TAPPAN ZEE BRIDGE/I-287
ENVIRONMENTAL REVIEW

New York State Thruway Authority
Metropolitan Transportation Authority
Metro-North Railroad

Alternatives Analysis for Commuter Rail Hudson River Crossing

TECHNICAL MEMORANDUM

Tappan Zee Bridge/I-287 Corridor
Environmental Review

September 26, 2005

ARUP / EarthTech

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Chapter	Title	Page

LIST OF FIGURES

LIST OF TABLES

Number **Title** **Page**

LIST OF ACRONYMS AND ABBREVIATIONS

AA	Alternatives Analysis
AGL	Above ground level
AREMA	American Railroad Engineering and Maintenance-of-Way Association
BPM	Best Practice Model
BRT	Bus Rapid Transit
cfm	Cubic feet per minute
CFR	Code of Federal Regulations
CRT	Commuter Rail Transit
CWA	Clean Water Act
cy	Cubic yards
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HOT	High Occupancy Toll
LOS	Level of service
LRT	Light Rail Transit
MPT	Maintenance and protection of traffic
MTA-MNR	Metropolitan Transportation Authority - Metro-North Railroad
MW	Megawatt
NFPA	National Fire Prevention Association
NO_x	Nitrogen Oxides
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYSDOT	New York State Department of Transportation
NYSTA	New York State Thruway Authority
RHA	Rivers and Harbors Act
ROW	Right-of-way
sq ft	Square feet
TBM	Tunnel boring machine
TDM/TSM	Transportation Demand Management/Transportation Systems Management
TOFC	Trailer on flat car
TPSS	Traction power substation
USACOE	US Army Corps of Engineers
USEPA	US Environmental Protection Agency
WRP	Waterfront Revitalization Program

1 INTRODUCTION/BACKGROUND

This paper is one of a series that documents the technical analyses that have been conducted as part of the Alternatives Analysis (AA) process for the Tappan Zee Bridge/I-287 Corridor Environmental Review. The federal lead agencies for this study are the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA).The sponsoring agencies are the New York State Thruway Authority (NYSTA) and the Metropolitan Transportation Authority (MTA), Metro-North Railroad in coordination with the New York State Department of Transportation (NYSDOT)

It is important to note that the AA process is the planning phase of the Environmental Review, the purpose of which is to develop a short list of alternatives to be carried forward into the Draft Environmental Impact Statement (DEIS). In the course of this planning phase, design concepts have been developed at a level of detail commensurate with making planning decisions. As such, the discussion of impacts in this study is indicative of what would be the upper bound of a range of potential impacts associated with these concepts. The analyses that will be conducted during the DEIS Stage will better define the nature, extent, and significance of impacts, and identify appropriate mitigation measures, where possible.

Two types of commuter rail transit (CRT) river crossings have been studied using the Level 2 Screening Criteria (engineering, transportation, environmental, and cost) that were used in selecting the type of highway crossing:

- **Bridge Option** – commuter rail on the lower level of a new dual-level highway bridge or on a new single-level highway bridge. This CRT bridge crossing is part of all proposed Draft Environmental Impact Statement (DEIS) build alternatives.

- **Tunnel Option** – a new commuter rail tunnel north of a new highway-only bridge.

The purpose of this paper is to determine whether or not a CRT tunnel crossing will be carried forward into the DEIS Stage in addition to the Bridge Option.

For the most part, the convention followed in this paper in addressing the potential impacts of both options (measured against the various evaluation criteria) is to focus on the **incremental** impacts only of adding rail to a highway-only bridge versus the impacts of constructing a new rail tunnel as an increment to a highway-only bridge. However, where appropriate, and to put potential impacts into context, the impacts of a new highway and CRT bridge are described against the impacts of a new highway bridge and CRT tunnel. In other words, **both** the Bridge and Tunnel Options have as their common benchmark, a highway-only bridge aligned slightly north of the existing bridge.

The overall study area for the AA process has been the entire I-287 Corridor from Suffern to Port Chester. The scope of this task encompasses the more limited area between Interchange 12 in Rockland and I-287 Exit 4 (Knollwood Road) in Westchester. In the course of this task, the focus has narrowed to the area between Thruway Interchange 10 in Nyack and Interchange 9 in Tarrytown, where the significant differences between the two options occur. In other areas of the corridor, potential impacts are generally common to each option.

Any option for a river crossing must meet the NYSTA's and Metro-North's operating and maintenance requirements. These requirements are fully described in Chapter 2 along with the facility design concepts.

Chapters 3, 4, 5, 6, and 7 present the evaluation of the design concepts with respect to the engineering (including fire/life safety), transportation, environmental, cost, and security criteria that were used in determining whether or not the Tunnel Option should be carried forward into the DEIS Stage (Chapter 8).

1.1 AA Process

One of the objectives of the AA process has been to reduce the large number of individual project elements identified at the onset of the study into a manageable number of alternatives to be carried forward into the DEIS Stage. The AA process included two levels of screening. In Level 1 screening, a "long list" of approximately 150 alternative elements was identified, analyzed, and evaluated according to a set of selection criteria. These alternative elements were developed through a comprehensive program of public outreach, review of previous studies, and recommendations from various agencies, and were grouped into four broad categories: Travel Demand Management/Transportation System Management (TDM/TSM); New/Improved Transit Services; Corridor Improvements; and Hudson River Crossing Improvements. The application of these screening criteria and evaluation methods narrowed down the long list of alternative elements to 72.

The 72 alternative elements that survived Level 1 screening were then combined into 15 corridor-wide scenarios that represented combinations of the more promising elements for TDM/TSM, highway, transit, and river crossing options, as follows:

- No Build.
- Rehabilitation of the bridge with TDM/TSM measures.
- A highway improvement only option with a replacement bridge.
- Six transit uni-modal scenarios consisting of full corridor bus rapid transit (BRT), light rail transit (LRT) (high-speed), or CRT options with a variety of river crossing options.
- Six multi-modal alternatives that combined various transit elements with a variety of river crossing and highway improvement options.

In the Level 2 screening process, the scenarios were developed in sufficient detail to permit the necessary transportation, engineering, environmental, cost, and security analyses. This involved advancing conceptual designs for highway, river crossing, and transit elements; developing conceptual level service plans for those scenarios with transit components; and extensive computer modeling to forecast future travel demand. During the Level 2 screening process, several decisions have been made regarding such factors as highway alignments, transit modes, and transit alignments. Studies have also been done to determine the type of river crossing (bridge vs. tunnel) for both highway and CRT that should be studied further in the DEIS Stage.

The process of determining the type of river crossing for highway and rail has been conducted in two steps. The first step resulted in the decision to eliminate a combined highway and CRT tunnel (because of significant transportation, environmental, and cost impacts) in favor of a highway and CRT bridge for inclusion in all proposed DEIS build alternatives (4A, 4B, and 4C as described below) that include CRT. The second step, described in this paper, examines the impacts of constructing and operating a highway-only bridge along with a supplemental CRT tunnel.

Within this limited study area, and for purposes of this paper, the highway bridge considerations have included the two generally accepted study goals: 1) congestion mitigation through traffic lane balancing to minimize traffic choke points and bottlenecks and; 2) any additional travel lane capacity to be considered primarily for transit purposes. Therefore, the highway bridge has been deemed to have four general travel lanes in each direction (matching the existing four lanes on each shoreline) and one new Bus Rapid Transit/High Occupancy Toll (BRT/HOT) lane in each direction.

It is understood that this paper will discuss physical locations in the study area where maximum impacts may be identified. The intention of the study is to minimize property takings and displacements wherever possible and stay within the existing Thruway and Metro-North rights-of way (ROWs). Any references made in this paper regarding expansions beyond those ROWs should simply be viewed at this time as preliminary and, if needed, mitigation measures will be studied and analyzed during the DEIS Stage.

The screening process and recommended DEIS alternatives are described in detail in the document *Alternatives Analysis, Process for Development of EIS Alternatives* (draft October 18, 2004, to be finalized in October 2005).

1.2 Proposed DEIS Alternatives

To date, the Level 2 screening process has resulted in the identification of the following set of proposed DEIS alternatives (with the type of CRT crossing to be determined in this paper):

- **Alternative 1 -** No Build.
- **Alternative 2 -** Bridge Rehabilitation with TDM/TSM Measures.
- **Alternative 3 -** Full Corridor BRT and Highway Improvements in Rockland.
- **Alternative 4A -** Full Corridor CRT and Highway Improvements in Rockland.
- **Alternative 4B -** Manhattan-Bound CRT with LRT in Westchester County and Highway Improvements in Rockland (with transfer to LRT in the Tarrytown vicinity).
- **Alternative 4C -** Manhattan-Bound CRT with BRT in Westchester County and Highway Improvements in Rockland (with transfer to BRT in the Tarrytown vicinity).

All of the recommended CRT build alternatives (4A, 4B, 4C) include CRT service in Rockland County and CRT on a bridge with a direct connection to the Hudson Line in the Tarrytown vicinity. (The need for a direct connection is addressed in the paper *Alternatives Analysis, Hudson Line Direct Connection vs. Tarrytown Transfer Station,* October 18, 2004.) They differ in the type of transit service proposed for Westchester County: CRT in Alternative 4A, LRT in 4B, and BRT in 4C.

For either the Bridge or Tunnel Option, transit service would follow similar routes, differing primarily in the Tarrytown area:

- For both the Bridge and Tunnel Options, the rail line enters a 2.3-mile shoulder tunnel east of Palisades Center Mall, ending at the Hudson River. From there, either a 3-mile separate rail tunnel would be built north of the highway-only bridge alignment or rail would be placed on the new 3-mile highway bridge, which would be built in either option.
- In the Bridge Option, the rail line coming off the bridge would enter a new underground Tappan Zee Station about 40 feet below and just north of the Tappan Zee toll plaza. This station would serve as a transfer point to LRT/BRT in Alternatives 4B and 4C, respectively, and as a new

Tarrytown area station (Tappan Zee Station) in Alternative 4A. Beyond the station, the CRT would continue in a 1-mile tunnel connecting to the Hudson Line north of Irvington.

- In the Tunnel Option at the Westchester shoreline, the alignment would curve below ground to meet the existing Tarrytown Station, where a lower level station would be constructed 60 feet below and adjacent to the existing station. The expanded station would serve as a transfer station to LRT/BRT in Alternatives 4B/4C and between commuter rail lines in Alternative 4A. The line would surface to meet the Hudson Line north of Irvington.

- For both options, in the full corridor CRT Alternative 4A, the lines split below ground to either a Hudson Line connection or an eastbound rail line to White Plains and Port Chester (connecting to the New Haven Line). Both options include a 4-mile shoulder tunnel from Tarrytown east towards White Plains.

2 ENGINEERING ELEMENTS

The following characteristics define the Bridge and Tunnel Options:

- **Bridge Option**: A highway bridge including four general purpose lanes, matching the existing lanes on both approaches, and one BRT/HOT lane in each direction, plus two CRT tracks configured in either a dual-level or single-level arrangement. CRT would connect Rockland County with Westchester County and the Hudson Line. A new underground station would be provided in the area of the existing Tappan Zee Bridge toll plaza (the Tappan Zee Station). In Alternatives 4B and 4C, riders would transfer at Tappan Zee Station between CRT and cross-Westchester LRT or BRT.

- **Tunnel Option**: A highway bridge including four general purpose lanes, matching the existing lanes on both approaches, and one BRT/HOT lane in each direction, plus a separate two-track CRT tunnel aligned north of the bridge. CRT would connect Rockland County with Westchester County and the Hudson Line with transfers at an expanded two-level Tarrytown Station. In Alternatives 4B and 4C, riders would transfer at Tarrytown Station between CRT and cross-Westchester LRT or BRT.

From previous analyses, the preferred alignments for these two options were determined to be just north of the existing Tappan Zee Bridge. Figures 2-1 and 2-2 show the alignments and the profiles of the Bridge and the Tunnel options. Both of the alignments are broken out by segments to facilitate the analysis in this paper.

2.1 Operating Requirements

One of the first steps in developing the engineering elements for both the Bridge and Tunnel Options was to define the operating requirements for the transportation systems. The specific requirements were provided by NYSTA and Metro-North.

2.1.1 NYSTA

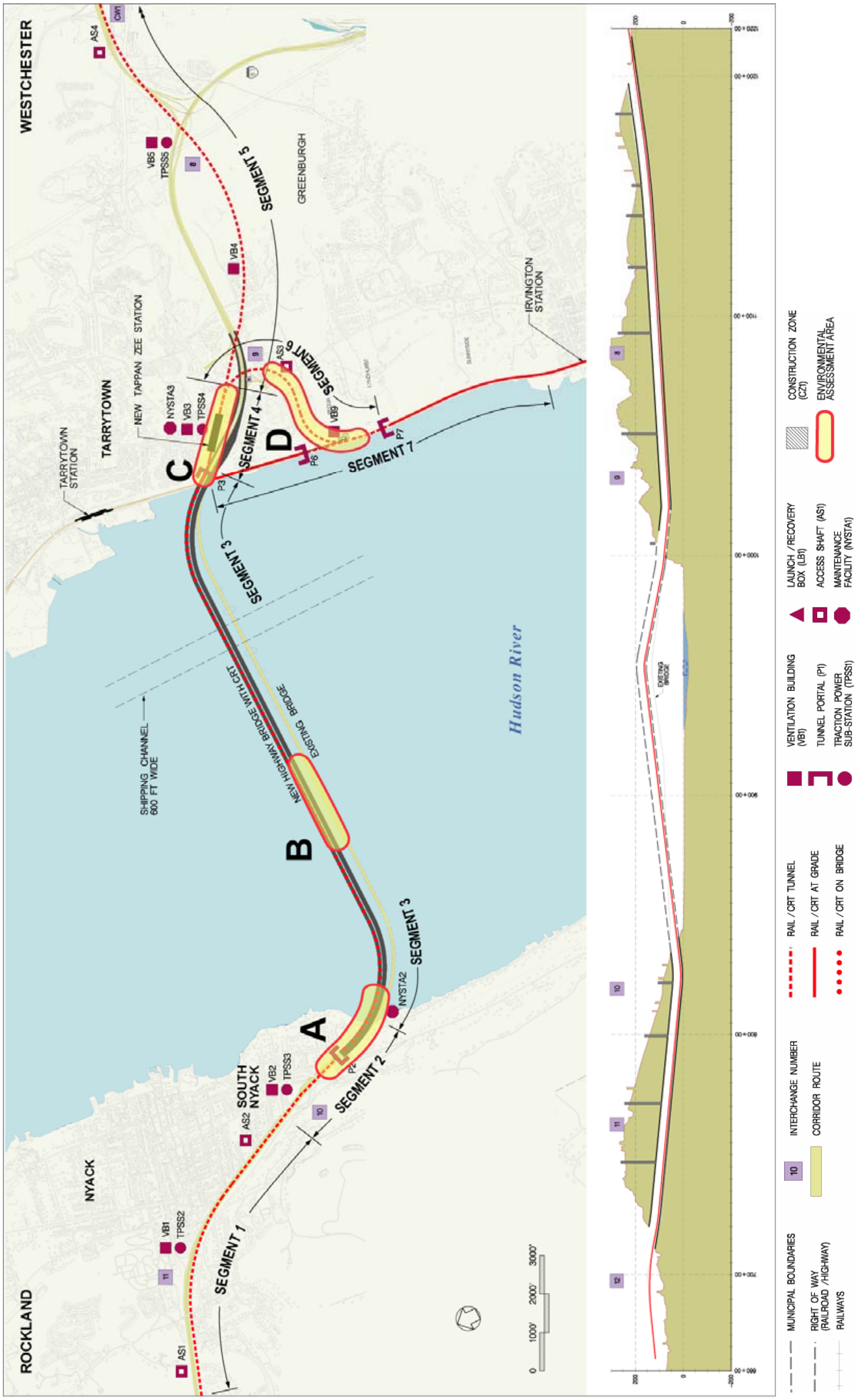
The key operating requirements identified by the NYSTA are:

- Provide independent and dedicated access (southbound and northbound) from Thruway maintenance and administrative facilities (including State Police) to the mainline at all times.

- Maintain or improve existing levels of service.

- Locate all highway (vehicular) lanes on one level to optimize lane utilization.

- Locate facilities such that State Police and Thruway emergency vehicles are in close proximity to the bridge. Provide one-minute access time to the northbound and southbound lanes on the bridge.



Bridge Option – Plan and Profile

Figure 2-1

Tunnel Option – Plan and Profile

Figure 2-2

- Provide four U-turns (with electronic gates) to accommodate emergency response and maintenance vehicles. Provide one U-turn on each end of bridge and two in between.

- Provide access roads at both ends of the bridge for turn-around of Thruway maintenance and State Police vehicles carrying out emergency response and maintenance activities.

- For safety reasons, locate access roads/ramps to and from the Thruway on the right side.

- Provide unrestricted access at all times to the bridge structure, including the area over commuter rail tracks.

- Design the bridge structure to accommodate pedestrians, cyclists, and alternative transportation modes.

- Include staging areas on both ends of the bridge for quick and safe stopping of commercial traffic for inspection before entering the bridge.

- Provide effective separation between pedestrians and CRT.

- Design the bridge such that the probability of loss of crossing is less than 1 percent in 100 years for any natural hazard.

- Provide new NYSTA facilities with adequate space for Tarrytown headquarters, the Rockland docking facility, and the New York Division at Tarrytown.

2.1.2 Metro-North

The key operating requirements identified by Metro-North are:

- Support electric, diesel, and dual-mode operations. Dual modes must be able to operate in diesel mode without disrupting service.

- Size ventilation systems and facilities to exhaust diesel fumes from tunnels within 5 minutes (to safely allow the passage of a following train without affecting schedule) and to provide acceptable air quality in underground stations at all times.

  The service plan includes scheduled operation of dual-mode locomotives on electric power in the shoulder and underwater tunnels. However, engine failures, third rail problems, power distribution problems, diesel work trains, diesel rescue trains and potential freight operations would all require diesel operations in the tunnels. Phasing-in of electrification in Rockland/Westchester would necessitate scheduled diesel operation during an interim period.

  During the course of this study, the average time between trains across the Hudson River was determined to be 4.5 minutes. It was agreed that this time would form the basis of design because further analysis indicated that to meet practical train schedules across Rockland, passage across the Hudson River would be required at intervals of 3 to 6 minutes.

- Provide adequate third rail power supply and distribution (e.g., substations per Metro-North requirements).

- Provide a vehicular maintenance way, or equivalent access, for scheduled and unscheduled maintenance activities in the Bridge and Tunnel Options in support of Metro-North's maintenance/inspection procedures that follow federally mandated code (Code of Federal Regulations (CFR) 49 Part 213- Track Safety Standards) for high speed class V track, ensuring minimum impact on operations. No vehicular access is required for shoulder tunnels in Westchester and Rockland, if frequent surface access is provided.

- Base criteria for fire/life safety on National Fire Prevention Association (NFPA) 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems* (2003 Edition) and NFPA 502, *Standard for Road Tunnels, Bridges and Other Limited Access Highways* (2004 Edition). Coordination with local authorities is deferred to the DEIS Stage and final design stages.

- Provide access for emergency vehicles in the Bridge and Tunnel Options.

- Provide access/egress for emergency and scheduled and unscheduled maintenance activities in the shoulder and connecting tunnels and underground stations through access points at not more than 0.5-mile centers. Access points may be combined with ventilation buildings where possible.

- Accommodate diesel freight operations assuming standard freight with maximum axle loads of 65,000 pounds and trailer on flat car (TOFC) requiring minimum vertical clearance of 17 feet 9 inches.

- Operate the system 24 hours a day, 7 days a week.

- Provide crossovers at each end of the river crossing and at each end of the shoulder tunnels to maximize operational flexibility and to ensure that any section of the system can be made available for one-track operation.

2.2 Physical Constraints

In addition to the operating requirements established by the agencies, a number of physical constraints influenced the engineering requirements within the crossing area:

- The advance and retreat of Pleistocene era glaciers through raised rock formations at the bridge site created a local river valley. On the west side, both bedrock and the overlying topography slope rapidly upward away from the river. On the east side there is a cliff formation with overlying topology that continues to rise away from the river. The high elevations and sustained grades on both sides of the river require long CRT shoulder tunnels in both the Bridge and Tunnel Options.

- Historical and recent data from borings in the river adjacent to the existing Tappan Zee Bridge indicate that soil conditions in the river are poor. Bedrock beneath the river varies from a depth of 200 feet on the eastern half to 750 feet and more on the western half. The rock is overlain by layers of progressively softer soils deposited by glacial action, by downstream river flow, and carried upstream by tidal action, respectively. Bridge foundations can reach the competent rock on the eastern half, but piers will have to be founded in the poor soils in the western half, making settlement and seismic forces of significant concern.

- Review of historical geological data received from NYSTA, Metro-North, and NYSDOT confirms the general knowledge of the corridor’s geology away from the river, with competent rock at generally shallow depth beneath the corridor in Westchester and Rockland counties. Therefore, the bulk of the CRT shoulder tunnels must be bored, mined or cut through rock.

- Limited historical geological data is available for the Westchester or Rockland shore areas. This is a key area for tunnel construction, as the elevation of the rock to soil interface would impact the location of launch and recovery boxes for tunnel boring machines (TBMs).

- There is a history of moderate seismicity in the New York City region, with earthquakes estimated at a magnitude of 5.2 having occurred in 1737 and 1884, along with numerous lesser ones. The deep soft soils overlaying the bedrock will tend to amplify the ground shaking in a seismic event. A site-specific design 500-year earthquake is likely to occur within the service lifetime of the bridge.

- Tidal range is not significant, but the existing Hudson Line and Tarrytown Station area elevations are below the 50-year flood level.

- The lower level of the Tarrytown Station (Tunnel Option) and a portion of the Hudson Line connecting tunnel (Bridge Option) would be below sea level.

- The main spans of the existing bridge are located over the natural channel for the river.

- A tributary of the Hudson River formerly occupied the area of the present Tarrytown Station and the proposed Ferry Landing site. Geotechnical information indicates soft soils extend 120 feet below existing ground with potential implications for construction methodology.

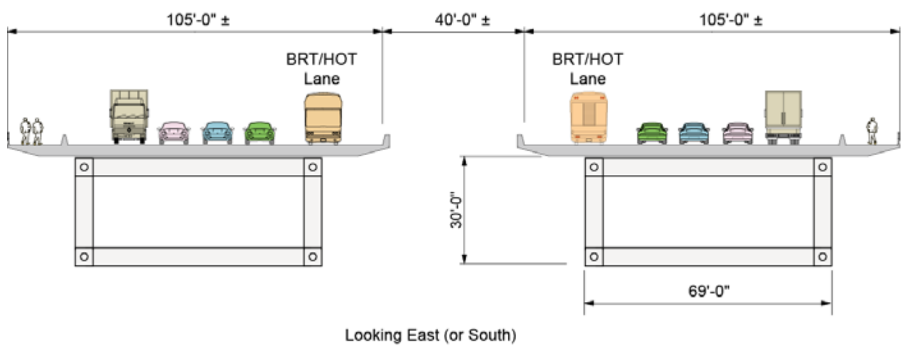
- Records indicate that fill placed in the area along the Hudson Line was uncontrolled during construction of Grand Central Terminal and could consist of large boulders. This condition would impact the design of the tunnel.

- To facilitate use of existing Metro-North rolling stock, the maximum grade for track underground is 1.5 percent for sustained lengths with short sections up to 2 percent and an absolute maximum of 2.5 percent where necessary due to geometric constraint. Above ground, the allowable grades are reduced to account for ice and fallen leaves. The allowable grades are 1.5 percent for sustained lengths with an absolute maximum of 2.0 percent for very short lengths.

- Every effort will be made to remain within the existing ROW and avoid partial takings, displacements, or easements. Further refinement of dimensional requirements and mitigation, if necessary, will be undertaken during the DEIS Stage.

2.3 Highway-Only Bridge

A highway-only bridge is the common component of both the Bridge and Tunnel Options. For the Tunnel Option, the bridge would have the configuration shown in Figure 2-3. The bridge would be configured with four general purpose lanes, matching the existing lanes on both approaches, and one BRT/HOT lane in each direction. It would be a minimum weight steel truss solution, thus reducing the demands on the poor founding soils. The use of trusses facilitates spans of up to 300 to 400 feet, resulting in 40 to 60 foundations across the river, each supporting two piers. The total area occupied by pilecaps in the river is 5 acres. The main span lengths would be 1,200 to 1,500 feet, compared to 1,212 feet for the existing bridge The total bridge width would be 250 feet, comprised of two truss structures each up to 105 feet in width separated by up to 40 feet to allow space for a tower in the main spans over the channel (Figure 2-3). This separation would not be required other than at the main towers.



Highway-Only Bridge Cross-Section

Figure 2-3

2.4 Bridge Option

The development of the Bridge Option involved the study of alignments, profiles, cross-sections, and a number of operating event scenarios. The primary objectives of the CRT alignment were to maximize the use of the existing NYSTA and Metro-North ROW in both the cross-corridor and Hudson Line routes and to provide a new station at the existing toll plaza (Tappan Zee Station). Considerations driving the profile included: a low profile on the Rockland shore; clearance over the shipping channel; elevation of the Saw Mill River; and connection from under the Hudson Line to the two existing express tracks.

From west to east, the alignment for the Bridge Option has seven distinct segments characterized primarily by common construction methods or location, with an overall length of approximately 65,000 feet (12.4 miles) (Figure 2-1):

- **Rockland CRT Shoulder Tunnel (Segments 1 and 2)** – These segments correspond to deep mining and cut-and-cover sections, respectively. The maximum grade required is 1 percent and segments cover a length of 12,000 feet and 2,000 feet, respectively, for a total of 14,000 feet from the Palisades Center Mall to River Road. Segment 2 also includes a 1,200-foot long cut and cover tunnel and subsequent retained cut for the BRT/HOT lanes.

