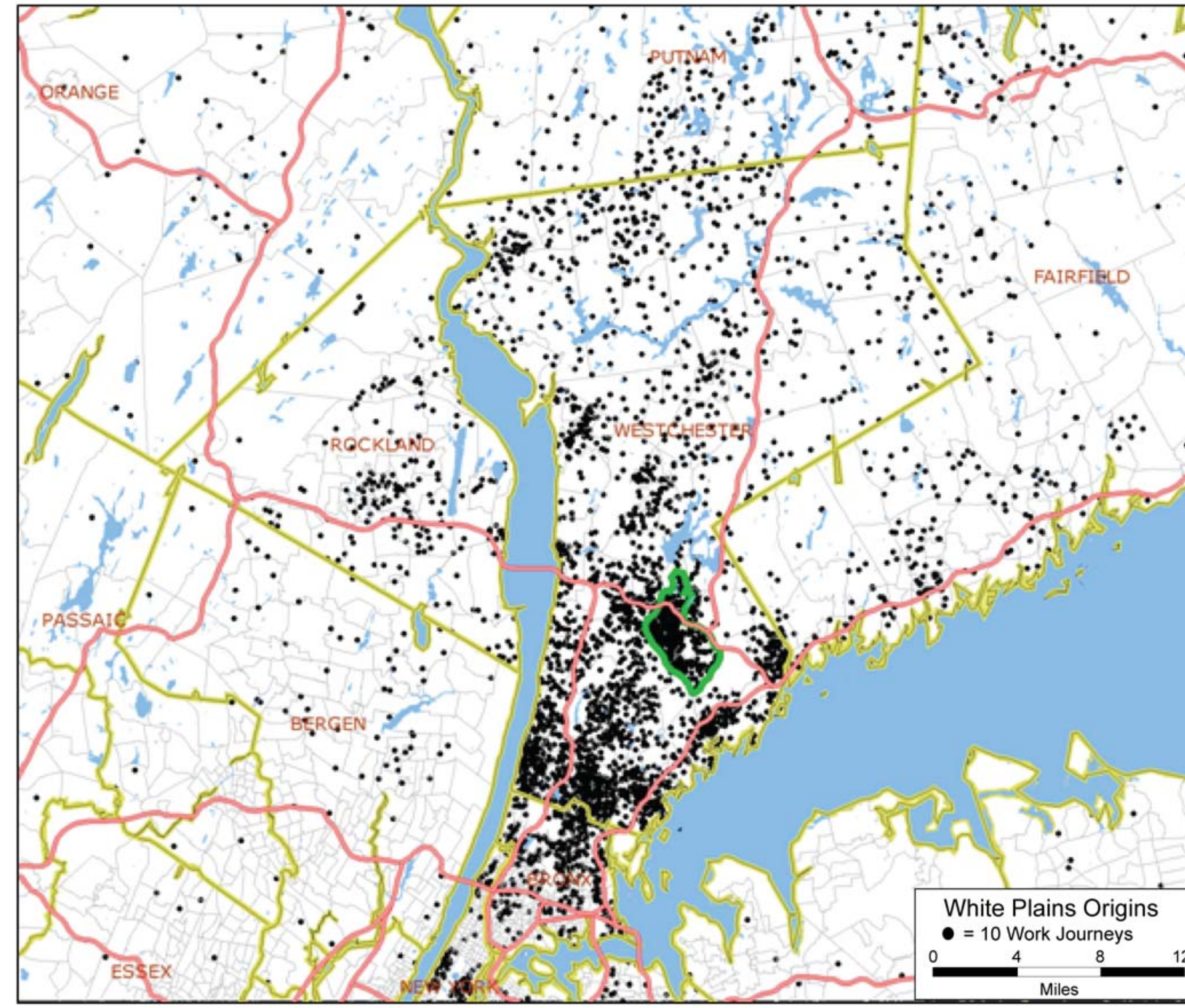


Figure 1-7 Major Intra-Westchester Work Journeys within the Corridor

Figure 1-8 and Table 1-7 isolate the origins of White Plains workers, and illustrate that movements from the south dominate, particularly from Yonkers and the Central Avenue corridor. White Plains also attracts a significant number of workers from the Bronx and Connecticut.



Note: White Plains Boundary Shown in Green.
Source: 2000 Census Journey-to-Work Data.

Figure 1-8 Residential Origins of White Plains Workers

Table 1-7

Residential Origins of White Plains Workers

Origin	Journeys	Percent
Westchester County	35,600	65
Bronx	4,300	8
Connecticut	3,900	7
Putnam and Dutchess Counties	3,500	6
Brooklyn, Queens, Staten Is. & Long Is.	2,400	4
Rockland County	1,900	3
Manhattan	1,300	2
New Jersey	1,100	2
Orange County	700	1
Other Upstate	100	0
Total	54,800	100
Source: 2000 Census Journey-to-Work Data.		

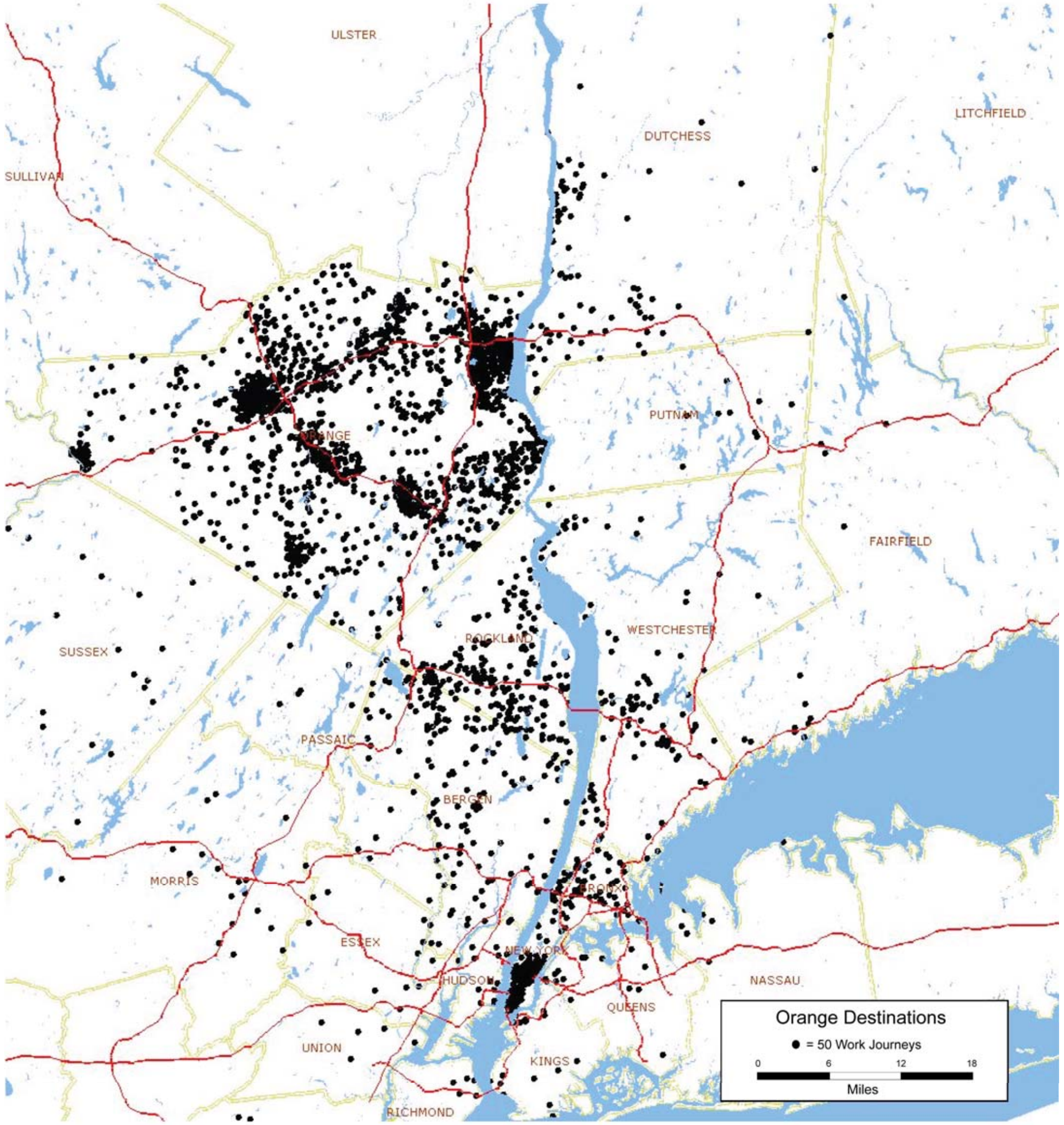
1.3.3 Journey-to-Work Patterns of Orange County Residents

The majority of work journeys in Orange County are destined for locations within the county, as indicated in Table 1-8. Rockland County and Manhattan attract the largest numbers of Orange County workers, outside of Orange County itself. Orange County resident trips are predominantly auto trips. Although the magnitude of Orange County residents bound for Manhattan is not large, the transit share to Manhattan (44 percent) is significant. Figure 1-9 illustrates destinations of Orange County workers. While the journeys to Rockland County and within Orange County are scattered, the majority of Manhattan- bound trips (51 percent) are concentrated in Lower Manhattan and Midtown West, as indicated in Table 1-9. This trend can be attributed to the relatively good transportation access to the two districts from Orange County. Bergen, Westchester, and Dutchess Counties attract a sizeable number of Orange County residents.

Table 1-8

Work Destinations of Orange County Residents

Destination	Total	Percent	Auto	Transit	Other
Orange County	99,900	68	88%	1%	11%
Manhattan	9,600	7	55%	44%	1%
Bronx	2,400	2	96%	4%	0%
Connecticut	600	0.4	100%	0%	0%
Rest of NYC	2,200	1	77%	23%	0%
Bergen	7,300	5	100%	0%	0%
Rest of New Jersey	4,000	3	98%	2%	0%
Rockland County	9,700	7	99%	1%	0%
Westchester County	5,600	4	96%	2%	2%
Dutchess	5,100	3	100%	0%	0%
Putnam	500	0.3	100%	0%	0%
Total	146,900				
Source: 2000 Census Journey-to-Work Data.					



Source: 2000 Census Journey-to-Work Data.

Figure 1-9 Work Destinations of Orange County Residents

Table 1-9

Distribution of Manhattan-Bound Work Journeys of Orange County Residents

Lower Manhattan	Valley	Midtown East	Midtown West	Uptown
24%	16%	16%	27%	18%
Source: 2000 Census Journey-to-Work Data.				

1.3.4 Key Corridor Markets

Table 1-10 illustrates key markets that use the Tappan Zee Bridge/I-287 Corridor and their transit patronage. The Manhattan, Bronx, and Westchester County markets from both Rockland and Orange Counties are relatively large, with the Manhattan-bound journeys capturing the largest transit shares. There is potential to increase transit usage with a cross-corridor transit system that serves markets such as Westchester County to Connecticut, Connecticut to Westchester County, and Rockland-Orange Counties to Westchester County, as shown in the transit share column of Table 1-10.

Table 1-10

Specific Markets Served by the Corridor Based on 2000 Journey-to-Work

Markets	Total Daily Journeys	Transit Share
Rockland – Westchester	11,000	1.4%
Rockland – Manhattan	17,000	33.7%
Rockland – Bronx	6,300	1.4%
Orange – Westchester	5,600	1.7%
Orange – Manhattan	9,600	44.1%
Orange – Bronx	2,400	3.5%
Bergen and Passaic – Westchester	4,200	0.4%
Westchester – Connecticut	18,200	5.4%
Connecticut- Westchester	18,400	1.2%
Westchester-Westchester	267,000	7.8%
Rockland-Rockland	72,000	3.8%
Source: 2000 Census Journey-to-Work Data.		

2 Bus Rapid Transit in the Corridor

Bus rapid transit (BRT) is a transit technology that has evolved from the application of existing technologies into a new and integrated transit alternative that offers a number of advantages over more traditional transit technologies. Quoting from the *Bus Rapid Transit Practitioner's Guide*:

> *BRT has been defined by the FTA as a "rapid mode of transportation that can provide the quality of rail transit and the flexibility of buses." In TCRP Report 90 (1), the definition of BRT was expanded to "a flexible, rubber-tired form of rapid transit that combines stations, vehicles, services, running ways, and ITS elements into an integrated system with a strong image and identity." BRT is an integrated system of features, services, and amenities that improves the speed, reliability, and identity of bus transit.*[1]

Much of what BRT accomplishes is through intelligent application of pre-existing practices, but what distinguishes it from previous attempts to make buses more attractive is its systems approach and attention to customer service, resulting in a truly new approach to passenger service.

BRT systems offer a number of attractive attributes to users, including:

- Easy and rapid boarding and alighting.
- Greater visibility.
- Understandable route structure.
- Frequent direct service to key destinations.
- Comfortable, modern, and attractive vehicles.
- Clean, affordable service.
- Low-emission and low-noise operations.

2.1 Description of BRT Systems

From top to bottom:
Express BRT Service
Urban Shuttle BRT Service
Local Collector/Distributor BRT Service

The elements of a BRT system are running ways, vehicles, stations, a service plan, and the use of Intelligent Transportation System (ITS) technologies to create an integrated system. Overall service can vary, as follows:

- **Express BRT Service** - Since speed is a key component of any successful transit technology, the backbone of a BRT system is its express bus component.
- **Urban Shuttle BRT Service** - Another aspect of making travel convenient is linking the system to nearby destinations, for which shuttle bus services are provided.
- **Local Collector/Distributor BRT Service** - The first and last leg of the service is local collector/distributor service, getting the customer to his or her home and ultimate destination.

One of the things that distinguishes BRT from LRT, Rail Rapid Transit (RRT), and CRT is the extreme range of options for each element of a BRT system. In its least sophisticated form, BRT is little more than enhanced bus service, while in its most complex form it has all the elements of a rail transit alternative. Figure 2-1 conveys the range of available elements in the BRT technology.

Element	Simple ⟵			⟶	Complex
Running Ways	Mixed Traffic	Queue Jumpers	Shared Lanes	Exclusive Lanes	Grade Separated Guideway
Stations	Shelters	"Super" Shelters	Shelters with High Level Platforms	Stations with Parking	Stations with Fare Collection
Service Plan	All Stops		Express Service	Feeder and Line Haul Services	
Vehicles	Buses with Unique Route	Unique Buses	Advance Design Buses	Guided Buses	Specialized BRT Vehicles
Systems	Digital Radios, GPS	Electronic Fare Boxes	Smart Cards	Transit Signal Priority	Central Control System

Figure 2-1 BRT Range of Options

The overall systems approach is to carefully and comprehensively integrate all of the elements of the system to maximize customer convenience while achieving cost savings and integration with current and planned development. This differs from typical bus system service planning in the way it approaches the question of designing the system, which typically focuses on routes and schedules with little consideration of ways to improve operations or enhance access through construction of dedicated facilities.

Three things in particular distinguish BRT from traditional bus-service planning:

- Consideration of capital improvements (busways, stations, unique vehicles).
- Integration of the land use/transit considerations into both transit planning and land use planning.
- The planning does not end once a viable BRT service has been identified, and the consideration of how to make the service as customer-friendly as possible, and to maintain that level, should be addressed.

This is not to say that typical bus-service planning efforts are inadequate or inferior, but rather that what is typically considered to be within the realm of the possible is much more modest, so that such efforts do not go to the lengths to which a BRT plan goes.

[1] Transit Cooperative Research Report 118, Transportation Research Board, Washington, D.C. 2007.

To maximize ease of use, BRT systems feature:

- Simple and understandable route layouts.
- Convenient transfers.
- Station locations that are coordinated with land use plans.
- Service to major activity centers.
- Frequent service on the main line.
- Feeder buses routed onto the BRT guideway (dedicated bus lanes or busway).

A central objective of the BRT concept is to eliminate or to reduce transfers and provide direct service to key destinations. In the past, attention to efficient routing has occasionally led to systems that require longer walks than necessary, more transfers than are desirable, and a lack of coordination between route planning and land use planning. BRT is intended to address these shortcomings. Figure 2-2 illustrates an approach in which some of these shortcomings may be alleviated. Local or feeder routes are given access onto the BRT guideway, eliminating the need to transfer to get the speed and reliability benefits of that guideway. Stations are coordinated with surrounding development. Transit centers provide convenient locations to transfer between routes and are integrated into major development projects such as business parks and shopping centers.

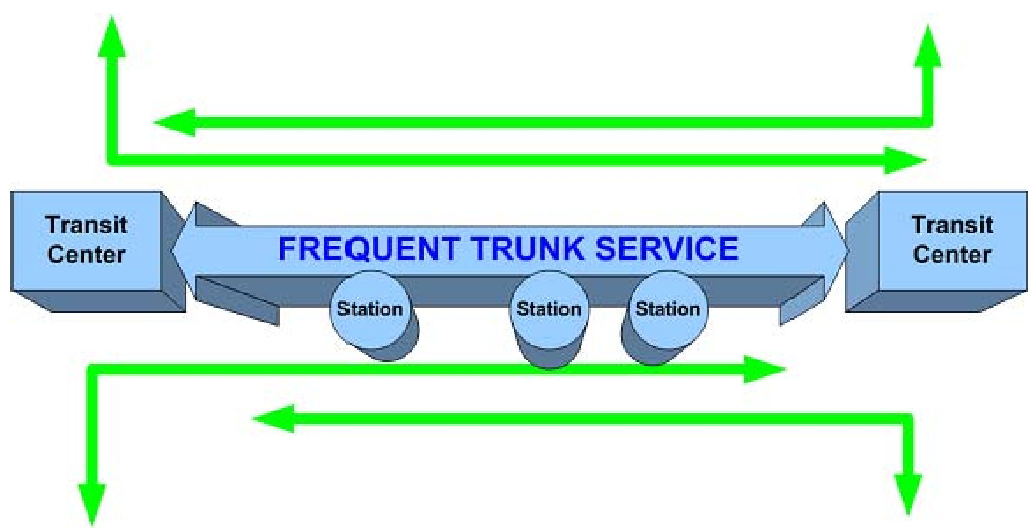


Figure 2-2 BRT Service Concept

BRT planning, therefore, begins from the presumption that there is a significant additional ridership benefit, as well as development benefits comparable to those achievable with rail transit alternatives/options. The question each BRT alternative/option must then address – as must all transit alternatives/options – is whether the potential additional benefits achievable will, in fact, justify the additional costs required to achieve those benefits.

2.1.1 Types of Transitway

Distinctive Pavement Treatment

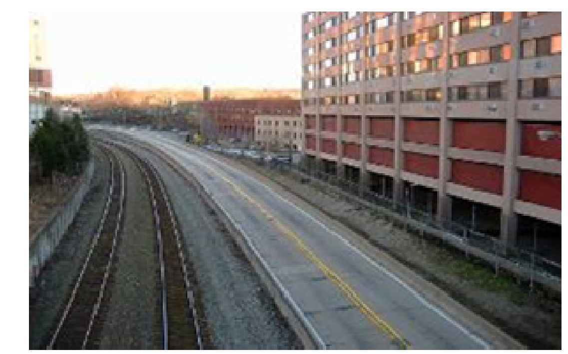
Not only should the guideway operate efficiently, but it should look like a guideway and be clearly distinguishable from lanes intended for mixed traffic.

Where the guideway is dedicated bus lanes, there is no need for special pavement treatments, but where the guideway abuts mixed-traffic lanes it is desirable for the BRT guideway to be visually distinct, not just to lend it identity, but to minimize confusion that could result in drivers illegally entering the guideway.

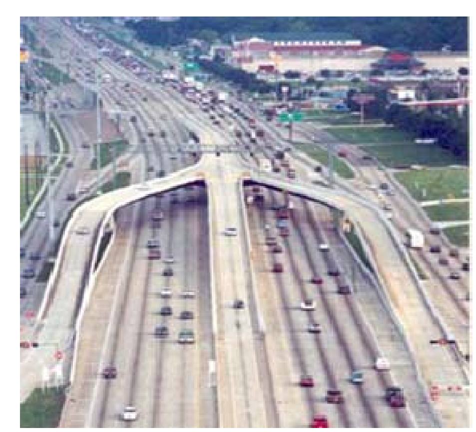
Busways can be located adjacent to railroads as well as highways. In Pittsburgh, Pennsylvania the M.L. King East Busway was built on what was railroad ROW, with the railroad still occupying one side of the alignment.

In Los Angeles, the Orange Line BRT used a former railroad ROW to create its exclusive guideway.

Orange Line Busway, Los Angeles



Pittsburgh Busway in Railroad Corridor



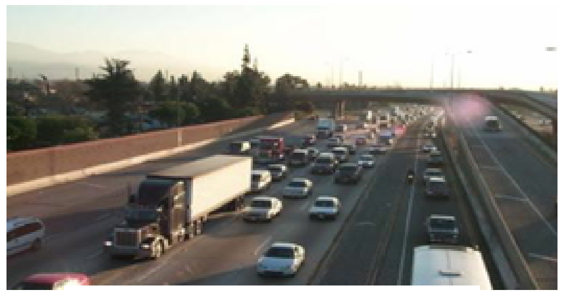
Houston Median Busway/HOV lane Entrance Ramps

In Houston, the busway/HOV system occupies freeway medians, among other configurations. The configuration of the Houston Median Busway shows a "T" ramp configuration used to provide access to the busway from frontage roads.

For freeway-median busways, the means of access to the busway is an important consideration. While it is possible to force the BRT vehicles to exit the busway and cross the mixed-traffic lanes, increasingly it is the practice to provide direct-access ramps onto the median guideways.

In addition to the major guideway options, there are design considerations that must be properly addressed in order to deliver on the potential of an exclusive guideway. How the guideway interfaces with local traffic at those points where buses leave that guideway is one such consideration.

Orange Line Intersection with Public Street



Usage with Other Vehicles

Usage by vehicles other than BRT vehicles is also possible, with HOVs the most common sharer of busways. As HOT lanes become more common, joint occupancy of BRT lanes with these users will become more common as well. The rationale for such joint occupancy is the availability of unused capacity in the typical busway. Whether this excess capacity can be used without impacting BRT operations should be the key consideration when assessing the feasibility of joint usage. Congestion pricing, ramp monitoring and proactive enforcement can all be used to keep busway joint usage at a level sufficiently low so as to guarantee that the BRT service will not be negatively affected.

Termination Points (Istanbul)

It is important that where vehicles leave the guideway, care be taken to avoid impacting both the busway and local traffic. A comprehensive approach to traffic management is, therefore, integral to BRT system development.

2.1.2 Key Vehicle Concepts

The concept of customer service begins with the vehicle. The following concepts are typical of BRT vehicles:

- Level boarding.
- Multiple doors.
- Distinctive "branded" exteriors consistent with stations.
- High capacity.
- Pleasant interior conveniences.
- Quiet operation.
- Low or zero emissions.

Examples of BRT vehicles follow.

40-Foot Stylized Buses

BRT buses are sized and configured to respond to the needs of the service into which they are placed. The most common size of bus is 40 feet, and for many applications it is the most cost-effective size to meet ridership demand. This does not mean that a standard-issue 40-foot bus is sufficient to meet the customer service objectives of BRT. In particular, increasing the attractiveness of the vehicles is desirable, and modern design concepts have been applied to make them more appealing.

Another important concept is making the vehicles fully accessible, which means ensuring that adequate doorways and ramps are provided to speed up boarding, and removing obstacles to entering the vehicles.

Wheel Chair Ramp Accessibility

A third element of a modern BRT vehicle is GPS (Global Positioning System) and AVL (Automated Vehicle Locator) capability. These technologies help knit each bus into the integrated system, supporting such capabilities as intelligent dynamic signing and passenger information systems.

Low-floor Bus

Among the measures to enhance the process of boarding and alighting from the vehicle is the use of low floors, which also make access within the bus easier and more convenient. This benefits all passengers but is especially helpful to the mobility-impaired and the elderly. The removal of interior steps initially entailed reconfiguring some of the mechanical components of the bus, but that challenge has been successfully met and there are now multiple models of buses that feature low floors.

NABI Articulated Bus

Articulated Buses

Where the ridership demand is high, the option of using articulated buses can be advantageous. In addition to having greater passenger-carrying capacity, these buses can have more side doors.

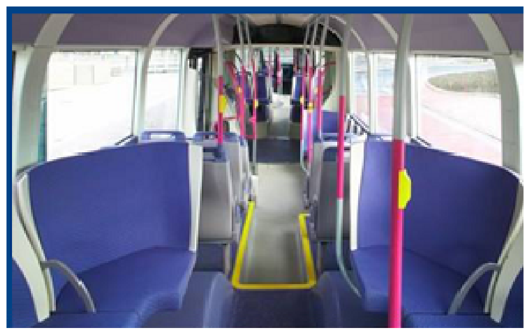
Specialized Vehicles

Specialized vehicles are also available that combine the characteristics of other BRT vehicles with futuristic and innovative styling. This category includes vehicles that can be fully guided as a tram, or operated manually and driven as a bus. Guided-bus technologies have evolved to include electronic guidance systems as well as mechanical systems.

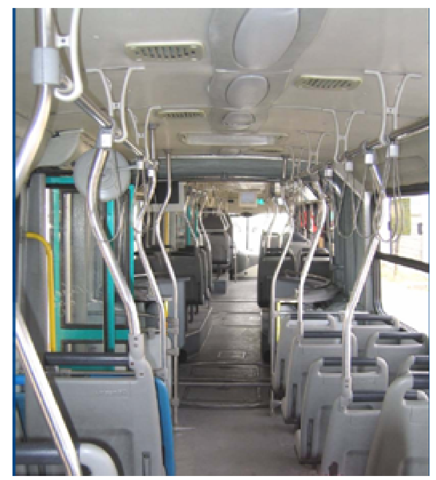
"Phileas" Bus

Attractive Interiors

Customer care extends to the experience of riding in the vehicle, and advances in the design of vehicle interiors have transformed the riders' experience.



Wright Streetcar, Las Vegas



Marco Volvo Leon, France

Advanced Propulsion Systems

As the appearance, size and configurations of vehicles have changed, so too have the choices for propulsion. In fact, as shown in Figure 2-3, BRT systems typically feature ultra-low-emission propulsion systems. These advanced propulsion systems are capable of reducing emissions and improving the energy efficiency of BRT systems, with further improvements expected to continue.

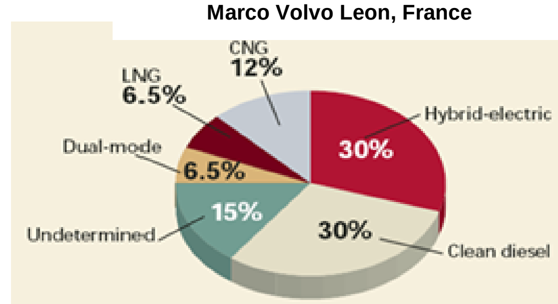


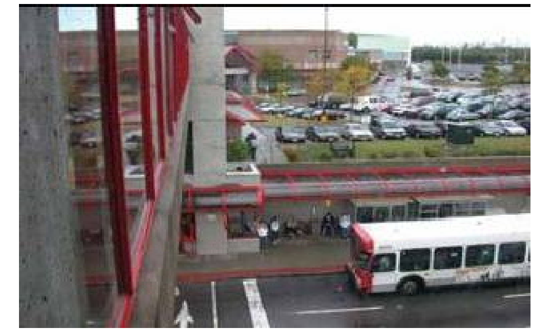
Figure 2-3 BRT Propulsion Systems

2.1.3 Key Station Concepts

The customer care concept is as important in the stations as it is in the vehicles. Among the concepts that make BRT a viable alternative are the creation of distinctive stations that feature level boarding and alighting, are attractive, and are clearly part of a system.

To realize the system concept, it is necessary that all of the components appear to be part of a system. This includes creating a visual signature that reassures users that they are in the BRT system. This is often referred to as "branding," with the color schemes of the buses and stations and all other elements of the system having a coordinated appearance.

Ottawa BRT Station



Ottawa BRT Station and Bus

The attention to details extends to providing high-quality, attractive and functional amenities that one would expect in any other transportation terminal, including water fountains, trash receptacles, benches, wind screens and even restrooms, depending on the size of the station.

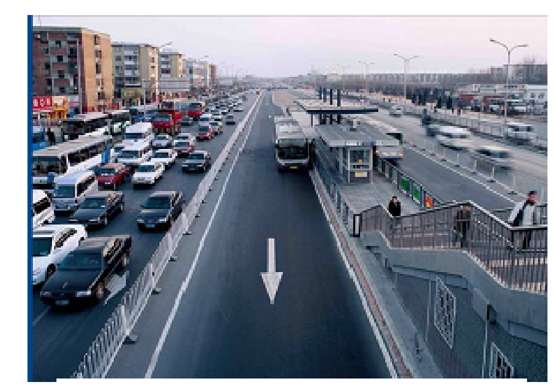
BRT station alternatives are as broad as they are for rail alternatives, and include elevated BRT stations and BRT subway stations. Among the more visually impressive are Seattle's downtown subway stations, which have been in operation for more than a decade.

Seattle Bus Subway Station

Seattle Bus Subway Station

BRT stations are common in roadway medians as well.

Transit stations are natural multimodal transportation centers, with the opportunity to provide a hub for transit service, auto access, bicycle access and pedestrian access. Where the transit mode is a dedicated ROW – such as with CRT, BRT or LRT – providing enhanced access means from surrounding areas is highly desirable to increase ridership and encourage transit use. Where the mix of adjacent land uses is appropriate, the development of transit oriented development (TOD) projects provides the means of capitalizing on the improved access the multimodal transportation center provides and further encouraging walk access to transit. Multimodal transportation centers can be important development hubs that have the capacity to enhance community transportation, transit usage and harmonious development.



Beijing BRT Station

2.1.4 Intelligent Transportation System (ITS) Components

Part of creating a system is providing a way of coordinating its components, and a state-of-the-art control center is the means to do that.

Rail systems have had centralized monitoring and control for decades, and providing this same means of monitoring and controlling performance is essential to achieving the desired levels of service and reliability that BRT promises.

BRT Operations Control Center

Transit Signal Priority

The control center is used to monitor operations, advise of delays, adjust service to meet demand, and deal with traffic incidents. New York State operates such a Traffic Management Center, which could provide this function.

Ideally, the BRT operation is integrated into the signal system in which the fleet operates. This includes giving BRT vehicles priority at traffic signals. Such priority is referred to as Transit Signal Priority.

Variable Signing and Incident Management

Another aspect of the management of the BRT system is the use of intelligent signage and advanced incident management to allow the system to adapt to changing conditions in time to avoid delays.

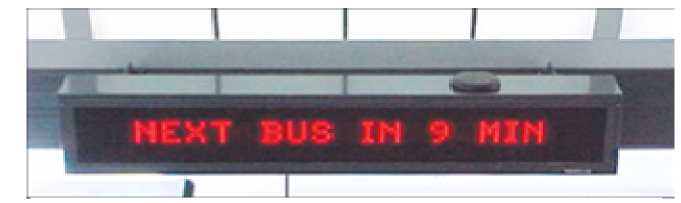
Smart Card Fare Collection System

Fare collection should be as advanced as all the other elements of the system. The technologies available include smart cards and equivalent systems, some of which do not even require the passenger to remove the farecard from his pocket or her purse. Faregates can be simplified or even eliminated entirely with a variety of available enforcement methods. The objective is to make fare collection not only seamless but to eliminate the delays formerly associated with them.

Intelligent Signage

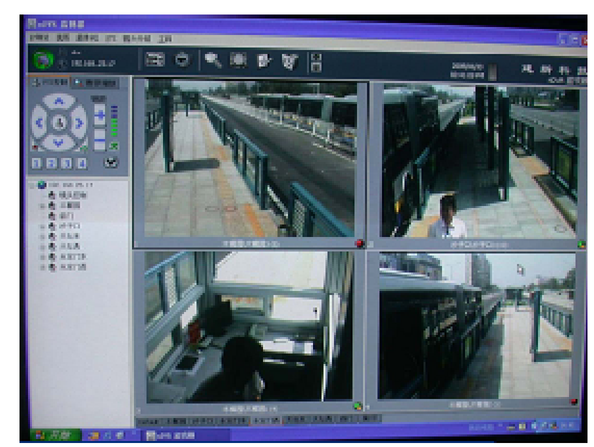
Passenger information systems can include visual and audio announcements of when the next bus will arrive, the location of the vehicle you are traveling on, its next stop, and the time remaining until arrival at the terminal.

Bus Station Next Bus Arrival Time Signage



On Board Information System

System security is another aspect of the control center and systems aspect of BRT systems. Through the use of closed-circuit television (CCTV) cameras and the active monitoring of the conditions throughout the system, the central control facility can deploy security personnel to the right location in a timely manner should the need arise. This includes health incidents as well as other events where specialized personnel are needed.



BRT Control Center Security Screens

CCTV Surveillance Camera in BRT Facility

2.1.5 US Cities with BRT or BRT Projects

BRT services have been implemented in over a dozen US cities (Figure 2-4). Some are relatively modest, but the more ambitious projects have been almost uniformly successful. A selection of those BRT systems follows.

Figure 2-4 US BRT Systems

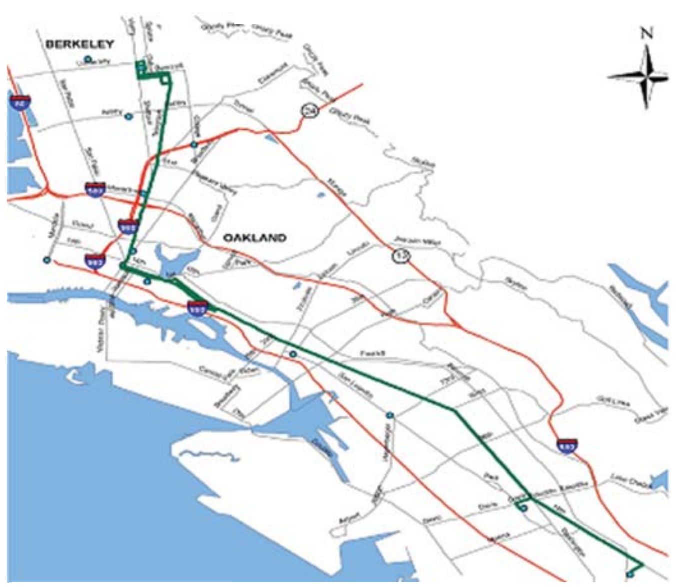


Figure 2-5 East Bay BRT Berkeley to San Leandro Route

2.1.5.1 Alameda Contra Costa Transit – East Bay BRT

The Alameda Contra Costa East Bay BRT project is programmed to open in 2011. It is more than 15 miles in length and features more than 35 stations (Figure 2-5). It is projected to cost $310 to $400 million when complete.

Projected ridership of this BRT system is from 42,000 to 49,000 weekday riders – over 14,000 more than the same corridor without BRT.

A 25-percent travel-time improvement is projected for users of the East Bay BRT project. As shown in Figure 2-6, this BRT project will convert the inner lanes and median of its route into a median busway.

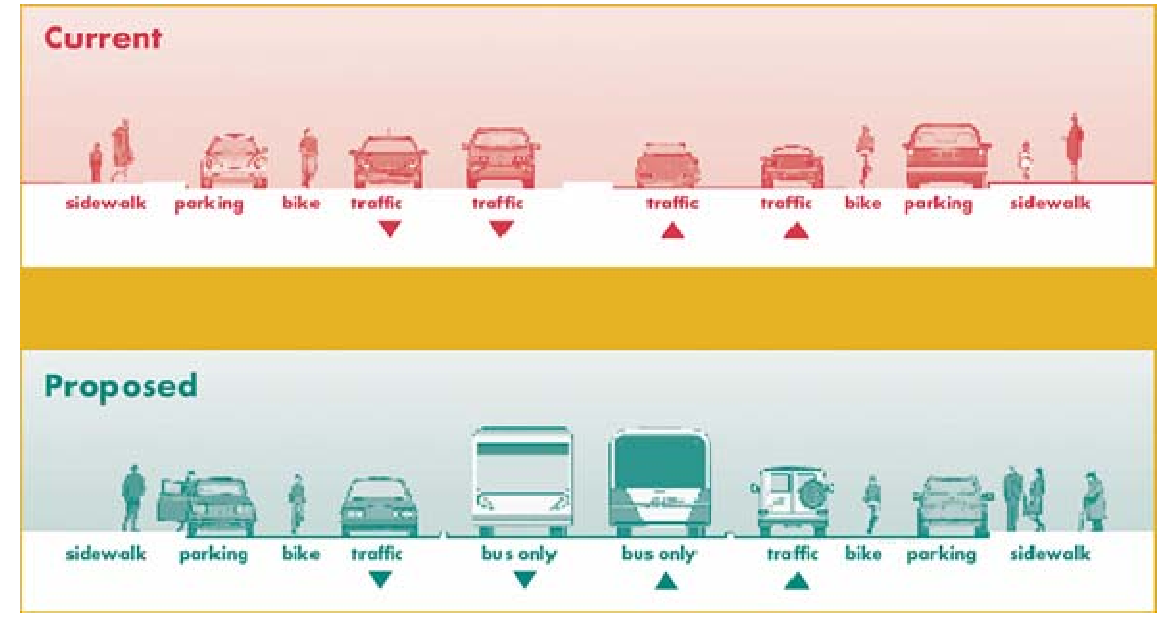


Figure 2-6 East Bay BRT Cross Section

2.1.5.2 Port Authority of Allegheny County

West Busway

The Port Authority of Allegheny County has three busways in addition to its LRT system and its extensive bus system. The West Busway extends from downtown Pittsburgh toward Carnegie and into the airport corridor to Pittsburgh International Airport (Figure 2-7). This corridor utilizes abandoned railroad ROW for much of its length, including a refurbished railroad tunnel.

The West Busway opened in 2000. It is five miles long and has six stations. It cost $258 million to construct and on an average workday carries more than 9,500 passengers on its 11 bus routes in 413 trips.

Figure 2-7 Pittsburgh West Busway

West Busway Station

Pittsburgh M.L. King East Busway Adjacent to Railroad

M.L. King East Busway

The M.L. King East Busway (Figure 2-8) is the longest of Pittsburgh's busways, at 9.1 miles, of which 2.3 miles were added in 2003. It opened in 1983 and has nine stations. The 2.3- mile extension cost $183 million. On an average weekday, 30,000 riders use this busway's 34 routes to access downtown Pittsburgh. This busway accommodates 943 bus trips on an average work day.

Figure 2-8 Pittsburgh M.L. King East Busway

South Busway

The South Busway is Pittsburgh's oldest, having opened in 1977. It has nine stops along its 4.3-mile length (Figure 2-9) and cost $27 million to construct. Sixteen bus routes use this busway to carry about 11,000 riders on an average weekday in 552 bus trips.

Figure 2-9 Pittsburgh South Busway

2.1.5.3 Greater Cleveland Regional Transit Authority

The Dual Hub Corridor project is a median busway along Euclid Avenue, as shown in Figure 2-10. It will connect downtown Cleveland and the University Circle area, a 10-mile-long corridor over which four bus routes will operate.

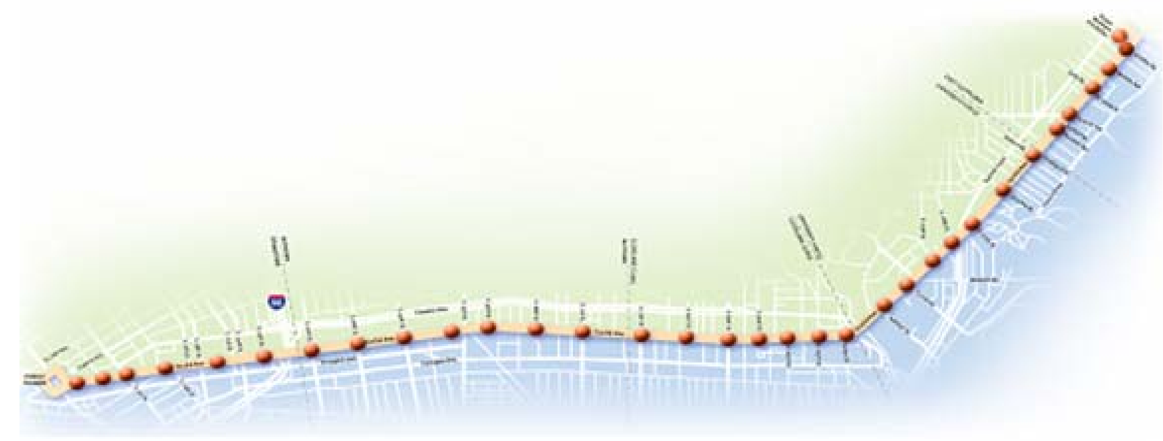


Figure 2-10 Dual Hub (Euclid) Corridor BRT Route

An integral part of the project is the planning for redevelopment and revitalization of the Euclid Corridor. The photo below conveys how this BRT project will fit into its urban setting.

Cleveland Dual Hub Corridor

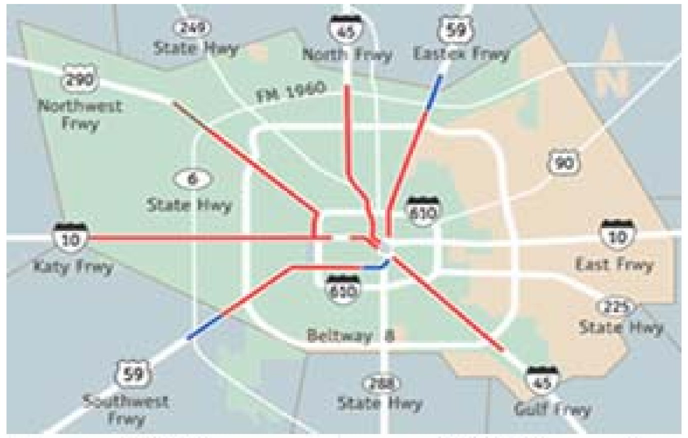
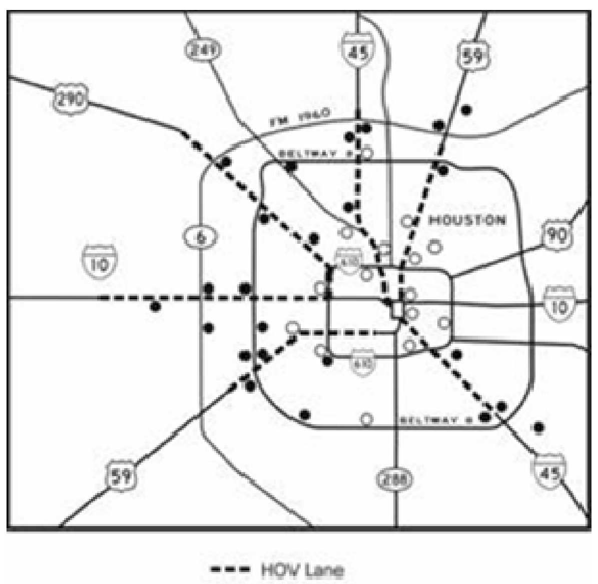


Figure 2-11 Houston Busway/HOV Network

2.1.5.4 Houston Bus/HOV System

Houston, Texas has an extensive busway/HOV system of 112.9 miles, extending in six corridors (Figure 2-11). This system features an extensive park-and-ride lot strategy that is used both for HOVs and bus passengers (Figure 2-12).

Because the system allows HOVs as well as buses on the guideway, the signage delineating where commuters are and are not allowed must be very clear; examples of such signage are shown below.



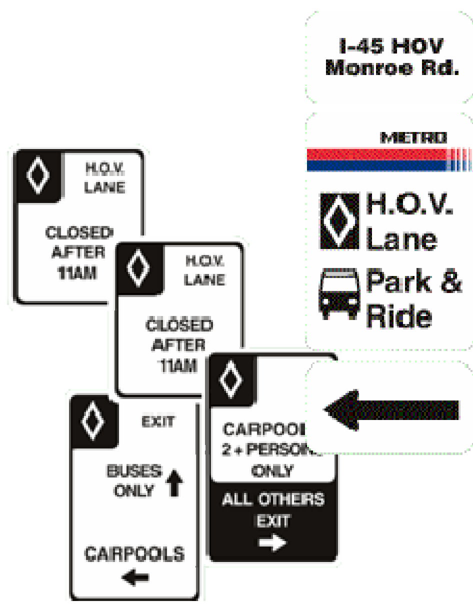


Figure 2-12 Houston Remote Park-and-Ride Lots

Houston Busway/HOV Guideway

2.1.5.5 Non-US BRT Examples

As discussed, there are many examples of successful BRT projects in the United States -- projects that have been developed in communities with similar economics, availability of automobiles, and commuting needs as exist in the Tappan Zee Bridge/I-287 Corridor. In addition, there are many notable examples of successful BRT systems in foreign cities, including:

- Ottawa, Canada
- Brisbane, Australia
- Curitaba, Brazil
- Bogota, Colombia
- Leon, France
- Mexico City, Mexico

BRT is a proven technology that can offer a viable alternative to other fixed-guideway transit modes.

2.2 Application of BRT Technology to the Tappan Zee Bridge/I-287 Corridor

The technology related to BRT that can be incorporated in this corridor includes the ITS technologies that are an integral part of all alternatives/options, and specific ITS applications that are particularly appropriate to BRT, including, but not limited to, vehicle-tracking and passenger-information technology. The HOT lanes would be fully monitored as part of the dynamic-tolling and volume-control technology, ramp metering with bus and HOV bypass are already included in the planning, and bus priority signals are being considered for all in-street operations of the BRT.

A BRT system has the flexibility to serve door-to-door journeys, eliminating transfers in many cases. This characteristic of BRT makes it attractive, especially for shorter journeys. This mode, with its inherent ability to deviate from a fixed path, also serves a greater number of markets. For example, in the Tappan Zee Bridge/I-287 Corridor, the Yonkers-to-White Plains or Spring Valley-to-Nanuet moves can be served by a one-seat ride on a BRT system.

A workshop was held on September 10 and 11, 2007 with panelists experienced in the planning and operation of BRT systems in Canada and Latin America, as well as the United States. At that workshop, the BRT alternative now described as Alternative 3 was explained to the panelists, who then developed a series of suggestions. Options 3A and 3B were developed in response to those suggestions, and are intended as enhancements to Alternative 3. The specific changes are:

- A trunk route was developed, serving all stations along the corridor, with frequent service using buses easily identified as "the BRT" throughout the day. The trunk route appears in the Service Plans for Options 3A and 3B as Route T, has five-minute peak-hour headways and 10-minute off-peak headways. The extensive network of routes developed in Alternative 3 was maintained, except that the routes would be feeders, terminating at the busway during off-peak periods with a transfer to Route T. During peak periods, they would join the busway and provide one-seat rides to most passengers.
- Additional stations were added, to provide a closer station spacing and easier access to the system. Stations were added at:

- Monsey, where Route 59 crosses I-287.
- Nyack, at Interchange 11.
- Broadway and Route 119 in Tarrytown (allowing a Tarrytown stop without diverting all buses to the Tarrytown Metro-North Station).
- White Plains Avenue east of the White Plains Central Business District.
- South Ridge Street in Rye Brook.
- Boston Post Road in Port Chester.

- Fewer routes were diverted to the Tarrytown Metro-North Station.

- The busway was extended all the way to the Port Chester Metro-North Station to provide convenient access to the New Haven Line, permitting a dependable trip to Connecticut destinations.

In Option 3B, the changes indicated above were incorporated into a full busway option, with exclusive grade-separated ROWs crossing Westchester County and serving the White Plains Transportation Center (WPTC).

2.3 Description of BRT Alternatives/Options

2.3.1 Alternative 3 – Full-Corridor BRT

Alternative 3 provides cross-corridor BRT service from Suffern to Port Chester, with a transfer to Tarrytown (Figures 2-13 and 2-14). It is described here because it was one of the preliminary DEIS alternatives identified in the *Alternatives Analysis Report* (January 2006) and is the basis for Option 3A. However, it is not further analyzed in the report, as Option 3A is an enhanced version of Alternative 3.

2.3.1.1 Rockland County

Alternative 3 in Rockland County primarily uses the HOV/HOT lanes as a busway sharing the lanes with high-occupancy vehicles-3 (HOV+3) and single-occupant vehicles (SOVs) willing to pay a toll. From the west, the HOV/HOT lanes would begin west of Interchange 14B (Airmont Road) in a reconstructed and widened the New York State Thruway (the Thruway) and continue uninterrupted across Rockland County, onto and across a rehabilitated or replacement Tappan Zee Bridge, through the toll plaza and ending just east of Interchange 9 (Tarrytown). The HOV/HOT lane toll would be adjusted to maintain uncongested flow, thereby ensuring that BRT travel times would be consistent with the service plans. Possible station locations along the BRT alignment are as follows:

Rockland County:	Downtown Suffern	Interchange 14A (Garden State Parkway)
	Airmont Road	Palisades Mall
Westchester County:	Tarrytown Metro-North Hudson Line Station	White Plains Transportation Center
	Meadow Street	Galleria Mall
	Benedict Avenue	Westchester Mall
	Elmsford West - Rte 9A	Corporate Park Drive–Platinum Mile
	Elmsford East - Knollwood Road	Westchester Avenue
	Westchester County Center	Port Chester Metro-North New Haven Line

Since downtown Suffern has no direct access to the Thruway, it could be served by converting a portion of the existing Piermont Line ROW into a busway from Route 202, Orange Avenue to Airmont Road, where buses could enter the HOV/HOT lane. The existing weekly freight service would continue on the Piermont Line ROW with no direct impact from the busway.

BRT stations in Rockland County are spaced approximately four miles apart and would generally be located near interchanges, in close proximity to major arterials, and where existing and/or proposed park-and-ride lots could allow commuters to easily transfer to buses. The proposed BRT stations would be located off the alignment, except for the downtown Suffern Station. Buses would access the stations by either bus-only dedicated flyover structures from the HOV/HOT lanes, or through drop ramps that exit into mixed traffic onto local arterials for short distances to and from the BRT stations.

Suffern Terminus and East of Suffern

A possible downtown Suffern BRT Station could be located on Route 202 at the NJTransit Suffern Station. Bus access to this station would be via a one-way loop on local streets, with a connection to the Piermont Line busway at Chestnut Street. BRT would run in a busway constructed in the Piermont Line ROW for approximately 2 miles to Airmont Road, where a possible BRT station would be located and would have access to/from the HOV/HOT lanes. The proposed station would include a park-and-ride facility south of the Thruway eastbound on-ramp, possibly at a site currently occupied by a commercial facility. Buses from the station heading east would exit the station onto Airmont Road, turn north to the center of the overpass, then turn east onto the drop ramp to enter the HOV/HOT lane. Buses from the Piermont Line would turn north onto Airmont Road and access the HOV/HOT lane using drop ramps. Since the service plan does not include buses from Orange County stopping at an Airmont Road Station, the proposed drop ramps would only provide HOV/HOT lane access to and from the east. Buses from the west would not have direct access to the station from the HOV/HOT lane.

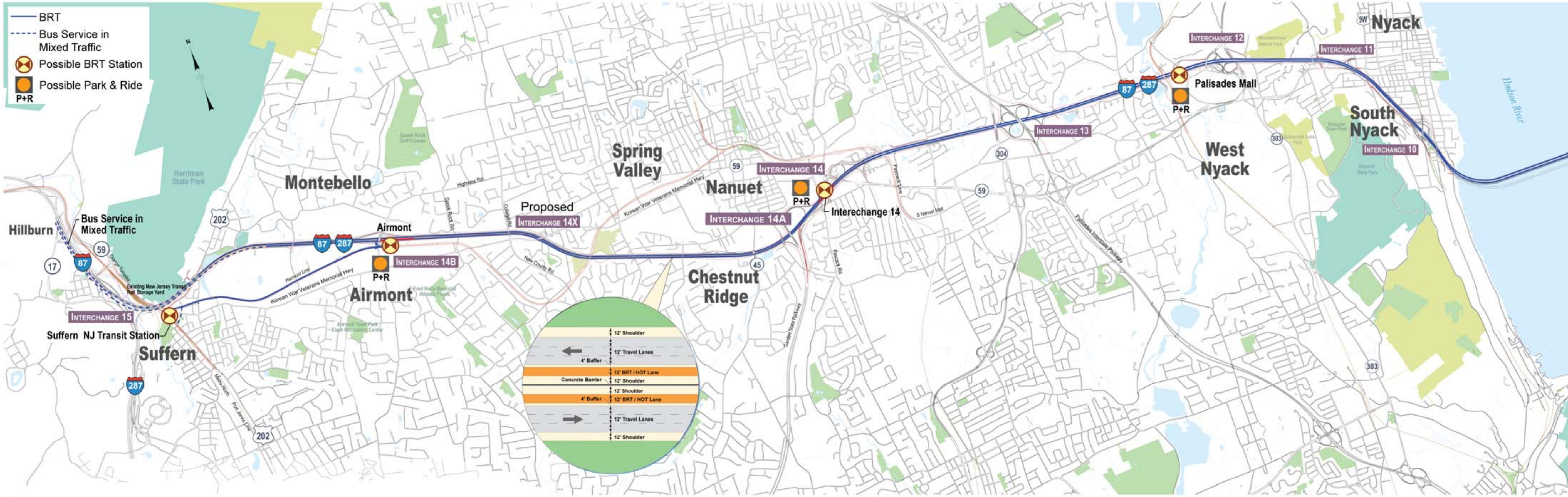
Spring Valley

East of Interchange 14B (Airmont Road), the BRT alignment would continue in the HOV/HOT lanes. A station that would serve Spring Valley would be located approximately 4.5 miles east of Airmont Road in the vicinity of Interchange 14A (Garden State Parkway). An existing park-and-ride facility on the north side of the Thruway, bordered by Route 59, Pascack Road and Forman Drive, could be expanded for additional parking, as required. Buses leaving a station at this location to access the HOV/HOT lane would proceed south on Pascack Road in mixed traffic to the HOV/HOT lane eastbound entrance ramp situated beneath the I-87/I-287 median. In an arrangement similar to that at Airmont Road, the HOV/HOT lane drop ramps would only service buses headed to or from the east. Station access to and from I-87 west would not be required based on the proposed service plan.

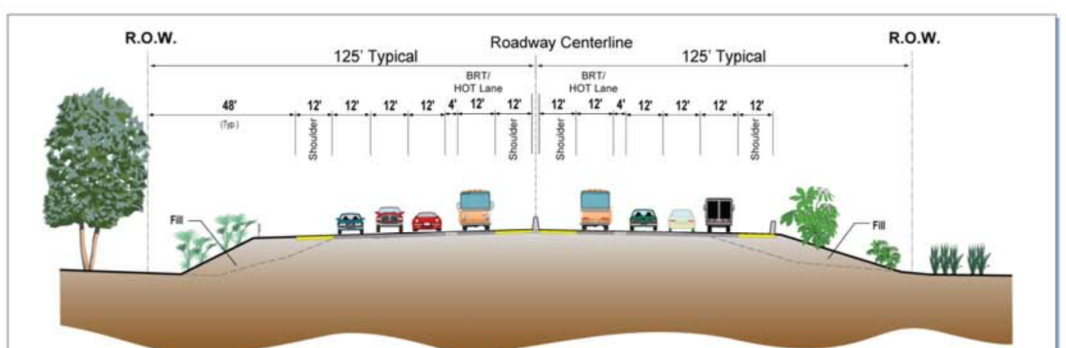
West Nyack and Nyack

The easternmost station in Rockland County would possibly be located at the existing park-and-ride lot at the Palisades Mall – commonly called Parking Lot J – which is located at the west end of the Mall. Access to this facility for commuters and potential feeder buses is through the perimeter "ring road" which circles the Mall. For buses in the HOV/HOT lanes, access to the facility would be from a "Texas T", which is an elevated intersection with a direct ramp over the highway into the station. Unlike the other Rockland County stations, the service plan would require bus access to this station from the west and would be provided with this ramp configuration.

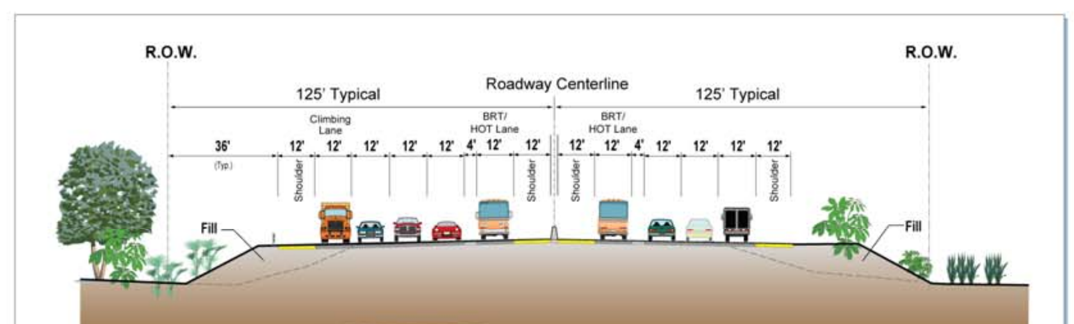
Other than from the three stations with their associated direct-access ramps, feeder-bus connectivity to the HOV/HOT lanes would be from two proposed "slip ramps" on I-87/I-287. These are located east of Interchange 13 (Palisades Interstate Parkway) and east of Interchange 11 (Nyack). Slip ramps would give buses in mixed traffic on the Thruway the opportunity to enter the eastbound HOV/HOT lane or exit the westbound HOV/HOT lane and follow their designated routes on local roads.



Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 3 - Rockland	0	0	71,300 ft	71,300 ft (13.5 Miles)

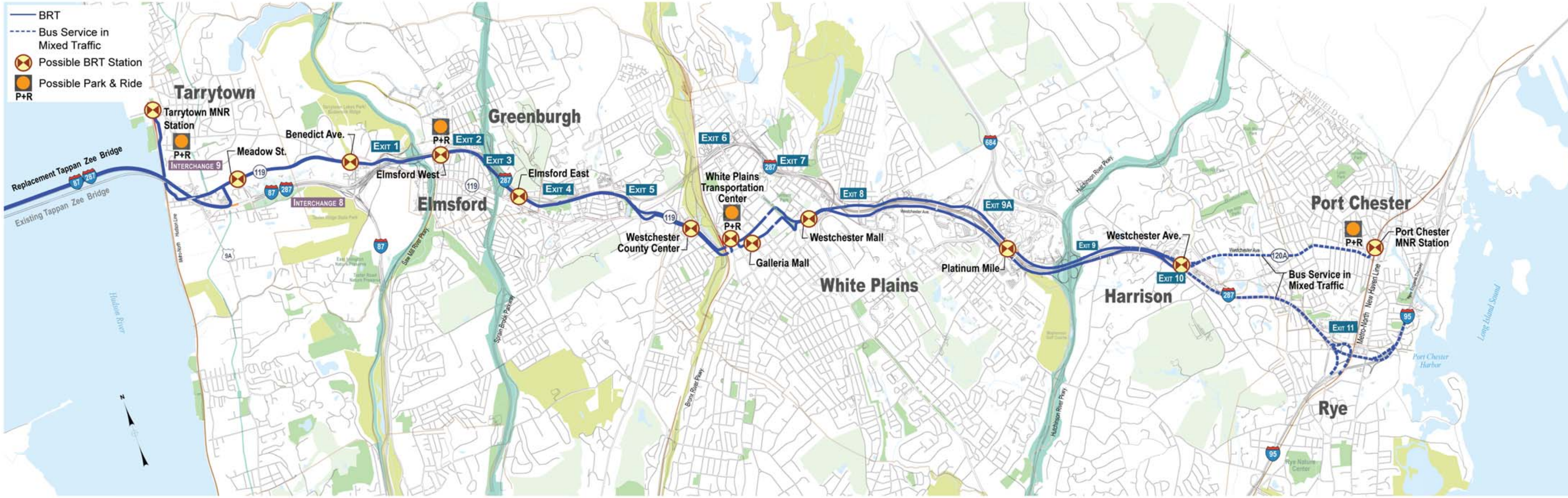


Typical Cross Section - Spring Valley
(Looking East)

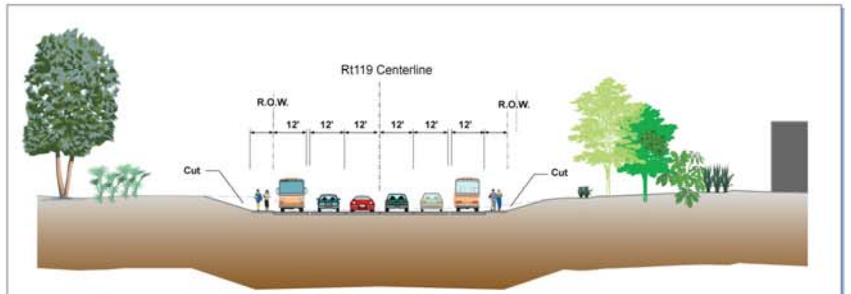


Typical Cross Section
Between Interchange 14A and Interchange 12
(Looking East)

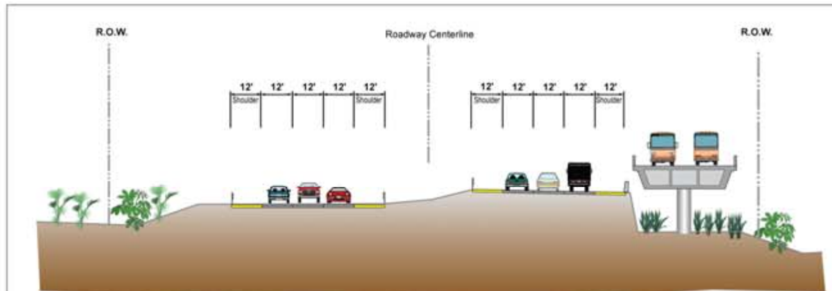
Figure 2-13 Alternative 3 – Full-Corridor Bus Rapid Transit in Rockland County



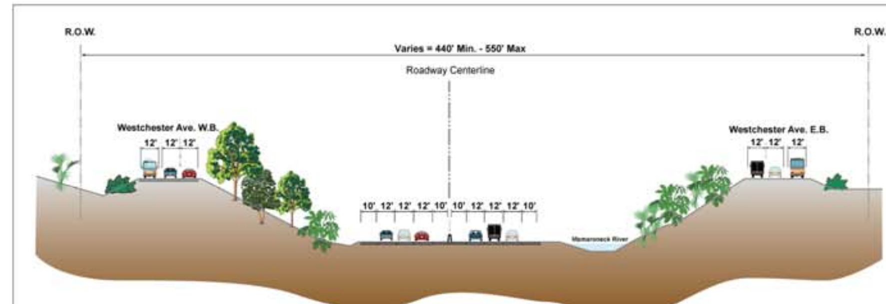
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 3 - Westchester	0	6,500 ft	43,500 ft	50,000 ft (9.5 Miles)



Typical Cross Section - Along Route 119 in Tarrytown
(Looking East)



Typical Cross Section in Elmsford
(Looking East)



Typical Cross Section - East of Exit 8
(Looking East)

Figure 2-14 Alternative 3 – Full-Corridor Bus Rapid Transit in Westchester County

2.3.1.2 Westchester County

Unlike the proposed highway improvements in Rockland County, which will feature the construction of new HOV/HOT lanes for BRT service, I-87/I-287 in Westchester County has been precluded from additional highway improvements, such as the addition of HOV/HOT lanes, based on the FHWA April 1998 ROD that provided selective safety and operational improvements along the highway. As a result, the BRT alignments in Westchester County are limited to the use of bus lanes on local roads, busways adjacent to I-287, and buses in mixed traffic where projected congestion levels determined in the AA process are considered light enough to allow buses to travel at speeds that would maintain their schedules. Providing BRT on local arterials has the advantage of providing more stations to serve local destinations, but overall travel times would be longer.

After crossing a rehabilitated or replaced Tappan Zee Bridge, the HOV/HOT lanes would terminate at Interchange 9 (Tarrytown), where a direct ramp connection would be provided from the HOV/HOT lanes to Route 119, White Plains Road in Tarrytown. Buses in the HOV/HOT lane would exit the highway and turn onto bus lanes with transit-signal priority along Route 119. Buses headed for the Tarrytown Metro-North Hudson Line Station would turn west onto Route 119, cross Broadway and continue on a new bridge spanning over the toll plaza, then turn north under the Tappan Zee Bridge approach and use a busway along the east side of the Hudson Line tracks that would run north into the Tarrytown Station.

BRT service not stopping at the Tarrytown Metro-North station would turn east onto Route 119 at Interchange 9 (Tarrytown) and stop at stations possibly located at Meadow Street and Benedict Avenue. To provide bus lanes on Route 119, the roadway would be widened from Broadway to the vicinity of White Plains Road (a distance of approximately one mile) to maintain the existing five-lane roadway configuration. East of Old White Plains Road, Route 119 widens, creating additional lanes, which allows taking the curb lanes for BRT without creating significant traffic impacts.

Continuing the use of bus lanes on Route 119 through Elmsford was considered, but rejected because of the heavily congested nature of the arterial and the negative impacts that would result from taking away the curb lanes for buses. Alternatively, an exclusive barrier-separated busway alignment adjacent to I-287 was developed. From Benedict Avenue this alignment would rise up on a viaduct and cross over I-287 at Exit 1 and continue east on the south side of the highway on a separate structure. A possible elevated station with parking – Elmsford West – would be located at Route 9A, Central Avenue (Exit 2). The busway would continue east on the south side adjacent to I-287 and drop down beneath the Sprain Brook Parkway (Exit 3) to an at-grade station – Elmsford East – possibly at the *Bed Bath and Beyond/Syms* shopping center just west of Knollwood Road (Exit 4). East of Knollwood Road the alignment adjacent to I-287 continues to Exit 5 (Hillside Avenue). Directly east of Hillside Avenue the busway would join the Exit 5 ramps and transition onto curbside bus lanes on Route 119 – Tarrytown Road for access into downtown White Plains. Transit-signal priority for buses would be provided at Route 119 intersections. A possible BRT station would be located near the Westchester County Center across from Central Avenue. The BRT lanes would cross over the Bronx River and under the Harlem Line as a one-way pair using Hamilton Avenue and Main Street, respectively, for access to and from the WPTC and for transfer to the Metro-North Harlem Line.

Several possibilities exist for BRT routes through downtown White Plains (see Subchapter 2.3.1.3 for more details). As yet there has been no consensus on the optimal BRT route through downtown. Discussions with the City and other stakeholders are expected to continue into the DEIS, and ultimately a final alignment will be established. Among those options under consideration, the option that has been exhibited at public open-house presentations has eastbound buses on Main Street and westbound buses on Hamilton Avenue, with transit-signal priority at all bus intersections. At Broadway both alignments would circle Tibbits Park and rejoin on Westchester Avenue. Two bus stations are proposed in downtown White Plains, with possible locations at the Galleria Mall and the Westchester Mall.

East of downtown White Plains, the alignment splits around Exit 8E and buses use dedicated lanes on Westchester Avenue. A possible Platinum Mile Station is proposed at Corporate Park Drive, and could include jitney service to the Platinum Mile and other corporate parks. Continuing east, a proposed station is possible at Exit 10, Westchester Avenue in Purchase. East of Purchase, the bus lanes would end and buses would either use Route 120A, Westchester Avenue for local service to downtown Port Chester and the Metro-North New Haven Line Station, or enter I-287 general-purpose lanes at Exit 10 and proceed to the I-95 interchange in mixed traffic for continued service north to Connecticut or south to New York City.

2.3.1.3 White Plains

A separate study (NYSDOT et al, August 2008) was conducted to compare alignment options for BRT routes in White Plains. As White Plains is the central hub of the corridor and traffic in White Plains is the most congested urban traffic in the corridor, special consideration was given to the routing through White Plains. Crossing White Plains from west to east, connecting to the WPTC and Metro-North Station and serving the other activity centers is not easily accomplished. Key destinations (Figure 2-15) include the Galleria Mall, White Plains Mall, and Westchester Mall, the complex of county buildings along Martine, and the White Plains City Hall.

The following criteria were developed and used to compare alignment options for BRT in downtown White Plains:

- **Minutes Run Time**: Walk time between Metro-North White Plains Station and Westchester Mall is about 22 minutes. Therefore, transit run times should be less than half walk times if they are to offer a serious advantage to travelers.

- **Split Service over One Block Apart**: Options that would run buses in different streets more than a block apart depending on the direction of operation (referred to in the table as split service) would have two undesirable traits, because split service would require use of different boarding and alighting locations for a given station. This would mean any destinations at the fringe of one route would be outside the limit of convenient walk distance from the other – meaning split stations would offer less coverage when convenience of the riders is considered. Furthermore, having to go to different streets to find a given station depending on the direction of travel can confuse users, particularly visitors.