- **River Crossing (Segment 3) –** This segment is the bridge over the Hudson River (approximately 16,000 feet). Based on discussions with the Coast Guard, clearance over the channel may need to be increased from the current 134 feet to 155 feet. This results in 1.2 and 2.0 percent grades, respectively, on the Rockland and Westchester structures approaching the shipping channel.

- **Tappan Zee Station Area (Segment 4)** – This segment is located north of and adjacent to the existing toll plaza and is characterized by cut-and-cover construction and a new underground Tappan Zee Station. The overall segment length is approximately 2,500 feet with a 1 percent grade through the station.

- **Cross-Westchester CRT Shoulder Tunnel (Segment 5)** – East of the Tappan Zee Station the tracks split, with one branch continuing across Westchester. This segment is characterized by mined tunnels, approximately 18,000 feet long. The alignment deviates from the Thruway mainline to avoid the Talleyrand Swamp.

- **Hudson Line CRT Connection Tunnel (Segment 6) –** This segment loops to the south from the Tappan Zee Station with a connection to meet the Hudson Line and is characterized by mining. The alignment is determined by the length required (4,500 feet) at the maximum grade of 2 percent to get below the Hudson Line and rises to meet the existing express tracks on the Hudson Line.

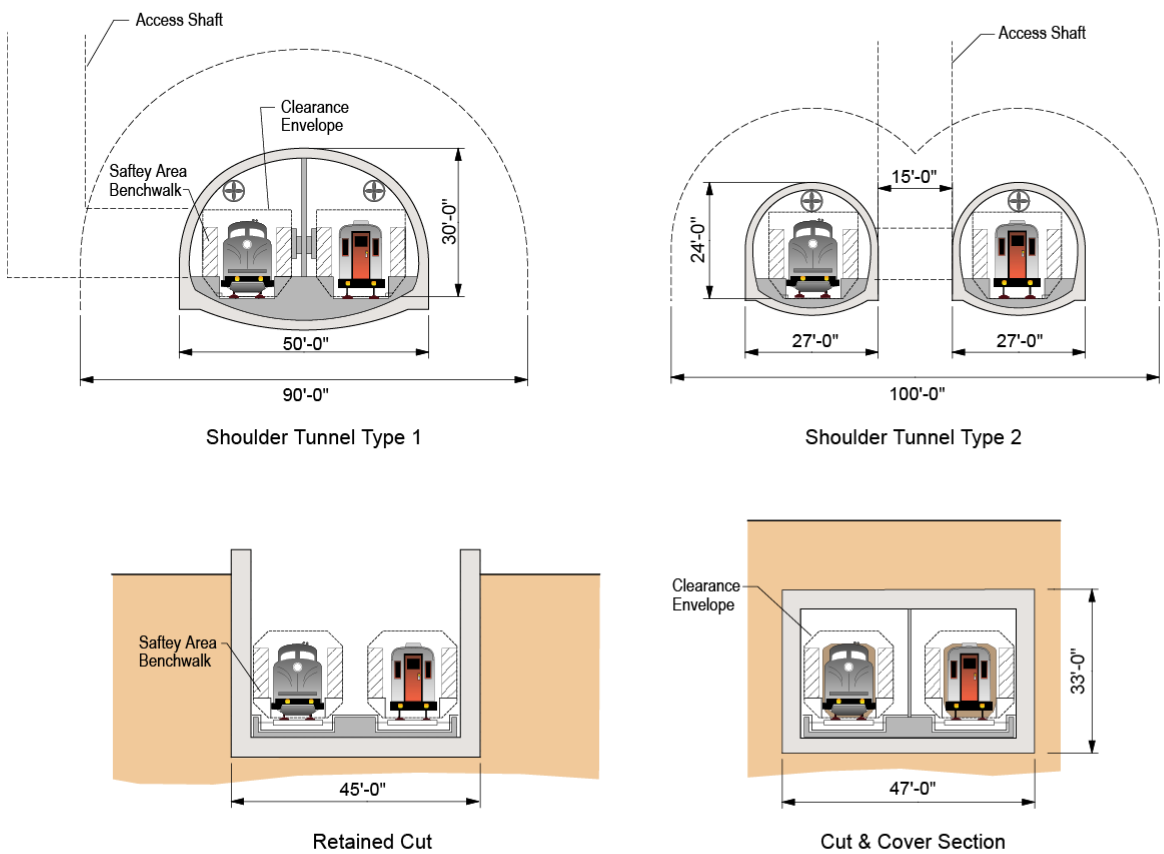
- **Hudson Line Connection (Segment 7) -** This segment is characterized by its location along the Hudson Line. The works along the Hudson Line include cut-and-cover, retained cut and raised sections, and modifications to trackwork beyond. The works extend from south of the Tappan Zee Bridge to just north of Irvington Station, approximately 10,000 feet.

Four modes of operation were studied including standard operation, congested operation, maintenance and inspection operation, and emergency operation. This study yielded spatial requirements for CRT track clearance, emergency/maintenance ways, support and safety systems, and ventilation, all of which, when combined with the geological conditions, were used to develop working cross-sections.

A number of potential bridge cross-sections were studied. A dual-level bridge formed the basis of the option, as it provided the greatest structural efficiency. The data presented below assumes the dual-level bridge but with additional discussion included on a single-level bridge where appropriate. Other bridge cross-sections will be studied in the DEIS Stage.

2.4.1 Rockland CRT Shoulder Tunnel (Segments 1 and 2)

Study of the spatial requirements for CRT track clearance, emergency/maintenance way, support and safety systems and ventilation yielded the basic spatial requirements for the cross-sections for the Rockland CRT shoulder tunnel, leading to four different basic cross-section types (Figure 2-4) to suit the varying geological and alignment constraints along the 14,000-foot segment.



CRT Shoulder Tunnel Cross-Sections

Figure 2-4

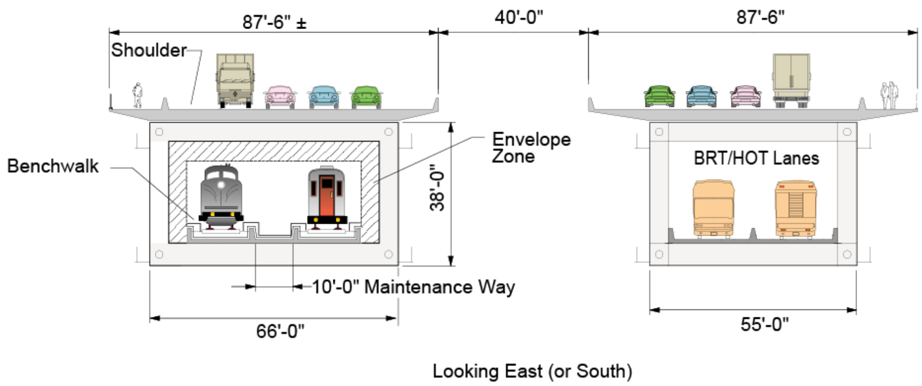
Construction of the shoulder tunnels would predominantly occur by drilling and blasting to reduce risks associated with varying ground conditions and to facilitate an early start to construction. Further geotechnical investigation may indicate that TBM tunneling is appropriate. Construction would commence from the portal near Interchange 12, with the majority of spoil rock suitable for recycling. Spoil would be transported via the Thruway to a suitable disposal area. The staging area required to facilitate construction would be approximately 1 to 2 acres.

Longitudinal ventilation would be used for the shoulder tunnel incorporating two ventilation buildings. The system does not require special air ducts within the tunnel cross-section but instead utilizes the main tunnel bores as air ducts. The volume of air, and hence the size and location of vent buildings, would be governed by the diesel ventilation requirements.

In the event of fire in the tunnel or other condition warranting train evacuation, passengers could pass into the area of the adjoining track through fire doors in a central fire-rated wall running the full length of the tunnel between the two tracks. This area would act as a place of safety until a rescue train arrives, or alternatively, walkways would lead passengers to points of egress. Access and egress would be through the vent buildings and additional access shafts at maximum half-mile intervals along the alignment.

2.4.2 River Crossing (Segment 3)

Two bridge options are being considered: a dual-level and a single-level bridge. For the dual-level option (Figure 2-5), it is assumed that each upper deck would carry four vehicular lanes with inside and outside shoulders. In addition, a pedestrian walkway would be provided on the outside of the right shoulder in each direction. To maximize off-site fabrication and facilitate erection, the structure would be separated into two similar halves corresponding to traffic direction. The total width would be up to 215 feet. The depth of the deck would facilitate long spans of 400 to 500 feet with 35 to 45 foundations across the river, each with two vertical piers with main span lengths of 1,200 to 1,500 feet.

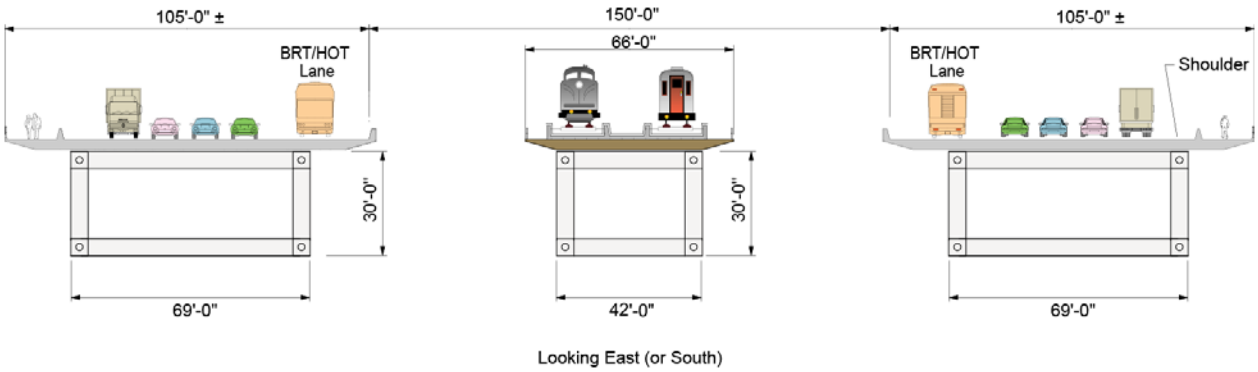


Dual-Level Bridge Cross-Section

Figure 2-5

Two CRT tracks separated by a 10-foot-wide maintenance way would be supported on the lower level of the north superstructure surrounded by a 5-foot clearance zone to allow for structure inspection and maintenance. Two BRT/HOT lanes, one in each direction, separated by a median barrier with shoulders would be supported on the lower level of the south superstructure. However, a dual-level bridge with BRT/HOT lanes does not meet NYSTA operating requirements of having all traffic on one level. These considerations will be addressed further in the DEIS Stage. The total area occupied by pilecaps in the river is approximately 6 acres.

The single-level bridge (Figure 2-6) would be comprised of three sections with the outer two supporting highway and BRT/HOT lanes and the center supporting CRT. Other arrangements would be possible, such as rail on the north side of the bridge, but their study is deferred to the DEIS Stage. The total area occupied by pilecaps in the river is approximately 8 acres. The total width would be up to 360 feet, with the same span arrangements as the highway-only bridge. The bridge superstructure would be constructed of open girders, thus not requiring any mechanical ventilation systems.



Single-Level Bridge Cross-Section

Figure 2-6

The alignments and profiles of both bridge options could be similar. The footprint of the single-level bridge option would be wider across the river. Nominally steeper grades would be required for CRT on the single-level structure because of the higher elevation to be achieved at the channel as a result of the deeper structure below the tracks. (A different kind of structure could be used at the crossing which could be shallower.)

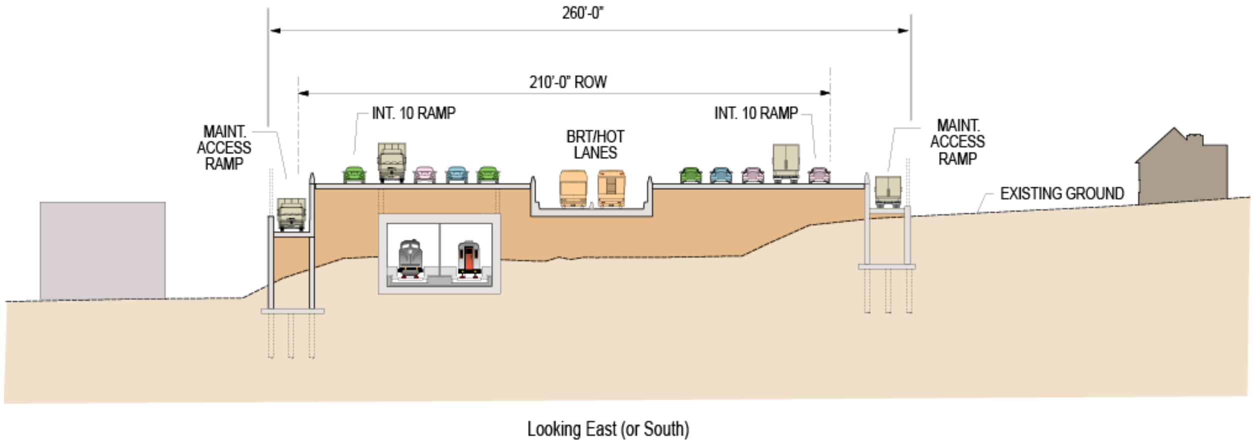
The arrangements of the bridge at the main spans are deferred to the DEIS Stage of this project.

Rockland Shore

Accepting standard specifications and prior to mitigation considerations (to be done during the DEIS Stage), the required width at the shore coming off a dual-level bridge is 260 feet (Figure 2-7), which includes highway and BRT/HOT lanes, shoulders, two ramps for Interchange 10, and an 8-foot allowance for sound walls/median and maintenance access ramps. The minimum existing ROW is 210 feet. For a single-level bridge, the maximum required width could be up to 290 feet (Figure 2-8). Reconfiguration of Interchange 10 and replacement of the associated bridges, including the Route 9W bridge would be required for either a single- or dual-level bridge.

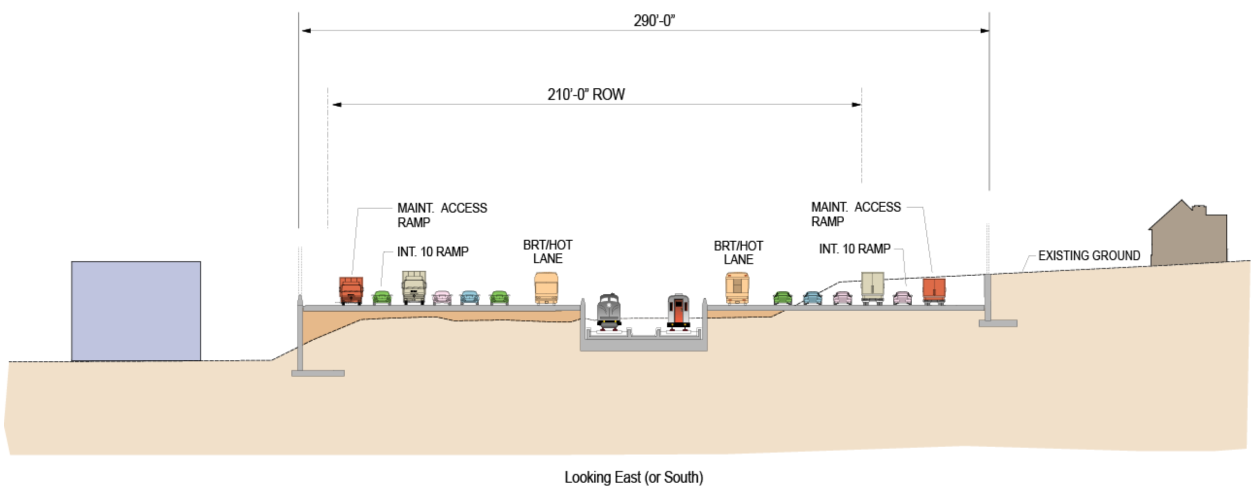
The construction of either a single- or dual-level bridge with CRT, with the associated access roads and ramps, while maintaining Thruway operations has the following consequences:

- Additional easements would be required on both sides of the ROW for tie-backs and retaining wall construction.
- Aside from temporary expansion during construction, the addition of the CRT shoulder tunnel under the Thruway does not require additional ROW.
- The alignment includes 2,000 feet of cut-and-cover CRT tunnel on the north side of the Thruway.
- The final elevation on the Thruway would be +70 feet or + 45 feet for dual-level and single-level bridges, respectively, compared to an existing elevation of +35 feet at the shoreline. The raised elevation is a consequence of raising River Road above the flood elevation to ensure access to the NYSTA maintenance and dock facilities, increasing the clearance over River Road and the deeper structure.



Section at Narrowest Point on Rockland Shore for Dual-Level Bridge

Figure 2-7



Section at Narrowest Point on Rockland Shore for Single-Level Bridge

Figure 2-8

Construction Staging

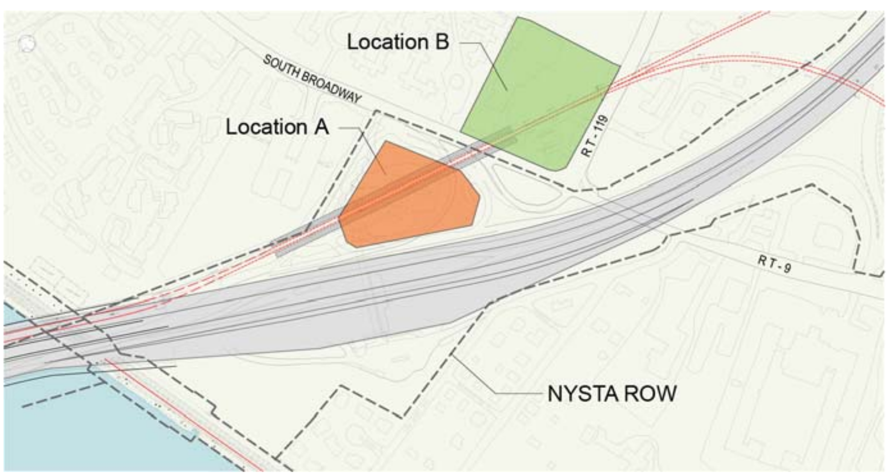
Construction of the Bridge Option in the shore area would most likely occur in three stages:

- **Construction Stage 1:** reconfigure Interchange 10 in anticipation of Construction Stages 2 and 3.
- **Construction Stage 2**: relocate the Thruway to the south for approximately 4,000 feet. This allows construction of the northern half of the new highway bridge and highway at grade with the CRT tunnel below. This temporary realignment would be anticipated for two to three years and would involve temporary access ramps at Interchange 10.
- **Construction Stage 3:** relocate Thruway traffic from the existing bridge to the newly constructed northern half of the replacement highway bridge with four restricted lanes in each direction in this temporary condition. The existing bridge would be demolished to make space for construction of the remaining half of the new highway bridge.

2.4.3 Tappan Zee Station Area (Segment 4)

In the Bridge Option, trans-Hudson trains would not be able to stop at the existing Tarrytown Station. A new Tarrytown area station (Tappan Zee Station) would be located near the Westchester end of the bridge, serving New York bound and cross-Westchester trains (or BRT/LRT via transfer).

The location of a new Tappan Zee Station and its orientation would be constrained by the northern alignment of a new bridge crossing and the location of CRT connection to the Hudson Line just to the north of the Lyndhurst property (a National Historic Landmark). These prime factors would confine the station to the area north of the existing toll plaza, with local track interlocking and curvature further constraining the potential locations. Pending further study in the DEIS Stage, the station platforms are assumed to be below Route 9, with approximately half the platform located underground within the NYSTA ROW (Location A) and the other half located underground east of Route 9 in an area currently occupied by banking and retail properties (Location B) (Figure 2-9).



Potential Tappan Zee Station Locations

Figure 2-9

The station platforms would be underground at depths varying from 35 to 65 feet below the existing ground; the high-end variation is the result of a 1 percent platform slope down towards the Hudson Line and a generally rising ground surface on the eastern side of Route 9. Facilities would include the following:

- Station head house.
- Parking for up to 500 vehicles.
- Kiss-and-ride curbs.
- Bus staging.
- Vertical and horizontal passenger circulation.
- Support facilities including ventilation and power.
- A small Metro-North maintenance facility.
- An upgraded NYSTA maintenance facility.
- Access and egress ramps.
- Associated internal vehicular circulation.
- Security and State Police staging.

The estimated square footage requirement of all these facilities is approximately 400,000 to 500,000 square feet (sq ft) and exceeds the space available at Location A (150,000 sq ft) or at Location B (200,000 sq ft) if constructed on one level. These facilities could be accommodated as multi-level facilities at Location A, Location B, or a combination of A and B. Initial layouts of Locations A and B were prepared to facilitate preliminary traffic studies but the specific configuration and location of the surface facilities were deferred to further study in the DEIS Stage.

Construction and Staging

Key considerations for construction of the Tappan Zee Station include:

- Construction of the station would be incremental to the activities associated with construction of the highway bridge and toll plaza and maintenance facilities.

- Construction of the underground station and some adjoining length on both ends would likely be by cut-and-cover techniques (pending further study in the DEIS Stage), requiring cut sections as deep as 65 feet and significant spoils storage.

- Because of the scale of the works in this area, simultaneous construction contracts would be anticipated, with storage and staging possibly required in Locations A and B.

- Spoil would be predominantly rock suitable for recycling.

- Maintenance and protection of traffic (MPT).

- Toll Plaza, maintenance yards, NYSTA maintenance facilities, Troop T operations, maintenance staging areas.

LRT/BRT

In Westchester, LRT or BRT alignments (Alternatives 4B and 4C) would commence at a terminal at Tarrytown Station, and continue south adjacent to the east side of the Hudson Line, turning east to provide a cross platform connection to Rockland/Manhattan CRT at Tappan Zee Station, and continue to Route 119 and further east. Through the Tappan Zee Station, the LRT or BRT alignments would be underground and would split to either side of the CRT platforms, allowing for a cross platform transfer. Construction in this area would be similar to that for CRT (cut and cover) but would extend along Route 119 to Meadow Street.

2.4.4 Cross Westchester CRT Shoulder Tunnel (Segment 5)

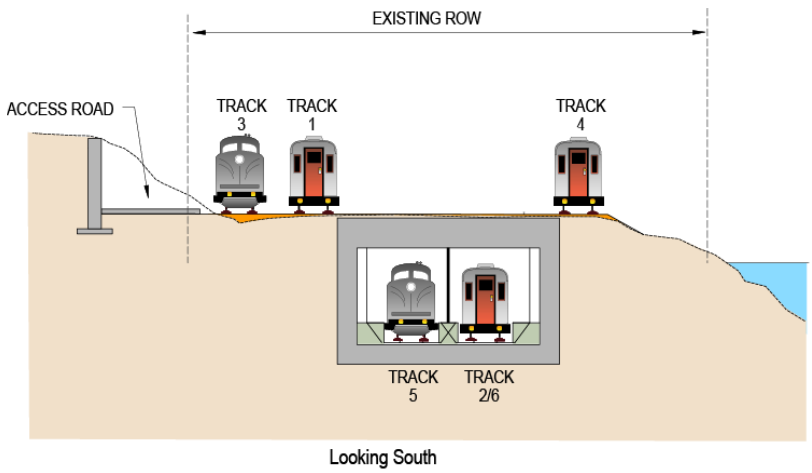
The Westchester shoulder tunnel has similar geological conditions to those of the Rockland shoulder tunnel and, therefore, utilizes the same four cross-section types. Similar to the Rockland shoulder tunnel, construction would be drill and blast mining due to the varied geological conditions and early construction start, though further geotechnical investigation may justify a TBM.

Construction access would be from a tunnel shaft in the region of Interchange 8, approximately mid-way along the overall 20,000-foot length of tunnel. The majority of spoil (rock) would be suitable for recycling and could be transported via the Thruway to a suitable disposal area. The staging area required to facilitate construction would be approximately 1 to 2 acres.

2.4.5 Hudson Line CRT Connection Tunnel (Segment 6)

The Hudson Line connection tunnel would be primarily a deep-mined rock tunnel whose top would be 50 to 100 feet below existing ground surface. Construction is assumed to be by drill and blast or TBM. Access for construction is from either end, with spoil (300,000 cubic yards [cy]) expected to be suitable for recycling. The tunnel passes under the Thruway in the region of Interchange 9 and a number of residential and commercial properties. The alignment developed for this study places the tunnel directly under or adjacent to the Kraft property.

At the connection to the Hudson Line, located under the Kraft-owned Requa House property (a NYS inventoried archaeological site) (Figure 2-10), soft soils in this area would require cut-and-cover type construction with access from temporary platforms in the river.



Connection to the Hudson Line at Requa House Property – Segment 6

Figure 2-10

2.4.6 Hudson Line Connection (Segment 7)

The CRT alignment along the Hudson Line and associated trackwork assumes a five-track configuration to contain all works within the existing ROW with the possible exception of a support structure of the currently unused Lyndhurst footbridge over the Metro-North ROW. This requires the southbound express track on the Hudson Line (Track 2) to be dropped into a tunnel to connect with Track 6 from the Hudson Line connection tunnel. The resulting tunnel section is 1,500 feet, with retained cuts at each end and flood ramps at each end. The total length of trackwork affected is 10,000 feet when additional turnouts are introduced to allow for Tracks 5 and 6 to reach the local tracks north of Irvington Station.

In the region of the Sunnyside property, for a length of approximately 2,500 feet, the required width is in excess of the practical width available. Though no new ROW is required, the new track would be built over the existing river edge rip rap protection. To meet current clearance requirements, the rip rap area would need reconstruction and the rip rap would need to be extended about 5 to 10 feet into the river. Alternatively, it may be feasible to reduce the required clearance between tracks from the standard of 14 feet to the current 12-foot clearance. Further study is deferred to the DEIS Stage.

The tunnels and retaining structures would conflict with two culverts under the existing Hudson Line; diversion of these culverts would be required. Staging and storage to support construction along the Hudson Line would be from temporary platforms in the river (2 acres).

2.4.7 Support Facilities

Support facilities (e.g., traction power substations (TPSSs), vent buildings, access shafts, maintenance facilities) would be required at 17 locations for the Bridge Option in the crossing area. The following are some notable requirements:

- Total surface area of all facilities in the crossing area would be approximately 200,000 sq ft, including nine ventilation buildings, seven TPSSs, and six access shafts. Some facilities would be combined, and some would be within underground CRT stations.
- The ventilation buildings would range in size from 5,000 to 20,000 sq ft. Four would be located entirely above ground, three would be within underground CRT stations, and two would be underground. All would have a vent shaft rising 50 to 100 feet above ground, ranging in plan from 24 feet by 24 feet to 38 feet by 38 feet. Three plants would be combined with traction power facilities. All ventilation buildings would serve as emergency access and egress points. The underground plants would require a single-story access building of roughly 850 sq ft. All nine ventilation facilities would require a 5,000 sq ft above-ground area for parking, staging and storage, and a security fence enclosing the entire facility.
- One 20,000 sq ft underground vent facility would be located on either Requa House or Kraft property adjacent to the Hudson Line.
- To refine the vent shaft height requirements, further study of emission control requirements and meteorological conditions through dispersion modeling will be done in the DEIS Stage.

- The seven TPSSs would range in size from 5,000 to 15,000 sq ft. Three would be within underground CRT stations and four would be above ground (three combined with ventilation buildings and one at the Palisades Mall portal).

- TPSSs would be located at 5,000-foot intervals, with larger facilities at both the Rockland and Westchester shores to account for the long crossing. As system robustness and power degradation have not been studied in detail, further analysis is required in the DEIS Stage to determine if a TPSS would be required at an intermediate point on the crossing.

- The six access shafts would require a single-story access building of roughly 850 sq ft, a 5,000-sq ft above-ground area for parking, staging and storage, and a security fence enclosing the entire facility. Access shafts would be located between ventilation buildings to provide access points to the shoulder tunnels at intervals not exceeding one-half mile.

2.5 Tunnel Option

The development of the Tunnel Option involved the study of alignments, profiles, cross-sections, and a number of operating event scenarios. The objectives of the CRT alignment were to maximize the use of the existing NYSTA and Metro-North ROW in both the cross-corridor and Hudson Line routes, thus minimizing construction impacts, and to provide a connection to the Hudson Line at a new lower level to be constructed beneath the Tarrytown Station.

From west to east, the alignment for the Tunnel Option has six distinct segments with an overall length of approximately 69,000 feet (13.1 miles) (Figure 2-2):

- **Rockland CRT Shoulder Tunnel (Segments 1 and 2)** – These segments comprise mined and cut-and-cover tunnels of 13,500 feet and 500 feet, respectively, with a total length of 14,000 feet. The grade is on average 1.7 percent, with a maximum depth to top of tunnel of approximately 170 feet.

- **River Crossing (Segment 3)** – This segment, approximately 14,000 feet long, is located under the Hudson River. The CRT alignment diverges from the bridge at the Rockland shoreline and curves north towards the existing Tarrytown Station. It includes two locations of minimum horizontal radii with a maximum allowable CRT speed of 35 mph. At the Rockland shore the alignments of the CRT tunnel and highway-only bridge are positioned to separate foundation structures and provide space for the necessary support facilities. The tunnel would be located at least one diameter below the river bed to counter buoyancy.

- **Tarrytown Station Area (Segment 4)** – This segment is located on the Westchester shore and comprises primarily cut-and-cover construction along the shore. The overall segment length is approximately 7,500 feet and includes new underground platforms at the expanded Tarrytown Station. To minimize the depth of the underground platforms, the maximum allowable 2 percent grade is used north of the station. To avoid property displacements at Van Wart Avenue, this segment adopts a five-track arrangement in which Track 1 is dropped underground into tunnel to connect with the cross-Rockland tracks.

- **Cross-Westchester CRT Shoulder Tunnel (Segment 5)** – This segment splits from Segment 4 in the area of the existing Tappan Zee Bridge and extends east across Westchester. Construction is predominantly deep mining with a total length of 20,000 feet.

- **Hudson Line Connection (Segment 6)** – This segment would be located along the Hudson Line south of Segment 4 and is comprised of retained cut and fill. In addition, this segment includes modifications to existing trackwork between Tarrytown and Irvington Stations for a length of 13,500 feet, including a turntrack.

The same four modes of operation detailed in the Bridge Option were considered for the Tunnel Option, as well. This analysis yielded spatial requirements for CRT track clearance, emergency/maintenance way, support and safety systems, and ventilation, all of which, when combined with the geological conditions, were used to develop working cross-sections for the river tunnel and shoulder tunnels.

2.5.1 Rockland CRT Shoulder Tunnel (Segments 1 and 2)

As the Rockland shoulder tunnels in the Tunnel Option are very similar to those of the Bridge Option, further analysis was not conducted as part of this study but deferred to the DEIS Stage.

2.5.2 River Crossing (Segment 3)

This section outlines the development of the basic twin-bore river tunnel cross-section, outlines the principal spatial requirements, and includes details with respect to the ventilation system adopted, fire events, and construction methodology assumed. The soft soils in the river require the use of a TBM, which implies: a circular cross-section; a limitation on overall size of 46 feet (the limit of proven technology); the need for launch and recovery shafts possibly in the river at each end of the tunnel at the soil/rock interface; and potential ground modifications at each end of the tunnel to ensure progress of the TBM through the rock/soil interface. The Tunnel Option includes the highway-only bridge as described in Subchapter 2.3.
Spatial requirements for the river tunnel include:

- **CRT Track Clearance Envelope.** The trainway was sized and clearances provided to allow for Metro-North commuter trains as well as American Railroad Engineering and Maintenance-of-Way Association (AREMA) standard TOFC. A basic envelope 18-feet wide and 17-feet 9-inches high was developed, which included separate emergency and maintenance benchwalks, and dynamic clearances.

- **Combined Emergency/Maintenance Way.** As included in the Metro-North criteria, vehicular or equivalent level of access is required in the tunnel. For the purposes of this study a 10-foot-wide vehicular road was initially assumed. This allowed for the use of special dual-ended vehicles up to 5 feet wide, with additional allowance for services and adjacent access. The maintenance way also functions as an emergency way for passengers to egress and for emergency services to enter the tunnel.

- **Support and Safety Systems.** Space was allocated to power, communications, signal, drainage, and other systems within the overall circular section.

- **Ventilation.** Space within the tunnel cross-section was dictated by the overall diesel requirements and is outlined in more detail in the following section.

Ventilation

Ventilation systems are required to control air quality, air temperature, and the migration of smoke in the event of a tunnel fire. The capacity and configuration of the ventilation system is determined by the volume of air to be handled, which is a result of the distance between vent buildings, the nature of contaminants (carbon monoxide, nitrogen oxides, and smoke from diesel locomotives), heat release, and the fire load.

The proposed distance between ventilation buildings is approximately 14,000 feet, assuming vent buildings located on both the Rockland and Westchester shores. As an adequate ventilation system could be developed with shore buildings, other alternatives utilizing vent buildings in the river were discounted to avoid the associated visual and access implications.

With the inclusion of freight and diesel locomotives, the preliminary fire event scenarios developed assumed a working peak design fire size of 100 megawatts (MW). The total volume of air for the design fire was calculated at approximately 210,000 cubic feet per minute (cfm) along the tunnel to achieve the required critical velocity, with the air moving longitudinally along the tunnel in a push-pull configuration.

A longitudinal push-pull ventilation system is not feasible for purging the tunnel of diesel exhaust because the resulting high air speed would make maintenance operations unworkable. A transverse system with separate supply and exhaust ducts along the tunnel is required, with a total duct area of 480 sq ft per direction; this is a significantly larger duct area than that required for the design fire.

Recent full-scale fire tests (Memorial Tunnel Fire Ventilation Program) have shown that under certain conditions transverse ventilation systems do not control smoke spread in fire events larger than 20 MW. Therefore, the ventilation system adopted for the river crossing is a hybrid system that includes both longitudinal and transverse system characteristics. This system works as fully transverse for diesel purge and as multi-zone longitudinal point extraction during a fire scenario. Because air is continually supplied and exhausted along the tunnel at regular intervals, large longitudinal air velocities are not induced.

Tunnel Cross-Section

A number of tunnel cross-sections that provide sufficient space to meet all requirements were evaluated against the design criteria. Two cross-sections were developed in detail: a twin-bore solution with tunnels of 40 feet 6 inches outer diameter (Figure 2-11), and; a single-bore cross-section with an outer diameter of 58 feet (Figure 2-12). The twin-bore option is recommended for the river crossing section of the Tunnel Option, and is the basis used for comparison throughout this paper. Though 40-foot diameter bores have not been constructed in the New York area, they are relatively common internationally and costs can be accurately estimated. The single-bore solution is not recommended at this stage, as the largest bore constructed internationally is 46 feet. However, recent orders have been placed with TBM manufacturers for diameters up to 54 feet for projects in China; this is not proven technology and is less than the 58 feet required for a single-bore tunnel.

Diesel Emissions

The above tunnel cross-section, ventilation flow rates and duct sizes, reflect US Environmental Protection Agency (USEPA) Tier 0 emissions, with specific allowable pollutant emission rates for nitrogen oxides

(NO_x), particulate matter, and other toxic gases. With the introduction of ever stricter USEPA air quality standards, all newly manufactured locomotives are required to comply with Tier 2 emissions by 2005, and Tier 4 by 2014. Current Metro-North diesel engines meet the Tier 0 standards.

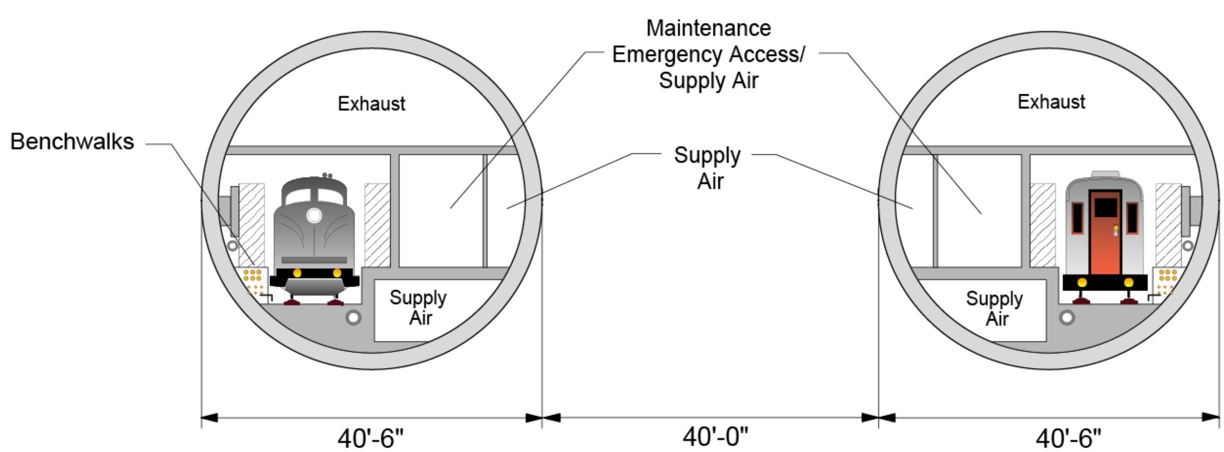
If USEPA Tier 2 emission standards were adopted, the required ventilation flow rate and tunnel duct sizes would be reduced by approximately 50 percent below the requirements for Tier 0 emissions. This would result in a reduced tunnel cross-section for the twin bore tunnel option – with bores of 36-feet diameter compared to the 40-feet proposed. The diameter of a single-bore alternative would be unchanged as the cross-section is dictated by lateral spacing of the tracks and the maintenance/emergency way and not by the ventilation requirements. The adoption of Tier 2 emission standards would have implications for Metro-North rolling stock.

If USEPA Tier 4 emission standards were adopted, the spatial requirements for the ventilation system in the tunnel would fall below those of the design fire. The resulting tunnel cross-section would be slightly smaller than that of the Tier 2 emission requirements.

In summary, lower diesel emissions standards (Tier 2 or Tier 4) would not significantly change the river crossing tunnel size requirements. The twin bore arrangement would still be the preferred section but with slightly smaller diameter and cost.

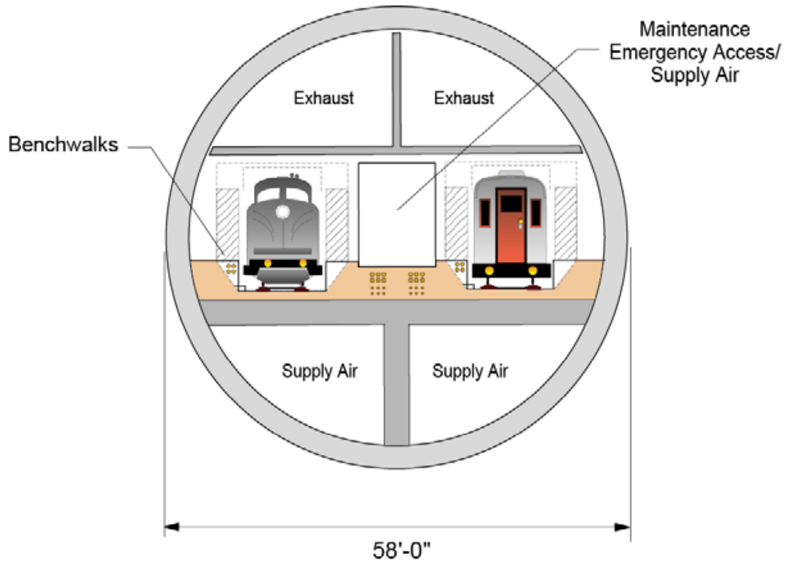
Crossing Headways

To avoid delay to trains in the tunnel, the ventilation ducts in the above cross-sections are designed to allow full venting of the tunnel in a maximum of 4.5 minutes, or about the average headway between trains (3 min – 6 min), as required in the criteria outlined in Chapter 2.



River Tunnel – Twin-Bore Cross-Section

Figure 2-11



River Tunnel – Single-Bore Cross-Section

Figure 2-12

If this period were increased, by delaying entry into the tunnels for those trains following a train operating in diesel mode, a reduction in the ducting requirements within the tunnel section would result. For the single bore, this reduction would not change the overall diameter of the tunnel cross-section as this is dictated by the width required for the tracks and the maintenance/emergency way and not by the ventilation requirements. For the twin-bore Tunnel Option, this would result in a reduced tunnel cross-section, similar to that for the above mentioned diesel emission, but the reduction would be limited by the ventilation requirements for the design fire events associated with diesel commuter and freight trains - two bores of 36-feet diameter compared to the 40-feet proposed would be required.

In summary, an increase in the time allowed for tunnel ventilation would not significantly change the river crossing tunnel size requirements. The twin-bore arrangement would still be the preferred section but with slightly smaller diameter and cost.

Electrification of West of Hudson Lines

A possible alternative to alleviate diesel ventilation requirements would be electrification of any Metro-North lines that would use the tunnel. While analyses (as presented above) showed the diesel ventilation requirements were not the driving force in determining tunnel size, it is useful to review the implications of the electrification of west of Hudson Lines.

Electrification would include the Port Jervis Line west of Suffern (electrification east of Suffern was assumed in this paper), the Pascack Valley Line (if a direct connection were to be made), and potentially New Jersey Transit lines that could run north in the future and connect with the cross-Rockland Line leading to the tunnel. An electrification program would include installation of third rail or catenary, construction of substations, breaker houses, and power distribution elements. These modifications are not included in any long-term capital program or any long-range planning horizon and have not been studied by Metro-North.

The primary considerations that preclude electrification on the west of Hudson Lines are:

- An undetermined number of property partial takings and displacements that would result in extensive capital expenditures and community impacts.

- The Operating Agreement with Norfolk Southern Railroad, the owner of the ROW, requires that lateral clearance from center of track to high level platform edge be at least 7 feet 6 inches whereas the Metro-North standard for high level platform clearance is 5 feet 7 inches, resulting in an unacceptable 23-inch gap between platform edge and door thresholds. (The Americans with Disabilities Act requires a gap of 3 inches or less.) Construction of low level platforms with third rail raises safety issues in terms of proximity to passenger access and presents unacceptable operating, equipment, and staffing impacts associated with using high platform rolling stock on low platform stations. The construction of an additional freight-only track at all stations to mitigate the above problem would require property displacements, be extremely costly, and greatly add to the complexity of train operations on the lines.

- Electrification of yards would be required and the Port Jervis Yard is in a floodplain with the associated dangers of flooding in an electrified yard.

- The alternative of catenary lines instead of third rail would involve major construction of catenary support structures as well as several large substations resulting in greater visual impacts in a suburban/exurban environment. The Norfolk Southern Railroad Operating Agreement requires a minimum height of 23 feet above top of rail whereas Metro-North would require a catenary power line no higher than 18 to 19 feet over top of rail, violating the Norfolk Southern operating requirement on the Port Jervis ROW.

Fire

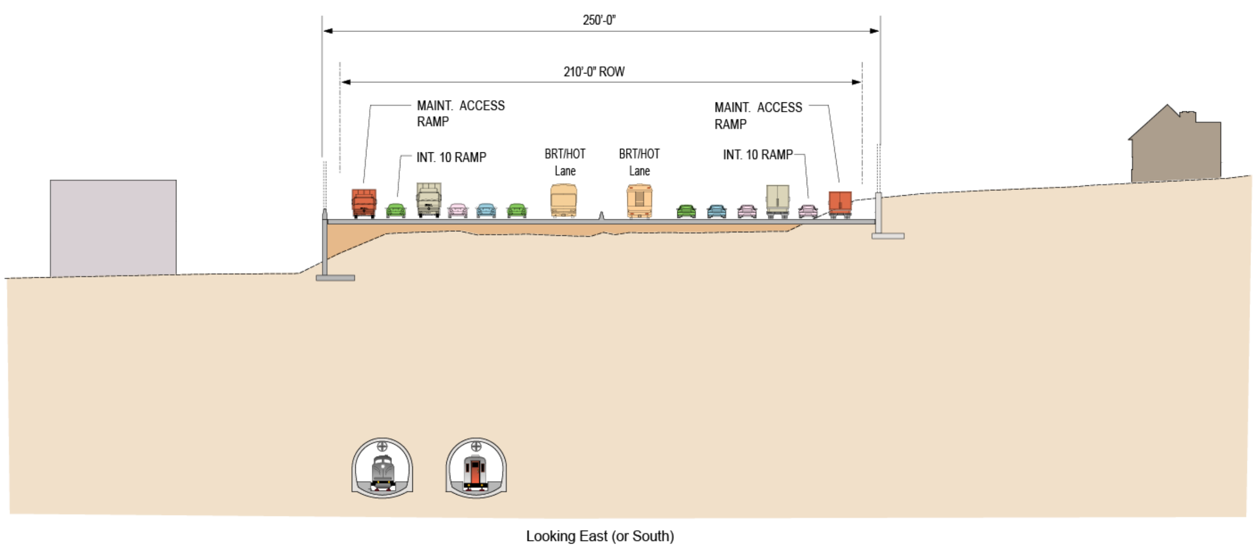
Passengers evacuating a train in a fire condition would exit the train way and utilize the emergency/maintenance way as a separated place of safety. To enter the emergency/maintenance way passengers would pass through a fire-rated concrete wall via fire doors spaced 200 to 300 feet apart, providing availability of two to three doors per train. From this place of safety, which would be supplied with fresh air, passengers could either wait for emergency assistance or make their way to the surface by walking to the vent buildings at either end of the river tunnel. Egress from the tunnel would be through pressurized and fire-rated stairways located at each ventilation building.

Rockland Shore

The construction of the new highway bridge with the associated access roads and ramps and the CRT tunnel, while maintaining Thruway operations, has the following consequences:

- A temporary bridge structure adjacent to and south of the existing bridge would be required for maintenance of traffic during construction (3,000 feet).

- The total new highway width required is 250 feet, which includes highway and BRT/HOT lanes, shoulders, two ramps for Interchange 10, an 8-foot allowance for sound walls/median, and maintenance access ramps. The narrowest point on the ROW is 210 feet (Figure 2-13).



Section at Narrowest Point on Rockland Shore for Tunnel Option

Figure 2-13

- Additional easements would be required on both sides of the ROW for tie-backs and retaining wall construction.

- In the permanent arrangement, the addition of the CRT tunnel under the Thruway does not require additional ROW.

- The alignment includes 500 feet of cut-and-cover CRT tunnel on the north side of the Thruway.

- The final elevation on the Thruway would be +45 feet compared to an existing elevation of +35 feet at the shoreline. The raised elevation is a consequence of raising River Road above the flood elevation to ensure access to the NYSTA facility and the adjacent vent building, and of increasing the clearance over River Road.

Construction Methodology

Construction of the twin-bore tunnels requires a launch or recovery box on either side of the river, with adjacent construction staging and storage areas. The area on the Westchester shore west of Tarrytown Station would be a suitable location for the larger of the two facilities. However, as this area may be developed before construction, the launch box would be located off the Rockland shore in close proximity to the Thruway, providing easy access and egress for construction personnel, material, and equipment. A total area of 7.5 acres is required in the river in this area, including a river location for the launch box (300 feet by 150 feet) to match the assumed soil/rock interface. All spoil (approximately 1.5 million cy) would be removed through the launch box and would be transferred to barges and/or trucks for disposal.

The recovery box (250 feet by 200 feet) would be located on the Westchester shore. Construction of up to 2 acres of temporary platforms in the river would be required for construction staging, storage, and transshipment of equipment and construction material as well as local ground modification.

Additional geotechnical investigation may identify suitable alternative locations for the launch and recovery boxes.

Construction Staging

The construction of the Tunnel Option at the Rockland shore would occur in three stages:

- **Construction Stage 1:** reconfigure Interchange 10 in anticipation of Construction Stages 2 and 3.

- **Construction Stage 2:** relocate the Thruway to the south for 4,500 feet, including 3,000 feet of temporary bridge structure. This allows construction of the northern half of the highway-only bridge and the river and shoulder tunnels. This temporary realignment would be anticipated for 4 to 5 years and would include temporary access ramps at Interchange 10.

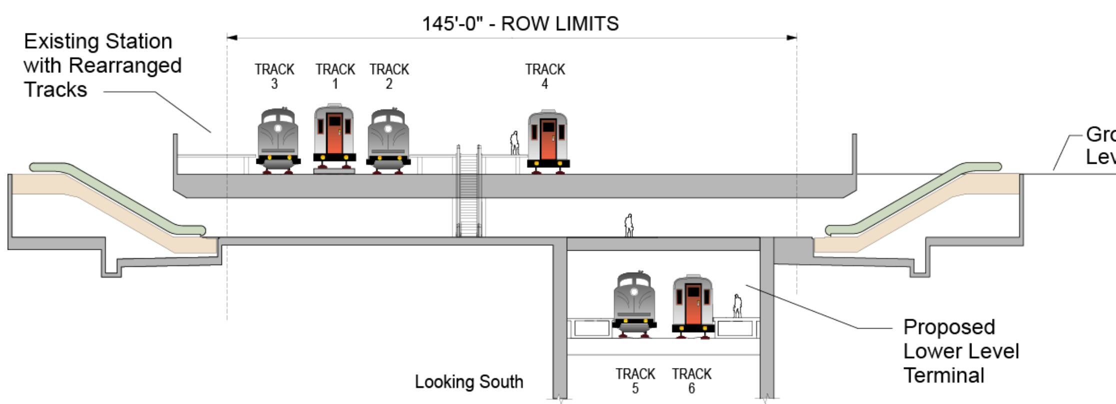
- **Construction Stage 3:** relocate Thruway traffic from the existing bridge to the newly constructed northern half of the replacement highway-only bridge. The existing bridge would be demolished to make space for construction of the remaining half of the replacement highway-only bridge. Construction would take 1 to 2 years.

2.5.3 Tarrytown Station Area (Segment 4)

This 7,500-foot section begins at the Westchester shore and goes through the expanded Tarrytown Station along the Hudson line to the portal adjacent to the Kraft property. The alignment through this area is shallow. The depth to the top of the tunnel varies from 90 feet at the shore to 5 feet adjacent to the Kraft property. The depth to rock varies from north to south. Rock in the north is approximately 100 to 120 feet below ground surface and 40 to 50 feet below ground approximately 1,000 feet south of Tarrytown Station.

The area is filled with spoil from the construction of Grand Central Terminal in New York City. The spoils are expected to be variable, containing large boulders, which would make the area unsuitable for mining. Cut-and-cover tunneling would be used in this area, though other forms of construction involving ground modification (freezing and grouting) could be justified based on additional geotechnical investigation. Further complicating construction are the high water table associated with the river, potential flooding as the area is below the 50-year flood elevations, and the potential Ferry Landing development.

To accommodate the new CRT tracks, the existing Tarrytown Station would be expanded and modified with a new platform constructed 60 feet underground to the west of the existing platforms. For access and station facilities, a new mezzanine level would be introduced between the surface and underground platforms (Figure 2-14). New vertical and horizontal circulation elements would be introduced linking all platforms and extending into the parking areas, possibly on both sides of the existing station. Because the station is below the flood elevations, groundwater infiltration must be controlled by extensive drainage facilities (including pumps) and raised entrances and exits. To ensure access in flood conditions, a raised access road to the river tunnel may also be required.