- **180° Turns**: Sharp turns reduce speeds significantly. Depending on turn geometry and gradients, some tight turns could require use of wider turns, potentially impacting traffic in both directions. Doubling back on a route is inherently inefficient.

- **Length in Miles**: The shorter a route that provides equivalent coverage, the less costly and more efficient that route will be both to build and operate. Because BRT systems involve signal-system modifications, street modifications for paving, curb and gutter changes and drainage inlet redesign/replacement, the longer a route the more costly it will be to construct. Similarly, the longer the route, the more bus miles and time will be required to provide the same level of service, requiring more operating dollars as well. Therefore, length of route was used as a measure of higher costs – both operating and construction.

- **Walk Distances to Key Destinations**: Walk distances of ½ mile to transit are observed, but most transit users walk ¼ mile or less to their destinations/stations. Therefore, walk distance is a surrogate for ridership potential. The options that required walk distances substantially greater than ¼ mile were judged to offer less access than the others.

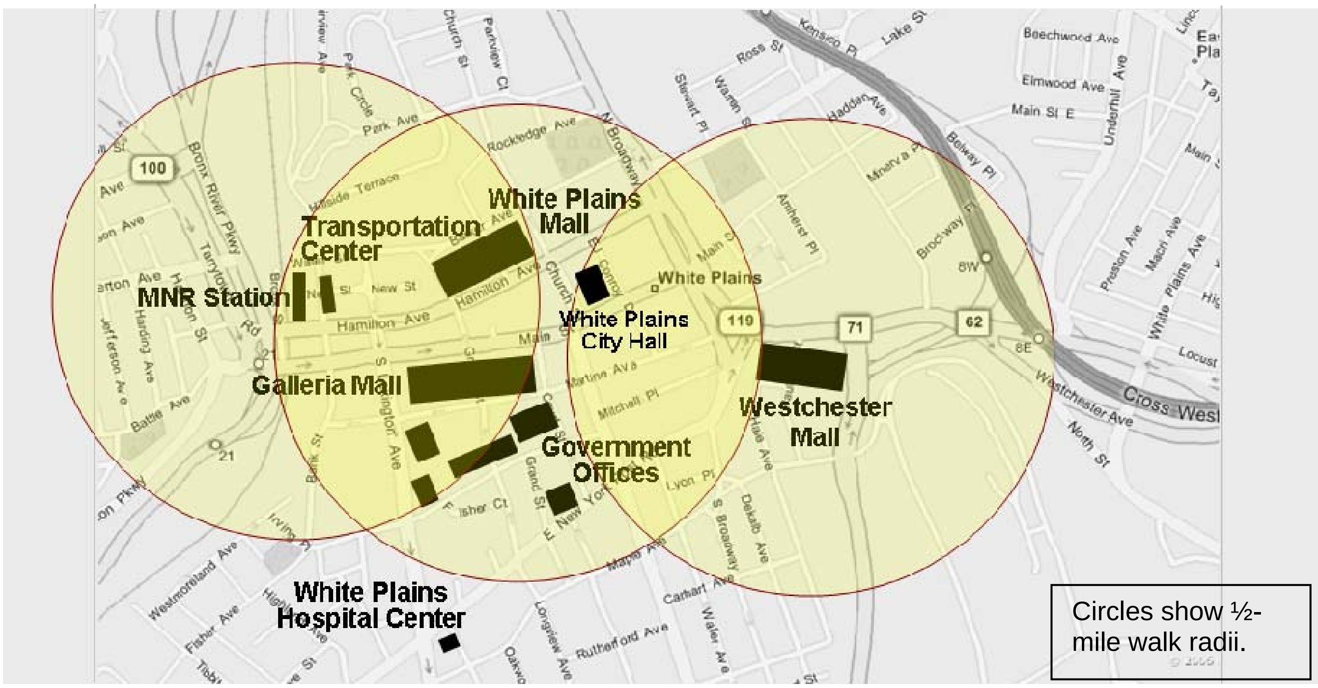


Figure 2-15 Key Destinations and Walk Distances in White Plains

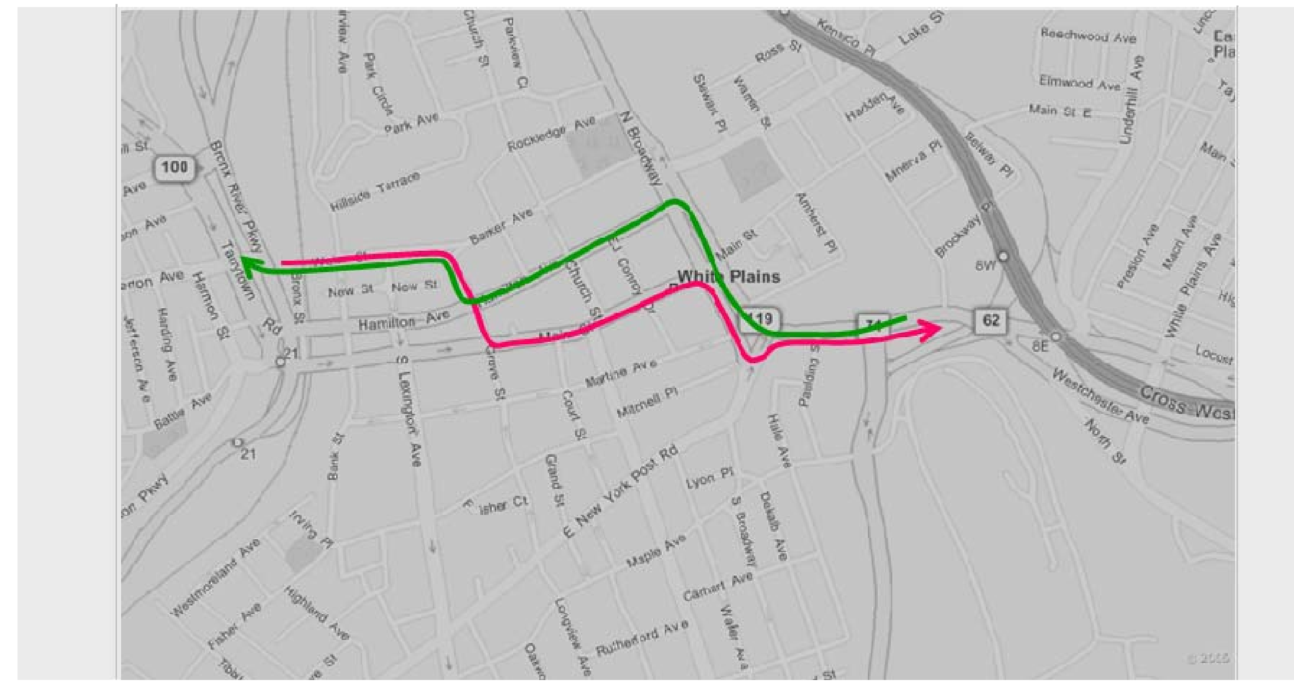


Figure 2-16 BRT White Plains Alignment Option 1

The alignment options considered use dedicated lanes on existing streets for the BRT operation, crossing streets at grade, and priority traffic signals. They were evaluated and compared, as shown in Table 2-1. Two of these alignment options – Options 1 and 3 – are being considered for further analysis (Figures 2-16 and 2-17). Variations of these alignment options may result from the detailed traffic analysis being performed in the DEIS. The alignment options not shown, each of which had significant operational, access, or service issues, generally followed these routes:

- **Option 2** – Main and Martine.
- **Option 4** – Main, Martine, and Grove.
- **Option 5** – Lexington, Maple, Church, and Barker.

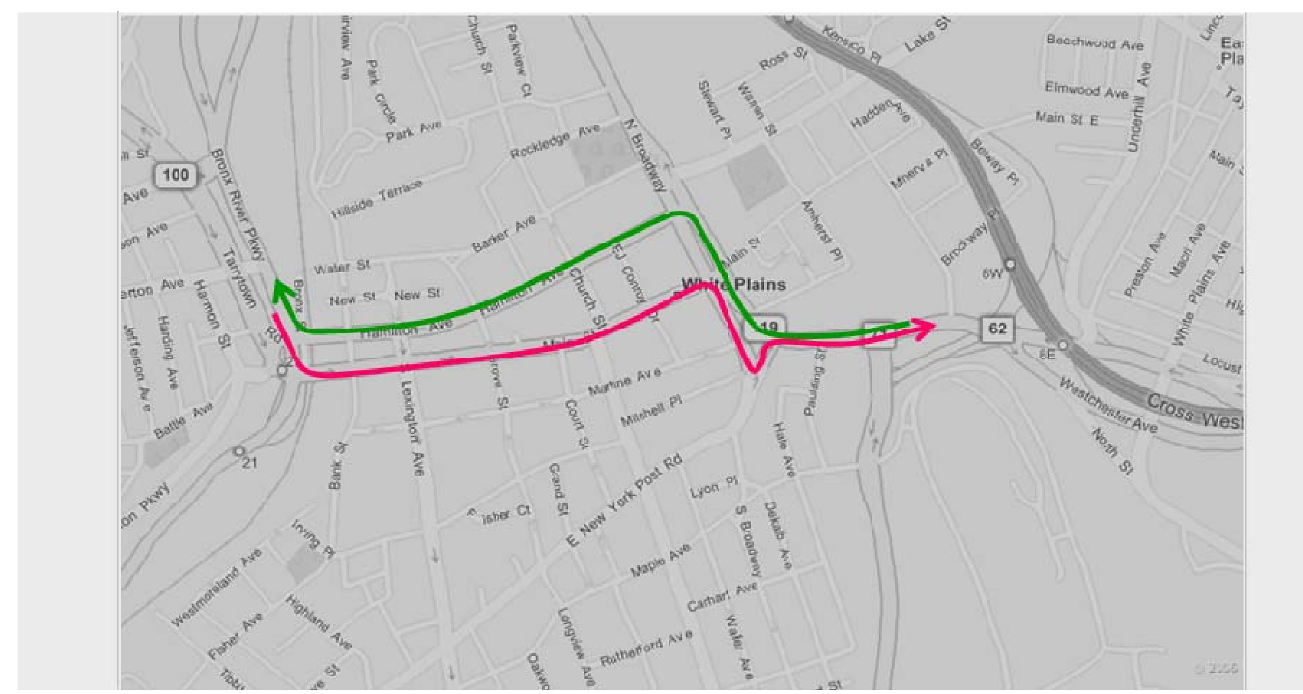


Figure 2-17 BRT White Plains Alignment Option 3

Table 2-1

BRT Alignment Options In White Plains - Performance Summary

Alignment Option	Minutes Run Time	Split Service Over 1 Block Apart	180° Turns	Length in Miles	Walk Distances to Key Destinations
BRT 1					
BRT 2			●		
BRT 3					
BRT 4		●	●		
BRT 5	●	●		●	●
Note: ● Does not meet criterion.					

2.3.2 Description of Option 3A

Option 3A improves the BRT service provided in Alternative 3 (Figures 2-18 and 2-19). This is accomplished by a number of methods, including more frequent headways, more bus stations, and improved running ways.

In Rockland County, the Option 3A improvements include enhanced service plans and two new stations: Route 59 in Monsey and Interchange 11 (Nyack). The Monsey Station would be an offline station, with parking possibly located just east of the Route 59 overpass and on the north side of the highway. Access from the HOV/HOT lanes to the station would likely be by direct flyover ("Texas T") similar to that proposed for access to Parking Lot J.

Establishing a possible Nyack Station at Interchange 11 would be challenging due to the combination of the highway geometry, the angle at which Route 59 passes under the Thruway, the Mountainview and Highland Avenue overpasses, and the interchange ramps. A possible layout would locate the station beneath the highway where it crosses Route 59 - Main Street. The Thruway would be widened an additional 30 feet approximately, to provide drop ramps from both directions to meet Route 59 at grade. Bus platforms and amenities would be provided on both sides of Main Street and transit-signal priority would be provided to allow buses to cross Route 59 without delay. An advantage of this layout is the ability of feeder buses to access the station and easily connect to the HOV/HOT lanes via the drop ramps.

In Westchester County, Option 3A would provide additional stations and a busway alignment east of White Plains that includes a direct connection to the Metro-North Port Chester Station. The proposed new stations could be provided at these possible locations:

- Broadway in Tarrytown.
- Hillside Avenue.
- White Plains Avenue at I-287.
- South Ridge Street in Rye Brook.
- Boston Post Road at the I-95 Interchange.

The Westchester County BRT alignment for Option 3A would remain basically unchanged through Tarrytown, except that a possible BRT station would be provided at Broadway and Route 119. In Elmsford directly after Knollwood Road, the Option 3A alignment on the south side of I-287 would cross over to the north side to create a possible station with parking located west of Hillside Avenue.

Directly east of Hillside Avenue, the busway would cross over I-287 and join the Exit 5 ramps to connect to bus lanes on Route 119 – Tarrytown Road, as proposed in Alternative 3. Although optional bus routes to the WPTC and through downtown White Plains will be investigated, the possible station locations would not appreciably change and the running times would be consistent with the service plans.

East of White Plains the bus lane arrangement on Westchester Avenue, as provided in Alternative 3, would continue to Exit 10, but a transition to a barrier-separated busway would begin at Exit 10 and continue to a direct connection to the Metro-North Port Chester Station. The busway would be located along the north side of I-287, with new on-line stations at South Ridge Street and east of Boston Post Road adjacent to the shopping center. East of this station the busway would turn north and parallel the west side of the Metro-North New Haven line and terminate at the Port Chester Station. Buses continuing north or south on I-95 would enter general-purpose lanes on I-287 at Exit 10.

2.3.3 Description of Option 3B

Option 3B in Westchester County would provide a busway with an independent alignment from the Hudson River crossing to Port Chester. Some essential elements of a BRT system that have been added include trunk line stations and feeder-bus connectivity. The infrastructure necessary to maintain a high-speed trunk line with minimal interference from general-purpose traffic on I-287 and local arterials has been provided. In Rockland County, Option 3B would be the same as Option 3A. The busway is described in segments across Westchester County (Figures 2-20 and 2-21) below.

2.3.3.1 Tarrytown to Interchange 8

Upon entering Westchester County in a HOV/HOT lane across a replacement or rehabilitated Tappan Zee Bridge, the first important destination is the Metro-North Hudson Line Tarrytown Station. The Option 3A plan to access the Tarrytown Station would have buses exit at Interchange 9 (Tarrytown) in the HOV/HOT lanes, then turn west onto dedicated lanes on Route 119, and cross Broadway to enter a busway that would extend to the Tarrytown Station. The concept developed for Option 3B would drop the BRT lanes just below a widened toll plaza to a lower-level, open-cut roundabout with a short tunnel link to a busway on the north side of the toll plaza. The busway would follow the same alignment proposed in Option 3A along the east side of the Hudson Line to the Tarrytown Station. The HOV/HOT lanes would remain at the toll plaza grade and bypass the lower level busway. Impacts of this concept include a wider toll plaza to allow for the drop ramps and retaining walls. Advantages of this concept include faster access to the Tarrytown Station and elimination of the need for bus lanes on Route 119 from the exit ramp to Broadway.

A possible trunk line station is proposed at Broadway, located just west of the Broadway overpass, and at the same lower level as the roundabout. Passenger access to the station would be from the west side of a widened Broadway Bridge down to the bus platforms.

East of the Broadway Station buses would join the HOV/HOT lane and exit ramp at Interchange 9 (Tarrytown), but just after the exit ramp passes over the I-287 westbound lanes, buses would traverse an elevated roundabout on the north side of I-87/I-287. From the roundabout, buses could continue north and exit onto Route 119 and become feeder buses, or head east from the roundabout and enter a busway on a viaduct adjacent to the north side of I-87/I-287. The viaduct would be within the I-87/I-287 ROW as it passed the Talleyrand Swamp toward Interchange 8.

Approaching Interchange 8, the busway alignment would have two options. The alignment option that would provide a preferred station location would curve to the north out of the I-87/I-287 ROW and transition to grade for a possible Benedict Avenue Station just south of Route 119. Buses could bypass the Benedict Avenue Station if it is not on their service plan. This alignment and station location would require property acquisition and/or easements between I-287 and Route 119. The second option would maintain the alignment along the north side of Interchange 8 on a viaduct, with a possible station located on the alignment at the rear of the commercial properties abutting the interchange.

It is important to note that the Option 3B alignment adjacent to I-287 would preclude a possible station at Meadow Street and Route 119, but this station could still be served by feeder buses that would have access to the busway at Broadway/Route 119 or further east, at Route 9A.

2.3.3.2 Interchange 8 to Route 9A

Heading east from the Benedict Avenue Station, the busway would transition onto a viaduct and cross over Route 119 and then continue on the north side of I-287 to cross the Saw Mill River valley. A possible Elmsford West Station would be located at Route 9A, Central Avenue. The busway would drop down beneath the westbound I-287 Exit 2 ramps through cut-and-cover bridge sections to bring the BRT to an at-grade crossing with Route 9A just north of I-287. Transit-signal priority would allow buses to cross Route 9A without delay.

The Elmsford West Station here would be an on-line, at-grade station, thus allowing feeder buses that currently operate on Central Avenue direct access to the busway. The BRT station would be located with platforms on both sides of Route 9A to provide pedestrian access to the eastbound and westbound buses prior to the bus crossing Route 9A. Park-and-ride lots could be constructed on either side of I-287 in this area. If the service plan modifications were to dictate that some BRT routes would bypass this station, the station could include pull-out bays for buses that would be stopping, and center bypass lanes for through buses.

2.3.3.3 Route 9A to White Plains

Proceeding east through Greenburgh, possible stations are proposed in the vicinity of Knollwood Road (Elmsford East), and Hillside Avenue, in addition to a direct connection to the WPTC.

Between Route 9A and the Sprain Brook Parkway, the busway would be on the north side of I-287 in a retained-cut and then in cut-and-cover bridge section beneath the Sprain Brook Parkway (Exit 3). Between the Sprain Brook Parkway and Knollwood Road the busway would be at grade and through cut-and-cover bridge sections under the westbound I-287 Exit 4 ramps at Knollwood Road. A possible Elmsford East Station would be at grade adjacent to I-287 and below the elevation of Knollwood Road. Pedestrian access to the station would be provided from the bus platforms up to a station facility constructed on the west side of the Knollwood Road overpass.

East of Knollwood Road, the busway would climb on a viaduct to the elevation of I-287 and then rise again as it approached a possible elevated Hillside Avenue Station on the north side of I-287. A proposed park-and-ride facility could be located on the north side of I-287 adjacent to the station; pedestrian access would be provided from Hillside Avenue up to the elevated bus platforms.

Continuing east of the station, the elevated busway would cross over Hillside Avenue and I-287, then follow alongside I-287 on the south side, at the same elevation as the existing I-287 viaduct over the Bronx River Parkway. In Alternative 3 and Option 3A, the BRT alignment transitions onto Route 119 at Exit 5 to access the WPTC and downtown destinations. In Option 3B, a busway from I-287 would be provided for direct access to the WPTC and thereby eliminate possible traffic impacts to Route 119. In this option, an elevated busway "T" intersection would be provided just west of where I-287 passes over the Metro-North Hudson Line, to allow buses to turn south on a viaduct then down to grade along the west side of the Metro-North Hudson Line. A short tunnel under the Harlem Line embankment would be provided for the buses to drive onto Water Street to access the WPTC. Depending on the service plan, buses would either return to the I-287 busway on the viaduct, bypassing downtown, or continue through downtown White Plains in bus lanes, as provided in Alternative 3 and Option 3A.

East of the elevated "T"-intersection, the busway would drop down beneath the two eastbound I-287 Exit 6 ramps at North Broadway (Route 22) through cut-and-cover bridge sections to bring the BRT down to the elevation of I-287 and pass beneath North Broadway. The busway would rise onto a viaduct between the North Broadway eastbound I-287 entrance ramp and Grant Avenue, along the south side of I-287, and continue over all crossing streets. East of Brockway Place, the alignment drops down beneath the four existing eastbound and westbound Exits 8W & 8E Interchange ramps, and then rises again onto a viaduct just west of White Plains Avenue.

2.3.3.4 East of White Plains to Port Chester

East of downtown White Plains, the elevated busway would pass over White Plains Avenue to enter a proposed White Plains Avenue Station, which would be on a retained fill and possibly located between the south side of I-287 and Westchester Avenue. This station would have central bypass lanes.

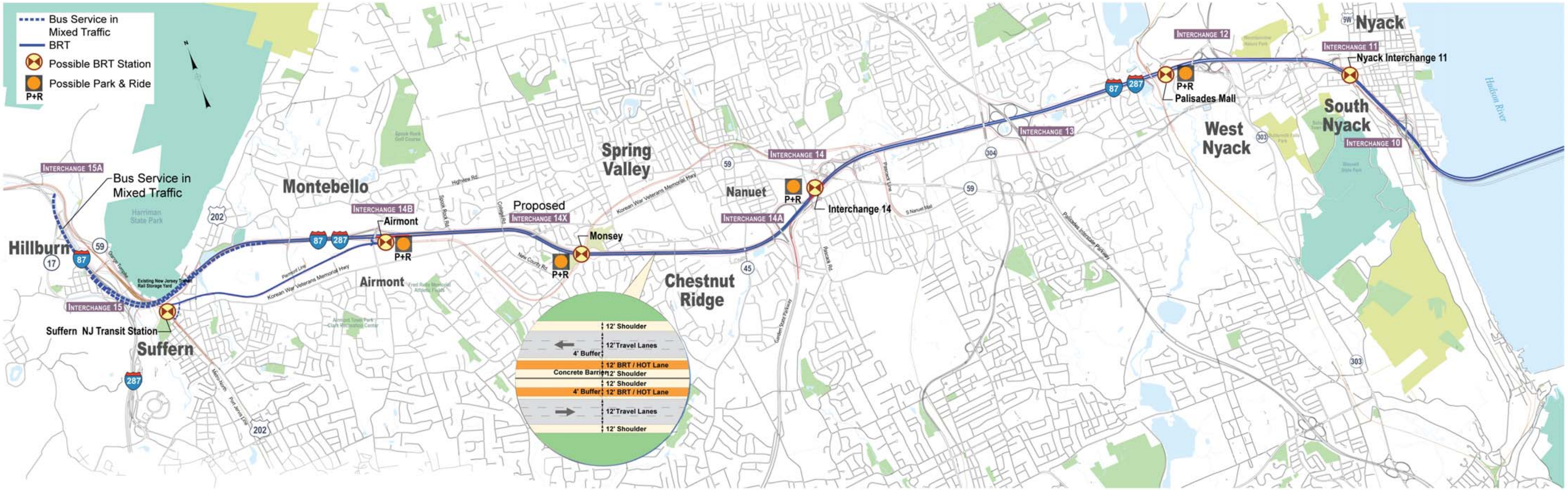
The busway would continue east on elevated viaduct located along the south side of I-287, cross over Bryant Avenue, and then drop down to a possible at-grade Platinum Mile Station. The station could have curb frontage along Westchester Avenue to facilitate connection to jitney service to the Platinum Mile and other corporate parks. Beyond the station, the busway would rise back onto elevated viaduct and follow along the south side of I-287, except where it would swing south along the outside of the eastbound I-287 ramps of the Hutchinson River Parkway (Exit 9) Interchange. The busway would remain elevated on the south side of I-287 and cross over to the north side of I-287 just west of Exit 10, where Westchester Avenue (Route 120A) turns north to Port Chester. A connection to grade would be provided to Westchester Avenue at this location to provide access for feeder buses on Westchester Avenue to the busway.

The busway would continue along the north side of I-287 on viaduct, with a possible elevated station just east of Westchester Avenue. The station would provide for pedestrian access to the elevated bus platforms from a possible park-and-ride site within the parking lot of a commercial property on Webb Avenue. This station would include central bypass lanes for through buses and pull-out bays for buses that would be stopping.

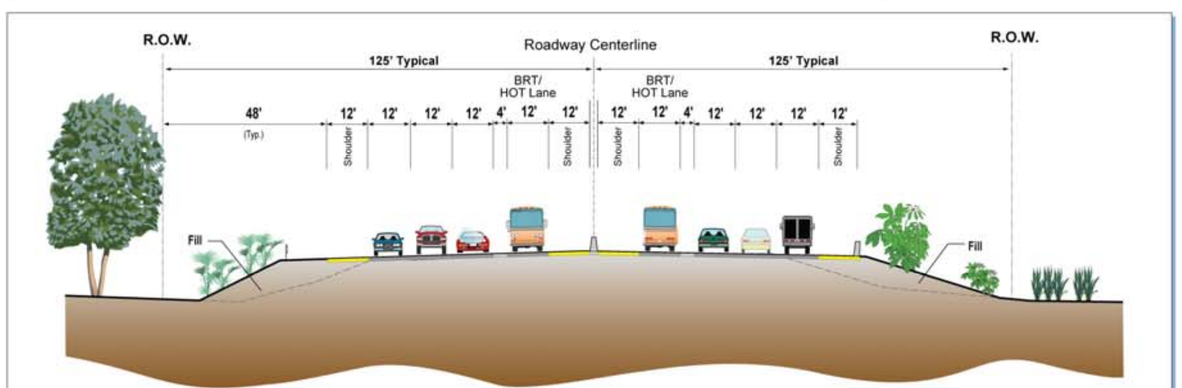
Between Bowman Avenue and South Ridge Street, a connection to the I-287 eastbound and westbound general-purpose lanes is provided for buses leaving the busway and continuing on I-287 to the I-95 Interchange. The I-287 roadway would require approximately 30 feet of widening in this area to provide for the connection.

Just west of South Ridge Street, the elevated busway would continue to a possible South Ridge Street Station, which would be on a retained fill north of I-287. This station would have central bypass lanes. The elevated busway would pass over South Ridge Street, High Street, and Boston Post Road, and drop down to a possible Boston Post Road Station, which could be located north of I-287 along the south side of the shopping center, and could include provision for parking.

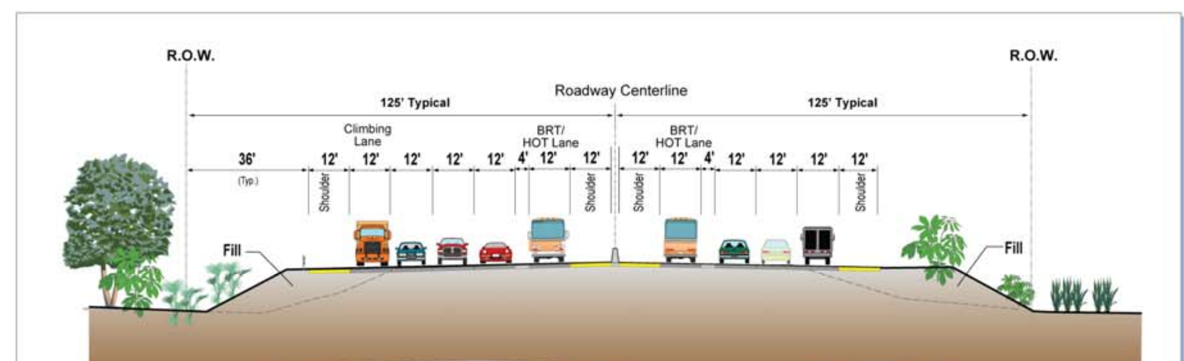
From the Boston Post Road station, the busway, in a dedicated alignment, would turn north and parallel the west side of the Metro-North New Haven Line, mostly at grade, and cross over Westchester Avenue and terminate at the Port Chester Metro-North Station.



Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Option 3A - Rockland	0	0	71,300 ft	71,300 ft (13.5 Miles)

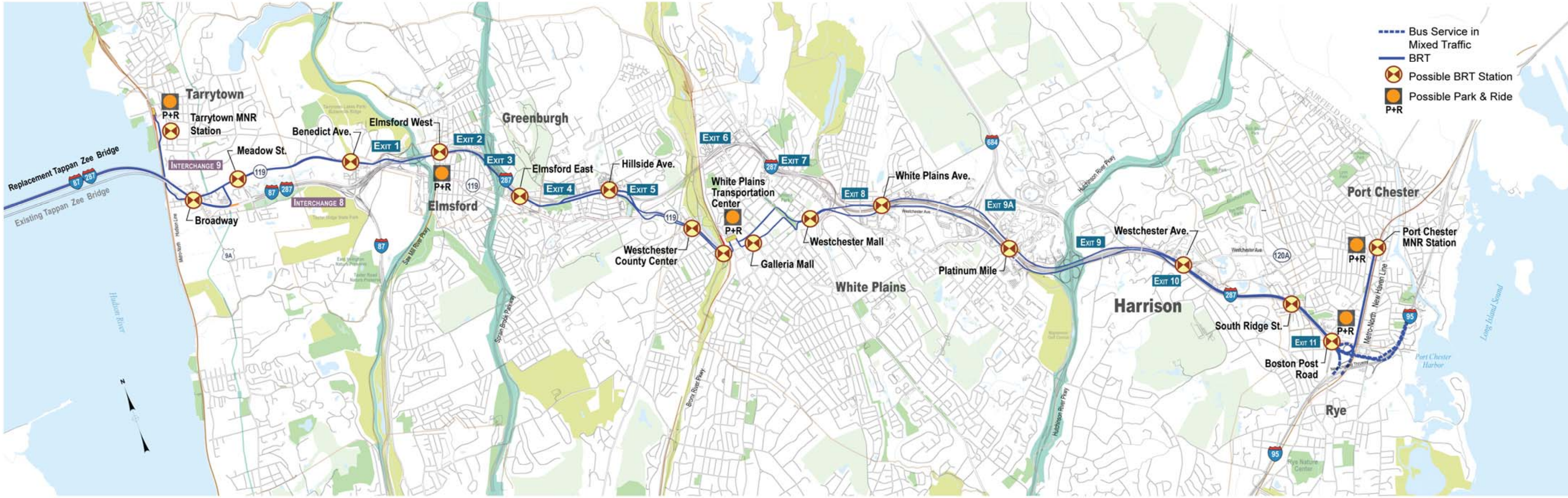


Typical Cross Section - West of Spring Valley
(Looking East)

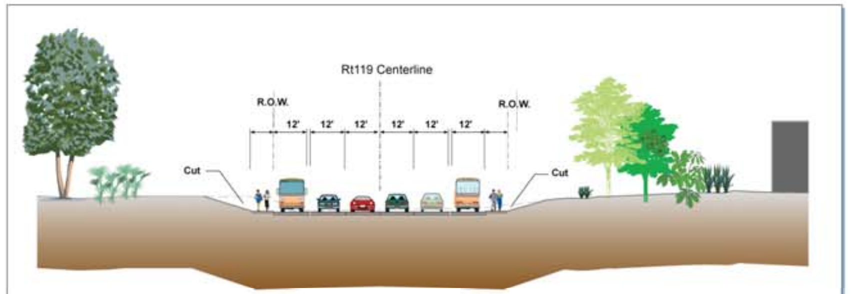


Typical Cross Section
Between Interchange 14A and Interchange 12
(Looking East)

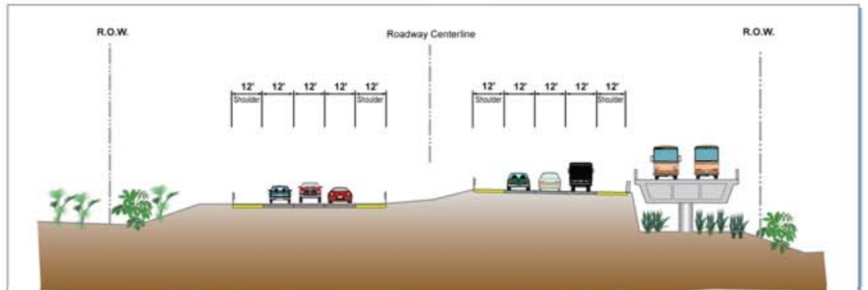
Figure 2-18 Option 3A - Full-Corridor Bus Rapid Transit in Rockland County



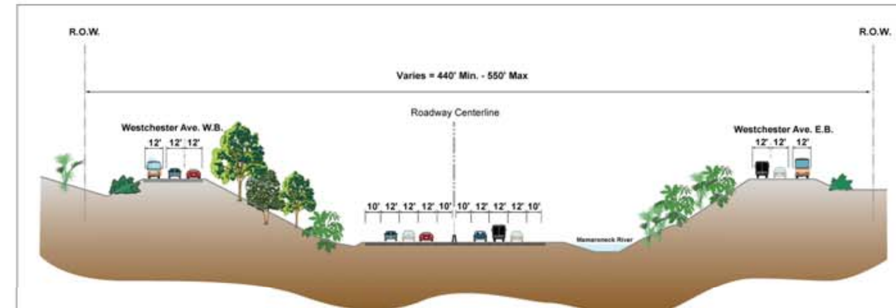
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Option 3A - Westchester	0	9,200 ft	65,700 ft	74,900 ft (14.2 Miles)



Typical Cross Section - Along White Plains Rd. (Route 119)
(Looking East)

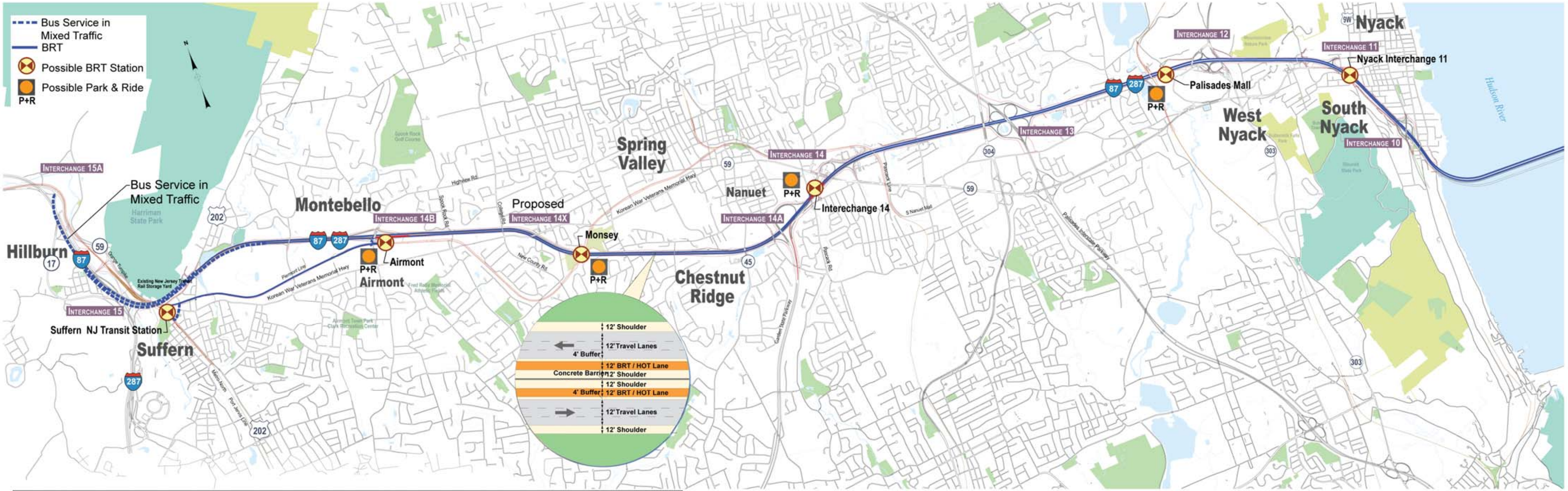


Typical Cross Section in Elmsford
(Looking East)

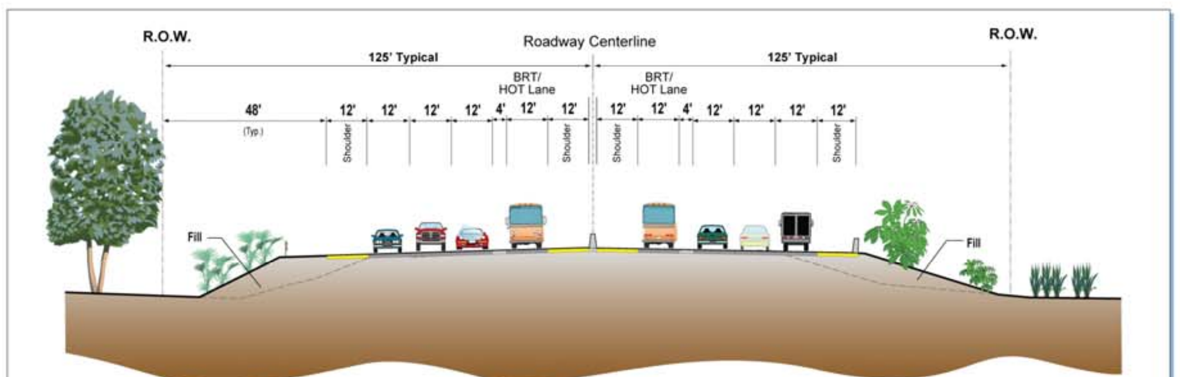


Typical Cross Section - East of Exit 8
(Looking East)

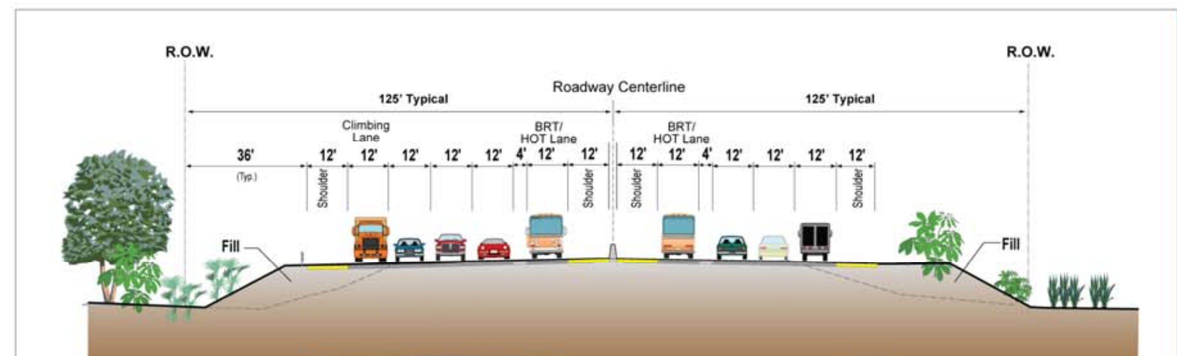
Figure 2-19 Option 3A – Full-Corridor Bus Rapid Transit in Westchester County



Alignment Quantities				
	Tunnel	Viaduct/Major Bridge	At Grade, Cut, or Fill	Total
Option 3B - Rockland	0	0	71,300 ft.	71,300 ft. (13.5 Miles)



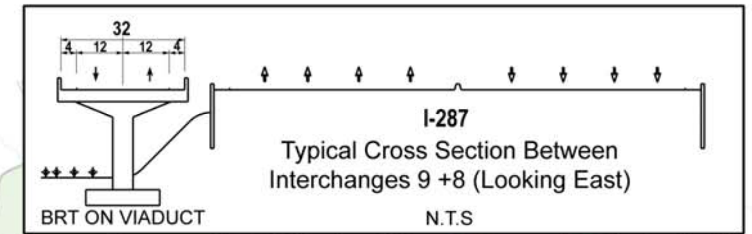
Typical Cross Section - West of Spring Valley
(Looking East)

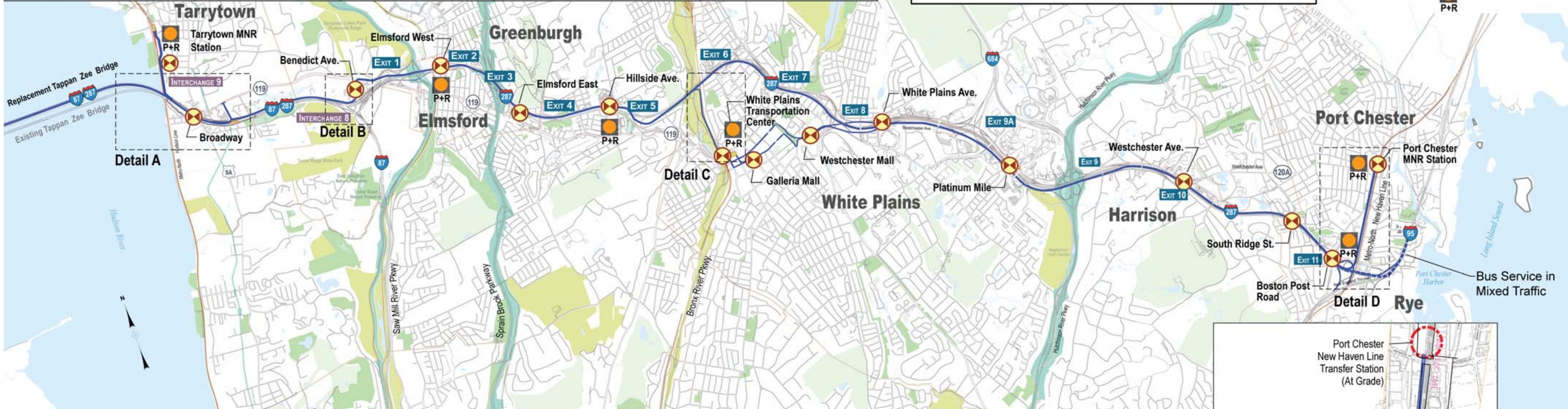


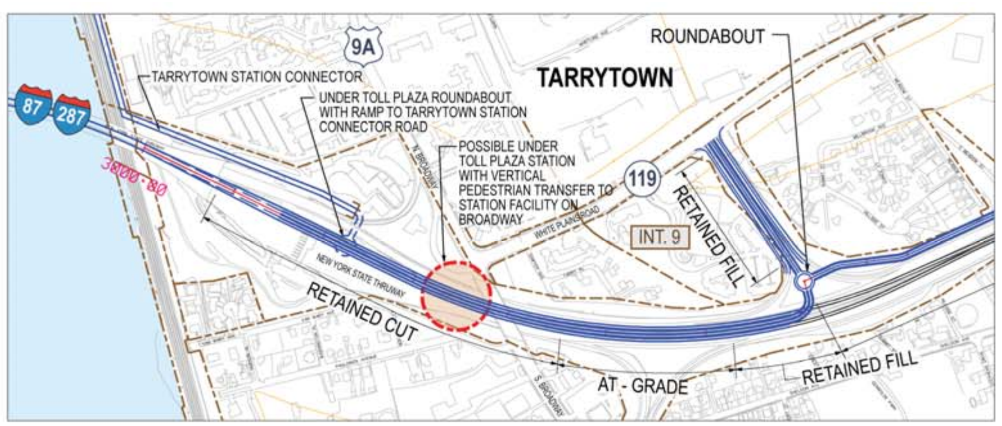
Typical Cross Section
Between Interchange 14A and Interchange 12
(Looking East)

Figure 2-20 Option 3B – Full-Corridor Bus Rapid Transit in Rockland County

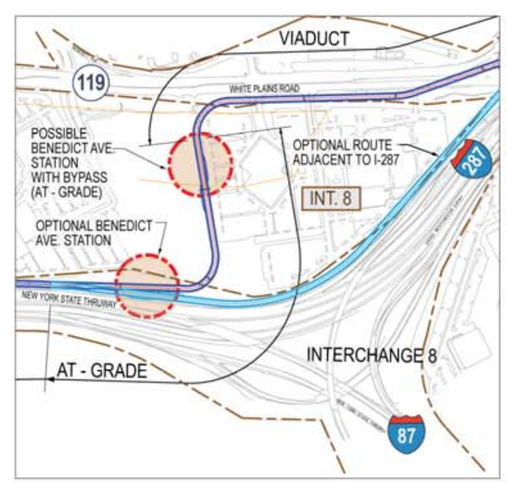
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Option 3B - Westchester	4,000 ft	49,800 ft	26,300 ft	80,100 ft (15.2 Miles)



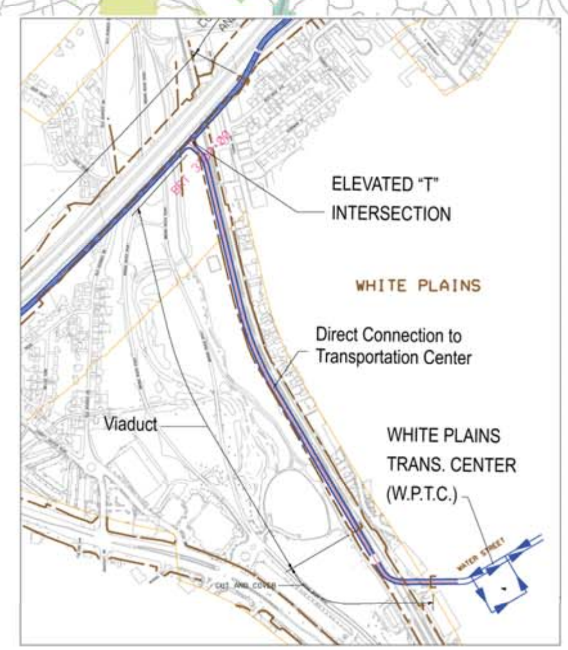




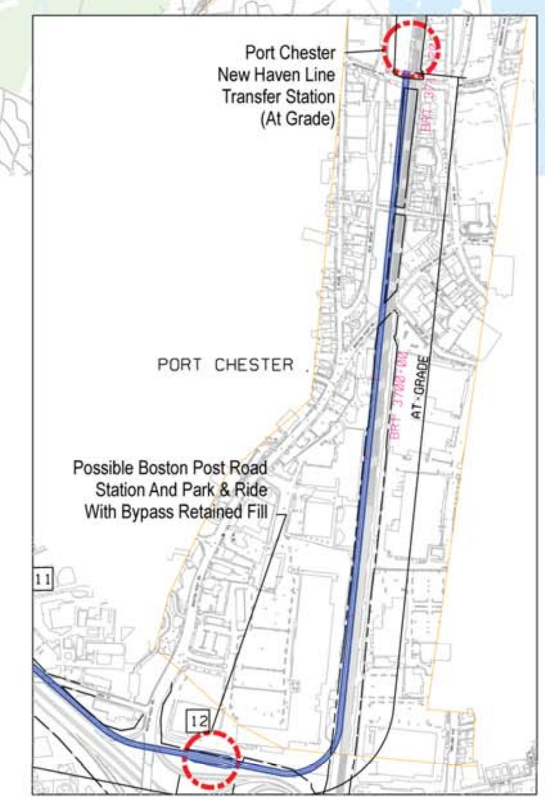
Detail A: BRT AT INTERCHANGE 9 - TARRYTOWN



Detail B: ALIGNMENT + STATION OPTIONS AT INTERCHANGE 8



Detail C: BRT ALIGNMENT I287 TO W.P.T.C.



Detail D: BRT ALIGNMENT TO PORT CHESTER STATION

Figure 2-21 Option 3B – Full-Corridor Bus Rapid Transit in Westchester County

2.4 Rockland County Busway

The *Alternatives Analysis Report* (January 2006) concluded that increased mobility in Rockland County utilizing I-287 could be achieved by providing HOV/HOT lanes that would also serve a BRT system with offline stations connecting to key locations along the corridor. While a Rockland County busway had not originally been considered in the analysis of transit modes, additional input during the scoping process has led the Project Sponsors to include a busway in the alternatives to be studied in the DEIS.

2.4.1 BRT Workshop and Public Input

When presented to county planners and to the public in February 2007, the transit solution that incorporated a BRT system in HOV/HOT lanes in Rockland County and bus lanes and mixed traffic in Westchester County was considered to be less than a full BRT system. As a result, a BRT Workshop was convened in September 2007 by the Project Sponsors, employing BRT experts to share their knowledge and experience in BRT planning. The feedback from the experts focused on service plans, stations, running ways and other BRT elements. Their main concern echoed that of the county planners and the public with respect to the use of bus lanes and HOV/HOT lanes for a BRT system. The experts agreed that the use of such travel ways would compromise BRT service levels. The panel suggested that separate busways would provide more efficient BRT service and would better serve transit users; they advanced a number of arguments to support their position.

Based on the discussions at the workshop, the Project Sponsors made revisions to the BRT service plan, leading to the development of Options 3A and 3B, which included a dedicated busway in Westchester County. The HOV/HOT lanes in Rockland County were retained because it was believed that the BRT system operating within the HOV/HOT was an effective transit solution that also offered increased mobility to HOV and those SOVs willing to pay a user fee. Furthermore, there was insufficient space within the I-87 / I-287 right-of-way to include a busway in addition to the HOV/HOT lanes and CRT as proposed in Option 4D, and the acquisition of additional land across the corridor to accommodate all three components would have significant environmental and cost implications.

When these alternatives/options were presented to the public during the scoping update process timeframe for the DEIS, there were additional comments restating that the multi-use HOV/HOT lanes, like the bus lanes on streets in Westchester County, were a “lesser” BRT solution and that only a busway would provide the level of service cross corridor that CRT provided for Manhattan-bound transit users. The concern expressed was that the Project Sponsors were comparing costly CRT solutions to BRT solutions that were not fully BRT in that buses were not in an exclusive travel way, thus not providing BRT in the true sense. Several members of the public also saw a busway as enhancing the potential for transit growth in the corridor and Orange County.

As a result, when the transit mode recommendation for the project was made, the Project Sponsors concluded that a busway in Rockland County should be considered to complement the proposed busway in Westchester County. This would permit an analysis of the effectiveness and impacts of a complete cross-corridor BRT busway compared to a cross-corridor BRT system using HOV/HOT lanes in Rockland County and bus lanes in Westchester County, and other travel way combinations. With the inclusion of a busway, the highway improvements in Rockland County would not include HOV/HOT lanes because the I-87/I-287 right-of-way is inadequate to accommodate all three components (HOV/HOT lanes, dedicated busway, and CRT).

Thus, the DEIS will consider cross-corridor BRT transit service comparable to rail, with the BRT advantages of flexibility and the ability to serve off-corridor destinations necessary for the variety of cross-corridor markets, the ability to better serve the White Plains central business district (CBD), and the ability to increase the number of stations across the corridor to provide increased accessibility to the residents and activities in the corridor. This was responsive to the suggestions of the expert panel at the workshop, responsive to the public comments from the scoping process, and responsive to the concern for balance between:

- Manhattan and cross - corridor markets.
- Rockland and Westchester improvements.
- High speed operation and one-seat rides.

The DEIS will also include an analysis of project alternatives with respect to differences in accessibility and passenger convenience, dependability and comfort, and cost. This will allow the development of a complete DEIS analysis of BRT with the examination of the full range of BRT travel ways including bus lanes, HOV/HOT lanes, and busway.

2.4.2 Description of Busway

2.4.2.1 Service Plan

The service plan that would be modeled for a Rockland County busway would include the same components as the BRT system designed for Option 4D (see Chapter 4). Specifically, the service frequencies, fares, stop locations, and termini would be the same. However, travel times in a busway analysis would be based on the design characteristics of the alignment (design speed of 60 to 70 mph), and could provide improved service compared to buses in HOV/HOT lanes where interference with other traffic could affect the consistency of the bus speeds. Travel times for a busway with online stations would also be more efficient than buses in HOV/HOT lanes that have offline stations that require buses to depart from their routes to access a station.

2.4.2.2 Alignment Concepts

In general, busways are grade-separated alignments that provide uninterrupted flow and full control of access. Highway rights-of-way provide an ideal location for busway alignments given that they make effective use of publicly owned land and would not require acquisition of private property, with the possible exception of parking facilities at some of the larger stations. The typical cross section for a busway can vary from a desirable 47 feet, which would include a full outside shoulder on each side of the bus lane, to a minimum of 28 feet that reduces the outside shoulders to only 2 feet.

The I-87/I-287 right-of-way in Rockland County is sufficiently wide enough to accommodate a busway on the north or south side without impacting the existing roadway. An important consideration, however, is the requirement for the alignment to stay grade-separated at interchanges to avoid conflicts with ramps. In addition a busway alignment would also likely require lengthening existing overpass bridges where abutments are in the path of the busway.

Busways within a highway corridor have three possible location options – either side of the roadway or in the median. Depending on the route structure, busways located along the side of a highway have a number of advantages over a median location. Side-located busways generally provide easier access to stations for passengers and feeder buses wishing to enter the trunk line. They also provide a better BRT identity and are more likely to generate TOD. Freeway median locations have the advantage of not impacting interchange ramps and are preferable when the majority of the service is focused on a single destination, such as a CBD, and there are few if any intermediate access points.

When BRT is combined with CRT service in Rockland County, as proposed in Option 4D, the two modes can be located together on one side of the I-87/I-287 or in the median. They could also be separated with a mode on each side, and still fit within the right-of-way. However, most of the available space would be used up, and as a result, future highway expansion would be precluded without significant property acquisition. If both modes are placed together in a designated transit corridor, whether on one side of I-87/I-287 or in its median, it would be necessary to reconstruct and relocate the roadway to accommodate the combined alignments. As an example, Figure 2-22 shows a busway alignment on the north side of the Thruway and CRT on the south side in Rockland County.

2.4.2.3 Station Concepts

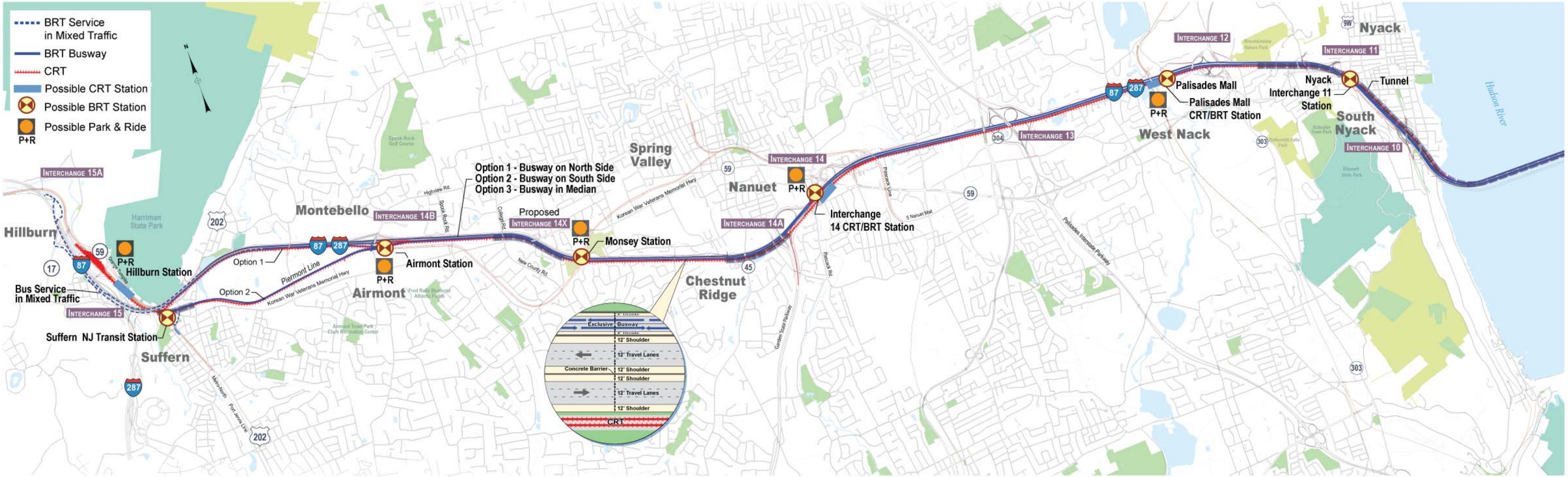
BRT stations for a busway within a freeway ROW have two basic locations with respect to the busway alignment. The stations can be either online along the trunk route or offline, where buses would leave the route to access the station. For either location the station should be accessible by pedestrians, bicycles, automobiles, and local buses. Park-and- ride facilities should be provided in locations where the majority access is by car.

Busways located in a highway median generally have online stations that are widened to include an additional bus lane for express buses to bypass the station. Passenger access to these stations is from overhead walkways situated on bridges that span the highway. In most cases local buses would include a stop on the bridge to allow a transfer to a bus on the trunk route. Median busways with offline stations require expensive flyover ramps to access the stations, which reduce operating speeds.

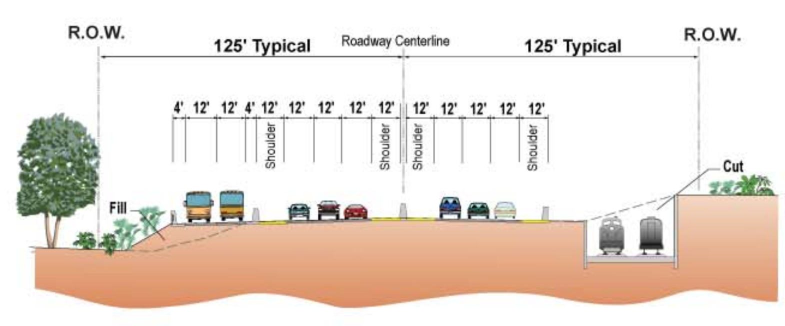
Busways along the side of the freeway would also provide additional lanes for buses to bypass the station. Side alignments would preferably have their stations located at arterials to facilitate feeder bus access to the trunk line, local bus transfers and easier access for passengers from adjacent park-and-ride facilities or simply walking to the station. These stations could be of the online type along the trunk route with widening for feeder bus access, or offline with space for bus circulation within the station.

2.4.2.4 Cost

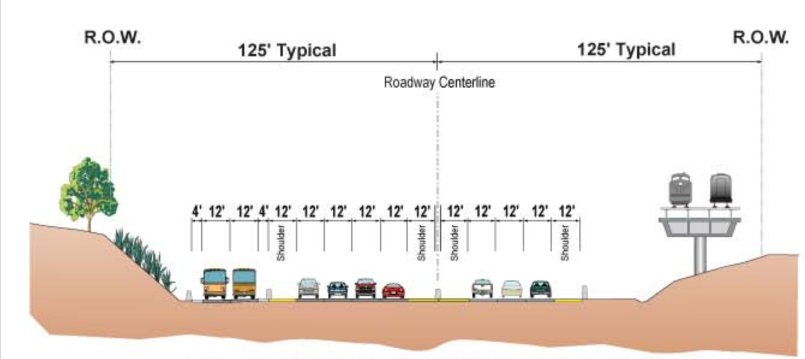
A Rockland County busway solution would be more costly than a Rockland County BRT/HOV/HOT solution. The estimated cost (2012 dollars) of a reconstructed highway in Rockland County including BRT in HOV/HOT lanes would be approximately $2.2 billion (this does not include CRT costs). A rough estimate of highway reconstruction with a busway in Rockland (without HOV/HOT lanes) would be about $3 billion, a cost differential of about $800 million.



ALIGNMENT QUANTITIES				
Rockland Busway and CRT	Cut and Cover	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
CRT	14,850 ft.	13,250 ft.	52,400 ft.	80,500 ft.
BRT Busway	9,750 ft.	6,100 ft.	55,550 ft.	70,900 ft.
Total	24,600 ft.	19,350 ft.	107,950 ft	151,800 ft (28.7 Miles)



Typical Cross Section - Busway on North Side
West of Spring Valley (Looking East)



Typical Cross Section - Busway on North Side
West of Interchange 12 (Looking East)

Figure 2-22 Bus Rapid Transit Busway in Rockland County

3 Light Rail Transit in the Corridor

PCC Car

Light rail transit (LRT) is the current version of the original streetcar technology, which actually began with horse-pulled carriages. The President's Conference Committee (PCC) car was the dominant transit mode in the early 1930s.

In the 1970s, European versions of the trolley, updated to current technologies and operating requirements, led to the modern LRT vehicle. "Light" in LRT refers to light capacity and light cost, as it was intended to be a lower-cost option to modern rail rapid transit (RRT) systems.

3.1 Description of LRT Systems

LRT systems are primarily designed for moderate- or short-distance trips in urban areas, and therefore feature more stations per mile than RRT or CRT. They are also designed to operate as single-car trains, but can be joined in trains of up to four cars. Because they start and stop often and may operate in mixed traffic, they have a lower top speed than CRT or RRT systems – usually around 55 mph. Key aspects of typical LRT systems are:

- Close station spacing.
- Broad choice of guideway types.
- Short trains (one to four cars in length).
- Typically low top speeds (55 mph).
- Coordination with local bus services.
- On-board fare collection.
- Moderate passenger capacity.

Because LRT technology has been adapted to a wide range of applications, it includes examples that range from simple streetcar systems to full metros. Figure 3-1 graphically portrays the range of systems available. While it is possible to mix and match between categories, the characteristics of most systems tend to all fall into the same column. For instance, having stations that include fare-collection provisions does not necessarily limit guideway options, but for automated operation to be possible, the guideway must have an exclusive ROW.

A top-end LRT system can consist of light-rail vehicles operating on exclusive ROWs at grade in freeway medians, on tracks adjacent to the freeway, or on elevated ROWs along other streets. The key point is that the guideway is exclusive – roadways do not cross its tracks, nor does it interact with either vehicles or pedestrians. As a result, it could be automated to operate without on-board personnel, as in Vancouver or the Docklands in London. Such a high-end LRT system can operate at speeds of up to 70 miles per hour (mph), in trains of up to four cars. Stations in such systems have platforms for direct access, which, for optimum operational efficiency, would need to be at least one mile apart.

Top-End LRT System

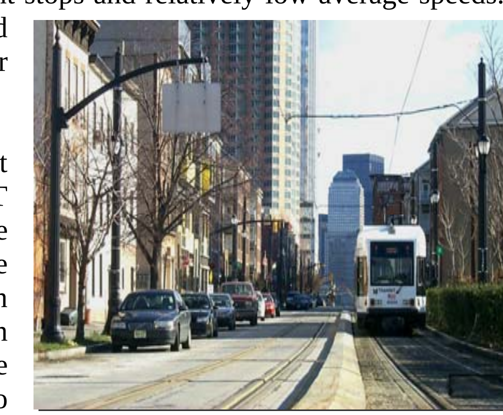
Element	Simple	⟷	Complex
Running Ways	Mixed Traffic	Grade Crossing	Exclusive Right-of-Way
Stations	Shelters	Stations	Stations with Fare Collection
Service Plan	Run with Traffic	Signal Preemption	Automated Operation
Vehicles	Trolley	Articulated Vehicles	Automated Articulated Vehicles
Systems	Line of Sight Operation	Central Train Control	Automated Train Control

Figure 3-1 Range of Options Available for LRT

In the low-end LRT concept, streetcars operate in mixed traffic, with no preferential treatment given to their operations over buses or automobiles. LRT operating in mixed traffic (as streetcars do) is subject to all of the vagaries of traffic congestion, and operates at traffic speeds, with the risk of delays due to congestion. In this study, the only in-street operations that were considered used reserved at-grade ROWs, so that vehicular traffic and pedestrians could cross the tracks, but only emergency vehicles could operate on the tracks. With allowances for catenary poles and platforms, the required ROW per set of tracks is in excess of a single lane for each direction.

Stations in such a system could be as simple as bus stops are, at street grade and with low-floor LRT vehicles. This type of LRT is designed to provide circulator-type service, with frequent stops and relatively low average speeds. A streetcar system might address short-distance circulation needs, but could not provide travel-time advantages over the length of the full corridor, or even over a significant portion of the corridor.

LRT systems operate as integrated services, with central controls that monitor system operations in a manner similar to the operations of CRT and RRT systems. Because most LRT systems operate with grade crossings where cars and pedestrians can cross the guideway, they are usually not operated in automated mode, but rather have drivers in control of the trains. The exception to this is the Vancouver Skytrain system, which operates on an exclusive guideway and does not have drivers in the vehicles, which operate as automated vehicles similar to the automated guideway transit systems most commonly encountered in airports or amusement parks.



In-Street LRT on Exclusive Guideway

Because LRT systems commonly operate in streets, their operations must be coordinated with the street signal system to provide a high level of service. This often takes the form of preferential treatment, by which the LRT trains are allowed to extend or shorten crossing signals by a modest amount to facilitate their crossing of intersecting streets. While pre-emption of traffic signals – by which the trains completely override street traffic-signal timing – is technically possible, it is not done in practice because it would have severe impacts on street traffic. Where the existing traffic-signal system is not fully automated, construction of an LRT system typically results in upgrading the traffic-signal system to allow the closer coordination of traffic and rail operations.

Like other guideway transit systems, LRT systems depend on coordinated bus services to provide the largest number of passengers access to the system. This includes provision of locations for passengers to transfer between the rail and bus systems; addition or modification of bus service to allow passengers to make transfers; and can include close coordination of bus and rail operations.

In general, the cost of systems with characteristics listed in the leftmost column in Figure 3-1 will be substantially lower than those with characteristics listed in the middle column, which in turn will be lower than those with characteristics listed in the column on the right. This is so because as the system becomes more complex it requires more structure, more equipment, and more-expensive equipment. The benefit of moving from the simpler to the more complex systems is in their capacity, with systems on the right side of the matrix having far greater passenger-carrying capacity, running at higher average speeds, and providing more reliable service. The objective in planning such systems is to strike a balance between capacity and need, as well as between cost and capacity.

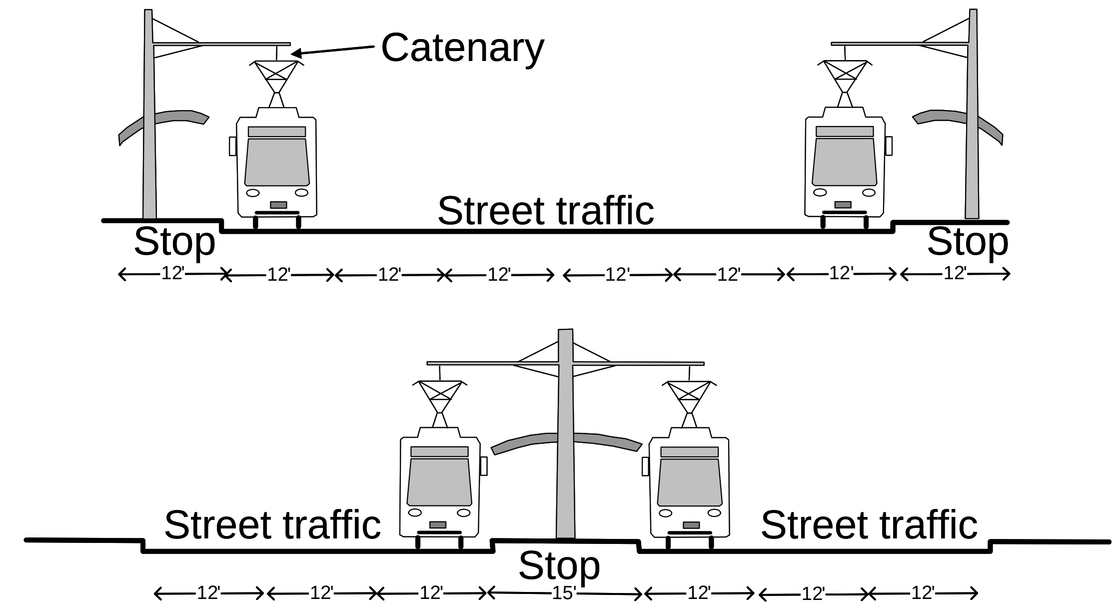


Figure 3-2 Typical LRT In-Street Configurations

3.1.1 Types of Guideway

As they are designed for street operations, LRT systems can work in a wide array of guideways. LRT can also operate on exclusive guideways similar to those of CRT systems. They even have the capability of operating in conjunction with other vehicles traveling down the guideway, although this arrangement is not common, as it severely compromises reliability. Therefore, LRT systems have the fewest guideway constraints of any rail-transit mode. They can operate with the following guideway types:

- Exclusive Guideway:
  - In-Street exclusive ROW.
  - Off-Street exclusive ROW.

- Non-Exclusive Guideway:
  - In-Street, with limited at-grade crossings.
  - In-Street, with other vehicles allowed along the guideway.

LRT guideways typically (although not always) include an overhead wire – the catenary – for power distribution. This allows people and vehicles to cross the tracks without danger of electrocution from the power system. Figure 3-2 shows two fairly typical LRT in-street configurations. In each case the guideway requires one lane-width to operate. In both cases the view is at a station location.

Among the more notable capabilities of LRT is its ability to negotiate steeper gradients and tighter curves than other rail-transit technologies. Maximum gradients over short distances of up to 10 percent have been occasionally achieved with LRT technology, although four- to six-percent gradients are more common. Of course, steep grades and tight turns affect system speeds for LRT systems as they would any other rail technology. Because the LRT vehicles can climb grades up to about six percent and make tighter turns than RRT or CRT vehicles, when they must go over an obstacle they can do so in a shorter distance, reducing the amount of elevated guideway and thereby saving money.

The photo shows a Pittsburgh Light Rail Vehicle negotiating one of the steeper grades of that system.

LRT Vehicle Negotiating Steep Grade

Typical At-Grade Crossing of LRT

Traffic coordination is an essential component of any LRT system that uses or crosses public streets. Most systems do not allow other vehicles to drive down the tracks, but do allow them to cross the tracks. The accompanying photo of the Dallas system's downtown transit mall shows people crossing behind the vehicle at an intersection, much as they would were it a bus.

The ability of LRT systems to make tighter turns than other rail transit technologies allows them to operate in streets and negotiate turns. The aerial photo shows a 90-degree turn that is part of the light rail system in Dallas.

LRT Vehicles Negotiating Curve

LRT Aerial Guideway at an Interchange

One of the consequences of being able to handle steeper grades and tighter turns is that where the guideway must go over or under an obstacle, it can do so in a shorter distance than is required with other rail technologies. Therefore, any necessary bridges and underpasses can be shorter, which reduces construction costs. The photo shows an LRT guideway threading through an interchange as well as a rail crossing.

3.1.2 Key Vehicle Concepts

LRT vehicles have a number of notable features:

- Overhead Power (typically).
- Articulated Vehicle Body.
- Double-Endedness (driver cab on both ends).
- Low Floor, High Floor or Partial Low Floor.

A wide array of LRT vehicles is currently available on the market. There is significant competition between vehicle manufacturers, and each system tends to be somewhat customized to fit the needs of the operating environment.

The Hudson River Waterfront LRT system vehicle, like almost all LRT vehicles, has an operator's cab at each end so that trains can reverse direction without being turned around. These vehicles can have low floors for level boarding from curb-height platforms, but there are also alternatives with high-level floors, as well as alternatives with a mix of floor types.

Typical LRT Vehicle

Diesel Powered LRT Vehicle

Although almost all LRT systems use overhead wires (catenary) to distribute power to the vehicles, a diesel-powered LRT vehicle is used in the South Jersey system. The choices for traction power can be expected to keep getting broader (hybrid systems are now coming on line for buses) so that a hybrid-powered LRT vehicle is possible in the future.

One of the more notable traits of LRT vehicles is their ability to bend in the middle, enabling them to navigate tighter turns than other rail-transit vehicles. This bending is accomplished with a hinge called an articulation unit. The accompanying two photos show how an articulation unit looks from inside the vehicle and an LRT vehicle bending as it navigates a tight turn.

LRT Articulation Unit

LRT Articulation Unit Bending

The interior design of LRT vehicles can be customized to suit the type of travel market being served. Where average trips are very short and there will be frequent boarding and alighting, the interior may feature few seats and a higher carrying capacity due to the predominance of standees. The photo shows an LRT interior optimized for this type of service.

Poles (stanchions) and grab bars are provided for standing riders. Most LRT vehicles are narrower than typical CRT or RRT vehicles, with many having an outside width of 8.5 feet, dictating a narrower interior. However, wider vehicles are available, and they have more space for seating as well as standees.

LRT Interior with Seating

LRT Interior Designed for Standees

Because LRT vehicles have an operator's cab at each end of the vehicle, most if not all LRT vehicles lack end doors to permit movement between the vehicles in a train.

The typical LRT vehicle can carry between 100 and 125 passengers per car (including standees), which translates to 400 to 500 passengers for a four-car train, which is the usual maximum length of train allowed. LRT train lengths are limited because where LRT systems run at grade, if the train is over a block in length, when stopped it would block cross streets. The shortest block-length of a route is thus the effective limit of train length. For this reason, most LRT systems run trains no more than four cars in length, and in some cases no more than three cars.

3.1.3 Key Station Concepts

LRT stations have the same elements as other guided transit technologies:

- Platforms.
- Platform Enclosures.
- Canopies.
- Waiting and Ticketing Areas.
- Parking Options.
- Bus Transfer Areas.
- Pedestrian Connections.

San Diego LRT Station on Exclusive ROW

Because LRT systems can operate in street ROWs, they can include stations in street medians or along the sides of streets, as well as stations off of street ROWs.

Street-median stations must be designed to fit in tighter locations than other stations. This can include the provision of end-loaded platforms fed from pedestrian crosswalks.

San Diego LRT In-Street Station

The photo of the Denver LRT station shows the platform, canopy, and amenities typical of rail stations. The size of the platform is a function of the length of the trains and the space needed for passengers to board and alight. The photo of the San Diego station shows a typical bus-stop style station located in a roadway.

Denver LRT Station

Stations can be as minimalist as a bus stop or as elaborate as any rail station. Typically they tend toward the minimalist, while offering weather protection and such amenities as wind screens and benches. They increasingly include interactive signage to inform customers of expected arrival times for the next train and the status of service.

As with BRT alternatives/options, LRT transit stations may offer an excellent opportunity to create multimodal transportation centers where pedestrians, bicycles, cars, and transit vehicles converge. They may also foster TOD.

3.1.4 ITS Components

The signal system of a modern LRT system includes the usual elements of any rail train control system, with provisions to allow the safe operation of trains by providing buffer spaces between the trains, scheduling service to meet the ridership levels of the system, and communications to inform the operators in the trains of any conditions they may need to be aware of and to report incidents. Unlike CRT and RRT systems, it is not uncommon for LRT systems to be closely coordinated with the street-signal system for at least those portions of the LRT system that operate in public-street ROWs. In addition, coordination with feeder-bus services is increasingly common. Passenger-information systems designed to provide projected arrival times, incident reporting, and rider alerts in stations and aboard vehicles are available as well.

Fare collection in LRT systems is often managed on board the vehicles, but proof-of-payment systems have become more common. In such systems, riders are required to show a valid ticket to inspectors, but inspectors only make spot checks, rather than attempting to inspect all tickets; results for such systems have been mixed, but there are successes. Barriered systems, typical of RRT systems, are not common, as the systems are designed for ease of access and egress, with generally shorter rides.

3.2 Application of LRT Technology to the Tappan Zee Bridge/I-287 Corridor

Introduction of LRT technology in the Tappan Zee Bridge/I-287 Corridor is an opportunity to begin with a clean slate and develop an entire system that will be independent of the existing bus and rail system. This independence allows for it to be as technologically advanced as desired. However, the LRT being considered in this stage of the process includes some elements operating at-grade within street ROWs, and such operations limit the use of automation technology and eliminate some forms of light-rail technology from consideration. For example, neither an Automated Guideway Transit (AGT) system nor a monorail system can operate in-street, as in-street operation requires an operator in active control, capable of reacting to any intrusions into the ROW by pedestrians or other vehicles, so that the system has the ability to stop suddenly. Exclusive-guideway alternatives were considered in the AA process and eliminated due to their cost and low ridership.

As with the BRT alternatives/options, the application of ITS technology to this corridor will be useful for the LRT operation. Vehicle tracking, passenger information, signal priorities, and responsiveness to incidents can all be applied to the LRT operation to improve reliability, reduce travel times, and improve passenger service. Where the LRT is operating in-street, the traffic-control system can be designed to be responsive to both the needs of the LRT vehicle and of the pedestrians accessing LRT stations.

Full-corridor LRT was dropped from consideration in the *Alternatives Analysis Report* (January 2006) for several reasons. It was found to be less effective than commuter rail in serving both cross-corridor passengers and Manhattan-bound passengers, requiring many transfers (at Suffern, Exit 14, Tarrytown, White Plains, and Port Chester to connect with Manhattan-bound service). The combination of high construction costs for a grade-separated ROW and low ridership results led to the highest net costs per passenger and per passenger-mile, making it the least cost-effective scenario studied. However, the Project Sponsors decided to re-examine this scenario and update the transportation analyses to be current with the DEIS alternatives/options studied in this report.

3.3 Description of LRT Alternatives/Options

3.3.1 Full-Corridor LRT

This alternative provides a combination of high-speed and in-street light-rail service from Suffern to Port Chester, with transfer provisions to existing commuter rail lines (Figures 3-3 and 3-4). The alignment utilizes a fully grade-separated option along portions of the corridor to minimize travel times, and in-street components along multilane arterials to literally bring the transit service closer to where local patrons would have better access to the service and to provide better connectivity to key destinations.

Light-rail design criteria were based on acceptable guidelines for other LRT systems currently operating within the United States. Both the grade-separated and in-street LRT segments within the corridor would be configured as a two-track system utilizing overhead catenary electrification. To ensure safety of operation, adequate lateral clearance would be provided between the LRT vehicles and adjacent traffic (with or without positive separation, such as raised medians and railings). The in-street alignment would follow the existing topography of the local roadways.

Track centers would be spaced at 18 feet (desirable), (14 feet minimum), with a dedicated ROW width of between 34 feet (minimum) and 40 feet (desirable). LRT can operate on steeper grades (up to 10 percent for short distances) and tighter curvatures than CRT. As a result, LRT would have relatively shorter and shallower viaducts and shallower depths of retained cuts/retained fills.

The LRT alignment would link all five north-south rail lines in the corridor via transfer facilities. Where connections would be made to other transit modes and to existing park-and-ride facilities, they would be constructed with provisions for bus circulation, kiss-and-ride, and parking facilities. At those locations where space for parking would not be readily available, a passenger-friendly, state-of-the-art LRT station would be provided. The possible stations and facilities proposed are as follows:

- **Rockland County**:
  - LRT to CRT Transfer Facilities: Port Jervis Line transfer in Suffern; Pascack Valley Line transfer at Route 59 in Spring Valley.
  - LRT Stations with park-and-ride facilities: Airmont Road and Palisades Mall.
  - LRT Stations: East Suffern, Monsey, Pascack Road, Grandview Avenue, Nanuet Mall, NY304, West Nyack and Nyack.
- **Westchester County**:
  - LRT to CRT Transfer Facilities: Hudson Line transfer at Tappan Zee Station; Harlem Line transfer at White Plains; New Haven Line transfer at Port Chester.
  - LRT Stations with park-and-ride facilities: Elmsford/Route 9A, Greenburgh, Hillside Avenue, Purchase and Boston Post Road.
  - LRT Stations: Meadow Street, Benedict Avenue, Greenburgh, County Center, Galleria Mall, Westchester Mall, Westchester Avenue, Platinum Mile (with Jitney Service), Purchase, and South Ridge Street.

3.3.1.1 Rockland County

Suffern Terminus/Port Jervis Line Transfer

At its western end, LRT would use the existing Piermont Line ROW, and its western terminus would coincide with a relocated NJTransit Suffern Station at the intersection of Routes 59 and 202. A possible transfer station would be developed, combining service to both LRT and commuter rail. To facilitate the LRT connection, the existing NJTransit Suffern Station would be relocated to the north, to be closer to the Piermont Line terminus at Routes 59 and 202 and to provide expanded parking.

East of Suffern

East of the Route 59 at-grade crossing in Suffern, the alignment would remain at grade within the Piermont Line ROW for a distance of approximately two miles before entering the I-87/I-287 ROW near Airmont Road. A possible East Suffern LRT Station could be located just to the west of Hemion Road. Just east of Airmont Road a proposed LRT station and park-and-ride lot would be located possibly at the site of a commercial facility along the south side of I-87/I-287. The alignment would enter the I-87/I-287 ROW directly east of the Airmont Road Station and would remain on the south side of the existing highway. A possible LRT station to serve the Monsey community could be located in the vicinity of where Route 59 crosses over the Thruway in Monsey.

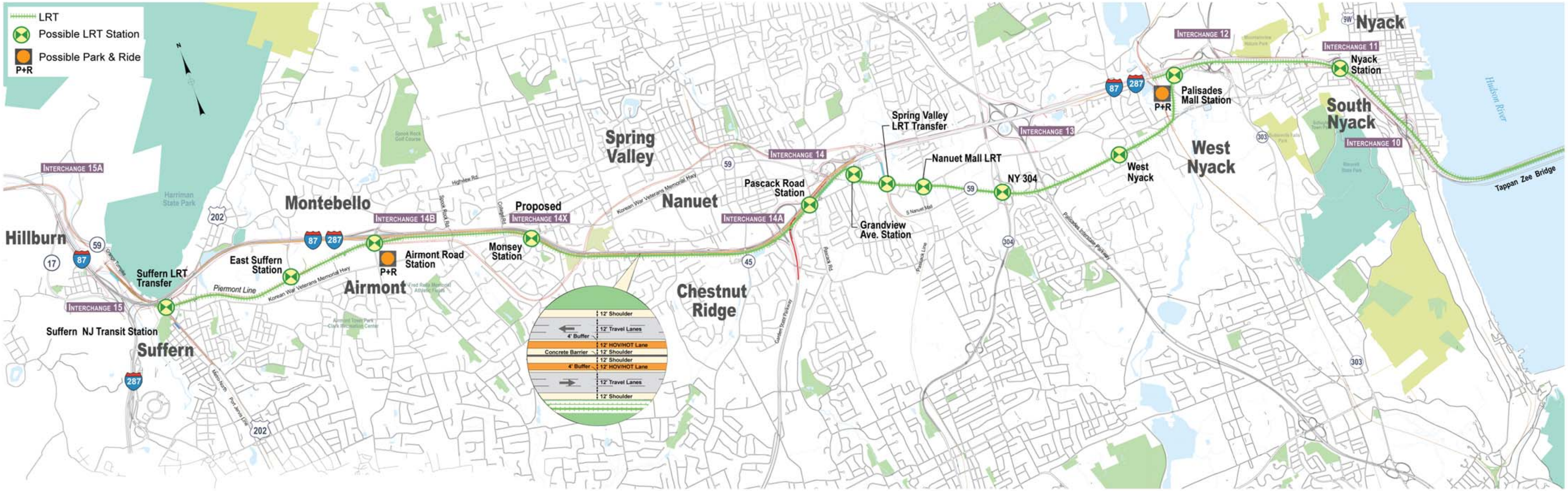
Spring Valley/Nanuet

East of Monsey the proposed LRT alignment would remain on the south side of the Thruway until Interchange 14A (Garden State Parkway). A station could possibly be located just east of Pascack Road, between the highway and Old Nyack Turnpike. The alignment would then turn south onto Route 59 and transition to in-street service along Route 59. The in-street LRT alignment would continue east along Route 59 through Nanuet (as Nyack Turnpike and West Nyack Road) for a distance of approximately four miles. Wherever the LRT alignment would cross an existing intersection at grade, the intersection would be reconstructed and equipped with transit-signal priority to maintain the LRT service schedules. In Nanuet, the LRT would provide transit service through the heavily commercialized shopping area that includes the Nanuet Mall. Where the alignment crosses the Pascack Valley Line a possible station would be provided, offering transfer capability to commuter rail service on the Pascack Valley Line.

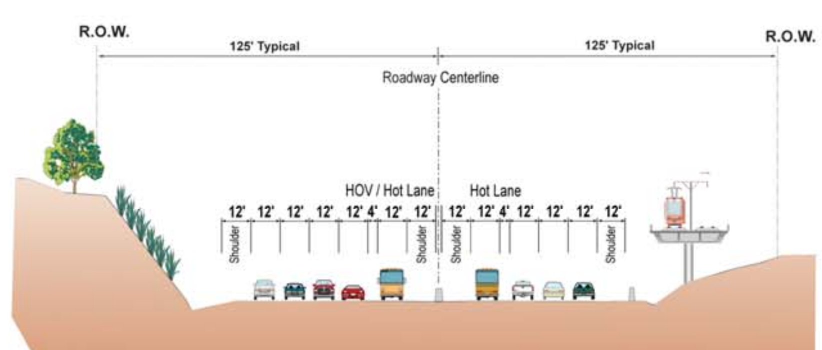
Throughout this segment the LRT would be built in the median, with at-grade platform stations spaced approximately one mile, or less, apart. These proposed stations would be located on Route 59, possibly at the following crossroads:

- Grandview Avenue (west side of Route 59).
- Pascack Valley Line Transfer Station.
- Nanuet Mall (west of Main Street/Middletown Road).
- NY304 (west of Smith Street).
- West Nyack (near Strawtown Road).

After passing over Western Avenue and the tracks of the West Shore Line, the alignment would turn north on a viaduct across westbound Route 59 and follow the west side of the Palisades Mall ring road to the Palisades Mall Station at Parking Lot J. From Parking Lot J, the LRT would move back into the I-87/I-287 ROW on a viaduct, span over the Interchange 12 (NY303) ramps and Route 303, and transition to the south side of I-87/I-287.

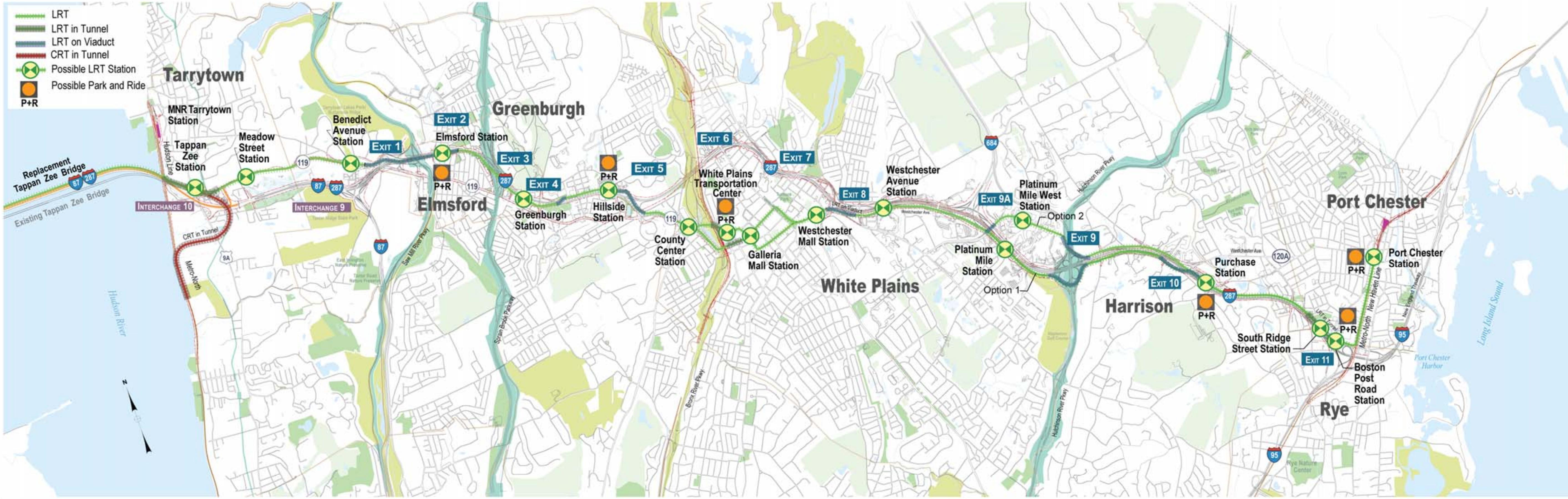


Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Full Corridor LRT - Rockland	2,500 ft	3,500 ft	75,850 ft	81,850 ft (15.5 Miles)

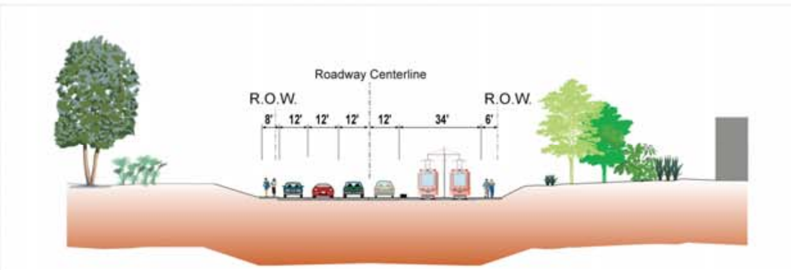


Typical Cross Section West of Interchange 12
(Looking East)

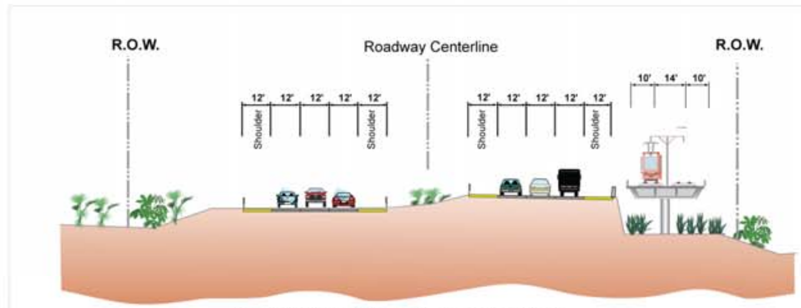
Figure 3-3 Full-Corridor Light Rail Transit in Rockland County



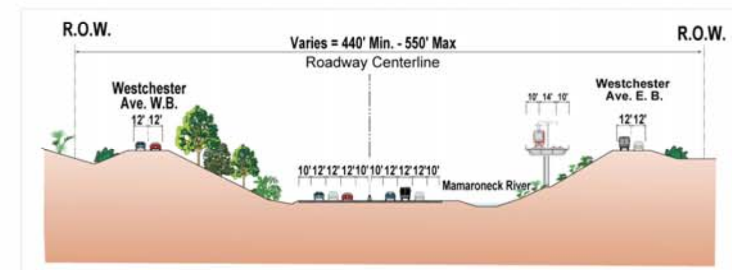
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Full Corridor LRT - Westchester	5,500 ft	40,000 ft	34,900 ft	80,400 ft (15.2 Miles)



Typical Cross Section - Along Route 119 in Tarrytown
(Looking East)



Typical Cross Section in Elmsford
(Looking East)



Typical Cross Section - East of White Plains
(Looking East)

Figure 3-4 Full-Corridor Light Rail Transit in Westchester County

Nyack/South Nyack

East of Route 303, the alignment would remain along the south side of the I-87/I-287 ROW. A proposed station could possibly be located east of Mountainview Avenue at Interchange 11 (US 9W/NY Route 59). Continuing east, the alignment would descend toward the Hudson River following the highway, with a shift of the alignment from the south side to the north side of the Thruway. The south-to-north alignment shift, achieved with the LRT crossing beneath I-87/I-287, would be necessary to facilitate aligning the LRT with the rehabilitated or replacement Tappan Zee Bridge.

3.3.1.2 Westchester County

Tarrytown

From the rehabilitated or replacement bridge, the alignment would continue – possibly elevated or in tunnel – into the Tappan Zee Station on the north side of the toll plaza for transfer to Manhattan-bound CRT. The CRT connection would be made by a proposed two-track CRT alignment from the Hudson Line extending north to the proposed station. The CRT would dead-end at the station.

After crossing Broadway, the LRT would transition to an at-grade alignment on the south side of Route 119, which would be widened from Broadway to the vicinity of White Plains Road – a distance of approximately one mile – to maintain the existing five-lane roadway configuration and a safe, segregated LRT alignment. A possible center-platform Meadow Street LRT Station could be located just east of Meadow Street, along the south side of Route 119.

Greenburgh

East of White Plains Road, Route 119 widens sufficiently to accommodate the LRT alignment and projected traffic. The LRT alignment would continue along the south edge of Route 119 to a proposed Benedict Avenue Station, which would be an at-grade station possibly located east of Benedict Avenue and opposite the office parks between Route 119 and I-287. To the east of this station, as Route 119 approaches I-287, the alignment would ascend on a viaduct, cross Route 119 and continue on the north side of I-287, then swing over to the south side of I-287 as it passes above the Saw Mill River Parkway, the Saw Mill River, Vreeland Avenue, and Central Avenue. A possible elevated Elmsford LRT Station and park-and-ride facility directly adjacent to I-287 is proposed between Nepperhan Road and North Central Avenue (Route 9A).

East of the station, the viaduct would continue and then transition into a retained cut and pass beneath the southbound lanes of the Sprain Brook Parkway. The alignment then rises up over the northbound Sprain Brook to avoid impacting the relatively shallow Catskill Aqueduct. The overhead transmission lines just east of the parkway would need to be reconstructed to a higher elevation to clear the LRT alignment. A proposed LRT Greenburgh Station could be located possibly at the existing *Bed, Bath and Beyond* and *Syms* commercial sites south of I-287.

The alignment would then climb above Knollwood Road and cross to the north side of I-287 just west of Manhattan Avenue. Just west of Hillside Avenue, a possible at-grade LRT station and park-and-ride facility is proposed. The alignment would then pass under Hillside Avenue and rise up onto a viaduct, cross back to the south and align on the east side of the Exit 5 westbound entrance ramp, then continue along the east side of Route 119 (Tarrytown Road) as it proceeds towards downtown White Plains. (An alternative I-287 alignment being considered would continue the LRT on the south side of I-287 east of Knollwood Road and possibly locate a station in the vicinity of Manhattan Avenue.)

An alternative alignment through Elmsford would be to continue the LRT on Route 119 (Main Street). However, the available ROW on Main Street narrows, and the roadway moves through a commercial district with congested travel lanes and parking along both curbs. In order to avoid both further congestion to the local roads and land-use impacts, the use of Route 119 through Elmsford as an LRT alignment was eliminated from consideration.

White Plains

As the LRT continues on the east side of Route 119, a station is proposed at the Westchester County Center, possibly at the intersection with Central Avenue. Directly after the County Center Station, the alignment turns east and crosses the Bronx River Parkway at a reconstructed intersection. The alignment would continue through the existing parking lot and turn south, parallel to the Metro-North Harlem Line bike trail, then cross under the tracks in a short tunnel to emerge onto Water Street, which is on the north side of the WPTC. A possible station would be provided along Water Street that would allow for a transfer to the Metro-North Harlem Line. An alternative alignment being considered for the entry into White Plains would have the LRT continue on Route 119 and turn east just north of Hamilton Avenue and cross under the Harlem Line. The LRT transfer station would be located on the north side of Hamilton Avenue.

There are a number of potential LRT routes through downtown White Plains (see Subchapter 3.3.1.3). Some of the routes considered include Hamilton Avenue, Main Street, and Martine Avenue, and a possible combination of these. Other routes are also possible, and would be further studied in the DEIS if LRT is the selected mode. In addition to the transfer station at the WPTC, and regardless of the chosen route, two additional LRT stations are proposed in downtown. One would possibly be in the vicinity of the Galleria Mall, and the other at the Westchester Mall.

The LRT alignment would leave downtown White Plains along Westchester Avenue on a viaduct that would continue over the I-287 Exit 8W ramps and follow along the south side of Westchester Avenue to a proposed elevated Westchester Avenue Station, possibly located at the intersection with Anderson Hill Road. The alignment would then cross Westchester Avenue and continue to the east in the vegetated area between the south edge of I-287 and Westchester Avenue. The alignment would be mostly at-grade, but would also have some elevated sections, to pass over I-287 ramps and bridges.

Harrison

After passing Exit 9A (I-684), the next proposed station would be the Platinum Mile Station, which could be located between Bryant Avenue and Corporate Park Drive. This station would include provision for a jitney service that would serve the many corporate offices within the Platinum Mile and other large office parks in the area. (An alternative alignment option would take the LRT alignment out of the I-287 ROW and bring it north and through the Platinum Mile office parks. A station would be located along this alignment to serve the office parks. The alignment would return to the I-287 ROW and continue on the north side to the proposed Purchase Station described below).

The LRT alignment adjacent to the south side of I-287 would continue eastward on a viaduct pass to the south of the Hutchinson River Parkway (Exit 9), then cross over to the north side of I-287. A possible elevated Purchase Station and park-and-ride facility could be located just east of Exit 10. The LRT alignment would continue on viaduct over Bowman Avenue, then descend and remain at-grade for a possible South Ridge Street Station. The alignment would continue at-grade and drop under South Ridge Street and High Street.

Rye/Port Chester Terminus

East of High Street the alignment would be in a retained cut, to pass beneath Boston Post Road and into the large shopping mall, where a possible LRT station and park-and-ride facility would be located north of the I-95 interchange. Beyond the station, the LRT alignment would turn north and proceed along the west side of the New Haven Line ROW and continue north to the Port Chester Station, where the LRT alignment would terminate. The station would incorporate facilities for a transfer to commuter rail service on the New Haven Line. While a Rye Station terminus was considered, the Port Chester Station was thought to offer greater potential to induce TOD and serve a larger transit-dependent population.

3.3.1.3 White Plains

A separate study (NYSDOT et al, August 2008) was done to determine the alignment of the LRT routes in White Plains. As White Plains is the central hub of the corridor, and traffic in White Plains is the most congested urban traffic in the corridor, special consideration was given to the routing through White Plains. Crossing White Plains from west to east, connecting to the WPTC and Metro-North Station, and serving the other activity centers is not easily accomplished. Key destinations, as shown on Figure 2-15, include the Galleria Mall, the White Plains Mall and the Westchester Mall, the complex of county buildings along Martine, and the White Plains City Hall.

Similar performance measures to those for BRT were also developed to compare LRT alignment options in White Plains:

- **Minutes Run Time**: Walk time between Metro-North White Plains Station and the Westchester Mall is about 22 minutes. Therefore, transit run times should be less than half walk times to offer a serious advantage to travelers.
- **Traffic Lanes Crossed:** This measure was used only for LRT routes. It was intended to measure the potential for traffic to affect transit operations. The more lanes a route must cross the greater the prospect for traffic interference. Obviously, this measure could also indicate the potential for the transit system to disrupt street traffic.
- **90° Turns**: Sharp turns reduce speeds significantly. Depending on turn geometry and gradients, some tight turns would slow operations to a crawl and induce significant wheel squeal.
- **Length in Miles**: The shorter a route that provides equivalent coverage, the less costly and more efficient that route will be both to build and operate. Because LRT systems involve street modifications for paving, curb and gutter changes and drainage inlet redesign/replacement, the longer a route the more costly it will be to construct. Similarly, the longer the route the more train miles and time will be required to provide the same level of service, requiring more operating dollars as well. Therefore, length of route was used as a measure of higher costs – both operating and construction.
- **Walk Distances to Key Destinations**: Walk distances of ½ mile to transit are observed, but most transit users walk ¼ mile or less to their destinations/stations. Therefore, walk distance is a surrogate for ridership potential. The options that required walk distances substantially greater than ¼ mile were judged to offer less access than the others.

All the alignment options considered use dedicated lanes on existing streets for the LRT operation, crossing streets at-grade, and using preemptive traffic signals. Nineteen options were tested (Table 3-1). As a result of that evaluation, four alignment options – LRT White Plains Options 2, 4, 5 and 12 – are being considered for further analysis (Figures 3-5 to 3-8). Variations of these alignments may result from the detailed traffic analysis to be performed in the DEIS if LRT is the selected mode. Those options not being considered further involved many combinations of north-south and east-west streets, too numerous to describe here. In general, these street combinations crossed too many traffic lanes, involved too many 90° turns, removed too many traffic lane miles, and were too far from walk destinations to merit further consideration.

Table 3-1

Summary of LRT Options in White Plains

Alignment Option	Crosstown Travel Time Excessive	Too Many Traffic Lanes Crossed	90° Turns	Too Many Traffic Lane Miles Removed	Too Far to Walk to Key Destinations
1					●
2					
3		●			
4					
5					
6		●	●	●	●
7		●	●		●
8		●	●	●	●
9	●	●	●	●	●
10	●	●	●	●	●
11	●	●	●	●	
12					
13	●		●	●	●
14	●	●	●	●	
15		●		●	
16				●	●
17		●		●	
18					●
19	●	●		●	
Note: ● Does not meet criterion.					

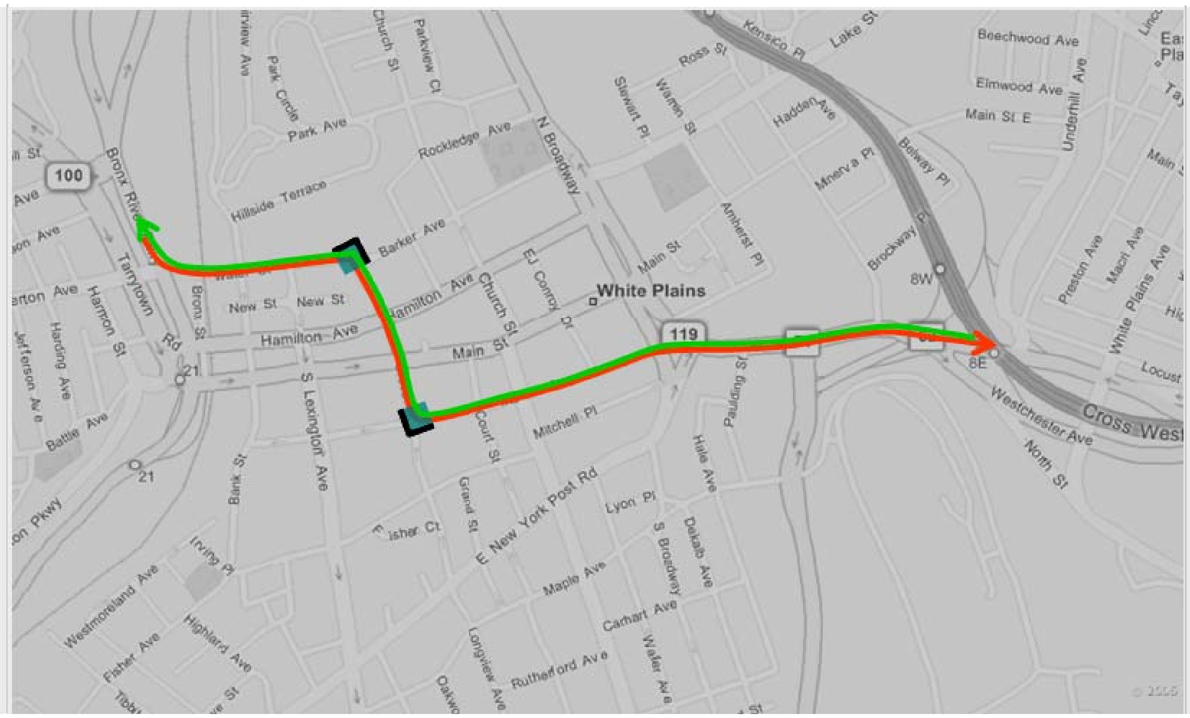


Figure 3-5 LRT White Plains Alignment Option 2

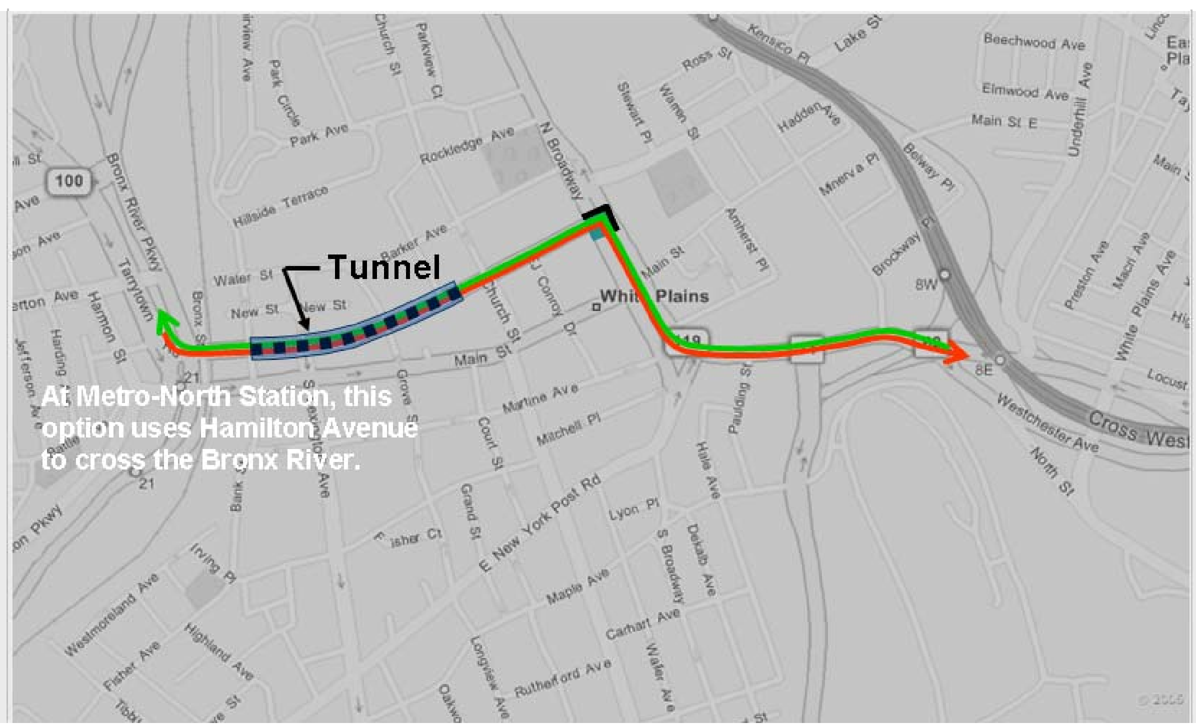


Figure 3-6 LRT White Plains Alignment Option 4

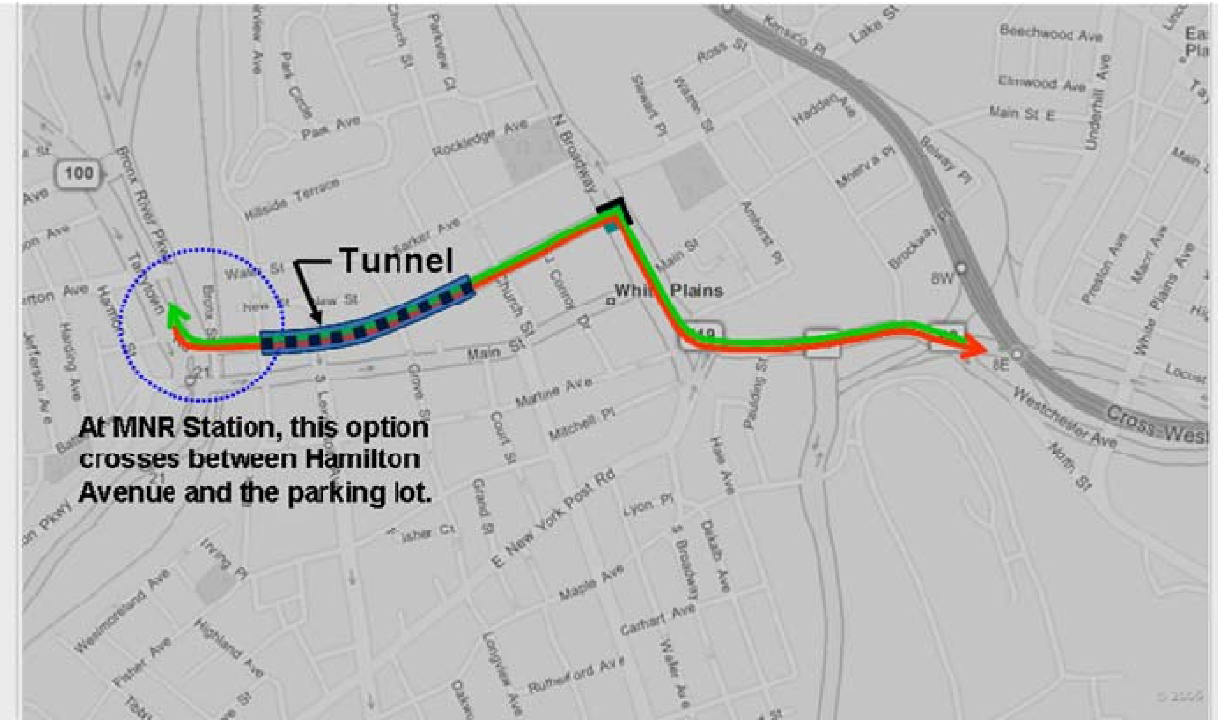


Figure 3-7 LRT White Plains Alignment Option 5

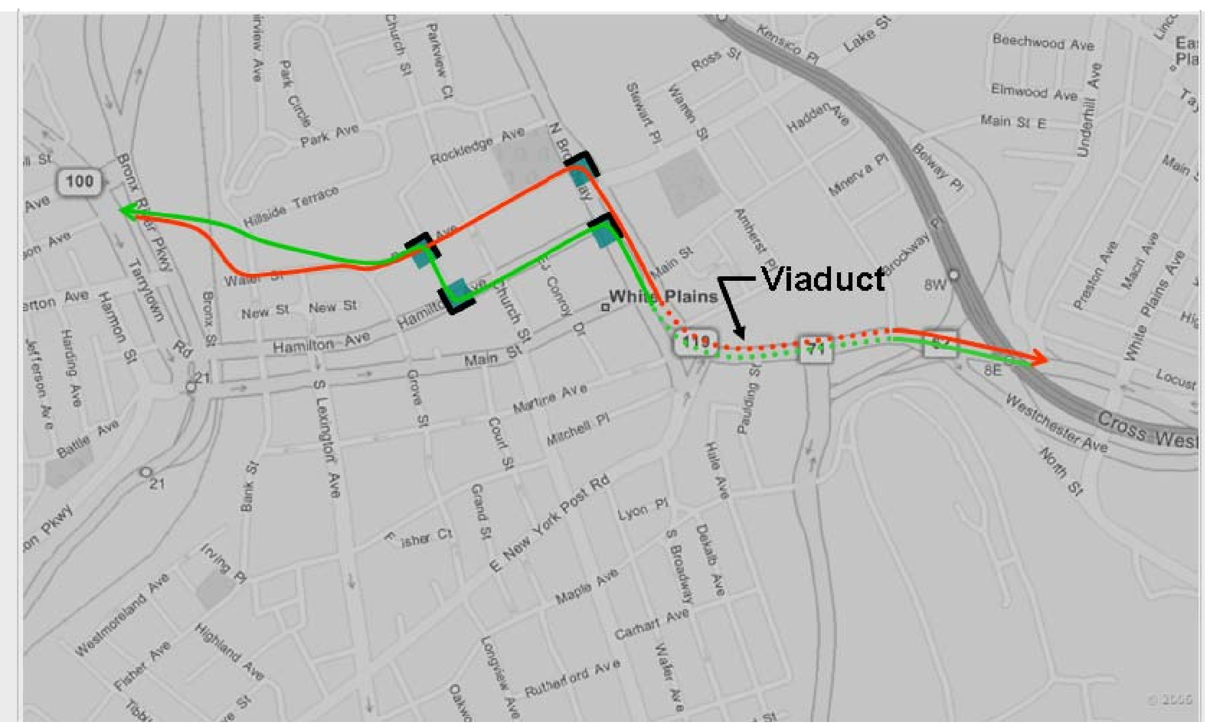


Figure 3-8 LRT White Plains Alignment Option 12

3.3.2 Alternative 4B – LRT in Westchester County

Although full-corridor LRT was dropped from consideration in the *Alternatives Analysis Report* (January 2006), LRT as a transit mode in Westchester County was retained in Alternative 4B, and combined with CRT in Rockland County that offered service to GCT.

The LRT alignment and service plan in Westchester County for Alternative 4B is basically identical to that proposed for full-corridor LRT. The only significant difference occurs in Tarrytown, where the LRT western terminus would be at the existing Metro-North Tarrytown Station. From this transfer station the LRT would travel south along the east side of the Hudson Line tracks to the Tappan Zee Bridge, then turn east and climb to connect with the proposed Tappan Zee Station. Two options are being considered for this connection:

- The LRT alignment enters the underground CRT station for a cross-platform transfer.
- LRT rises above grade on a viaduct leading to an elevated LRT station that would require a vertical transfer to the underground CRT platform.

For either option at the proposed Tappan Zee Station, the LRT would continue to the east through Westchester County as a hybrid alignment, as proposed for the full-corridor LRT alignment, with its eastern terminus at the existing Port Chester Metro-North Station.

BRT

LRT

CRT

4 Commuter Rail Transit in the Corridor

Commuter rail transit (CRT) provides suburb-to-central city commuter service as well as suburb-to-suburb service. Commuter rail was the original engine for many of the older suburbs and "bedroom" communities surrounding major American cities, predating the rise of the automobile for commuting. The service is typically heavily weighted to serve the commuting needs of workers, with a concentration of service during rush hours and reduced service at other times.

Commuter Rail Transit

Nowhere else is this better demonstrated in the US than in the NYC Metropolitan Area. Metro-North is the second-largest commuter railroad system in the US. The Metro-North system covers a vast area, connecting New York City (Manhattan and the Bronx) with Westchester, Putnam, Dutchess, Rockland, and Orange Counties, as well as Fairfield and New Haven Counties in Connecticut. Metro-North captures a dominant market share of total peak-hour trips to the Manhattan central business district (CBD) from the suburbs north of New York City and Connecticut. In 2007, it moved 80.7 million passengers on its entire network.

The railroad is organized around five lines, with two discrete networks: East-of-Hudson and West-of-Hudson. The East-of-Hudson network consists of the Hudson, Harlem, and New Haven Lines. The West-of-Hudson network consists of the Port Jervis and Pascack Valley Lines. Metro-North carries its weekday ridership on over 600 daily scheduled trains on the East-of-Hudson network and over 60 trains on the West-of-Hudson network.

Each of Metro-North's five major lines crosses the I-287 Corridor in a north-south direction (Figure 4-1). There are no Metro-North facilities that run in an east-west direction, either parallel to the corridor, or across the Hudson River. One of the objectives of the current study is to establish the feasibility of instituting new commuter rail service across the corridor and the Hudson River.

East-of-Hudson Commuter Rail Service

The East-of-Hudson network is mostly electrified. Rolling stock on the majority of services on the Hudson and Harlem Lines are provided by electrical multiple units (EMUs) of the M7 class, drawing power from a third-rail system with an under-running current pickup. Metro-North also operates dual-mode (third-rail and diesel) locomotives and coaches in push-pull mode on the East-of-Hudson lines into GCT.

The Hudson Line extends to Dutchess County, and runs along the eastern bank of the Hudson River through Putnam and Westchester Counties, into the Bronx and Manhattan – a distance of 76 miles from Poughkeepsie to GCT. The Hudson Line is shared with Amtrak services (in the Empire Corridor to and from Penn Station New York) and with CSX and CP Rail (north of Highbridge).

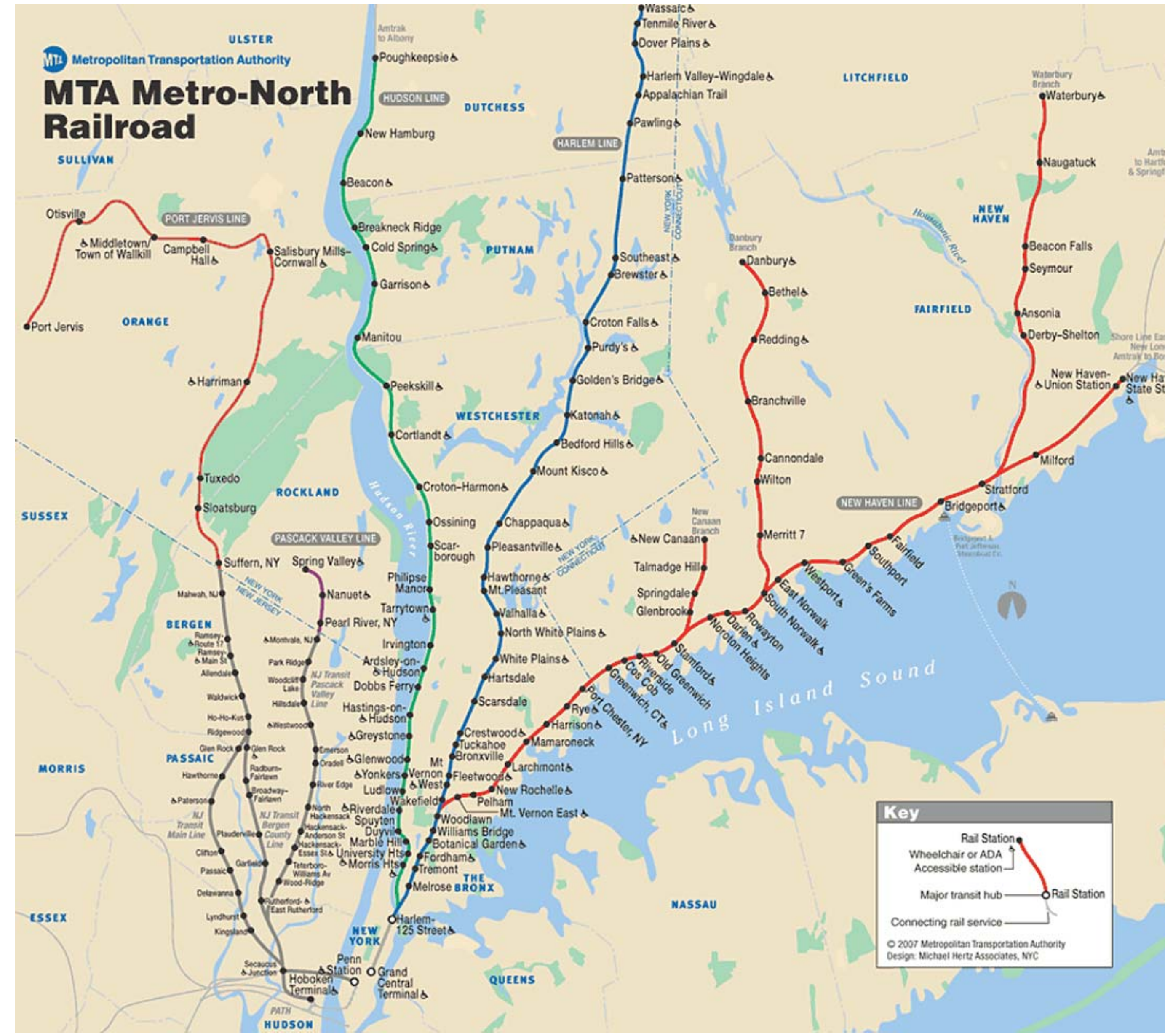


Figure 4-1 MTA Metro-North Railroad Map

The Harlem Line begins in Wassaic, also in Dutchess County, and continues south through the heart of Putnam and Westchester Counties into the Bronx, where it joins the Hudson Line at Mott Haven junction – a distance of 77 miles.

From their junction at Woodlawn, the New Haven and Harlem lines continue south and merge with the Hudson Line at Mott Haven, from which point they continue over the Harlem River into Manhattan and onto the Park Avenue Viaduct, with a station at 125th Street in Harlem. The Viaduct continues to 97th Street, where the line goes into the Park Avenue Tunnel, feeding into GCT.

The New Haven Line begins in New Haven, Connecticut, and continues into Fairfield County, in between and paralleling Interstate 95 and the Long Island Sound shore, the area commonly referred to as the Gold Coast. The line enters New York State in Westchester County and then continues into the Bronx, joining the Harlem Line at a point just north of Woodlawn Station. The length of the New Haven Line from New Haven to the junction with the Harlem Line is 61 miles. In addition, the New Haven Line has three branches: the New Canaan Branch, at nearly 8 miles in length, the Danbury Branch, at 24 miles in length, and the Waterbury Branch, at 27 miles in length. The New Haven Line is operated under a joint agreement with the Connecticut Department of Transportation (ConnDOT), which provides funding to Metro-North for both operating and capital expenses, and maintains all of the stations in Connecticut.

The New Haven Line is also mostly electrified. The line is equipped with under-running third rail to a point just south (west) of Pelham Station. The remainder of the line to New Haven is equipped with an overhead catenary. Three unique classes of EMUs, known as the M-2, M-4, and M-6 cars, provide service on the New Haven Line. These cars are equipped with both third-rail shoes and pantographs for current pickup from the overhead catenary.

West-of-Hudson Commuter Rail Service

The West-of-Hudson network consists of two lines: the Port Jervis Line and the Pascack Valley Line. These two lines are operated under an agreement with NJTransit, utilizing a common equipment pool manned by NJTransit personnel. The West-of-Hudson network is not electrified; diesel locomotives and coaches in push-pull mode provide services on those lines.

The Port Jervis Line originates at Port Jervis near the Pennsylvania, New Jersey, and New York border. It initially loops north through Orange County before turning south again at Salisbury-Mills Cornwall, from which it heads to Suffern. South of Suffern, express rail service continues along NJTransit's Main/Bergen Line to Hoboken, New Jersey via Secaucus.

The Secaucus Transfer is a hub for 10 of New Jersey's 11 rail lines. It allows passengers traveling on the Main/Bergen and Port Jervis lines to transfer to NJTransit trains directly into New York's Penn Station on Manhattan's west side. The Secaucus Transfer provides a more direct trip to Penn Station, New York, cutting travel time by about 15 minutes. Transfer is also available at Secaucus to trains to Newark, Trenton, Long Branch, and Morristown. At Hoboken, passengers have the option of transferring to a PATH train to Midtown or the World Trade Center site, or to a commuter ferry for service to lower or Midtown Manhattan. The total length from Port Jervis to Hoboken is over 95 miles.

The Pascack Valley Line originates in Spring Valley, Rockland County, serving Nanuet and Pearl River before crossing into New Jersey. It merges with the Main/Bergen Line just north of Secaucus. It is nearly 31 miles from Spring Valley to Hoboken. Metro-North in conjunction with the Village of Spring Valley and NYSDOT constructed a new bus intermodal area at the Spring Valley Station and rehabilitated the station building, platform, and parking facilities.

4.1 Description of CRT Systems

CRT systems are primarily designed for longer-distance trips than the other transit modes, and feature fewer stations per mile than RRT or LRT. They are also designed to operate on exclusive guideways at high speeds. CRT systems typically have few stations in the downtowns they serve, most often having a single central terminal where all or most of the lines converge. Key aspects of typical CRT systems are:

- Long station spacing (usually over two miles).
- Guideway types largely limited to exclusive ROWs.
- Long trains (four to 10 cars).
- Typically high top speeds (90 mph or more).
- Coordination with local bus services.
- On-board fare collection.
- High passenger capacity.

CRT systems operate as integrated services, with central controls that monitor system operations. Because CRT systems operate in exclusive guideways, they are able to operate at high speeds, with long trains that give them very high passenger capacities. New commuter rail systems are usually designed with few grade crossings. Commuter services often have both local and express services, which is less common with other types of rail transit service. They are high-capacity systems operating trains of 10 or even more cars generally on less-frequent headways than LRT or RRT. Typical peak-hour headways of 30 minutes are common, although some lines operate on headways as short as 15 minutes. Where CRT systems have tighter headways, it is not uncommon for them to vary their station stop pattern so that not all trains stop at each station.

CRT systems tend to be more dependent on automobile access to their stations than other rail transit systems are. This is at least partly due to their being typically designed to serve longer-distance commuters located in suburban areas, where automobiles predominate over public transit services. Consequently, it is common for commuter rail stations to have large parking areas. Despite the prevalence of auto access, CRT systems also need good feeder-bus access. This includes provision of locations for passengers to transfer between the rail and bus systems, addition or modification of bus service to allow passengers to make transfers, and may also include close coordination of bus and rail operations.

Unlike the other rail-transit technologies, to operate within railroad ROWs commuter rail trains must comply with Federal Rail Administration (FRA) regulations. The FRA has broad powers to regulate such commuter-rail systems, including the establishment of:

- Track safety standards.
- Workplace safety standards.
- Operating rules.
- Communications.
- Employee hours of service.
- Safety appliance standards.
- Signal systems, including grade-crossing warning devices.
- Passenger equipment safety standards.
- Passenger train emergency preparedness.

The FRA can also set vehicle requirements to ensure the ability to interoperate with freight rail systems. The net result of these restrictions is that CRT systems generally abide by the same constraints as the freight railroads in terms of track design, including maximum gradients of two percent and minimum curves of over 2,000 feet radius.

4.1.1 Types of Guideway, Grades, and Geometry

For reasons of safety and to permit higher-speed operations, commuter rail guideways are confined to exclusive ROWs. The desirable space to accommodate a set of two commuter rail tracks at grade is about 54 feet (without parapets or barriers) or 57 feet (with parapets or barriers); the minimum distances would be 34 and 37 feet, respectively. Greater width would be required at stations where platforms of 15-foot width add a total of 30 feet of additional width. Figure 4-2 provides a cross-section showing the space needed for a typical guideway segment.

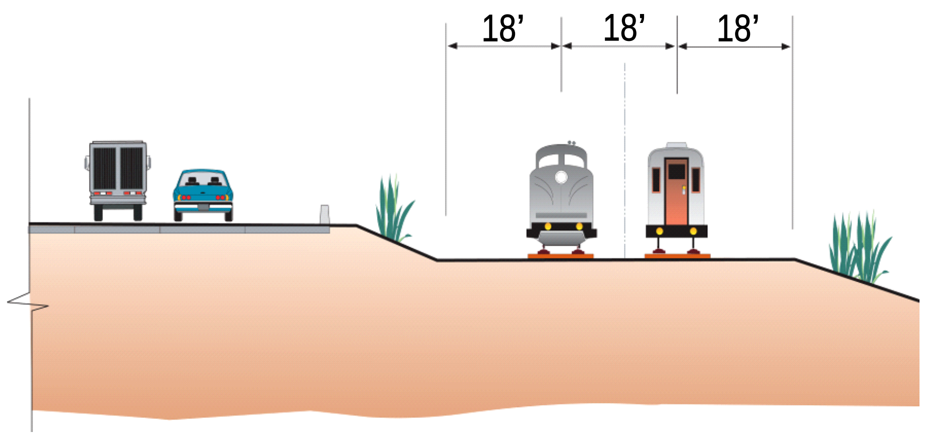


Figure 4-2 Typical Guideway Segment

Where a surface alignment is not possible, the guideway may need to be placed in an open cut or on an elevated structure. CRT systems must be designed to avoid gradients of greater than two percent. Since this is not always possible without raising or lowering the guideway relative to the natural grade of a potential alignment, this requirement can lead to the need for open cuts, tunnels, embankments, and viaducts. Each of these structures requires more space than does an at-grade guideway, and each costs substantially more to construct and maintain than does an at-grade guideway.

For this reason, the process of route selection for a commuter rail system must carefully consider the potential structures a route could entail. This does not mean routes that require structures cannot be selected, but rather only that such routes require careful consideration of their operational consequences.

Sixth Street Embankment

Elevated guideway alternatives generally take three forms: 1): embankments, 2) bridges, and 3) trestles (aka viaducts). Embankments are used where the height of the guideway over grade is sufficiently small (usually less than 30 feet) to accommodate the width required. Embankments may be retained by walls or simply have steep unretained side slopes. They are earthen structures that may have portals under them to accommodate crossing streets. Retained-fill segments are generally preferred where possible because of their lower cost compared to bridges and viaducts. If the width of structure is an issue, concrete or stone retaining walls are commonly used. The photo shows an abandoned embankment called the Harsimus Stem Embankment, an elevated stone structure that once carried seven tracks of the Pennsylvania Railroad to the Hudson River Waterfront for a half mile along 6th Street in downtown Jersey City, New Jersey.

Embankments are not always possible or desirable, in which case a trestle may be appropriate. Unlike embankments, trestles can be quite tall, as evidenced by the Metro-North Railway's Moodna Viaduct. A trestle is essentially a bridge with a continuous support structure holding it up. Unlike an embankment, the supporting structure does not form a continuous wall at grade level, enabling movement under the trestle without the need for portals or tunnels.

Commuter Rail Viaduct (Moodna Viaduct – Metro-North)

Where it is not possible to have a continuous support structure, bridges are used to span gaps, often in combination with trestles and embankments for their approach sections. The size and complexity of the necessary bridge structure varies with the site conditions, projected usage, and the span of bridge required. The forms of bridge structures available are quite broad, but except for the Tappan Zee Bridge itself, it is unlikely any bridges in the corridor would be large structures. In the past, railroad bridges were often large and not necessarily attractive structures typical of the era in which they were built. There are now numerous bridge forms available that blend well in urban environments. As the photo of the Dallas Area Rapid Transit bridge shows, they can be harmoniously integrated into an urban environment.

Dallas Area Rapid Transit Bridge and Embankment

There are also two basic methods of putting guideways below grade, tunnels and open cuts. Open-cut structures, sometimes called ditches, can be created with earthen sides or retaining walls. The deeper the open cut, the more likely retaining walls will be needed. Open-cut segments are commonly used for the transition sections from at-grade to tunnel sections called portals. Like embankments, open-cut sections form a barrier to crossing traffic that requires a structural solution, in this case overpasses. Open cuts are generally less than 30 feet deep.

Tunnels are underground structures that do not restrict access on the ground surface, but are very expensive to construct. Tunnels can be built by two basic methods – cut-and-cover construction or driven-tunnel construction. Without exploring the many variants of these techniques, it is sufficient to say cut-and-cover construction consists of digging a ditch, creating the tunnel structure and filling the ditch back to the previous natural grade. It entails significant surface disruption during construction. Driven tunnels typically use boring machines, and are usually less disruptive during construction.

Open Cut Section

While structures can overcome natural topography, there are limited solutions to curvature constraints. Here again, walls and fill may be required to provide adequate length to accommodate the gentle curves needed for commuter rail systems. A consequence of curves is that the tighter the curve, the more slowly trains must travel to traverse it, and tight curves can cause wheel squeal, an undesirable quality. In addition, curved track causes accelerated wear of wheels, the rail itself wears out more quickly, and for passengers on trains negotiating tight curves the imbalance felt in the vehicles can be uncomfortable. Track can be superelevated to alleviate some of the impact of curves on speed and passenger comfort, but that introduces additional maintenance costs. Therefore, curves can reduce speeds, lower service levels, cause undesirable noise levels, require more maintenance, and reduce ride quality – all things to be minimized or avoided completely.


Commuter Rail Curved Segment

The guideway geometric constraints described above give rise to several guideway considerations:

- Alignments that are perpendicular to rather than parallel with the natural fall of streams and other topographical features can necessitate significant amounts of cut and fill and even open cuts and viaducts.
- Operational and geometric constraints generally limit the location of curves to relatively flat areas with space for wide turns.
- Existing freight rail routes are prime candidates for new commuter rail service, since suitable ROW exists.

4.1.2 Key Vehicle Concepts

There are two basic varieties of commuter rail trains. One has passenger coaches pulled or pushed by a locomotive. The second integrates the motive power into the passenger car, so the passenger cars are themselves powered. The power systems available for either configuration are diesel or electric power. In addition, whatever the power system configuration, single- and bi-level versions are available. Thus there are three distinct types of commuter rail vehicles:


Metro-North Diesel Electric Locomotive

- Push-pull locomotive/passenger car systems.
- Electric multiple unit (EMU) systems.
- Diesel multiple unit (DMU) systems.

Although wide ranges of both vehicle types and configurations are available, each has unique characteristics that make it more or less suited to particular applications. For example, double-stack freight rail can operate with overhead catenary as long as sufficient clearance is provided, however double stack freight rail cannot be accommodated with third rail electrical power because the third rail interferes with the clearance envelope. DMUs are most appropriate to routes where ridership is light, and tend to be used where there are not subway stations or long tunnels, since ventilating of diesel fumes complicates construction and increases costs.


Acela Train

Locomotives

Locomotives include diesel/electric dual-mode locomotives, in which the electric mode is typically used in tunnels and subway segments, with diesel power used on non-electrified track. The electric power could be provided by either a powered third rail or an overhead catenary, although the combination of diesel with overhead catenary is in the development stage.

The most common locomotives are referred to as “diesels.” They are not dual-mode, as just described, but do use a diesel engine to power an electric generator, which drives electric traction motors.

The third type of locomotive is the electric locomotive, which requires a catenary or, less commonly, a powered third rail. These locomotives can only be used where the entire route has electric power. When the power is supplied by third rail, they are not mixed with certain types of freight rail because the third rail interferes with the clearance envelope of the double-stack freight cars. These locomotives are further divided into those designed for typical commuter rail operations and those designed for high-speed rail operations. The electric locomotives designed for high-speed rail operations operate at speeds higher than 100 mph, often substantially higher. An example of such a locomotive would be the Acela locomotive used by Amtrak. These vehicles usually have a distinctive look, with front ends approximating those of aircraft.

Passenger Cars

Passenger coaches come in two major types, single-level and bi-level. Single-level passenger cars can carry between 80 and 120 passengers each, with the exact number of seats determined by the length of the car and any space needed for other purposes.


Metro-North Passenger Car – Single Level

The bi-level versions provide greater capacity per car, although not double that of single-level cars, as they must accommodate stairs providing access to the second level, as well as single-level sections to provide accessible seating.

In addition, some railroads elect to use gallery cars, which have the second level open to the first down the center aisle of the car, which allows ticket agents to collect tickets from both levels at the same time while walking down the aisle on the first level. Such cars have lower seating capacity than standard bi-level passenger cars.


Gallery Car

Regardless of the configuration of commuter rail passenger cars, none are designed to provide for numerous standees. This includes provision of narrower aisles than on LRT or CRT cars, since the aisles are not intended to accommodate standees.


Metro-North Electric Multiple Unit

EMU cars are self-propelled, eliminating the need for a locomotive. These vehicles require the entire alignment to have electric power, which is usually provided via a powered third rail.

In addition, there are also DMUs that provide many of the benefits of EMU commuter-rail vehicles but are diesel-powered.

DMU

As of this writing, there is only one manufacturer of such vehicles whose product meets FTA requirements, and that is the Colorado Car. It is a self-propelled passenger vehicle with seating for up to 188 passengers in the bi-level version and 92 in the single-level version. These cars have been used in revenue service in Florida on the TriRail system.

These vehicles are potentially more cost-effective for low-volume operations where trains of fewer than four cars are required. However, where passenger demand is expected to exceed the capacity of a four-car train, analysis has shown EMU and push-pull commuter trains to be more economical.

4.1.3 Key Station Concepts

Tarrytown Commuter Rail Station

CRT stations have the same elements as other guided transit technologies:

- Platforms and platform enclosures.
- Waiting and ticketing areas.
- Parking.
- Bus transfer areas.
- Pedestrian access.

Commuter rail stations are typically larger than LRT or RRT stations because they often provide waiting areas, as the frequency of service is usually lower than it is for the other rail modes. As an example, the Tarrytown Station is a free-standing commuter rail station, including the building, parking, and transfer areas where buses and cars can pick up and drop off passengers.

Station Platform with Overpass

The platforms of CRT stations are typically high-level platforms, to provide level boarding to the trains, although low-level platforms are not uncommon. High-level platforms offer the advantage of both faster boarding and alighting, resulting in reduced dwell time, and the elimination of stairs in passenger cars. Some lines have a mixture of high- and low-level platforms, in which case the passenger cars must have interior stairs as well as plates to overlay those stairs to access high-level platforms. The CRT station shows a high-level platform accessed via a pedestrian overpass. Typical attributes of the platforms include canopies for weather protection, lighting, benches for waiting passengers, and signage to direct passengers.

Beacon Station

The appearance of CRT stations tends to display greater variety than is the case with other rail-transit technologies. The Beacon Station shows a very open style of station. This station was upgraded with the active participation of the City of Beacon, and includes an expanded parking area, a modern canopy, and extensive landscaping.

Yonkers Station

The Yonkers Station is an example of an historic restoration that won the 2006 Excellence in Historic Preservation Award. The photo shows the front of the station.

Pedestrian Access

Enhancing pedestrian access to stations is as important as providing good access for vehicles, since for every person walking to a station, the need to provide space to store a car (and perhaps the auto trip itself) is eliminated. The methods used to enhance station access for CRT stations are equally applicable to other transit modes.

Pedestrian Underpass

Pedestrian underpasses need to be as open as possible for security and the appearance of security for walkers. The use of materials appropriate to the area is important to visually integrate underpasses or overpasses into the surrounding community.

Pedestrian Overpass

Overpasses may be needed to span roadways, waterways or similar obstacles. When properly sited and designed, they can make the difference between passengers walking to the station or choosing to drive. Protection for those below an overpass is as important as providing a sense of safety for those using the overpass.

Where station sites are below or above local grades, or where a station site itself has more than one level, it is necessary to provide stairs and ramps to facilitate access. Elevators could also be provided. Finally, cross-walks need to be clearly delineated and have curb cuts to facilitate access for the mobility-impaired. Such delineation may be achieved by means as simple as painted treatments, though it may also take other forms, including the use of embedded paving materials that offer a distinctive appearance.

Station Parking

Poughkeepsie Station with Parking

Parking areas are important because adequate parking eliminates the tendency of commuters to search for on-street spaces in surrounding neighborhoods or to simply give up and drive to work. While surface lots are entirely appropriate where space permits, parking structures may be needed where the footprint of the site is inadequate to accommodate all the parking needed.

Structured Parking at Poughkeepsie Rail Station

Where space is limited and demand warrants the investment, parking structures may be needed. As with surface lots, the design of such structures should complement the architecture of the area. An alternative to unavailable station parking is use of connecting services (e.g., Metro-North's Hudson Rail Link or Transit of Rockland to Tarrytown).