Tarrytown Station Cross-Section (Looking South)

Figure 2-14

Lowering of Track 1 in the tunnel to the south of the station (as part of the five-track configuration to avoid displacements at Van Wart Avenue) would require the introduction of additional flood protection ramps. If the standard flood ramp is adopted, the existing western platform at the station would need to be relocated to provide sufficient space for the necessary retaining walls.

Staging and Access

Key considerations for construction of the Tarrytown Station expansion include:

- The proposed Ferry Landing site near the Tarrytown Station may not be available for construction staging and storage due to the proposed development. Therefore, staging and storage areas would be within local construction areas supplemented by temporary platforms in the river (2 acres).

- Some of the area currently used for station parking may be needed for staging. A parking structure may be needed to compensate for lost spaces.

- To facilitate competitive bidding, multiple large construction contracts could be awarded to separate contractors requiring separate staging areas, which would require more complex construction coordination.

- Access for materials is possible from the river.

- Construction of the underground tracks south of Tarrytown would require widening of ROW by placement of additional riprap (5 to 10 feet) in the river for a length of up to 2,000 feet. This can be mitigated by utilizing a 12-foot track separation.

2.5.4 Cross-Westchester CRT Shoulder Tunnel (Segment 5)

Though the Westchester shoulder tunnel in the Tunnel Option is deeper than that in the Bridge Option, it has essentially the same cross-section and alignment. Therefore, it was not considered in detail in this study, but was deferred to the DEIS Stage. In addition, similar to the Rockland shoulder tunnel further study of a maintenance/emergency way was also deferred to the DEIS Stage.

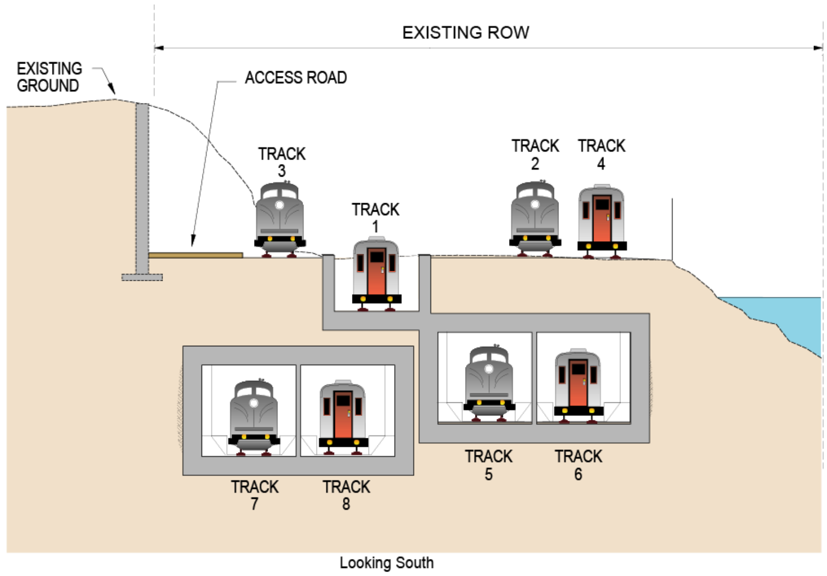
LRT/BRT

LRT and BRT are alternatives to CRT in Westchester with alignments commencing at Tarrytown Station connecting to Route 119 through the existing toll plaza area. Through this area the LRT would be underground, mined through the existing rock, with the eastern portal located on Route 119 near Meadow Street. For BRT, a surface route would be possible incorporating a new roadway adjacent to the east side of the Hudson Line tracks from Tarrytown Station to the replacement bridge and a new cut slope through the toll plaza area to provide a connection to Van Wart Avenue.

2.5.5 Hudson Line Connection (Segment 6)

South of Segment 4, a retained cut and flood ramp would be required to bring the trans-Hudson tracks (and the lowered Track 1) to the surface to allow connection to the Hudson Line tracks. South of the connection a full interlocking would be incorporated to reinstate the operational capability lost by the removal of the existing interlocking (CP25) at the Tarrytown Station. The trans-Hudson tracks surface along the centerline of the Hudson Line to facilitate connection to the express tracks (Figure 2-15).

To facilitate single-track operation around the new underground platforms of the Tarrytown Station, an interlocking is introduced immediately outside both ends of the station. Due to the curved alignment in the area to the north of the station only a diamond interlocking is feasible. This is not consistent with Metro-North standards. Though the diamond interlocking has maintenance implications, the adoption of this non-standard solution at this location has been accepted by Metro-North.



Cross-Section of Hudson Line Connection

Figure 2-15

2.5.6 Support Facilities

Support facilities are required at 19 locations for the Tunnel Option in the crossing area. Each facility has a number of functional requirements including TPSSs, vent buildings, etc. The following are some notable requirements:

- Total surface area of all facilities in the crossing area would be approximately 260,000 sq ft, including 11 ventilation buildings, eight TPSSs, and five access shafts. Some facilities would be combined, and some would be within underground CRT stations.

- The ventilation buildings would range in size from 5,000 to 40,000 sq ft, with the largest located at the shores to serve the under-river tunnels. Four would be located partially or entirely above ground, five would be within underground CRT stations and the two largest plants would be underground within the TBM launch and recovery boxes. All would have a vent shaft rising 50 to 100 feet above ground, ranging in plan from 24 feet by 24 feet to 46 feet by 46 feet. Four plants would be combined with traction power facilities. All ventilation buildings would serve as emergency access and egress points. All 11 ventilation facilities would require a 5,000 sq ft above-ground area for parking, staging and storage, and a security fence enclosing the entire facility.

- To refine the vent shaft height requirements, further study of emission control requirements and meteorological conditions through dispersion modeling will be conducted in the DEIS Stage.

- The eight TPSSs would range in size from 5,000 to 15,000 sq ft. Two would be within underground CRT stations, one would be within the Westchester launch/recovery box, and five would be above ground (three combined with ventilation buildings, one at the Palisades Mall portal and one along the Hudson Line).

- TPSSs would be located at 5,000-foot intervals, with larger facilities at both the Rockland and Westchester shores to account for the long crossing. As system robustness and power degradation have not been studied in detail, further analysis is required in the DEIS Stage to determine if a TPSS would be required at an intermediate point on the crossing.

- The five access shafts would require a single-story access building of roughly 850 sq ft, a 5,000-sq ft above-ground area for parking, staging and storage, and a security fence enclosing the entire facility. Access shafts would be located between ventilation buildings to provide access points to the shoulder tunnels at intervals not exceeding one-half mile.

3 ENGINEERING CRITERIA

This section reviews four engineering criteria: fire/life safety, emergency response, redundancy, and construction impacts. The first three consider operation of the crossing in emergency conditions as determined from provisions included in the engineering concept design. The fourth criterion concerns potential impacts on local residents and businesses during the construction process.

3.1 Fire/Life Safety

As part of the operations assessment of both the Bridge and Tunnel Options an outline review of emergency operations was conducted to determine potential hazards (both natural and manmade) and included fire, explosion, flood, ship collision, earthquakes, and loss of power. From this study, emergency procedures were considered for fire/life safety, emergency response, and redundancy.

This criterion considers the procedures and provisions for fire events, one of the hazards reviewed, and uses the size of the maximum potential fire and ease of egress to a place of safety as the comparative measure between the Bridge and Tunnel Options. Only the maximum CRT fire event is considered. The fire/life safety requirements for other fire events, notably tanker truck fires, would be similar. The details presented below will be considered further in the DEIS Stage.

3.1.1 Bridge Option

The maximum fire size from CRT trains on either the dual-level or single-level bridge would be up to 250 MW but would depend on the fire source, the material available for combustion, and the type of train car (commuter, freight, or locomotive). This maximum fire would correspond to flammable liquids from a stopped diesel locomotive or bulk carrier and assumes a high leakage rate and an unconstrained spill area, with the resulting flames estimated at up to 75-feet high.

For the dual-level bridge, where CRT would be on the lower level, flames would likely engulf the surrounding structure and the deck above and traffic would come to a stop on the upper level and disperse from the area of the fire. To limit consequences, structural elements would be increased in size to provide redundant capacity and additional protection and control measures would be introduced. For this event potential measures would include drainage to allow for removal of the flammable liquid (channeling) and CRT deck segmentation to control the maximum liquid pool size. Standpipes and other related firefighting equipment would be included to facilitate firefighting. After the fire event, some damage to the primary and secondary structural members would be anticipated, requiring closure of part of the bridge to traffic while inspection and structural repairs were conducted.

Life safety in this event scenario would require evacuation from the fire area to a place of safety along the bridge at some distance from the incident. Smoke would not be the major life safety concern as this would be blown off the bridge by the prevailing wind. For CRT passengers, egress to the place of safety would be through the train doors (on both sides) to 3-foot wide emergency benchwalks located at the same elevation. Benchwalks would lead to steps at 200- to 300-foot intervals to access the central 10-foot maintenance way between the two tracks or the outer 5-foot inspection walkway (see Chapter 2). From here passengers would walk away from the incident to the end of the bridge along the CRT maintenance ways or along the roadway on the upper level via access stairs located at regular intervals. Alternatively, passengers could await the arrival of emergency services on either level. Once the decision to evacuate is made, evacuation to a place of safety would take 10 to 20 minutes for most passengers from a full train. Additional time would be required for elderly and disabled passengers.

For the single-level bridge, NYSTA operations would be less vulnerable to rail fire events; most incidents would be unlikely to stop traffic though some would result in reduced traffic capacity during the event as lanes would be occupied by emergency services. For the fire event scenario outlined above, similar protection and control measures would be included in the structure. In addition, procedures for egress to a place of safety would be similar, though to the adjacent highway. Distinct from the dual-level bridge, flames would not affect any structure above and only the local floor beams would be damaged. After the event, full traffic capacity on the adjacent highway could be reinstated more quickly than the dual-level bridge, even while repairs were made to the CRT supporting structure.

3.1.2 Tunnel Option

Similar to the bridge option, the maximum fire size would be associated with flammable liquids in an event scenario involving a stopped diesel locomotive or bulk carrier with a high leakage rate and an unconstrained spill area. The maximum fire size would be smaller than that of the bridge because of the limited supply of air from the ventilation system and would be up to 100 MW. A fire in the CRT tunnel would have no effect on traffic on the associated highway-only bridge other than traffic disruption generated by responding emergency equipment on the Thruway ROW.

In the tunnel, flames would reach the walls resulting in spalling concrete and reduced structural capacity. Structural elements would be increased in size to provide redundant capacity and similar protection and control measures would be introduced as in the Bridge Option. To control smoke and temperature, the Tunnel Option would require a full ventilation system as described in Chapter 2, including the necessary detection and communication systems to provide warning.

Life safety in this event scenario would require evacuation from the fire and smoke to a place of safety. This would be the combined emergency and maintenance way, an enclosed concrete chamber that is located adjacent to the track along the full length of each tunnel bore. Egress to this place of safety would be through the train doors on one side of the train to a 3-foot wide emergency benchwalk located at the same elevation, from which passengers would access fire doors at 200- to 300-foot intervals.

While on the benchwalks passengers may be subject to a smoke environment depending on the direction of air flow in the ventilation system, the location of exhaust vents, and their location on the train. In the case of a fire on the locomotive, smoke would be blown away from the passenger cars and extracted at the first exhaust port. In the case of a fire in a train passenger car, smoke would be blown in the direction away from the largest number of cars but would by necessity be over some cars. Because only one train would be allowed in any single vent zone, smoke would not be blown over a second train but extracted at an exhaust vent in between.

During evacuation, channeling of passengers from the train to a single benchwalk would slow evacuation, compared to a bridge, and require single file movement towards the place of safety. Up to 45 minutes would be required for most passengers from a full train to reach the place of safety. Additional time would be required for elderly and disabled passengers. Once in the place of safety, passengers could walk away from the incident to either end of the tunnel or await emergency services. At each end of the tunnel elevators and stairs would be located to bring them to the surface. The total time for most passengers from a full train located in the center of the tunnel to reach the surface would be 60 to 90 minutes. Successful evacuation would require rapid implementation of fire ventilation procedures by trained personnel in a permanently manned monitoring station.

This in turn would require the inclusion of monitoring systems (sensors and cameras) to allow for quick interpretation of events by controllers and the ability to quickly locate the source of a fire in order to decide the direction of air flow and systems to activate. This would be done in communication with the train operator. The time for these decisions and the consequent notification to train crews to evacuate passengers, would add to the total time for passengers to reach the surface.

3.1.3 Comparison of Options

The Bridge and Tunnel Options provide for the evacuation of CRT passengers to a place of safety, and access to shore areas. The Bridge Option has the advantages of egress from both sides of the train, the inclusion of emergency/maintenance ways on both sides of both tracks, and quick access to emergency services on adjacent or upper levels.

In the Tunnel Option, a smoke condition in a confined area would dictate more extensive provisions not required in the Bridge Option. These would include: a sophisticated ventilation system; management and operating staff; system monitoring and controls to inform operations; continuous specialist staff training and; an extensive maintenance program. The Tunnel Option would represent a greater fire/life safety risk to passengers because of the longer time required to reach a place of safety (30 to 45 minutes compared to 10 to 20 minutes); potential evacuation through a smoke zone; potential failure of detection systems or vent systems and possible controller error; and the long time (60 to 90 minutes) to access the surface.

3.2 Emergency Response

Provision for emergency response would be included in both the Bridge and Tunnel Options. Detailed emergency response plans would be developed in the course of final design and coordinated with the appropriate authorities based upon best practices in the industry. This criterion focuses on the ability of emergency services to access emergency events.

3.2.1 Bridge Option

In the Bridge Option, first responders to minor incidents either on the upper or lower level of the bridge would be maintenance personnel who are permanently stationed at both ends of the bridge. They would be supported by state police and would form a first level of response, able to reach an incident from staging areas that would be permanently located on or adjacent to the bridge with dedicated access ramps. The expected response time would be within the first few minutes of the incident.

On the upper level, incident sites would be accessed using one of the four shoulders. On the lower level incident sites would be accessed using one of the two shoulders provided on each side of the BRT/HOT lanes or the emergency/maintenance lane provided between the CRT tracks. As the bridge would be configured as parallel twin structures, cross-over ramps would also be incorporated at regular intervals on the upper level to provide access between the two traffic directions.

For more significant incidents, second responders that include medical and fire services would access the bridge on the same route as first responders, with response times expected to be in the range of 5 to 10 minutes after notification. For a major incident involving a CRT fire or derailment, a second wave of responders would be expected to include the necessary specialist emergency personnel. In this event scenario, traffic on the incident side of the bridge would likely be stopped and diverted to the opposite side of the bridge, which could be converted to two-way traffic flow to maintain reduced Thruway capacity. The incident side of the bridge would be available for all emergency personnel and could also be used for helicopter evacuation from close to the incident site.

For a single-level bridge with CRT separated on its own structure, additional access lanes may be necessary adjacent to the CRT tracks, closure of one direction of highway traffic would still be likely in major incidents, and additional highway crossovers would be necessary. However, the principle of first and second responders would be the same.

3.2.2 Tunnel Option

In the Tunnel Option, emergency response to incidents on the highway-only bridge would be the same as outlined for the Bridge Option.

For minor incidents in the tunnel, such as a train breakdown, first responders would be Metro-North personnel who would be specially trained in the procedures necessary to either transfer passengers to another train or pull the train from the tunnel using a standby locomotive.

First responders for a fire emergency would include trained medical and fire service personnel who would access the tunnel from the vent buildings at both shores. They would descend to the level of the tracks and travel along the emergency way to meet passengers exiting the tunnel. Time for first responders, once notified, would be 5 to 10 minutes to the vent buildings and a further 20 to 30 minutes to walk to the center of the tunnel. Though special vehicles would be available to access the maintenance way to evacuate injured passengers, the majority of passengers would have to walk out of the tunnel. The first responders would be local to the area of the tunnel, possibly supplemented by specially trained Metro-North personnel. Access for emergency personnel would be on foot as the use of specialized emergency or maintenance vehicles would be impeded by evacuating passengers.

The Tunnel Option would likely require supplemental assistance as well. These would be personnel from regional emergency services specially trained to access tunnels in the case of emergency. Their task would be both rescue of passengers and specialized fire fighting techniques. They would be familiar with the tunnel and its systems and would be an addition to existing regional emergency services capabilities. Response times for the supplemental responders would be 30 to 60 minutes, once notified. This increases the complexity of the emergency response. When considering the release of toxic gases, the need for specialized training for supplemental responders becomes a distinction from the emergency response requirements in the Bridge Option.

3.2.3 Comparison of Options

Both the CRT Bridge and Tunnel Options would be designed for adequate emergency response. The CRT Bridge Option would have quicker response times because there are multiple vehicular access routes including highway travel lanes, shoulders, and pedestrian paths as well as the CRT maintenance way. In the tunnel, access in emergencies would involve non-motorized access along the maintenance way. Specialized training for all responders would be required for the CRT Tunnel Option.

3.3 Redundancy

Redundancy is a measure of the capacity of the crossing (people and goods) after a major emergency and the time taken to re-establish full capacity. Table 3-1 presents a summary comparison between the Bridge and Tunnel Options for various events.

Table 3-1

Emergency Event Scenarios

CRT Scenario (Single Event)	CRT Bridge Option		CRT Tunnel Option
	Dual Level	Single Level	
Fire	Potential loss of CRT and 50% highway capacity (the half of the bridge with CRT below) for up to one year	Potential loss of CRT and 10% highway capacity (one lane needed for construction access) for up to one year	Potential loss of 50% CRT (one bore) for up to three years but no loss of highway capacity
Explosion	Potential loss of CRT and 50% highway capacity (the half of the bridge with CRT below) for up to one year	Potential loss of CRT and 10% highway capacity (one lane needed for construction access) for up to one year	Potential loss of 50% CRT (one bore) for up to three years but no loss of highway capacity
Hudson River flood	No loss of highway but potential loss of Hudson Line connection for up to one year	No loss of highway but potential loss of Hudson Line connection for up to one year	No loss of highway but potential loss of all CRT service for one to two years
Ship collision main spans	No loss of service – impact protection included	No loss of service – impact protection included	No loss of service
Seismic *	Loss of service for up to two months	Loss of service for up to two months	Loss of service for up to two months
Note: *This bridge is most likely to be designated a “critical bridge” which according to AASHTO means it must remain open to all traffic after the design earthquake (500-year return period) and open to all traffic emergency vehicles after a large earthquake (2500- year return period).			

The advantage of the Tunnel Option derives from the fact that events occurring solely within the CRT tunnel would not disrupt service on the highway-only bridge (200,000 vehicles daily in 2025), whereas events in the Bridge Option could disrupt both highway and CRT service. Further, with a twin-bore tunnel, the track in the bore not involved in the incident would be available for limited service once the emergency situation had been resolved, with the exception of a river flood.

The disadvantage of the Tunnel Option, from a redundancy perspective, is that events affecting the tunnel would disrupt CRT service for longer periods of time (35,000 riders daily in 2025) and it would potentially be more costly to reinstate full services.

The redundancy provided by the dual-level bridge is not comparable to the Tunnel Option as any single event could result in the loss of all CRT and 50 percent of highway capacity. However, the redundancy provided by the single-level bridge would be a significant improvement over the dual-level bridge as the consequences of any single event can be limited to one mode, and the time and cost for recovery are likely to be lower than for the Tunnel Option. For either bridge configuration, the loss of capacity in one direction in an emergency can be partially compensated for by converting the other direction into a two-way facility (by using BRT/HOT lanes and shoulders).

The inherently greater redundancy of the Tunnel Option, which is limited to rail operations only, is balanced by the longer duration of disruption and greater cost of restoration of service after an incident. Thus, redundancy is not considered an important discriminator between the Bridge and Tunnel Options but the single-level bridge has notable redundancy advantages because of the separation in the three bridge superstructure components.

3.4 Construction Impacts

This discussion of construction impacts identifies the type, scale, and duration of construction and the potential effects on local residents and businesses. The types of potential effects described here include the more general types of impacts typically associated with construction projects such as restricted access, noise and vibration, traffic disruption, air quality, and the presence of construction personnel. More specific construction impacts (e.g., property takings, visual, effects on historic properties and the Hudson River) are addressed in Chapter 5 (Environmental Criteria). Impacts to Thruway and Metro-North operations are addressed in Subchapters 4.3 and 4.4. As detailed studies are not part of the AA process, comparison between the Bridge and Tunnel Options is based on the number and location of construction sites, the type of construction, and the scale of construction activities.

3.4.1 Bridge Option

Rockland

Two principal construction sites are anticipated for both the Bridge and Tunnel Options. The first, located at the intersection of the Thruway and Route 303 at Interchange 12 is the same for both options, and is, therefore, not considered further in this study. The second construction site extends from the island within the Interchange 10 ramps to the Hudson River; it is also required for both options but with notably different activities and duration for each.

Under the Bridge Option, CRT activities would primarily involve cut-and-cover and embankment construction (3,000 feet) conducted from above ground over a 2- to 3-year period.

Westchester

Both the Bridge and Tunnel Options would share a common site around Interchange 8 for construction of cross-Westchester CRT; however, the required construction sites in and around the Hudson Line differ substantially with construction taking up to 5 years, concurrently with construction of the bridge.

Two construction sites are anticipated for the Bridge Option. The first, located near the existing toll plaza, would primarily involve cut-and-cover excavation in rock extending from the river, under Route 9, and through to Route 119. Construction impacts would include:

- Temporary or permanent impacts on the NYSTA Division maintenance offices, Troop T barracks, and the shopping center east of Route 9.
- Disruption of traffic operations during underpinning of Route 9 and relocation of the westbound on- ramp at Interchange 9.
- Noise and vibration associated with rock mining for residents and commercial facilities directly above and in the surrounding area.
- Access for site personnel and equipment; however, direct access could be allowed from the Thruway.

The second site would be located on the Hudson Line and at the Requa House and Kraft properties. Construction would involve both cut-and-cover and retained cut for 5,000 to 6,000 feet along the Hudson Line in a mixture of soft soils and rock. The site would also service construction of the mined Hudson Line CRT connection tunnel (in rock). Temporary platforms in the river would be required to support construction with temporary access along the Hudson Line from Tarrytown Station or from a temporary bridge from the NYSTA toll plaza area. The potential construction impacts would be:

- Noise and vibration at the Kraft facility and residences along the connection tunnel alignment.
- Noise and vibration along the Hudson Line adjacent to Lyndhurst, Sunnyside, County Park, and several residences.
- Construction traffic through Tarrytown along the Hudson Line.

3.4.2 Tunnel Option

Rockland

Construction activities in the Tunnel Option would involve some cut-and-cover construction (500 feet) in the area between the Interchange 10 ramps and the river. In addition, the river tunnel would be constructed and staged from 7.5 acres of temporary platforming in the river adjacent to the Rockland shoreline including launch box construction, removal and processing of tunnel spoils (1.5 million cy), barging operations, materials storage, and construction of ventilation facilities. Construction duration in this area would be 3 to 4 years.

Westchester

For the Tunnel Option, construction would require a long linear construction site extending from the shore north of Tarrytown Station south to the Requa House property. Construction would involve 7,500 feet of cut and cover in soft soils at depths ranging from 30 to 100 feet, followed by 3,000 feet of retained cut and embankment. As adequate space within the Metro-North ROW would not be available, temporary platforms in the river would be anticipated from which spoil could be removed. Construction duration would be up to 6 years and would be concurrent with the highway bridge. Potential construction impacts would include:

- Loss of some of the existing Tarrytown Station parking lot as a staging area (a parking structure may be needed).
- Reconstruction of local streets such as River Street, Railroad Avenue, and Green Street with staging of construction to maintain local traffic.
- Disruption to traffic on the H-bridge during underpinning.
- Noise, vibration, access, disruption, dust and traffic circulation impacts to Ferry Landing, Ichabod's Landing, Horan's Landing Park, and other waterfront properties.
- Noise and vibration associated with rock mining for residents along the Hudson Line.
- Construction traffic through Tarrytown.
- Transport / storage of spoils.

The general scale of construction would warrant many separate construction contracts in this area with implications for access and circulation along the construction site and local roads. The scale of construction would likely warrant temporary bridges for local traffic.

3.4.3 Comparison of Options

In Rockland County under both options, significant work would occur between Interchange 10 and River Road. Due to the longer and deeper segment of cut-and-cover tunneling (3,000 vs. 500 feet) under the Bridge Option, construction impacts for the shoulder tunnels would be greater than for the Tunnel Option. However, for the Tunnel Option all river tunnel spoil (1.5 million cy) could be processed and transshipped from temporary platforms constructed along the shoreline. The duration and scale of the work on the platforms would be significantly greater than any activities that would occur along the shoreline under the Bridge Option (up to 4 years), making impacts of the Tunnel Option (up to 6 years) notably greater in this area.

In Westchester County, the key comparison of the Bridge and Tunnel Options is between the impacts at the toll plaza and Hudson Line connection tunnel for the Bridge Option and those at the Tarrytown Station and Hudson Line connection for the Tunnel Option.
While the number of residences potentially impacted by construction would be comparable under both options, the duration and scale of construction in and around the Ferry Landing development under the Tunnel Option would make impacts to that development severe.

While extensive construction would occur on and below local roads in the vicinity of Tarrytown Station under the Tunnel Option with major local impacts, the location and the volume of traffic during construction in the vicinity of the Tappan Zee Station under the Bridge Option has the potential to cause significant impacts throughout that area. In addition, impacts caused by placing rail on the bridge are incremental to the impacts occurring due to construction of the highway bridge.

Finally, the Hudson Line connection tunnel under the Bridge Option may pass beneath the Kraft research center.

3.5 Summary

Assessment of the engineering criteria resulted in a preference for the Bridge Option in three of the four engineering criteria considered: fire/life safety, emergency response, and construction impacts. Primary issues in support of the Bridge Option included the multiple vehicular accessways and rapid emergency response. The Bridge Option would not be without major construction impacts, particularly, in the area of the Tappan Zee Station, where the magnitude of construction would have considerable local impact.

Issues adverse to the Tunnel Option include the severe construction impacts at Ferry Landing, emergency egress times that would be significantly longer than the Bridge Option (30 to 45 minutes to a place of safety and 60 to 90 minutes to the surface), and the magnitude of construction at both the Rockland shore and Tarrytown Station area.

For the fourth criterion (redundancy), the Tunnel Option would provide greater redundancy because of two independent crossings. However, based on time out of service after a major emergency event and the cost for recovery, the single-level Bridge Option would have significant advantage over the Tunnel Option as a result of its three separate superstructures and reduced consequence of emergency events.

4 TRANSPORTATION CRITERIA

The alternatives analysis process includes several transportation criteria that must be evaluated in comparing the Bridge and Tunnel Options. The relevant criteria for this analysis are as follows:

- Transit ridership and travel times.
- Transportation systems integration.
- Metro-North operations.
- New York State Thruway operations.
- Roadway congestion.
- Rail freight.

As there are no significant differences in the highway network between the Bridge and Tunnel Options, the analysis of transportation criteria is focused on the transit elements of the two options. The key comparison between the Bridge and Tunnel Options is the development of the Tappan Zee Station in the Bridge Option vs. the expanded Tarrytown Station in the Tunnel Option.

The Tappan Zee Station supplements the Tarrytown Station and provides an additional access point to rail service across the corridor and south on the Hudson Line. In the Tunnel Option, all trips would be served at Tarrytown Station and a direct connection would be provided between the Upper Hudson Line and the cross-corridor line. This difference affects transportation system integration, transit ridership, and roadway traffic within Tarrytown. Other differences are also discussed below.

To assist in the analysis of potential transportation impacts, two types of computer modeling programs were used:

- **Best Practice Model (BPM)**. Four operational scenarios were tested using BPM to develop an estimate of the demand for transit and highway services for two variations of both the Bridge and Tunnel Options:

    - Commuter rail service connecting to the Hudson Line and continuing across Westchester County through White Plains to a connection to the New Haven Line at Port Chester with service through to Stamford.

    - Commuter rail service connecting to the Hudson Line and LRT service across Westchester County, operating in exclusive rights-of-way along I-287 and in street on Route 119 in Tarrytown and through downtown White Plains. Results of this analysis for LRT would be comparable to BRT; thus, BRT model runs were not done.

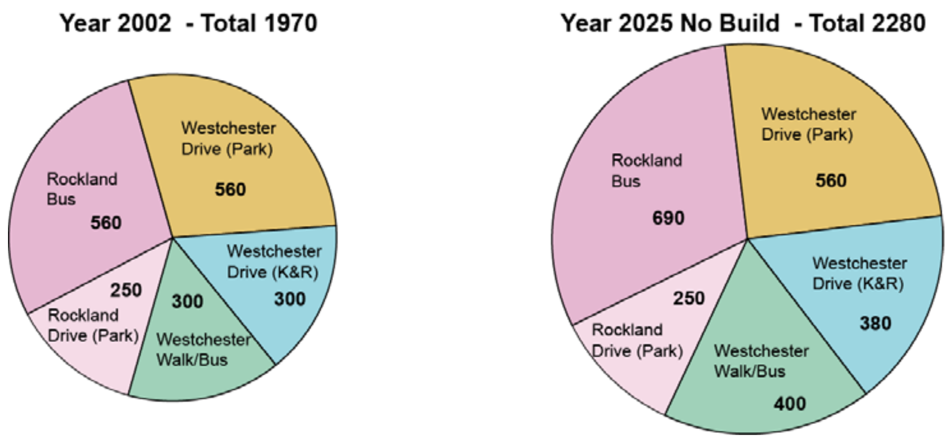
    These BPM runs provided ridership estimates at each station in the network, indicating whether passengers would drive to or use public transportation/walk to the station. The basis of the BPM includes all ongoing projects and those included in the local municipal planning organizations' Transportation Improvement Plan.

- **Level of Service (LOS).** The results of the four BPM runs were used to create a Synchro simulated traffic analysis of the Tarrytown area for each of the four scenarios, concentrating on the vicinity of the Tarrytown and Tappan Zee Stations. Of particular concern was the change in the LOS at critical intersections in the vicinity of the stations and the traffic along Broadway (Route 9) between the Thruway and central Tarrytown.

4.1 Transit Ridership and Travel Times

In 2002, 810 Rockland commuters used the Tarrytown Station in the AM peak, or more than 40 percent of 1,970 total arrivals. Figure 4-1 illustrates the percentage who park, are dropped off, and arrive at the station by walking or by bus. By 2025 in the no build condition, total arrivals at Tarrytown would grow to 2,280, including 1,340 arrivals from Westchester and 940 from Rockland. Because the parking lots are now at capacity, the number of park-and-ride passengers would not grow; as a result, all of the growth would occur in the kiss-and-ride or walk/bus sectors. Rockland County growth would all be bus riders.

In both options the introduction of CRT would remove Rockland commuters from Tarrytown. This would free up parking space for Westchester residents, which would reduce the number of kiss-and-ride passengers.



Rail Boardings at Tarrytown Station - Existing and No Build
AM Peak Period - (6 AM - 10 AM)

Figure 4-1

4.1.1 Bridge Option

For the Bridge Option, the following travel time and transfer time assumptions were built into the BPM model runs:

	Minutes
• Travel time from Palisades Mall to Tappan Zee Station by CRT	10
• Travel time from Tappan Zee to Elmsford by CRT	3
• Travel time from Tappan Zee to 125th Street non-stop by CRT	20
• Travel time from Tarrytown Station to Tappan Zee by LRT	3
• Travel time from Tappan Zee to Meadow Street by LRT	2.8

- Transfer time - Rockland CRT to LRT/BRT at Tappan Zee Station <1
- Transfer time - Rockland /Westchester CRT at Tappan Zee Station to Hudson Line at Tarrytown Station 7
- Transfer time - Rockland CRT to Local Bus at Tappan Zee Station 3
- Transfer time – Rockland CRT to parking at Tappan Zee Station 4
- Transfer time – Hudson Line to LRT/BRT at Tarrytown Station 3

Travel times for travelers driving, walking, or taking a bus to the station are calculated by BPM based on an analysis of the network for individual journeys. The Tappan Zee Station would provide a second station in the Tarrytown vicinity, away from the congested and capacity-constrained area in the village at the existing station and surrounding access streets. This would increase access to, and capacity for, Westchester residents traveling both to New York City and traveling in the I-287 Corridor.

The number of combined Westchester AM peak arrivals at the Tarrytown and Tappan Zee Stations would increase from 1,340 in the No-Build to 2,025 in the CRT Option (of which 285 would use the cross-corridor service) and 1,915 in the LRT option (205 on the cross-corridor LRT) (Figure 4-2 and Table 4-1). Some of these Tappan Zee Station users would be diverted from other Metro-North stations such as Irvington or even White Plains, and some would be new to the system.

4.1.2 Tunnel Option

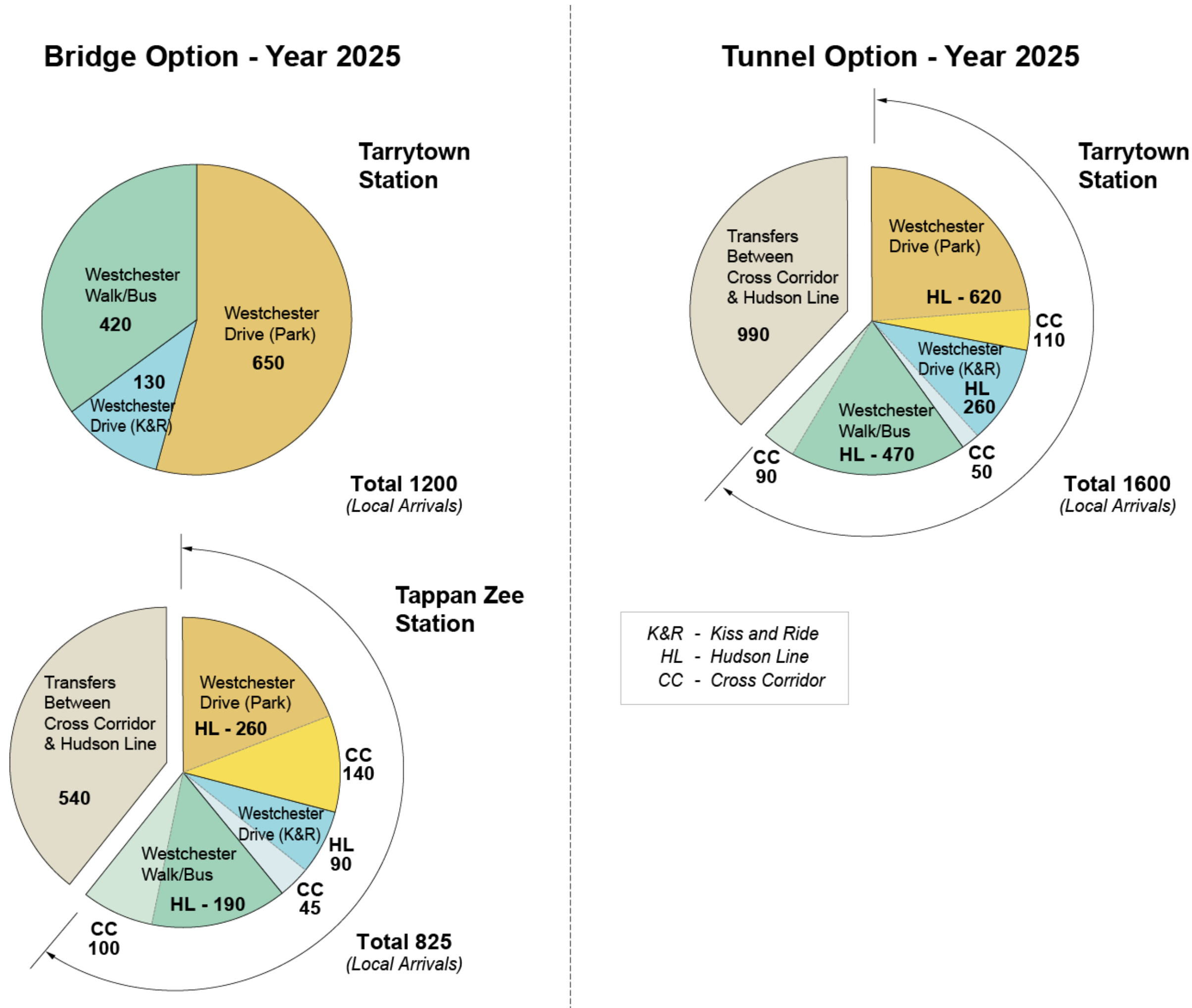
For the Tunnel Option, the following assumptions were made with respect to travel and access times:

Minutes

- Travel time from Palisades Mall to Tarrytown Station by CRT 10
- Travel time from Tarrytown to Elmsford by CRT 4
- Travel time from Tarrytown to 125th Street, non-stop by CRT 21
- Travel time from Tarrytown to Route 119 & Broadway by LRT 5
- Travel time from Route 119 & Broadway to Meadow Street by LRT 3.3

- Transfer time - Rockland CRT to LRT/BRT at Tarrytown Station 5
- Transfer time - Rockland /Westchester CRT to Hudson Line at Tarrytown station 3
- Transfer time - Rockland CRT to Local Bus at Tarrytown Station 4
- Transfer time – Rockland CRT to parking at Tarrytown Station 7
- Transfer time – Hudson Line to LRT/BRT at Tarrytown Station 3

The Tunnel Option does not include new stations for Metro-North to New York in Westchester. As a result, the local Westchester arrivals at Tarrytown headed to New York would be about the same as in the no build condition (1,350). However, the presence of cross-corridor service would increase total arrivals at Tarrytown to 1,600 with CRT only and 1,495 in the LRT scenario (Figure 4-3 and Table 4-2). The LRT option would attract fewer cross-corridor riders to Tarrytown because it includes an LRT-only stop at Route 119 and Broadway. If the 165 users of that stop are included, total local arrivals to the combined stations would become 1,660.



Rail Boardings at Tarrytown and Tappan Zee Stations
for CRT/CRT Scenario
AM Peak Period - (6 AM - 10 AM) for 2025

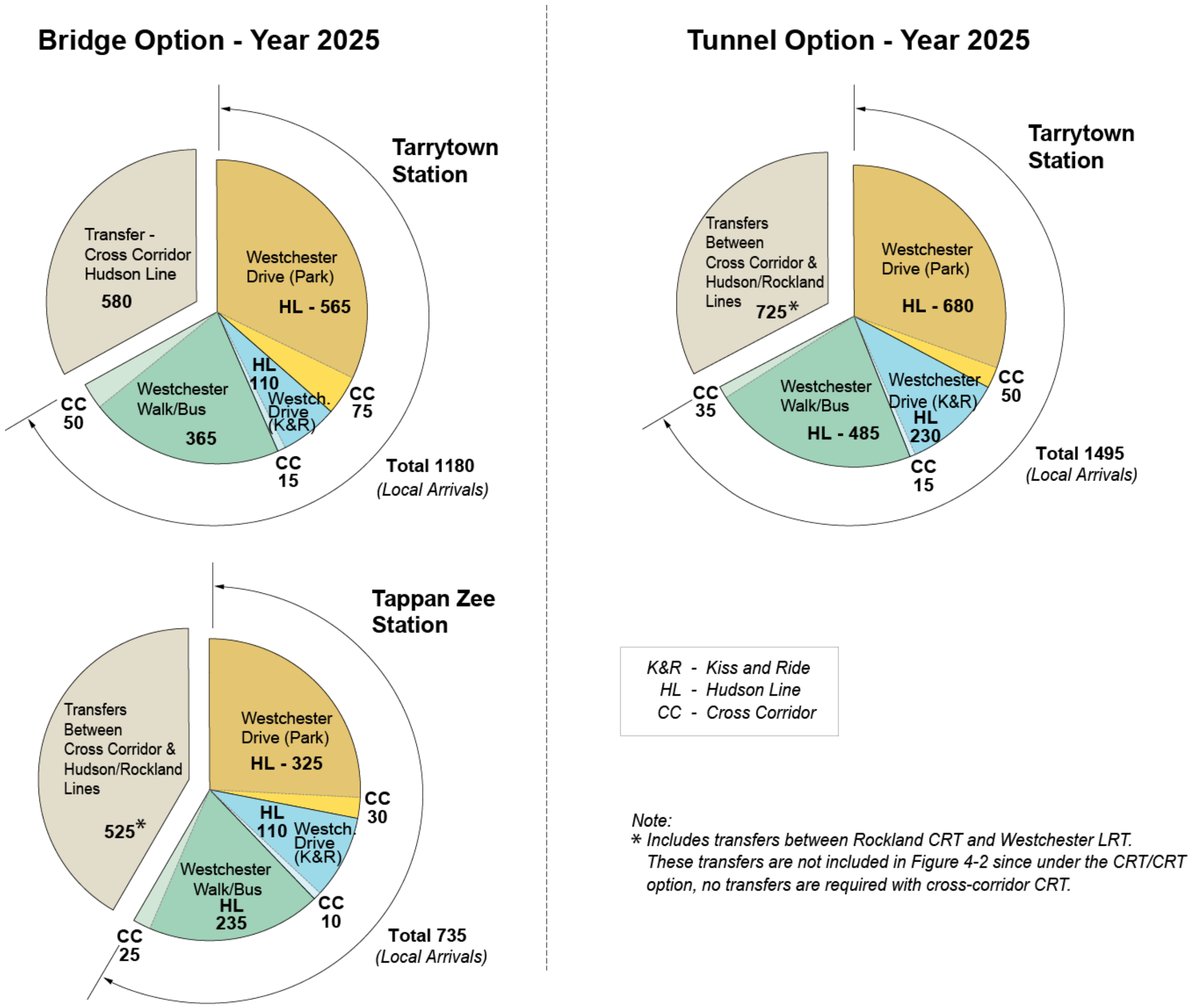
Figure 4-2

Table 4-1

Rail Boardings at Tarrytown and Tappan Zee Stations for CRT/CRT Scenario
AM Peak Period (6 AM – 10 AM)

Boardings for Hudson Line	Tarrytown Station			2025 Bridge Option		
	2002	2025 No-Build	2025 Tunnel Option	Tarrytown Station	Tappan Zee Station	Total
Westchester Walk/Bus	300	400	470	420	190	610
Westchester Kiss'n Ride	300	380	260	130	90	220
Westchester Drive/Park	560	560[1]	620	650	260	910
From Rockland via Bus	560	690	0	0	0	0
From Rockland Drive/Park	250	250[1]	0	0	0	0
Cross Corridor (E-W) Trips	-	-	250[2]	-	285[3]	285
Totals	1,970	2,280	1,600	1,200	825	2,025
Total Parkers	810	810	730	650	400	1050
Transfers (not included in above)	-	-	990	-	540	540

Notes:
[1] Doesn't grow – parking is at capacity.
[2] 110 of these are drive/park; 50 are kiss'n ride; 90 are walk/bus.
[3] 140 of these are drive/park; 45 are kiss'n ride; 100 are walk/bus.



Rail Boardings at Tarrytown and Tappan Zee Stations
for CRT/LRT Scenario
AM Peak Period - (6 AM - 10 AM) for 2025

Figure 4-3

Table 4-2

Rail Boardings at Tarrytown and Tappan Zee Stations for CRT/LRT Scenario AM Peak Period – (6 AM – 10 AM)

Boardings for Hudson Line	Tarrytown Station			2025 Bridge Option		
	2002	2025 No-Build	2025 Tunnel Option	Tarrytown Station	Tappan Zee Station	Total
Westchester Walk/Bus	300	400	485	365	235	600
Westchester Kiss'n Ride	300	380	230	110	110	220
Westchester Drive/Park	560	560[1]	680	565	325	890
From Rockland via Bus	560	690	0	0	0	0
From Rockland Drive/Park	250	250[1]	0	0	0	0
E-W Trips	-	-	100[2]	140[3]	65[4]	205
Totals	1970	2280	1495	1180	735	1915
Total Parkers	810	810	730	640	355	995
Transfers (not included in above)	-	-	725[5]	580	525[5]	1105

Notes:
[1] Doesn't grow – parking is at capacity.
[2] 50 of these are drive/park; 15 are kiss'n ride; 35 are walk/bus.
[3] 75 of these are drive/park; 15 are kiss'n ride; 50 are walk/bus.
[4] 30 of these are drive/park; 10 are kiss'n ride; 25 are walk/bus.
[5] Includes CRT Rockland riders transferring to LRT in Westchester or reverse.

4.1.3 Comparison of Options

For full corridor CRT riders originating in Orange and Rockland Counties there would be no significant difference in travel time between the Bridge and Tunnel Options. However, there are several key differences between the two options:

- The Tappan Zee Station would attract 425 additional Tarrytown area riders (diverted and new) in the AM peak period because of its location on Broadway, the provision of additional parking, and the express service to Grand Central Terminal.

- The Tappan Zee Station would divert approximately 400 riders from the Tarrytown Station in peak periods, relieving parking capacity constraints.

- The Tappan Zee Station would provide a much more convenient transfer (cross-platform and less than 1 minute) between CRT and LRT/BRT compared with the Tunnel Option, which requires 5 minutes to go from the lower level of Tarrytown Station to LRT/BRT at the surface, east of the Hudson Line.

- The CRT Tunnel Option would facilitate transfers between the Upper Hudson Line and the Cross-Corridor Line, with the opportunity for a direct transfer. Both LRT options would provide the same transfer opportunities, but with increased transfers with the Bridge Option, as described below.

4.2 Transportation System Integration

The transit improvements proposed in the Bridge and Tunnel Options would be to an existing network of transportation facilities and services in the region. These improvements are intended to enhance major movements, but would fit into a network that serves a variety of smaller movements as well. Transit is generally oriented to serving the ‘many-to-one’ movements, in this case service to Manhattan. However, increasingly, commuting patterns are ‘many-to-many,’ and transit has a more difficult time serving them.

Both options would provide opportunities for a large number of other trips (e.g., from Orange County to Stamford or Tarrytown to White Plains). Some cross-corridor trips are more attractive than others because of the concentration of employment at the destination. For example, there are markets from Dobbs Ferry to the “Platinum Mile” east of White Plains, or from Croton to Elmsford, or Suffern to Poughkeepsie. How well the system serves these markets, while concentrating on the major markets, is the measure of system integration. In addition, both options would provide service to Manhattan from Rockland and Orange Counties and from either the Tarrytown or Tappan Zee Stations in Westchester County.

4.2.1 Bridge Option

In the full CRT alternative (4A), trains from Rockland would either follow a direct connection to the southbound Hudson Line or continue east across Westchester and on to Stamford. These direct connections would serve all major markets. Other markets would be served by transfers at a new Tappan Zee Station. Westbound cross-Westchester passengers could transfer to the southbound Hudson Line at this new station. Northbound Hudson Line riders could transfer at the Tappan Zee Station for eastbound trains for destinations in White Plains and Connecticut.

There would be about 550 transfers in the AM peak, of which 450 are transfers between westbound cross-Westchester service and New York. The other 100 transfers are for four minor markets which would require a connection between the Tarrytown and Tappan Zee Stations, provided by buses using local streets. These minor markets are from eastbound cross-corridor from Rockland County to the Upper Hudson Line (and its return trip) and from the Upper Hudson Line to the eastbound cross-corridor (and its return trip).

In the CRT/LRT scenario, transfers for these markets are more direct because the LRT would serve both Tarrytown and Tappan Zee Stations. This more direct transfer would attract about 500 passengers. However, there would be no direct connection between Rockland and cross-Westchester service. A transfer would be required at the Tappan Zee Station for passengers from Rockland County to continue east across Westchester on LRT or BRT. This transfer would be cross-platform. It is estimated that about 225 passengers would use this transfer in the AM peak. In total, the Bridge Option with CRT would handle about 540 transfers, while the Bridge Option with CRT/LRT would handle a combined 1,100 transfers at the two stations.

4.2.2 Tunnel Option

As in the Bridge Option, trains from Rockland would either follow a direct connection to the southbound Hudson Line or continue east across Westchester. These direct connections would serve all major markets. Other markets would be served by transfers at an expanded bi-level Tarrytown Station. Transfer times between levels would be up to 5 minutes. There would be about 1,000 transfers in the AM peak (Table 4-1), of which 500 are transfers between westbound cross-Westchester service and New York. The other 500 transfers are for the four minor markets described above.

For east-west LRT service, the Tarrytown Station would also serve as the terminal for cross-Westchester transit with about 725 transfers in the AM peak (Table 4-2).

4.2.3 Comparison of Options

Both options provide direct (one-seat) service to major markets and provide for transfers to minor markets. The CRT Tunnel Option facilitates transfers between the Upper Hudson Line and the cross-corridor line, with the opportunity for a direct transfer. It would provide 400 more CRT-to-CRT minor market transfers in the AM peak than the Bridge Option. The Bridge Option attracts 425 local passengers to the Tappan Zee Station bound to New York City. When both local Westchester passengers and transferring passengers are considered, the Bridge Option serves more local passengers and the Tunnel Option serves more transferring passengers. Thus, while the Tunnel Option provides for more convenient transfers for certain minor markets, the total users of the stations are roughly equal.

In the case of CRT/LRT, the Bridge Option attracts more riders because of its more convenient transfers within the Tappan Zee Station.

4.3 Metro-North Operations

Current Hudson Line operations would be affected by both the construction and operation of the Bridge and Tunnel Options. Those effects would occur for Alternatives 4A, 4B, and 4C.

4.3.1 Bridge Option

During construction, track work modifications would extend 10,000 feet, and include:

- Closure of Track 4 between Tarrytown and Irvington Stations for the duration of construction (3 to 4 years).
- Closure of Track 2 during non-peak hours for the duration of construction.
- Closure of all tracks for a small number of overnight periods.
- For a length of 2,000 feet, staged relocation of tracks would be required to facilitate the construction of tunnels.
- Track 2 would be dropped into a tunnel in the area of Lyndhurst, resulting in a five-track configuration. Flood ramps would be located at each end of the tunnel.

Although occasional service delays would likely occur, overall Hudson Line service would generally be maintained throughout construction.

4.3.2 Tunnel Option

During construction, track work modifications would extend 14,000 feet, and include:

- Temporary closure of Track 4 for the duration of construction (up to 3 to 4 years) and of Track 3 during off peak hours for the duration of construction.
- For a length of 4,000 feet, staged relocation of tracks would be required to facilitate the construction of tunnels.
- The interlocking south of Tarrytown Station (CP25) would be relocated to just north of Irvington Station.
- To avoid property taking at the end of Van Wart Ave., Track 1 would be dropped into a tunnel to the north beginning at Tarrytown Station and rising again to rejoin the Hudson Line tracks at grade to the south. The width of accompanying flood ramp walls may necessitate narrowing or relocation of the western platform through the Tarrytown Station.
- During construction in the station area, slow running on all tracks would be required (3 to 4 years).

- During construction, the width of the western platform at Tarrytown Station would be reduced from its current 30 feet to approximately 20 feet along its full length.

- Parking adjacent to the fence west of the Tarrytown station would be eliminated during construction (approximately 50 spaces).