The surface parking area with landscaping treatments can provide a visual separation of the lot from the surrounding area. Parking lots also require adequate lighting, but it must be provided in such a manner as to avoid spillover of light into the surrounding area. In addition, spaces and movement lanes need to be clearly delineated, and parking near the station entrance should be reserved for the mobility-impaired. Internal walkways are needed for large lots in order to separate walkers from cars circulating through the lot.


Landscaped Commuter Rail Station Parking Area

Surface parking adjacent to such structures is usually reserved for short-term parking, and in cases in which the structure can be integrated into the station itself, riders can benefit from the weather protection the structure provides when moving from their cars to the station.

As with BRT and LRT, CRT stations may offer an excellent opportunity to create multimodal transportation centers where pedestrians, bicycles, cars, and transit vehicles converge. They may also foster TOD.

4.1.4 ITS Components

Commuter rail systems require integrated control and communications systems to manage train movements, monitor performance and adjust for changed operating conditions. A central control facility is the hub of CRT operations, with the capacity to monitor and control the entire rail system. Among the functions of the central control facility are management of the traction power system, control of all train movements, monitoring of operations, monitoring of stations, communications between stations and central control, communications between trains and central control, and monitoring of safety. These systems enable commuter rail systems to adapt to changing conditions and coordinate and adjust operations as necessary to maintain service.

Also commonly implemented in CRT systems are passenger information systems designed to provide projected arrival times, incident reporting, and rider alerts in stations and aboard vehicles. Fare collection in CRT systems is usually managed on-board the vehicles, with the conductors validating all tickets. Coordination with feeder-bus services is usually through schedules, as commuter trains arrive on fixed schedules.

4.2 Application of CRT Technology to the Tappan Zee Bridge/I-287 Corridor

4.2.1 Technology

CRT service already reaches into this corridor, although perpendicular to the east-west direction of travel, so a new technology is not being introduced. Any new equipment or trackage would be 'state-of-the-art' technology to permit smoother operations and enhance passenger ride experience, but would be incorporated with a view toward the continued utilization of existing equipment as well. Bi-level passenger cars currently being used in the region could be investigated for compatibility with the Park Avenue tunnel; if this possibility is realized then the vertical clearance criteria in the project corridor would also be compatible, and these bi-level cars could then be used in this corridor as well Any new stations would be equipped with passenger information technology that would display the timing and destination of the next arriving train on each platform. This equipment can also be provided at existing stations beyond the corridor as system upgrades. As the equipment would also operate on existing rail lines, no automation of operation is anticipated.

4.2.2 System Connectivity

Because the CRT improvements are additions to the existing infrastructure, connectivity is an important concern. As currently planned, connectivity is provided to the Port Jervis Line from the north in Alternatives 4A, 4B, and 4C and Option 4D, to the Hudson Line to the south in the same alternatives, and to the New Haven Line to the north in Alternative 4A. Consideration was also given to connectivity with other rail lines that cross the corridor, with the following conclusions:

- Connectivity could be provided to the West Shore CSX freight line, but no passenger service is anticipated on that line, either to the north or south, as it is a heavily used single-track freight line.
- Connectivity could be provided from the Hudson Line to the eastbound cross-corridor line in Alternative 4A, permitting service down the Hudson Line and east to White Plains, but it was eliminated in the AA as too expensive and serving only limited markets.
- Connectivity could be provided to the Harlem Line at White Plains in Alternative 4A, but the Harlem Line is already at capacity south of White Plains, so there would not be available capacity for additional trains from either the east or west. With a direct connection to the Hudson Line in 4A, there is no need for a direct connection to the Harlem Line (however, a transfer would be provided).

The direct connection to the Hudson Line southbound is complicated by grade changes, and results in a tunnel from the bridge down to the river shore. Transfer to the Hudson Line was considered in the AA as an alternative, and was re-studied in Option 4A-X. The loss in ridership caused by that transfer (whether the connection is to the existing Tarrytown Station or a new Tappan Zee Station) was sufficient to justify the expense of the connection.

4.3 Description of CRT Alternatives/Options

4.3.1 Alternative 4A

Alternative 4A provides full-corridor CRT, which includes both cross-corridor service and Manhattan-bound service to GCT via a direct connection to the Hudson Line (Figures 4-3 and 4-4). At the river crossing, the commuter rail alignment for Alternative 4A could be constructed on either a rehabilitated or replacement Tappan Zee Bridge that would carry both the highway and the commuter rail. The rehabilitated bridge would include a supplemental structure parallel to the existing bridge to accommodate the commuter rail.

The commuter rail alignments were developed using design criteria and guidelines based on Metro-North practices prepared for this project. Generally, track centers would be spaced between 14 feet (minimum) and 18 feet (desirable), centered within a ROW width of between 37 feet (minimum) and 57 feet (desirable) that would include parapets or barriers. The absolute maximum grade that would be allowed on the line would be 2.0 percent, at covered locations and for short distances at uncovered locations; otherwise, the maximum grade would be 1.5 percent. Within the I-87/I-287 ROW, the CRT alignment would generally be parallel/concentric to the highway alignment. Where the desirable design speed (110 mph) would cause the CRT alignment to drift outside the ROW, design speed would be reduced appropriately and would generally be maintained at between 90 and 95 mph at these locations. The minimum design speed would be 45 mph. Given the highly variable terrain in both counties, a significant part of the alignment would be in tunnel or on viaduct. The track would be electrified from Suffern to Port Chester and to the Hudson Line via third rail.

Alternative 4A would link four of the five existing north-south rail lines in the corridor by providing direct connections to the Port Jervis, Hudson, and New Haven Lines, and a transfer facility to the Harlem Line. Alternative 4A also includes 11 proposed stations with 860-foot minimum length platforms, and most would include park-and-ride facilities:

- **Rockland County** – Hillburn, Airmont, Garden State Parkway/Interchange 14A, and Palisades Mall. Each of these stations would include new or expanded park-and-ride facilities.
- **Westchester County** – Tappan Zee, Elmsford, WPTC, Westchester Mall, Platinum Mile, and Purchase. All of these, except Platinum Mile, would include new or expanded park-and-ride facilities.

4.3.1.1 Rockland County

The CRT alignments in Rockland County for Alternatives 4A, 4B, 4C and Option 4D are fundamentally identical, However, they each would have two alignment options from downtown Suffern to Airmont Road (Interchange 14B) – Piermont ROW or I-87/I-287 south side. In addition, there are two alignment options east of Interchange 14B – CRT in the I-87/I287 highway median or along the highway's south side. The highway median option would divert from the south side option about a mile and a half east of Interchange 14B and continue in the median for approximately 8 miles to the tunnel that extends under Nyack to the rehabilitated or replacement Tappan Zee Bridge.

The Piermont ROW in Suffern and the south side alignment east of Interchange 14B are used in this study as a basis of comparison for each of the CRT alternatives/options and they are described in detail in the following paragraphs. These pairs of alignment options will be analyzed in the DEIS to determine the optimal solution based on the established evaluation criteria and the project's goals and objectives.

Hillburn/Suffern

The alignment developed to connect the new service from the Port Jervis Line would take the commuter rail from the proposed Hillburn Station just south of 4th Street onto a curved alignment that would descend under Route 59 and continue east either hugging the south side of I-287 (Option 1) or onto the Piermont ROW in a cut-and-cover tunnel under Route 59 and open-cut configuration until it passes over the Mahwah River (Option 2).

A possible Hillburn Station could be located south of the 4th Street Bridge between Route 59 and the railroad tracks in a space that is currently a commercial facility. A proposed storage yard could be located where a commercial area exists north of 4th Street between Route 59 and the tracks. The Hillburn Station would serve downtown Suffern and provide transfers from the NJTransit Bergen/Main Line that would extend service to the proposed Hillburn Station. The location of the existing NJTransit Suffern Station is too far south to accommodate direct rail connections from the Port Jervis Line to the I-287 Corridor.

East of Suffern

Alignment Option 1 would bring the CRT over Route 59 where it crosses under Interchange 15 (Suffern) and curve east and climb to the south side of I-87/I-287 parallel to Wayne Avenue. In this option the CRT would continue adjacent to the south side of the highway within the I-87/I-287 ROW. The CRT would rise up to a viaduct over Airmont Road as would the CRT in the Piermont alignment.

In Option 2, the CRT alignment would continue in a cut-and-cover tunnel along the Piermont ROW east of Route 59 to Chestnut Street and transition to a retained open cut. East of Washington Avenue the CRT would remain in an open cut and ascend to cross over the Mahwah River. The CRT would share the Piermont ROW with an existing single-track freight line that operates on an infrequent schedule. East of the river the alignment for the most part would follow the elevation of the existing freight line tracks until it approaches Airmont Road, where the CRT would ascend onto a viaduct to avoid conflict with the existing Interchange 14B ramps and Airmont Road.

Just east of Airmont Road, a CRT station is proposed between I-87/I-287 and the Piermont Line ROW, and could be located at the site of an existing commercial facility. East of the Airmont Station, the alignment would join the I-87/I-287 ROW and proceed along the south side of the highway. The alignment would cross above Spook Rock Road, under College Road, and below Route 59 (Nyack Turnpike), which is essentially at the highest elevation of I-87/I-287 within Rockland County. East of the Route 59 crossing near Monsey, the CRT would cross above the Piermont Line on structure, then continue at grade and transition onto a viaduct to cross over Saddle River Road and then, in a retained cut, cross beneath Hungry Hollow Road. Approaching Route 45, the alignment would enter a 900-foot-long tunnel, then remain in a retained cut and enter a 2,000-foot-long tunnel that would extend under Scotland Hill Road and the Garden State Parkway (GSP), then daylight in a retained cut, with two GSP ramps (Interchange 14A) carried on structure above.

Spring Valley/Nanuet

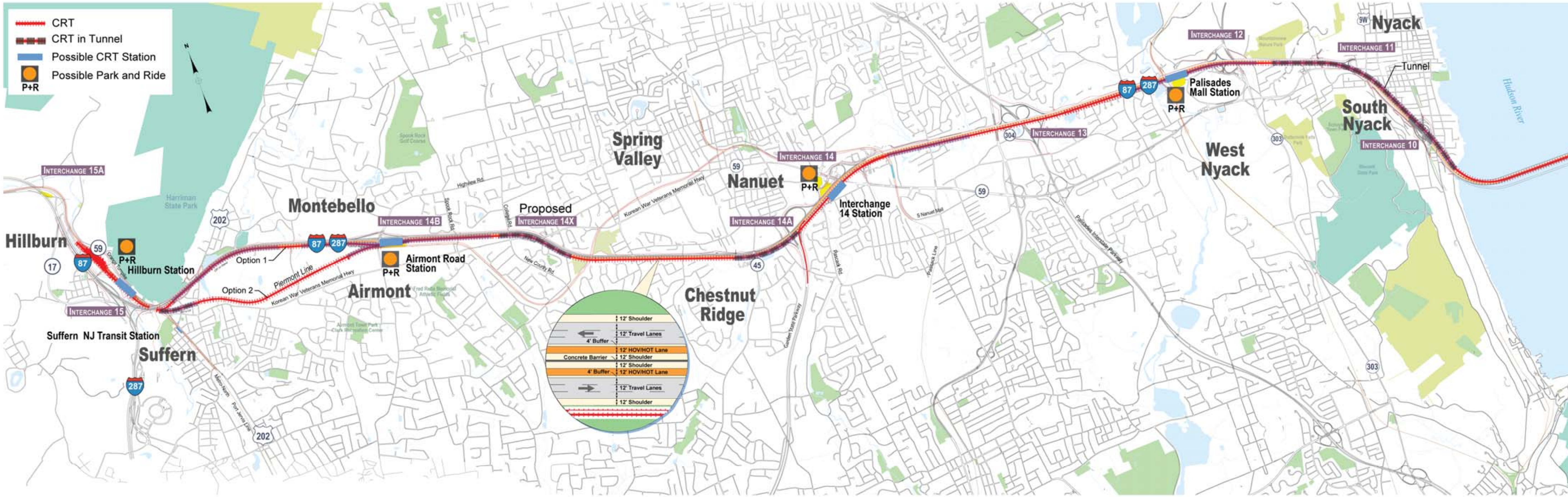
East of the GSP, the CRT would be carried on a viaduct over Pascack Road and the Pascack Brook, then return to retained cut and pass beneath Route 59 and the ramps of Interchange 14 (Spring Valley). A proposed GSP/Interchange 14 Station could be located between Pascack Road and Route 59, with the platform on the south side, near Old Nyack Turnpike. This possible station could utilize the existing park-and-ride facilities on the north side of the Thruway at Pascack Road and Forman Drive, which could be expanded as necessary. A pedestrian bridge over the highway would be built to provide patron access from the parking lots to the station platforms.

After passing beneath the Pascack Valley Line rail bridge, the alignment would extend on a viaduct over the Nauraushaun Brook, and on retained fill and structure over North Middletown Road, and on retained cut and a short tunnel beneath Route 304 and the Palisades Interstate Parkway (Interchange 13).

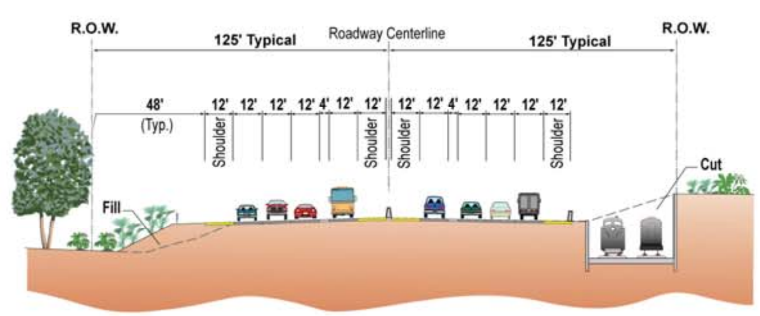
West Nyack

As the CRT alignment descends toward the Hackensack River valley, the retained-cut section would transition onto a long viaduct. This viaduct, more than a mile and a half long, extends from west of Strawtown Road to east of Route 303, crossing above Strawtown Road, the Hackensack River, the CSX West Shore Line, Palisades Center Drive, Interchange 12 ramps, and Route 303.

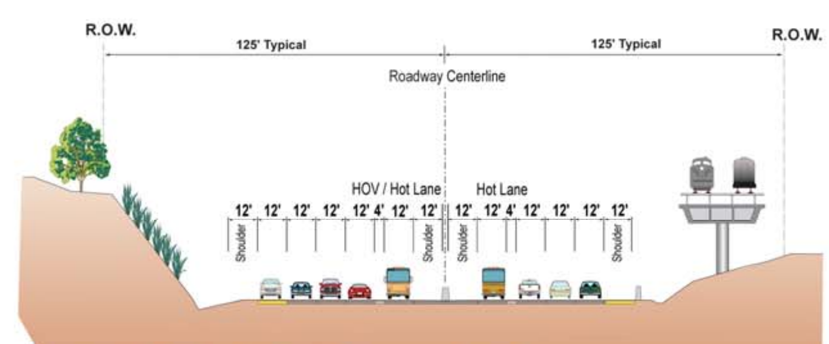
Just east of the CSX West Shore Line, a proposed commuter rail station could be located at the existing park-and-ride facility referred to as Parking Lot J, which is adjacent to the Palisades Mall. The commuter rail alignment on viaduct at this location would require station platforms approximately 45 feet above the I-87/I-287 roadway and approximately 25 feet above the existing park-and-ride surface. East of Route 303, the viaduct section would transition into a retained cut before entering the portal for a tunnel section for the approach to the Hudson River. The western portal would be located on the hillside, east of Route 303.



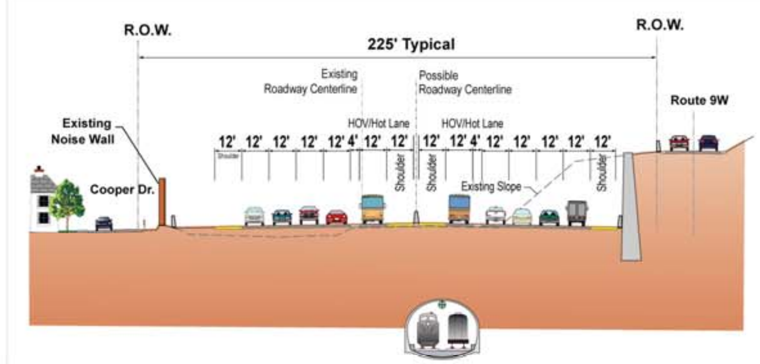
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 4A, 4B, 4C - Rockland	14,850 ft.	13,250 ft.	52,400 ft	80,500 ft (15.2 Miles)



Typical Cross Section - West of Spring Valley
(Looking East)

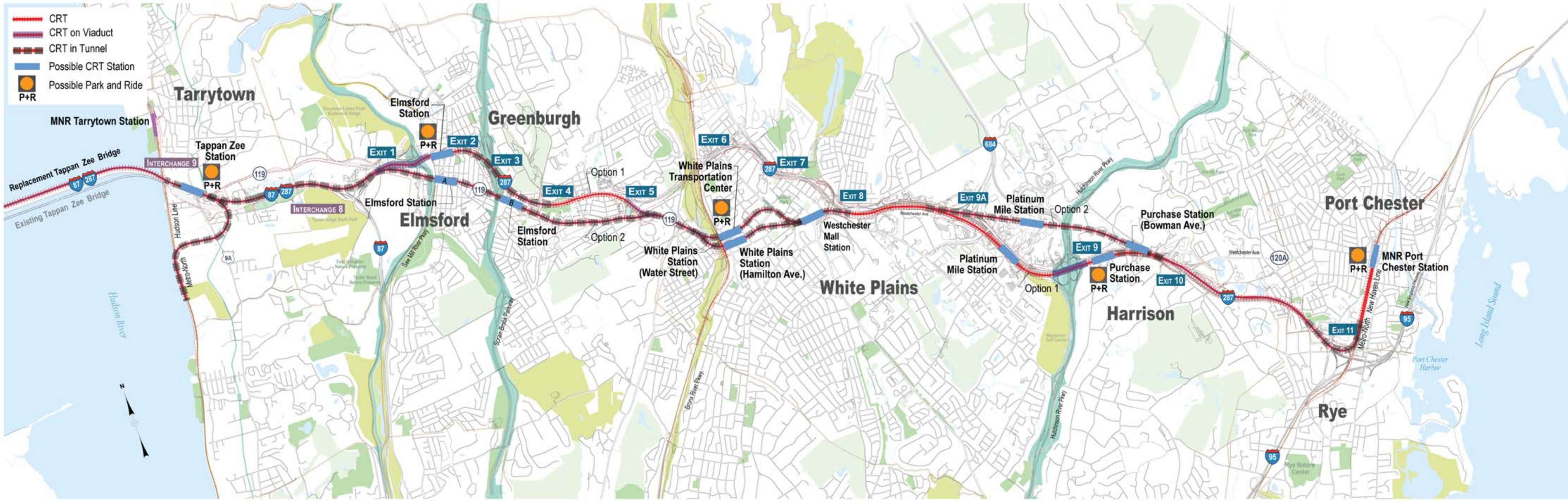


Typical Cross Section at Interchange 12
(Looking East)

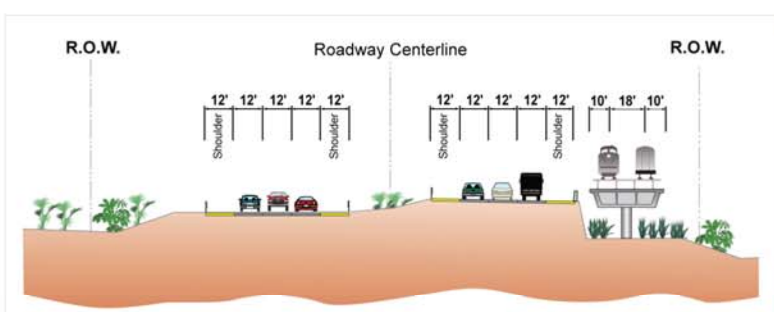


Typical Cross Section East of Interchange 11
(Looking East)

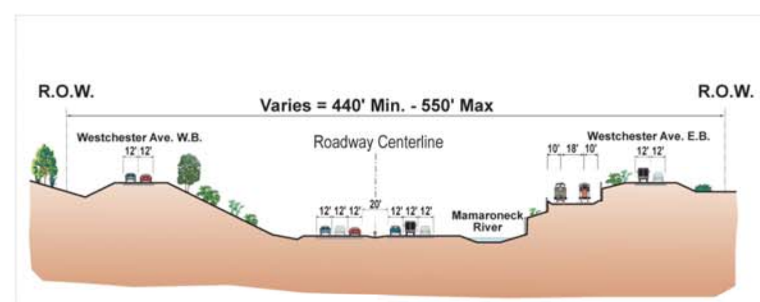
Figure 4-3 Alternative 4A-4B-4C Full-Corridor Commuter Rail Transit in Rockland County



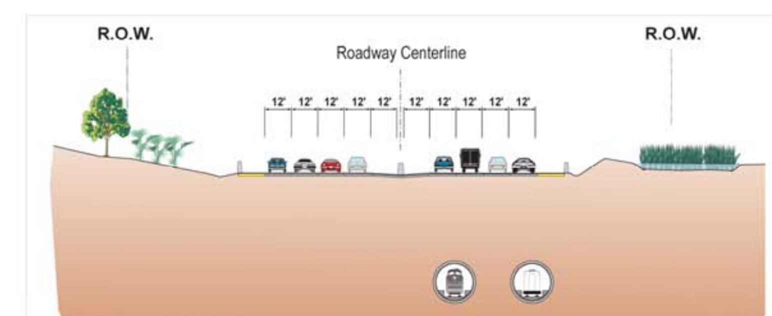
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 4A - Westchester	42,400 ft	3,900 ft	41,700 ft	88,000 ft (16.7 Miles)



Typical Cross Section in Elmsford (Option 1)
(Looking East)



Typical Cross Section East of White Plains
(Looking East)



Typical Cross Section East of Exit 11
(Looking East)

Figure 4-4 Alternative 4A Full-Corridor Commuter Rail Transit in Westchester County

Nyack

The combination of a steep I-87/I-287 profile in South Nyack and the grade constraints for commuter rail would require that the rail line be in tunnel passing below the Nyack Palisades. The rail tunnel would daylight and transition onto the proposed replacement or rehabilitated bridge. The rail tunnel from east of Route 303 to the portal near the Hudson River shoreline would be approximately 2 miles long.

4.3.1.2 Westchester County

Tarrytown

A rehabilitated or replacement river-crossing structure that would accommodate CRT at the Westchester County shoreline would carry the commuter rail from the bridge into a proposed Tappan Zee Station and then diverge for the cross-Westchester CRT alignment and the Hudson Line Connector tunnel. The descending Hudson Line Connector tunnel would essentially follow an ‘S’ configuration to the east and south, with a design speed of 45 mph. It would ultimately lead under, and then up to the Hudson Line, to meet existing top-of-rail elevation between the express tracks before the Irvington Station.

The Hudson Line Connector tunnel described above would begin as a diverge from the through tracks extending eastward for the cross-corridor commuter rail alignment. East of the diverge, the profile would transition from the 2.0 percent downgrade, allowing the cross-corridor track tunnel to rise and ultimately daylight east of Interchange 8.

Prior to the track diverge an underground Tappan Zee Station would be located on the north side of the toll plaza and extend east under Broadway into the existing shopping center. The existing Tarrytown Station would remain, and a shuttle bus service would be provided for transfers to the cross-corridor service at the Tappan Zee Station.

East of Broadway, the CRT tunnel would the follow the I-87/I-287 alignment and be deep enough to avoid potential conflict with the Talleyrand Swamp and Interchange 8 (Cross Westchester Expressway). Overall, the rail tunnel extending from the Hudson River shoreline to Interchange 8 would be approximately 2 miles long.

Greenburgh/Elmsford

East of the tunnel beneath Interchange 8, the CRT could run along the south side of I-287, proceeding for about one-half mile in retained cut/retained fill sections before rising onto a viaduct that would carry the CRT alignment over the Saw Mill River Parkway, the Saw Mill River, and North Central Avenue (Route 9A). A proposed elevated CRT Elmsford Station could be centered between Nepperhan Road and North Central Avenue. A parking structure with a vertical connection to the platforms would be provided as part of this facility.

East of the Elmsford Station viaduct, a 4,000-foot-long tunnel would carry the alignment beneath the Sprain Brook Parkway and the Catskill Aqueduct. The tunnel would daylight west of Knollwood Road, and would rise over Manhattan Avenue and then descend in retained cut beneath Hillside Avenue before entering the west portal of the proposed rail tunnel that would be constructed beneath White Plains to avoid land use and traffic impacts in the densely developed city.

An alternative to the I-287 alignment is an option to continue the tunnel that runs beneath Interchange 8 (Cross Westchester Expressway) along Route 119 through Elmsford (labeled Option 2 on Fig. 4-4). A possible underground Elmsford Station could be located at the intersection of Route 9A and Route 119, (A), or possibly further east near Knollwood Road, (B). The tunnel in this option would continue under Route 119 into downtown White Plains.

White Plains

The rail tunnel alignment would depart from the I-287 ROW at Exit 5, Hillside Avenue, and proceed to the southeast beneath Route 119 en route to the WPTC and the existing Metro-North Harlem Line station. The CRT tunnel would cross beneath the Bronx River Parkway and the Harlem Line tracks for the proposed underground White Plains Station with provision for vertical transfer to the Harlem Line and the WPTC. Depending on the tunnel alignment chosen, the proposed White Plains Station would be located immediately east of the Harlem Line and either under Water Street or Hamilton Avenue. Beyond the White Plains Station, the CRT would proceed to the east, following either Hamilton Avenue or Main Street (depending upon the results of further subsurface investigations).

To the east, after passing beneath Broadway and Tibbits Park, an additional underground station – East White Plains – could be located at the Westchester Mall. After this station, the CRT tunnel would daylight north of Westchester Avenue at Exit 8 and re-enter the I-287 ROW. The alignment would be along the south side of I-287, predominantly at-grade and in retained cut to the east of the I-684 Interchange (Exit 9A). Between I-684 and the Hutchinson River Parkway, a possible station is proposed at Corporate Park Drive that could include jitney service to the Platinum Mile and other office parks accessible from Westchester Avenue.

An optional alignment to the I-287 alignment being considered would put the CRT in a tunnel under the Platinum Mile office parks (Option 2 on Figure 4-3) and then re-enter the I-287 ROW east of Bowman Avenue, where a possible Purchase Station could be located adjacent to the north side of I-287.

Harrison

The I-287 CRT alignment would continue eastward in retained cut/retained fill, and be located between I-287 and eastbound Westchester Avenue. East of the Hutchinson River Parkway crossing, a partially below-ground Purchase Station could be located in the vicinity of Kenilworth Road. To the east of the station, the alignment would enter a 3,600-foot tunnel passing under Purchase Street and daylight where Westchester Avenue departs from the I-287 ROW. The CRT alignment would continue east into Rye along the south side of I-287 in retained cut/retained fill sections.

Rye/Port Chester

Just west of South Ridge Street, the alignment would enter a tunnel beneath Boston Post Road (Route 1) and the I-95 Interchange. The mile-long tunnel carrying the westbound CRT track would daylight at the north side of the I-95 Interchange at the southeast corner of the large shopping center east of Boston Post Road. Beyond the tunnel, direct connection at-grade would be achieved with the New Haven Line southbound local track. For connection to the New Haven Line northbound local track, the eastbound CRT would be carried in a tunnel extended beneath all four tracks of the New Haven Line, and then ascend along the east side to meet existing grade for connection to the northbound local track. To the north, the CRT would platform at Port Chester Station from the local tracks.

4.3.2 Option 4A-X

An option to Alternative 4A that does not include the direct connection to the Hudson Line has been modeled in the transit mode analysis as Option 4A-X. With this option, Manhattan-bound CRT riders who had a one-seat ride to GCT in Alternatives 4A, 4B, and 4C would be required to exit the train at the proposed Tappan Zee Station and board a shuttle bus to the Metro-North Tarrytown Station for service on the Hudson Line. Alternatively these Manhattan-bound riders could transfer to the Harlem Line at the White Plains Station.

Apart from the elimination of the Hudson Line connection, the proposed number and possible station locations, and the basic CRT alignment of Option 4A-X would be identical to that of Alternative 4A.

4.3.3 Alternative 4B

Alternative 4B would provide Orange and Rockland County commuters a one-seat CRT ride to Manhattan and transfer capability to LRT serving employment centers in Westchester County and Connecticut (Figures 4-4 and 4-5). Alternative 4B would provide increased mobility within Westchester County and between Westchester County and Connecticut, as well as increased access to Metro-North rail lines serving Manhattan. This alternative also provides a transfer from the Metro-North upper Hudson Line service territory at Tarrytown to LRT serving Westchester County and Connecticut.

Alternative 4B provides a two-track CRT alignment from the Port Jervis Line in Suffern to the Hudson Line at Tarrytown (as in Alternative 4A), and LRT service from the existing Tarrytown Hudson Line station to the Port Chester New Haven Line Station. The Manhattan-bound CRT alignment would connect to the Hudson Line through the Hudson Line Connector tunnel, as in Alternative 4A. There would be a new Tappan Zee Station at the existing bridge toll plaza for transfers between CRT and LRT. At the river crossing, the commuter rail alignment could be constructed on either a rehabilitated or replacement Tappan Zee Bridge.

The LRT service in Alternative 4B would start at the Hudson Line Tarrytown Station, allowing a transfer to/from the existing Hudson Line. A proposed LRT rail alignment from the Tarrytown station along the east side of the Hudson Line would connect to the proposed Tappan Zee Station. The LRT alignment through Westchester County would follow a hybrid, high-speed/in-street LRT alignment, as proposed in the Full-Corridor LRT alternative. The in-street alignment would be used on Route 119 in Tarrytown to I-287 and through downtown White Plains. The high-speed alignment, constructed adjacent to I-287, would be used in Elmsford and Greenburgh, as well as east of White Plains to the direct connection to Port Chester Station.

Alternative 4B would link four of the five existing north-south rail lines in the corridor by providing direct connections to the Port Jervis and Hudson lines, and transfer facilities at the Harlem and New Haven Lines. Alternative 4B would provide four possible CRT stations in Rockland County, in addition to the proposed Tappan Zee Station, and 14 possible LRT stations in Westchester County, as follows:

- **Rockland County** – Hillburn, Airmont, GSP/ Interchange 14, and Palisades Mall.
- **Westchester County** – Meadow Street, Benedict Avenue, Elmsford, Greenburgh, Hillside Avenue, County Center, WPTC, Galleria Mall, Westchester Mall, White Plains Avenue, Corporate Park Drive, Purchase, South Ridge Street and Boston Post Road.

4.3.4 Alternative 4C

Alternative 4C (Figures 4-3 and 4-6) would provide Orange and Rockland County commuters a one-seat ride CRT to Manhattan and transfer capability to BRT serving employment centers in Westchester County and Connecticut. It would provide increased mobility within Westchester County and between Westchester and Connecticut, as well as increased access to Metro-North rail lines serving Manhattan. This alternative also provides a transfer from the Metro-North upper Hudson Line service territory at Tarrytown to BRT serving Westchester County and Connecticut.

Alternative 4C provides a two-track CRT alignment from the Port Jervis Line in Suffern to the Hudson Line at Tarrytown (as in Alternative 4A), and BRT service from the existing Tarrytown Hudson Line station to the Port Chester New Haven Line station. The Manhattan-bound CRT alignment would connect to the Hudson Line through the Hudson Line Connector tunnel as in Alternative 4A. There would be a new Tappan Zee Station north of the new toll plaza for cross-platform or vertical-transfer transfers between CRT and BRT depending on the station configuration. Buses in Rockland County would use the HOV/HOT lanes for faster service and access them through slip ramps. At the river crossing the commuter rail alignment could be constructed on either a rehabilitated or a replacement Tappan Zee Bridge.

The BRT service in Alternative 4C would begin at the Hudson Line Tarrytown Station, providing for a transfer to/from the existing Hudson Line. A proposed busway from the Tarrytown station along the east side of the Hudson Line would connect to the proposed Tappan Zee Station. The BRT alignment through Westchester County would follow the Alternative 3 alignment consisting of bus lanes with transit-signal priority on Route 119 in Tarrytown and through downtown White Plains, on a busway adjacent to the south side of I-287 through Elmsford and Greenburgh, and on bus lanes along Westchester Avenue east of White Plains to Exit 10. East of Exit 10 buses would either use Route 120A, Westchester Avenue for local service to downtown Port Chester and the Metro-North New Haven Line Station, or enter I-287 general purpose lanes at Exit 10 and proceed to the I-95 interchange in mixed traffic for continued service north to Connecticut or south to NYC.

Alternative 4C would link four of the five existing north-south rail lines in the corridor by providing direct connections to the Port Jervis and Hudson lines, and transfer facilities at the Harlem and New Haven Lines. Alternative 4B would consider providing four CRT stations in Rockland County, in addition to the proposed Tappan Zee Station in Tarrytown, and 10 proposed BRT stations in Westchester County at the same possible locations proposed in Alternative 3.

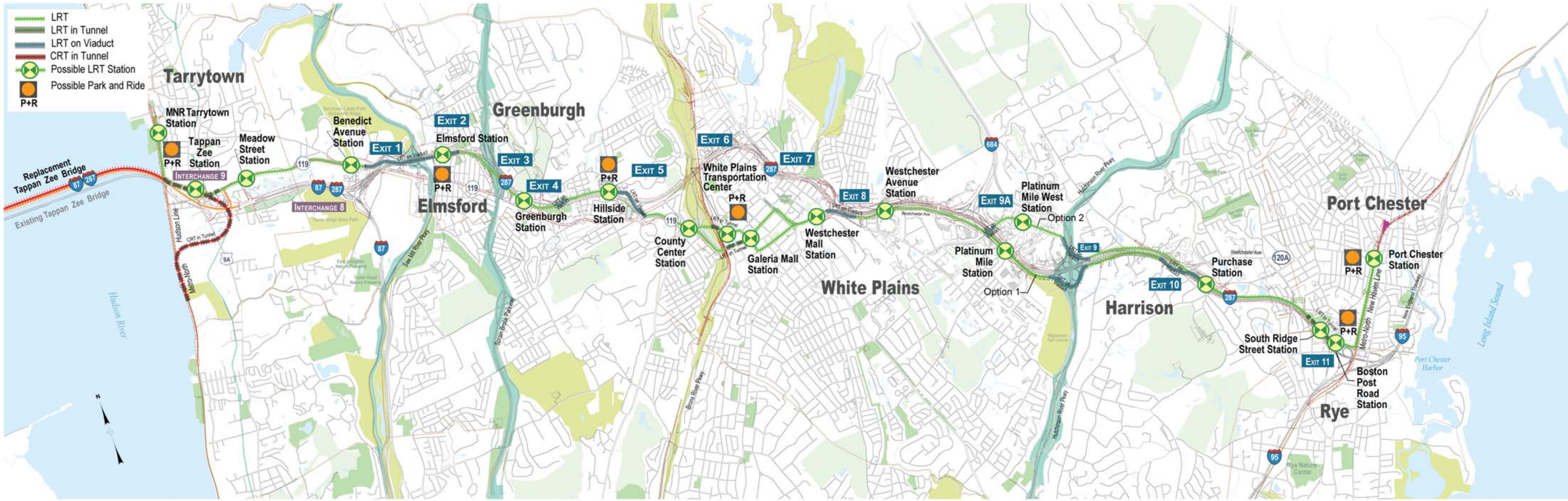
4.3.5 Option 4D

Option 4D (Figures 4-7 and 4-8) was developed in response to comments from the general public, stakeholders, and sponsoring agencies at various times during the study, including the open-house presentations in February 2007 of the proposed alignments of the six build alternatives developed in the *Alternatives Analysis Report* (January 2006), and on the basis of the results of the two-day BRT workshop in September 2007. In addition, the Project Sponsors continued its analyses of the alternatives with the goals of improving the BRT cross-corridor service proposed in Alternative 3 and providing more cost-effective CRT service to GCT in Manhattan.

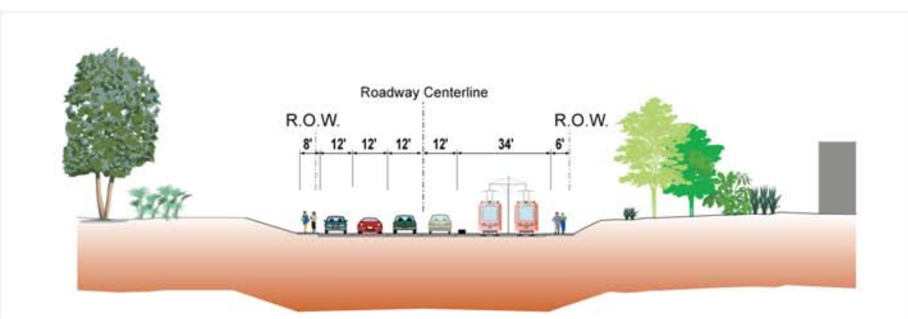
To meet these objectives, Option 4D combines the two transit modes (BRT and CRT) and focuses on the two key markets to be served by the project by providing commuter rail service from Suffern to GCT in Manhattan, and enhanced trunk-line BRT cross-corridor service from Suffern to Port Chester.

Option 4D - CRT

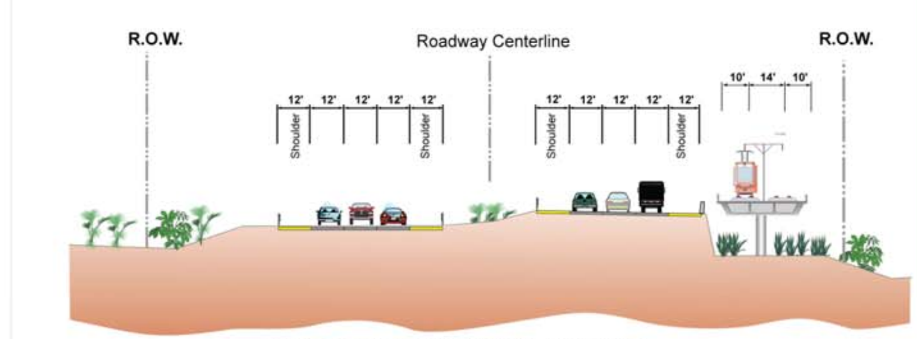
The Option 4D CRT component in Rockland County would have the same alignment options as Alternative 4A. The only significant difference would be the elimination of the proposed Airmont Road Station for cost- and travel-time savings considerations. In addition to a Hillburn Station at the connection to the Port Jervis line, CRT stations could be located at GSP/Interchange 14A and Palisades Mall/Parking Lot J, as in Alternatives 4A, 4B, and 4C, but, as an additional cost-saving consideration in Option 4D, the Tappan Zee Station in Westchester County would not be included. The CRT would use the replacement or rehabilitated bridge and descend into the Hudson Line Connector tunnel for its connection to the Hudson Line for the Manhattan-bound service.



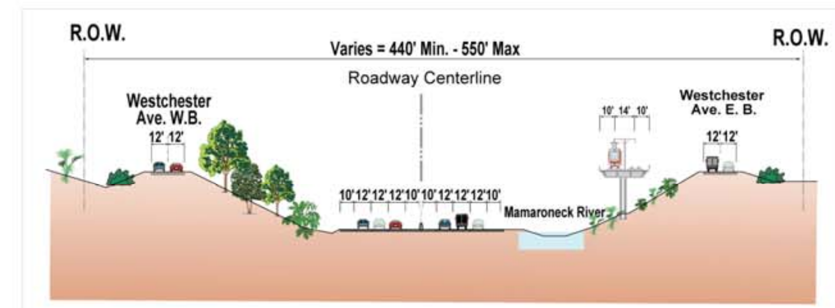
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 4B - Westchester	5,500 ft.	40,000 ft.	34,900 ft	80,400 ft (15.2 Miles)



Typical Cross Section - Along Route 119 in Tarrytown
(Looking East)

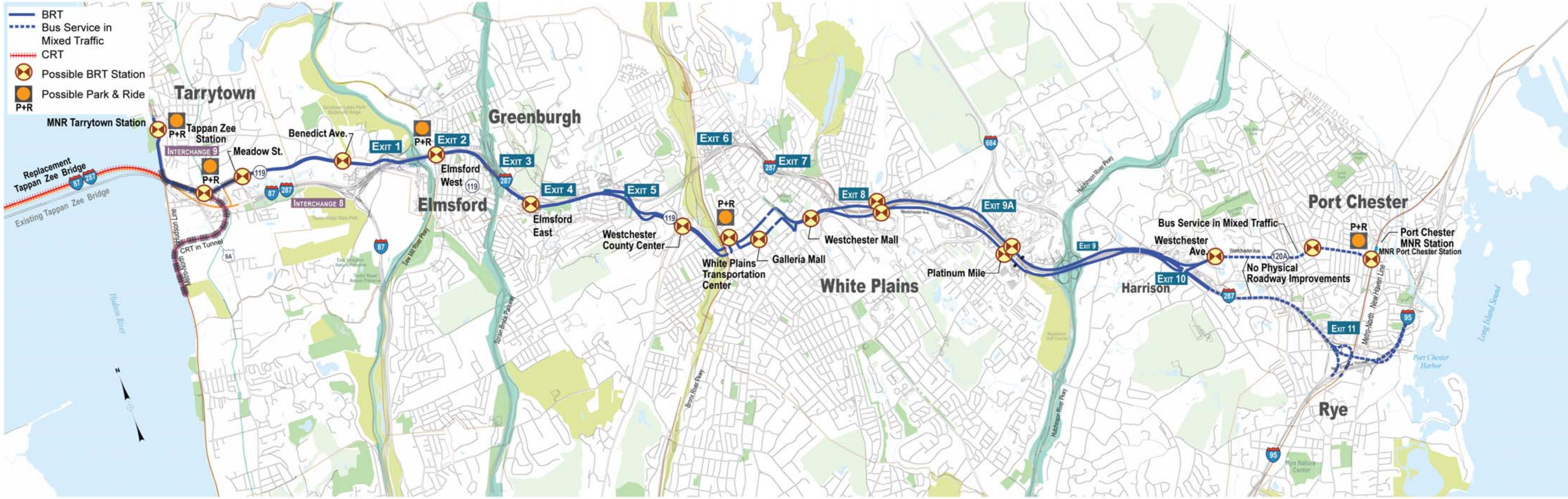


Typical Cross Section in Elmsford
(Looking East)

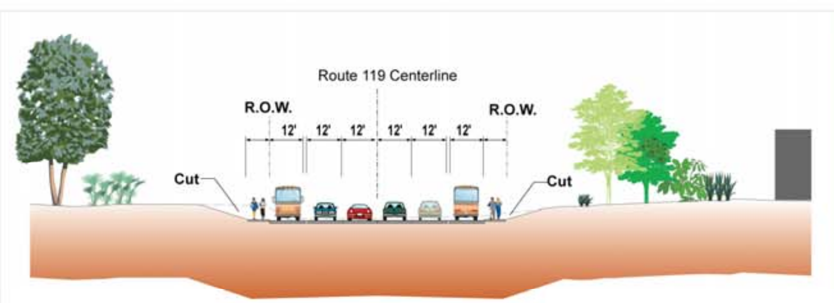


Typical Cross Section - East of White Plains
(Looking East)

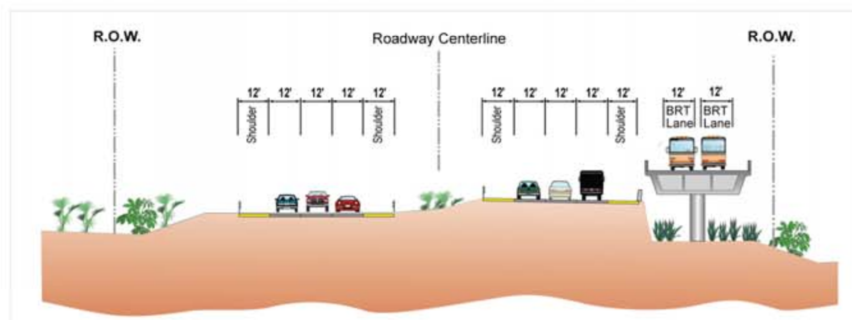
Figure 4-5 Alternative 4B Manhattan-Bound Commuter Rail Transit with Light Rail Transit in Westchester County



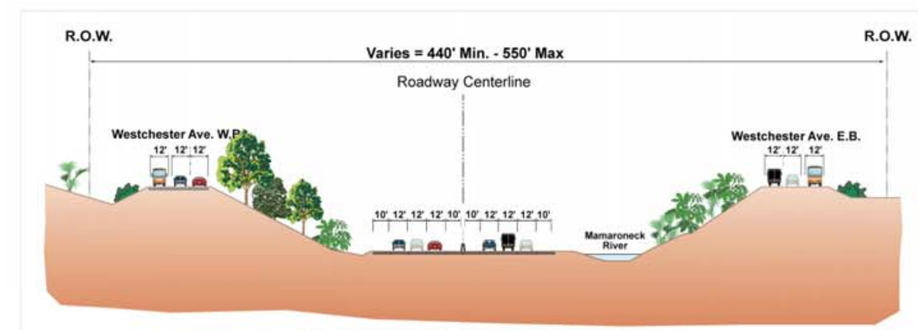
Alignment Quantities				
	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
Alternative 4C - Westchester	5,500 ft	6,500 ft	43,500 ft	55,500 ft (10.5 Miles)



Typical Cross Section - Along Route 119in Tarrytown
(Looking East)

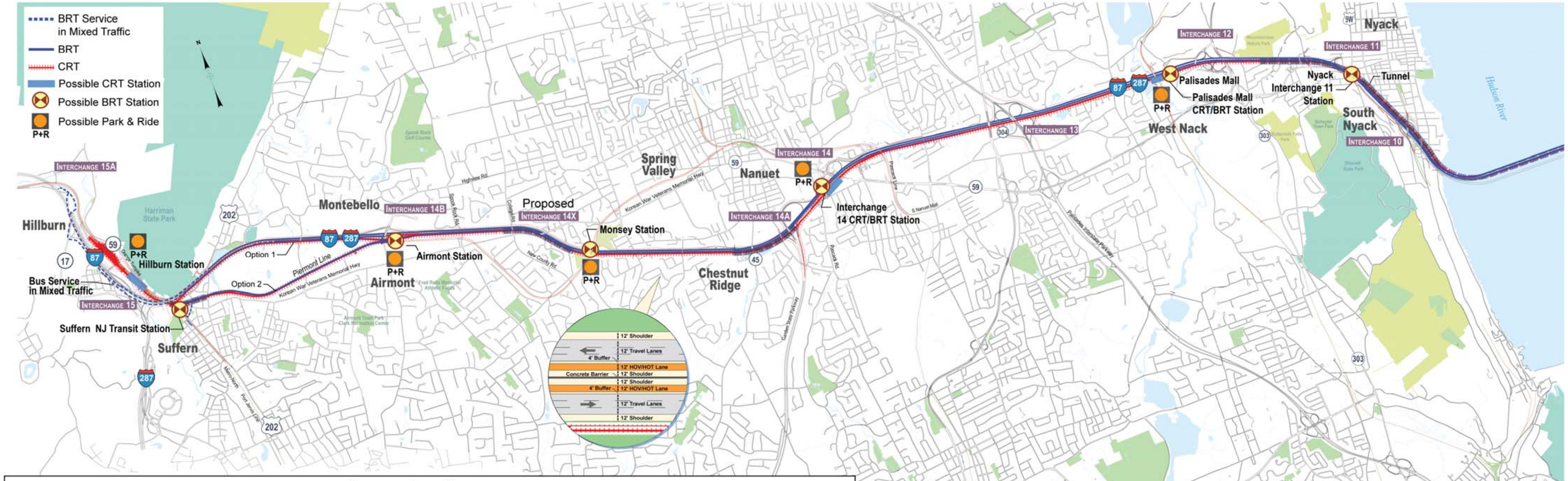


Typical Cross Section in Elmsford
(Looking East)

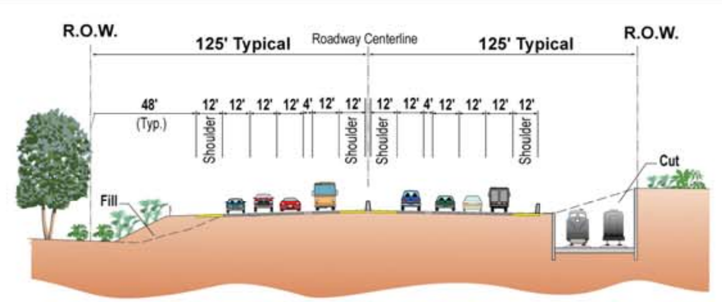


Typical Cross Section - East of Exit 8
(Looking East)

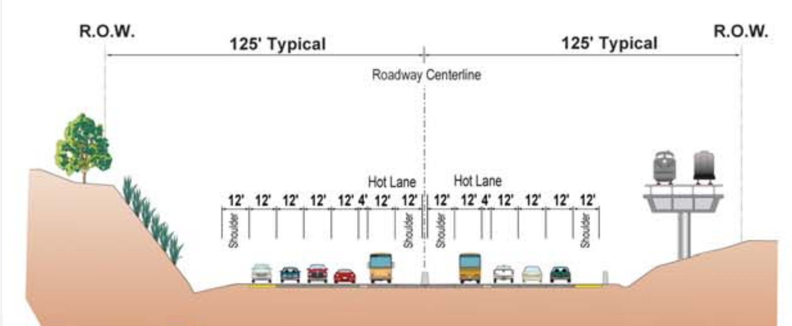
Figure 4-6 Alternative 4C - Manhattan-Bound Commuter Rail Transit with Bus Rapid Transit in Westchester County



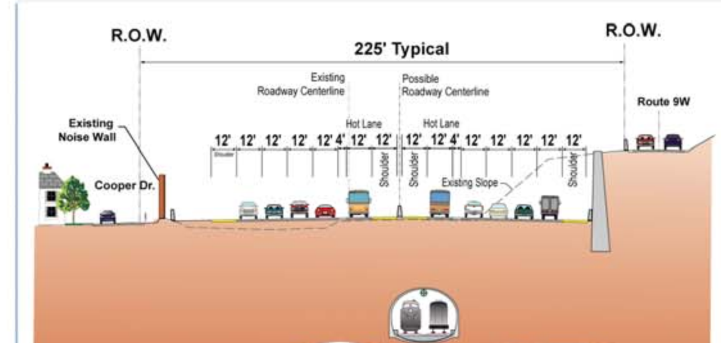
Alignment Quantities				
Option 4D - Rockland	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
CRT	14,850 ft.	13,250 ft.	52,400 ft.	80,500 ft.
BRT	0	0	71,300 ft.	71,300 ft.
Total	14,850 ft.	13,250 ft.	123,700 ft	151,800 ft (28.8 Miles)



Typical Cross Section - West of Spring Valley
(Looking East)

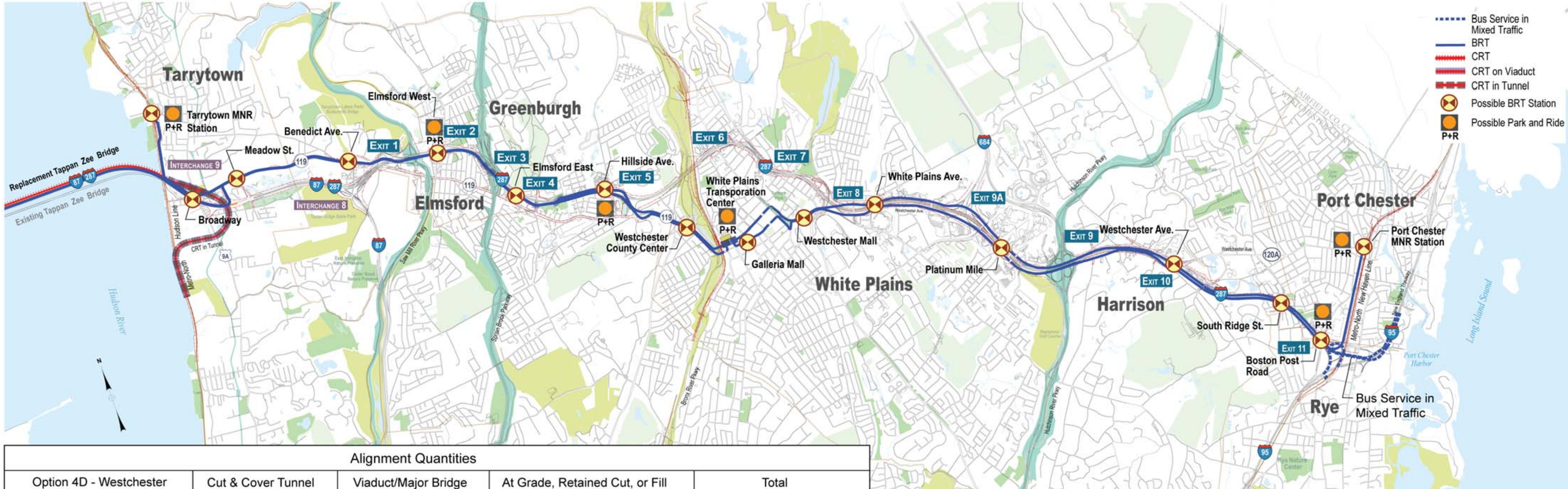


Typical Cross Section West of Interchange 12
(Looking East)

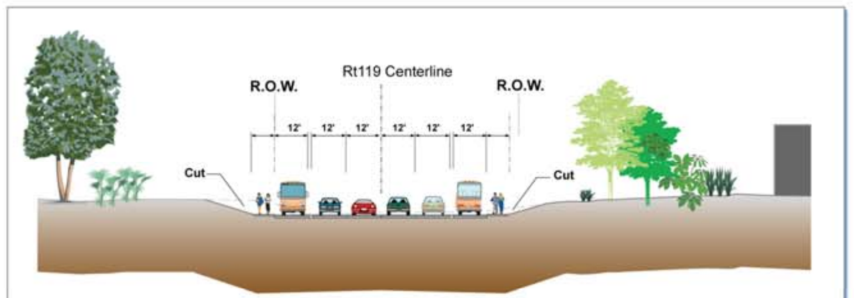


Typical Cross Section East of Interchange 11
(Looking East)

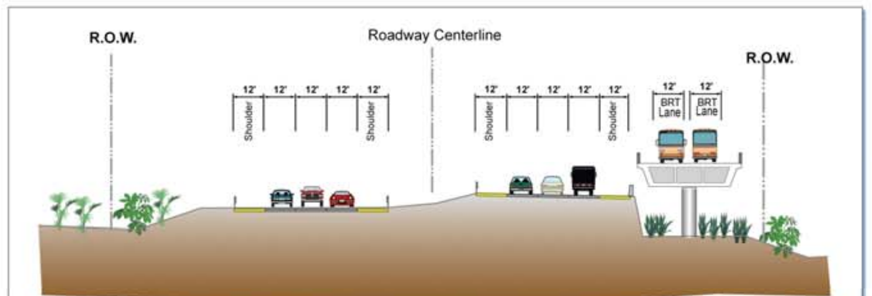
Figure 4-7 Option 4D - Manhattan-Bound Commuter Rail Transit with Cross Corridor Bus Rapid Transit in Rockland County



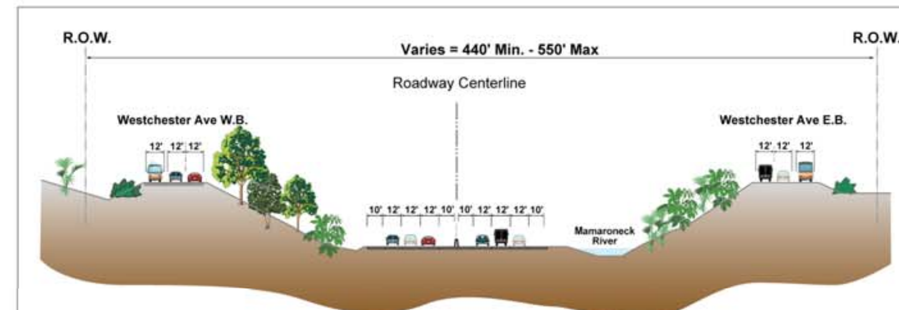
Alignment Quantities				
Option 4D - Westchester	Cut & Cover Tunnel	Viaduct/Major Bridge	At Grade, Retained Cut, or Fill	Total
CRT	5,550 ft	0	0	5,500 ft
BRT	0	9,200 ft	65,700 ft	74,900 ft
Total	5,500 ft	9,200 ft	65,700 ft	80,400 ft (15.2 Miles)



Typical Cross Section - Along Route 119in Tarrytown
(Looking East)



Typical Cross Section in Elmsford
(Looking East)



Typical Cross Section - East of Exit 8
(Looking East)

Figure 4-8 Option 4D - Manhattan-Bound Commuter Rail Transit with Cross Corridor Bus Rapid Transit in Westchester County

Option 4D - BRT

The BRT component of Option 4D is the same as in Option 3A, with service from Suffern to Port Chester, which improves on the BRT service provided in Alternative 3. This is accomplished by several means, including the addition of a single "trunk-line" route running the full length of the BRT alignment, with five-minute headways in both directions during peak periods, more bus stations, and improved running ways that would allow feeder buses to access the exclusive busways.

In Rockland County, Option 4D would provide enhanced service plans and two new stations, with preliminary locations at Route 59 in Monsey and Interchange 11 (US 9W/NY 59) in Nyack. One of the key planning issues that would be studied in the DEIS is the proposed shared usage of the Piermont ROW for CRT and BRT between Suffern and Interchange 14B (Airmont Road), and consideration of alternative alignments for each of the modes at this location in the corridor. The other key planning issue is the proposed CRT and BRT coincident stations at GSP/Interchange 14 and Palisades Mall/Parking Lot J that could become Intermodal Centers with potential highway-design impacts and unique access issues for buses to/from the HOV/HOT lanes and passengers to/from parking areas.

In Westchester County, Option 4D would provide the identical proposed BRT stations and a busway alignment east of White Plains (including a direct connection to the Metro-North Port Chester Station on the New Haven Line) that are provided in Option 3A.

5 Transportation Evaluation

Transportation performance measures were developed to evaluate the various alternatives/options under study. Ridership was measured both on the proposed service itself and in the study area as a whole. Door-to-door time savings for a representative sample of transit trips, as well as an overall aggregate time savings measure, were developed. The alternatives/options were also evaluated in terms of their capacity, both with their planned service plans and the maximum capacity supported by the proposed infrastructure. Large-scale impacts on roadway traffic were measured in terms of volumes across the Hudson and total vehicle miles traveled (VMT).

The transportation analysis was based mainly on outputs of the BPM developed by the NYMTC. The analysis was based on a model year of 2035. In the EIS, a sub-area Paramics traffic microsimulation model will also be used to obtain more comprehensive and detailed traffic impacts.

5.1 Transportation Demand Modeling

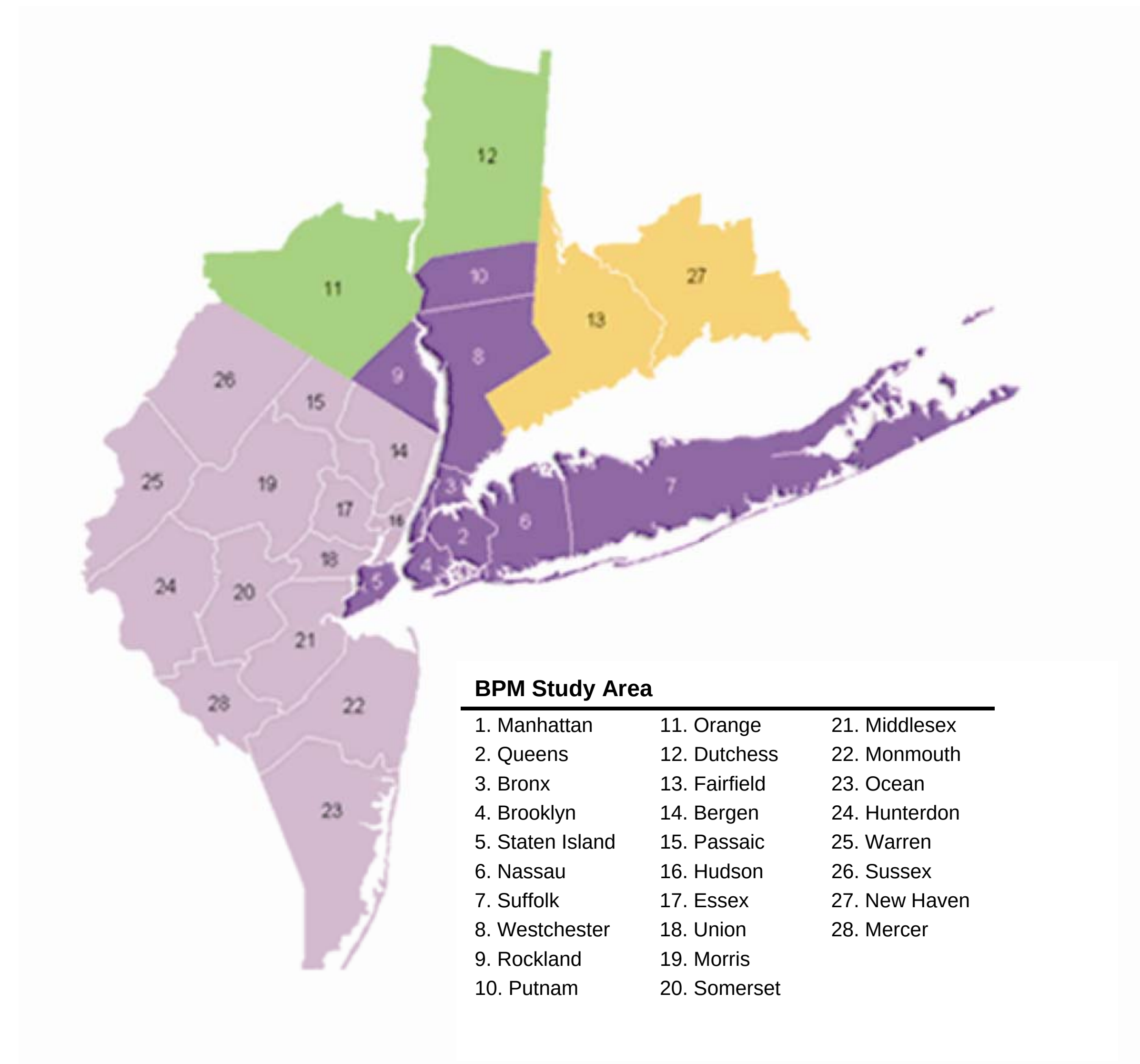
5.1.1 BPM Structure

BPM represents a state-of-the-art process for forecasting future urban travel based on assumptions regarding land use and transportation facilities and services. The model region consists of 28 counties in the New York Metropolitan Area, including 14 counties in northern New Jersey and two counties in southwestern Connecticut (Figure 5-1). The regional roadway network is represented in BPM with about 40,000 links. A separate transit network includes about 3,300 transit routes.

The counties are divided into 3,586 internal zones and 111 external stations (i.e., points where vehicles from outside the model area enter the model network). In Manhattan and other dense areas, the zones are typically equivalent to census tracts, and in some places are subdivisions of tracts. In the study area in Rockland County and Westchester County, several zones are composed of multiple tracts, and the tracts themselves are quite large. Figure 5-2 shows the BPM zone structure in the corridor.

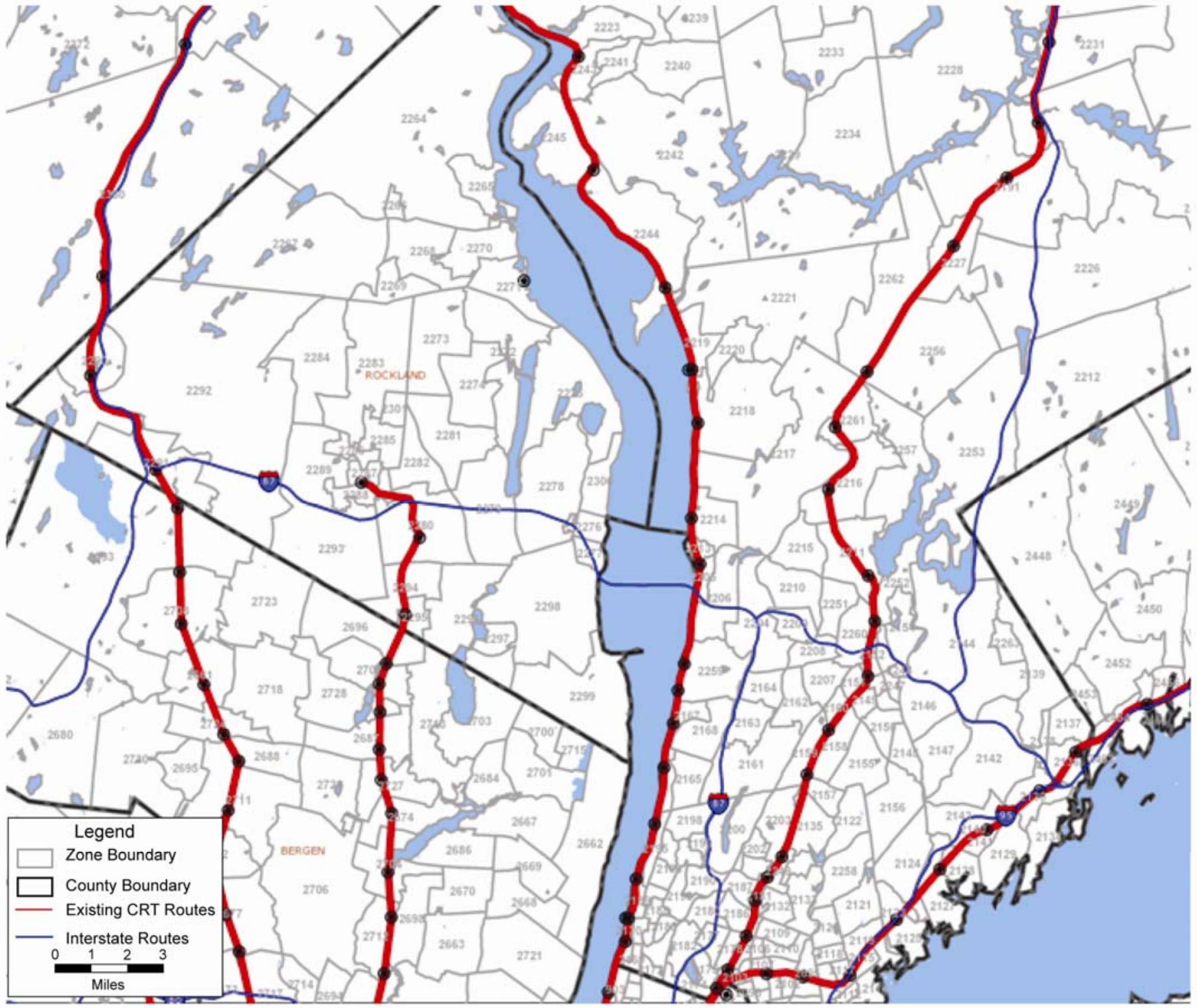
Demographic variables are prepared by NYMTC for each zone and are available for 1996, 2000, 2002, and five-year increments through 2030 (2035 forecasts are described below in Subchapter 5.1.2). These variables are:

- Household Population.
- Population in Group Quarters (Total).
- Population in Group Quarters (in institutions, i.e., college dormitories, prisons, etc.).
- Population in Group Quarters (street population).
- Population in Group Quarters (other).
- Number of Households.
- Average Household Size.
- Employed Labor Force (by place of residence).
- Median Household Income.



Source: NYMTC, January 30, 2005.

Figure 5-1 BPM Study Area



Source: New York Best Practice Model, 2007.