Although occasional service delays would likely occur, overall Hudson Line service would generally be maintained throughout construction.

4.3.3 Comparison of Options

The duration and extent of track work modifications in the Tunnel Option would be greater than the Bridge Option affecting the flexibility and reliability of Metro-North operations during construction. In particular, modifications associated with the interlockings and switches in the Tarrytown vicinity in the Tunnel Option would not be required in the Bridge Option. The Tunnel Option also impacts the Tarrytown Station with closing of Track 4 and possible narrowing of the inbound platform during construction.

4.4 NYS Thruway Operations

4.4.1 Bridge Option

During construction on both the Rockland and Westchester shorelines, the transition of the CRT alignment from the bridge to the shoulder tunnels would involve relocation of the Thruway around the work zones. In Westchester, this would further complicate the staging associated with the toll plaza, while in Rockland, roadway reconstruction from Broadway to the bridge would complicate staging due to the highway's increased elevation. In addition, access to the Thruway maintenance facility under the existing bridge and the Interchange 10 ramps would require staged relocation.

Due to complications associated with construction of the Tappan Zee Station in the toll plaza area, overall reconstruction of the Thruway would take approximately 6 months longer than under the Tunnel Option. From the long-term perspective, access and surface support facilities for the new Tappan Zee Station could displace Thruway support facilities to the north of the toll plaza or place them under the station parking (Location A).

4.4.2 Tunnel Option

During construction on the Rockland shoreline, the transition of the CRT alignment from the river tunnel to the shoulder tunnel would involve relocation of the Thruway around the work zones. Staging of the construction of the tunnel launch box on the Rockland side would complicate bridge construction because of its constrained location and the need to maintain River Road. In addition, access to the Thruway maintenance facility under the existing bridge and the Interchange 10 ramps would require staged relocation.

4.4.3 Comparison of Options

The Tunnel Option would have fewer construction impacts to Thruway operations because of the absence of the Tappan Zee Station in the toll plaza area. Permanently, the absence of rail on a dual-level bridge would reduce the complexity of bridge maintenance operations. However, for a single-level bridge, separation of highway and CRT maintenance operations would be possible on the bridge crossing but shared facilities might still be required at the Tappan Zee Station.

4.5 Local Roadway Congestion

The construction of CRT from Rockland and Orange County would eliminate about 400 current parkers from the Tarrytown Station, people who now drive across the bridge daily. It would also eliminate several daily Tappan Zee Express bus movements. While that does not alleviate the problems at Tarrytown, it frees up some capacity so that the increased activity caused by growth in the Tarrytown-Manhattan market and by the introduction of rail (or BRT) across the corridor would be more easily accommodated.

Currently, the major traffic problems in Tarrytown are on Broadway, where one lane of traffic in each direction north of Route 119 handles in excess of 1,500 vehicles in the peak hour (Figure 4-4), including a variety of turning movements. Most of the major intersections on Broadway operate at LOS E or F for most movements. The intersection of Broadway with Route 119, which is wider and has a protected left turn movement, still has movements operating at LOS F.

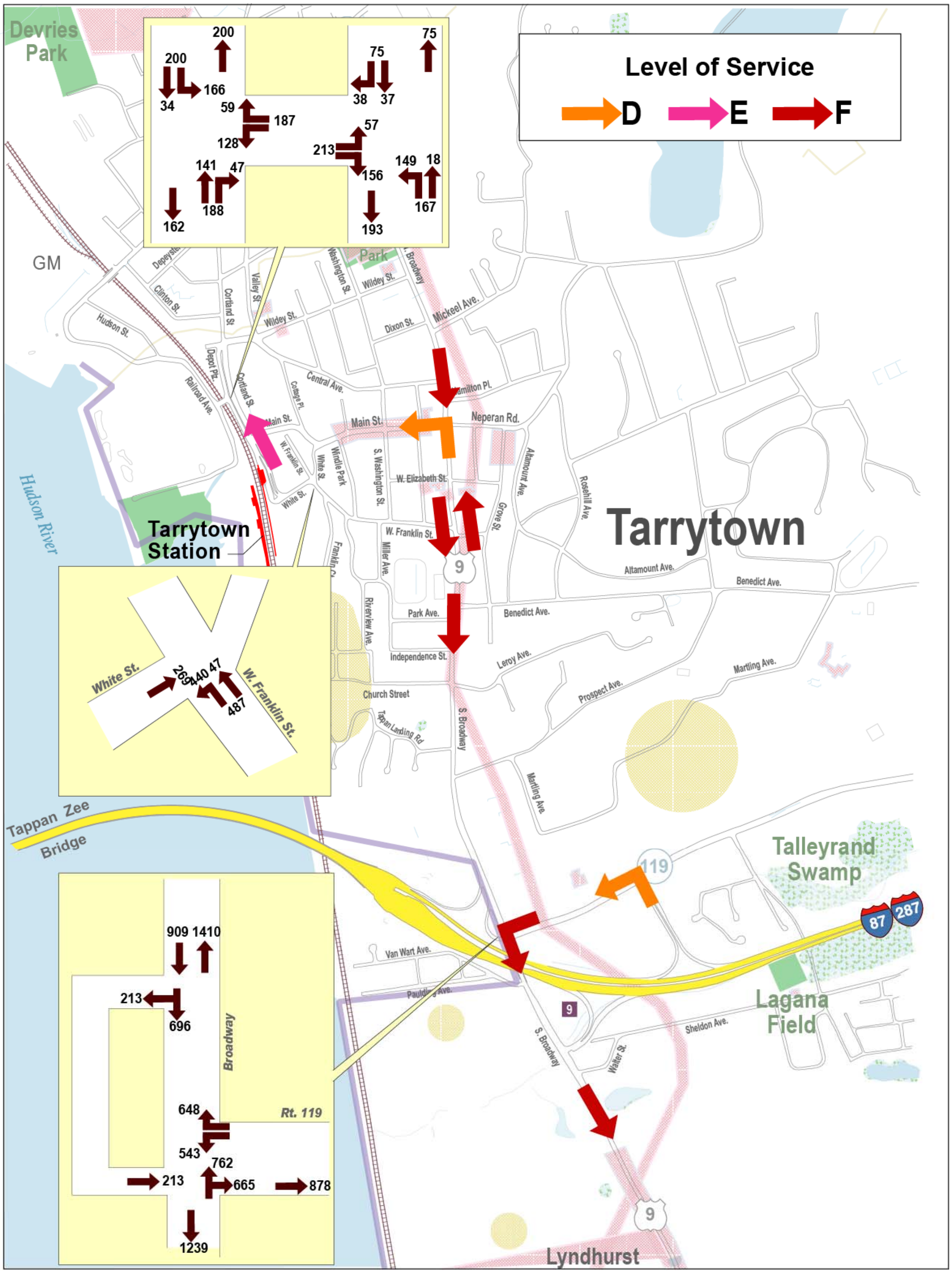
The major difference between the two options with respect to local roadway congestion relates to the development of the Tappan Zee Station. The station at Route 119 and Broadway would attract users (parkers, bus riders, and drop-off/pick-up passengers), lessening the traffic to the Tarrytown Station but concentrating activity at an already congested location. The nature of the traffic at Route 119 and Broadway is dependent in part on the configuration of the station at Tappan Zee, so several options were considered to determine whether a station was feasible (from a traffic perspective) at that location.

To evaluate the options, Synchro analyses were performed by growing 2002 counted traffic to represent the 2025 no build condition. Volumes were then adjusted to represent usage of the Tarrytown and Tappan Zee Stations as determined by the transit assignments from BPM.

4.5.1 Bridge Option

All cross-corridor trains and some trains crossing the river heading for Manhattan would stop at the Tappan Zee Station. This would provide an opportunity for Tarrytown area residents bound for Stamford, White Plains, Rockland and Orange Counties, or Manhattan to board a train (or LRT or BRT) at the Tappan Zee Station. By using the Tappan Zee Station, passengers coming from south or east (where the majority are expected to originate) would avoid the most congested portions of Broadway north of Benedict Ave. and the circuitous routes from Broadway down the hill to the Tarrytown Station. Traffic from Rockland County to Tarrytown would also be removed. Shifting activity from the Tarrytown Station to the Tappan Zee Station would alleviate some of the congestion on Broadway, but not enough to improve upon the LOS F rating.

The Synchro analysis for the Bridge Option considered three options for the Tappan Zee Station location and configuration in the vicinity of Route 119 and Broadway (Figure 2-9).



Existing Level of Service and Traffic Volumes – AM Peak Hour

Figure 4-4

- Station Option A – all station activity west of Broadway (the existing Thruway facility).
- Station Option B – all station activity east of Broadway (the shopping center).
- Station Option A+B – station activity split between locations east and west of Broadway.

Option A requires traffic coming from either the east or south to turn left off Broadway to enter the station area. Option B requires traffic from the north to turn left to enter, and traffic headed east to turn left exiting onto Route 119. Splitting the activity (Option A+B) can lessen the concentration of conflicting movements.

The Synchro analysis for the Bridge Option indicated that traffic conditions at Route 119 and Broadway would deteriorate from the no build condition with Option A, mainly due to the left turn movements into the station area. There were fewer conflicts and congested movements in Options B and A+B.

Traffic further north on Broadway would continue to be congested, but delays would be slightly lower than in the no build condition. For example, at the intersection of Broadway and Benedict Ave., the average delay for the northbound through movement would drop from 137 to 118 seconds. Traffic problems at the Tarrytown Station would also be alleviated (e.g., the westbound “H” Bridge movement delay drops from 61 to 28 seconds). The LOS and average peak hour delays are shown in Table 4-1 and Figure 4-5.

4.5.2 Tunnel Option

In the Tunnel Option, all transit activity, including transfers, would be focused on the existing Tarrytown Station. Access to the Tarrytown Station today is accomplished in a number of ways due to the congestion on Broadway and the complications of the grade-level railroad track. Access to the station from west of the tracks and access to the developments and parking west of the tracks is through use of the “H” Bridge north of the platforms that connects Railroad Avenue west of the tracks with Depot Plaza east of the tracks.

There are 12 possible movements using the two roadways and the “H” Bridge; currently they are uncontrolled, with the exception of a yield sign for eastbound drivers. As the bridge is largely uncontrolled, LOS cannot be quantified, but volumes exceed capacity, causing congestion. These data also appear on Figure 4-5 and in Table 4-3.

Because of the large parking facility west of the tracks, there is a steady stream of drivers approaching the station from the south in the morning and crossing the “H” Bridge heading south to the parking lot. Others approach from the north on Depot Plaza and also use the bridge. Still others come from Beekman Avenue and down Railroad Avenue straight to the parking. While the morning approach is a steady stream, the evening activity, based on train arrivals, is highly concentrated. More than 50 drivers attempt to leave the parking area in timeframes of less than 15 minutes, exacerbating short-term congestion problems.

Reconstruction and/or relocation of the “H” Bridge would offer opportunities to improve traffic operations. There may also be a need for an additional bridge across the tracks, particularly if the planned developments west of the tracks come to fruition. Access from Broadway down the hill to the station would remain unchanged from the no build condition, and traffic conditions on Broadway would remain at highly congested levels. For example, the northbound through movement at Broadway and Benedict Ave. improves slightly (128 seconds compared to 137 seconds in the no build condition).

Table 4-3

Level of Service and Average Delay in Seconds for the CRT Bridge and Tunnel Options

AM Peak Hour

Intersection	Location	Movement	Existing	No Build 2025	Bridge - TZ Station Options A	Bridge - TZ Station Options B	Bridge - TZ Station Options A+B	Tunnel Option
Broadway & Route 119	1	WB-R (Route 119 to Broadway)	36/D	71/E	97/F	65/E	67/E	74/E
	2	EB-T (Jug Handle to Route 119)	34/C	34/C	34/C	34/C	34/C	34/C
Broadway & TZ Station Entrance	3	NB-L (Left turn into TZ station)			67/E			
Broadway & Church St	4	NB-L (Broadway)	21/D	39/E	27/D	26/D	27/D	32/D
Broadway & Benedict Ave.	5	NB (Broadway) - Through	92/F	137/F	118/F	118/F	118/F	128/F
	6	SB (Broadway) - Through	71/D	119/F	113/F	113/F	113/F	116/F
H- Bridge*	7	WB	29/C	61/F	28/C	28/C	28/C	38/D
Main St/Depot Plaza/Cortlandt St	8	SB-T Depot Plaza (bridge)	48/C	63/D	63/D	63/D	63/D	63/D

PM Peak Hour

Intersection	Location	Movement	Existing	No Build 2025	Bridge - TZ Station Options A	Bridge - TZ Station Options B	Bridge - TZ Station Options A+B	Tunnel Option
Broadway & Route 119	1	WB-R (Route 119 to Broadway)	16/B	17/B	17/B	1/7/B	17/B	17/B
	2	EB-T (Jug Handle to Route 119)	123/F	171/F	209/F	165/F	168/F	163/F
Broadway & TZ Station Entrance	3	NB-L (Left turn into TZ station)			14/B			
Broadway & Church St	4	NB-L (Broadway)	21/C	34/D	31/D	31/D	31/D	32/D
Broadway & Benedict Ave.	5	NB (Broadway) - Through	15/B	22/C	21/C	21/C	21/C	21/C
	6	SB (Broadway) - Through	153/F	201/F	184/F	184/F	184/F	198/F
H- Bridge*	7	WB	14/B	16/C	15/B	15/B	15/B	15/B
Main St/Depot Plaza/Cortlandt St	8	SB-T Depot Plaza (bridge)	76/E	111/F	59/E	59/E	59/E	72/E

* Although Synchro did not report the eastbound movement LOS, since there is no form of signalization, the volume/capacity ratio is greater than one - creating congestion.

Level of Service A
Level of Service B
Level of Service C
Level of Service D
Level of Service E
Level of Service F

LOS Analysis Locations

Figure 4-5

4.5.3 Comparison of Options

In either option, the removal of 400 daily Rockland County commuters from the Tarrytown Station would alleviate some local traffic problems. The Bridge Option would also remove many additional vehicles from Broadway between Route 119 and Main Street, reducing delays but not achieving significant LOS improvements. Some of the parking configurations in the Bridge Option create problems at Route 119 and Broadway, but there is room at that intersection for mitigation. Therefore, the Tappan Zee Station is feasible from a traffic perspective and can be designed to work in that location. Traffic mitigation measures will be investigated further as part of the more detailed DEIS Stage to determine the most appropriate solutions to reduce traffic congestion in these areas.

The Tunnel Option would continue to concentrate activity at the Tarrytown Station. Reconstruction or relocation of the “H” Bridge would potentially alleviate capacity problems but congestion on Broadway would continue. Planned developments west of the tracks would exacerbate those problems.

4.6 Rail Freight

Freight use of either the Bridge or Tunnel Options would be limited by hours of availability, clearance limitations, and grades on the rail line. Both options exceed the 1 percent desirable grade for freight rail service, requiring multiple locomotives for adequate tractive power. Usage would be limited to standard freight cars and TOFC with relatively light loads. It is more likely that the freight diverted to this crossing would be freight now traveling by rail (crossing the Hudson at Selkirk) than by truck. To the extent it is diverted from truck, it may lessen truck traffic on the Tappan Zee and George Washington Bridges. Either result would be positive. There is no significant transportation difference between options as to freight impacts.

4.7 Summary

Of the six criteria studied, the principal discriminators were transportation system integration, ridership, and traffic congestion with the Bridge Option providing greater benefits because of a new CRT station (Tappan Zee Station, which also provides more convenient transfers to LRT or BRT), increased ridership, and improvements in local Tarrytown traffic.

As shown in previous papers and reinforced by the results of the BPM analysis conducted for this crossing study, the inclusion of CRT in both the Bridge or Tunnel Options would greatly improve overall mobility (transportation performance and integration) in the markets served by the corridor, with significant benefits in both Rockland and Westchester counties. Both options would provide direct connections for the major markets between Rockland/Orange Counties to Westchester County and further east and also to New York City and other destinations to the south along the Hudson Line. Similarly, both options could accommodate BRT or LRT across Westchester. Transportation performance differences between the two options would, therefore, not be associated with overall major market mobility. Though the Tunnel Option provides better connectivity, it is for minor markets only in Alternative 4A. In Alternatives 4B and 4C the Bridge Option is better.

The BPM analysis indicates that the Bridge Option (with full corridor CRT) would generate 425 more new local riders in the AM peak than the Tunnel Option. The Tunnel Option would produce an increase in the number of transfers (450 more in the AM peak hour) than the Bridge Option. However, with CRT combined with LRT in Westchester, the Bridge Option maintains most of its advantage in generating new local riders (420 more) and also serves more transfers (380) than the Tunnel Option.

Under both options, traffic congestion in the Tarrytown Station area would be reduced as Rockland riders formerly using that station would use local stations in their county. There would be further reductions in Tarrytown Station area traffic because of the Tappan Zee Station under the Bridge Option. This station provides an alternative route for Westchester commuters to the south and east of Tarrytown to access the Hudson Line, thus reducing the demand on the existing Tarrytown Station and the associated road network. The Tappan Zee Station would not adversely impact traffic in the vicinity of the new station. With respect to local traffic congestion, the Bridge Option is favored because it further reduces local traffic in the Tarrytown Station area.

5 ENVIRONMENTAL CRITERIA

The discussion of potential environmental impacts presented here is based on detailed review of the engineering concepts presented in Chapter 2. The criteria addressed are:

- Displacements, easements, and partial takings.
- Land use.
- Historical/archaeological resources.
- Parklands.
- Ecosystems and water resources.
- Visual resources.
- Contaminated soils and groundwater.
- Air quality and noise.

Each criteria discussed is introduced by a summary of the impacts of a new highway-only bridge. The new highway-only bridge thus provides a baseline for the comparison of CRT impacts between the Bridge and Tunnel Options. The environmental analysis focused on those environmental assessment areas shown in Figures 2-1 and 2-2.

It is important to note that the AA process is the planning phase of the Environmental Review, the purpose of which is to develop a short list of alternatives to be carried forward into the DEIS Stage. In the course of this planning phase, design concepts have been developed at a level of detail commensurate with making planning decisions. Thus, the environmental impacts discussed below are preliminary and have not been evaluated beyond the level needed for comparison of the Bridge and Tunnel Options. Further in depth evaluation of environmental impacts will occur in the DEIS Stage. The analyses that will be conducted during the DEIS Stage will better define the nature, extent, and significance of impacts, and appropriate mitigation measures, where possible, can be developed.

5.1 Displacements, Easements, and Partial Takings

The terminology used in this paper is defined as follows:

- **Displacements** – takings of property that preclude its existing use (e.g., taking of a structure, permanent disruption of access).
- **Easements** – the temporary or permanent use of a property that does not preclude its current use.
- **Partial Takings** – takings of property (not structures) but not precluding current use.

For the highway-only bridge between the Rockland shore and Interchange 10, less than five residential displacements and less than five residential partial takings would be required. These are associated with widening of the Thruway and improvements to Thruway maintenance facilities and access ramps. Between the Westchester shore and Interchange 9, there would be less than five partial takings of residential property.

5.1.1 Bridge Option

Rockland

In Rockland County, between Interchange 10 and the river, construction of the dual-level Bridge Option would have impacts comparable to the highway-only bridge, with the exception of a partial taking at South Nyack's Elizabeth Place Park.

For the single-level bridge, between Interchange 10 and the river, there would be less than 15 residential displacements, less than 15 residential partial takings, and a partial taking from Elizabeth Place Park (Figure 5-1).

Westchester

On the Westchester shore, the Bridge Option would require partial takings and displacements of property for the new Tappan Zee Station (Figure 5-2). The below ground station extends from the Thruway administrative complex east under Route 9 and the shopping center parking area. It would displace the Chase Bank building, a gas station, and part of the parking lot. Station access and parking at Location A would displace the NYSTA maintenance and Troop T facilities; at Location B the shopping center would be displaced. Further evaluation of these two station sites will be done during the DEIS Stage. West of the proposed station, closer to the river, there would be partial takings from one commercial property adjacent to the ROW and less than five partial takings of residential properties.

Easements would be required for the one-mile Hudson Line CRT connection tunnel and the Hudson Line. The tunnel would pass beneath several dozen residential and commercial properties. One of the properties is a relatively large research complex operated by Kraft Foods. There would also be a vent structure on the Kraft and/or Requa properties requiring a partial taking of approximately 1 acre. An access road running parallel to the MNR tracks to Tarrytown Station may require a partial taking at the western end of Van Wart Avenue (Figure 5-3).

The addition of LRT/BRT to the Tappan Zee Station would result in less than five partial takings of commercial properties along Route 119.

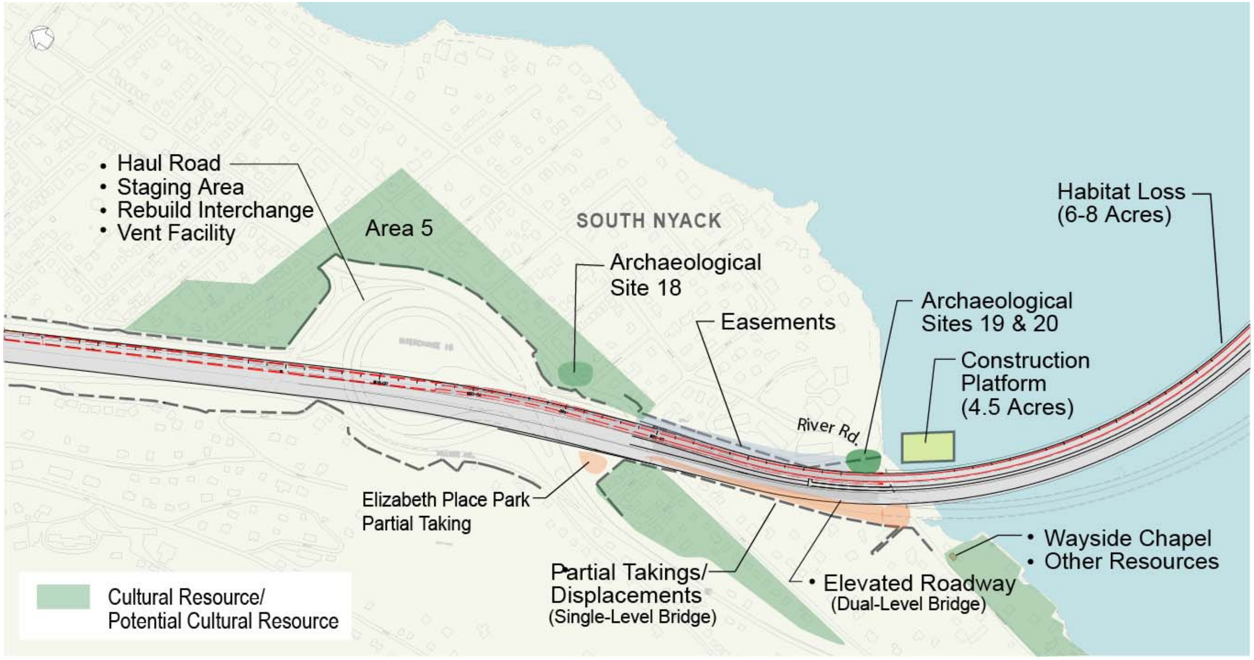
5.1.2 Tunnel Option

Rockland

At the Rockland shore, there would be no additional partial takings or displacements beyond those required for the highway-only bridge (Figure 5-4).

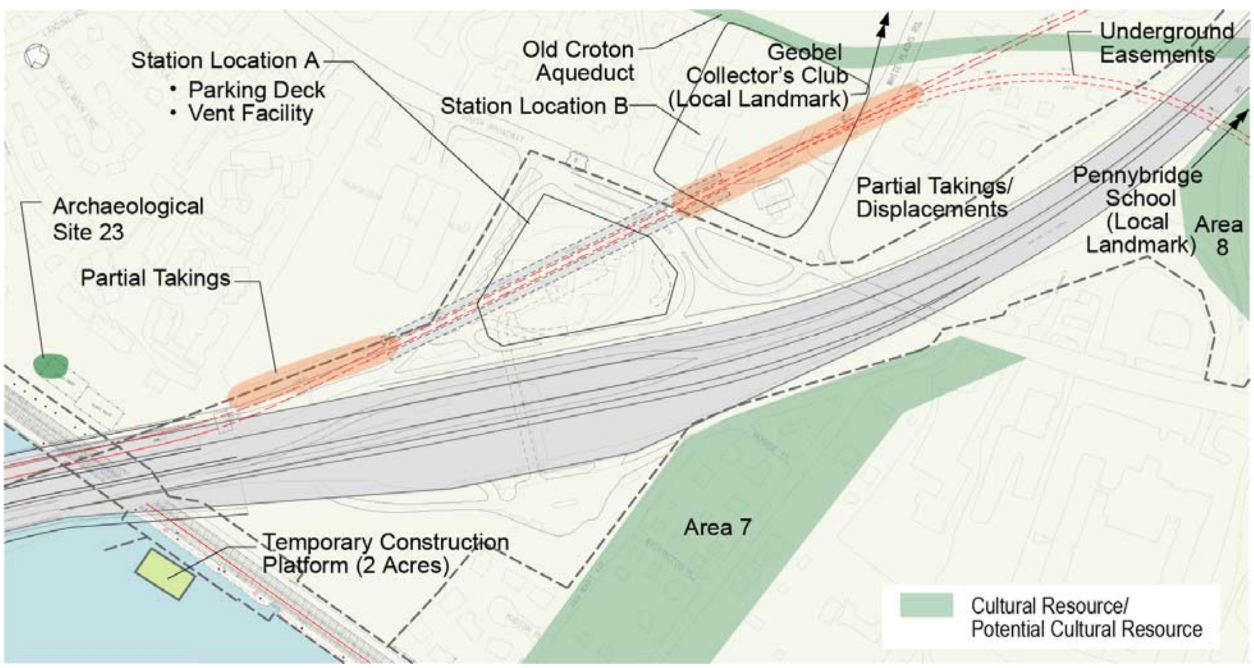
Westchester

On the Westchester shore, the tunnel would require the displacement of the Castle Oil property for a temporary TBM recovery box and a permanent ventilation structure (Figure 5-5). Construction between the recovery box and Tarrytown Station would entail either partial takings or displacements of about 4 acres of the 30-acre proposed Ferry Landing residential development site (about 15 to 20 units depending upon the final approved site plan). If the asphalt plant is moved to its proposed site, the Tunnel Option would displace the plant.



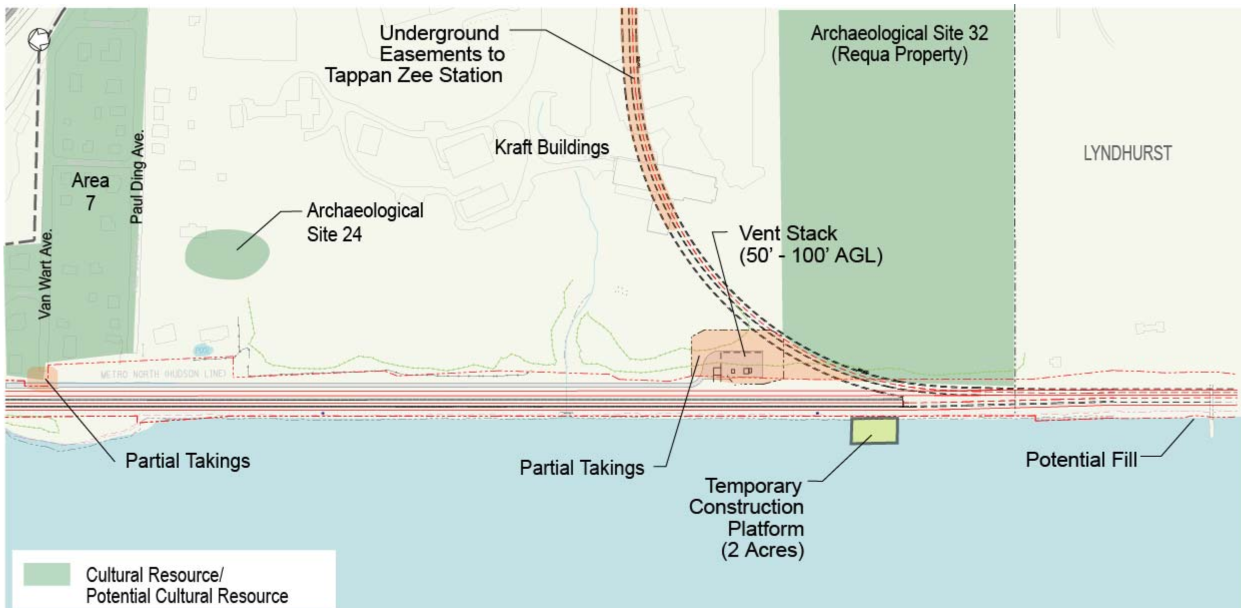
Environmental Considerations - Bridge Option in Rockland

Figure 5-1



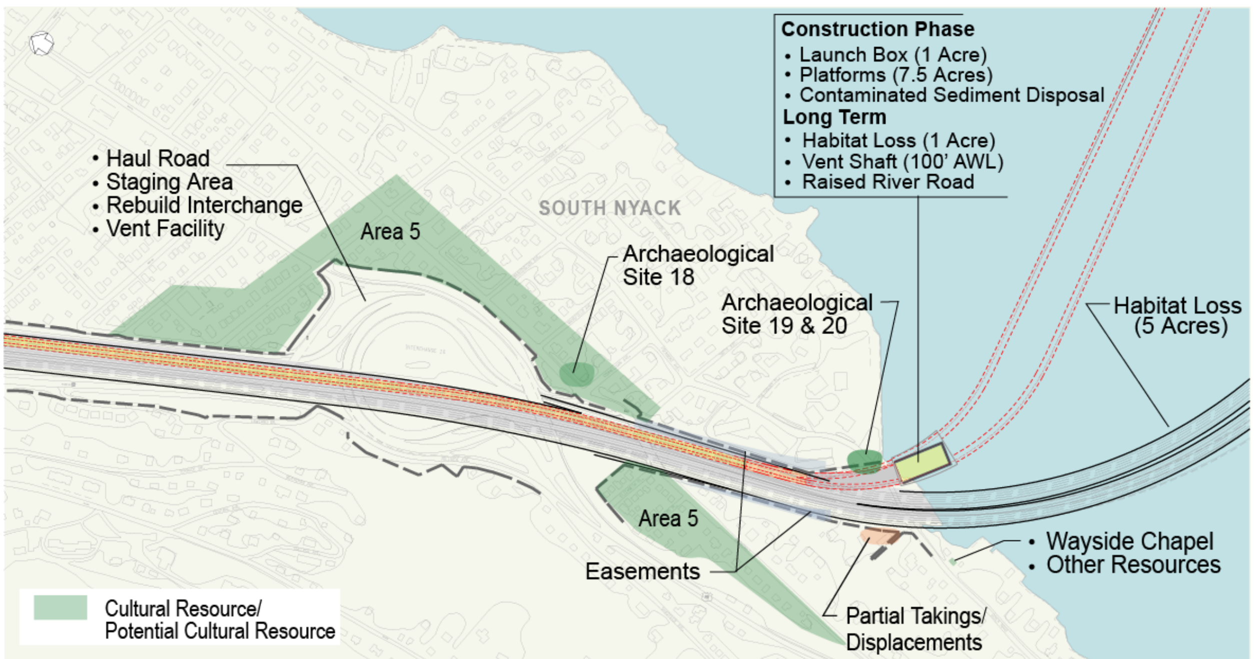
Environmental Considerations - Bridge Option in Westchester

Figure 5-2



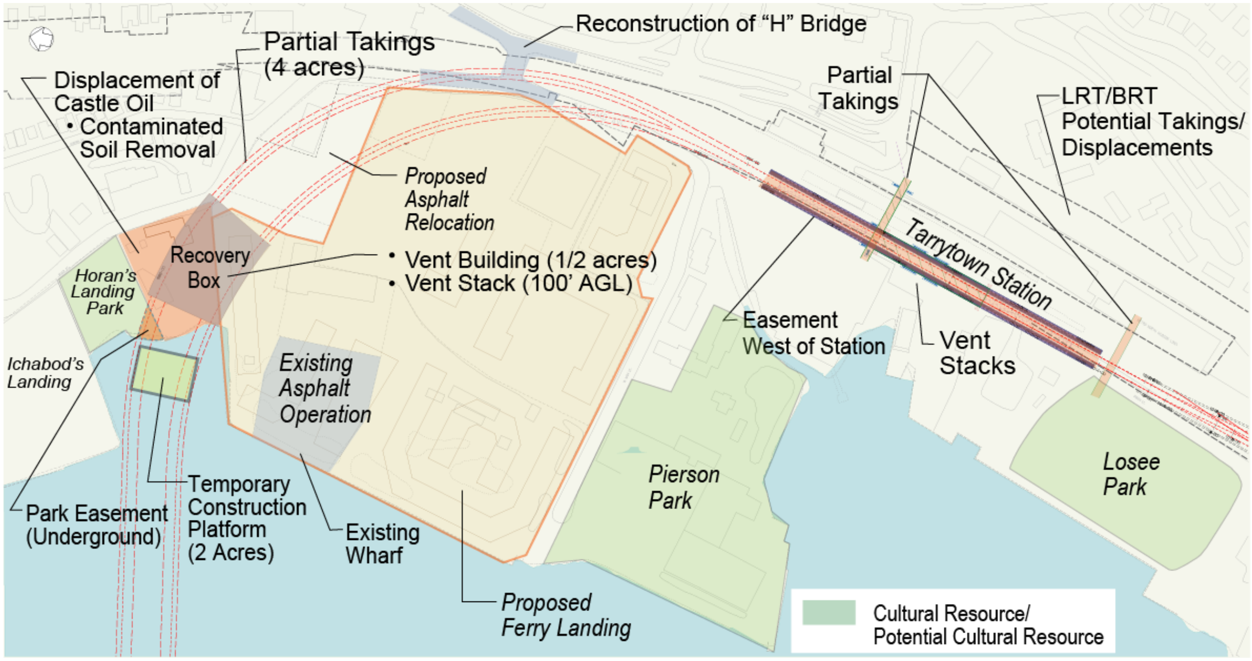
Environmental Considerations - Bridge Option in Westchester (South)

Figure 5-3



Environmental Considerations - Tunnel Option in Rockland

Figure 5-4



Environmental Considerations - Tunnel Option in Westchester

Figure 5-5

At the Tarrytown Station some minor partial takings of village property used for parking or ROW would be required for pedestrian movements. Two commercial properties east of the station would be displaced. An easement would be required for the tunnel beneath Horan's Landing Park.

The addition of LRT/BRT would affect the same number of properties as for the Bridge Option, but with a slightly greater area.

5.1.3 Comparison of Options

In Rockland, the dual-level Bridge Option and the Tunnel Option would have a comparable number of partial takings and displacements (Table 5-1). However, for the single-level bridge there would be a greater number of partial takings and displacements. Some of these impacts could be mitigated with further study.

In Westchester County, for the Bridge Option there would be commercial partial takings and displacements associated with the Tappan Zee Station for either Locations A or B. The Hudson Line CRT connection tunnel would pass beneath multiple properties requiring easements. Partial taking of 1 acre of Kraft and/or Requa property would also be required. Some of these impacts could be mitigated with further study.

For the Tunnel Option, there would be major partial takings and displacements of residential properties at the proposed Ferry Landing development (4 acres, 15 to 20 units), asphalt plant, and Castle Oil terminal. Additional partial taking of industrial property and public ROW would be required to construct the connection to Tarrytown Station. Some of these impacts could be mitigated with further study.

In summary, on the Westchester side, the displacements and partial takings would be more significant with the Tunnel Option.

5.2 Land Use

The potential for land use impacts considers the land use changes (from residential, commercial, and industrial uses to transportation), as well as the relationship of the project to key planning documents such as master plans and waterfront revitalization programs. Development of a new highway-only bridge would not significantly alter land use character in the bridge vicinity since it would replace the existing bridge, which has been operating for over 50 years in the same location.

In Rockland County, the Tappan Zee Bridge lands in the Town of Orangetown, at the boundary between the villages of South Nyack and Grand View on Hudson. The town is in the process of updating its comprehensive plan and has planning consultants assisting with this effort. Public meetings are proposed over the next several months. The focus will be on land use issues and opportunities, the need for diverse housing types and the preservation and revitalization of downtown areas.

The Village of South Nyack does not have a master plan and implements its land use policies through local zoning. The zoning seeks maximum protection of residential areas and values. The Village of Grand View similarly has no master plan and relies on local zoning to implement its land use policy, which emphasizes a variety of goals focused on preservation of its hillsides and natural beauty. The consistency of a new highway-only bridge with zoning policies in these two Rockland County waterfront villages would principally depend on the sensitivity of the selected design.

Rockland County has a vision document that serves as its land use policy guidance, *Rockland County: River to Ridge A Plan for the 21st Century* (2001). This document recognizes that transportation corridors will continue to shape the growth of the county and devotes a major focus to them. It does not, however, provide a specific focus on the area of the bridge landing. In overall terms, its transportation vision is one of “an integrated vehicular, mass transit and alternative transportation infrastructure with an efficient network of intra- and inter-county and state roadways, railways and pathways.” No specific discussion is provided of cross river transportation mode preferences.

In Westchester, the bridge landing is in the village of Tarrytown, within the town of Greenburgh. The Town of Greenburgh is in the process of finalizing a new comprehensive plan; however, none of its targeted areas or “elements” address a new highway-only bridge; therefore, constructing a new bridge would not be inconsistent with the town’s policies. The Village of Tarrytown does not have a master plan but controls zoning in the relevant area. Zoning goals emphasize preservation and enhancement of property values, protecting natural and aesthetic qualities, and ensuring appropriate development with regard to those elements.

Tarrytown also has a draft Waterfront Revitalization Program (WRP) that particularly emphasizes public access to the waterfront, ecological protection, and preservation of historic areas. In addition, a section devoted to air quality places special emphasis on problems in the vicinity of the Thruway toll plaza and proposes further study of congestion and air pollution problems with a view to mitigating problems in this vicinity. Consequently, proposals to build a new highway-only bridge would receive scrutiny to determine consistency with this draft WRP. Further analysis of air quality effects related to a new highway-only bridge (particularly in the vicinity of a new toll plaza) will also be evaluated in greater detail as part of the DEIS Stage. This effort would expand on the findings of Tarrytown’s forthcoming WRP on the potential air quality impacts at all nearby sensitive receptors.

Westchester County has a land use policy guidance document, *Patterns for Westchester: The Land and the People* (1996). Among the principal policies relevant for the river crossing discussion are:

- To channel development, whenever possible, to centers where infrastructure can support growth, where public transportation can be provided efficiently, and where economic redevelopment can enhance economic vitality.

- Enhance the appropriate functions of the county's corridors by adapting already developed sections into efficient and attractive multi-use places, by protecting the quality of scenic routes and by making road and transit improvements that will reduce congestion and ease movement on travel routes.

While these polices offer substantial generalized guidance, it is not clear how their interpretation would favor or be inconsistent with any of the river crossing alternatives.

In addition to local plans and zoning regulations, New York State's Quality Communities Interagency Task Force (Lieutenant Governor Mary O. Donohue, Chair) has issued a report titled *Partnering for a Better New York* (January 2001) in which a series of recommendations are provided for creating "quality communities". Two of the report's recommendations are directly applicable to the current project: Recommendation 31 – Continue to construct new intermodal transportation centers to address passenger needs and anticipated future growth; and Recommendation 32 – Expand efforts to accommodate bicycle and pedestrian access on all new transportation facilities. The first of these recommendations is intended to improve transit interconnectivity while the second is focused on reducing automobile dependency.

5.2.1 Bridge Option

Rockland

Similar to the highway-only bridge, there would be minor land use changes (residential to transportation) associated with the access ramps for the dual-level bridge. For the single-level bridge, the more extensive partial takings and displacements would result in greater changes in residential land use.

Westchester

Partial taking or displacement of the shopping center would be a change in land use for the village. However, upon completion of the station this property could be redeveloped to provide enhanced commercial services. Also, the presence of a transportation complex at Broadway and Route 119 would provide the opportunity for transit-oriented planning and development with potential long-term benefits for the community.

5.2.2 Tunnel Option

Rockland

The Tunnel Option would have similar land use impacts to the dual-level bridge.

Westchester

A portion of the Castle Oil property would become a transportation land use to house the ventilation facility. The remainder of this property could be redeveloped for other purposes in accordance with village land use policies. The Ferry Landing property could be restored to residential land use upon completion of construction.

5.2.3 Comparison of Options

In Rockland, land use impacts would occur with the single-level Bridge Option as a result of the conversion of residential and institutional property to transportation use. The highway-only bridge, dual-level Bridge, and Tunnel Option would have relatively fewer land use impacts.

In Westchester, it is assumed that the Ferry Landing site would be essentially restored. Thus, with the exception of the Castle Oil displacement, there would be no permanent land use impacts under the Tunnel Option. Under the Bridge Option, there would be no permanent land use impacts if the shopping center were restored. With further opportunities for transit-oriented development in the vicinity of the Tappan Zee Station, there would be a positive impact on land use in Tarrytown.

In summary, land use is not a discriminator between the Bridge and Tunnel Options.

5.3 Historical/Archaeological Resources

The potential for impacts to cultural resources (historical and archaeological resources) is based on a review of pertinent federal, state and local documentation. Direct impacts are associated with the partial taking or displacement of a resource; indirect impacts relate to nearby construction work and long-term visual effects.

For the highway-only bridge in Rockland County, construction activity between River Road and Interchange 10 would abut an area (Area 5) identified as having numerous potentially significant historic architectural resources (Figure 5-1); thus, any impacts would be indirect. At River Road, construction work would have an indirect impact on Wayside Chapel, an eligible resource. In Westchester, construction would occur adjacent to one area (at Van Wart Avenue) having potentially significant historic architectural resources (Area 7) and could have an indirect impact on one local landmark (Pennybridge School).

5.3.1 Bridge Option

Rockland

The construction of the dual-level Bridge Option would have a minor direct impact (partial taking) on potentially significant historic properties in Area 5. Additionally, the single-level bridge would displace up to six potentially historic properties (pending further study) in Area 5 (Figure 5-1), thereby having a direct impact on these resources.

Westchester

Direct impacts to cultural resources would include:

- Construction along the Hudson Line would entail relocation and reconfiguration of an existing unused access bridge over the tracks at Lyndhurst.
- The Old Croton Aqueduct, a National Historic Landmark, runs through the study area. Earlier development along Broadway may have already removed this subsurface feature. If it remains, direct impacts would be avoided by tunneling under without disturbance.
- A portion of the Requa House property would be directly impacted by the partial taking for the ventilation facility.
- Construction associated with LRT would have a direct impact to the Geobel Collector's Club (a local landmark).

Indirect impacts to cultural resources would include:

- Construction of the Hudson Line connection tunnel and access shaft east of the toll plaza would indirectly impact Pennybridge School (a local landmark), which is situated within an area having potentially significant historic architectural resources (Area 8, Figure 5-2).
- Lyndhurst and Sunnyside, both National Historic Landmarks, would be indirectly impacted by construction along the Hudson Line.
- Construction of the Tappan Zee Station would have indirect impacts on two areas of potential historic sensitivity (Areas 7 and 8, Figure 5-2).

5.3.2 Tunnel Option

Rockland

In Rockland, no direct impacts to historic architectural resources are expected. Indirect impacts of the Tunnel Option would be comparable to those of the dual-level Bridge Option.

The launch box, ventilation building, and associated facilities and staging areas along the Rockland County shoreline would directly impact two potential archaeological sites (Sites 19 and 20) (Figure 5-4).

Westchester

Direct impacts to cultural resources would include:

- Relocation and reconfiguration of an existing unused access bridge over the Hudson Line at Lyndhurst.
- The expansion of Tarrytown Station would have a direct impact on one archaeological site (Site 23) (Figure 5-2).

Indirect impacts to cultural resources would include:

- The expansion of Tarrytown Station would have an indirect impact on the station building (a local landmark) and on the near-river historic architectural districts of the Village of Tarrytown.

5.3.3 Comparison of Options

Both the Tunnel and Bridge Options would cause direct and indirect impacts to cultural resources in Rockland and Westchester Counties. Both options would have a direct impact on the unused access bridge at the Lyndhurst historic property. The Bridge Option with LRT would have a direct impact on one local landmark (Geobel Collector’s Club). Both options could have direct impacts on archeological resources, but these cannot be more precisely identified at this stage. Both options would have indirect impacts on a variety of historic resources.

In summary, the dual-level Bridge Option and the Tunnel Option have comparable impacts on cultural resources; however, the single-level bridge would directly impact more potentially eligible resources in Rockland.

5.4 Parklands

Historic properties that are protected under Section 4(f) of the Transportation Act have been addressed in the previous section. For the highway-only bridge, there are no parklands at the Rockland or Westchester shores that would be affected.

5.4.1 Bridge Option

Rockland

Between Interchange 10 and the river, there would be a partial taking of one park (Elizabeth Place) with both the single-level and dual-level bridges.

Westchester

There are no parklands on the Westchester shore that would be directly affected by the Bridge Option. There would be indirect impacts during construction to Lagana Park (west of Meadow Street) and to the County Park adjacent to Lyndhurst.

5.4.2 Tunnel Option

Rockland

The Tunnel Option would have no impacts on parklands at the Rockland shore.

Westchester

At the Westchester shore an easement beneath the waterfront Horan's Landing Park in the village of Sleepy Hollow would be required. The tunnel boring beneath the park is not expected to have significant impacts to the park because it would be approximately 60 feet below grade at this point. The park would be indirectly impacted by construction at the adjacent launch box and ventilation facility. The ventilation stack would have a permanent indirect impact.

There would be minor indirect impacts to Pierson and Losee Parks due to construction of the new Tarrytown Station.

5.4.3 Comparison of Options

The Bridge Option would have a direct impact to one park, and minor indirect impacts to Lagana and County Parks in Westchester. The Tunnel Option would have indirect impacts during construction on Horan's Landing Park and the ventilation structure would have a permanent indirect impact on the park. There would be minor indirect impacts to Pierson and Losee Parks.

In summary, parklands is not a discriminator between the Bridge and Tunnel Options.

5.5 Ecosystems and Water Resources

Ecosystem and water resource impacts are categorized as temporary or permanent. Temporary impacts are disturbances of the river bottom or shoreline that would be restored by natural means or active on-site restoration measures. Permanent impacts are irreversible disturbances to river bottom or shoreline that must be offset by implementation of either near-site or off-site mitigation measures.

For bridges, permanent impacts of the river bottom are measured by the area of the pile foundation caps. Construction of the highway-only bridge foundations would result in a permanent loss of 5 acres of Hudson River habitat. Temporary ecosystem impacts would also occur during construction of a new bridge as a result of the need to bring both construction materials and equipment to various work sites and to dispose of soils and rock from project excavations. Temporary platforms would be constructed along both shorelines to handle incoming equipment and outgoing spoils. These platforms would be located along the shoreline at either end of the new bridge and would cover 4 acres total.

5.5.1 Bridge Option

Construction of the dual-level and single-level Bridge Option foundations would increase the permanent loss of Hudson River habitat to 6 acres and 8 acres, respectively, an increase of 1 to 3 acres over the highway-only bridge. In addition, the need to stabilize the existing shoreline embankment along the Hudson Line in the vicinity of a proposed County Park and Sunnyside would result in the placement of about 0.5 acres of riprap into the river for both bridge options. The need for additional riprap along the Hudson Line could be mitigated by using less than the standard 14-foot track centers).

Temporary construction-related platforms totaling 8.5 acres would be required in the river. These temporary platforms would be situated at both ends of the bridge and adjacent to the Kraft and/or Requa property. This would be the same for either a single-level or dual-level bridge.

5.5.2 CRT Tunnel Option

Construction of the highway-only bridge foundations for the Tunnel Option would result in 5 acres of permanent habitat loss. The ventilation facility in the river at the Rockland shore would result in an additional 1 acre of permanent loss of habitat, and reconstruction of the rip-rap along the Hudson Line between Tarrytown Station and the bridge would result in 0.5-acre permanent loss of habitat, for a total of 6.5 acres. The need for additional riprap along the Hudson Line could be mitigated by using less than the standard 14-foot track centers).

Temporary platforms, covering 12.5 acres, to support bridge and tunnel construction operations would be required. These platforms would be situated at either end of the bridge and adjacent to the Westchester recovery box. Additionally, a temporary bridge structure at the Rockland shoreline for maintenance of Thruway traffic during construction would result in a 1-acre temporary loss of river habitat.

5.5.3 Comparison of Options

Adding CRT to the highway-only bridge would result in 1.5 to 3.5 acres of permanent river habitat loss and 4.5 acres of temporary habitat impacts beyond that of the highway-only bridge (Table 5-1). The Tunnel Option would result in 1.5 acres of permanent river habitat loss and 9.5 acres of temporary habitat impacts beyond that of the highway-only bridge.

In summary, while the permanent impacts are comparable for the Bridge and Tunnel Options, the Tunnel Option would have greater temporary impacts.

Table 5-1

Acres of Affected River Habitat

Source of Impact	Highway-Only Bridge	CRT Bridge Option		CRT Tunnel Option	
		Increment	Total	Increment	Total
Permanent					
Bridge Piers, etc.	5	1 to 3	6 to 8	-	5
Tunnel Ventilation	-	-	-	1	1
Fill on Westchester Shore	0	0.5	0.5	0.5	0.5
Total Permanent	5	1.5 to 3.5	6.5 to 8.5	1.5	6.5
Temporary					
Work Platforms	4	4.5	8.5	8.5	12.5
Temporary Bridge	-	-	-	1	1
Total Temporary	4	4.5	8.5	9.5	13.5

5.5.4 Permitting

A permit to construct the new Tappan Zee Bridge will be required from the US Coast Guard pursuant to Section 9 of the Rivers and Harbors Act (RHA). Other aspects of the project including permanent fills, temporary work platforms, and dredging will necessitate obtaining approvals from the US Army Corps of Engineers as per requirements of Section 10 of RHA and Section 404 of the Clean Water Act (CWA). Since the Hudson River at Tappan Zee is a migratory way for the endangered short-nosed and Atlantic sturgeon, a Section 10 Endangered Species Act permit will be required prior to starting construction. This approval is issued by National Oceanic and Atmospheric Administration (NOAA) Fisheries.

At the state level, principal environmental approvals will be needed from the New York State Department of Environmental Conservation (NYSDEC) and from the New York State Department of State (NYSDOS). NYSDEC will issue approvals related to water quality, protection of waters, and wetlands. NYSDOS will review project plans for consistency with the state's coastal zone management program. In addition to various environmental approvals, it is likely that a grant of easement may be required from New York State's Office of General Services pursuant to New York's Public Lands Law will also be needed to construct a new bridge or tunnel across the Hudson River.

The scale of in-river impacts and the ability to mitigate those impacts will be the principal factors in the complexity of obtaining environmental approvals. Ultimately, however, the complexity of obtaining approvals will depend on the EIS presentation of all issues engendered by the project and not exclusively on those associated with in-river impacts. Permitting will proceed concurrently with the EIS such that the regulatory agencies would be in a position to render permit decisions after a Record of Decision is issued.