Figure 5-2 Zone Structure in the Corridor

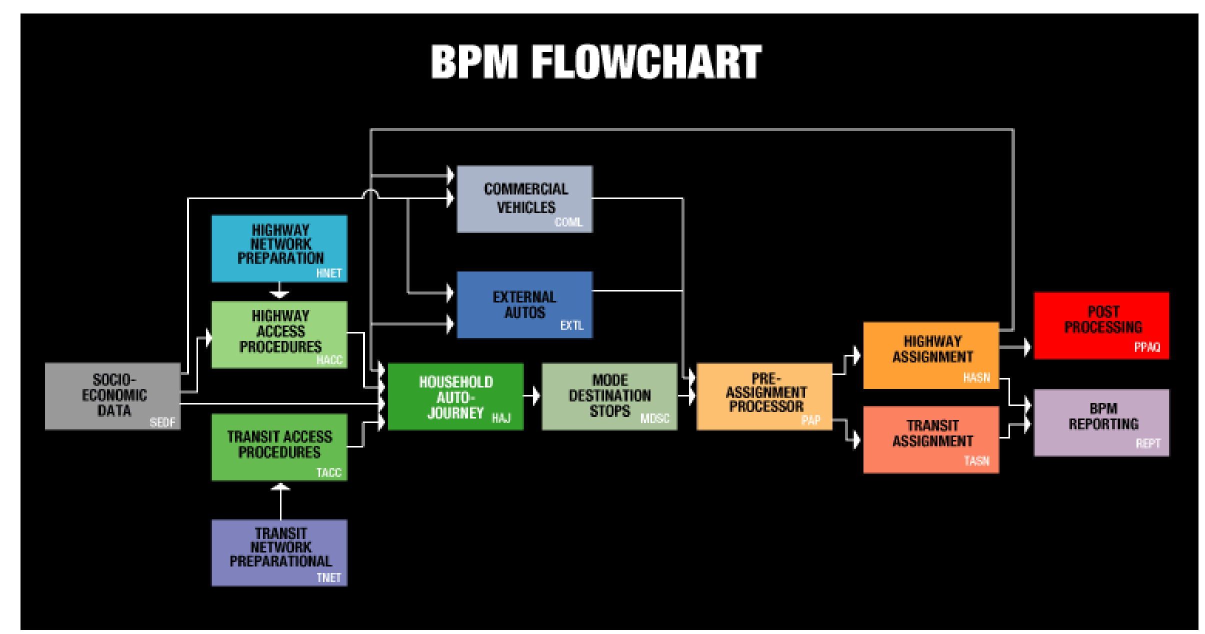
- Total Employment (by place of work).
- Retail Employment.
- Office Employment.
- Median Earnings of Employees.
- University Enrollment (by location of university).
- K-12 Enrollment (by location of school).

The model is structured as a series of modules (Figure 5-3). The outputs of each module are used as inputs to successive modules. Starting with the socioeconomic data for a given year, the Household Auto-Journey (HAJ) module generates a list of households and trip-makers with various characteristics for each zone. It then generates a list of typical weekday journeys by six different purposes:

- Work.
- School (K-12).
- University.
- Household maintenance.
- Discretionary activity.
- At-work journeys (i.e., office-to-office, lunch time trips).

The generation rates of each type of trip from each type of household are based on an extensive 1997 household survey conducted by NYMTC.

The destinations and modes of journeys are modeled in the BPM's "Mode Destination Stops Choice" (MDSC) module. The key variable in determining mode choice is the comparison of best paths by various modes – by commuter rail, by transit (i.e., subway and bus only) and by highway. These paths are expressed as matrices that describe the travel time and costs between any two zones by a given mode.



Source: NYMTC, January 30, 2005.

Figure 5-3 BPM Flow Chart

After those two modules are run, a "Pre-Assignment Processor" (PAP) creates a set of trip tables for highway and transit assignment by several modes for four time periods: AM Peak (6am-10am), Midday (10am-3pm), PM Peak (3pm-7pm) and Night (7pm-6am). Besides the outputs of the MDSC, additional inputs are used from modules that forecast commercial vehicles and external auto trips (i.e., auto trips with either origins or destinations outside the model area).

A separate trip table is prepared for each mode. The six highway modes are as follows:

- Drive Alone.
- Shared Ride-2/Taxi (a driver plus one passenger, or taxis).
- Shared Ride-3+ (a driver plus two or more passengers).
- External (autos with one or both trip ends outside of the BPM region).
- Truck.
- Other Commercial Vehicles.

In the mode-choice procedures, bus, subway and light rail are grouped as one mode[1], while any trip using commuter rail is in a separate commuter rail mode. (If a trip includes both bus and commuter rail, or both LRT and commuter rail, it is placed in the commuter rail category.) For both of these modes, there is a sub-division between those who drive to the first transit mode, and those who walk. Thus, the transit trip tables are divided into four modes:

- Commuter Rail (with transit feeder lines) with walk access.
- Commuter Rail with drive access.
- Other Transit (including bus, subway, light rail and ferry) with walk access.
- Other Transit with drive access.

Once the trip tables are in place, highway and transit assignments in BPM are similar to those in traditional models. The assignment process is capacity-restrained – trips are first assigned to the minimum time path, volumes are compared to capacities, speeds are adjusted, then traffic is reassigned in an iterative process. Weekend travel forecasts are not available for either transit or highway assignments. Transit assignments are only available for AM peak periods.

The BPM was delivered by NYMTC calibrated to 2002 baseline conditions. As part of the project, the Project Sponsors updated the baseline to match 2005 conditions and then recalibrated the model to better match markets served by the corridor (NYSDOT et. al., June 10, 2008).

5.1.2 No Build

At the time of the transit mode analysis, NYMTC had not prepared official 2035 forecasts. Instead, a set of 2035 forecasts were developed for this project by extrapolating from 2025 to 2030 growth. Since then, NYMTC has released updated 2035 forecasts, which will be the basis of the EIS. Population and employment forecasts developed for the project are summarized in Table 5-1.

[1] The BPM has been structured with LRT grouped with bus and subway for mode-choice purposes. Since no LRT currently exists in the project corridor, a stated preference survey was conducted in 2003 to validate the reasonableness of that structure. It was found that when variables such as fare, run time and wait time were held constant, survey respondents do not show a statistically significant preference for LRT.

Table 5-1

Demographic Forecasts by County, 2005 and 2035

County	Population			Employment		
	2005	2035	Growth	2005	2035	Growth
Rockland	298,907	383,966	28%	106,336	139,428	31%
Orange	375,620	567,913	51%	136,723	197,317	44%
Westchester	968,070	1,021,621	6%	405,667	510,770	26%
Putnam	101,914	143,177	40%	26,242	36,277	38%
Dutchess	300,052	486,328	62%	117,633	173,207	47%
Fairfield	916,115	1,105,758	21%	432,178	513,404	19%
New Haven	850,374	1,008,446	19%	358,188	432,561	21%
Manhattan	1,583,303	1,726,196	9%	2,081,871	2,693,638	29%
Queens	2,272,677	2,835,038	25%	610,676	748,765	23%
Bronx	1,367,473	1,567,226	15%	280,920	355,641	27%
Kings	2,515,300	2,831,161	13%	641,590	877,712	37%
Richmond	470,890	677,983	44%	128,253	222,613	74%
Bergen	905,374	1,017,043	12%	434,363	518,847	19%
Passaic	498,753	569,188	14%	167,958	183,798	9%
Rest of North NJ	5,522,541	6,967,784	26%	2,338,810	3,287,990	41%
Nassau	1,353,012	1,445,423	7%	550,769	629,068	14%
Suffolk	1,480,046	1,832,743	24%	587,691	830,825	41%
Total	21,782,426	26,189,029	20%	9,407,873	12,353,896	31%

Compared to the rest of the region, these forecasts show somewhat higher than average growth in Rockland County, but very high growth in Orange County. Westchester County population is expected to grow at a much slower than average pace, although its job growth is projected to be closer to average.

For 2035, a No-Build Alternative (Alternative 1) was initially developed as a baseline, with other alternatives/options subsequently built upon Alternative 1 networks. The 2035 forecasts described above, combined with 2035 transit and highway networks, were the key inputs to 2035 runs. Alternative 1 included network improvements from NYMTC's Transportation Improvement Program (TIP). Among the notable highway improvements included were the programmed improvements to I-287 in Westchester County. Transit improvements included Access to the Region's Core (ARC), East Side Access, Second Avenue Subway, and the extension of New York City Transit's (NYCT) #7 train.

Amongst the transit projects mentioned, ARC is the most notable in terms of potential impact on the Tappan Zee Bridge/I-287 Corridor Project. It would provide a one-seat ride from Orange and Rockland Counties (in addition to counties in New Jersey) to west mid-town Manhattan and almost double the capacity. The principal difference between the two projects is improved access to the west side of Manhattan via ARC and to the east side via the Tappan Zee service. Although the majority of the markets served by the two projects are different, there is some overlap, especially the Orange, Rockland, and Northern Bergen County to Manhattan market. Transit users originating in these markets would prefer to ride a transit service that terminates either on the east side or the west side, depending on their work location. Employment projections indicate that the employment split between the east side and the west side will be approximately 45 percent to 55 percent in 2035. For this project, ARC service plans were adjusted to match updated service plans assessed in the March 2008 ARC Supplemental DEIS. An analysis was also done regarding the potential to divert transit riders from the ARC project. BPM modeling has shown that there is a potential to divert roughly 30 percent of the ARC riders from Orange and Rockland Counties; however, this diversion is less than three percent of the total ARC ridership.

5.1.3 Coding of Alternatives/Options

For each build alternative/option, new transit services were coded into the TransCAD[2] route structure (Figures 5-4, 5-5, and 5-6), and the entire model process was re-run. Service plans are coded in as TransCAD "routes". Each route corresponds to a column in the service plans described in Appendix A (i.e., every service with a unique set of stops is considered a route, so there can be multiple routes over the same physical space). Only AM and Midday periods are modeled, and assignments by route are only produced for the AM period.

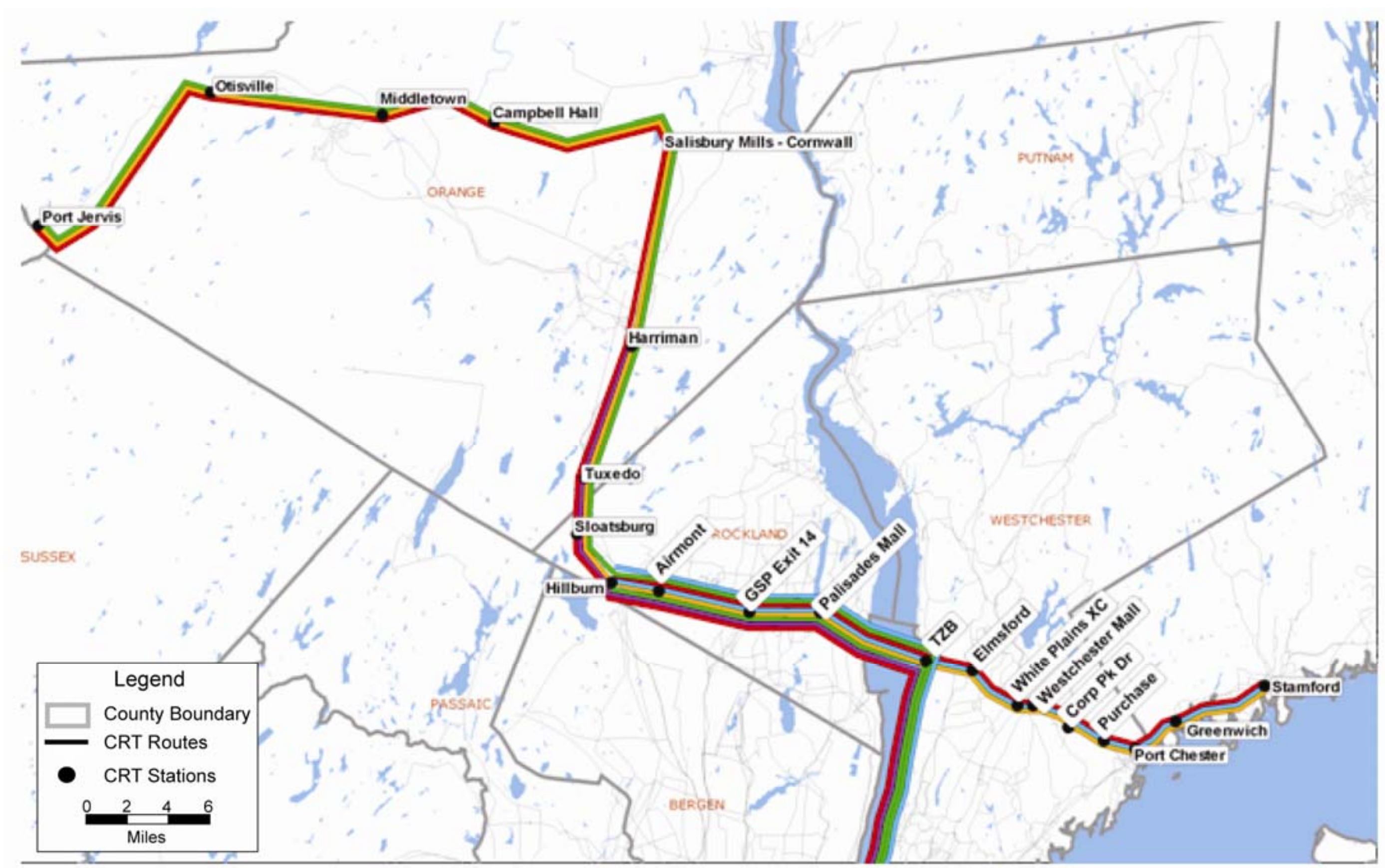


Figure 5-4 CRT Route Coding

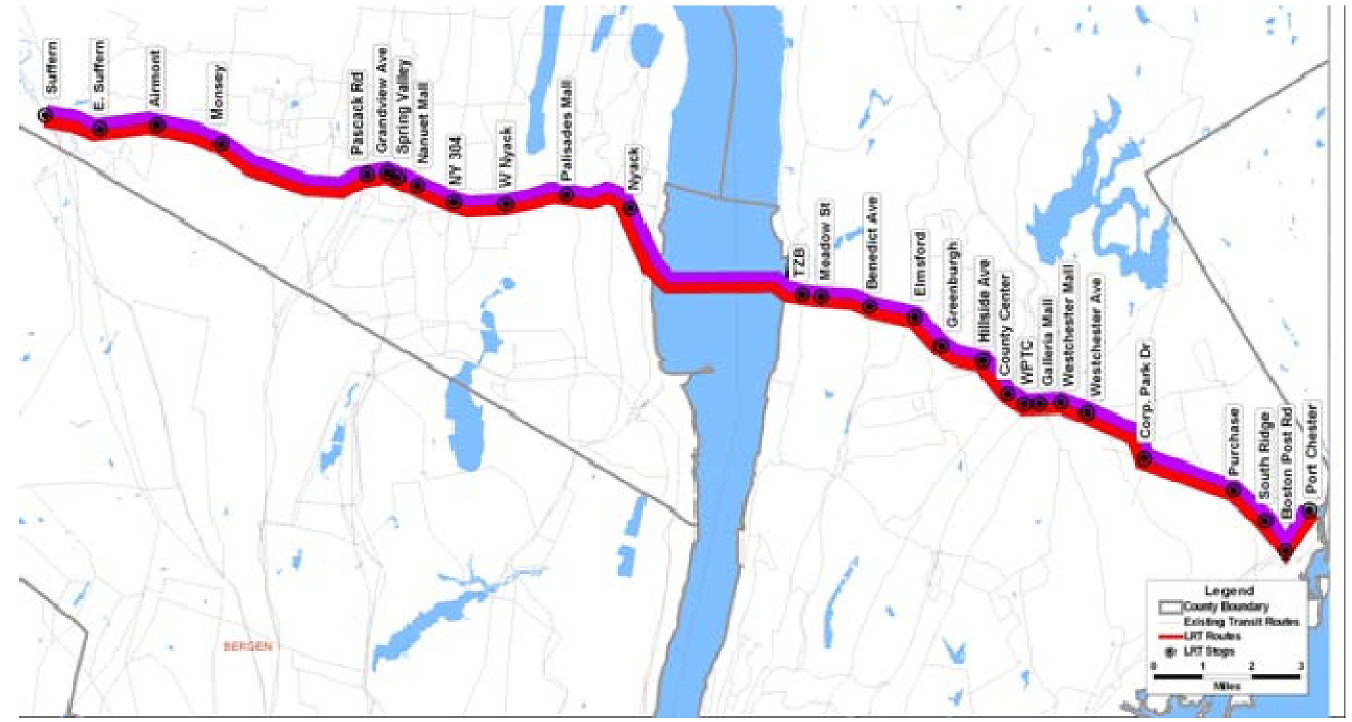


Figure 5-5 Light Rail Route Coding

[2] TransCAD is a transportation planning software package developed by Caliper Corporation.

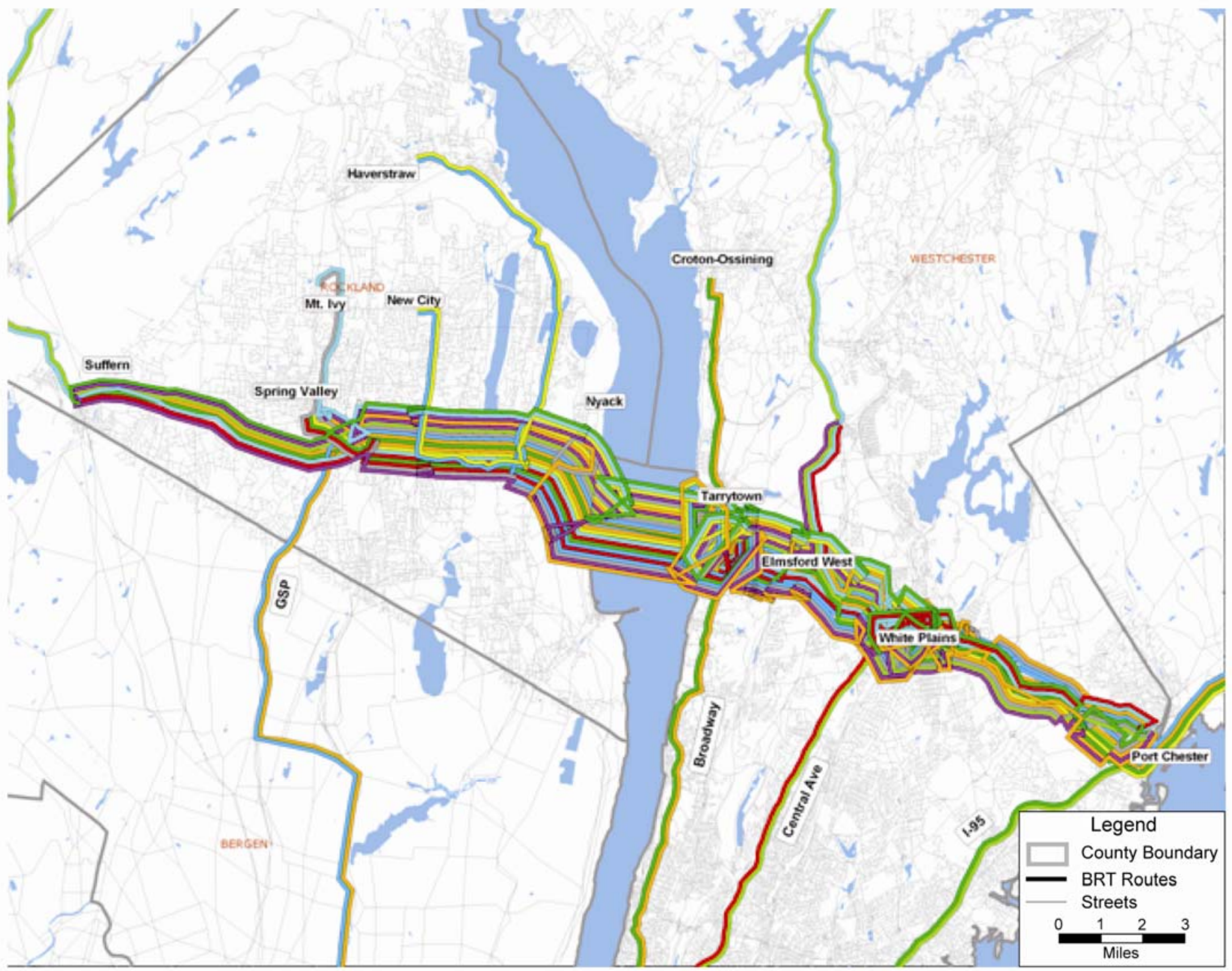


Figure 5-6 BRT Route Coding

Within the "other transit" mode, there are sub-mode definitions that are used in determining best paths (but which are not used in the mode-choice procedures described above in Section 5.1.1). Among these are LRT, express bus and local bus. BRT routes were coded as express bus routes. In the course of the project, it was determined that using the express bus designation led to conservative ridership results, due to the way BPM handles the interaction of express bus routes with CRT[3].

[3] In determining best paths, the express bus portion of a path which includes commuter rail is assigned a relatively high weight to discourage transfers between the two modes. Transfers between the two modes are discouraged since traditionally, express buses are not feeders to commuter rail and vice-versa. By comparison, in paths which include both local bus and commuter rail, the local bus portion of the path is assigned a relatively lower weight. Since the BRT was conceived in part to specifically serve such transfers, the Project Sponsors also tested sensitivity runs with BRT coded as "local bus", but with identical service characteristics (stopping patterns, headways and run times). These runs showed substantially higher ridership, particularly for longer-distance trips, such as the GCT-bound riders connecting at Tarrytown, and trips between Connecticut and the corridor connecting at Port Chester.

Commuter rail fares were set at one fortieth (1/40) of the monthly commuter fares, to represent the discounted one-way fare to which BPM modeling is calibrated. (See Appendix A for station-to-station fares). LRT routes were given a flat fare of $1.50 (1996 dollars); BRT routes were given flat fares, ranging from $1.25 to $2.85. (Distance-based fares cannot be simulated on bus routes.) Note that while BPM transit procedures are able to simulate free or discounted transfers between bus routes or between bus and LRT routes, they cannot simulate any discount on transfers between LRT and CRT, or between BRT and CRT.

All new fixed rail stations were modeled with effectively unlimited parking, to determine the unconstrained demand. Parking costs at new stations and park-and-rides were made comparable to costs at the nearest existing CRT stations.

All build alternatives/options also included the identical highway improvements – an eight-lane bridge, HOV/HOT lanes in Rockland County, as well as climbing lanes. For modeling purposes, HOT lanes were assumed and a range of tolls on the HOT lanes was iteratively tested until traffic assignments reached target HOT-lane volumes (about 1,300 per hour).

5.2 Transit Ridership

Transit ridership indicates how many people will directly benefit by using the proposed service. Ridership is measured here both in terms of total transit users by market (i.e., using any transit route), and in terms of ridership on the new proposed service itself. "Transit Accessibility West of Hudson" explicitly measures peak cross-Hudson flows, both on the Tappan Zee Bridge, and on all cross-Hudson crossings. Passenger miles is a metric that indicates the average length of trips on new service, which has substantial variations across alternatives/options.

5.2.1 Criterion

Several measures of transit ridership were developed and analyzed, as described below.

5.2.1.1 Total Daily Transit Trips for Selected Major Markets (Weekday)

This measure looks at total transit riders on all routes in markets served by the corridor. These reflect origins and final destinations of travelers (i.e., "trip table" data), regardless of which transit mode or transit route they use – in other words, on both no-build and proposed service. The BPM calculates trips for the 28-county region, but for this measure, markets that potentially could be served by the corridor were isolated. A wide range of markets are served by the corridor, but for this purpose they have been grouped into two categories: cross-corridor markets and NYC-bound markets.

Cross-corridor markets include:

- Rockland and Orange County trips to and from Westchester County and Connecticut.
- Trips between Orange and Rockland Counties.
- Intra-Rockland County trips with at least one end in the corridor.
- Intra-Westchester County trips with at least one end in the corridor.
- Connecticut trips to and from central and western Westchester County.
- New Jersey trips to and from central and northern Westchester County.
- New Jersey trips to and from central Rockland County.

NYC-bound markets here include:

- All of Rockland County to and from NYC.
- All of Orange County to and from NYC.
- Central Westchester County along the corridor to and from NYC.

5.2.1.2 New Transit Trips

New transit riders were directly estimated by looking at the increase in total daily transit trips for each alternative/option as compared to the No-Build Alternative.

5.2.1.3 Daily Transit Ridership on the New Service (Weekday)

This measure shows the number of passengers specifically on the new BRT, LRT or CRT services. While measuring total transit trips in major markets indicates how many new transit riders are attracted to the overall transit system, it does not show the extent to which people shift from existing transit lines to the new routes. Ridership on new service is based on BPM AM assignments, with a factor of 2.86 to arrive at a total number of daily trips. Alternative 1, which, as the No-Build alternative, has no proposed new service, by definition attracts no passengers to new service.

Ridership has been grouped into segments defined by station boardings and alightings. Thus, an intra-Rockland trip is a single passenger boarding and exiting a new service in Rockland County. However, because the final destinations of passengers exiting at a given station are not reported by the BPM, many of these passengers may actually transfer to southbound buses to New Jersey or even NYC. Similarly, individuals identified as "intra-Westchester County" trips could also transfer to bus or rail to the Bronx, Manhattan, Connecticut, or elsewhere.

The exception to this type of grouping is Cross-Hudson Manhattan-bound passengers. While these passengers are directly served by new service in Alternatives 4A, 4B and 4C and in Option 4D, they require transfers at Tarrytown in Options 3A and 3B, at the Tappan Zee Station in LRT, and at White Plains in Option 4A-X. (The model suggests that traveling to White Plains would be quicker than using a shuttle bus from Tappan Zee Station to Tarrytown.) For the sake of consistency, these trips are, therefore, placed in the "Cross-Hudson to Manhattan" category in all alternatives/options. (Although the origin and destination of passengers cannot be directly determined when examining station boardings, in the case of BRT and LRT to Tarrytown/Tappan Zee Stations, it has been assumed that most passengers making that transfer would continue on to Manhattan).

In presenting ridership on new transit routes, the modeling team excluded trips that only use existing portions of the transit network. For example, in Alternative 4A passengers may use the new commuter rail routes to travel within Orange County, or between Port Chester and Stamford, but these trips are already served by existing commuter rail routes, so they have not been included in this measure. (Such riders are, however, accounted for in the total transit market measures.) Similarly, ridership in the BRT scenarios was limited to passengers who would ride over some portion of the BRT, and excluded passengers who would board and exit a new route prior to its entry onto the BRT.

5.2.1.4 Transit Accessibility West of the Hudson

Transit accessibility west of the Hudson is defined here as two measures: (1) the number of weekday AM peak-period transit passengers crossing the Tappan Zee Bridge from west to east, and (2) the number of weekday AM peak-period transit passengers crossing the Hudson River in either direction. The second category includes:

- All cross-Hudson ferries.
- Bus (and potential rail) routes across the Tappan Zee Bridge.
- Bus routes across the George Washington Bridge.
- Bus routes through the Lincoln Tunnel.
- NJ Transit trains into Penn Station and the new 34th St. Station planned for ARC.
- PATH trains through both tubes.
- Bus routes through the Holland Tunnel.

5.2.1.5 Passenger Miles

Passenger-mile measures indicate whether certain modes tend to serve longer- or shorter-distance trips. Passenger-miles are assessed in two categories – along proposed infrastructure, and along existing infrastructure. Passenger miles on existing infrastructure were determined by measuring passenger loads along the main transit corridor from Suffern to Port Chester. Passenger miles were divided by riders on proposed new service to determine an average trip length.

Passenger miles on existing infrastructure were estimated by including the following components:

- In Alternatives 4A, 4B, and 4C, and in Option 4D, the portion of trips along the Hudson Line to GCT as well as along the Port Jervis Line to and from Orange County. Intra-Orange County passengers were excluded.

- In Alternative 4A, the portion of trips along the New Haven Line, to and from Stamford. For mileage purposes, it was assumed that all such Connecticut riders start or stop in Stamford.

- BRT and LRT transfers to and from the Tarrytown Metro-North Station. They are assumed to travel the full length to GCT.

- BRT and LRT transfers at Suffern to and from commuter rail. They are assumed to travel the same average number of miles as Orange County CRT riders (30.6 miles).

- BRT and LRT transfers to and from commuter rail at Port Chester. They are assumed to travel to Stamford.

- Passenger miles on the portion of other BRT routes not actually in BRT are not included (e.g., the distance between New City and the corridor traveled by riders of Route H, or the distance between Yonkers and the corridor traveled by riders of Route F). (See service plans in Appendix A.)

- In Alternative 4A without a Hudson Line connection (Option 4A-X), Manhattan-bound transfers at White Plains from west of the Hudson were estimated, and their mileage to GCT was included.

5.2.2 Comparison of Transit Modes

In general, ridership results show that BRT performs best in cross-corridor markets, particularly among shorter-distance intra-Rockland County and intra-Westchester County trips compared to other modes. CRT alternatives/options (with the exception of Option 4A-X) generate the greatest number of NYC-bound trips. The numbers for Alternative 1 (Figure 5-2) represent No-Build transit riders for those markets. These are daily numbers, so a person traveling to work in the morning and returning home in the evening would generate two trips. If that person makes a stop on the way for some other purposes, three trips would be measured.

In examining total transit trips, Option 4D attracts the greatest number of trips in both cross-corridor and NYC-bound markets. In cross-corridor markets, Option 4D has BRT service comparable to Options 3A and 3B, but in addition, the CRT component helps to serve Orange-Rockland Counties and intra-Rockland County trips. Alternatives/options with Manhattan-bound rail generate the greatest number of NYC-bound trips. Option 4D generates slightly more than the others, indicating that the time saved by eliminating Airmont and Tappan Zee Stations more than makes up for the associated reduction in access.

Alternatives/options without the Manhattan-bound rail connection still lead to an increase in transit trips in that market compared to the No Build Alternative, indicating that substantial numbers of passengers would use new cross-corridor service to access existing NYC-bound routes (i.e., one of the five branches of Metro-North, express bus service into the Port Authority Bus Terminal, or Bee-Line bus service from Westchester County). The results are shown in Table 5-2.

Table 5-2

Daily Transit Trips for Selected Major Markets (Weekday)

Criterion	Alternative/Option								
	1 No Build	3A Full-Corridor BRT Enhanced	3B Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	4A Full-Corridor CRT with Hudson Line (HL) Connection	4A-X Full-Corridor CRT without HL Connection	4B CRT in Rockland, HL Connection, LRT in Westchester	4C CRT in Rockland, HL Connection, BRT in Westchester	4D CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Cross-Corridor	66,500	81,000	81,100	75,200	74,200	73,900	74,000	83,400	75,500
To/From NYC	94,900	103,800	104,100	108,000	101,000	108,500	108,800	109,200	102,800
Total	161,400	184,800	185,200	183,200	175,200	182,400	182,800	192,600	178,300
New Transit Trips*	NA	23,400	23,800	21,800	13,800	21,000	21,400	31,200	16,900

* New transit trips are estimated by taking the difference between the total transit trips in the build alternative/option versus the no build. It includes any new transit trip on any mode in the selected major markets considered. The new transit trips are not necessarily on the new transit infrastructure.

Ridership on the proposed new service (Figure 5-7, Table 5-3) is mostly consistent with the measures for total transit market numbers, with Option 4D services attracting the most total transit riders, and Option 4A-X and LRT attracting the fewest. In specific route segments, ridership trends are as follows:

- **Intra-Rockland.** BRT shows the most intra-Rockland County ridership, with LRT outperforming CRT. This is because the multiple routes made possible by BRT allow for greater access and egress than both LRT and CRT, while LRT makes more frequent stops than CRT. Option 4D performs best because it includes full BRT in Rockland County as well as CRT service, which can serve some additional intra-Rockland County and Orange County -to-Rockland County trips.

- **Intra-Westchester County /Westchester County - Connecticut.** Similar patterns are seen in this segment, with BRT attracting the most riders. One difference is that cross-corridor CRT (Alternative 4A and Option 4A-X) is competitive with LRT (Alternative 4B and Full-Corridor LRT) because CRT serves the Connecticut to Westchester County market without a transfer, while LRT requires a transfer at Port Chester. Note that Alternative 4C generates significantly less ridership than Options 3A and 3B, indicating that the robust service plans in Options 3A and 3B (i.e., 5-minute headways in both directions on the trunk line) and additional stations are key to their ridership potential.

- **Cross-Hudson Circumferential.** For this segment (i.e., Rockland County-to-Westchester County trips), CRT slightly outperforms BRT, with LRT lagging behind both. Since these tend to be longer-distance trips than the intra-Rockland County and intra-Westchester County segments, it appears that the faster in-vehicle times and added comfort of CRT outweigh the access and egress benefits of BRT. Alternative 4B, which requires a transfer, attracts the fewest riders in this segment. Alternative 4C, in which some – but not all – cross-Hudson circumferential trips require a transfer, also performs poorly. Option 4D attracts fewer cross-corridor trips than Option 3A, even with an identical bus service plan. This appears to be due to the relative attractiveness of Manhattan-bound CRT, which shifts origin-destination patterns so that more people travel between Rockland County and Manhattan and fewer travel between Rockland County and other places (including Westchester County).

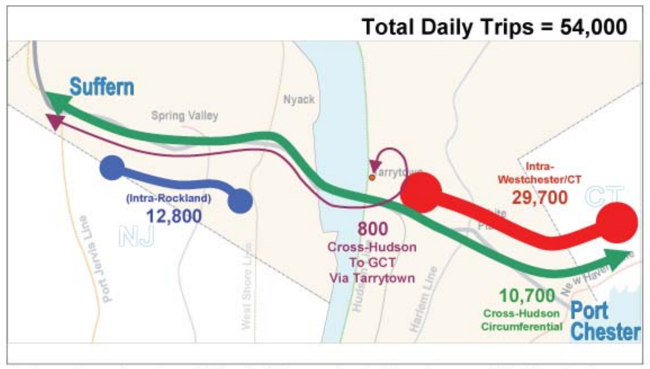
- **Manhattan-bound CRT.** Predictably, Manhattan-bound CRT alternatives/options dominate in the GCT-bound segment, with ridership ranging from 25,800 in Alternative 4A to 29,200 in Option 4D (Figure 5-7, Table 5-3). Again, Option 4D attracts the most riders, indicating that the time saved by eliminating Airmont and Tappan Zee Stations attracts more riders at other stops in Rockland County and Orange County than are lost from the Airmont Station. With ARC present in both the No-Build and all build alternatives/options, the two-seat ride to GCT required with BRT and LRT is not attractive for trips from Orange County, western Rockland County, or central Rockland County, which could use the Port Jervis Line and the Pascack Valley Line for direct service into Manhattan; only passengers from eastern Rockland County (e.g., Nyack, Haverstraw) would benefit.

- **Manhattan-bound BRT and LRT.** Less predictably, BRT and LRT perform differently relative to each other in the GCT-bound segment than when looking at the market-based measures in Table 5-2. Options 3A and 3B show low numbers of riders making the transfer at Tarrytown between BRT and the Hudson Line (with 800 and 1,400 daily riders respectively), while LRT and Option 4A-X show about 4,000 to 4,500 daily making similar moves. The LRT service plan allows for a transfer at the Tappan Zee Station, which reduces the in-vehicle time required to reach the Hudson Line. In Option 4A-X, a dedicated shuttle bus between The Tappan Zee Station and Tarrytown was coded into the transit network. However, that bus attracted no riders. Instead, it appears that GCT-bound passengers would find it more convenient to continue on cross-corridor rail to White Plains and transfer to the Harlem Line there. (That number was estimated from the increase in AM Eastbound cross-corridor rail alightings in White Plains in Option 4A-X with Alternative 4A.) This pattern is the opposite of that found in Table 5-2, where BRT outperformed LRT and Option 4A-X in the NYC-bound markets. This shows that, as described above, significant numbers of NYC-bound passengers from Rockland and Orange Counties would still use BRT service to gain access to the Port Jervis Line, Pascack Valley Line, or express bus service at Interchange 14 or Palisades Mall. Similarly, NYC-bound Westchester County riders could use the BRT to gain access to the Harlem Line at White Plains or the New Haven Line at Port Chester. However, since such trips are mixed in with other local moves from which they cannot be distinguished, they would be included in the intra-Rockland County or intra-Westchester County segments in Table 5-3. Also note that, as described in Subchapter 5.1, BRT-to-CRT transfers may have been conservatively estimated in general.

- **Tappan Zee Station.** Alternatives 4A, 4B, 4C and Full-Corridor LRT include a Tappan Zee Station, which attracts some Westchester County riders destined for GCT, a market segment not directly served in other alternatives/options. These riders would mostly be diverted from the Tarrytown or White Plains Stations.

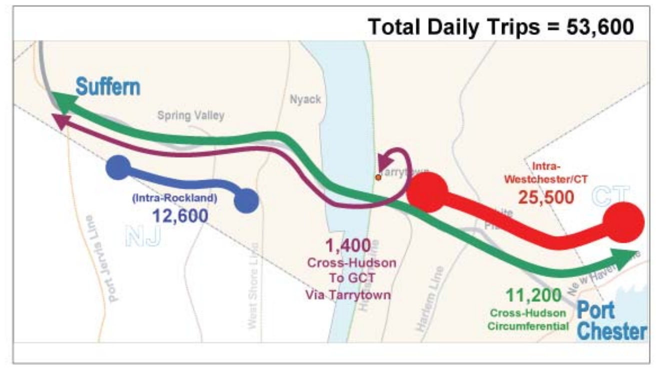
The first measure in Table 5-4 (Transit Accessibility, West of Hudson) predictably shows Alternatives 4A, 4B, and 4C and Option 4D carrying more transit passengers across the Tappan Zee Bridge, as they include Manhattan-bound rail. For the broader measure of all cross-Hudson transit trips (including New Jersey to Manhattan), Option 3A performs best. Alternative 4A and Option 4D are the next-highest performing alternatives/options.

Option 3A
Daily Trips (2035)



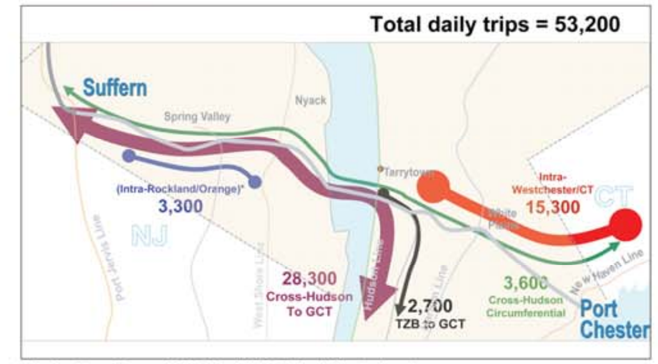
Enhanced service plan additional stations, extended bus lanes on Westchester Ave., and connection to Port Chester Station

Option 3B
Daily Trips (2035)



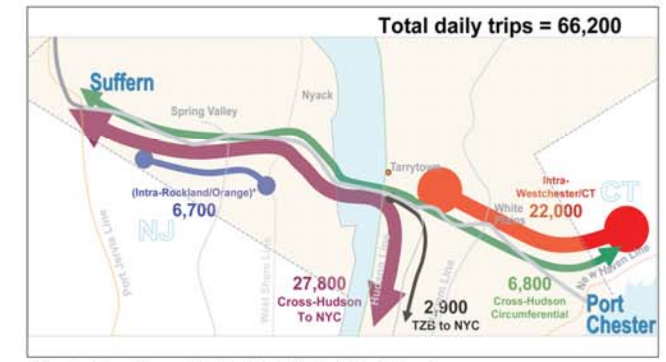
High occupancy toll (HOT) lanes in Rockland and a dedicated busway in Westchester

Alternative 4B
Daily Trips (2035)



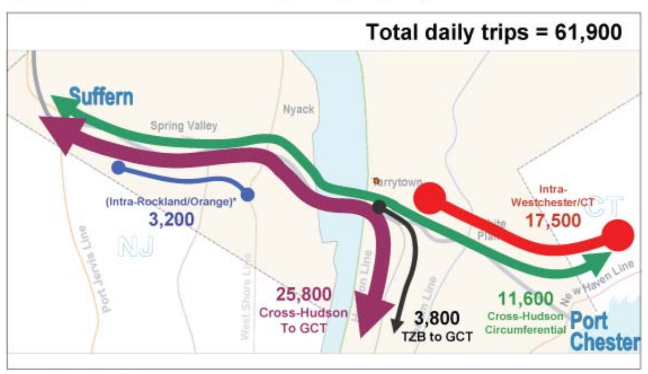
Manhattan Bound CRT with LRT in Westchester

Alternative 4C
Daily Trips (2035)



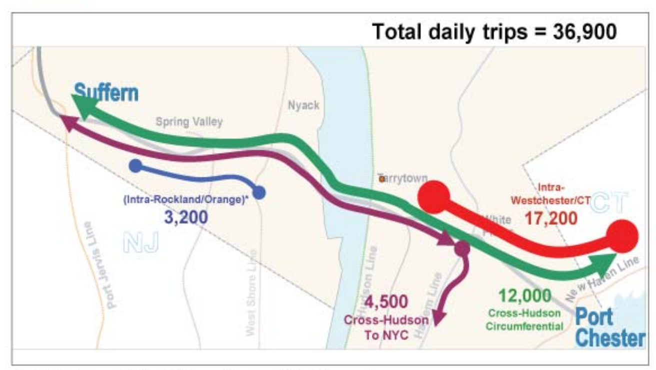
Manhattan Bound CRT with BRT in Westchester

Alternative 4A
Daily Trips (2035)



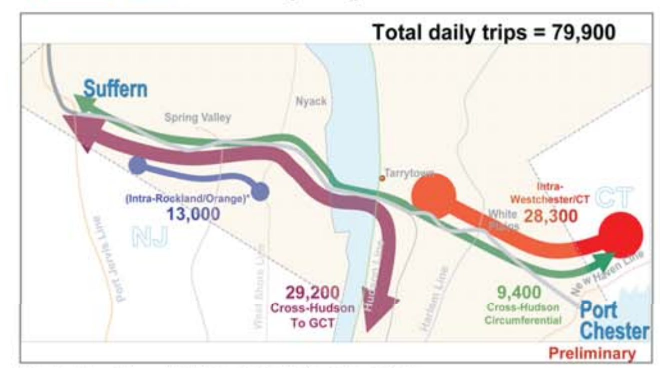
Full Corridor CRT

Option 4A-X
(No Hudson Line Connection)
Daily Trips (2035)



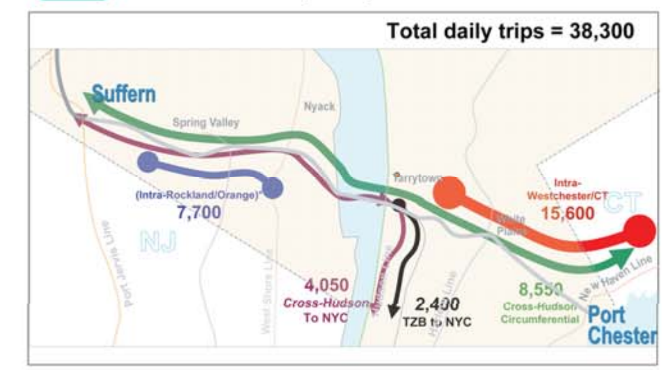
Full Corridor CRT - With no Hudson Line Connetion

Option 4D
Daily Trips (2035)



Manhattan Bound CRT with Full Corridor BRT
(as in Alt 3A) but with no Airmont or Tappan Zee CRT Stations)

Cross Corridor LRT
Daily Trips (2035)



Cross Corridor LRT - with new TZ station and cross platform transfer to Manhattan Bound CRT

Figure 5-7 Daily Transit Ridership on New Service (Weekday)

Table 5-3

Daily Transit Ridership on New Service (Weekday)

Segment	Alternative/Option								
	No Build	**3A** Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/HOT Lanes in Rockland Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland HL Connection LRT in Westchester	**4C** CRT in Rockland HL Connection BRT in Westchester	**4D** CRT in Rockland HL Connection Full-Corridor BRT (3A)	Full-Corridor LRT
Intra-Rockland/ Orange-Rockland	NA	12,800	12,600	3,200	3,200	3,300	6,700	13,000	7,700
Cross-Hudson Circumferential	NA	10,700	11,200	11,600	12,000	3,600	6,800	9,400	8,550
Intra-Westchester/ Westchester-CT	NA	29,700	28,400	17,500	17,200	15,300	22,000	28,300	15,600
Cross-Hudson to/from GCT	NA	800	1,400	25,800	4,500*	28,300	27,800	29,200	4,050
Tappan Zee Station to/from GCT	NA	NA	NA	3,800	NA	2,700	2,900	NA	2,400
Total	NA	54,000	53,600	61,900	36,900	53,200	66,200	79,900	38,300

Notes:
NA = Not applicable
*Option 4A-X totals to Manhattan are inferred from changes in passengers alighting at White Plains Station, and then deducted from the Intra-Westchester figure.

Table 5-4

Transit Accessibility, West of Hudson

Criterion	Alternative/Option								
	1 No Build	**3A** Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Transit Accessibility West of Hudson (AM peak period, peak direction passengers) on TZB	820	3,260	3,560	11,830	4,660	10,400	11,400	12,380	3,540
Transit Accessibility West of Hudson (AM peak period total passengers, both directions) on Hudson River Crossings *	454,900	492,600	473,600	480,900	474,100	476,900	477,700	478,700	473,300

Note: * Hudson River Crossings include all crossings from the Holland Tunnel to the Newburg-Beacon Bridge.

Table 5-5 shows total passenger miles carried by the proposed new services. Rail alternatives/options tend to perform best, as they carry longer-distance trips. Alternative 4A carries the most passenger miles, slightly ahead of Option 4D, even though Option 4D carries more riders. This indicates that cross-corridor rail carries more long-distance trips (such as those between Orange and Westchester Counties, or between White Plains and Connecticut), while Option 4D would carry more intra-Rockland County and intra-Westchester County trips. Options 3A and 3B carry the fewest passenger-miles, indicating that BRT specializes in local trips. Note that Option 3B carries slightly more passenger miles than does Option 3A, as the benefits of the full busway tend to favor trips over the full length of the corridor, while slightly reducing access, making it less attractive for local trips. However, because this measure does not fully account for passengers on all feeder routes (such as those serving Nyack, Haverstraw, and Spring Valley) before they enter the BRT system, it may underestimate BRT passenger-miles.

Table 5-5

AM Peak Passenger Miles (Thousands of Miles)

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT HOT Lanes in Rockland Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland HL Connection LRT in Westchester	**4C** CRT in Rockland HL Connection BRT in Westchester	**4D** CRT in Rockland HL Connection Full-Corridor BRT (3A)	Full-Corridor LRT
In Corridor	97	113	226	95	193	212	249	106
On Existing Facilities Beyond Corridor	54	68	428	147	404	415	399	118
Total	151	181	654	242	596	627	648	224
Miles per Rider	7.8	9.5	29.6	18.4	31.4	26.5	22.7	16.4

5.3 Transit Travel Time

Several measures of transit travel time were developed and analyzed, as described below.

5.3.1 Description of Criterion

In order to facilitate the analyses of travel time, numerous trip pairs were selected to illustrate changes in areas where new facilities and services are provided, so as to represent the variety of markets served by the corridor. The results are presented in Tables 5-6, 5-7, and 5-8. It is important to note that the travel times in the tables are door-to-door values.

5.3.1.1 Transit Travel Time for Selected Trip Pairs

AM peak-period transit times in minutes were calculated from BPM runs (Table 5-6). As described in Subchapter 5.1.1, BPM uses four different "modes" – drive to commuter rail, walk to commuter rail, drive to other transit, and walk to other transit. For any alternative/option, a best path is determined for each of these four modes. The transit times shown here represent the fastest of those four times, with all components of time (i.e., in-vehicle time, wait time, walk time, etc.) weighted equally. In some cases, the best path remains a path using No Build service.

Table 5-6

AM Peak Travel Times, Selected Trip Pairs (Minutes)

Market Group	from	to	1	3A	3B	4A	4A-X	4B	4C	4D	Cross-Corridor LRT
Intra-Rockland	Suffern	Palisades Mall	60	25	25	30	34	34	34	29	32
Rockland-Westchester	Spring Valley	White Plains	78	37	32	45	45	58	51	37	60
	Spring Valley	Mt. Pleasant	94	56	54	63	61	72	58	56	70
	Nyack	Platinum Mile	80	41	35	46	46	62	45	40	48
	Suffern	White Plains	96	44	40	51	51	65	59	44	57
	Suffern	Yonkers	114	72	72	97	102	94	99	72	104
Manhattan Bound	Harriman	45th & Madison	114	114	114	97	114	97	97	97	114
	Nyack	45th & Madison	96	77	78	63	81	63	63	61	64
	Suffern	45th & Madison	85	85	85	68	89	68	68	65	86
	Newburgh	40th & 3rd Ave	141	141	141	123	146	123	123	123	141
	Spring Valley	40th & 3rd Ave	105	107	107	71	89	71	71	69	98
	Middletown	34th & 7th	142	142	142	142	142	142	142	142	142
	Nyack	34th & 7th	113	91	92	77	95	77	77	75	78
	Middletown	World Trade Center	154	151	151	154	154	154	155	155	154
	Spring Valley	World Trade Center	102	100	100	84	102	84	84	82	103
	Harriman	Javits Center, 36th & 11th	115	115	115	116	116	116	116	116	116
	Nyack	Javits Center, 36th & 11th	118	104	105	86	104	86	86	84	86
Westchester-CT	Elmsford	Stamford	67	57	50	53	53	81	53	54	81
Ct-Westchester	Darien	Platinum Mile	80	75	74	62	62	72	75	75	72
Westchester-Westchester	Port Chester	White Plains	41	28	27	34	34	38	41	28	38
To and from Bronx	Bronx (Grand Concourse, 180th St.)	Palisades Mall	130	93	92	89	89	90	84	85	110
	Spring Valley	Bronx (Montefiore Hospital)	115	74	81	101	101	96	84	74	98

These reflect "door-to-door" times as calculated by the BPM, not station-to-station times.
Note that BPM calculates "best path" travel times for four "modes" (Walk to Bus/Light Rail, Walk to Commuter Rail, Drive to Bus/Light Rail, Drive to Commuter Rail)
This table shows the minimum total time (with no extra weight given to walking or waiting time) among those four "modes"
In some cases, the travel time may be slower than the No Build time because the model accepts longer in-vehicle time in order to avoid a transfer or have somewhat shorter waits or walking times.
With the presence of ARC, travel times to PSNY will be 7 minutes faster in Alternative 1 than with current conditions.

5.3.1.2 Transit Travel-Time Savings for Selected Trip Pairs

Travel-time savings were calculated by comparing the results of each alternative/option to the No Build Alternative (Table 5-7). Note that due to what is considered the "best path", the unweighted time in the build alternatives/options is in some cases slightly slower than in the No Build. For example, Spring Valley to 40th St. and 3rd Avenue would take two minutes longer in Options 3A and 3B than in the No Build Alternative. This indicates that a trip on BRT with a single transfer at Tarrytown to GCT would take two minutes longer in pure time, but would still be slightly preferable to using the No Build path, which appears to use the Pascack Valley Line with two transfers in Manhattan (i.e., the NYCT 1 train and the 42[nd] St. Shuttle) to get to the East Side.

Table 5-7

AM Peak Travel Time Savings, Selected Trip Pairs (Minutes)

Market Group	from	to	1	3A	3B	4A	4A-X	4B	4C	4D	Cross-Corridor LRT
Intra-Rockland	Suffern	Palisades Mall		35	35	30	26	26	26	31	28
Rockland-Westchester	Spring Valley	White Plains		41	46	33	33	20	27	41	18
	Spring Valley	Mt. Pleasant		39	41	31	33	22	36	39	24
	Nyack	Platinum Mile		40	45	35	35	18	36	40	33
	Suffern	White Plains		52	56	44	44	31	36	52	38
	Suffern	Yonkers		42	42	17	12	21	15	42	10
Manhattan Bound	Harriman	45th & Madison		0	0	17	0	17	17	17	0
	Nyack	45th & Madison		19	18	33	15	33	33	35	32
	Suffern	45th & Madison		0	0	16	-4	16	16	19	-1
	Newburgh	40th & 3rd Ave		0	0	18	-5	18	18	18	0
	Spring Valley	40th & 3rd Ave		-2	-2	34	16	34	34	36	7
	Middletown	34th & 7th		0	0	0	0	0	0	0	0
	Nyack	34th & 7th		21	20	35	18	35	35	37	35
	Middletown	World Trade Center		3	3	0	0	0	-1	-1	0
	Spring Valley	World Trade Center		2	2	18	0	18	18	20	-1
	Harriman	Javits Center, 36th & 11th		0	0	0	0	0	0	0	0
	Nyack	Javits Center, 36th & 11th		14	13	33	15	33	33	35	32
Westchester-CT	Elmsford	Stamford		11	18	15	15	-14	15	14	-14
Ct-Westchester	Darien	Platinum Mile		5	6	18	18	8	5	5	8
Westchester-Westchester	Port Chester	White Plains		13	14	7	7	3	0	13	3
To and from Bronx	Bronx (Grand Concourse, 180th St.)	Palisades Mall		36	37	41	41	40	45	45	20
	Spring Valley	Bronx (Montefiore Hospital)		42	34	14	14	19	32	42	17

5.3.1.3 Number of Transfers

The number of transfers was also determined (Table 5-8). The same BPM output files showing travel times for the best transit path also show the number of transfers between routes. Note that in some markets where the traveler has a choice among different reasonable paths, the BPM will calculate an average. In some cases this results in a fractional number of transfers. However, in Table 5-8, all values are rounded to whole numbers. Auto-to-transit movements are not counted as transfers.

5.3.1.4 Aggregate Transit Travel-Time Savings

Aggregate travel-time savings represent a single composite time-savings measure for each alternative/option by combining travel-time savings for each origin-destination pair and weighting them by the number of travelers actually making that trip. Time benefits have also been disaggregated by cross-corridor and NYC-bound markets.

The measure was calculated using these time savings for all zone pairs in markets affected by new service – basically the same markets analyzed for "Total Weekday Daily Transit Trips". For each pair, time saved in the AM peak period was multiplied by the number of No-Build transit trips for that pair. To account for time benefits accrued by new transit riders, half of that time saved was multiplied by the new transit trips for that zone pair, and added to the total. Half of that time is used because, on one extreme, these new transit riders could be shifted over to transit with a time savings of just one second, and on the other extreme, the full savings experienced by existing transit users is necessary to shift them. Thus, on average, their time savings benefit would be comparable to half of that full time savings. Time savings were divided by total riders on the proposed new service to determine average time saved per rider. Aggregate time savings in hours for the AM peak period would be:

- 3A – 4,400   4A – 7,400   4B – 6,200   4D – 8,100
- 3B – 4,500   4A-X – 3,900   4C – 6,000   LRT – 3,800

Table 5-8

AM Peak Transfers, Selected Trip Pairs

Market Group	from	to	1	3A	3B	4A	4A-X	4B	4C	4D	Cross-Corridor LRT
Intra-Rockland	Suffern	Palisades Mall	0	0	0	0	0	0	0	0	1
Rockland-Westchester	Spring Valley	White Plains	0	0	0	0	0	1	2	0	1
	Spring Valley	Mt. Pleasant	1	0	0	1	1	2	0	0	2
	Nyack	Platinum Mile	1	0	0	0	0	1	1	0	0
	Suffern	White Plains	0	0	0	0	0	1	1	0	0
	Suffern	Yonkers	1	1	1	1	2	2	2	1	2
Manhattan Bound	Harriman	45th & Madison	1	1	1	0	1	0	0	0	1
	Nyack	45th & Madison	1	1	1	0	1	0	0	0	1
	Suffern	45th & Madison	2	2	2	0	1	0	0	0	2
	Newburgh	40th & 3rd Ave	2	2	2	0	1	0	0	0	2
	Spring Valley	40th & 3rd Ave	2	1	1	0	1	0	0	0	2
	Middletown	34th & 7th	0	0	0	0	0	0	0	0	0
	Nyack	34th & 7th	1	2	2	1	2	1	1	1	2
	Middletown	World Trade Center	1	1	1	1	1	1	1	1	1
	Spring Valley	World Trade Center	1	1	1	1	1	1	1	1	1
	Harriman	Javits Center, 36th & 11th	1	1	1	1	1	1	1	1	1
	Nyack	Javits Center, 36th & 11th	2	3	3	1	2	1	1	1	2
Westchester-CT	Elmsford	Stamford	2	1	1	0	0	1	0	1	1
Ct-Westchester	Darien	Platinum Mile	2	2	1	1	1	2	1	2	2
Westchester-Westchester	Port Chester	White Plains	0	0	0	0	0	0	0	0	0
To and from Bronx	Bronx (Grand Concourse, 180th St.)	Palisades Mall	2	2	2	1	1	1	1	1	2
	Spring Valley	Bronx (Montefiore Hospital)	2	1	1	1	1	1	2	1	2

5.3.2 Comparison of Transit Modes

In cross-corridor markets, substantial time savings are available in all alternatives/options. In part this is due to improvements in running time, because existing transit services in the No Build Alternative would slow down with increases in traffic, especially across the bridge. However, large savings are also attributable to improvements in access to possible station locations, and, in the case of Options 3A and 3B, to much shorter wait times. Alternative 4B tends to have the smallest time savings cross-corridor, since it requires a transfer at the Tappan Zee Station. BRT offers time savings to a wider variety of trips cross-corridor. Even trips to major centers like White Plains and Stamford can be faster with BRT because in many cases the bus can get closer to the final destination than can rail.

In Manhattan-bound markets, the largest savings are found from trips originating in Nyack, as that part of Rockland County is not well-served by ARC, and all alternatives/options show improvements. BRT and LRT offer little savings to Manhattan for areas west of Nyack. Substantial savings to East Midtown from all origins in Rockland County are obtained with Manhattan-bound rail, with smaller savings to the west side and lower Manhattan, depending on the origin. In general, savings from Orange County origins are smaller, as there are no stations proposed in Orange County, so station access is the same across all alternatives/options, including the No Build. Direct service to GCT would offer time savings for trips from Orange County to East Midtown. However, trips from Orange County to West Midtown or lower Manhattan would not necessarily be improved over the No Build service.

Another way of assessing travel times is to graphically illustrate best paths. Travel times into Manhattan are particularly complicated because there are multiple routes between the study area and Manhattan, with commuter rail stations at GCT, Penn Station (and the proposed 34th St. Terminal used by ARC), and Hoboken, from which passengers can use PATH trains to reach Manhattan. Figure 5-8 illustrates just one case of how different parts of Manhattan are best served by the various commuter rail services from a sample zone in Orange County (in this case, a zone in Harriman) in Alternatives 4A, 4B and 4C. As expected, according to BPM outputs, the new GCT-bound service serves the East Side, the new 34th Street Station built for ARC would serve the West Side, and Hoboken trains would continue to be the most convenient station for many lower Manhattan destinations as well as Greenwich Village. A few zones would be equally well-served by two or even all three of these branches. Table 5-9 shows employment in these zones (a proxy for trip destinations), grouped according to the most convenient commuter rail station. Zones best served by GCT or 125th Street contain just over 50 percent of Manhattan's office employment.

Table 5-9

Distribution of Manhattan Jobs by Best Commuter Rail Station from Orange County, Alternatives 4A, 4B, 4C (2035)

Best Station	All Jobs	Retail Jobs	Office Jobs	% Office Jobs
GCT	1,279,664	145,712	835,535	49%
125th	179,455	19,557	54,882	3%
34th	606,089	73,476	391,663	23%
Hoboken	372,755	23,884	264,654	15%
GCT or 34th	68,071	7,278	51,806	3%
34th or Hoboken	132,756	19,000	87,825	5%
GCT or Penn or Hoboken	34,700	4,861	22,527	1%
Other Stations	19,756	3,838	7,511	0%
TOTAL	2,693,246	297,606	1,716,403	100%

It is important to note that both this map and this allocation of employment would be different for other areas of Orange County, and would vary by zone in Rockland County. Figure 5-9 shows a similar map for a zone in Spring Valley, showing that the new GCT service would be most convenient for a much larger portion of Manhattan than it would be for Orange County residents.

Figures 5-10 through 5-12 show the converse side of these patterns – illustrating which rail branches would be most convenient for Orange and Rockland County zones for a particular Manhattan zone.

- Figure 5-10 shows that the zone including Rockefeller Center (east of 6th Avenue) would be best reached via GCT for almost all of Orange and Rockland Counties.

- Figure 5-11 shows that for the zone on the other side of 6th Avenue, Penn Station is more convenient from the southern part of Orange County and from additional areas in Rockland County.

- Figure 5-12 shows that the zone containing the Empire State Building is best reached from Penn Station for almost all of Orange County and the majority of Rockland County.

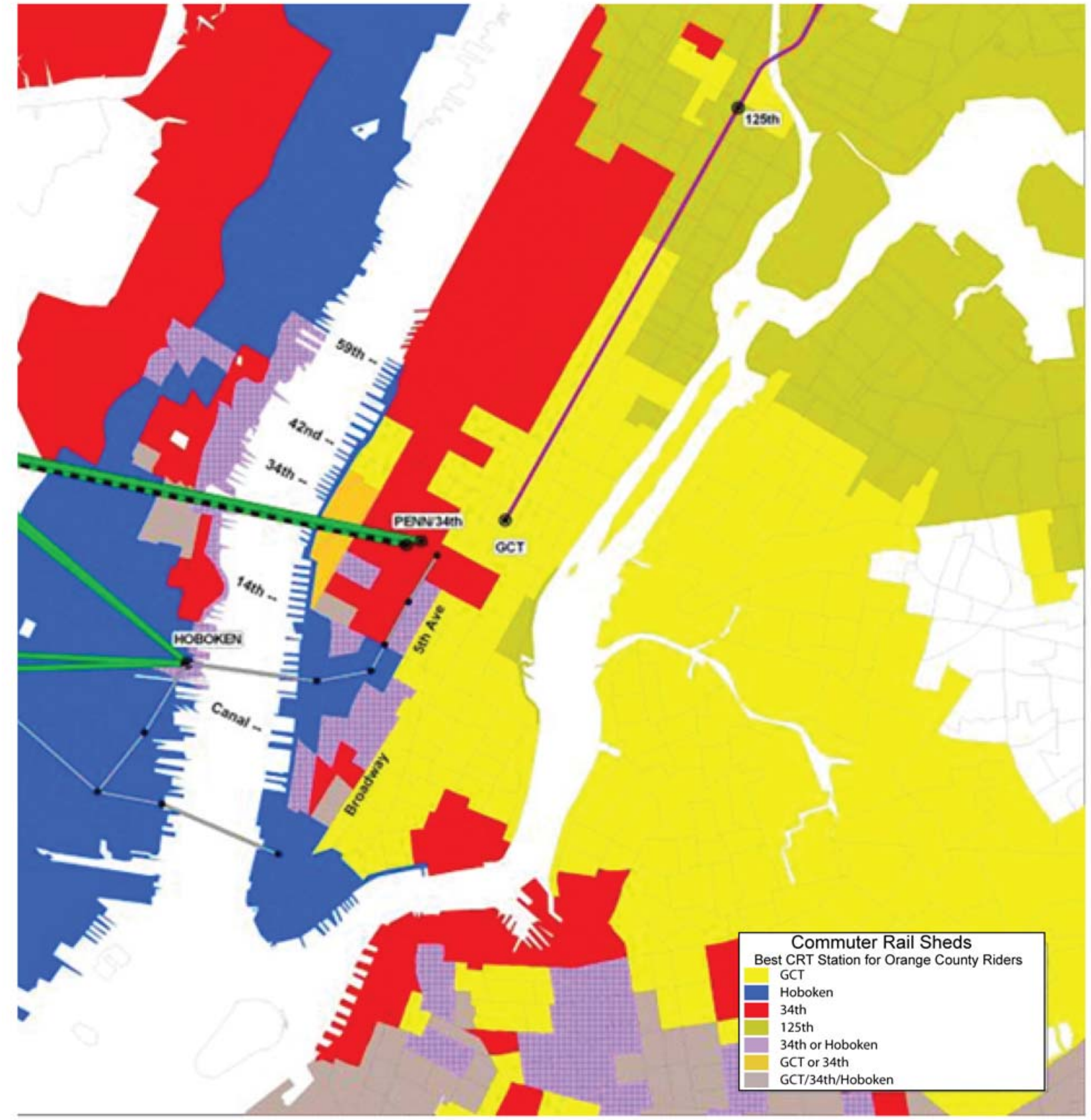


Figure 5-8 Commuter Rail Sheds from Orange County (Alternatives 4A, 4B, 4C)

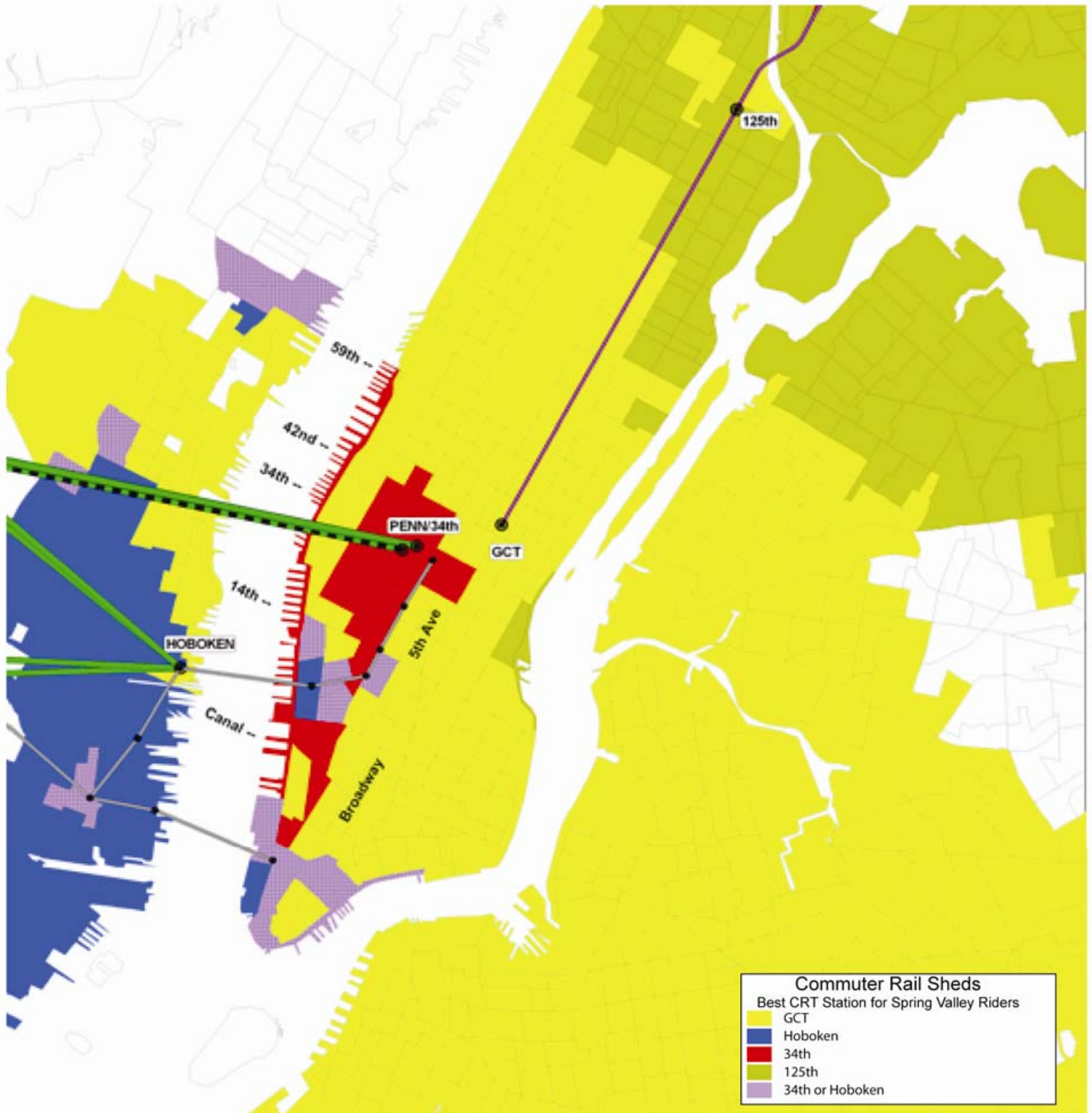


Figure 5-9 Commuter Rail Sheds from Spring Valley (Alternatives 4A, 4B, 4C)

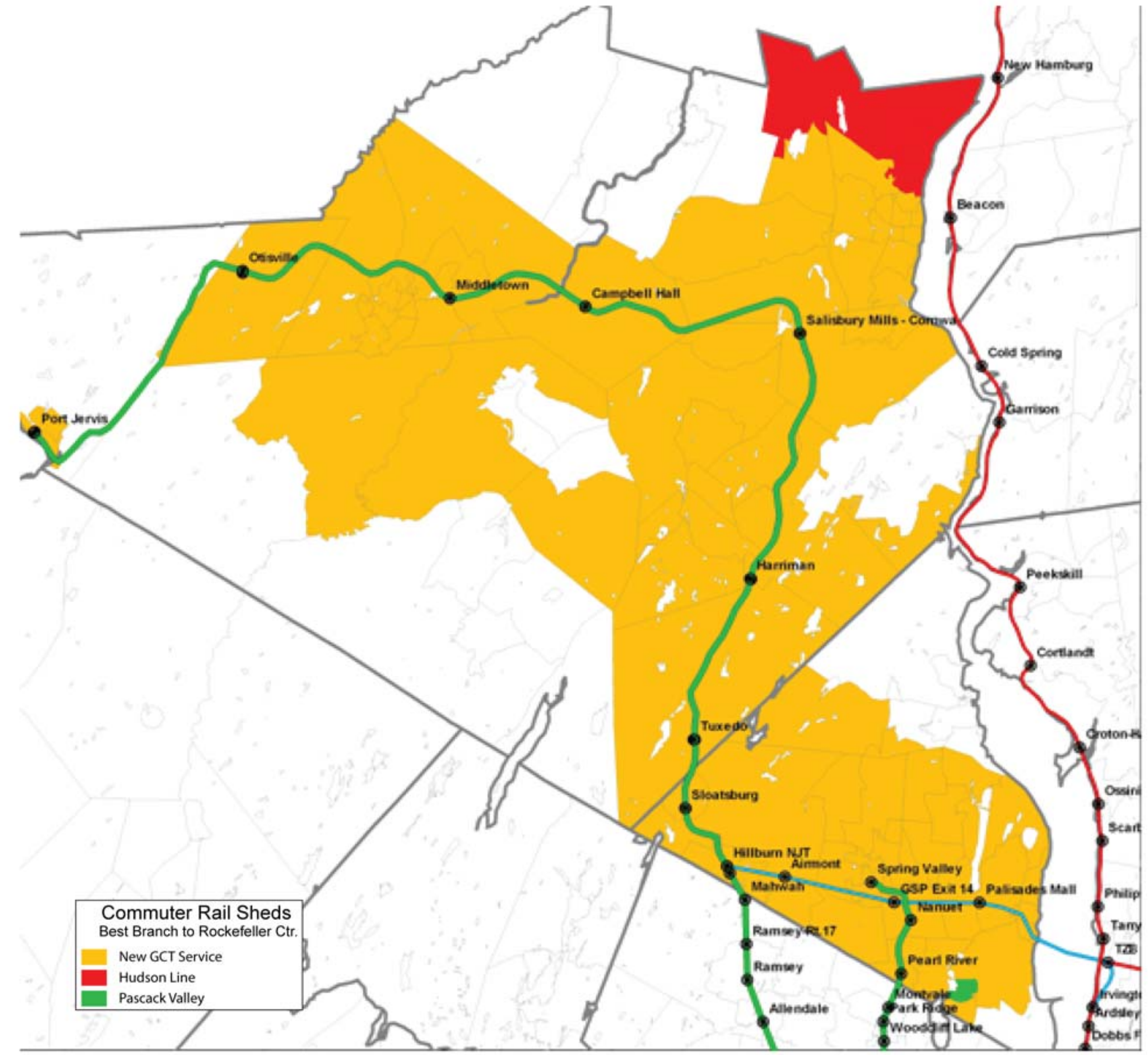


Figure 5-10 Commuter Rail Sheds to Rockefeller Center (East Side)

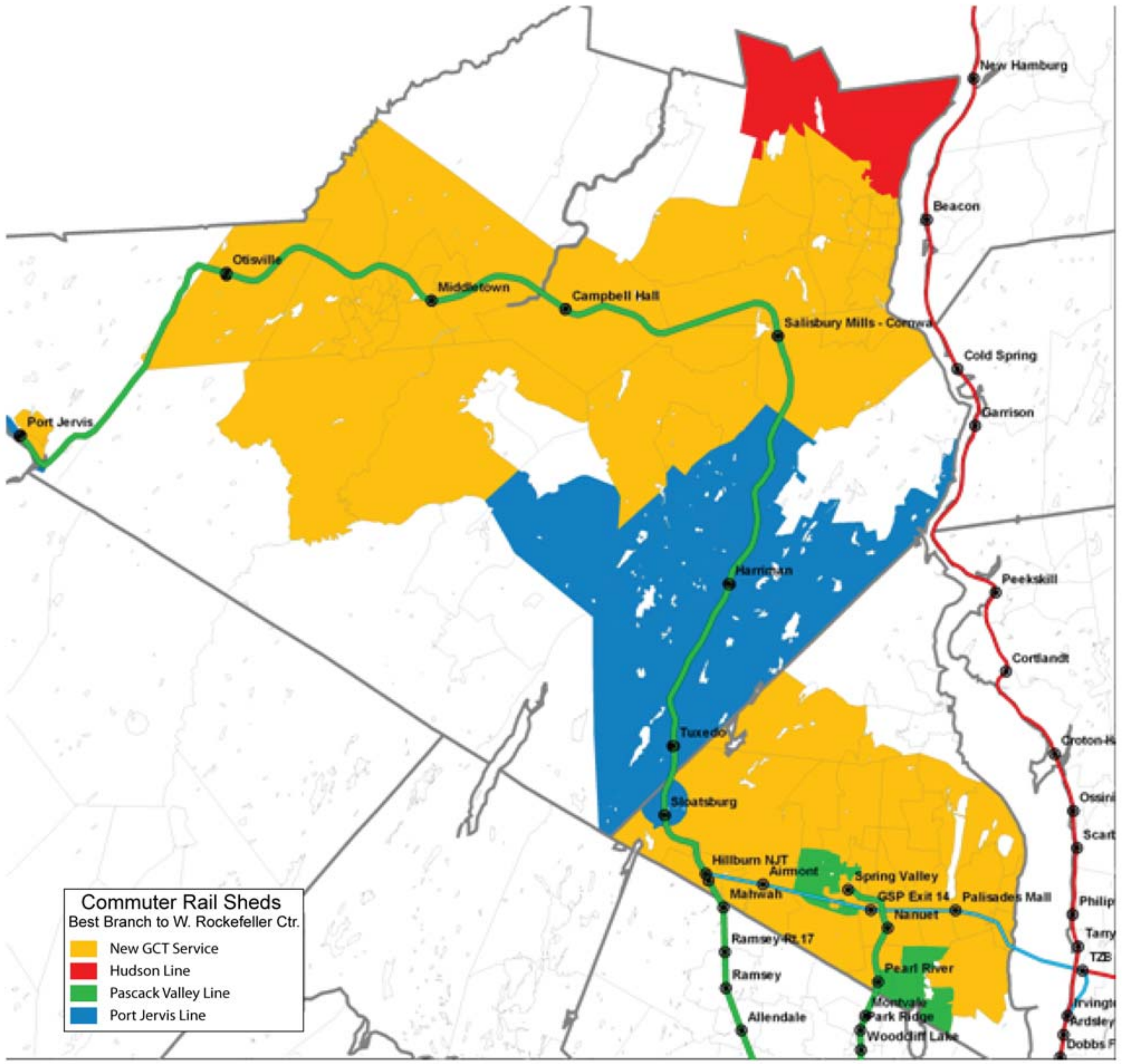


Figure 5-11 Commuter Rail Sheds to Rockefeller Center (West Side)

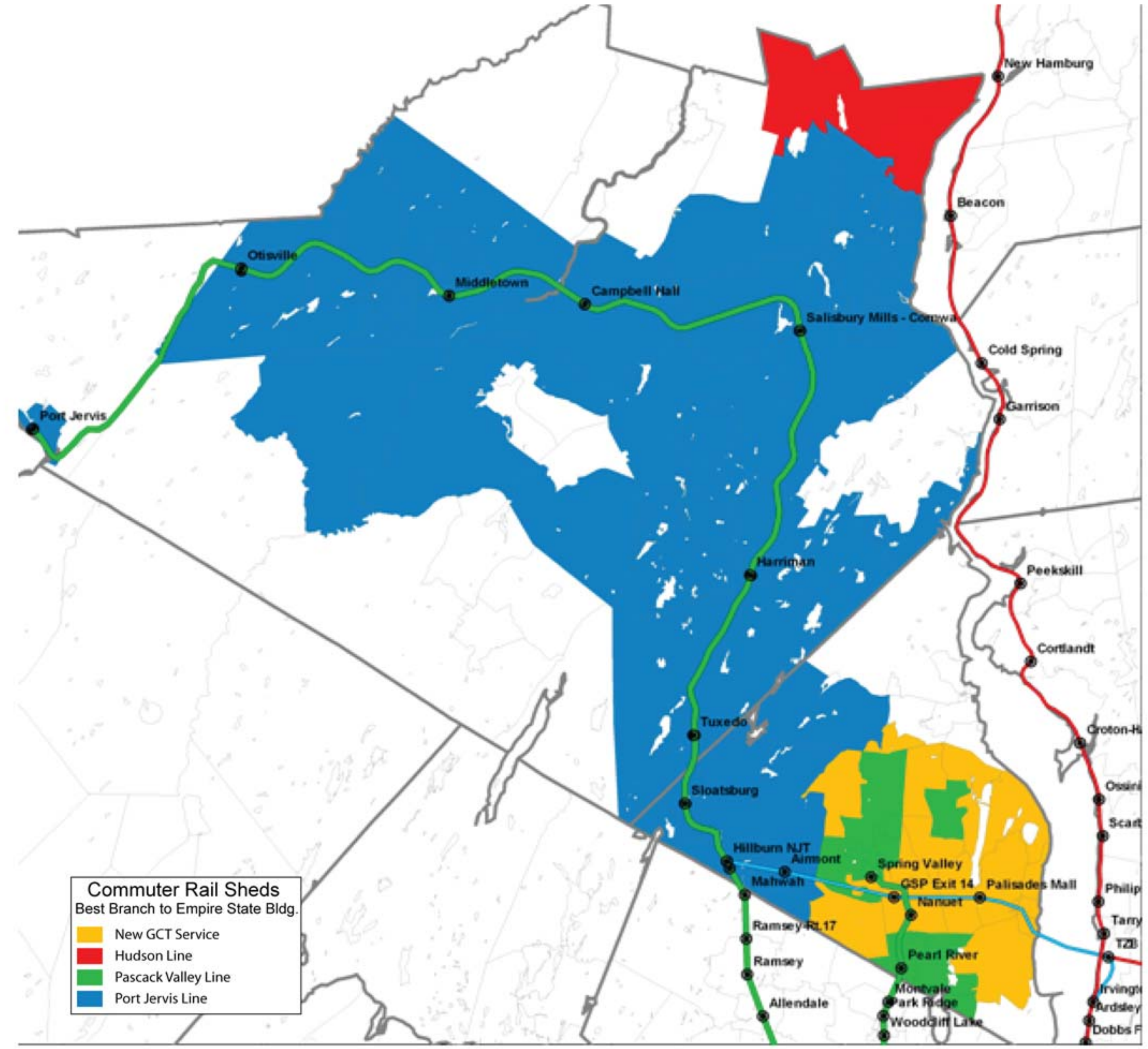


Figure 5-12 Commuter Rail Sheds to the Empire State Building

In terms of aggregate time savings, Option 4D leads the alternatives/options, with 8,100 hours (Table 5-10). Alternative 4A outperforms Alternative 4C, even though it carries fewer riders, especially in the cross-corridor market. This indicates that CRT across the corridor saves more time per trip on average than BRT does. Similarly, Options 3A and 3B only moderately exceed both Option 4A-X and Full-Corridor LRT, even though they generate far more riders, again indicating that BRT serves proportionally more trips with fewer time benefits. This is consistent with measures showing that BRT serves more short-distance trip and more intra-Westchester County trips (where BRT savings over Bee-Line bus service are smaller).

Table 5-10

Aggregate Travel-Time Savings (Hours in the Peak Period [6-10 AM])

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Total Time Savings	4,400	4,500	7,400	3,900	6,200	6,000	8,100	3,800
Cross-Corridor Markets	3,900	4,100	3,600	3,600	2,400	2,500	4,200	2,900
NYC-Bound Markets	400	400	3,800	300	3,800	3,500	3,900	900
Minutes Saved Per Rider	14.0	14.4	20.5	18.1	20.0	15.6	17.4	17.0

5.4 Capacity

5.4.1 Description of Criteria

Two types of capacity measures were calculated: capacity based on the alternative/option service plans, and a theoretical maximum capacity of the proposed infrastructure. Capacity based on the service plan was calculated separately for the cross-corridor and Manhattan-bound routes. In both analyses, the peak-load point is the Tappan Zee Bridge. It should be noted that the capacity based on the service plan calculations is highly flexible, as the percentage utilization for any mode can readily be increased or decreased by changing train consists, type of bus, etc.

5.4.1.1 Capacity at Peak-Load Point for New Service

Weekday peak-hour transit ridership was derived from the BPM outputs by multiplying AM peak-period (6-10 AM) ridership by a factor of 0.40; this factor was arrived at on the basis of a combination of available Metro-North and Bee-Line data. The service plans developed were then used to derive a "capacity" for the new service at the bridge, and the percentage of service utilization was calculated. Capacity was calculated assuming maximum seated loads as follows:

- **Bus** – 50 passengers per vehicle.
- **Light Rail** – 320 passengers per train (four cars at 80 passengers per car).
- **Commuter Rail** – 100 passengers per car (with train lengths varying from four to eight cars, depending on the service pattern).

Service plans called for the following frequency of vehicles. (Note that the service plans for non-BRT alternatives/options – Alternatives 4A and 4B, Option 4A-X, and Cross-Corridor LRT – maintained the No-Build frequency of five cross-Hudson buses per hour. In the alternatives/options with BRT, those five buses have been converted into BRT service and are among the numbers listed.)

Hourly Frequencies

- **Option 3A:** 30 cross-corridor buses and 12 Tarrytown-bound (serving Manhattan market).
- **Option 3B:** 32 cross-corridor buses and 12 Tarrytown-bound (serving Manhattan market).
- **Alternative 4A:** cross-corridor - 5 buses and 4 commuter trains (24 cars); Manhattan-bound commuter trains – 10 (48 cars).
- **Option 4A-X:** cross-corridor - 5 buses and 4 commuter trains (24 cars).
- **Alternative 4B**: 5 cross-corridor buses and 10 Manhattan-bound commuter trains (52 cars).
- **Alternative 4C:** 18 cross-corridor buses and 10 Manhattan-bound commuter trains (48 cars).
- **Option 4D:** cross-corridor- 40 buses and 10 Manhattan-bound commuter trains (48 cars).
- **Cross-Corridor LRT**: cross-corridor - 6 light-rail trains and 5 buses.

Note that while Alternative 4B includes an LRT element, it begins on the Westchester County side, and thus does not factor into capacity on the bridge. Similarly, the commuter rail spur at the Tappan Zee Station is not factored into the capacity calculation in the full-corridor LRT. Allocation of capacity to "Manhattan-Bound" and "Cross-Corridor" segments is relatively straightforward in alternatives/options with Manhattan-bound commuter rail. In Options 3A and 3B, the capacity of buses serving Tarrytown Station was placed in the Manhattan-bound category. In Full-Corridor LRT and Option 4A-X, capacity was simply apportioned according to estimated ridership patterns.

5.4.1.2 Potential to Meet Future Growth Projections

The potential to meet future growth projections is defined as the theoretical maximum seated capacity at a peak-load point (the Tappan Zee Bridge). Vehicle assumptions in this case differ from the capacity based on the service plan. It was assumed that the number of cars per train is higher – 10 cars per train for trains originating at Harriman or south of it, and 8 otherwise. The number of passengers per train was assumed to be 1,000. Additionally, a minimum headway of two minutes was assumed for both LRT and CRT, and 20 seconds for bus in a HOV/HOT lane or bus lane.

Alternatives 4A, 4B, and 4C, Option 4D, and Option 4A-X (commuter rail without the Hudson Line connection) all have the same theoretical maximum capacity, as they all include BRT/HOV/HOT lanes on the bridge and commuter rail. The theoretical capacity calculation assumes the maximum number of buses in the BRT/HOV/HOT lanes and the maximum number of trains on the CRT tracks. Thus, the theoretical capacity is the same for all.

5.4.2 Comparison of Transit Modes

Results show adequate capacity in all alternatives/options, with total utilization rates ranging from 64 percent to 82 percent (Table 5-11). As can be seen in the table, these service utilization rate totals mask considerable differentials between the rates for the two component markets. In particular, although Options 3A and 3B show the highest and second-highest utilization rates, respectively, in the cross-corridor market, they have the lowest and second-lowest utilization rates, respectively, in the Manhattan-bound market. That is, there is relatively low ridership on the bus routes that make the Tarrytown connection, as discussed above in Subchapter 5.2.2. This indicates that there is room to further adjust service plans to more precisely match demand.

The maximum capacity is clearly highest with rail alternatives/options, as CRT with minimum headways could theoretically carry 39,000 passengers per hour across the bridge. Maximum LRT capacity exceeds BRT capacity.

Table 5-11

Transportation Criteria – Capacity (2035)

Criterion	Alternative/Option								
	1 No Build	**3A** Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Capacity at Peak-Load Point for New Service									
Weekday AM Peak Hour, Peak Direction Transit Ridership on New Service									
Total	NA	1,330	1,430	4,760	1,860	4,160	4,560	4,950	1,420
Manhattan-Bound	NA	80	130	3,500	600	3,750	3,870	3,840	560
Cross-Corridor	NA	1,250	1,300	1,260	1,260	420	690	1,110	850
Weekday Peak Hour, Peak Direction Transit Ridership Capacity(seated capacity based on service plan)									
Total	NA	2,000	2,100	7,450	2,650	5,050	5,700	6,800	2,170
Manhattan-Bound	NA	500	500	4,800	855	4,400	4,800	5,300	860
Cross-Corridor	NA	1,500	1,600	2,650	1,795	650	900	1,500	1,310
Service Utilization (Percent)									
Total	NA	67	68	64	70	82	80	73	65
Manhattan-Bound	NA	16	26	73	70	85	81	72	65
Cross-Corridor	NA	83	81	48	70	65	77	74	65
Potential to Meet Future Growth Projections									
Seated Capacity	NA	9,000	9,000	39,000	39,000	39,000	39,000	39,000	18,600

Notes:
NA = Not applicable.
Potential to Meet Future Growth Projections = theoretical maximum peak direction seated capacity at a peak-load point (Tappan Zee Bridge).

5.5 Roadway Congestion

Transit alternatives/options can have varying impacts on the roadway network, as people switch from auto to transit. Note that all the build alternatives/options include an eight-lane bridge, HOV/HOT lanes and climbing lanes. It is important to remember that not all new transit trips are trips diverted from autos – many will be new trips to those markets. Moreover, in a congested region, the benefits of reductions in vehicle demand tend to get diluted over a wide area, as vehicles on congested roads seek out newly freed-up capacity.

A much more thorough analysis of roadway impacts will be conducted for the DEIS, with a microsimulation model assessing traffic conditions all along the corridor.

5.5.1 Description of Criteria

5.5.1.1 Eastbound Vehicles Crossing Hudson River

The BPM AM peak-period (6-10 AM) highway assignment was used to estimate eastbound vehicles crossing the Hudson River, from the Holland Tunnel to the Newburgh-Beacon Bridge. The difference in volumes obtained from BPM for each alternative/option was then compared, to determine the net number of autos diverted to transit for a given alternative/option.

5.5.1.2 Vehicle Miles Traveled (VMT)

BPM assignments for the AM peak period were used to calculate VMT for counties where notable changes were observed across alternatives/options. These were Rockland, Westchester, Orange, Bergen, and Bronx Counties.

5.5.2 Comparison of Transit Modes

Table 5-12 shows the results for roadway congestion for the five measures in the AM peak – eastbound vehicles crossing the Hudson, eastbound autos diverted from Hudson crossings, eastbound diversions from the Hudson crossings based solely on transit impacts, eastbound Rockland and Orange County vehicles crossing the Hudson, and Regional VMT. Option 4D removes the greatest number of autos from Hudson River crossings, which is consistent with transit ridership results. The 6,000 vehicles removed over four hours are nearly equivalent to the capacity of one vehicle lane. Options 3A and 3B reduce peak-period cross-Hudson traffic the least, at 4,300 and 4,000 vehicles, respectively. This is consistent with their attracting the fewest total cross-Hudson passengers.

All build alternatives/options include highway improvements (HOV/HOT lanes, climbing lanes, and a rehabilitated or replacement bridge) which have substantial impact on traffic measures. To isolate impacts of transit only, another model run with highway improvements but no transit improvements was conducted. That run showed 142,100 vehicles crossing the Hudson. The peak-period cross-Hudson diversions when compared to this alternative are even higher when comparisons are made to the No Build alternative, since it has a higher number of vehicles crossing the Hudson. Table 5-12 also illustrates the eastbound Rockland and Orange County vehicle crossings which were derived from trip tables and not highway assignments in order to isolate vehicles from the two counties.

In regional VMT, Alternative 4A and Option 4D show the lowest overall VMT levels, with 17.335 million miles; Alternative 4B is essentially the same, at 17.336 million miles. However, on a percentage basis, the differences among alternatives/options are not significant, as the total for the worst performer among the build alternatives/options – Option 3B – is 17.38 million miles, a figure which is just over one-quarter of one percent larger than the best performer.

Table 5-12

Transportation Criteria – Roadway Congestion (2035)

Criterion	Alternative/Option								
	1 No Build	**3A** Full-Corridor BRT Enhanced	**3B** Full- Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full- Corridor BRT (3A)	Full- Corridor LRT
Eastbound Vehicles Crossing Hudson River (AM Peak Period)	139,600	135,300	135,600	134,700	134,800	134,400	134,100	133,600	134,800
Eastbound Autos Diverted from Hudson River Crossings (AM Peak Period)	NA	4,300	4,000	4,900	4,800	5,200	5,500	6,000	4,800
Eastbound auto Diversions solely based on transit impacts (AM Peak Period)*	NA	6,700	6,400	7,300	7,200	7,600	7,900	8,400	7,200
Eastbound Rockland and Orange vehicles crossing the Hudson River (AM Peak Period)	41,500	40,400	40,400	39,900	40,600	40,000	40,000	39,400	40,300
Regional Vehicle Miles Traveled (AM Peak Period)***	17,561,000	17,366,000	17,376,000	17,335,000	17,370,000	17,336,000	17,345,000	17,335,000	17,360,000
Reduction in Regional Vehicle Miles Traveled (AM Peak Period)***	NA	195,000	185,000	226,000	191,000	225,000	216,000	226,000	201,000

* These numbers reflect a comparison with a different base which includes the No Build transit network and HOT lanes in the highway network.

** Includes journeys across all Hudson River crossings - from the Verrazano to the Newburgh-Beacon Bridges.

***VMT in five counties: Rockland, Orange, Westchester, Bergen and the Bronx.
NA = Not applicable.

5.6 Summary

The various measures discussed in this chapter tell similar stories – Option 4D attracts the most transit riders, though Alternative 4A includes proportionally more longer-distance trips with greater time savings, so on some measures, Alternative 4A ranks highest. BRT serves the most shorter-distance trips, whether they are intra-Rockland County or intra-Westchester County trips. CRT serves the Manhattan-bound market best. Longer-distance circumferential trips show mixed results; all modes that do not require a transfer perform well, with CRT slightly outperforming BRT, which in turn outperforms LRT. Since LRT requires a transfer for Orange County users (at Suffern) and for Connecticut users (at Port Chester), it lags behind both CRT and BRT. While CRT offers greater in-vehicle time savings than BRT, the ability of BRT to support a geographically extensive service plan enables it to compensate for slower run times by reducing both access and egress times.

BRT

LRT

CRT

6 Environmental Evaluation

The environmental evaluation criteria used in the evaluation of the transit modes are:

- Consistency with land use plans.
- Residential and commercial acquisitions/displacements.
- Transit-oriented development (TOD) potential.
- Wetlands.
- Parklands.
- Historic and archaeological resources.
- Hudson River habitat disturbance.
- Air quality.
- Energy and greenhouse gases.

The analysis focuses on direct impacts only (e.g., acquisition of a property), not indirect impacts (e.g., secondary economic effects). In addition, direct construction impacts are addressed for a limited number of critical locations (e.g., Lyndhurst and the Hudson River). Construction staging impacts and access easements are not addressed at this stage. In general, given the significant overlap in transit mode alignments, environmental factors are not substantial differentiators in the selection of a transit mode.

6.1 Consistency with Land Use Plans

This subchapter evaluates the consistency of transit mode alternatives/options with local land use plans as expressed in zoning and other land use policy documents, such as master plans, coastal zone management plans, urban renewal plans, etc. Zoning is also considered, to the extent that it regulates permitted uses, bulk, and other attributes of projects (site layout, design, parking, etc.). Transit projects may have land use consequences, both direct and indirect. For example, land uses may be displaced, and alignments may alter the character of a neighborhood or induce new development, desired or otherwise. Acquisition and displacement is addressed separately in Subchapter 6.2.

6.1.1 Description of Criterion

The land use criterion is focused on the project's consistency with land use plans. The plans and zoning codes reviewed include the following: Westchester County and Rockland County comprehensive plans; the towns of Clarkstown, Orangetown and Ramapo, and the villages of Nyack, South Nyack, Upper Nyack, Grand View on Hudson, Chestnut Ridge, Montebello, Spring Valley, Hillburn, and Suffern in Rockland County; and the cities of Rye and White Plains, the towns of Greenburgh and Harrison, and the villages of Rye Brook, Port Chester, Elmsford, Irvington, and Tarrytown in Westchester County. Other types of comprehensive plans of affected jurisdictions (e.g., Waterfront Revitalization Plans) that were determined to be applicable to the alternatives/options under consideration were also reviewed.

Relatively rarely do local plans address the provision of transit directly, although a few (e.g., Ramapo) have language in their comprehensive plan that encourages more effective transit service and land use patterns that encourage concentration where transit and other infrastructure exist. Waterfront revitalization plans typically express a desire for more public access to the waterfront, a feature that will be enhanced by the provision of pedestrian/bikeways on the Tappan Zee Bridge under all bridge and transit alternatives/options.

6.1.2 Comparison of Transit Modes

The absence of specific transit policies in local land-use policy documents permits little or no differentiation between the transit alternatives/options with respect to their consistency with these policies. One exception would be transit alternatives/options that require the conversion of existing general-traffic lanes to dedicated bus or light-rail use (e.g., in downtown White Plains), which, in addition to transportation impacts, have the potential for localized land-use impacts that may be inconsistent with local policy documents.

6.2 Residential and Commercial Acquisitions/Displacements

Project options that extend beyond the existing ROW are likely to require the acquisition of private or public property. Acquisition that is of a minor character (e.g., a sliver alongside a rear yard) may not require the displacement of the property's occupants, but when an acquisition is of a scale that affects structures or denies access to the property, displacement may be a necessary consequence. Therefore, linear projects such as this may involve displacement of existing property uses and/or acquisition of a portion of a property while enabling the use to continue.

There are also situations where property acquisition is required but may be only in the form of an easement, which may be either permanent (e.g., for a tunnel below ground) or temporary, lasting only for the period of construction (e.g., to gain access to build a retaining wall). Owners of properties subject to acquisitions and easements are compensated at fair market rates, and those displaced are also eligible for relocation assistance.

6.2.1 Description of Criterion

The criterion for displacement applies to those properties where there is a potential for displacement of occupants and/or activities. Therefore, residential displacements represent the number of structures and displaced units; and commercial displacements represent the number of commercial uses displaced. With regard to acquisitions, the linear nature of the project warrants identifying impacts in terms of linear feet of acquisitions along the ROW. Thus, criteria for acquisitions include an estimation of the linear feet of sliver-taking on property impacted, and not the individual number of properties so affected. In addition, underground easements are required for most alternatives/options, and they too have been calculated in terms of linear feet of underground easements.

6.2.2 Comparison of Transit Modes

Displacement of residences varies from an estimated 38 units under Option 3B to as few as nine units under Alternatives 4B, 4C and Full-Corridor LRT (Table 6-1). The number of residential structures displaced, however, is quite small for such a major transit project, ranging from five to 12 among the alternatives/options. (Option 3B displaces the highest number of units because of an affected apartment building adjacent to I-287 in White Plains).

Commercial displacements are also relatively small in number for all alternatives/options, ranging from 10 in Option 3A to 23 in Alternative 4B (Table 6-1). Of the eight alternatives/options, six (all except 3A and 3B), cluster at between 20 and 23 displaced businesses, so there is little differentiation among them on this metric. None of the affected businesses would be characterized as large employers, and most are small retail and highway-oriented businesses.

Table 6-1

Displacements, Acquisitions, and Easements

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Estimated Residential Displacements	5 structures 17 units	10 structures 38 units	12 structures 15 units	12 structures 15 units	6 structures 9 units	6 structures 9 units	7 structures 21 units	6 structures 9 units
Estimated Commercial Displacements	10	11	20	20	23	22	20	22
Estimated Total Acquisitions (linear feet of sliver-taking)	17,900	21,000	8,300	8,300	16,600	8,200	11,500	16,600
Underground Easements (linear feet)	0	0	9,400	5,300	4,400	4,100	4,100	4,400

Acquisition that does not require the displacement of residences, businesses, or institutions is typically of slivers of property adjacent to the proposed ROW in instances where the existing ROW is insufficient and/or topography necessitates acquisition for a specific transit alignment. In terms of linear feet, such acquisitions range from 8,200 feet under Alternative 4C to 21,000 feet under Option 3B (Table 6-1). Three of the CRT alternatives/options – 4A, 4A-X, and 4C – have the smallest acquisition totals because they utilize tunnels more than do the other alternatives/options, thereby avoiding many sliver-takings. The alternatives/options with the largest linear acquisitions are 3A and 3B, which involve enhanced BRT and busways, followed by the two LRT alternatives/options – 4B and Full-Corridor LRT – which have similar acquisition requirements, and which have somewhat smaller acquisition totals than the enhanced-busway alternatives/options. Option 4D has a smaller acquisition total than the other BRT alternatives/options because it plans for buses to merge into general traffic east of the Hutchinson River Parkway.

Underground easements are estimated separately, and are primarily associated with CRT alternatives/options (4A, 4A-X, and 4C). The largest underground easements are estimated for Alternative 4A – 9,400 linear feet. At the other extreme are the BRT alternatives/options with no CRT or LRT (Options 3A and 3B), which have no underground easements.

When acquisition of property is required for federally-funded transportation projects, there are formal procedures that require the fair market compensation of property owners for their loss of property value. In addition, displaced residents and businesses (whether owners or tenants) are eligible for additional relocation assistance under the procedures of the federal Uniform Relocation Assistance Act.

6.3 Transit-Oriented Development (TOD) Potential

Development induced by transit – usually rail transit – is commonly referred to as transit-oriented development (TOD). Typical TOD developments consist of high-density, mixed-use, pedestrian-oriented communities, usually within one-quarter mile of a transit station. The goal of TOD is to provide an environment in which people can live, work, shop, or be entertained within walking distance of a transit station. The proposed transit mode alignments have the potential to induce TOD.

6.3.1 Description of Criterion

Possible station locations have been considered in the transit service plans but final locations are not available at this project stage. Therefore, in this report, only generalized TOD potential in proximity to possible station areas can be assessed. Alternatives/options are rated in terms of minor, moderate, or major potential for generating TOD.

6.3.2 Comparison of Transit Modes

The TOD potential of the various transit alternatives/options is anticipated to vary by mode, with CRT stations usually associated with a greater potential than the other options. The reason for this is that the greater public investments required for CRT, together with the typically greater passenger usage, tend to assure private investors that less risk attaches to such development. At the other extreme is a simple bus stop, which requires little public investment and, hence, is likely to be perceived as a less-permanent feature, creating more risk for private investment. Some bus stations, however, can be major features, requiring significant public investment, and can generate significant private TOD investment, although this is much less common. LRT stations are generally considered to fall somewhere between CRT and BRT – although LRT stations may often be quite modest, they typically require more public investment than bus stops, and their fixed-rail character contributes to their perception as permanent. Consequently, the alternatives/options with more CRT stations are considered to have moderate to major TOD potential, those only with BRT to have minor to moderate TOD potential, and those with LRT to have moderate TOD potential. However, it should be noted that the impact of BRT systems on land use patterns is not well established given the relative "newness" of such systems in the US.

6.4 Wetlands

The corridor ecological study area is approximately 30 miles in length. Within the study area can be found a wide range of ecosystems, from the Rockland highland region near Suffern, to the Hudson River Estuary, to the Westchester coastal plain near Long Island Sound. Within the study area, there are more than 20 notable waterbodies and numerous wetlands. Among the significant watercourses are the Ramapo, Mahwah, Hackensack, Saw Mill, Bronx, and Mamaroneck Rivers. Wetlands that occur within the study area are highly variable, ranging from small, disturbed, low-ecological-value roadside ditches to large, undisturbed, high-ecological-value wetlands. The boundaries of most study-area wetlands typically extend beyond the I-287 ROW, particularly along the banks of streams that cross the highway corridor.

Wetlands provide critical ecological functions and values (e.g., floodflow alteration, nutrient/toxicant removal, groundwater recharge/discharge and wildlife habitat, etc.). As such, wetlands are managed under a variety of federal and state statutes and programs, including Section 404 of the Clean Water Act, US Executive Order 11990, and New York State's Environmental Conservation Law, Articles 24 and 25.

The New York State Department of Environmental Conservation (NYSDEC) regulates all wetlands in New York State that are either larger than 12.4 acres or of unusual local importance. The New York State wetland protection program also defines a regulated area adjacent to NYSDEC-regulated wetlands; this area is normally 100 feet beyond the wetland boundary for freshwater wetlands and up to 300 feet for tidal wetlands. The NYSDEC ranks wetlands in one of four classes ranging from Class I to Class IV. Class I wetlands provide the greatest ecological value and receive the highest level of protection under NYSDEC's regulations.

Six NYSDEC-regulated wetlands occur within the study area. In Rockland County, one Class I wetland and three Class II wetlands are located within and/or adjacent to the I-287 ROW. One Class II wetland is located within the Piermont Railroad ROW. In Westchester County, one Class II wetland is located within the I-287 ROW.

6.4.1 Description of Criterion

Construction of any of the proposed transit modes can impact wetland resources either directly or indirectly. Based on the level of engineering information available for this analysis, only direct impacts are considered. Such impacts would occur when the limits of transit-mode development extend directly onto a mapped resource. The direct impact is then the area (in square feet or acres) resulting from the intersection of the mapped resource and the transit mode.

The use of a direct-impact approach for this analysis may underestimate the extent of actual wetland loss, since indirect impacts and construction impacts are not considered. However, these additional effects are expected to occur in proportion to the direct losses and, therefore, the results presented here are generally indicative of the relative scale of impacts for the various modes. Furthermore, wetland resources such as those found along the Hackensack River, a source of drinking water, have greater ecological value than resources that serve as highway drainage channels. Thus, to the extent possible at this stage in project development, note will be made of those instances wherein the resource potentially impacted is considered to have high value.

6.4.2 Comparison of Transit Modes

Within the study area the wetland boundaries were mapped using federal and New York State methodologies. The wetland boundaries were established by means of a Global Positioning System (GPS) system with +/- 1-meter accuracy. In those areas where wetlands extended beyond the limits of the study area, wetland boundaries were estimated by interpreting infra-red photographs. Ultimately, once a preferred alternative has been established, a formal delineation of wetlands will be undertaken so that permit applications for the use of wetlands can be submitted to the appropriate federal and state agencies. Unavoidable impacts to wetlands would require mitigation, either through the creation of new wetlands, the enhancement of existing wetlands, and/or the purchase of wetland mitigation credits from an existing wetland mitigation bank.

The estimated aerial extent of wetland impacts for each transit mode is shown on Table 6-2. The estimates were generated by overlaying the limits of development for the transit modes on a geographically referenced map of the study area's GPS-mapped wetland resources. As can be noted from the results of the analysis, at approximately 8 acres, the BRT mode generally has the least impact. This is largely due to the smaller development footprint presented by BRT in Rockland County in comparison to CRT options. Modes that include an LRT component are estimated to be intermediate to BRT and CRT in terms of direct wetland loss.

A significant percentage of the mapped wetlands impacted by the transit modes are highway drainage courses, which are typically wetlands of low ecological value. However, all modes also impact NYSDEC Class I areas adjacent to the Hackensack River. Since the CRT mode would have the largest footprint in Rockland County, it would also have the greatest impact to the Class I wetlands that abut the Hackensack River.

Table 6-2

Wetlands

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Wetlands (acres)	8	8	14	14	12	12	12	12

While Options 3A and 3B are estimated to have the least impact to wetland resources, the BRT mode has the potential to uniquely impact Talleyrand Marsh (Option 3B), a Class II NYSDEC wetland. Also, both BRT and LRT could cross the Bronx River Park Reservation on structure and both modes would have impacts to wetlands along Blind Brook, east of the Hutchinson River Parkway. CRT would run in a tunnel beneath the Bronx River and also has a tunnel option that avoids Blind Brook.

6.5 Parklands

Potential effects to parklands are an important consideration because they would typically require an analysis under Section 4(f) of the Transportation Act. Such analysis would require, among other elements, an assessment of avoidance alternatives. A requirement that no other feasible and prudent alternative exists is required, unless the park operator concurs that the impacts to the affected resource are *de minimis* and/or that there would be a net benefit to the resource as a result of the project.

6.5.1 Description of Criterion

Parklands with potential direct impacts have been identified, and the location and significance of the impacted resources are described, as appropriate. The discussion of Section 4(f) requirements for affected historic and archaeological resources is provided in Subchapter 6.6.

6.5.2 Comparison of Transit Modes

Table 6-3 shows the affected park resources by alternative/option. Certain parks are affected by all alternatives/options, in particular Elizabeth Place Park, a small (approximately one acre) neighborhood resource in South Nyack adjacent to the Thruway; the adjacent rail trail would be affected by the widening of the highway and reconstruction of Interchange 10 (US 9W). The anticipated construction would require acquisition of a sliver of the park and relocation of the rail trail onto a new bridge crossing the Thruway. The other park resources potentially affected by all alternatives/options are the north-south parkways (the Palisades Interstate Parkway, the Saw Mill River Parkway, etc.) that would be crossed.

Table 6-3

Parklands

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Parklands (direct impacts)	Elizabeth Pl. & adjacent rail trail Tibbits Park (slivers) Parkways	Elizabeth Pl. & adjacent rail trail Parkways Tibbits Park (slivers)	Elizabeth Pl. & adjacent rail trail Yosemite (sliver) Lyndhurst footbridge Old Croton Aqueduct Trail Parkways	Elizabeth Pl. & adjacent rail trail Yosemite (sliver) Parkways	Elizabeth Pl. & adjacent rail trail Yosemite (sliver) Lyndhurst footbridge Old Croton Aqueduct trail Tibbits Park (major) Parkways	Elizabeth Pl. & adjacent rail trail Lyndhurst footbridge Old Croton Aqueduct trail Tibbits Park (slivers) Parkways	Elizabeth Pl. & adjacent rail trail Old Croton Aqueduct Trail Lyndhurst footbridge Tibbits Park (slivers) Parkways	Elizabeth Pl. & adjacent rail trail Yosemite (sliver) Lyndhurst footbridge Old Croton Aqueduct trail Tibbits Park (major) Parkways

Additional park resources are affected under specific alternatives/options. Thus, Tibbits Park in White Plains is affected by the BRT and LRT alternatives/options. For the BRT alternatives/options (Options 3A, 3B, and 4D and Alternative 4C) only slivers of the park are required, but the LRT alternatives/options – Alternative 4B and Full-Corridor LRT – would require major acquisition at this park. The CRT options do not impact Tibbits Park because they would be in tunnel. Most CRT alternatives/options, however, would affect other resources. In particular, those that would connect to the Hudson Line – Alternatives 4A and 4B and Option 4D – would affect a closed footbridge across the Metro-North Railroad tracks at Lyndhurst and use an alignment beneath the Old Croton Aqueduct, which is a trail as well as an historic resource. All cross-Westchester CRT and LRT alternatives/options – 4A, 4A-X, 4B and Full-Corridor LRT – have the potential to require a sliver of Yosemite Park in Greenburgh.

While the alignments of all transit alternatives/options have been designed to avoid or minimize park impacts, some parks are affected by all alternatives/options, so that no differentiation among them is possible. Other resources are affected by specific alternatives/options, mostly as minor sliver acquisitions. The LRT alternatives/options in White Plains, however, would have the potential for the greatest impact to a park resource, namely, Tibbits Park, an important downtown public space. When park resources are potentially affected by transportation projects involving federal funding, all efforts to avoid or minimize impacts must be made. New Section 4(f) rules, however, do offer more opportunities to provide mitigation that results in a “net benefit” to the park resource, or a waiver when the impacts are *de minimis*, although in either case, the park operator must concur.

6.6 Historic and Archaeological Resources

Analysis of impacts of transit-mode alignments on historic and archaeological resources (cultural resources) are based on relevant federal and state cultural resources regulations. The federal and state regulations include:

- Section 106 of the National Historic Preservation Act (NHPA) (16 USC 470 *et seq*.; and 36 CFR Part 800 – Protection of Historic Properties).
- Section 14.09 of the New York State Historic Preservation Act (SHPA) (Chapter 354 of the Parks, Recreation and Historic Preservation Law).
- Section 110 of NHPA.
- Section 4(f) of the US Department of Transportation Act of 1966 (as amended in 2005).

Section 106 and Section 14.09 have similar requirements. For this project, Section 106 and Section 4(f) are the most relevant federal regulations. Section 106 requires lead agencies to identify an Area of Potential Effect (APE) that takes into account the potential direct and indirect impacts of project implementation on National Historic Landmarks (NHLs); National Register-listed (NRL) resources; National Register-eligible (NRE) resources; and recommended NRE resources. Significant cultural resources (buildings, structures, sites, objects and historic districts) are eligible for listing in the National Register if they are over 50 years old and possess local, state or national significance for their association with historic events; individuals or groups; design/construction; or information potential. Following identification of significant cultural resources, Section 106 requires analysis of direct and indirect impacts on those resources, and coordination with consulting parties to minimize harm as much as practical.

Section 110 of NHPA requires that federal agencies exercise a higher standard of care when considering undertakings that may directly and adversely affect NHLs. The law requires that agencies, to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm to such landmarks. Furthermore, agencies should consider all prudent and feasible alternatives to avoid an adverse effect on an NHL.

Section 4(f) stipulates that federal transportation agencies cannot approve the use of a significant cultural resource (i.e., NHL; NRL property; NRE property; recommended NRE property) or public park unless there is no feasible and prudent alternative to the use, and the action includes all possible planning to minimize harm.

6.6.1 Description of Criterion

The goal of this report is to determine whether there are critical differences and/or benefits among transit-mode alignments being evaluated for this project. While Section 106 and Section 110 require analysis of direct and indirect impacts on significant cultural resources, Section 4(f) is primarily limited to analysis of direct impacts on such resources. Using aspects of Section 106, Section 110 and Section 4(f) as a point of departure, this report will only focus on potential temporary and permanent direct impacts that transit-mode alignments may have on such resources because such impacts could function as a differentiator among mode alignments, and assist in the selection of preferred mode alignments.

Section 106 defines a project’s direct impacts that result in adverse effects as activities that may alter characteristics of a cultural resource that qualifies it for inclusion in the National Register in a manner that would diminish the integrity of the property’s location, design, setting, materials, workmanship, feeling, or association. Temporary activities associated with construction may result in adverse effects and therefore are considered part of the environmental evaluation criteria. Direct impacts that result in adverse effects to cultural resources include:

- Physical destruction or damage to all or part of a property.
- Alteration of a property that is not consistent with the Secretary of the Interior's Standards for Treatment of Historic Properties.
- Removal of a property from its historic location.
- Change of the character of the property's use or physical features within the property's setting that contribute to its historic significance.

Similarly, under Section 4(f), direct impacts to significant cultural resources may be considered a use, and therefore must also be analyzed to ensure that there is not a feasible and prudent alternative to such a use.

Historic Architectural Resources

In terms of historic architectural resources, this analysis examined temporary and permanent direct impacts of transit-mode alignments on five categories of resources:

- NHLs.
- NRL resources.
- Resources determined eligible for listing in the National Register by the New York State Historic Preservation Office (NYSHPO).
- Resources surveyed for this project in accordance with Section 106 and recommended eligible for listing in the National Register, pending NYSDOT and NYSHPO review.
- Resources surveyed for this project in accordance with Section 106, which must also be evaluated for National Register eligibility (hereafter referred to as yet-to-be-evaluated properties).

Archaeological Resources

The potential for direct impacts is the principal screening criterion employed to measure the effects of each transit-mode alignment on archaeological resources. This analysis examined direct impacts of transit-mode alignments on previously identified archaeological resources as well as on areas determined to be archaeologically sensitive as a result of research conducted to date as part of the Section 106 compliance survey for this project. It should be noted that for areas determined to be archaeologically sensitive, the Phase 1B presence-or-absence subsurface-testing survey is in progress and has not yet been completed in either Rockland County or Westchester County. The purpose of the Phase 1B subsurface testing is to determine whether the location *actually* contains archaeological resources, as opposed to whether such resources may *potentially* exist at the location.

6.6.2 Comparison of Transit Modes

Historic Architectural Resources

In general, direct impacts to historic architectural resources are analyzed to determine whether they constitute an adverse effect in accordance with Section 106. If adverse effects result, mitigation would be developed by lead agencies in conjunction with NYSHPO, consulting parties, and the Advisory Council on Historic Preservation (ACHP), as appropriate. In compliance with Section 4(f), direct impacts to historic architectural resources would also be analyzed to determine whether the impacts constitute a Section 4(f) use, and whether there are feasible and prudent alternatives to such uses.

Table 6-4 compares the impacts that the alternatives/options would have on historic architectural resources. All alternatives/options would impact the NRE Tappan Zee Bridge because the bridge would be rehabilitated or replaced under all. Options 3A and 3B (the full-corridor BRT transit modes) would have direct impacts on multiple categories of resources, as indicated in the table. The impacts include acquisition of land from individual properties and historic districts and utilization, bisection and/or tunneling across historic railroad ROWs and/or roadways. In addition, Option 4A-X has similar impacts to Options 3A and 3B. However, as noted in Table 6-4, the exact number of impacts to the various categories of resources would differ slightly between these three options. Direct impacts caused by Options 3A, 3B and 4A-X would be analyzed in accordance with Section 106 and Section 4(f), as noted above.

Options which include CRT with the Hudson Line connection, either full corridor or in combination with BRT and LRT transit modes (Alternatives 4A, 4B, 4C, Full-Corridor LRT, and Option 4D) result in similar impacts to multiple categories of resources caused by the BRT and CRT options described above (Options 3A, 3B and 4A-X). However, these five alternatives/options also result in temporary and direct impacts to nationally significant NHLs caused by construction of the Hudson Line connection. As indicated in Table 6-4, these impacts include temporary construction impacts to waterfront parcels associated with Lyndhurst and Sunnyside. Direct impacts include removal of a pier and a thru-truss footbridge associated with Lyndhurst, and construction of a tunnel in the vicinity of the Old Croton Aqueduct. Impacts to the three NHLs would be analyzed in accordance with Section 106 and Section 4(f) to determine whether they result in adverse effects and whether such impacts constitute a Section 4(f) use. NHLs are overseen by the Secretary of the Interior. Therefore, in accordance with Section 110, mitigation of potential adverse effects to these properties would also require coordination with the Secretary of the Interior and ACHP. This would result in a more involved and complex consultation process to devise methods to minimize direct effects to such resources.

Archaeological Resources

Table 6-4 compares the direct impacts that the eight alternatives/options would have on archaeological resources. The direct impacts indicated on Table 6-4 refer to previously identified archaeological resources listed in the New York State Museum (NYSM) and NYSHPO site files and those located during reconnaissance walkover surveys of targeted portions of the study area.

All eight alternatives/options would create comparable impacts to archaeological resources in Rockland County. No differences in impacts are seen between alternatives/options that utilize either full- or partial-corridor BRT, CRT, or LRT modes in Rockland County.

In Westchester County, the options that include a full-corridor BRT mode – 3B and 4D – would create the greatest number of direct impacts to previously identified archaeological resources when compared to alternatives/options that utilize a LRT mode (Alternative 4B and Full-Corridor LRT), a full-corridor CRT mode (Alternative 4A and Option 4A-X), or a partial CRT mode (Alternative 4C).

Table 6-4

Historic and Archaeological Resources

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Historic Resources (direct impacts)	2 NRL 2 NRE 5 rec. NRE 5 yet-to-be-evaluated resources	2 NRL 2 NRE 2 rec. NRE 6 yet-to-be-evaluated resources, including potential historic districts	2 NHLs (Old Croton Aqueduct; Lyndhurst) Temporary impacts on 2 NHLs (Lyndhurst; Sunnyside) 2 NRL 3 NRE 2 rec. NRE 6 yet-to-be-evaluated resources	2 NRL 3 NRE 2 rec. NRE 4 yet-to-be-evaluated resources	2 NHLs (Old Croton Aqueduct; Lyndhurst) Temporary impacts on 2 NHLs (Lyndhurst & Sunnyside) 3 NRL 2 NRE 2 rec. NRE 6 yet-to-be-evaluated resources	2 NHLs (Old Croton Aqueduct; Lyndhurst) Temporary impacts on 2 NHLs (Lyndhurst & Sunnyside) 2 NRL 2 NRE 3 rec. NRE 5 yet-to-be-evaluated resources	2 NHLs (Old Croton Aqueduct; Lyndhurst) Temporary impacts on 2 NHLs (Lyndhurst & Sunnyside)) 2 NRL 2 NRE 2 rec. NRE 6 yet-to-be-evaluated resources	2 NHLs (Old Croton Aqueduct; Lyndhurst) Temporary impacts on 2 NHLs (Lyndhurst & Sunnyside) 3 NRL 2 NRE 2 rec. NRE 6 yet-to-be-evaluated resources
Archaeological Resources (direct impacts)	Piermont ROW Five sites in Rockland Old Croton Aqueduct One site in Westchester	Piermont ROW Five sites in Rockland Old Croton Aqueduct Three sites in Westchester	Piermont ROW Five sites in Rockland Old Croton Aqueduct One site in Westchester	Piermont ROW Five sites in Rockland Old Croton Aqueduct	Piermont ROW Five sites in Rockland Old Croton Aqueduct One site in Westchester	Piermont ROW Five sites in Rockland Old Croton Aqueduct One site in Westchester	Piermont ROW Five sites in Rockland Old Croton Aqueduct Two sites in Westchester	Piermont ROW Five sites in Rockland Old Croton Aqueduct One site in Westchester

Notes:

NHL = National Historic Landmark
NRL = National Register Listed
NRE = National Register Eligible

Direct impacts to archaeological resources caused by the selected transit mode would be analyzed to determine whether they constitute an adverse effect in accordance with Section 106. If adverse effects result, mitigation would be developed by lead agencies in conjunction with the NYSHPO.

6.7 Hudson River Habitat Disturbance

The project area of the Hudson River is a productive estuary that provides regionally significant ecological values and functions for many species, including anadromous, estuarine, and certain marine species that are dependent on the river for spawning, feeding, and overwintering activities. The proposed Tappan Zee Bridge options are within a US Fish and Wildlife Service-designated Significant Habitat of the New York Bight Watershed and upriver from a New York State Significant Coastal Habitat (i.e., Piermont Marsh). These adjoining habitats are of regional importance based on the ecological values they provide to fish, invertebrates, birds, and wildlife. Striped bass, American shad, Atlantic tomcod, white perch, Atlantic sturgeon, bay anchovy, shortnose sturgeon, blue crab, several species of herring, bluefish, and peregrine falcons are among the important fauna in this reach of the Hudson River.

The river’s ecological resources are managed under a variety of federal programs, including the Clean Water Act, the Fish and Wildlife Coordination Act, the Magnuson-Stevens Fishery Conservation and Management Act, the Emergency Striped Bass Act, Executive Order 11990 (Protection of Wetlands), the Coastal Zone Management Act, and the Endangered Species Act. Relevant New York programs are based on the State’s Environmental Conservation Law and its implementing regulations and on the Waterfront Revitalization & Coastal Resources Act.

6.7.1 Description of Criterion

Impacts of the transit modes to Hudson River habitats are estimated in terms of the area of river bottom that would be impacted either permanently or for an interim period (during project construction). Loss of bottom habitat, as presented in this report, is a surrogate for a range of in-river effects that may occur as a result of developing a transit mode across the Hudson River, including sediment resuspension, acoustic emissions, shading and others. Thus, the comparisons provided here should be considered relative indicators of potential impacts and not absolute impact levels. In addition, no inference should be made as to whether the indicated loss of bottom habitat will ultimately prove significant from an ecological perspective, since the significance of the various effects associated with a transit crossing will not be established until the DEIS analysis is completed.

Thus, transit mode impacts on Hudson River resources are compared using the following two criteria:

- Permanent impacts (in acres) associated with the modified or new bridge foundations (for bridge rehabilitation or replacement).
- Temporary impacts (in acres) associated with such construction support features as platforms that provide access to in-river work sites or that support construction equipment. Temporary impacts may last for several years but would be removed once construction is completed and the impacted area is restored.

6.7.2 Comparison of Transit Modes

Comparative impacts of the transit modes on Hudson River resources are presented in Table 6-5. In terms of temporary impacts to the river bottom, modes that require a rail connection to Metro-North's Hudson Division potentially have a greater temporary impact since construction of the connection is likely to involve placement of a two acre work platform in the river to facilitate construction. This two-acre work platform is in addition to the four acres of temporary work platforms that all modes would require over the river to facilitate construction of a rehabilitated or new bridge.

Table 6-5

Hudson River Habitat Disturbance

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Hudson River Habitat Disturbance (acres of river bottom)	10-11 permanent 4 temporary	10-11 permanent 4 temporary	12-15 permanent 6 temporary	11-14 permanent 4 temporary	12- 15 permanent 6 temporary	12-15 permanent 6 temporary	12-15 permanent 6 temporary	12-15 permanent 6 temporary

Note: The transit modes can be accommodated on more than one bridge option.

With regard to long-term or permanent impacts to bottom habitats, a crossing that accommodates the BRT mode uses somewhat less of the river's bottom habitat, since its in-river foundations are less extensive than those needed for a commuter rail-capable crossing. The difference in potential impacts between BRT and CRT modes ranges from less than one acre (e.g., comparing 3B to 4A-X the difference in potential impacts can be approximately 0 acres depending on bridge option) to approximately 5 acres (e.g., comparing Option 3B to Alternative 4A, the difference in potential impact can be up to 5 acres depending on bridge option). Since actual construction methods and work locations are not known at this time, it is not possible to ascertain the significance of the bottom disturbances shown on Table 6-5.

6.8 Air Quality

Because the various transit alternatives/options would cause changes in travel patterns (i.e., volume, speed and mix) in the region, an evaluation of potential air-pollutant emissions effects on a mesoscale level was conducted. The analysis addresses direct operational effects. The mesoscale network considered included those counties where the roadway and transit network would be impacted by the proposed project, including Rockland, Westchester, Orange, and Bronx Counties in New York and Bergen County in New Jersey. The VMT within the network including the BRT component were used as the main inputs for the analysis. The VMT were forecasted by the BPM for the 2035 AM peak period (6 AM to 10 AM during a typical weekday).

The US Environmental Protection Agency (USEPA) has established National Ambient Air Quality Standards (NAAQS) for six contaminants, referred to as criteria pollutants (40 CFR 50). These are carbon monoxide (CO), nitrogen oxides (NO_x), ozone (O_3), particulate matter (PM_{10} and $PM_{2.5}$), lead (Pb), and sulfur dioxide (SO_2). Areas that meet the NAAQS are designated as being "in attainment." Areas where criteria pollutant levels exceed the NAAQS are designated as "nonattainment." O_3 nonattainment areas are further classified, based on the severity of the pollution problem, as marginal, moderate, serious, severe, or extreme. CO and PM_{10} nonattainment areas are classified as either moderate or serious. A maintenance area is an area that has been redesignated as an attainment area from a former nonattainment area. The current designations for the five counties considered in the mesoscale analysis are as follows:

Westchester, Bronx, and Bergen Counties:

- Moderate nonattainment area for the O_3 standard.
- Nonattainment area for the $PM_{2.5}$ standard.
- CO maintenance area.
- Attainment area for all other criteria pollutants.

Rockland and Orange Counties:

- Moderate nonattainment area for the O_3 standard.
- Nonattainment area for the $PM_{2.5}$ standard.
- Attainment area for all other criteria pollutants.

The 2035 mesoscale emissions analysis was performed for ozone precursors (NO_x and Volatile Organic Compounds [VOC]), PM (PM_{10} and $PM_{2.5}$) and CO. The NYSDOT-provided MOBILE6.2 emission factors based on roadway type and county were used for predicting emissions within New York State. The emission factors for Bergen County were assumed to be the same as those applicable for Westchester County.

Criteria pollutant emissions from LRT and CRT components were assumed to be negligible compared to motor vehicles within the network, particularly for those new trains that would be principally electric-powered. The BRT component merging into the highway mix was also taken into account.

6.8.1 Description of Criterion

The mesoscale effects of air emissions from each transit alternative/option are described through the determination of the net change as compared to the 2035 No Build condition. The net effects among these alternatives/options were evaluated through the net mesoscale increase or decrease in terms of tons of NO_x and VOC, PM (PM_{10} and $PM_{2.5}$) and CO emissions.

6.8.2 Comparison of Transit Modes

Table 6-6 summarizes the mesoscale changes in NO_x and VOC, PM (PM_{10} and $PM_{2.5}$) and CO emissions during a typical weekday AM peak period (i.e., 6 AM to 10 AM), as compared to the 2035 No Build condition, under each alternative/option. The predicted overall emissions reductions under each alternative/option are primarily due to slight improvements in highway traffic within the analyzed mesoscale network. The levels of reduction are comparable among the analyzed alternatives/options, with no discerning differences.

Table 6-6

Mesoscale Air Emissions

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Net Air Emissions Reduction (Tons) Compared to No Build, 2035 AM Peak Period in the Five-County Area								
CO	2.306	1.989	2.585	2.258	2.606	2.491	2.513	2.328
NOx	0.052	0.049	0.061	0.052	0.059	0.060	0.061	0.055
VOC	0.151	0.133	0.154	0.157	0.173	0.154	0.153	0.153
PM_{10}	0.004	0.004	0.005	0.004	0.005	0.005	0.005	0.005
$PM_{2.5}$	0.002	0.002	0.003	0.002	0.003	0.003	0.003	0.003

Notes:

Mesoscale emissions are those that occur on a sub-regional basis, in this case, the five counties of Westchester, Rockland, Orange, Bronx, and Bergen.

6.9 Energy/Greenhouse Gases

The United States depends almost entirely on petroleum to fuel its transportation sector, and transportation accounts for approximately 67 percent of all the petroleum consumed in the US (NYSDOT, *Draft Energy Analysis Guidelines for Project-Level Analysis*, November 2003). Therefore the conservation of energy is one of the planning concerns for a regionally significant transportation project such as the proposed action. Moreover, the level of greenhouse gas emissions is directly related to the level of energy consumption, since the majority of greenhouse-gas emissions result from fossil-fuel combustion. The greenhouse-gas emissions further contribute to global warming, which occurs from the emission into the upper atmosphere of carbon dioxide (CO_2) and other gases that trap heat and warm the earth. Therefore, for a regionally significant transportation project, a mesoscale analysis of potential effects on energy consumption and associated greenhouse-gas emissions is necessary.

The energy and greenhouse-gas estimates were conducted using the Urban Fuel Consumption Method based on NYSDOT's energy analysis guidance (December 2003). The BPM-predicted highway VMT along each roadway link was divided into various vehicle classes using the NYSDOT-defined county- and roadway-specific classification mix. In order to apply fuel type-specific CO_2 emission factors, the VMT associated with various vehicle classes were further divided into two fuel-powered categories: gasoline and diesel. For the transit component, the BPM-predicted net changes in transit VMT over the No Build condition were used to predict the net changes in transit-related energy and CO_2 levels under each studied alternative/option. The VMT reductions from the LRT and CRT alternatives/options were further divided into two power categories: electric and diesel. The associated energy components were calculated based on the energy rates published in *Conserving Energy and Preserving the Environment: the Role of Public Transportation* (July 2002), the report commissioned by the American Public Transportation Association (APTA). The calculated energy in British thermal unit (BTU) was further converted to equivalent diesel-fuel gallons. It was also assumed that BPM-predicted BRT VMT net changes are all diesel-related.

6.9.1 Description of Criterion

The mesoscale effects of energy consumption and greenhouse gas emissions from each transit alternative/option are described through the determination of the net change as compared to the 2035 No Build condition. The net effects among these alternatives/options were evaluated through the net mesoscale increase or decrease in terms of fuel gallons for energy consumption and tons of carbon emitted for greenhouse gases.

6.9.2 Comparison of Transit Modes

Table 6-7 summarizes the mesoscale changes in energy consumption and greenhouse-gas emissions during a typical weekday AM peak period (i.e., 6 AM to 10 AM) compared to the 2035 No Build condition under each alternative/option. The net effects among these alternatives/options were evaluated through the net mesoscale increase or decrease in terms of:

- Fuel (in gallons) for energy consumption.
- Total carbon (CO2) emissions (in tons) for greenhouse gases (which were calculated based on the change in energy consumption.

The predicted energy and greenhouse-gas emissions under the 2035 No Build condition are as follows:

- Gasoline: 891,747 gallons.
- Diesel: 112,820 gallons.
- Total fuel: 1,004,567 gallons.
- CO_2 emissions: 2,695 tons.

The net increase in diesel fuel consumption over the 2035 No Build condition is due to the increase in usage by the proposed transit systems. The net decrease in gasoline fuel consumption reflects the expected decrease in energy consumption as a result of Build highway traffic improvements. The overall combined energy consumption and associated greenhouse-gas emissions under each alternative/option were predicted to be lower than the No Build condition. Although the LRT mode would likely achieve the greatest energy savings and greenhouse-gas reductions, the benefit levels are comparable among the analyzed alternatives/options, with no discerning differences over the analyzed mesoscale network. For example, the greatest difference in benefit between two alternatives/options (Full-Corridor LRT and Option 3B) would reflect an approximate 0.4 percent change in 2035 No Build levels for both total fuel consumption (gallons) and CO_2 emissions (tons).

Table 6-7

Energy and Greenhouse Gases

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Net Energy Savings (Fuel Gallons) Compared to No Build, 2035 AM Peak Period in the Five-County Area								
Gasoline	22,417	21,108	24,994	22,373	25,215	24,591	25,598	23,059
Diesel[1]	-92	-723	-2,077	994	-737	-2,210	-3,479	2,783
Electric Equivalent Diesel[2]	n/a	n/a	-941	-323	-1,254	-693	-693	-1,541
Total Net Fuel Savings	22,325	20,385	21,976	23,044	23,224	21,688	21,426	24,301
Net Greenhouse-Gas Reduction (Tons) Compared to No Build, 2035 AM Peak Period in the Five-County Area								
CO_2	59	54	57	62	61	56	55	65

Notes:
1. The diesel fuel component includes contributions from highway vehicles and, where applicable, BRT and CRT diesel components.
2. Electric energy was equated to diesel fuel usage for the LRT and CRT electric component.

The five counties are Westchester, Rockland, Orange, Bronx, and Bergen.

6.10 Summary of Environmental Evaluation

An environmental evaluation of the transit modes was conducted using the criteria described above. Implications for the natural and built environment were considered and the results were tabulated for each environmental resource category considered.

For the majority of resource categories, modes that include CRT tend to have greater estimated impacts than modes that include only BRT. This is particularly the case where impacts were estimated by overlaying the transit development footprint on geo-referenced maps of environmental resources identified along the transit alignments. In such cases, the mode with the largest development footprint shows the greatest potential to impact resources. One exception to this is the potential for the Option 3B alignment to result in displacement of a relatively large residential structure along the corridor in Westchester County that would be avoided by other transit alignments.

A set of unique impacts potentially occurs for transit modes that involve a connection to the Metro-North Hudson Division at the Hudson River near Lyndhurst. These alignments would entail obtaining extensive underground easements, would potentially have impacts to several NHLs, and could create some temporary and permanent disturbance of Hudson River habitats. Should avoidance prove infeasible, extensive mitigation measures would need to be considered as components of these alignments.

With regard to air emissions within the five-county area that includes Rockland and Westchester Counties, only a minor difference was found among the transit modes, with modes that include CRT having a small advantage for all pollutants evaluated. Also, no significant difference was discerned among the transit alternatives/options in terms of their potential to reduce fuel consumption or to emit greenhouse gases.

BRT

LRT

CRT

7 Cost Evaluation

The cost evaluation criteria used in the evaluation of the transit modes are:

- Capital cost.
- Annual operating costs.
- Fare revenue.
- Net cost per passenger/passenger-mile.
- Travel-time benefits.

7.1 Capital Cost

A capital cost estimate was developed for each alternative/option and escalated to 2012 dollars. The estimates include the following three categories of costs:

- Cost of construction.
- Equipment costs.
- Allowances for other project costs (e.g. design, insurance, and construction management).

7.1.1 Description of Criterion

7.1.1.1 Construction Costs

This subchapter presents details of the capital costs for each of the alternatives/options. Details of the methodology used are as follows:

- The capital costs encompass all works across the full corridor extending from Suffern to Port Chester.

- The methodology used in the development of the cost estimates for each alternative/option was as follows:

  - Determine individual construction activities and related quantities from data sheets (300 scale drawings).

  - Combine construction activities into compound activities. For example, all activities required for a particular type of road construction would be considered a composite activity.

  - Develop unit rates corresponding to the combined construction activities. This would include forecasts of all material, labor and equipment costs, as well as factors to account for location, market escalation, contractors' or subcontractors' methods of determining prices, competitive bidding, and market conditions.

  - Schedule all compound activities. These activities have been ordered per Construction Specifications Institute (CSI) format, which organizes all tasks by trade.

  - Include mark-up for contractors' general conditions, insurance and overhead and profit.

  - Include mark-up cost for escalation, design and construction contingencies, insurance, general conditions, and soft costs such as design, permitting, construction management, program management and agency staff.

  - The capital costs were produced in 2007 dollars and escalated to 2012, the mid-point of construction, using a 4.5 percent yearly inflation rate.

- All options assume a replacement bridge (for cost estimating purposes).

- The capital cost estimates do not include allowances for:
  - ROW acquisition.
  - Third-party mitigation works.
  - Hazardous materials handling.

7.1.1.2 Vehicle Equipment Costs

The cost of vehicles for each alternative/option was estimated based on the fleet size required to provide the level of service shown in the service plans in Appendix A and, in the case of rail alternatives/options, the length of train needed, to adequately serve the ridership levels projected for that alternative/option. The level of service refers to the headways used, which is the time between buses or trains at any given point on a route.

To determine the number of buses needed in the BRT alternatives/options, as well as those buses planned to operate as part of the rail alternatives/options, the following steps were followed:

- Each bus route was evaluated in terms of its end-to-end run time at speeds appropriate to the roadways that would be used by the route. Speeds were adjusted for each route for peak-period operations (congested speeds) and off-peak operations (uncongested speeds).

- The end-to-end run times were then summed for both directions with an allowance for turn-around times, schedule slippage, and layover times, resulting in a cycle time – the total time it would take for a bus to return to a given point on its route after departing from that point. This was used to determine the number of buses that would be needed to achieve the desired headway on each route in the AM peak, midday, PM peak, and off-peak periods. For example, a route that takes two hours to cycle (the bus takes two hours to complete a round trip) and has a headway target of 30 minutes would require four buses to maintain that 30-minute headway.

- The number of buses needed was then estimated using the most demanding service period (usually the AM or PM peak) with an allowance for spares.

Depending on the peak link demand level, the type of bus required was then assigned, with a choice of standard 40-foot buses, express coach buses (for express routes only), articulated 60-foot standard buses, or articulated 60-foot BRT-specific buses. The unit cost for each bus type was based on published figures or recent experience in the New York Metropolitan area. The number of buses was then multiplied by the appropriate unit price to arrive at the fleet cost. This was done for each route of every alternative/option. Table 7-1 summarizes the vehicle equipment costs used.