5.6 Visual Resources

The potential for visual impacts relates primarily to two considerations. A replacement bridge would alter the existing visual environment by a change in the bridge's design, alignment and profile. Secondly, other project facilities (in particular, ventilation facilities) would affect local visual character.

The highway-only bridge would be aligned immediately to the north of the existing bridge. It would have approximately the same profile as the existing structure, which includes a long causeway section to the west and a pronounced span over the Hudson River's shipping channel. It would have about 60 piers compared to 200 for the existing structure, resulting in less obstructive far field views. It is probable that the new bridge would be either a suspension or cable-stayed type, which would give the main span a clean, modern appearance in contrast to the busy steel work of the existing structure.

5.6.1 Bridge Option

Rockland

At the Rockland shore, the dual-level Bridge Option would be higher than the existing bridge by up to 40 feet and about 10 feet higher than the highway-only bridge. The existing bridge touches down 35 feet above river level compared to 75 feet for the new bridge. Present views from residences between the 35-foot and 75-foot elevations would be obscured, affecting several dozen residences.

The single-level Bridge Option would be higher than the existing bridge by up to 10 feet, thus avoiding most of these visual impacts. Although the bridge would be wider, creating some modest visual changes for viewers in the near-field, these would be largely indiscernible for more distant viewers of the bridge.

Hudson River

Given the grade limitations imposed by efficient rail operations, the profile of the Bridge Option would differ considerably from that of the highway-only bridge. Instead of the relatively long, flat causeway section of the existing bridge, the Bridge Option would have a profile that rises fairly uniformly in elevation (from west to east) until it reaches the elevation required to cross the shipping channel. From the channel to the Westchester shore the Bridge Option descends toward the new toll plaza and Tappan Zee Station. The dual-level bridge would have about 45 piers.

The change in bridge profile would be most noticeable to viewers standing immediately adjacent to the bridge at the Rockland shoreline. From greater distances the modified profile would be less noticeable. Ultimately, for the Bridge Option, the most far-field visual impact would come from the new bridge towers and main spans, which would be new and modern features on the landscape.

It should be noted that an additional feature of the Bridge Option is that railroad passengers would have views of the Hudson River. This benefit would not be realized under the Tunnel Option; however, if the tracks were in the center of the bridge, the views would be somewhat limited by vehicular traffic on both sides.

Westchester

On the Westchester shore, views from sensitive properties (e.g., County Park, Lyndhurst, and Sunnyside) would be largely unaffected because the rail lines are in a cut at the river’s edge obscured by topography and vegetation. Distant views of the bridge from sites such as Lyndhurst would primarily see the new bridge supporting towers and main spans. In the vicinity of Route 9 and the shopping center at Route 119, visual changes would occur because of the facilities associated with the new Tappan Zee Station (parking facilities, roadway modifications, entryways, vent structures, etc.). Existing visual qualities are not high at this location, so potential impacts would not be significant.

Adjacent to the Requa property north of Lyndhurst, the clearing of 1 acre of woodland and construction of a ventilation facility would cause visual changes to the waterfront, noticeable only from the river, and, therefore, would not affect the views from sensitive properties. However, the vent stack may be noticeable from Lyndhurst. Further study regarding the design of the facility, including the stack height, will be conducted in the DEIS Stage.

5.6.2 Tunnel Option

Rockland

On the Rockland shore, the most significant permanent visual impact is related to the ventilation facility. The ventilation building would rise 40 feet above water level, with a ventilation stack rising up to 100 feet and would add a significant feature to the landscape, comparable in height to the seven-story apartment buildings north of the bridge. While the adjacent bridge itself would mask this impact, particularly for viewers to the south, the new ventilation facility would be an intrusive visual feature on the South Nyack waterfront.

Westchester

On the Westchester shore, a permanent underground ventilation facility would be located on the site of the Castle Oil terminal, with up to a 100-foot stack. The stack would be a new intrusive feature on the Sleepy Hollow/Tarrytown waterfront. It would be highly visible from Horan's Landing Park and possibly cast shadows there. With the Ichabod's Landing project nearing completion to the north of Horan's Landing Park and the proposed Ferry Landing project pending to the south, a tall ventilation tower would be an intrusive feature to these three- to four-story residential developments. Further to the south, the two ventilation stacks at the Tarrytown Station, up to 100 feet in height, would impact the visual setting along the Westchester shoreline.

5.6.3 Comparison of Options

For distant viewers the appearance of the new bridge would be substantially the same in all options. In the near field on the Rockland shore, the dual-level bridge would be more intrusive upon the views of several dozen residences than the highway-only bridge or single-level CRT bridge. Rail commuters on the bridge would have views of the river. The Tappan Zee Station would alter the visual setting in the vicinity of the toll plaza.

The ventilation building and stack on the Rockland shore and ventilation stacks on the Westchester shore would be new and intrusive features in the Tunnel Option, affecting residences in South Nyack, Ferry Landing and Ichabod's Landing as well as users of Horan's Landing Park.

In summary, the single-level bridge has fewer visual impacts than the dual-level bridge or the Tunnel Option. The dual-level bridge has greater near-field impacts on the Rockland side than the tunnel but the Tunnel Option has greater visual impact due to the vent stacks on both shores.

5.7 Contaminated Soils and Groundwater

In a developed setting, historic and current land uses may have contaminated the soil and groundwater through leaks and spills of hazardous materials. Furthermore, as a result of historic industrial discharges, sediments in the Hudson River have become contaminated. As a result of the extensive earthwork and in-river construction activity associated with the project, it is likely that contaminated soils and sediments would be encountered and would need to be properly handled and disposed.

There have been reports of minor petroleum spills within the I-287 Corridor in the vicinity of both the Rockland and Westchester bridge approaches. As a result, construction work on the highway-only bridge may encounter some contaminated soils but it is expected that the implications for the project would be minor.

Based on available data it is likely that the top 2 or 3 feet of river sediment in the highway-only bridge location is contaminated and would require special handling procedures when removed. The quantity of contaminated sediment that would require special handling is estimated to be 20,000 cy.

5.7.1 Bridge Option

Rockland

The implications of encountering contaminated soils are the same as for the highway-only bridge.

Hudson River

The implications of encountering contaminated sediments are the same as for the highway-only bridge.

Westchester

The implication of encountering contaminated soils within the Tappan Zee Station-Toll Plaza vicinity would be the same as those for the highway-only bridge, with the possible exception of the following:

- Construction activity at the shopping center site may encounter buried fuel storage tanks with some history of discharges.
- The Hudson Line CRT connection tunnel would run beneath the Kraft/General Foods Technical Center, which is listed as a large-quantity generator of potentially hazardous materials; the facility has reported spills of industrial chemicals and a leaking underground storage tank.
- Contaminated soils may be encountered along the Hudson Line ROW where a connection would be made to the existing Metro-North system. Historical rail operations may have resulted in discharge of fuels and other industrial products within the ROW. The quantity of contaminated soils that would be encountered at the above referenced locations cannot be estimated with the available information.

5.7.2 Tunnel Option

Rockland

Within Rockland County the impacts of the Tunnel Option are comparable to the Bridge Option.

Hudson River

The launch box near the Rockland County shoreline would be an in-river structure, necessitating the removal of contaminated sediment. Assuming a 1-acre launch box, and 3 feet of contaminated material, 5,000 cy of contaminated sediment would be removed.

Westchester

The recovery box on the Westchester side of the river would be on land at the current Castle Oil terminal in Sleepy Hollow where there have been several reports of petroleum spills. Continuing south from the recovery box, the CRT is in cut-and-cover or retained cut construction to the junction with the existing railroad. Although there are no specific reports in the regulatory databases of contamination along the railroad ROW, some soil contamination can be expected in this area as well.

5.7.3 Comparison of Options

The principal difference between the Bridge and Tunnel Options on land occurs in Westchester County. The Bridge Option may encounter contaminated soils at the shopping center, the Kraft property, and along the Hudson Line ROW. The Tunnel Option may encounter contaminated soil at the Castle Oil facility and also along the Hudson Line ROW. In the river, the Tunnel Option also may encounter contaminated sediment along the Rockland shoreline at the launch box.

In summary, contaminated soils and groundwater are not a discriminator between the Bridge and Tunnel Options.

5.8 Air Quality and Noise

With respect to air quality and noise, these criteria have been found not to be discriminators between the Bridge and Tunnel Options, principally because both options have highway bridges with the same amount of motor vehicle traffic. The difference between the options is that in the case of the Bridge Option air pollutants would be emitted directly into the atmosphere, while in the case of the Tunnel Option, CRT air pollutants would be emitted through vent stacks. Air emissions in both cases, however, would be the same, and would not be significant given the infrequent events when rail engines would be operated in diesel mode. Furthermore, ventilation systems and stacks would be located and designed during the DEIS Stage in such a manner as to have no significant impacts on air quality.

Similarly, with a highway bridge in both options, the only noise difference between the two is that CRT noise emissions would be in the open air with the Bridge Option and in an enclosed tunnel in the Tunnel Option. Thus, while local communities would be subject to slightly higher noise levels with the Bridge Option, this difference would not be significant as the highway noise levels would be the dominant noise source under both options. The ultimate design of noise abatement measures (e.g., noise barriers) in the DEIS Stage would further diminish this difference.

In summary, air quality and noise not discriminators between the Bridge and Tunnel Options.

5.9 Summary

Of the eight criteria studied, the principal discriminators were displacements/easements/partial takings, ecosystems, and visual resources with the Bridge Option being preferable.

Major distinctions between the Bridge and Tunnel Options relate to partial takings and displacements at the existing Tarrytown and proposed Tappan Zee Stations. For the Tunnel Option, in the vicinity of the existing station, approximately 4 acres of property would be needed to accommodate construction; this land is intended for the Ferry Landing development. With Ferry Landing in-place, impacts between the river and Tarrytown Station would be considered severe to that residential use, involving displacements. For the Bridge Option, construction of the proposed Tappan Zee Station would occur on Thruway property, on a portion of the existing shopping center, and on portions of several adjacent properties. In addition, the single-level bridge would entail partial takings and displacements of residential properties in Rockland between Interchange 10 and the river.

In the Hudson River, the Bridge and Tunnel Options would have comparable permanent impacts to aquatic resources. The Tunnel Option would have greater temporary impacts to aquatic resources, thus, favoring the Bridge Option.

Visual impacts of a new bridge crossing would be most significant in the near-field or shoreline areas. Addition of CRT to the bridge would increase the near-field visual change resulting from a larger bridge structure. In the far-field, the most notable feature of a new crossing would be the new, modern appearing bridge towers. The more significant difference in visual impacts between the two options is related to the presence of a number of large vent structures necessary to ventilate the river tunnel, particularly the tunnel vent stacks in the river near River Road and at Horan's Landing Park.

6 COST CRITERIA

As the bulk of the shoulder tunnels in both Rockland and Westchester Counties are essentially the same in both the Bridge and Tunnel Options, the scope of the cost estimates has been limited to the river crossing and those associated landside segments of the project that are different in the two options. These segments include:

- Interchange 10 to the waterfront in Rockland.
- The waterfront to Interchange 9 in Westchester.
- The Hudson Line shoulder tunnels and connections.
- The expanded Tarrytown Station in the Tunnel Option and the new Tappan Zee Station in the Bridge Option.

6.1 Basis of Estimate

Construction cost estimates for the Bridge and Tunnel Options were based on unit costs for construction as shown on concept engineering drawings, soft costs, and contingencies, using available ROW, aerial mapping, and historical geotechnical investigation data. The estimates were built-up from approximately 200 individual cost items and were done in 2004 dollars without escalation. Unit costs were either calculated from analysis of material costs, crew costs and productivity, and equipment costs, or from bid prices or cost estimates available for similar projects in the region. These unit costs reflect the direct cost of the work plus:

- General contract conditions.
- Contractor overhead.
- Contractor profit.
- Contractor performance bond.
- Allowance for design changes, changes in scope, additional work orders, etc.

The estimates do not include allowance for:

- ROW acquisition.
- Insurance and financing.
- Third party mitigation.
- Hazardous material handling.
- Extraordinary utility relocation costs.
- Signature bridge main spans.
- Rolling stock.
- Agency force accounts.
- System upgrades.

Soft costs have been set by project team consensus at 45 percent of the direct construction costs, and include:

- Program management cost.

- Design fees.
- Construction management cost.
- Direct agency costs.

Industry practice is to apply a contingency of 30 percent to conceptual cost estimates on bridge projects. This value has been adopted for all bridge-related work in both options. It has also been adopted for work items common to both options, including systems, ventilation and temporary works.

Recent tunneling projects in the region have used a 40 percent contingency. This reflects the common industry experience that tunneling projects entail greater risk than bridge projects. This value has been adopted for all direct tunneling-related work. As a significant number of engineering parameters would only become known during tunnel construction, there is risk that a longer construction period may be required.

6.2 Cost Estimate

The total estimated cost of each option, including soft costs and contingency, is shown in Table 6-1.

Table 6-1

Capital Cost Summary

Component	Bridge Option	Tunnel Option	Cost Differential
Highway-Only Bridge	$3.0 billion	$3.0 billion	-
Incremental Cost of Adding CRT to Highway Bridge or Constructing a CRT Tunnel	$4.0 billion	$5.3 billion	$1.3 billion
Total Cost of Option	$7.0 billion	$8.3 billion	$1.3 billion
Note: All costs are in $2004. Bridge Option cost is for a dual-level bridge. The incremental cost of a single-level bridge would be 10 percent higher.			

6.3 Summary

A comparison of the preliminary capital cost estimates for the Bridge and Tunnel Option resulted in a preference for the Bridge Option. The estimate for the Bridge Option, including highway and BRT/HOT lanes and two CRT tracks, is $1.3 billion (20 percent) less than that of the Tunnel Option ($7.0 vs. $8.3 billion respectively at 2004 prices). A 40 percent contingency was applied to tunnel construction to account for the greater risks inherent in underground construction; a 30 percent contingency was used for all other elements including bridge construction. Some general items, notably costs for a signature bridge span, were excluded.

7 SECURITY

Bridge and tunnel security is important enough to be a matter of national security policy and so security concerns are an important part of the total range of considerations in reviewing the Bridge versus Tunnel Options. While it is beyond the scope of this paper to perform a design threat analysis, the general consequences of attacks were considered including: threats to the integrity of the structure; damage that inhibits the structure's operability for an extended period; and contamination of the tunnel resulting in extended closure or loss of operability or catastrophic failure. Another consideration is the ability of first response organizations to cope with the consequences of the attack.

As the Tunnel Option is compared to the Bridge Option, structural damage is easier to address and to repair on the bridge from the perspective of access, prepositioning of replacement road bed sections, and normally the ability to work in three dimensions, than it would be in the tunnel. Acceleration of repairs and further return to functionality would also be better achieved on the bridge versus the tunnel. Contamination with biochemical/hazardous materials would have far more impact in a tunnel than on a bridge. Given the fact that the initial fire/emergency response would come from the surrounding Rockland and Westchester County communities, it is much more likely that a bridge incident is within their training and experience profile than would be expected in responding to a fire, explosion, or hazardous materials incident in a tunnel. Communications, training and response strategy and tactics as developed in mutual aid drills for a bridge emergency are less complex and more intuitive than similar issues for a tunnel.

While a tunnel can be hardened to protect it from explosions and fire and protected by other long-term and short-term security efforts, the extended after-effects that can impact a tunnel as well as the greater difficulties in preparing for, assessing, and responding to tunnel incidents make a bridge a less complex alternative. It is the opinion of security experts consulted for this review that, from a security perspective, a bridge is preferable to a tunnel.

8 CONCLUSIONS

The objective of the AA process (Level 1 and Level 2 screening) is to reduce and combine the 150 elements identified at the onset of the study into a manageable number of alternatives to be carried forward into the DEIS Stage. This paper presents the results of the analysis of one of these elements: CRT in a tunnel across the Hudson River (Tunnel Option). The analyses were based on agency operating requirements and the Level 2 Screening Criteria, and were developed in conjunction with CRT on a replacement highway bridge (Bridge Option) for comparison, which had previously been recommended for inclusion in the DEIS Stage.

This chapter presents an outline of the transportation benefits to be gained by both the Bridge and Tunnel Options followed by an overview of the key environmental, engineering, security, and cost impacts.

8.1 Transportation Performance

As shown in previous papers prepared for the AA process, the introduction of CRT across the Hudson River would improve mobility for the markets served by the corridor. The type of crossing of the Hudson River, whether a bridge or tunnel, would not affect this overall transportation benefit as both options could provide the necessary direct connections for the major markets (across corridor and beyond, and to New York City). In the Tarrytown area, however, benefits would differ, primarily due to differing station locations.

For the Bridge Option, benefits beyond those associated with the introduction of CRT would result from the inclusion of a new Tappan Zee Station, situated just north of the existing Thruway toll plaza in Tarrytown. These benefits would include:

- Greater Tarrytown area CRT ridership than the Tunnel Option (425 more riders in the AM peak hour).
- An alternative station for riders from the south and east of the station, resulting in reduced traffic congestion in Tarrytown (400 fewer riders), particularly in the area of the existing Tarrytown Station.
- A simple cross-platform transfer between CRT and LRT in Alternative 4B and BRT in Alternative 4C.

However, the Bridge Option in Alternative 4A (full corridor CRT) would rely on bus services between the existing Tarrytown Station and the new Tappan Zee Station for a small number of riders transferring between the Upper Hudson Line and the Cross Corridor (East-West) Line.

A benefit of the Tunnel Option would be the provision of a direct transfer (small market) between the Upper Hudson Line and the Cross Corridor (East-West) Line at Tarrytown by creation of a new underground (lower level) station at Tarrytown. This option would generate up to 400 more transfers than the Bridge Option. Thus the total users of the stations in both options are roughly equal in the case of full corridor CRT. However, the Tunnel Option would have the negative impacts of increased traffic due to a greatly expanded transit facility in Tarrytown surrounded by a capacity-constrained street network.

In either Alternative 4B or 4C (CRT with Cross-Westchester LRT or BRT), travelers between Rockland and Westchester Counties would be required to transfer between CRT and LRT or BRT at Tarrytown (whereas under full-corridor CRT, no transfer would be necessary). This would reduce overall ridership on the new services compared to full-corridor CRT, regardless of whether the Bridge or Tunnel Option is selected. In these alternatives both the Bridge Option and Tunnel Option would facilitate transfers between the Upper Hudson Line and Cross-Westchester LRT or BRT Service, and due to the more convenient configuration at Tappan Zee Station (cross-platform transfer versus a change of levels at Tarrytown), the Bridge Option would attract more transfers than the Tunnel Option. Therefore, should Alternative 4B or 4C be selected as the preferred alternative, the Bridge Option would be superior to the Tunnel Option, both in terms of Tarrytown area ridership, and for transferring passengers.

Overall, shifting of riders from Tarrytown to Tappan Zee Station results in local traffic improvements in Tarrytown under the Bridge Option and would be of greater benefit than the higher number of transfers to/from the Upper Hudson under the Tunnel Option, particularly given the constrained street network in the area of the existing Tarrytown Station, and local traffic concerns.

8.2 Environmental Impacts

Both the Bridge and Tunnel Options would have environmental impacts, with those associated with the Tunnel Option being somewhat greater. The more notable environmental impacts of both options would include displacements/partial takings/easements, impacts on visual resources, aquatic habitat impacts, and construction impacts.

Under the Tunnel Option, potential impacts would include:

- Residential displacements within Ferry Landing (15 to 20 units).
- Displacement of the Castle Oil terminal, asphalt plant, and other commercial properties.
- An easement under Horan’s Landing Park.
- Relocation of the currently unused Lyndhurst pedestrian bridge over the Hudson Line tracks.
- Less than 5 residential displacements and less than 5 residential partial takings near the Rockland shore.

For the dual-level Bridge Option there would be fewer residential property displacements and more partial takings than for the Tunnel Option. For the single-level bridge, there would be an increase versus the tunnel in the number of partial takings and displacements. Specific property impacts would include:

- Potential temporary or permanent partial takings or relocation of the shopping center in Tarrytown adjacent to the toll plaza depending on the configuration of the Tappan Zee Station.
- Partial takings at the Requa House property adjacent to the river.
- Relocation of the currently unused Lyndhurst pedestrian bridge over the Hudson Line tracks.
- For Westchester, the impacts of the single or dual level bridge are the same, resulting in less than 5 partial residential takings and one commercial as well as potential impact on the shopping center. The impacts of the tunnel include less than 20 displacements / partial takings at Ferry Landing, relocation of the asphalt plant and Castle Oil.
- For Rockland, the single level bridge results in less than 15 residential displacements and less than 15 partial residential takings. The dual level bridge is the same as the tunnel except for a piece of Elizabeth Park.

Visual impacts of a new bridge crossing would be most significant in the near-field or shoreline areas. Addition of CRT to the bridge would increase the near-field visual change resulting from a larger bridge structure. In the far-field, the most notable feature of a new crossing would be the new, modern appearing bridge towers. The more significant difference in visual impacts between the two options is related to the presence of large vent structures necessary to ventilate the river tunnel. One vent structure would be situated in the river near River Road in Rockland and the other near Horan's Landing Park in Westchester.

In the Hudson River, the Bridge and Tunnel Options would have comparable permanent impacts to aquatic habitat. The Tunnel Option would have greater temporary impacts to aquatic habitat due to longer duration of construction from temporary river platforms thus, favoring the Bridge Option.

Overall, the environmental impacts associated with the Bridge Option would be less than those associated with the Tunnel Option.

8.3 Engineering and Security

Though both the Bridge and Tunnel Options would be designed to meet all code requirements and to provide sufficiently strong and safe crossings, analysis of the engineering and security criteria for both Highway and Transit resulted in a clear preference for the Bridge Option, particularly the single-level bridge. In the engineering criteria, the objective was essentially to assess the implications to the crossing structure and its users under key accidental but natural event scenarios, while in the security criteria, the objective was to assess the implications to the crossing structure and its users under malicious event scenarios. The bridge scored well in these criteria because of its inherent characteristics:

- Limitation of event consequences, such that any event would only affect a small part of the overall crossing (both single level and dual). This would be a major differentiator compared to the Tunnel Option where some event scenarios could result in damage to the complete crossing (e.g., flooding).

- Multiple access points for emergency responders (both single level and dual). Emergency responders would use the highway lanes to access emergency CRT events rapidly with standard emergency vehicles. In the Tunnel Option, access would be on foot for first responders and it would take considerably longer to reach incident locations.

- Multiple egress paths (both single level and dual). The bridge section incorporates sufficient space on both sides of both CRT tracks to allow passengers to egress a train in an emergency event through all doors with egress to a place of safety possible for most passengers in 10 to 20 minutes. For the Tunnel Option, egress to a place of safety would only be possible through one side of the train with subsequent funneling of passengers along benchwalks, resulting in longer egress times than the Bridge Option. Egress time for most passengers to a place of safety would be 30 to 45 minutes or 60 to 90 minutes to the surface.

- Open framework. The open nature of the Bridge Option (dual or single level) would allow for natural dissipation of smoke without the need for a ventilation system on the crossing. In the Tunnel Option a major ventilation system with supporting monitoring, management and maintenance systems would be required. Extensive training and specialist personnel would also be required to operate these systems to ensure optimum performance in event scenarios.

- All incidents would be essentially visible. One of the keys to emergency response is the correct identification of an incident location and magnitude. This would be inherent in the Bridge Option (single or dual) but would depend on cameras and other detection equipment in the Tunnel Option that would be subject to malfunction and misinterpretation.

- A single river crossing (either single or dual). It would be easier and more efficient to provide security for a single facility than for the multiple facilities including key vent buildings required in the Tunnel Option.

- Separation between the superstructure elements supporting the highway and CRT on the single level bridge. Consequently should any emergency event occur in any mode the other would only be minimally affected. This separation would also be available in the Tunnel Option.

8.4 Construction Impacts

Construction Impacts are much more significant for the Tunnel Option than the Bridge Option as follows:

- All construction impacts for the tunnel are in addition to those associated with construction of a highway-only bridge.
- Removal and processing of 1.5 million cubic yards of spoil materials as well as transport off site by truck and barge, and need for a continuously available disposal site(s).
- Severe impact of duration and scale of construction in and around the Ferry Landing development.
- Construction of launch boxes for the tunnel boring machines.
- Construction of ventilation facilities.
- Duration of work on temporary platforms along the shoreline of up to 6 years for tunnel construction as opposed to up 4 years for Bridge Construction.

While there are potential location and volume of traffic impacts in the vicinity of the Tappan Zee Station, the construction impacts of the Tunnel Option are much more significant overall.

8.5 Cost

The preliminary cost estimates for the dual level Bridge and Tunnel Options are $7.0 billion and $8.3 billion respectively, including contingency and soft costs. The Tunnel Option is $1.3 billion (20 percent) more expensive than the dual level Bridge Option (10% more expensive than a single level bridge), and would be considered the greater risk because of the extensive works through the soft ground beneath the Hudson River and along the Westchester shore.

8.6 Recommendation

The Bridge Option has identifiable advantages over the Tunnel Option in the areas of local traffic improvements in Tarrytown, lower cost, lower construction risks, fewer environmental impacts, including property displacements, lesser construction impacts and better security. The only discriminating benefit of the Tunnel Option would be the greater ease of transfers at the expanded Tarrytown Station to/from minor markets such as the Upper Hudson to the Cross Corridor (East-West) line (only in Alternative 4A-full corridor CRT. Transfers from these markets to LRT or BRT (Alternatives 4B, 4C) are equal or better in the Bridge Option.

For these reasons, it is recommended that the Tunnel Option be eliminated from further consideration in the DEIS stage. The issue of the single level versus the dual level bridge will be addressed in the DEIS Stage.