Table 7-1

Vehicle Equipment Capital Costs

Vehicles	Cost 2012 $
BRT Vehicles	
Standard 40-foot Bus	$422,500
Express Coach Bus	$552,500
Articulated 60-foot Bus (Standard)	$780,000
Articulated 60-foot Bus (BRT-Specific)	$988,000
CRT Vehicles	
Diesel-Electric Locomotive	$4,587,700
Coach Car (gallery)	$1,977,300
Cab Car (gallery)	$2,284,100
LRT Vehicle	$2,730,000

In the case of rail alternatives/options, the same methodology as was used for estimating bus equipment was applied, but in the case of rail alternatives/options the basic unit being calculated was trains. Each train's capacity was adjusted by the number of cars in the train to provide adequate service to meet ridership needs. A minimum train consist of four coach cars was used for the CRT alternatives/options. The CRT alternatives/options were assumed to use trains consisting of conventional push-pull diesel-electric locomotives with coaches (gallery) and a cab car (gallery) – the end car used to remotely operate the train when the locomotive is on the trailing end of a train in push mode. As with the buses, the individual pieces of equipment were estimated based on recent experience, and the number of each type of vehicle was then multiplied by the appropriate unit price to arrive at a fleet cost. This included allowances for spares.

The LRT vehicles estimate varied from the CRT estimate only in that there is but one type of LRT vehicle – a self-propelled and -operated car. So the number of cars per train was multiplied by the number of trains needed to operate the planned service, and that was multiplied by a spare factor, the result of which was multiplied by the unit price of each LRT vehicle.

The number and cost of the respective vehicles were used to establish the vehicle and equipment costs presented below.

7.1.2 Comparison of Transit Modes

The capital cost estimate results for each alternative/option are summarized in Figures 7-1 and 7-2 as total and transit costs respectively. The total capital cost across all alternatives/options ranges from $8 billion to $22 billion, with the highest costs for those alternatives/options that include CRT ($16 billion to $22 billion) and the lowest for those alternatives/options that include only BRT ($8 billion to $10 billion). The estimated costs for the transit-only parts of the alternatives/options range from $1 billion to $2.5 billion for BRT, $9 billion to $15 billion for CRT, and $5 billion to $6 billion for LRT.

Overall, the estimated costs for BRT transit are notably less than the costs for LRT and significantly less than the costs for CRT. The primary differences in costs result from:

- The ability of the BRT system to utilize the HOV/HOT lanes included in the highway component of each alternative/option, particularly in Rockland County, which substantially reduces the transit cost for BRT.

- The ability of the BRT system to stay largely at-grade and within the existing highway infrastructure, which substantially reduces costs compared to CRT and LRT. For CRT and LRT, there are substantial sections that are not at-grade (either elevated or in tunnel), and these sections increase the estimated capital cost.

BRT Alternatives/Options

The estimated capital transit cost for BRT is $0.9 billion for Option 3A and $2.5 billion for Option 3B. Both options have the same cost in Rockland County ($263 million). This cost is primarily for stations and ramps, as the cost of the travel way for BRT in Rockland County (and on a possible replacement TZB) is not included in the transit cost estimate, as the BRT system will utilize the HOV/HOT lanes, the cost of which was included in the highway apportioning.

Across Westchester County, the estimated capital cost is $560 million for Option 3A to $2.2 billion for Option 3B. The higher cost for Option 3B results from the extensive use of viaducts to provide mostly elevated BRT along I-287, compared to generally at-grade BRT in Option 3A.

LRT Alternatives/Options

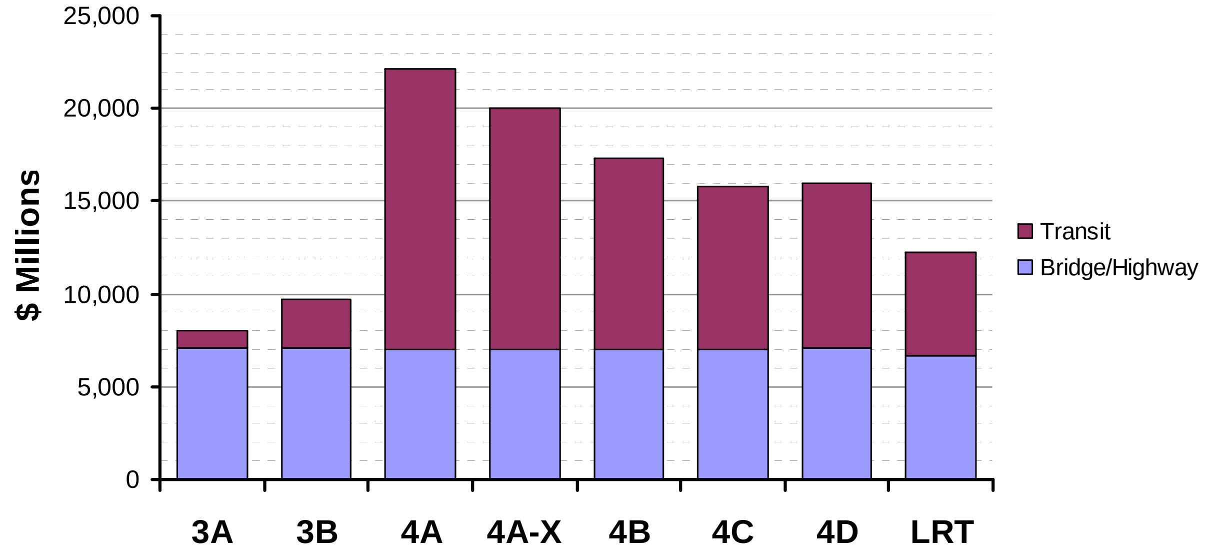
At $5.5 billion, the transit cost for full-corridor LRT is six times the cost of full-corridor BRT as presented in Option 3A ($0.9 billion). The larger costs are attributable to the more extensive requirement for elevated structures to pass over the constraints of the built environment, particularly in Westchester County. In Rockland County, the costs associated with a new travel way for LRT is the primary source of difference – travel way costs are not included in the BRT costs, as BRT can utilize the HOV/HOT lanes.

CRT Alternatives/Options

The estimated capital transit cost for CRT ranges from approximately $9 billion to $15 billion for alternatives/options 4A, 4A-X, 4B, 4C and 4D. In Alternative 4A, the alternative with the most extensive CRT, the cost to provide CRT is approximately $15 billion. In this alternative the costs for CRT in Rockland and Westchester Counties are approximately $4.5 billion and $7 billion, respectively. The larger costs in Westchester County result from more extensive tunneling and the cost of underground stations. The Hudson Line connection, at $1.5 billion, is a major cost component in this alternative and includes extensive tunneling in the approach to the Hudson Line as well as two-miles of modifications on the Hudson Line itself to merge the necessary trackwork within the existing ROW.

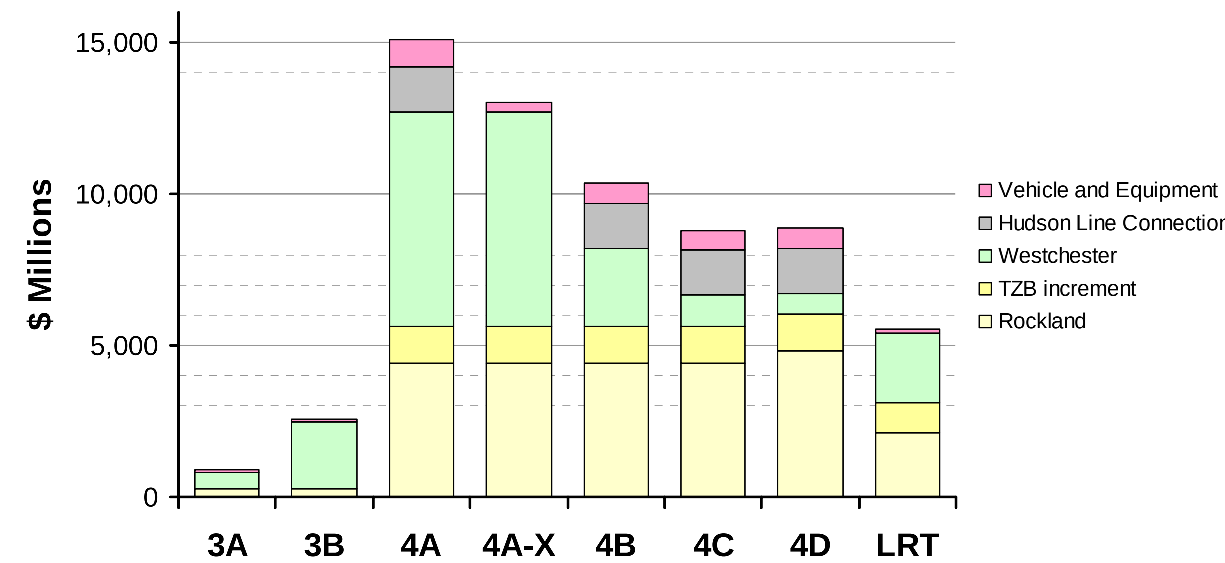
In Option 4A-X, which differs from Alternative 4A only by the exclusion of the Hudson Line connection, the overall capital transit cost estimate is approximately $13 billion. The $2 billion difference in cost between 4A and 4A-X is directly related to the cost of the Hudson Line connection, but there is also a reduction in the number of vehicles and equipment required.

In Alternative 4C, one of the alternatives with the least-extensive CRT system, the cost to provide CRT is $8.2 billion in an overall transit cost of $8.8 billion – the difference being the cost to realize BRT in Westchester County. Compared to Alternative 4A, the major cost difference in Alternative 4C is a substantial decrease in the cost of transit across Westchester County, where the transit mode is BRT instead of CRT. Option 4D is similar to Alternative 4C but with a reduction in the number of CRT stations and an increase in the extent of the BRT system across the full corridor. These changes result in a marginal increase in total transit cost ($8.9 billion) but a reduction in the cost of CRT ($7.9 billion).



	Capital Cost Estimate (millions) 2012 dollars							
	3A	**3B**	**4A**	**4A-X**	**4B**	**4C**	**4D**	**LRT**
Bridge/Highway	$7,130	$7,130	$6,980	$6,980	$6,980	$6,980	$7,130	$6,690
Transit	$897	$2,548	$15,111	$13,022	$10,372	$8,775	$8,869	$5,561
	$8,027	**$9,678**	**$22,091**	**$20,002**	**$17,352**	**$15,755**	**$15,999**	**$12,251**

Figure 7-1 Capital Cost Estimate



	Transit Capital Cost Estimate (millions) 2012 dollars							
	3A	**3B**	**4A**	**4A-X**	**4B**	**4C**	**4D**	**LRT**
Rockland	263	263	4410	4410	4410	4410	4830	2110
TZB increment	0	0	1220	1220	1220	1220	1220	1000
Westchester	560	2210	7080	7080	2560	1020	660	2295
Hudson Line Connection	0	0	1500	0	1500	1500	1500	0
Vehicle and Equipment	74	75	901	312	682	625	659	156
	$897	**$2,548**	**$15,111**	**$13,022**	**$10,372**	**$8,775**	**$8,869**	**$5,561**

Figure 7-2 Capital Cost Estimate – Transit Split

In Alternative 4B, the total cost for transit, at approximately $10.4 billion, is in the mid-range between the highest- and lowest-cost CRT alternatives/options, with cost differences primarily associated with transit modes in Westchester County. For alternatives 4A, 4B and 4C, with CRT, LRT and BRT modes in Westchester County respectively, the transit cost estimates are $7.0, $2.5, and $1.0 billion. LRT costs are substantially lower than CRT costs, as the greater flexibility in the LRT system capability eliminates the need for expensive tunnels and underground stations. However, extensive elevated lengths are required to cross existing infrastructure, making LRT more expensive than BRT.

All CRT options include an incremental cost ($1.2 billion) for the possible replacement Tappan Zee Bridge beyond that required for the highway components. Unlike in the BRT-only options, where BRT could be accommodated within the highway envelope on a possible replacement bridge, this is not possible for CRT, and additional width would be required to carry CRT.

7.2 Annual Operating Costs

Annual operating costs for the transit alternatives/options were projected based on the operating plan for each component of the alternative/option, with bus and rail costs estimated separately and then combined for the total operating cost. The measure used was the vehicle hours of operation. This measure was selected because of the ready availability of recent and directly relevant operating costs within the region for existing mature transit services. While no assumptions have been made about what agency might operate a given service, it is reasonable to assume that whatever agency operates the service it will have similar costs to those of the current operators of equivalent services.

Annual operating costs for highway and bridge operations were similarly based on the actual operating cost experience of highways and bridges in the region or the corridor itself. In either case, the observed costs of operations were used to develop the cost per lane mile.

All costs were escalated to 2012 using growth factors that reflect recent experience, with transit costs rising more rapidly in the near future and then leveling to the same growth rate as for highway and bridges.

7.2.1 Description of Criterion

7.2.1.1 Highway and Bridge Operations and Maintenance Costs

Highway operating and maintenance costs were calculated using the unit costs for highway operation and maintenance per lane mile for the New York Division of the NYSTA ($47,000/lane mile). These costs do not include State Police costs. They were applied to the existing lane miles and the lane miles in the alternatives/options, and inflated to 2012 dollars using an inflation rate of 4.5 percent.

The cost of maintaining the Tappan Zee Bridge in this year’s budget is $6 million. That cost per lane mile was applied to the new highway bridge, and those numbers were also inflated to 2012 dollars.

7.2.1.2 Operations and Maintenance Cost Estimates

The estimate of operating and maintenance costs was calculated using the same concepts as in the fleet cost estimates in order to determine the number of vehicles needed to provide the planned level of service.

For the calculation of the cost of operations and maintenance, the number of vehicles operating in each service period (AM peak, midday, PM peak, and nighttime) was multiplied by the hours in that period (4 hours in the AM and PM peaks and 5 hours in the midday and nighttime periods) to arrive at the total daily revenue vehicle hours of service. The daily hours of vehicle service were converted to annual figures using an annualization factor of 291. The annualization factor reflects full service each weekday and reduced service levels on weekends and holidays (which is why it is not 365).

The annual vehicle revenue hours of service were then multiplied by the cost per revenue hour based on the actual cost of operations per revenue hour for that type of vehicle for each transit provider. The costs per hour of operation were based on 2005 National Transit Database figures for MTA New York City Transit for express buses, Transport of Rockland, Clarkstown Mini-Trans and Westchester County Bee-Line System for bus operations in those locales, NJTransit for LRT operations, and Metro-North Railroad for CRT operations. Table 7-2 provides the 2005 cost per revenue vehicle hour.

Table 7-2

Cost per Revenue Vehicle Hour

Operation	Cost per Revenue Hour of Service (2005)
Bus Operations	
MTA New York City Transit	$139.72
Transport of Rockland	$118.72
Clarkstown Mini-Trans	$78.20
Westchester County Bee-Line System	$142.21
Rail Operations	
NJTransit Corporation Light Rail	$349.79
Metro-North Commuter Railroad	$480.58

The main trunk route in BRT was assumed to use articulated buses. The cost per hour of operation of articulated buses was increased by 25 percent over standard buses based on industry experience. In addition, for the portion of all BRT routes running in the BRT ROW, a factor of 1.1 was used to escalate per-hour costs. This is due to the higher operating speeds of BRT, which result in more miles traveled per hour of operation but lower fuel efficiency, and to the higher operating costs associated with fare collection and the operation of stations.

The 2005 CRT and LRT operating costs were escalated to 2007 levels, based on Metro-North data showing a 12 percent increase over those two years. BRT costs were escalated by 10.8 percent over that time[1]. From 2007 to 2012, a 4.5 percent inflation rate was assumed for all modes.

7.2.2 Comparison of Transit Modes

Table 7-3 provides the annual operating cost of each transit alternative/option. Alternative 4A has the highest transit annual operating cost – $347 million – followed by Option 4D and Alternative 4C, $309 and $306 million, respectively. The alternative/option with the lowest transit annual operating cost is Option 3A, at $75 million, followed closely by Option 3B and Full-Corridor LRT, each with an annual operating cost of $81 million.

[1] This represents a combination of 4.5% percent inflation for 2005-2006, and 6.1 percent for 2006-2007. In determining an inflation factor from 2006 to 2007, it was found that fuel costs rose 30 percent. Fuel costs made up 6 percent of the overall cost of bus operations. Using the same 4.5 percent inflation originally assumed for all non-fuel costs, this led to an overall inflation rate of 6.1 percent.

Table 7-3

Annual Operating Costs (2012)

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Transit Annual Operating Costs ($ Millions)	75	81	294	161	223	265	268	80
Bridge and Highway ($ Millions)	23	23	23	23	23	23	23	23

7.3 Fare Revenue

The revenue projections developed in this study, as well as the operating cost projections used, were intended solely to permit the comparison among alternatives/options. Before any alternative/option would advance into implementation, a complete operations and maintenance cost model would be developed, as would a more detailed analysis of the farebox potential for the chosen alternative/option. The recovery rates which the current estimates imply are not intended for, nor should they be used for, financial planning. They are unbiased and provide a reasonable basis to compare the alternatives/options, and that is their sole intent. The fare revenue estimate for each alternative/option used the existing fare levels escalated to 2012 for each service, and the appropriate fare based on the distance traveled for the CRT alternative/option and the boarding and alighting points for the LRT and BRT alternatives/options.

7.3.1 Description of Criterion

Fare revenue was calculated for each alternative/option based on the following assumptions:

- Fares used in the BPM analysis (BPM was 1996 dollars), which are assumed monthly pass costs per ride in 1996 dollars, were applied to 2035 forecast ridership for all new services.
- Fares for rail services were assumed to be 95 percent of fare to GCT for Manhattan-bound services, and 95 percent of fare to White Plains for cross-corridor services, to approximate the number of passengers taking shorter trips.
- AM Peak-period ridership was factored to daily ridership using a multiplier of 2.86.
- Daily ridership was factored to annual ridership using a multiplier of 291, reflecting weekday and weekend ridership.
- Revenues in 1996 dollars (BPM uses 1996 dollars) were inflated to current dollars using a factor of 1.33, based on the Consumer Price Index (CPI), then further inflated by 4.5 percent annually to 2012, so that dollars are comparable to cost dollars.

7.3.2 Comparison of Transit Modes

Annual fare revenues vary from $27 million to $127 million (Table 7-4), with those alternatives/options carrying more people on commuter rail generating the higher fare revenues. Rail alternatives/options with service to Manhattan vary from $98 million to $127 million. The option without the Hudson Line connection generates only $34 million, among the lowest. Bus-only alternatives/options and cross-corridor LRT generate less revenue from flat fares (i.e., fares that are not distance-based).

Table 7-4

Annual Fare Revenue*

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Fare Revenue ($ Millions)	40	39	105	34	98	113	127	27

Note:
* The revenue projections used in this study are intended solely to permit the comparison among alternatives/options, and are not intended to be used for financial planning purposes.

7.4 Cost/Net Cost Per Passenger and Passenger-Mile

7.4.1 Description of Criteria

Cost/net cost per passenger and net cost per passenger-mile are measures of the cost effectiveness of the alternatives/options. The value of such measures is that they combine the costs of the alternatives/options and their benefits, so that alternatives/options can be compared despite having significantly different costs or benefits. Another way of expressing the value of this type of measure is to say that it provides a way of assessing whether a particular investment provides sufficient return to warrant the investment. For public transit systems, these measures are roughly equivalent to the private market measures of Return on Investment (ROI) used to evaluate private-sector projects. Cost per passenger or passenger-mile does not factor in revenue. Net cost is the total 'subsidy' for the alternative/option, on a per-passenger or per-passenger-mile basis.

7.4.1.1 Cost and Net Cost Per Passenger

The cost or net cost per passenger has two inputs – the cost or net cost of the alternative/option and the total number of passengers (Table 7-5). The cost measure is the sum of the annualized capital costs and annual operating cost; net cost deducts the annual fare revenues. Annualized capital costs are calculated using a discount rate (7 percent) applied to the expected economic life of the facilities needed to create the alternative/option. It is analogous to an amortization rate, representing the annual level of investment needed to finance the alternative/option over its economic life. While transit systems are not privately financed, this allows comparison of alternatives/options having different economic lives to be equitably compared. For example, some alternatives/options have longer economic lives than do others. The economic life expectancy of buses is far shorter than trains, so over the life of a project the bus fleet may need to be entirely replaced once or even twice for every time the rail vehicles need to be replaced. The annualized capital cost measure accounts for this difference by reflecting such differences.

Table 7-5

Cost/Net Cost per Passenger and Passenger-Mile

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Cost per Passenger	$8.92	$17.03	$77.16	$103.23	$62.87	$46.68	$39.08	$43.51
Net Cost per Passenger	$6.39	$14.55	$71.36	$100.13	$56.52	$40.81	$33.66	$41.13
Cost per Passenger-Mile	$1.00	$1.77	$2.53	$5.52	$1.95	$1.73	$1.69	$2.54
Net Cost per Passenger-Mile	$0.72	$1.51	$2.34	$5.36	$1.75	$1.51	$1.45	$2.40

The annual ridership of each alternative/option is based on the daily ridership projected for that alternative/option expanded to an annual figure. The process of adjusting from daily to annual estimates uses an annualization factor that reflects how many days each year full service will be provided versus those days when less than full service will be provided. The days when less than full service is likely to be provided are holidays and weekends. The annualization factor weights those days and adds them to the full-service days to arrive at the equivalent factor to provide annual ridership. In the case of this project, the annualization factor used is 291, so daily ridership was multiplied by 291 to arrive at an annual ridership figure.

7.4.1.2 Cost and Net Cost Per Passenger-Mile

The cost/net cost per passenger-mile (Table 7-5) uses the same annualized capital cost as does the cost/net cost per passenger measure. However, annual passenger miles differ from passengers by reflecting the trip lengths projected for those passengers. This gives another measure that is useful in spotting the length of trips being served, so that longer trips are valued appropriately. Passenger-miles were determined by measuring passenger loads along the main transit corridor from Suffern to Port Chester.

The BPM outputs represent the AM-peak period (6-10 AM). A factor of 2.86 was used to derive daily passenger miles. A factor of 291 was then used to convert daily miles to annual miles. Annual costs/net costs were then divided by the total number of passenger-miles for each alternative/option.

The revenue/cost measure developed in this analysis is not a cost/benefit measure nor is it a cost/effectiveness measure. These figures were developed to enable comparison among multiple alternatives/options and are not intended for financial analyses. They are performance measures and not financial measures, since significant additional work will be needed for the selected alternative/option to develop reliable revenue and cost estimates. The FTA uses a cost/effectiveness measure that captures the benefits of alternatives/options using "transit system user benefits" – taking the number of hours of commute time saved and monetizing those savings, converting them to dollars. The measures presented in this section on costs/net costs do not purport to monetize those benefits and are, therefore, not comparable to the FTA measure.

7.4.2 Comparison of Transit Modes

Table 7-5 provides the cost/net cost per passenger and per passenger-mile for the alternatives/options. The lowest cost per passenger was achieved by BRT Options 3A and 3B. The highest cost per passenger was recorded by Option 4A-X, followed by Alternative 4A. Option 4A-X has the highest cost per passenger-mile, followed by Full-Corridor LRT. The lowest cost per passenger-mile was achieved by Option 3A.

Net costs range from roughly $6 per passenger to over $100 per passenger, and from less than $1 to over $5 per passenger-mile, with the bus-only alternatives/options having lower unit costs, and the option of full-corridor CRT without a connection to Manhattan having the highest unit cost.

7.5 Travel-Time Benefits

Travel-time benefits place a dollar value on the amount of time saved by commuters under each alternative/option compared to the No Build Alternative. These include direct benefits (time saved by transit users) and indirect benefits (time saved by non-transit commuters due to reduced congestion). The time saved by transit users is determined by direct comparison of travel times in the No Build and in each of the alternatives/options. Travel time saved by non-transit users is calculated as a multiplier, using federal guidelines. These are benefits that accrue to individuals, and are therefore not included in the net-cost calculation.

7.5.1 Description of Criterion

Travel-time benefits were derived by applying a value of time to the aggregate travel-time savings described above. Based on FTA guidance, the value of time was based on a 2007 wage of $12.00 per hour. FTA has established allowances of 100 percent for indirect benefits such as congestion relief and economic development, which leads to a value of time of $24.00 in 2007 dollars, and $29.90 in 2012 dollars (assuming an inflation rate of 4.5 percent per year). It should be noted that this estimate of travel-time benefits is not the same as the user benefits measure used by FTA in New Starts analysis.

7.5.2 Comparison of Transit Modes

Table 7-6 summarizes the travel-time savings of each alternative/option. Unlike some of the other measures, this measure varies by origin and destination. Each origin/destination pair would have different savings for each alternative/option. Therefore, there are three tables nested within the following table.

Table 7-6

Travel-Time Savings

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Aggregate Travel-Time Savings (Hours in the Peak Period (6-10 AM)	4,400	4,500	7,400	3,900	6,200	6,000	8,100	3,800
Annual Travel-Time Benefits ($ millions)	110	112	184	97	154	149	202	95

The benefits from most rail alternatives/options are greater than those from the bus-only or LRT alternatives/options, due to the longer trips taken at higher speeds compared to highway speeds. The exception is the variant without the connection to the Hudson Line, where trips to Manhattan are low.

7.6 Summary of Cost Evaluation

A summary of all the cost analyses is presented in Tables 7-7 and 7-8. The data have all been described above. The rail options have higher capital costs, which result in higher unit costs, but have advantages in travel-time savings and revenue generation. While total ridership is similar, the rail options attract more riders diverted from other modes, which removes vehicles from the roadways.

Table 7-7

Cost Criteria – Project Costs

Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Project Capital Cost ($ Millions)	8,027	9,678	22,091	20,002	17,352	15,755	15,999	12,251
Transit Capital Cost ($ Millions)	897	2,548	15,111	13,022	10,372	8,775	8,869	5,561
Project Capital Cost Annualized ($ Millions)	582	701	1,601	1,449	1,257	1,142	1,159	888
Transit Capital Cost Annualized ($ Millions)	65	185	1,095	944	752	636	643	403
Project Annual Operating Costs ($ Millions)	98	104	317	184	245	288	291	103
Transit Annual Operating Costs ($ Millions)	75	81	294	161	223	265	268	80
Project Annual Total Costs ($ Millions)	679	805	1,918	1,633	1,503	1,429	1,450	991
Transit Annual Total Costs ($ Millions)	140	266	1,389	1,105	974	901	911	483

Notes: Based on Year 2012 dollars. Project costs include transit, highway, and bridge costs. Cost estimate was prepared October 25, 2007. Note that value planning for all alternatives/options will be studied and developed in the future.

Table 7-8

Cost Criteria – Transit Costs

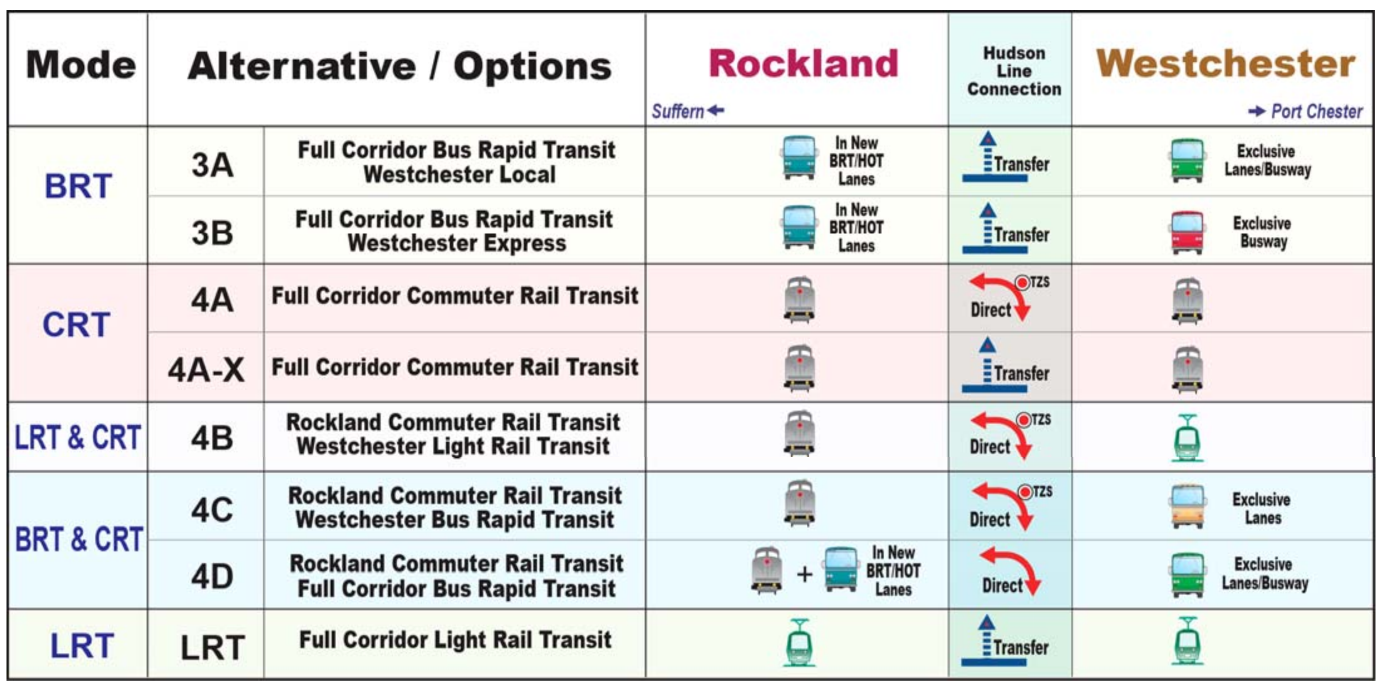
Criterion	Alternative/Option							
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full-Corridor BRT (3A)	Full-Corridor LRT
Annual Transit Costs ($ Millions)	140	266	1,389	1,105	974	901	911	483
Fare Revenue ($ Millions)	40	39	105	34	98	113	127	27
Net Annual Transit Costs ($ Millions)	100	227	1,284	1,071	876	788	784	456
Travel-Time Benefits ($ Millions)	110	112	184	97	154	149	202	95
Weekday Daily Ridership								
New	23,400	23,800	21,800	13,800	21,000	21,400	31,200	16,900
Diverted From Other Transit Routes	30,600	29,800	40,100	23,100	32,200	44,800	48,700	21,400
Total	54,000	53,600	61,900	36,900	53,200	66,200	79,900	38,300
Annual Passenger-Miles (Millions)								
In Corridor	100	90	190	80	160	176	207	90
On Existing Facilities Beyond Corridor	40	60	360	120	340	346	332	100
Total	140	150	550	200	500	522	539	190
Cost per Passenger	$8.92	$17.03	$77.16	$103.23	$62.87	$46.68	$39.08	$43.51
Net Cost per Passenger	$6.39	$14.55	$71.36	$100.13	$56.52	$40.81	$33.66	$41.13
Cost per Passenger-Mile	$1.00	$1.77	$2.53	$5.52	$1.95	$1.73	$1.69	$2.54
Net Cost per Passenger-Mile	$0.72	$1.51	$2.34	$5.36	$1.75	$1.51	$1.45	$2.40

Notes: Based on Year 2012 dollars. Net cost per passenger-mile is based on total passenger-miles.

8 Transit Mode Evaluation and Recommendation

The transportation, environmental, and cost analyses presented in Chapters 5, 6, and 7 evaluated the transit modes against a wide variety of criteria. In the course of those analyses, it was found that many of the criteria were not differentiators amongst the transit modes. Thus, the analysis presented here is focused on those measures of performance that distinguish among the modes. As a result, some measures, while important considerations, are not presented here because each of the alternatives/options performed in a nearly equivalent manner for those measures.

The data provided in this section, while identified by alternative/option, has been grouped into five modes or combinations of modes (Figure 8-1): BRT, CRT, combined LRT/CRT, combined BRT/CRT, and LRT. The evaluation focuses on the modes based on what has been learned about each of them from the alternatives/options developed for this corridor. In this way the selection of a preferred mode is not done in the abstract, but in the specific corridor in which it is to be carried forward. While this introduces variations, the availability of more than one alternative/option can provide a range of possible performance for the mode.



Mode	Alternative / Options		Rockland (Suffern ←)	Hudson Line Connection	Westchester (→ Port Chester)
BRT	3A	Full Corridor Bus Rapid Transit Westchester Local	In New BRT/HOT Lanes	Transfer	Exclusive Lanes/Busway
	3B	Full Corridor Bus Rapid Transit Westchester Express	In New BRT/HOT Lanes	Transfer	Exclusive Busway
CRT	4A	Full Corridor Commuter Rail Transit		TZS Direct	
	4A-X	Full Corridor Commuter Rail Transit		Transfer	
LRT & CRT	4B	Rockland Commuter Rail Transit Westchester Light Rail Transit		TZS Direct	
BRT & CRT	4C	Rockland Commuter Rail Transit Westchester Bus Rapid Transit		TZS Direct	Exclusive Lanes
	4D	Rockland Commuter Rail Transit Full Corridor Bus Rapid Transit	+ In New BRT/HOT Lanes	Direct	Exclusive Lanes/Busway
LRT	LRT	Full Corridor Light Rail Transit		Transfer	

Figure 8-1 Description of Alternatives/Options

8.1 Planning Context

Planning for this corridor has been underway for several years, and the complex conditions of the corridor have been subject to considerable analysis. It is a circumferential corridor around New York City, connecting New Jersey to Connecticut as a northern loop around New York City, with strong elements of radial movement both to Manhattan and crossing the corridor serving a variety of other movements:

- From Rockland and Orange Counties to the Bronx and Westchester County.
- From Westchester and Putnam Counties to Bergen and Passaic Counties in New Jersey.
- From Fairfield and New Haven Counties in Connecticut to counties west of the Hudson.

The radial movements have all been served by commuter rail services for several decades, and these services are well established. Those that are west of the Hudson have connected to Manhattan via Hoboken, and more recently, via Secaucus. The ARC tunnel will provide a direct connection to 34th Street on the West Side. East of the Hudson, the focus has been on Grand Central Terminal (GCT) at 42nd Street and Park Avenue. Express bus services also connect the corridor to Manhattan, focusing on the Port Authority Bus Terminal for routes west of the Hudson.

Cross corridor movements are now served by buses, operating in mixed traffic on I-287 and the parallel arterials (Routes 59, 119, and 120). With the introduction of HOV/HOT lanes on I-287, the opportunity exists to provide bus services with dependable speeds, better than existing highway speeds. The concept is extended beyond the HOV/HOT lanes by using dedicated lanes elsewhere in the corridor. These dedicated lanes can be incorporated into a number of bus routes that extend beyond the corridor to several destinations. The BRT routes can also connect with the radial commuter rail services at all crossing points.

The desire for CRT service in the corridor is based on several planning issues: there is an existing rail infrastructure that can be utilized to increase the usefulness of investments in new infrastructure, the potential development benefits of commuter rail are generally considered more desirable with the plans of corridor communities than LRT or BRT; and the perceived comfort level of CRT is superior to that of BRT or LRT. CRT, as defined in Alternative 4C and Option 4D, could be designed such that it would not preclude continuation across Westchester County to the New Haven Line as a future possibility. Finally, direct service to GCT for passengers originating west of the Hudson is attractive and complements the transit service to be provided by ARC by providing a one-seat ride to the east side of Manhattan. This offers more transit choices for Rockland and Orange County residents.

There has been an attempt to utilize the existing ROWs of I-287 for the alignment of all modes of transit, wherever possible, particularly within Rockland County, where it is more readily available. Both LRT and BRT also use roadway ROWs on other roads in the corridor. While these are publicly owned, they are currently used by traffic, and conversion to exclusive ROWs will have impacts.

The criteria examined below include transportation measures, environmental issues, and cost criteria. As discussed previously, the environmental criteria were not differentiators amongst modes.

8.2 Transportation Criteria

Transportation measures used in this evaluation included total daily transit ridership on the new service and travel-time benefits. The first measure – ridership on the new service – allows a comparison between the “local” transportation market and the Manhattan market.

8.2.1 Ridership on New Transit Services

Two major travel markets will be affected by the project: the east-west market confined largely to the corridor and the market of those commuting to or from Manhattan. There are other markets but these are the two largest. Figure 8-2 shows the number of riders on new services each mode could attract. There are differences among the modes, with the combined BRT/CRT mode estimated to attract more riders than either the CRT or the BRT modes separately. The differences between the BRT mode and the CRT mode were relatively slight with BRT edging out CRT. Finally, the LRT mode was projected to attract the fewest riders. The BRT modes attract largely cross-corridor riders, while the CRT modes, with connections to Manhattan, attract a significant number of Manhattan bound riders as well. The combined services in Option 4D attract large numbers in both markets.

Another measure of transit mode ridership performance on the new service relates to those commuting to Manhattan. These numbers (Figure 8-2) include many current transit users who could be expected to start using the new services and stop using the existing ones. This is likely because the new alternatives/options prove more convenient or faster than the existing ones for those commuters. Figure 8-2 shows that the differences among the modes on this measure were substantial.

The combined BRT/CRT mode would have the highest daily ridership, and the gap between it and the BRT mode would be much greater than it was for overall transit ridership. However, the gap between the combined BRT/CRT mode and the CRT mode would actually reduce. This indicates that far more current riders of transit services would be moving onto the combined BRT/CRT mode than would be the case for just the BRT mode, at least in part because some of the CRT mode provides better service to Manhattan. So for this measure, the CRT mode passed the BRT mode. Finally the LRT mode would be least effective for those headed to Manhattan.

8.2.2 Travel Time Benefits

Travel time benefits accrue when the new services take less time than the existing services. Services that are not subject to delays caused by traffic congestion save more time than those that operate in mixed traffic. As a result, all alternatives with rail service have greater time savings than those that are dependent on bus operations – even when the bus operates largely in dedicated ROWs. The combined BRT/CRT mode saves the most travel time. One of the criteria used to compare alternatives was the aggregate travel time for selected markets served by the corridor. Figure 8-3 shows the value of the aggregate travel time saved in these selected markets, in 2035, for the AM peak period. The results are indicative of an effective transit system serving the biggest markets: cross-corridor and Manhattan-bound service.

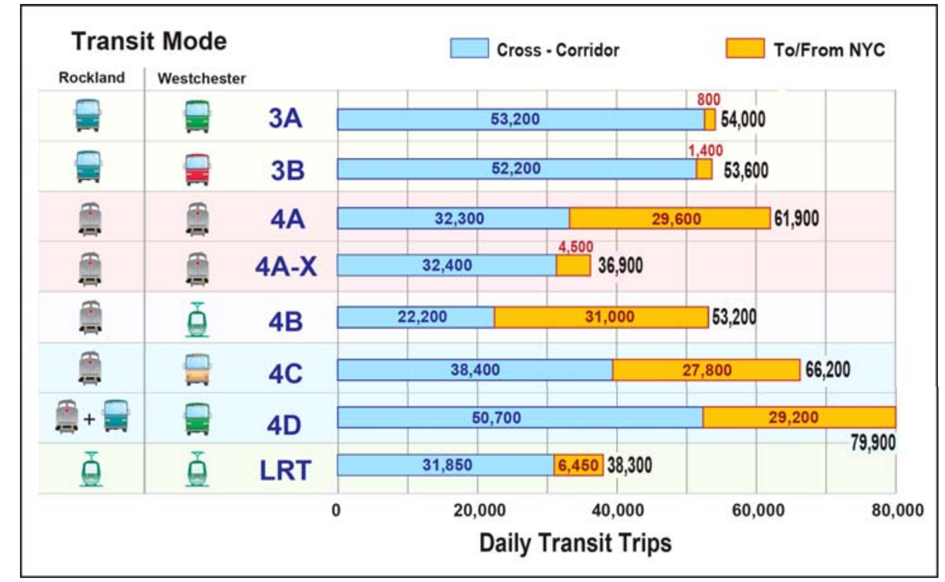


Figure 8-2 Ridership on New Transit Service (2035)

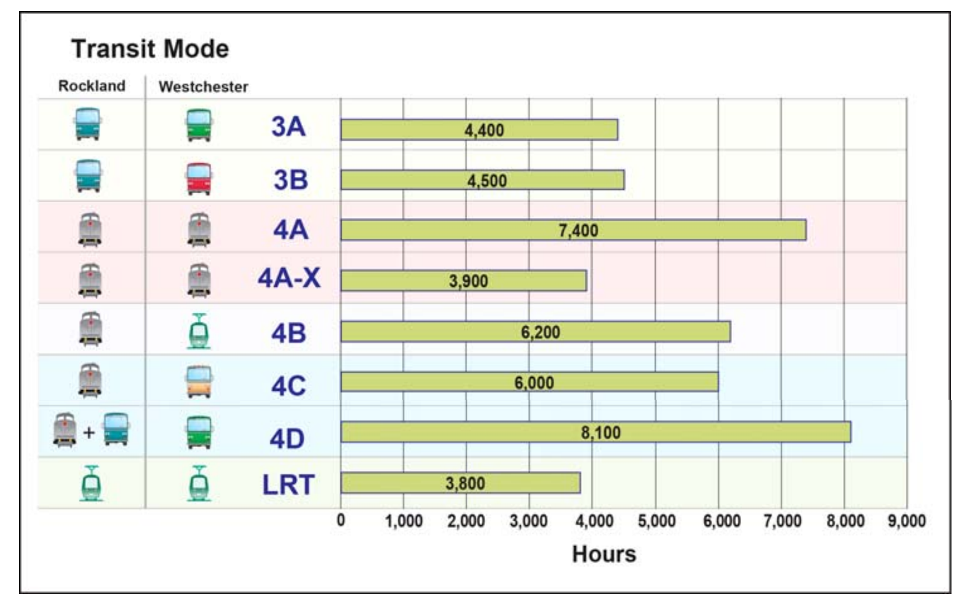


Figure 8-3 Travel Time Savings (AM Peak Period, 2035)

8.3 Environmental Criteria

With respect to environmental criteria, the modes were generally similar (Table 8-1), largely because of the commonality of alignments and because most construction in Rockland County occurs within existing Thruway right-of-way. In short, the differences over the 30-mile corridor were slight and unique to particular alternatives/options (i.e., they were not indicative of a mode's inherent characteristics). Thus, environmental criteria were not a differentiator in the transit mode recommendation.

Table 8-1

Potential Environmental Impacts/Benefits

Parameter	Impact or Benefit
Displacements	5 to 12 residential structures (Note: Option 3B had much higher number of residential units than other modes). 10 to 20 commercial properties.
Wetlands	8 to 14 acres - most of the directly impacted wetlands are drainage courses that parallel I-287 and collect water running off the interstate. Several of the modes also impact, to a limited degree, wetlands adjacent to tributaries of several rivers.
Parklands/4f	Elizabeth Street Park, Tibbits Park, Yosemite Park, Parkways that I-287 crosses.
Historic and Archaeological Resources	4 to 7 properties: • National Historic Landmarks (Old Croton Aqueduct, Lyndhurst, and Sunnyside) • National Register Listed (Palisades Interstate Parkway, Bronx River Parkway, Port Chester Station) • National Register Eligible (Tappan Zee Bridge and the Piermont RR ROW). Other properties recommended eligible but not yet evaluated could be affected.
Hudson River Habitat Disturbance	10 to 15 acres (permanent) due to new or modified bridge foundations. 4 to 6 acres (temporary) associated with temporary work platforms that would be erected in the river to facilitate construction work.
Fuel Savings (2035, AM peak period, five-county area)	Savings of about 20,500 to 23,500 gallons from the 1,000,000 gallons of fuel used in the No-Build condition.
Air Emissions Reductions (2035, AM peak period, five-county area)	Reductions from the No-Build condition of: • 2 to 2.7 tons CO • 0.13 to 0.17 tons VOCs • 0.049 to 0.061 tons NOx • 0.004 to 0.005 tons PM10 • 0.002 to 0.003 tons PM2.5

8.4 Cost Criteria

The cost factors used in this evaluation are capital cost, annual operating costs and fare revenues, and cost per passenger and passenger-mile.

8.4.1 Capital Costs

Capital costs range from $1 billion to $15 billion (constant 2012 dollars). Figure 8-4, which displays transit mode capital costs, shows that BRT would be the lowest cost mode (for estimating purposes, HOV/HOT lanes were common to the modal alternatives studied). The modes that would have to provide their own guideways are BRT in Westchester County, LRT, and CRT, with BRT and LRT requiring the least new guideway since ROWs could be shared with surface traffic in at least some areas. The combined BRT/CRT mode was the next least-expensive option, while the cross-corridor CRT would be the most expensive transit mode to build in the corridor.

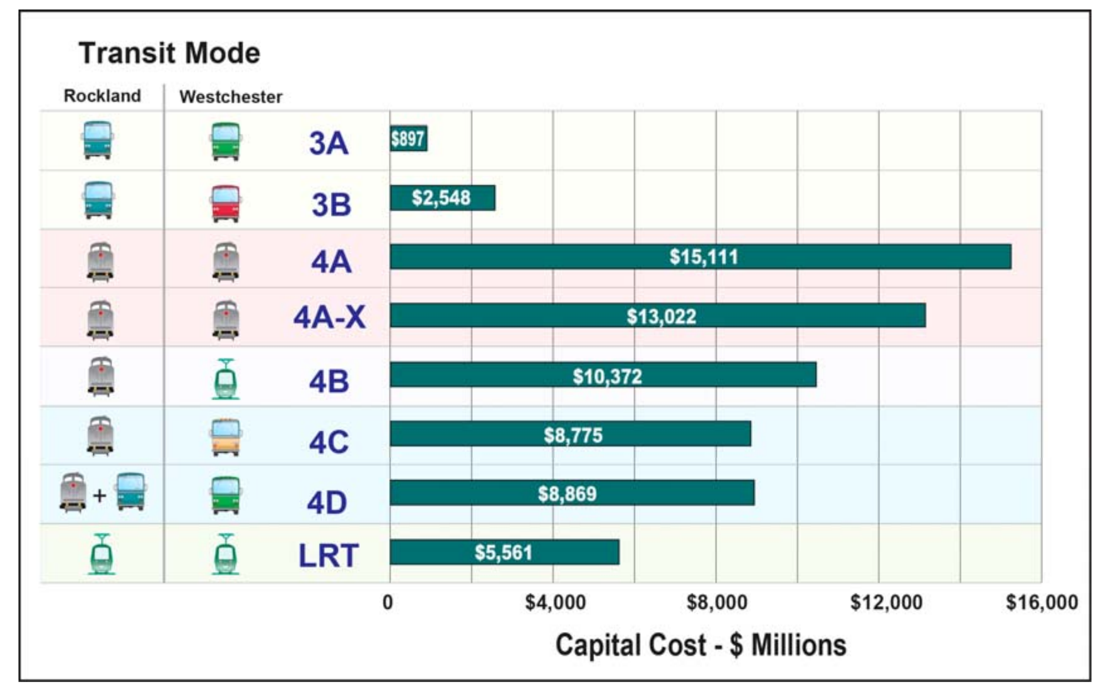


Figure 8-4 Capital Cost Estimate (year 2012 dollars)

8.4.2 Operating Costs and Fare Revenues

Figure 8-5 provides the projected annual operating cost for each of the alternatives/options. The CRT mode and the combined BRT/CRT mode are the alternatives/options that are most expensive to operate. LRT would have the next-lowest annual operating cost, while BRT is projected to be the least-expensive mode to operate.

Figure 8-5 also provides the projected fare revenue levels for the alternatives/options. In most cases, the more expensive modes garnered the higher revenues. The mode with the highest revenue potential is combined BRT/CRT, closely followed by CRT alone. BRT would generate far less revenue, followed by LRT. It should be noted that these figures are intended solely for comparative purposes, and are not intended for financial planning or analysis purposes.

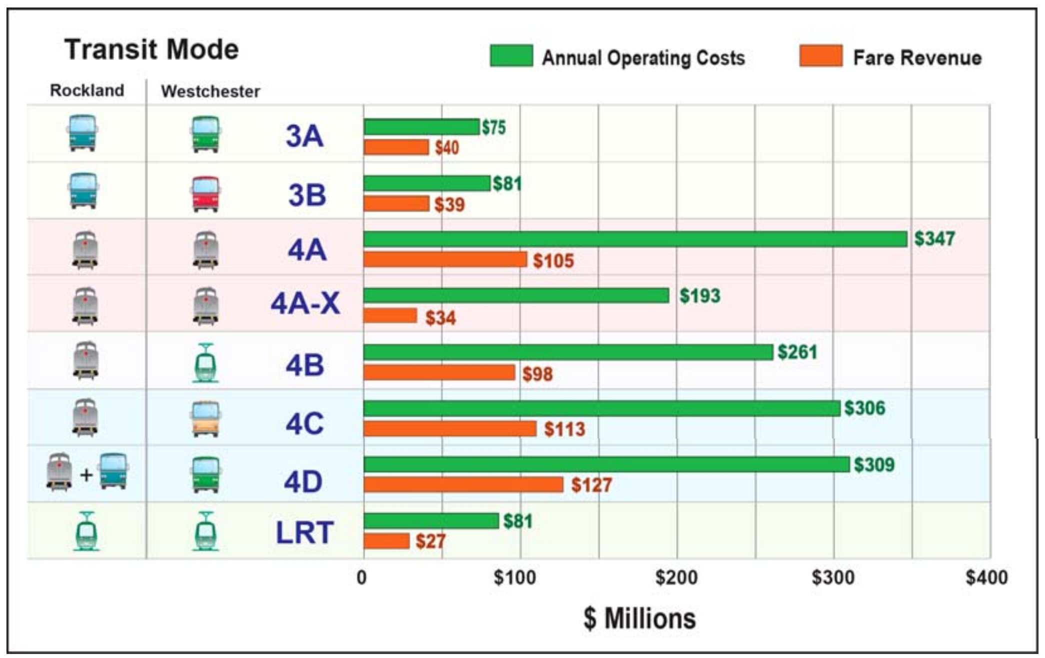


Figure 8-5 Transit Annual Operating Costs and Fare Revenues (2035)

8.4.3 Cost per Passenger and Passenger-Mile

Table 8-2 provides the cost/net cost per passenger and per passenger mile for the modes. As discussed in Chapter 7, for each pair, cost is the sum of the annualized capital costs and annual operating cost, while net cost deducts the annual fare revenues. The lowest cost per passenger was achieved by BRT. The highest cost per passenger was recorded by CRT. Option 4A-X has the highest cost per passenger mile, followed by full-corridor LRT. The lowest cost per passenger mile was achieved by BRT.

Net costs range from approximately $6 per passenger to over $100 per passenger, and from less than $1 to over $5 per passenger-mile, with the BRT options having lower unit costs, and Option 4A-X (cross-corridor rail without a direct connection to Manhattan) having the highest unit cost.

Table 8-2

Cost/Net Cost per Passenger and Passenger-Mile

	Mode by Alternative/Option							
	Criterion **BRT**		**CRT**		**LRT/CRT**	**BRT/CRT**		**LRT**
	3A Full-Corridor BRT Enhanced	**3B** Full-Corridor BRT, HOV/ HOT Lanes in Rockland, Busway in Westchester	**4A** Full-Corridor CRT with Hudson Line (HL) Connection	**4A-X** Full-Corridor CRT without HL Connection	**4B** CRT in Rockland, HL Connection, LRT in Westchester	**4C** CRT in Rockland, HL Connection, BRT in Westchester	**4D** CRT in Rockland, HL Connection, Full Corridor BRT (3A)	Full-Corridor LRT
Cost per Passenger	$8.92	$17.03	$77.16	$103.23	$62.87	$46.68	$39.08	$43.51
Net Cost per Passenger	$6.39	$14.55	$71.36	$100.13	$56.52	$40.81	$33.66	$41.13
Cost per Passenger-Mile	$1.00	$1.77	$2.53	$5.52	$1.95	$1.73	$1.69	$2.54
Net Cost per Passenger-Mile	$0.72	$1.51	$2.34	$5.36	$1.75	$1.51	$1.45	$2.40

8.5 Recommendation

The recommendation of a transit mode has been developed within the context of the goals adopted for this study in the Scoping Process:

- **Goal 1:** Improve the mobility and accessibility of people, goods and services for the travel markets served by the Tappan Zee Bridge/I-287 Corridor. *All modes improve personal mobility – to differing degrees.*

- **Goal 2:** Maximize the flexibility and adaptability of new transportation infrastructure to accommodate changing long-term travel demand. *BRT is the most flexible mode, preserving CRT options provides maximum ability to meet changing demand.*

- **Goal 3:** Maintain and preserve vital elements of the transportation infrastructure. *Utilization of existing infrastructure enhances its preservation (e.g., Hudson and Port Jervis Lines).*

- **Goal 4:** Improve the safety and security of the transportation system. *CRT is the safest mode, followed by LRT and BRT. It has been established that CRT is the safest surface transportation mode (Federal Transit Administration, Commuter Rail Safety Study, November 2006), by virtue of its minimal interaction with other surface transportation modes and pedestrians.*

- **Goal 5:** Avoid, minimize, and/or mitigate any significant adverse environmental impacts caused by corridor improvements. *Initial environmental analysis indicated that none of the modes has significant unmitigatable environmental impacts and that environmental factors are not differentiators among the modes. (A more detailed environmental impacts analysis will be performed in the EIS.)*

- **Goal 6**: Develop feasible, cost effective solutions that can be implemented within a reasonable time horizon. *Starting with BRT, while preserving the options for CRT, best meets this goal.*

Table 8-3 assigns a performance rating to each of the measures presented in the preceding analysis to arrive at an overall recommendation. The solid circles represent the highest-rated performers, while the three-quarters-hollow circles represent the lowest-rated performers. Ratings for quantitative measures were derived by applying the Quartiles method to the numerical results from the analysis. Ratings for the qualitative measures were derived by comparing the modes' performance to the elements within each goal.

The two major travel markets that will be affected by the project are the east-west market, confined largely to the study corridor, and the market of those commuting to or from Manhattan. The east-west market comprises inter-county and intra-county riders as well as cross-Hudson riders. With populations of Rockland and Orange Counties expected to grow at rates higher than the regional average, the corridor will benefit from having a mass transit system that serves these rapidly growing areas. The key characteristic of the cross corridor market is many trip origins coupled with many trip destinations – "many to many." Serving population and employment spread out within these counties can best be accomplished by adopting a flexible mode such as a BRT to serve areas that are not in the immediate proximity of a trunk route, while providing a high level of service typical of such modes. BRT best serves these circumferential movements, as it has the flexibility to reach destinations on and off the corridor.

The other market that has potential in terms of attracting workers from areas served by the proposed transit system is Manhattan. The key characteristic of the Manhattan market is many trip origins with one destination – "many to one." Given the large potential demand for travel to Manhattan, the already strained highway network and the existing transit infrastructure, along the Port Jervis Line and the Hudson Line into Manhattan, CRT would serve this market well. CRT functions best when it uses existing infrastructure to reach Manhattan destinations. The combined BRT/CRT mode takes advantage of both, resulting in the highest forecasted daily transit trips of 79,900.

Table 8-3

Summary Performance Ratings

Mode	BRT		CRT		LRT & CRT	BRT & CRT		LRT
Alternative/Option No.	3A	3B	4A	4A-X	4B	4C	4D	Full LRT
Goal 1: *Improve Mobility*	◕	◕	●	◔	◑	◕	●	◑
Goal 2: *Flexibility and Adaptability*	●	●	◕	◔	◑	◕	●	◑
Goal 3: *Vital Elements of the Transportation Infrastructure*	◕	◕	●	◑	◑	◕	◕	◑
Goal 4: *Improve Safety and Security*	◑	◑	●	◑	◑	●	●	◑
Goal 5: *Environmental Impacts*	◕	◕	◑	◑	◑	◕	◕	◑
Goal 6: *Feasible Cost - effective Alternatives*	●	◕	◑	◔	◑	◕	◕	◔
Daily Transit Trips for Selected Markets	◑	◑	◑	◑	◑	◑	◕	◑
Daily Transit Ridership on New Service	◑	◑	◕	◔	◑	◕	◕	◔
Capital Cost Estimate	●	◕	◔	◔	◔	◑	◑	◕
Cost/Passenger Mile	●	◕	◑	◔	◔	◑	◕	◔
Aggregate travel-time savings	◑	◑	◕	◔	◕	◕	●	◔

Legend *Very Good* ● *Good* ◕ *Fair* ◑ *Poor* ◔

The transit mode selection analysis, therefore, concludes that the BRT mode offers the best opportunity to improve transit service and ridership in the corridor at the lowest cost. However, implementing the combined BRT/CRT mode offers further significant benefits for the reasons outlined above. Both the CRT and BRT modes were less effective alone than when complemented by each other, as is evidenced by the transit ridership projections. The LRT mode did not provide sufficient benefits to warrant further consideration for either of the two major markets.

Therefore, full-corridor BRT in combination with CRT from Suffern connected to the Hudson Line is the recommended transit mode because that combination best meets present and future travel demand and mobility needs. The combined BRT/CRT mode provides the most flexibility to accommodate many markets, especially the key cross-corridor and NYC travel markets. The BRT/CRT recommendation is the transit solution that will fulfill the goals of this study by:

- Meeting corridor travel demand needs.
- Minimizing environmental impacts.
- Contributing to sustainable transportation and land use.
- Providing a flexible and adaptable transportation system with excess capacity to meet changing needs in the corridor.
- Enhancing quality of life in a energy and cost effective manner.

8.6 Transit Components to be Studied in the DEIS

Full-corridor BRT from Suffern to Port Chester and CRT from Orange/Rockland County to GCT will be studied in the DEIS as a Tier 1 analysis. As described in Chapter 1, the study will be performed at a planning level of detail, providing transportation and environmental analyses appropriate to a planning study and related decisions regarding transit mode(s), transit alignments, and logical termini. While proposed station locations are identified in this report, and will be analyzed at a planning level in the DEIS, it is important to note that these will form the basis for a corridor-level decision and, together with supportive infrastructure, will be subject to further studies as part of the future Tier 2 transit analysis.

While a busway in Rockland and Westchester Counties was not originally included in the preliminary DEIS alternatives that were the output of the Alternatives Analysis Report (January 2006), for several reasons the Project Sponsors decided that elements of a busway should be carried into the DEIS for a complete assessment of the range of BRT travel ways. This decision resulted from input that was received at the BRT Workshop conducted by the Project Sponsors in September 2007 and comments received from the public as described in Subchapter 2.4.

The DEIS analysis will include a range of reasonable alternatives likely to include the following components:

- **Bus Rapid Transit**
  - BRT/HOV/HOT Lanes in I-287 median, from Suffern and across the Tappan Zee Bridge.
  - BRT in a busway in I-287 ROW in Rockland with options of using north side, south side, or the median.
  - BRT integrated in existing street system in Westchester.
  - BRT in a busway in Westchester.
- **Commuter Rail Transit**
  - CRT in I-287 median; from Suffern and across the Tappan Zee Bridge, connecting to the Hudson Line.
  - CRT on south side I 287 ROW; from Suffern and across the Tappan Zee Bridge, connecting to the Hudson Line.

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www.tzbsite.com

BRT

LRT

CRT

Appendix A

BPM Model Inputs

A BPM Model Inputs

A.1 BRT Service Plans

Service plans have been developed for the BRT alternatives/options crossing the entire corridor (3, 3A, and 3B), as well as one that concentrates on Westchester County (4C). Station locations by alternative/option and route are shown in Tables A-1 and A-2. All three service plans are presented in Table A-3 and are illustrated on Figures A-1, A-2 and A-3.

Table A-1

BRT Stations by Alternative/Option

Station	**3** Full Corridor BRT	**3A** Full Corridor BRT Enhanced	**3B** Full Corridor BRT Busway in Westchester
Rockland			
Suffern NJ Transit Station	✓	✓	✓
Airmont Road	✓	✓	✓
Monsey/Route 59		✓	✓
Interchange 14	✓	✓	✓
Palisades Mall	✓	✓	✓
Nyack Interchange 11		✓	✓
Westchester			
Tarrytown Metro-North Station	✓	✓	✓
Broadway		✓	✓
Meadow Street	✓	✓	
Benedict Avenue	✓	✓	✓
Elmsford West	✓	✓	✓
Elmsford East	✓	✓	✓
Hillside Avenue		✓	✓
Westchester County Center	✓	✓	
White Plains Transportation Center	✓	✓	✓
Galleria Mall	✓	✓	✓
Westchester Mall	✓	✓	✓
White Plains Avenue		✓	✓
Platinum Mile (Corporate Park Dr.)	✓	✓	✓
Westchester Avenue	✓	✓	✓
South Ridge Street		✓	✓
Boston Post Road		✓	✓
Port Chester Metro-North Station	✓	✓	✓

The service plans include routes, frequencies, fares, stop locations and termini. This permits the coding of the complete route into the Best Practice Model (BPM). Travel speeds on the busways are determined by analysis of the design characteristics of the busway. Bus travel speeds in general traffic are determined by BPM based on the street functional class and the area that the street is located in. Transfers are possible wherever the coded stops coincide with the stops of other routes, and all potential connecting routes have been modified to assure that possibility. Timed connections, where schedules are meshed so that both services arrive at the stop simultaneously, cannot be coded in BPM, so waiting times equivalent to half the headway of the second bus are assumed. In a few cases, jitney service was assumed, connecting the BRT station to surrounding office parks and educational institutions with frequent service using smaller vehicles – particularly in the Platinum Mile in Harrison and along Route 119 in Tarrytown.

The service plans are an iterative process – first a service is planned, then the model results are analyzed, then the service is modified to optimize the effectiveness of the equipment and routings. Options 3A and 3B are largely iterations of Alternative 3. Further iterations are possible after physical improvements and optimization levels are agreed to.

A.1.1 Alternative 3

Routes A-P were developed in Alternative 3, and include several existing express bus routes: Tappan Zee Express, Orange Westchester Link (OWL) and I-bus as well as BeeLine routes 3, 11, 21 62 and 77. Some of these routes were modified to take advantage of the busway and exclusive bus facilities of the BRT system within the corridor. No changes were made to facilities or services outside the corridor. Additional routes were added to connect residential communities (Mt. Ivy, New City, Haverstraw, Croton, and Yorktown) and employment opportunities (Bergen County, Beverly, Yonkers, and, to some extent, the Bronx), in an attempt to connect the corridor to the opportunities around it. In general, peak period services were on half-hour headways, except where activity was anticipated that required more frequent service. This was based on an understanding of suburban commuter bus service that operates on a schedule, where riders leave their homes to arrive at the bus stop/station to meet that schedule. This differs from urban bus routes that operate at a greater frequency.

A.1.2 Options 3A and 3B

Route T is the new trunk bus route in Options 3A and 3B that did not appear in Alternative 3. The new trunk route is intended to operate more like an urban line-haul route. It covers the entire corridor from Suffern to Port Chester, connecting the NJ Transit Port Jervis Line Suffern Station to the Port Chester Metro-North New Haven Line Station and serving the Metro-North Harlem Line White Plains Station as well. A connection is provided to the Tarrytown Metro-North Hudson Line Station. Service is provided to all stations within the corridor, in both directions, on five-minute headways throughout the four hour peak periods in the morning and evening. Service on ten-minute headways covers the rest of the day. It would be supplemented by the other routes during peak periods, and fed by those routes during midday operations. It is envisioned as the "branded" BRT route, with distinctive buses and markings.

The fully grade-separated BRT in Option 3B does not have access to Meadow Street because it is adjacent to I-287 and the Talleyrand Swamp. It also does not have a stop at the Westchester County Center, as the busway is east of the Bronx River Parkway. Other than that, it has the same station locations and service levels as Option 3A, with the exception of Route B, the route that bypasses downtown White Plains to connect Rockland County to the Platinum Mile and Connecticut. It has increased frequency taking advantage of the busway bypass route. Trunk Route T will go directly to the White Plains Transportation Center (WPTC), then cross White Plains on dedicated lanes before returning to the busway at White Plains Ave.

Table A-2

BRT Stations by Route- Options 3, 3A and 3B

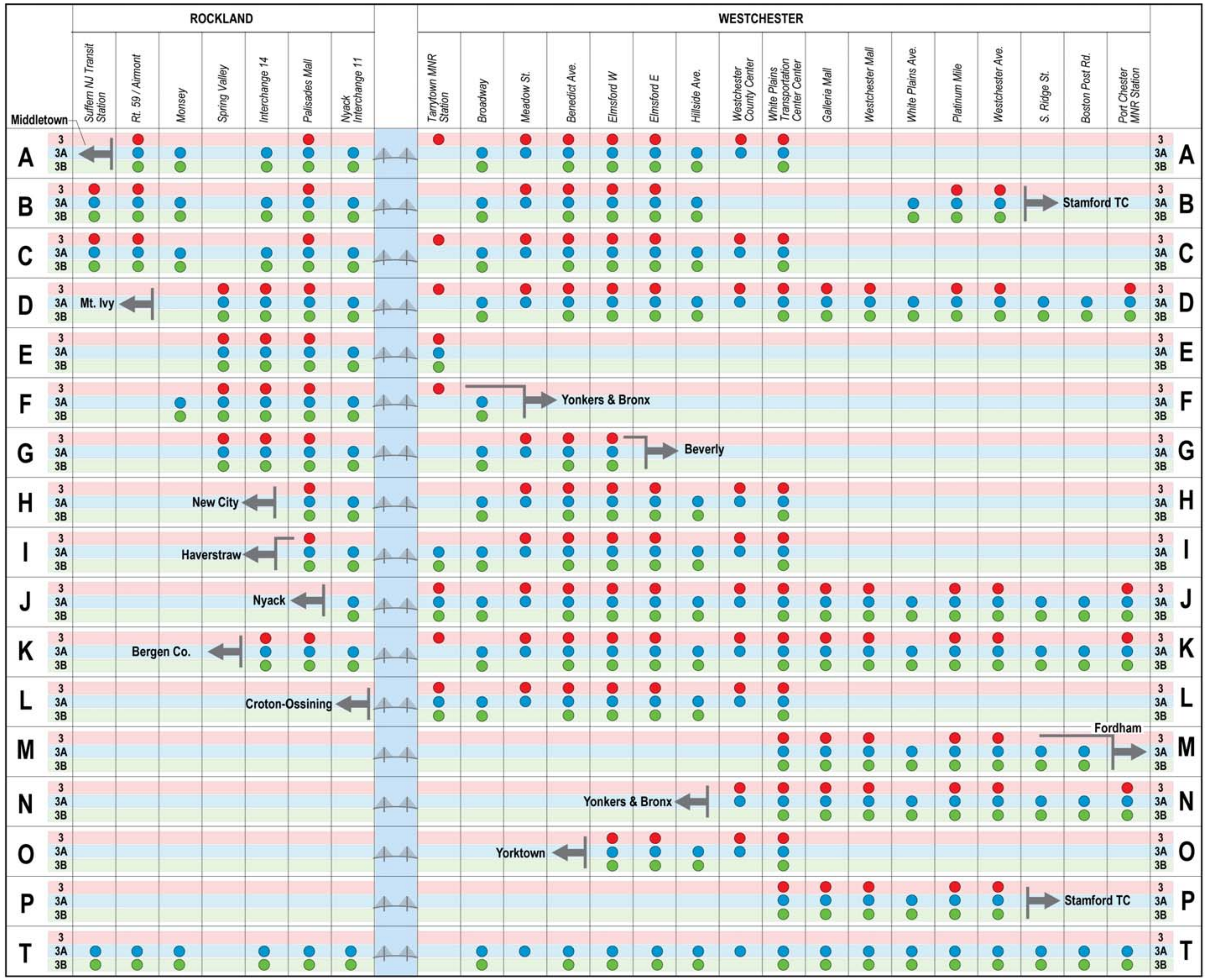


Table A-3

Alternative 3 Service Plans

BRT Route	Fare (1996 dollars)	Currently	Description	Enter Busway	Terminus	Option 3 Headway		Option 3A Headway		Option 3B Headway		Option 3 Frequency		Option 3A Frequency		Option 3B Frequency	
						Peak	Off Peak	Peak	Off Peak*	Peak	Off Peak*	Peak	Off Peak	Peak	Off Peak	Peak	Off Peak
A	2.85	OWL	Middletown-White Plains	Airmont	WPTC	30	60	30	60	30	60	2	1	2	1	2	1
B *	2.00		Suffern-Stamford – Bypass White Plains	Suffern	Stamford TC	15	20	30	60	10	30	4	3	2	1	6	2
C	1.25	TZExpress	Suffern-White Plains	Suffern	WPTC	30	x	30	x	30	x	2	x	2	x	2	x
D	1.50		Mt Ivy-Spring Valley-Port Chester	Int 14	Port Chester	20	60	20	60	20	60	3	1	3	1	3	1
E	1.25	TZExpress	Spring Valley-Tarrytown	Int 14	Tarrytown Station	20	x	20	x	20	x	3	x	3	x	3	x
F*	1.50		Spring Valley-Bronx via Rt. 9	Int 14	Bronx subway	30	60	30	60	30	60	2	1	2	1	2	1
G	1.50		Spring Valley to Route 9A	Int 14	Rt 9A and Beverly	30	60	30	60	30	60	2	1	2	1	2	1
H	1.25		New City-White Plains	Palisades Mall	WPTC	20	60	20	60	20	60	3	1	3	1	3	1
I	1.25		Haverstraw-White Plains	Palisades Mall	WPTC	30	60	30	60	30	60	2	1	2	1	2	1
J	1.50		Nyack-Port Chester	Int 11	Port Chester	30	60	30	60	30	60	2	1	2	1	2	1

Note: * = Routes operate at peak headways in both directions.

Table A-3 (con't)

Alternative 3 Service Plans

BRT Route	Fare (1996 dollars)	Currently	Description	Enter Busway	Terminus	Option 3 Headway		Option 3A Headway		Option 3B Headway		Option 3 Frequency		Option 3A Frequency		Option 3B Frequency	
						Peak	Off Peak	Peak	Off Peak*	Peak	Off Peak*	Peak	Off Peak	Peak	Off Peak	Peak	Off Peak
K	2.00		Bergen County-Port Chester via GSP	Int 14	Port Chester	30	60	30	60	30	60	2	1	2	1	2	1
L	1.30	BeeLine 11	Croton-Ossining-White Plains via Rt. 9	Route 119	WPTC	60	x	60	x	60	x	1	x	1	x	1	X
M	1.30	BeeLine 62	Fordham-New Rochelle-White Plains via I-95 and I-287	Westchester Ave	WPTC	30	60	30	60	30	60	2	1	2	1	2	1
N	1.30	BeeLine 3 and BeeLine 21	Yonkers-Port Chester via Central	Route 119	Port Chester	30	60	30	60	30	60	2	1	2	1	2	1
O	1.30	BeeLine 77	Yorktown-White Plains via Taconic	Sprain Brook Parkway	WPTC	30	60	30	60	30	60	2	1	2	1	2	1
P*	1.30	I-Bus	Stamford-White Plains	Westchester Ave	WPTC	15	30	15	30	15	30	4	2	4	2	4	2
T*	1.50	Trunk Route	Suffern-Port Chester	Suffern	Port Chester	N/A	N/A	5	10	5	10	N/A	N/A	12	6	12	6

Note: * = Routes operate at peak headways in both directions.

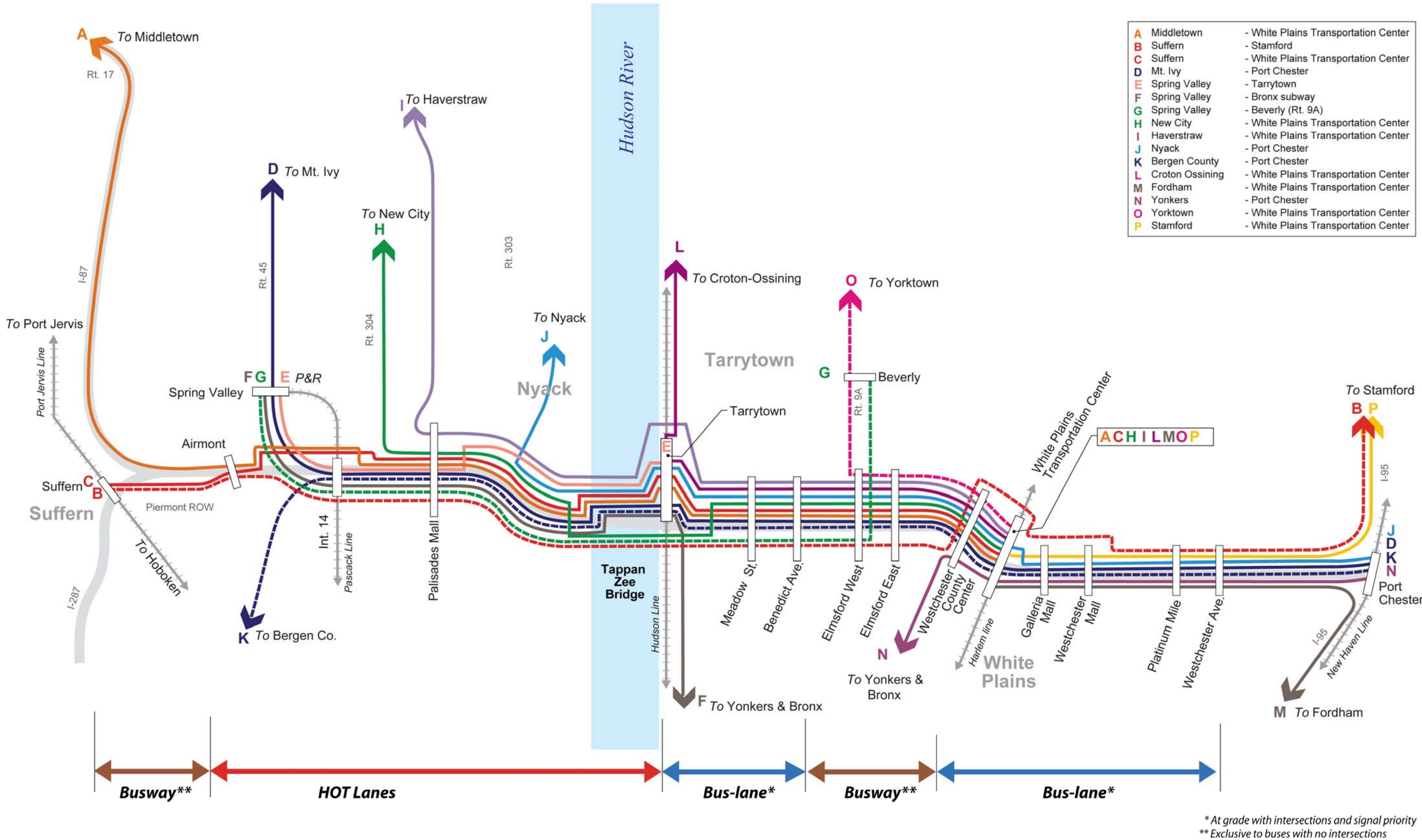
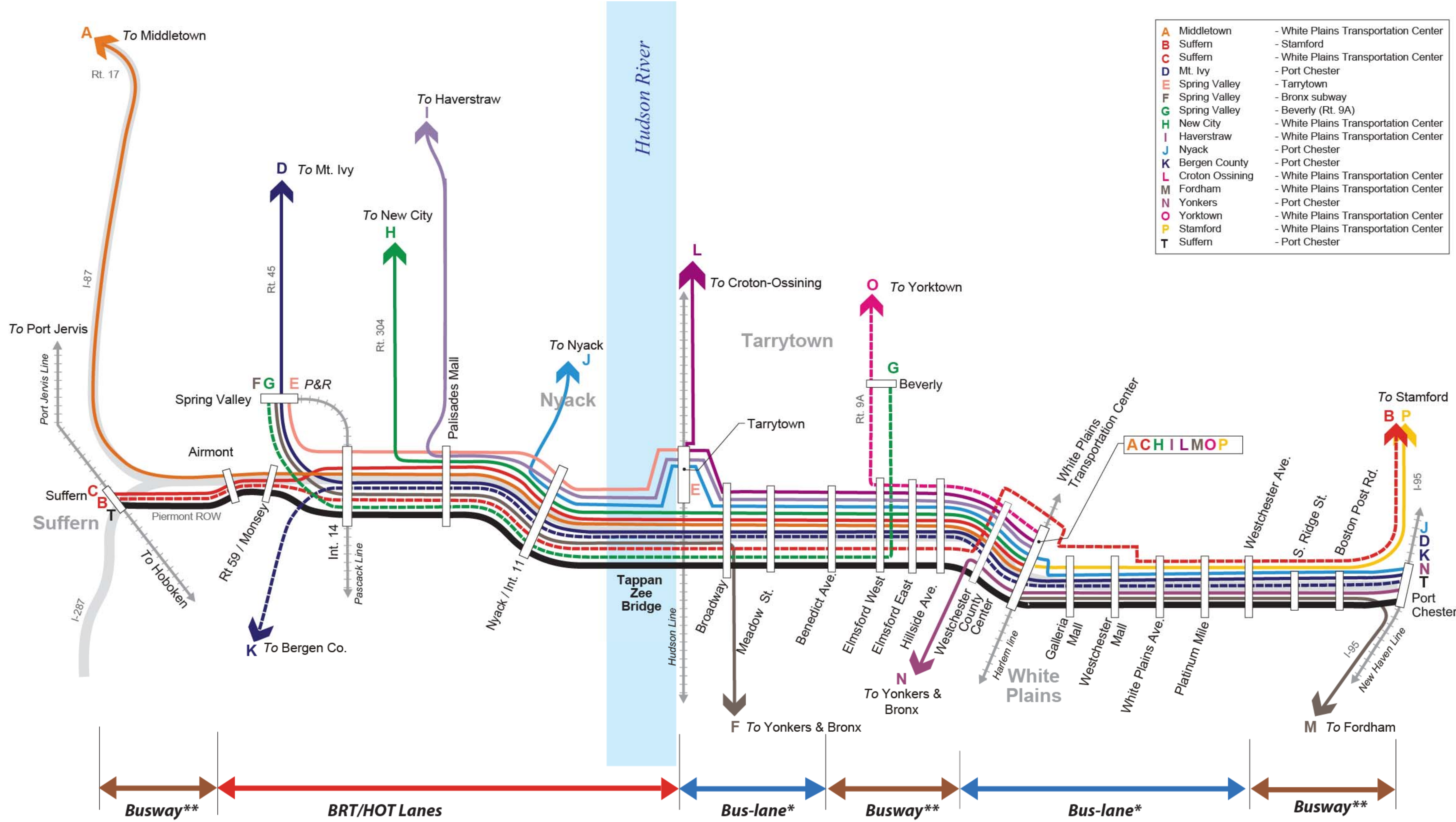


Figure A-1 Alternative 3 Bus Rapid Transit Service Plan



* At grade with intersections and signal priority
** Exclusive to buses with no intersections

Figure A-2 Option 3A Bus Rapid Transit Service Plan

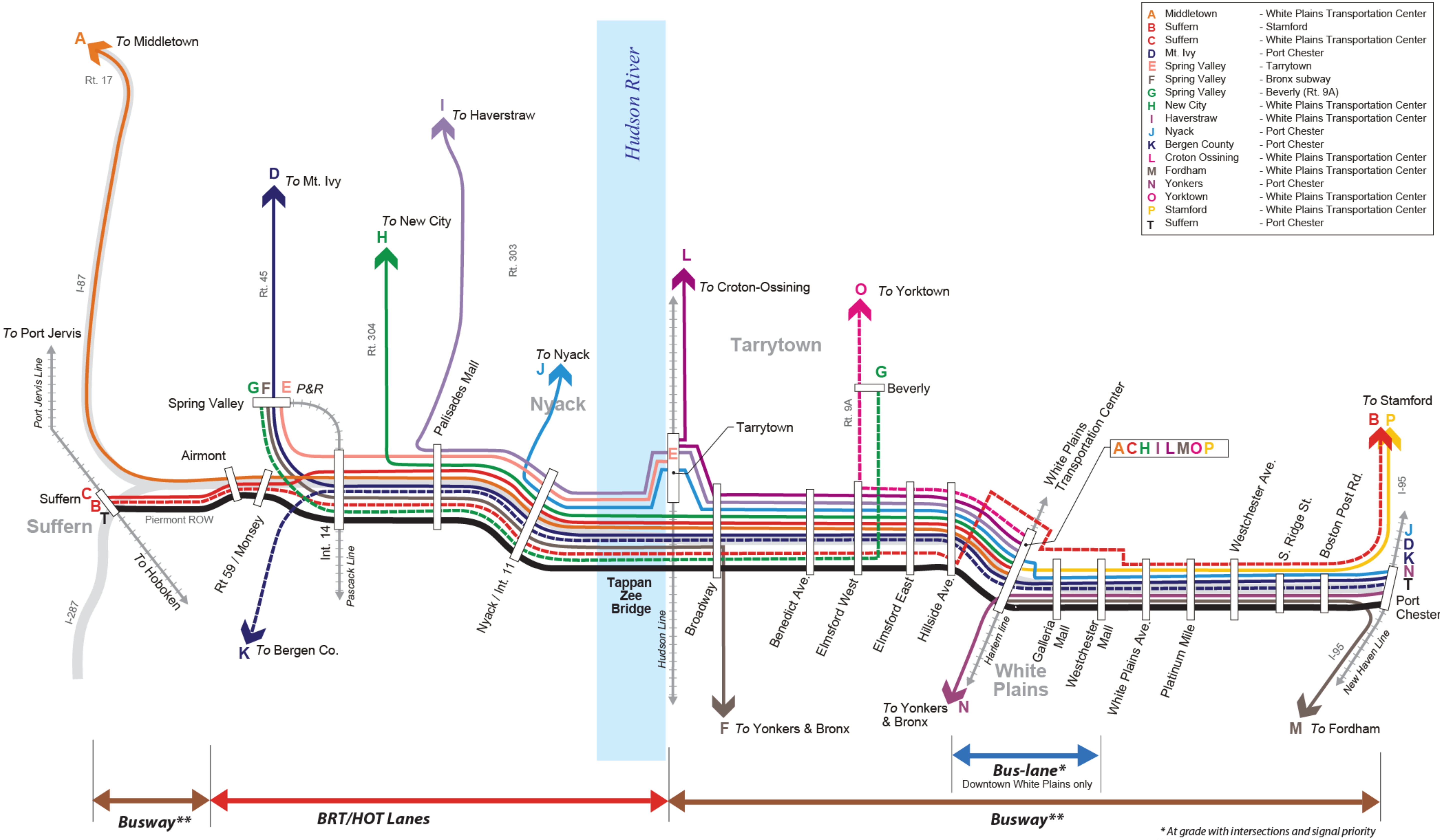


Figure A-3 Option 3B Bus Rapid Transit Service Plan

A.1.3 Alternative 4C BRT Service Plan

The Alternative 4C Express Bus Service Plan is an abbreviated version of the Alternative 3 Service Plan, with all of the intra-Westchester and Westchester-Connecticut routes retained, and a limited number of routes connecting Orange and Rockland County locations to Westchester and Connecticut destinations that would provide more direct service than a train connection at the Tappan Zee Station. This service plan also includes the Tappan Zee Station for all western Westchester County and trans-Hudson routes. The routes are shown diagrammatically on Figure A-4 and Table A-4.

A.2 CRT and LRT Service Plans

A.2.1 Alternative 4A

Attached are the CRT Service Plans for Alternatives 4A, 4B and 4C, developed based on Stage 1 service plans and results, and reviewed by Metro-North. The Alternative 4A Service Plan is similar to the Full Corridor CRT Service Plan in Stage 1, but with some additions:

- Additional services to New York Penn Station in 2030 and 2035 via the Main/Bergen Line, and the new Trans Hudson Express tunnel, based on the agreement between Metro-North and NJTransit. The routes are shown on Table A-5, with stop patterns and headways.

A.2.2 Alternatives 4B and 4C

The Alternative 4B and 4C CRT Service Plan is based on same Service Plan in Stage 1, with the same additions as 4A, but without the cross-Westchester services. The routes are shown in Table A-6 with stop patterns and headways and in and Figure A-6

A.2.3 Alternative 4D

The Alternative 4D service plan is a combination of the 3A BRT option and the CRT component of the 4B-4C service plan without the Airmont and Tappan Zee Stations. The stop patterns and routes are shown in Table A-7 and Figure A-7.

A.3 Feeder Bus Service Plans for 4A and 4B

Feeder bus service plans are shown in Tables A-8 and A-9

A.4 LRT Service Plans

The Alternative 4B LRT service plan is based on the In-street LRT Service Plan in Stage 1, and is based on a single LRT route pattern, from Tarrytown to Port Chester, serving all stops. Details are shown in Table A-10. Table A-11 lists the LRT stops for Alternative 4B.

A.5 Transit Fare Structure

For the BPM model runs, the following principles were used in developing the fare matrices:

- For all runs, 2005 fares were used, expressed in 1996 dollars. Fares were maintained in constant 1996 dollars for all forecast years, consistent with the model calibration factors. A factor of 1.19 was used to deflate fares, representing the national CPI for urban transportation between 1996 and 2005.

  All costs were updated to 2005 values, including auto operating costs, tolls and transit fares. They are expressed in 1996 dollars because the BPM model was calibrated originally in 1996, and the relationship between cost and time determined in 1996 dollars.

- Metro-North and Long Island Railroad (LIRR) fares were 1/40 of monthly fares. NJTransit fares were daily one-way fares, discounted by 30 percent, which were equivalent to the monthly discount. This is an idiosyncrasy of the BPM model because it was a merger of models developed independently for New York and New Jersey. For Metro-North West-of-Hudson services, NJTransit fares were adjusted to reflect monthly fares, when the 30 percent discount was not appropriate. NJT fares to Penn Station via Secaucus were added. Fares on the Pascack Line were adjusted to reflect their additional discount on Penn Station service. These fares are shown in Tables A-12 and A-13.

- For all alternative runs, fares on the new cross-corridor services were based on Metro-North fare policies and distances. Fares to GCT were set to be roughly equal to fares to GCT from stations on the Hudson or Harlem lines of comparable distance to GCT. Fares to intermediate or cross-corridor destinations were developed using Metro-North's distance based fare algorithm, shown on Table A-14. Fares to Penn Station were further adjusted on the NJTransit run Metro-North services (Port Jervis and Pascack) to be equal to the fares directly to GCT or Penn Station.

- For alternative/option runs, fares on new express buses were set at current express bus fares within the corridor. Light rail was set at Bee Line bus fares. Adjustments were made to account for the Joint Fare monthly tickets provided by Metro-North with the bus companies for fares to the Tarrytown Station. Thus, fares from Rockland and Orange Counties to Tarrytown were set at 37¢, to represent a joint Metro-North/bus monthly ticket.

- For future years, BeeLine bus fares were set at NYCT Metrocard fares, as Bee Line became part of the Metrocard system in April 2007.

- For New Starts analysis, FTA requires that the same fare be used regardless of mode. For that analysis, Metro-North's distance based fare policy was applied to BRT and LRT travel as if it were commuter rail. These fares will differ from the fares used in the EIS analysis, but in no case is the difference greater than 40¢.

Table A-4

Alternative 4C Express Bus Service Plans

BRT Route	Fare (1996 dollars)	Currently	Description	Enter Busway	Intermediate Stops	Terminus	Peak	Off Peak	Peak	Off Peak
A	2.85	OWL	Orange Co-White Plains	Int 14B	Palisades Mall	WPTC	30	60	2	1
B *	2.00		Palisades Mall-Stamford	Int 12	All	Stamford TC	10	30	6	2
C	1.50		Tappan Zee- Stamford	Rt 119	Meadows, Benedict Ave, Elmsford W, Elmsford E, Platinum Mile	Stamford TC	20	60	3	1
D	1.50		Mt Ivy - Platinum Mile	Int 12	Palisades Mall, Tappan Zee, Meadows, Benedict Ave, Elmsford W, Elmsford E, Platinum Mile	Port Chester	20	60	3	1
F*	1.50		Spring Valley-Bronx via Rt. 9	Int 14	Palisades Mall, Tarrytown, Yonkers	Bronx subway	30	60	2	1
G	1.50		Spring Valley to Route 9A	Int 14	Palisades Mall	Rt 9A and Beverly	30	60	2	1
H	1.25		New City- White Plains	Int 12	Palisades Mall, Tappan Zee, Meadows, Benedict Ave, Elmsford W, Elmsford E, WCC	WPTC	20	60	3	1
I	1.25		Haverstraw-Nyack-Platinum Mile via 9W	Int 11	Tarrytown, Benedict, Elmsford, Greenburgh, White Plains	Platinum Mile	30	60	2	1
L	1.30	BeeLine 11	Croton-Ossining-White Plains via Rt. 9	Route 119	Benedict, Elmsford, Greenburgh	WPTC	60	x	1	x
M	1.30	BeeLine 62	Fordham-New Rochelle-White Plains via I-95 and I-287	Westchester Ave	Platinum Mile	WPTC	30	60	2	1
N	1.30	BeeLine 3 and BeeLine 21	Yonkers-Platinum Mile via Central	Route 119	White Plains	Platinum Mile	30	60	2	1
O	1.30	BeeLine 77	Yorktown-White Plains via Taconic	Sprain Brook Parkway		WPTC	30	60	2	1
P*	1.30	I-Bus	Stamford-White Plains	Westchester Ave	Platinum Mile	WPTC	15	30	4	2

Note: * = Routes operate at peak headways in both directions.

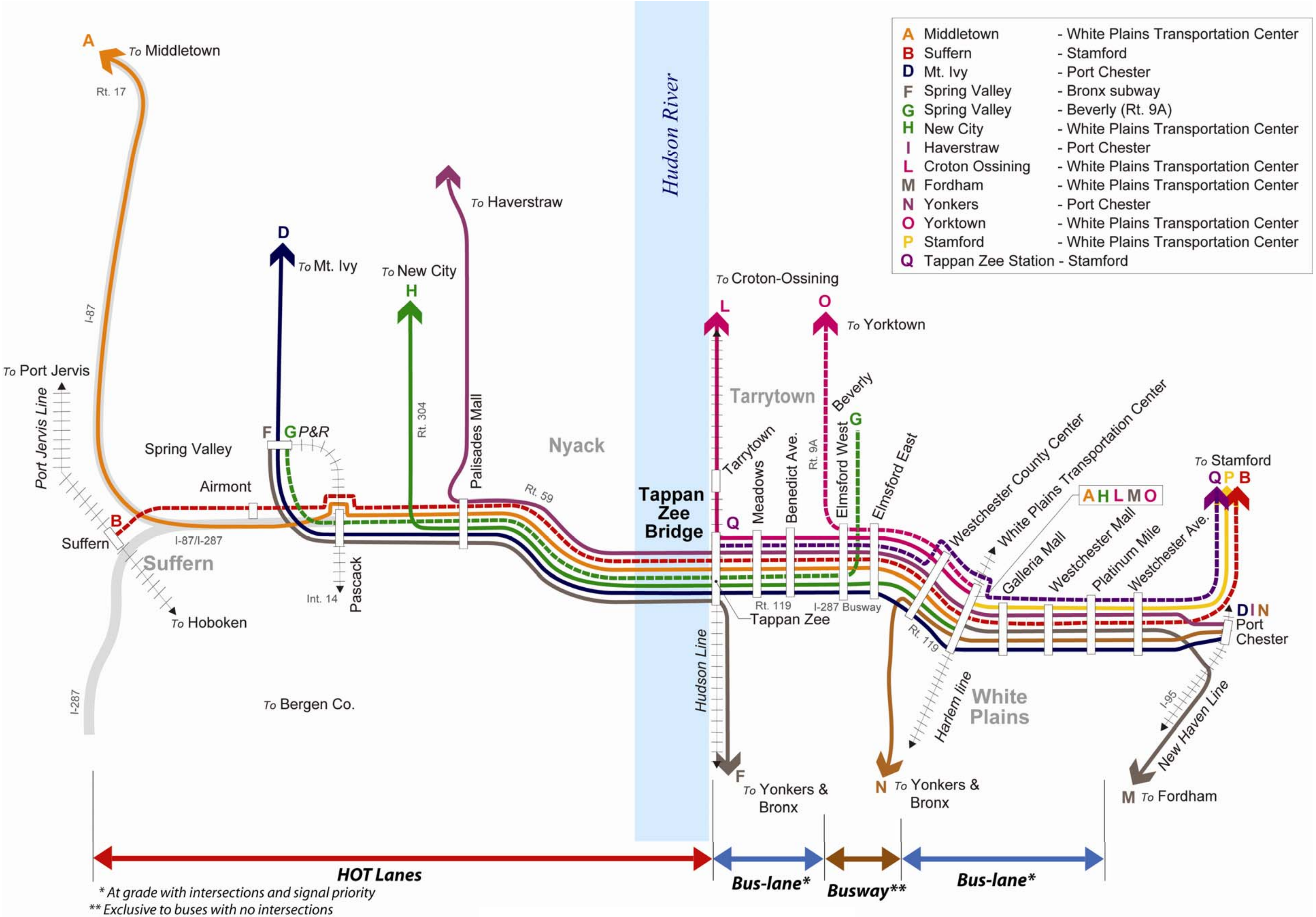


Figure A-4 Alternative 4C Express Bus Service Plan

Table A-5
Alternative 4A Commuter Rail Service Plan

Stops	Peak										Off-Peak - Bi-Directional Reverse Peak - Uni-Directional				Off-Peak Bi-Directional
	Uni-Directional Service								Bi-Directional Service	By Terminal					
	A	B**	C	D**	E	F	G	H	I		A	B**	E	G	I
No Trains in peak hour	1	1	1	1	2	4	4	2	2	18					
Peak Hour Headways	60	60	60	60	30	15	15	30	30						
Shoulder-Peak Headways	X	X	60	60	30	30	30	60	40						
Off-Peak Headways											120	120	60	60	60
Port Jervis	●	●	●	●	●			●			●	●	●		
Otisville	●	●	●	●	●			●			●	●	●		
Middletown	●	●	●	●	●			●			●	●	●		
Campbell Hall	●	●	●	●	●			●			●	●	●		
Salisbury Mills	●	●	●	●	●			●			●	●	●		
Harriman	●	●	●	●	●	●		●			●	●	●		
Tuxedo			●	●		●		●			●	●	●		
Sloatsburg			●	●		●		●			●	●	●		
Hillburn			●	●		●	●	●	●		●	●	●	●	●
Airmont Road							●	●	●				●	●	●
Exit 14/Garden State Pky							●	●	●				●	●	●
Palisades Mall							●	●	●				●	●	●
Tappan Zee							●	●	●				●	●	●
Westchester Stops*								●	●						●
Greenwich								●	●						●
Stamford								●	●	4					●
Yonkers							●						●	●	
Harlem-125th Street					●	●	●						●	●	
Grand Central					●	●	●			10			●	●	
Suffern			●	●							●	●			
Ramsey-Route 17			●	●											
Secaucus	●	●	●	●							●	●			
Hoboken	●		●							2	●				
New York Penn		●		●						2		●			

NOTES: In addition to the direct service to each terminal, customers will have additional service to each terminal via transfers at Harriman, Hillburn, Exit 14 and Palisades Mall Stations.
Reverse peak and off peak Bergen Line and Main Line trains will terminate at Hillburn instead of Suffern.
* Westchester Station Stops include Elmsford, White Plains, Westchester Mall, Corporate Pk Dr, Purchase, Port Chester.
** Additional trains in 2030 and 2035, using the Trans Hudson Express tunnel. They will not operate in 2015.

Service Branch

Green	Hoboken/New York Penn
Orange	Grand Central Terminal
Blue	Cross-Corridor

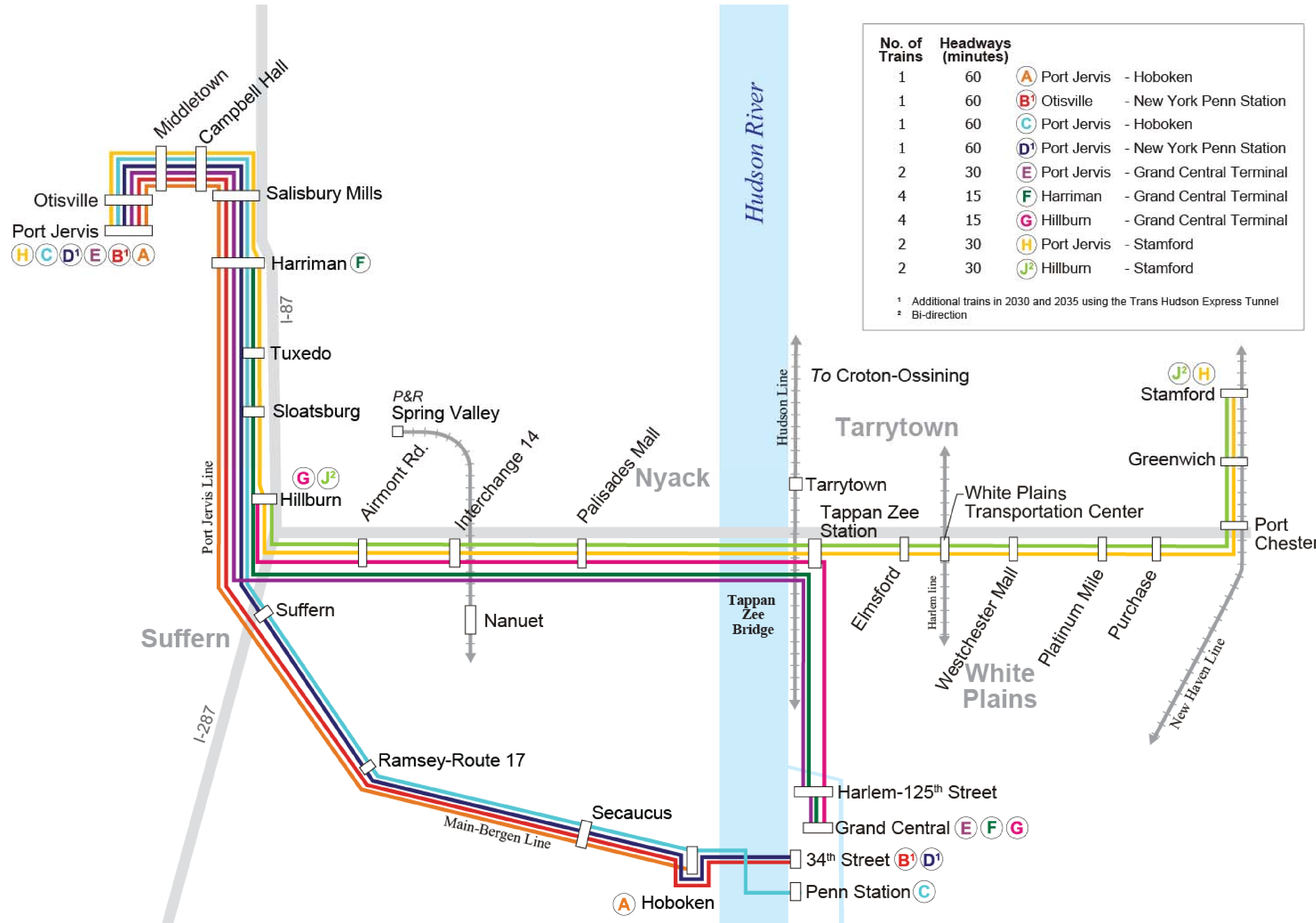


Figure A-5 Alternative 4A Commuter Rail Service Plan

Table A-6
Alternatives 4B and 4C Commuter Rail Service Plan

Stops	Peak – Uni-Directional Service A	B*	C	D*	E	F	G	Peak – By Terminal	Off-Peak - Bi-Directional / Reverse Peak - Uni-Directional A	B*	E	G
No Trains in peak hour	1	1	1	1	2	4	4	14				
Peak Hour Headways	60	60	60	60	30	15	15					
Shoulder-Peak Headways	X	X	60	60	30	30	30					
Off-Peak Headways									120	120	60	60
Port Jervis	●	●	●	●	●				●	●	●	
Otisville	●	●	●	●	●				●	●	●	
Middletown	●	●	●	●	●				●	●	●	
Campbell Hall	●	●	●	●	●				●	●	●	
Salisbury Mills	●	●	●	●	●				●	●	●	
Harriman	●	●	●	●	●	●			●	●	●	
Tuxedo			●	●		●			●	●	●	
Sloatsburg			●	●		●			●	●	●	
Hillburn						●	●		●	●	●	●
Airmont Road							●				●	●
Exit 14/Garden State Pky							●				●	●
Palisades Mall							●				●	●
Tappan Zee					●	●	●				●	●
Harlem-125th Street					●	●	●				●	●
Grand Central					●	●	●	10			●	●
Suffern			●	●					●	●		
Ramsey-Route 17			●	●					●	●		
Secaucus	●	●	●	●					●	●		
Hoboken	●		●					2	●			
New York Penn		●		●				2		●		

NOTES: In addition to the direct service to each terminal, customers will have additional service to each terminal via transfers at Harriman or the new Hillburn Stations.
Reverse peak and off peak Bergen Line and Main Line trains will terminate at Hillburn instead of Suffern.
* Additional trains in 2030 and 2035, using the Trans Hudson Express tunnel. They will not operate in 2015.

Service Branch

Service Branch	
(green)	Hoboken/New York Penn
(orange)	Grand Central Terminal
(blue)	Cross-Corridor

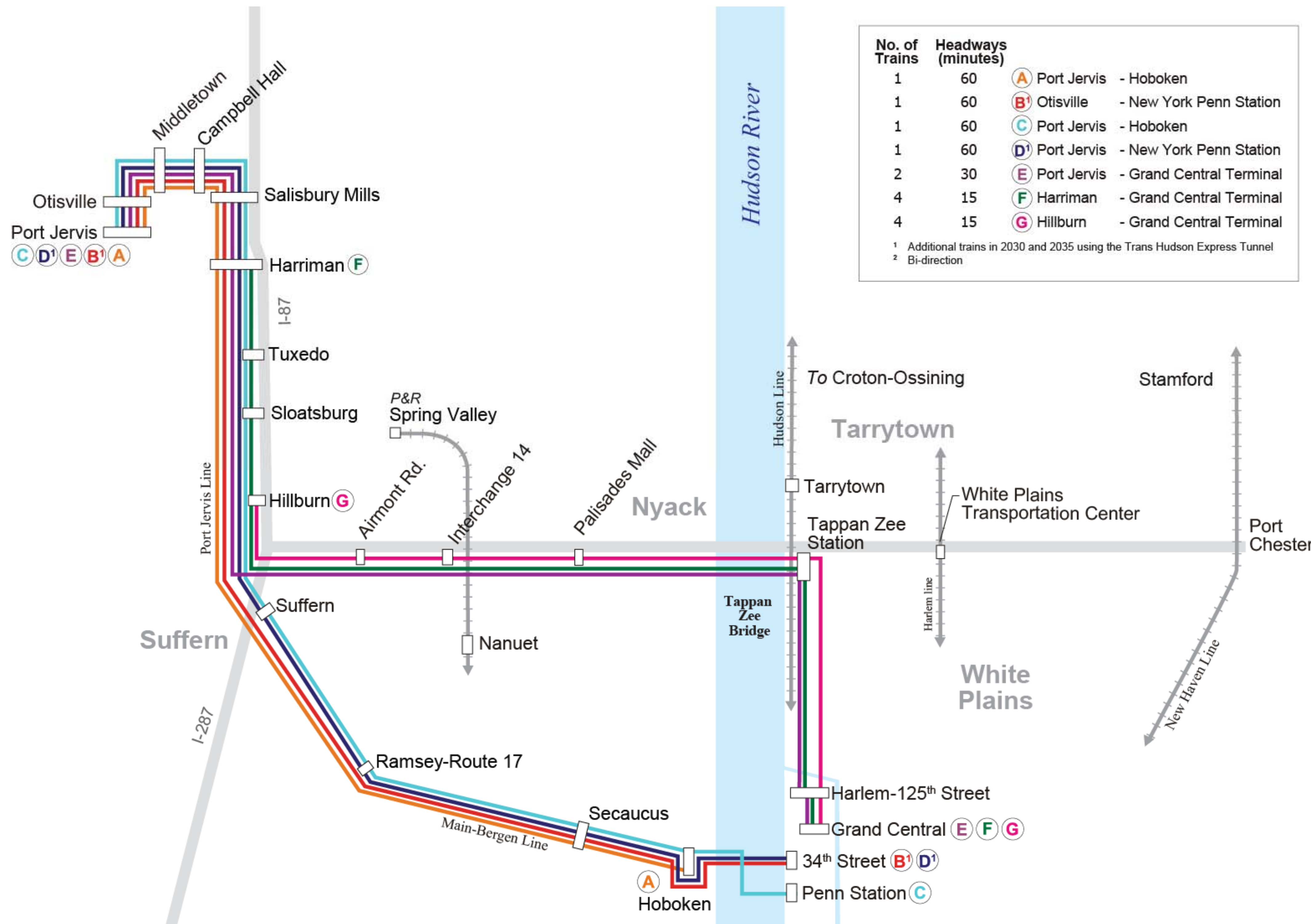


Figure A-6 Alternatives 4B and 4C Commuter Rail Service Plan

Table A-7
Alternative 4D BRT and CRT Service Plans

BRT Service

ROUTE	ROCKLAND: Suffern NJ Transit Station	Rt. 59 / Airmont	Monsey	Spring Valley	Interchange 14	Palisades Mall	Nyack Interchange 11	WESTCHESTER: Tarrytown MNR Station	Broadway	Meadow St.	Benedict Ave.	Elmsford W	Elmsford E	Hillside Ave.	Westchester County Center	White Plains Transportation Center	Galleria Mall	Westchester Mall	White Plains Ave.	Platinum Mile	Westchester Ave.	S. Ridge St.	Boston Post Rd.	Port Chester MNR Station	ROUTE
A	Middletown ←	●	●		●	●	●		●	●	●	●	●	●	●	●									A
B	●	●	●		●	●	●		●	●	●	●	●	●					●	●	●	→ Stamford TC			B
C	●	●	●		●	●	●		●	●	●	●	●	●	●	●									C
D		Mt. Ivy ←		●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	D
E				●	●	●	●	●																	E
F			●	●	●	●	●		●	→ Yonkers & Bronx															F
G				●	●	●	●		●	●	●	●	→ Beverly												G
H			New City ←			●	●		●	●	●	●	●	●	●	●									H
I			Haverstraw ←			●	●	●	●	●	●	●	●	●	●	●									I
J					Nyack ←		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	J
K		Bergen Co. ←			●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	K
L					Croton-Ossining ←			●	●	●	●	●	●	●	●	●									L
M																●	●	●	●	●	●	●	●	Fordham →	M
N											Yonkers & Bronx ←				●	●	●	●	●	●	●	●	●	●	N
O									Yorktown ←			●	●	●	●	●									O
P																●	●	●	●	●	●	→ Stamford TC			P
T	●	●	●		●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	T

Commuter Rail Service

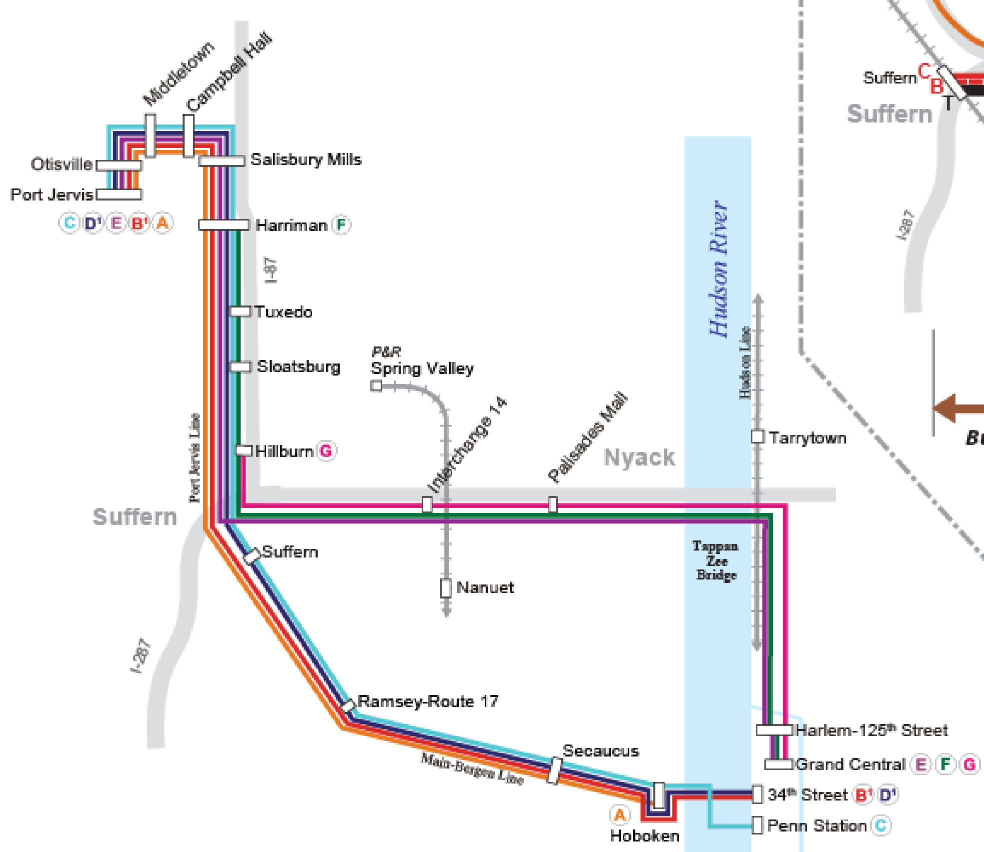
Stops	Peak (Uni-Directional Service): A	B*	C	D*	E	F	G	By Terminal	Off-Peak - Bi-Directional / Reverse Peak - Uni-Directional: A	B*	E	G
No Trains in peak hour	1	1	1	1	2	4	4	14				
Peak Hour Headways	60	60	60	60	30	15	15					
Shoulder-Peak Headways	X	X	60	60	30	30	30					
Off-Peak Headways									120	120	60	60
Port Jervis	●	●	●	●	●				●	●	●	
Otisville	●	●	●	●	●				●	●	●	
Middletown	●	●	●	●	●				●	●	●	
Campbell Hall	●	●	●	●	●				●	●	●	
Salisbury Mills	●	●	●	●	●				●	●	●	
Harriman	●	●	●	●	●	●			●	●	●	
Tuxedo			●	●		●			●	●	●	
Sloatsburg			●	●		●			●	●	●	
Hillburn						●	●		●	●	●	●
Exit 14/Garden State Pky							●				●	●
Palisades Mall							●				●	●
Harlem-125th Street					●	●	●				●	●
Grand Central					●	●	●	10			●	●
Suffern			●	●					●	●		
Ramsey-Route 17			●	●					●	●		
Secaucus	●	●	●	●					●	●		
Hoboken	●		●					2	●			
New York Penn		●		●				2		●		

Service Branch
- Hoboken/New York Penn
- Grand Central Terminal
- Cross-Corridor

NOTES:
In addition to the direct service to each terminal, customers will have additional service to each terminal via transfers at Harriman or the new Hillburn Stations.
Reverse peak and off peak Bergen Line and Main Line trains will terminate at Hillburn instead of Suffern.
* Additional trains in 2030 and 2035, using the Trans Hudson Express tunnel. They will not operate in 2015.

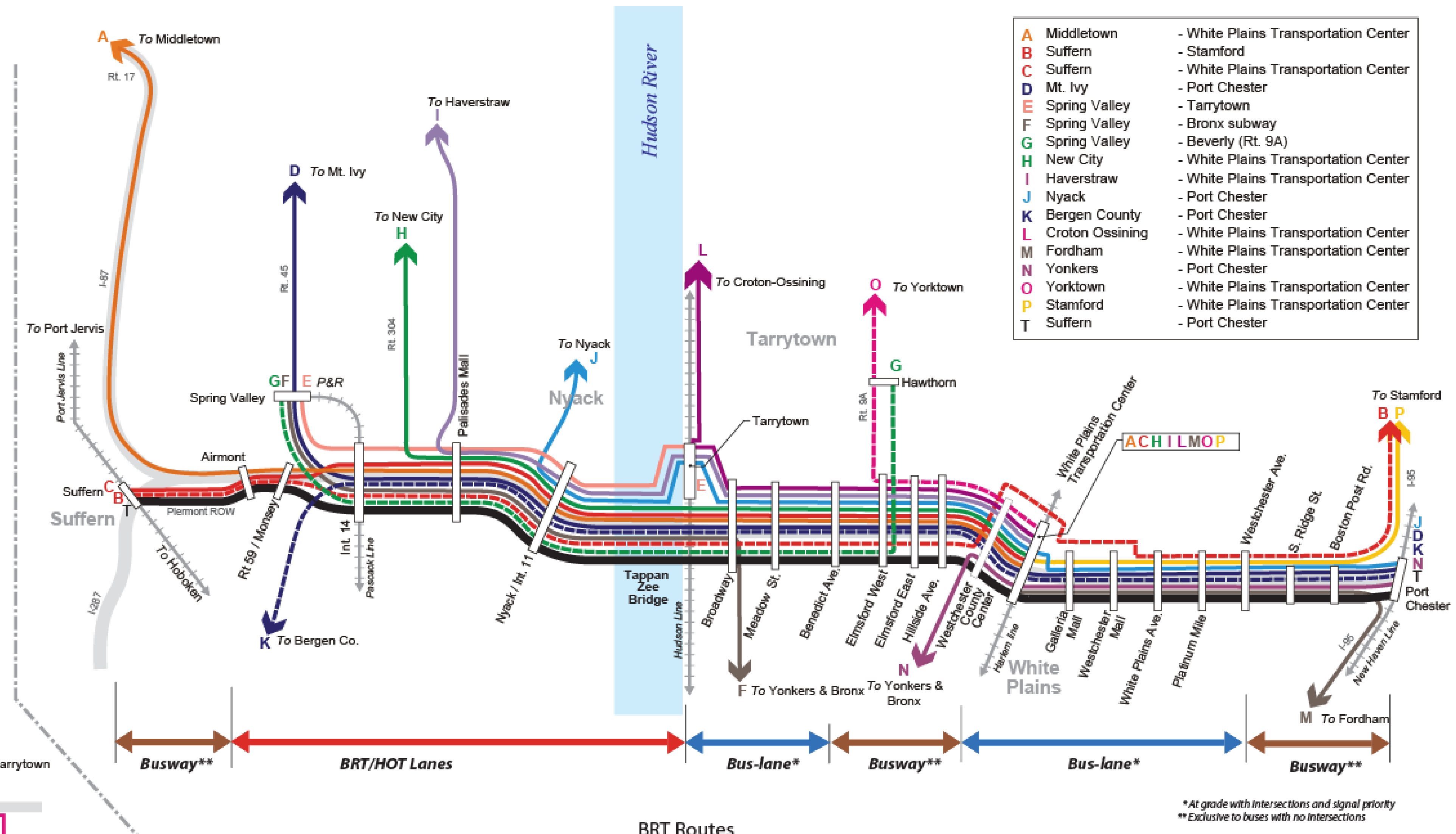
No. of Trains	Headways (minutes)			
1	60	A	Port Jervis	- Hoboken
1	60	B[1]	Otisville	- New York Penn Station
1	60	C	Port Jervis	- Hoboken
1	60	D[1]	Port Jervis	- New York Penn Station
2	30	E	Port Jervis	- Grand Central Terminal
4	15	F	Harriman	- Grand Central Terminal
4	15	G	Hillburn	- Grand Central Terminal

[1] Additional trains in 2030 and 2035 using the Trans Hudson Express Tunnel
[2] Bi-direction



Commuter Rail Routes

A	Middletown	- White Plains Transportation Center
B	Suffern	- Stamford
C	Suffern	- White Plains Transportation Center
D	Mt. Ivy	- Port Chester
E	Spring Valley	- Tarrytown
F	Spring Valley	- Bronx subway
G	Spring Valley	- Beverly (Rt. 9A)
H	New City	- White Plains Transportation Center
I	Haverstraw	- White Plains Transportation Center
J	Nyack	- Port Chester
K	Bergen County	- Port Chester
L	Croton Ossining	- White Plains Transportation Center
M	Fordham	- White Plains Transportation Center
N	Yonkers	- Port Chester
O	Yorktown	- White Plains Transportation Center
P	Stamford	- White Plains Transportation Center
T	Suffern	- Port Chester



BRT Routes

Figure A-7 Alternative 4D Bus Rapid Transit and Commuter Rail Service Plans

Table A-8

Alternative 4A- Commuter Rail Cross Corridor Feeder Bus Plan

Station	Route	Revision	Headways	
			peak	offpeak
Suffern				
	TOR 59	reroute; west terminal at new station	30	30
	TOR 93	reroute; west terminal at new station	60	60
	OWL	truncate service from Middletown at station	30	90
Airmont				
	TOR 59	deviate via station; Option trips via RCC & Maple (replace TOR94)	30	30
Monsey				
	TOR 59	Option trips via RCC-Maple; add stop at station on NY 59 trips	60	60
	TOR 94	reroute: s. on College to NY 59, term. at station; Maple service covered by branch of #59	60	60
Spring Valley (Pascack Valley/I-287)				
	TOR 59	deviate via station	30	30
	TOR 91	extend via NY 59 to term. at station	30	60
	TOR 93	via New Clarkstown, NY 59 to station, then Nanuet Mall	60	60
	Clarkstown C	extend from Nanuet Mall to station	35	70
	Clarkstown D	deviate via station	35	70
	Clarkstown E	extend from Nanuet Mall to station	35	70
Palisades Mall				
	TOR 59	deviate via station	30	30
	TOR 91	deviate via station	30	60
	TOR 91X	terminate at station	30	x
	TOR 92	deviate via station	30	60
	Clarkstown A	deviate via sta; reroute via "B" route to Nanuet Mall	35	70
	Clarkstown B	reroute to term. at station (vs. Nanuet Mall)	35	70
	Clarkstown D	reroute; east term. at station	35	70
Tarrytown (Broadway)				
	Bee-Line 1T	add stop at Tappan Zee Station	60	60
	Bee-Line 1W	add stop at Tappan Zee Station	60	60
	Bee-Line 13	add stop at Tappan Zee Station; route Ossining trips via Broadway, new station, NY 119 vs. Benedict; Benedict service terminates at existing Tarrytown Sta.	20/40	30
Elmsford Station				
	Bee-Line 1C	add stop at Elmsford Station	no change	
	Bee-Line 5	add stop at Elmsford Station	no change	
	Bee-Line 11	add stop at Elmsford Station	no change	
	Bee-Line 14	add stop at Elmsford Station	no change	

Table A- 8 (con't)

Alternative 4A- Commuter Rail Cross Corridor Feeder Bus Plan

Station	Route	Revision	Headways
	Bee-Line 27	add stop at Elmsford Station	no change
White Plains RR			
	all existing routes at White Plains TransCenter (except TZX, CRX, OWL, I-BUS)		no change
Westchester Mall			
	existing routes in area - no routing changes		no change
Harrison (Kenilworth Rd.)			
	Bee-Line 3-12-13	add stop at station	no change
Port Chester (New Haven Line)			
	Bee-Line 13, 61, 76; CT-11 (no routing change)		no change
Note; Delete all Tappan Zee Express, Cross Rockland Express, and I-Bus service			

Table A-9

Alternative 4B Commuter Rail Cross Rockland, LRT Cross Westchester Feeder Bus Plan

Station	Route	Revision	Headways	
			peak	offpeak
Suffern				
	TOR 59	reroute; west terminal at new station	30	30
	TOR 93	reroute; west terminal at new station	60	60
	OWL	truncate service from Middletown at station	30	90
Airmont				
	TOR 59	deviate via station; Option trips via RCC & Maple (replace TOR94)	30	30
Monsey				
	TOR 59	Option trips via RCC-Maple; add stop at station on NY 59 trips	60	60
	TOR 94	reroute: s. on College to NY 59, term. at station; Maple service covered by branch of #59	60	60
Spring Valley (Pascack Valley/I-287)				
	TOR 59	deviate via station	30	30
	TOR 91	extend via NY 59 to term. at station	30	60
	TOR 93	via New Clarkstown, NY 59 to station, then Nanuet Mall	60	60
	Clarkstown C	extend from Nanuet Mall to station	35	70
	Clarkstown D	deviate via station	35	70
	Clarkstown E	extend from Nanuet Mall to station	35	70
Palisades Mall				
	TOR 59	deviate via station	30	30
	TOR 91	deviate via station	30	60
	TOR 91X	terminate at station	30	x
	TOR 92	deviate via station	30	60
	Clarkstown A	deviate via sta; reroute via "B" route to Nanuet Mall	35	70
	Clarkstown B	reroute to term. at station (vs. Nanuet Mall)	35	70
	Clarkstown D	reroute; east term. at station	35	70
Tarrytown (Broadway)				
	Bee-Line 1T	add stop at Tappan Zee Station	60	60
	Bee-Line 1W	add stop at Tappan Zee Station	60	60
	Bee-Line 13	add stop at Tappan Zee Station; route Ossining trips via Broadway, new station, NY 119 vs. Benedict; Benedict service terminates at existing Tarrytown Sta.	20/40	30
Elmsford Station				
	Bee-Line 1C	add stop at Elmsford Station	no change	
	Bee-Line 5	add stop at Elmsford Station	no change	
	Bee-Line 11	add stop at Elmsford Station	no change	
	Bee-Line 14	add stop at Elmsford Station	no change	
	Bee-Line 27	add stop at Elmsford Station	no change	

Table A-10

LRT Service Plan

Parameter	Value Used
Length	13.8 miles
Running Time	28 minutes
Peak Hour Headways	10
Shoulder-Peak Headways	10
Off peak Headways	15

Table A-11

List of Alternative 4B LRT Stops

Sl. No.	Stations
1	Tarrytown
2	Tappan Zee
3	Meadow St
4	Benedict Ave
5	Elmsford
6	Greenburgh
7	Hillside Ave
8	Westchester County Center
9	White Plains
10	Galleria Mall
11	Westchester Mall
12	Westchester Ave
13	Corp Park Dr
14	Purchase
15	South Ridge St
16	Boston Post Road
17	Port Chester

Table A-12

2005 Metro-North Fares Adjusted to 1996 Dollars

Stations		GCT/ 125th	Bronx	Ludlow-Greystone	Hasting-Irvington	Tarrytown-Croton Harmon	Courtland-Peekskill	Manitou-Cold Spring	Beacon-New Hamburg	Poughkeepsie	Fordham	Mt. Vernon-New Rochelle	Larchmont Harrison	Rye- Port Chester	Greenwich-Old Greenwich	Stamford	Glenbrook-New Canaan	Noroton Hts - Rowayton	S. Norwalk E. Norwalk	Westport-Fairfield	Bridgeport	Stratford-Milford	New Haven	Merritt 7-Cannondale	Branchville-Danbury	Derby Shelton-Waterbury
ZONE	ZONE	1	11	21	22	23	24	31	41	42	51	61	62	63	71	72	73	74	75	76	77	81	82	91	92	101
City Terminal Zone - GCT/125th	1	0.11	0.21	0.22	0.23	0.24	0.31	0.41	0.42	0.51	0.61	0.62	0.63	0.71	0.72	0.73	0.74	0.75	0.76	0.77	0.81	0.82	0.91	0.92	1.01	0.00
Bronx	11		3.42	3.87	4.47	5.27	6.07	6.74	7.42	3.00	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Westchester - Mount Vernon W. - Crestwood/Ludlow - Greystone	21			1.18	1.49	2.31	3.24	4.12	4.85	9.99	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Westchester - Scarsdale-N. White Plains/Hastings - Irvington	22				1.41	2.10	2.65	3.66	4.52	9.99	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Westchester - Vallahalla-Chappaqua/Tarrytown - Croton Harmon	23					1.64	2.31	3.07	4.03	9.99	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Westchester - Mt. Kisco- Goldens Bridge/Courtland - Peekskill	24						1.87	2.54	3.53	9.99	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Putnam - Purdy's-Brewster Norther/Manitou - Cold Spring	31							1.85	2.54	9.99	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dutchess - Patterson - Pawling /Beacon - New Hamburg	41								1.76	9.99	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Dutchess - Harlem Valley-Wassaic/Poughkeepsie	42									9.99	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bronx (Fordham)	51											9.99	9.99	9.99	9.99	9.99	9.99	9.99	9.99	9.99	9.99	9.99	9.99	9.99	9.99	0.00
Westchester (Mount Vernon-New Rochelle)	61											1.18	1.49	1.64	2.16	2.16	2.16	2.54	3.05	3.63	3.99	4.85	2.77	3.34	4.20	0.00
Westchester (Larchmont-Harrison)	62												1.03	1.64	2.16	2.16	2.16	2.54	3.05	3.63	3.99	4.85	2.71	3.05	4.03	0.00
Westchester (Rye-Port Chester)	63													1.28	1.83	1.83	1.83	2.18	2.67	3.19	3.55	4.41	2.35	2.77	3.66	0.00
Fairfield (Greenwich-Old Greenwich)	71														1.55	1.55	1.55	1.93	2.39	3.05	3.28	4.14	2.08	2.50	3.40	0.00
Fairfield (Stamford)	72																1.05	1.18	1.49	2.08	2.44	3.30	1.68	2.02	2.75	0.00
Fairfield (Glenbrook-New Caanan)	73																1.05	1.05	1.13	1.53	1.87	2.73	1.40	1.68	2.29	0.00
Fairfield (Noroton Heights-Rowayton)	74																	1.05	1.58	1.68	2.04	2.98	1.53	1.84	2.50	0.00
Fairfield (S. Norwalk - E.Norwalk)	75																		1.13	1.21	1.47	2.15	1.10	1.32	1.80	0.00
Fairfield (Westport-Fairfield)	76																			1.24	1.58	2.31	1.38	1.66	2.26	0.00
Fairfield (Bridgeport)	77																				1.32	1.93	1.13	1.36	2.26	0.00
New Haven (Stratford-Milford)	81																					1.26	1.64	1.97	1.67	0.00
New Haven (New Haven)	82																							2.17	1.11	0.00
Inner Danbury Branch (Merritt 7 - Canondale)	91																							3.13	2.12	0.00
Outer Danbury Branch (Branchville-Danbury)	92																								2.48	0.00
Waterbury Branch (Derby-Shelton-Waterbury)	101																									0.00

Table A-13

2005 NJT Fares Adjusted to 1996 Dollars

Stations	BPM FARE ZONES	Newark Penn Station	Secaucus	Kingsland, Lyndhurst	Delwanna, Rutherford, Wood Ridge	Passaic, Garfield, Teterboro	Clifton, Plauderville, Essex St. Anderson St	Broadway, Radburn, Paterson, N. Hack, River Edge	Hawthorne, Oradell	Glen Rock, Emerson	Ridgewood, Westwood, Hillsdale	Ho-Ho-Kus, Waldwick, Montvale	Allendale	Spring Valley, Nanuet, Pearl R.	Ramsey	Suffern, Mahwah	Sloatsburg, Tuxedo	Harriman	Salisbury Mills	Campbell Hall	Middletown	Otisville	Port Jervis
		5	**7**	**22**	**31**	**32**	**41**	**42**	**51**	**52**	**61**	**62**	**71**		**72**	**81**	**91**	**121**	**161**	**171**	**181**	**191**	**201**
Penn NY	**3**	2.65	2.65	2.82	3.18	3.53	3.71	4.24	4.59	4.94	5.12	5.65	0.00	6.00	6.71	6.89	7.59	8.30	9.18	9.71	10.42	11.48	0.00
Hoboken	**4**	2.12	1.90	2.48	2.79	3.03	3.32	3.05	4.03	4.24	4.59	4.95	0.00	4.98	5.88	5.71	6.66	6.89	7.77	8.30	9.00	10.06	0.00
Newark Penn Station	**5**		1.82	2.82	3.18	3.45	3.79	2.91	4.59	4.83	5.23	5.65	0.00	6.00	6.71	6.89	7.59	8.30	8.86	9.46	10.27	11.48	0.00
Secaucus	**7**			2.82	3.18	3.45	3.79	3.05	4.59	4.83	5.23	5.65	0.00	6.00	6.71	6.89	7.59	8.30	8.86	9.46	10.27	11.48	0.00
Kingsland, Lyndhurst	**22**			2.39	2.69	2.92	3.21	1.91	3.88	4.09	4.43	4.78	0.00	n/a	5.68	5.83	6.42	6.89	7.50	8.01	8.69	9.71	0.00
Delwanna, Rutherford, Wood Ridge	**31**				2.65	2.88	3.16	1.62	3.83	4.03	4.36	4.71	0.00	4.60	5.59	5.74	6.33	6.36	7.39	7.89	8.56	9.57	0.00
Passaic, Garfield, Teterboro	**32**						3.09	1.46	3.74	3.94	4.27	4.61	0.00	4.50	5.47	5.61	6.19	6.21	7.22	7.72	8.37	9.36	0.00
Clifton, Plauderville, Ess. St, Andsn. St.	**41**						2.97	1.17	3.60	3.79	4.11	4.43	0.00	4.33	5.26	5.40	5.96	5.98	6.95	7.42	8.06	9.00	0.00
Broadway, Radburn, Paterson, N. Hack, River Edge	**42**							1.01	3.53	3.72	4.03	4.35	0.00	4.24	5.16	5.30	5.84	5.86	6.81	7.28	7.90	8.83	0.00
Hawthorne, Oradell	**51**									3.57	3.87	4.17	0.00	4.07	4.95	5.08	5.61	5.63	6.54	6.99	7.58	8.47	0.00
Glen Rock , Emerson	**52**										1.21	5.65	0.00	3.90	4.75	4.87	5.37	5.39	6.27	6.70	7.27	8.12	0.00
Ridgewood, Westwood, Hillsdale	**61**										1.06	1.06	0.00	1.06	1.59	2.65	5.26	5.28	6.13	6.55	7.11	7.94	0.00
Ho-Ho-Kus, Waldwick, Montvale	**62**											1.06	0.00	1.06	1.52	2.53	5.02	5.04	5.86	6.26	6.79	7.59	0.00
Allendale	**71**													n/a	1.45	2.41	4.79	4.81	5.59	5.97	6.48	7.24	0.00
Spring Valley, Nanuet, Pearl River														1.06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ramsey	**72**														1.06	1.77	4.67	4.69	5.45	5.82	6.32	7.06	0.00
Suffern, Mahwah	**81**															1.06	4.09	4.10	4.77	5.09	5.53	6.18	0.00
Sloatsburg, Tuxedo	**91**																0.00	3.40	3.95	4.22	4.58	5.12	0.00
Harriman	**121**																		1.54	1.64	1.78	1.99	0.00
Salisbury Mills	**161**																			1.51	1.64	1.84	0.00
Campbell Hall	**171**																				1.41	1.57	0.00
Middletown	**181**																					1.13	0.00
Otisville	**191**																						0.00

Table A-14

2005 East of Hudson Intermediate
Monthly Commutation Fare Structure

Mileage Between Stations			Monthly Fare
0.0	-	9.8	$47
9.8	-	11.3	$53
11.3	-	12.7	$58
12.7	-	14.2	$63
14.2	-	15.7	$68
15.7	-	17.2	$74
17.2	-	18.7	$79
18.7	-	20.2	$84
20.2	-	21.7	$89
21.7	-	23.2	$95
23.2	-	24.6	$100
24.6	-	26.1	$105
26.1	-	27.6	$110
27.6	-	29.1	$116
29.1	-	30.6	$121
30.6	-	32.1	$126
32.1	-	33.6	$131
33.6	-	35.1	$137
35.1	-	36.5	$142
36.5	-	38.0	$147
38.0	-	39.5	$152
39.5	-	41.0	$158
41.0	-	42.5	$163
42.5	-	44.0	$168
44.0	-	45.5	$173
45.5	-	47.0	$179
47.0	-	48.5	$184
48.5	-	49.9	$189
49.9	-	51.4	$194
51.4	-	52.9	$200
52.9	-	54.4	$205
54.4	-	55.9	$210
55.9	-	57.4	$215
57.4	-	58.9	$221
58.9	-	60.4	$226
60.4	-	61.8	$231
61.8	-	63.3	$236
63.3	-	64.8	$242

Table A-14 (con't)

2005 East of Hudson Intermediate
Monthly Commutation Fare Structure

Mileage Between Stations			Monthly Fare
64.8	-	66.3	$247
66.3	-	67.8	$252
67.8	-	69.3	$257
69.3	-	70.8	$263
70.8	-	72.3	$268
72.3	-	73.8	$273
73.8	-	75.2	$278
75.2	-	76.7	$284
76.7	-	78.2	$289
78.2	-	79.7	$294
79.7	-	81.2	$299
81.2	-	82.7	$305
82.7	-	84.2	$310
84.2	-	85.7	$315
85.7	-	87.1	$320
87.1	-	88.6	$326
88.6	-	90.1	$331
90.1	-	91.6	$336
91.6	-	93.1	$341
93.1	-	94.6	$347
94.6	-	96.1	$352
96.1	-	97.6	$357
97.6	-	99.0	$362
99.0	-	100.5	$368
100.5	-	102.0	$373
102.0	-	103.5	$378
103.5	-	105.0	$383

A.6 Toll Structure

Toll structures for the Tappan Zee Bridge, HOT lanes, and bus park and ride facilities used in the BPM modeling are explained below.

Bridge Tolls

With respect to Tappan Zee Bridge tolls, the analyses assumed the same 2007 tolls as for the George Washington Bridge ($5 peak E-ZPass toll adjusted to 1996 dollars). (All tolls, fares, and incomes in the BPM were adjusted to 1996 dollars). It was noted that BPM does not distinguish between E-ZPass and cash customers. While a weighted average could be used, since peak period E-ZPass penetration rates are now at about 90 percent and E-ZPass penetration is slightly different by facility, it was determined that for demand modeling purposes (rather than for revenue analysis), the E-ZPass toll would be simplest and most accurate for reflecting travelers' choices. Tolls will remain constant in all alternatives/options, for all years, to avoid complicating the analysis by changing variables.

Tolls greater than GWB tolls would likely cause changes in travel patterns – changes that may not be easily observed using the current models. They represent another set of options that would require complete BPM runs to analyze.

HOT Lanes

The nominal toll will be an output of the modeling process (i.e., the toll required to achieve target volumes on the HOT lanes). The three major components that were agreed upon in discussions with NYSTA (November 2006) were:

- **Target Volumes/Level of Service.** Minimum speeds in the HOT lane should be about 50 mph, which can be maintained with volumes as high as 1,300 vehicles per hour per lane. In modeling the HOT lanes, an iterative process was used, adjusting the toll levels upward or downward to get volumes as close as possible to 1,300, to represent the dynamic tolling proposed.

- **Geographic Segmentation.** Two toll segments were set up on the HOT lanes, with the split placed at Interchange 12/Palisades Mall Lot J. The toll on the eastern segment (between Interchange 12 and Interchange 9) was in addition to the regular $5 toll on the Tappan Zee Bridge. While this structure would likely leave some capacity unused on the western portions of the HOT lanes, any additional segments would require that motorists be confronted with complex and potentially confusing signs.

- **Tolls by HOV Class.** It was assumed HOV2s would be tolled at the SOV rate while HOV3+ vehicles would use the HOT lanes for free. Other options include (1) tolling HOV3+ vehicles and (2) giving HOV3+ a 50 percent discount during most hours (and charging them the full SOV toll during Friday and Sunday evenings).

  The main reason to toll HOV3 vehicles during the week is not to earn extra revenue, but to avoid the burden of enforcement. For this reason a 50 percent discount was eliminated, as it would require the same level of enforcement as not tolling HOV3. It was decided that the first 2035 HOT lane BPM run would simulate HOV3 free use; the magnitude of HOV3 demand would be assessed from a second set of BPM runs with all autos tolled equally.

Bus Park and Ride Facilities

Current bus park-and-ride charges in the NY area are:

- About 98 percent of current bus park-and-ride users in Rockland County are charged no fees.
- Orange County park and rides are charged $102/year = $0.41/day.
- Charges at the New Jersey Turnpike Authority's Vince Lombardi Park-and-Ride are an equivalent of $1.50/day.

Parking charges at CRT stations range from $0.77 to $2.13 per day. While it is not likely that this range will lead to any significant changes in ridership forecasts, in order to compare BRT and CRT ridership on as consistent a basis as possible, the same charge at new bus park-and-rides would be used as that levied at equivalent CRT stations in Alternatives/Options 4A, 4B, 4C and 4D. The proposed charges, equal to the nearest existing CRT station, are shown below:

Rockland	Nearest Existing Commuter Rail Station	Cost
Exit 15A	Suffern	$25/month = $1.25/day
Airmont Rd	Suffern	$25/month = $1.25/day
GSP/Exit 14	Spring Valley	$192/yr = $0.77/day.
Palisades Mall/Lot J	Spring Valley	$192/yr = $0.77/day.

Westchester	Nearest Existing Commuter Rail Station	Cost
Elmsford	Irvington	$2.13/day
Hillsdale Ave.	Irvington	$2.13/day